GHANA COLLEGE OF PHYSICIANS AND SURGEONS,

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FACULTY OF EMERGENCY MEDICINE

CHARACTERISTICS AND OUTCOMES OF PAEDIATRIC TRAUMATIC BRAIN INJURIES PRESENTING TO KOMFO ANOKYE TEACHING HOSPITAL.

BY

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(FGCS)

KWAME EKREMET

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DECLARATION

I, Kwame Ekremet, hereby declare that the work presented here is the result of my composition except for the work of others, which has been duly acknowledged in the reference section. I affirm that neither the whole nor part of this thesis has been presented to any other institution. I am solely responsible for the content of this thesis.

Signature……………………………………………

Kwame Ekremet

Senior Resident

CERTIFICATION

This dissertation was supervised by

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DEDICATION

I dedicate this work to my lovely wife, Dr Mrs Peggy Asiedu Ekremet and my children, Ewurabena Mampanyin Ekremet, Papa Kofi Gyasi Ekremet, and Nabanyin Fiifi Anim Ekremet.

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ABSTRACT

Introduction: Traumatic Brain Injury (TBI) in children is a major cause of morbidity and mortality in many countries. Despite the magnitude of this problem in children, there are limited studies to characterise paediatric TBI in Ghana. The primary objective of this study was to determine the characteristics and outcomes of children less than 15 years presenting to a tertiary academic teaching hospital with acute traumatic brain injury at discharge and three months post-injury. The secondary objective was to identify the factors which accounted for the variation in the outcomes of children presenting with TBI.

Methods: This was a hybrid study consisting of a prospective cross-sectional study of consecutive children, less than 15 years of age, who presented with TBI to the Komfo Anokye Teaching Hospital Emergency Department (KATH ED): in addition, an embedded cohort study was performed which followed up for three months those patients discharged from the hospital. Socio-demographic and injury characteristics were collected. Participants were followed until hospital discharge. Mortality as an outcome at hospital disposition was determined. Another outcome, the Paediatric Glasgow Outcome Scale-Extended (GOSE), was assessed within 24 hours of discharge and repeated at three months post-TBI. Research Electronic Data Capture (REDCap) was used to enter the data into a secured database electronically. Data was exported to Microsoft Excel ® for data cleaning, after which STATA 13.1 was used for the analysis.

Results: A total of 369 patients presented with paediatric trauma to the KATH ED during the study. 136 of these children were managed for traumatic brain injury (TBI) giving a prevalence of 36.86%. Males predominated (63.24%) with the 5- to 9-year age group mostly (41.91%) affected. Road traffic crashes (69.12%) with pedestrian-vehicle collision (67.02%, 63/94) were the most frequent mechanisms of paediatric TBI. The majority (94.12%) of the children with TBI were managed conservatively with a neurosurgical operative rate of 1%. Paediatric TBI mortality rate was 10.29%. Most (61.98%, 75/121) were discharged with a moderate-to-severe disability according to the paediatric GOSE. At three months post-TBI, the majority (91.18%, 93/102) of the discharged patients had a good recovery from the TBI. Severe TBI (adjusted OR [AOR] 136.02, 95% CI 2.76 to 6,706.22) and the development of complication on the ward (AOR 29.03, 95% CI 2.44 to 344.91) were independent positive predictors of mortality for children with TBI, whereas anti-seizure requirement was less likely to predict a good recovery at 3 months post-TBI (AOR, 0.15; 95% CI, 0.03 to 0.72).

Interpretation: A significant number of children with TBI were discharged with an acquired disability; however, by three months post-TBI, most of the children had made a good recovery. For many children with TBI, conservative management may be sufficient as the definitive management plan.

Conclusions: Paediatric TBI was common affecting 1 in 3 children presenting with paediatric trauma to KATH ED. It mainly affected males, those aged between 5 and 9 years, with RTCs being the principal mechanism of injury. Although most children with TBI were discharged with moderate-to-severe disability from the TBI, three months following the injury, most of them had recovered adequately. Successful long-term follow-up of paediatric trauma, and specifically paediatric TBI, is feasible in LMICs such as Ghana. The paediatric TBI care in Ghana could inform such care in High-Income Countries.

Keywords

TBI, Injuries, KATH, Children, Ghana

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LIST OF ABBREVIATIONS

AIS	Abbreviated Injury Score
CDC	Centre for Disease Control and Prevention
CSI	Cervical Spine Injury
CT	Computed Tomography
DAI	Diffuse Axonal Injury

DALYs	Disability Adjusted Life Years
ED	Emergency Department
EDH	Epidural haemorrhage
EN	Emergency Nurse
EP	Emergency Physician
GCS	Glasgow Coma Scale
GSRRS	Global Status Report on Road Safety
HICs	High Income Countries
ICH	Intracerebral haemorrhage
ISS	Injury Severity Score
KTS	Kampala Trauma Score
LMICs	Low-Middle-Income-Countries
RTIs	Road Traffic Injuries
SDG	Sustainable Development Goals
SDH	Subdural haematoma
SSA	Sub-Saharan Africa
TBI	Traumatic Brain Injury
USD	United States Dollars
YLD	Years Lived with Disability
YLL	Years of Life Lost

CHAPTER ONE: INTRODUCTION

1.1 Background information.

Up until approximately a decade ago, communicable, maternal, neonatal, and nutritional diseases were a significant cause of death globally, but the trends are changing.[1] While mortality attributable to these diseases altogether has decreased significantly by 20% between 2005 and 2015, the injury mortality rate decreased by less than 0.5% during the same period.[2] According to the recent Global Status Report On Road Safety (GSRRS) 2018, Road Traffic Injuries (RTIs) are the leading cause of death for children and young adults aged 5-29 years.[3] After a trauma, one of the significant causes of morbidity and mortality in many countries is Traumatic Brain Injury (TBI); this is of significant public health concern in both High-Income-Countries (HICs) as well as Low-Middle-Income Countries (LMICs).[4]

The United States Centre for Disease Control and Prevention (CDC) defines a traumatic brain injury (TBI) as a disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury.[5] In most studies in Africa, head injury, which is described as nonspecific and archaic terminology, is used instead of the more precise clinical entity of traumatic brain injury.[6,7]

Children constitute one of the major groups adversely impacted by TBI.[7] In both emergency department (ED)- and population-based age-specific TBI incidence studies, children constitute one of the peaks, whether it is a bi-modal or tri-modal distribution, respectively.[7] Seventy-five percent of children involved in injuries have a head injury according to a global perspective study on the impact of TBI.[6] A 2016 study done at the Komfo Anokye Teaching Hospital, in Ghana, reported that 20% of the 504 TBI patients were children aged 0-14 years old.[8] Almost 10% of these children died within 48 hours of ED stay. In an earlier study by Abantanga et al.[9] at the same hospital, over 40% of children aged 0-14 years who died from trauma had a head injury.

Several mechanisms of injury have been identified to cause TBIs in children. Though there are some geographic variations in the causes of TBI,[10] road traffic injuries (RTIs) are the most common cause of TBIs.[4] In HICs, children are involved in RTIs as occupants of vehicles whereas, in most LMICs, they are involved as pedestrians.[10,11] In some LMIC regions, such as Asia, RTIs are approaching epidemic magnitude.[6,12] This trend is not different from what is happening in Africa, including Ghana. In Ghana, Osei-Kwame et al.[8] reported RTIs as the primary cause of TBI, confirming an earlier report by Abantanga et al.[9] that transport-related injuries were a significant cause of childhood trauma. Globally, falls are the second leading cause of TBIs, especially among the 0-4-year-olds.[10] Guerrero et al. reported that falls were the primary cause of TBI among 0-14-year-old children in the United States.[13] Assault or intentional injury is another cause of childhood TBI reported worldwide.[10] It is, however, under-reported in some countries for fear of being arrested by the police.[14]

Once an injury has occurred, the emergency medical system must be activated.[3] Even though the average response time to a patient for the Ghana National Ambulance Service (NAS) is 16.9 minutes,[15] less than one-quarter of patients ever call for an ambulance in the case of an emergency such as an injury.[16] Ghanaians prefer to use Taxis to transport the injured as well as the sick to the hospital.[16]

The diagnosis of TBI is made clinically, and the anatomic injury confirmed radiologically. There are several means of determining the severity of a traumatic brain injury. Clinically, the most common scale used is the Glasgow Coma Scale (GCS). The severity of injury for a patient with multiple trauma, including a head injury, is better assessed using the Injury Severity Score (ISS).[17] Among other things, this scoring usually requires knowledge of the anatomic injury causing the TBI after a radiological investigation. Radiologically, computed tomography (CT) scan of the head is the commonly used modality to determine the anatomic injury. The Rotterdam CT score of TBI can be calculated to predict mortality at six months and has been validated in children.[18] In most hospitals in Ghana, if not all, the cost of doing any CT scan is entirely borne by the patient. The cost of a head CT scan, which ranges from three hundred to five hundred and twenty-five Ghana Cedis ($66-104), depending on where it is done, limits some patients from obtaining this essential investigation. According to Osei-Kwame et al., more than forty percent of patients with TBI who required a head CT scan did not obtain one.[8]

After a traumatic brain injury, brain recovery varies greatly and results in several outcomes. The worst outcome is death, which may occur in the pre-hospital, in-hospital, or after patient discharge from the hospital. The mortality associated with TBI is worrying. Globally, mortality ranged from 1-7% among children.[10] It is however noted to be higher than ten percent in countries such as Sweden, Spain, South African, and the United States of America. Udoh et al.[11] found mortality of 8.7% in Nigeria, while Osei-Kwame et al.[8] identified mortality among children to be 9.7% within 48 hours of their ED stay in Ghana. However, these mortality rates may be underestimating the burden of paediatric TBI. The underestimation results from lack of access to pre-hospital data and weak injury surveillance systems.

Children who survive from TBIs may recover completely or have some residual neurologic deficit and live with a disability for a period or the rest of their lives.[4,19,20] The quality of life (QoL) after a traumatic brain injury may, therefore, be affected adversely. According to Kraus et al.,[21] some children who were discharged with good recovery after a brain injury had functional neurologic limitations such as posttraumatic seizures, speech and gait difficulties, extremity weakness as well as hearing and visual changes. Neuropsychologically, the impact of TBI on children, may negatively affect their developmental processes such as learning, social function, and emotional awareness.[22] It is therefore not enough to know the severity of the TBI but to go further to determine how these injuries impact the quality of life of children who survive these injuries. Comparatively, although children have better outcomes compared to adults with the same severity of traumatic brain injury, they tend to live with a permanent disability longer than adults.[23]

In a recent study at the Komfo Anokye Teaching Hospital, the authors observed the outcomes of TBI participants for 48 hours, which is not an adequate time frame to identify significant sequelae following a TBI.[8] There are several measures to evaluate the outcomes of TBIs. The Glasgow Outcome Scale, Extended (GOSE) is the most widely used scale.[24]

To the best of our knowledge, the outcomes of paediatric TBIs beyond 48 hours in Ghana is not known.

The primary aim of this study was to answer the following question: What are the characteristics and outcomes of children presenting with acute traumatic brain injury at discharge and three months post-injury?

The secondary aim was to address the question: what factors account for the variation in the outcomes of children presenting with acute traumatic brain injury?

1.2 The rationale for the study.

Although paediatric TBI is a significant cause of injury morbidity and mortality in Ghana, the characteristics, and outcomes beyond 48 hours of children sustaining these injuries are unknown. Whereas some studies in Ghana have looked at in-hospital childhood injuries as well as household and neighbourhood childhood injuries,[9,25] the characteristics of children sustaining TBIs and their outcomes were not the focus of those studies. When the burden of TBI at an urban ED in Kumasi, Ghana, was studied, participants included children who were followed for 48 hours.[8] Albeit this study provided some characteristics of children aged 0-14 years, the 48-hour follow-up period was not adequate to identify the longer-term sequelae of paediatric TBIs. Some paediatric TBI studies which were done in Nigeria, Kenya and South Africa were either retrospective or did not follow participants beyond discharge.[11,26,27] Another Nigerian in-hospital study used a more comprehensive outcome measure, Glasgow Outcome Scale, to assess the outcomes of children with head injuries who were managed nonoperatively.[28] This study, which was retrospective, focused on children who were only managed nonoperatively and excluded children with mild head injuries.

To address the limitations of the short duration of follow-up and the retrospective nature of the studies above, our study sought to determine the characteristics of all children sustaining TBI and their outcomes at discharge and three-months postinjury prospectively using the Paediatric Glasgow Outcome Scale-Extended (GOSE). It also determined the characteristics of the child as well as of the injury that accounted for the variations in their outcomes.

1.3 Aims of study including the definition of the research problem.

1.3.1 Research Problem

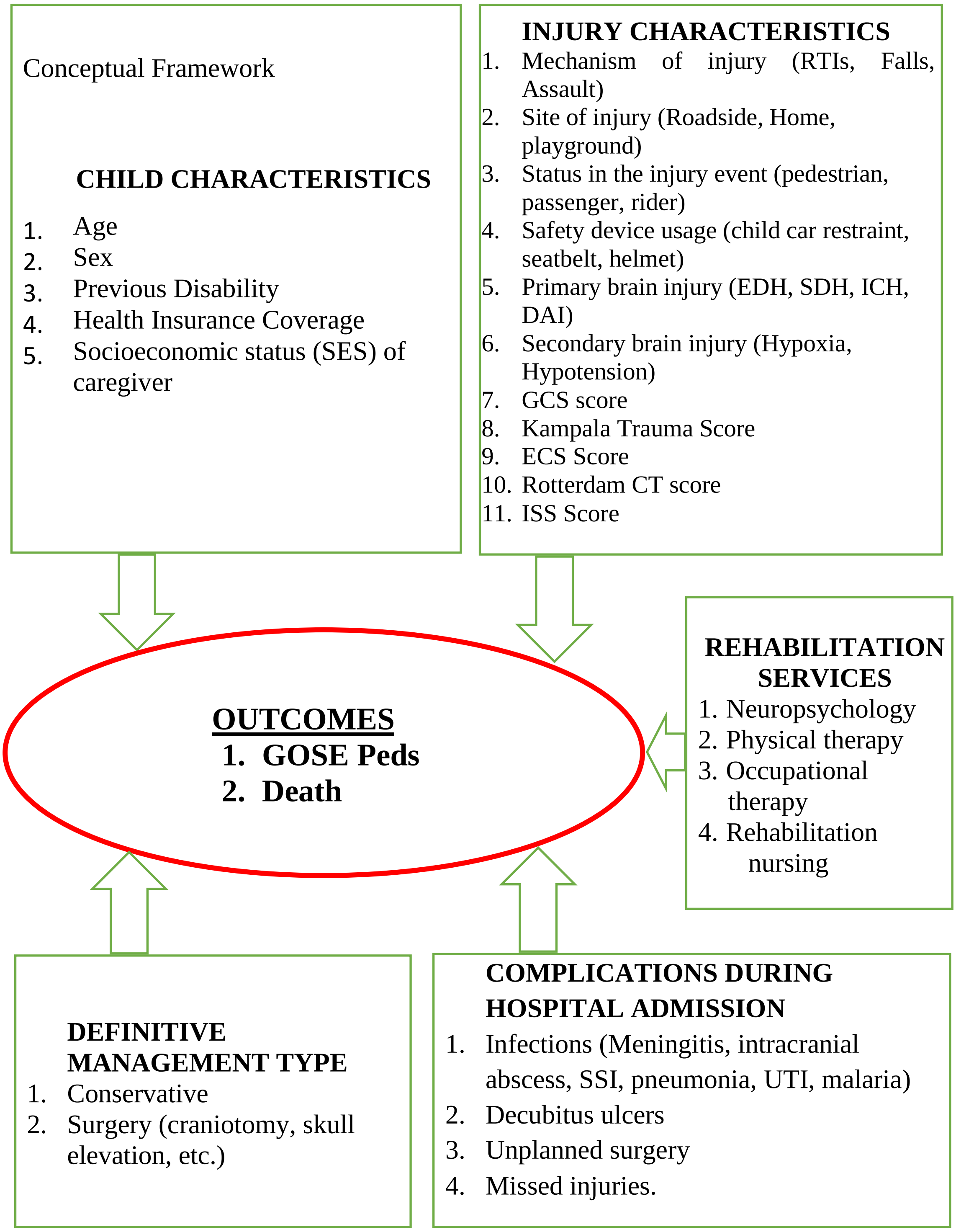
LMICs, including Ghana, have a disproportionately high burden of injury.[29] Of the nature of unintentional injuries sustained by children under 15 years globally, intracranial injury is leading with about 440.4 per 100,000 population, constituting 17.1% of all unintentional injuries followed by open wounds and poisoning with 12.3% and 10.9% respectively.[30] This makes TBI a major cause of injury mortality and morbidity among children.[9] However, there is limited comprehensive local data and research findings on paediatric traumatic brain injury.

Even though the burden of TBI is global, it is especially significant in LMICs due to the higher number of risk factors for the causes of TBI and a health system which is inadequately prepared to address the associated health outcomes.[6]

Efficient pre-hospital, in-hospital acute care and rehabilitation services positively impact on the outcome of TBI both in children and adults. There is a National Ambulance Service (NAS) in Ghana. The majority of Ghanaians believe in the safety of an ambulance in the transportation of the sick or injured: however, a few would call an ambulance even if the call was free.[31] Also, there is limited pre-hospital capacity in terms of the number of ambulances.[16] As of data collection for this study, there were only three out of 17 NAS stations, which were operational in the Ashanti Region.[32] It is therefore expected that the lack of adequate pre-hospital care would increase the probability that the post TBI outcomes among children might be poor. Also, most hospitals do not have Emergency Physicians (EPs) or Emergency Nurses (ENs); neither do they have Advanced Trauma Life Support (ATLS) providers. As such, secondary causes of TBI such as hypoxia and hypotension are either not identified or poorly managed before patients are referred. Compounding this problem is the lack of complete and adequate rehabilitation services in most facilities and communities where patients with neurologic deficits are managed and discharged to respectively.[33]

TBI studies in Ghana are not common, and the situation is even worse when it comes to that of children. Due to limited studies, the outcomes following post-traumatic injuries are inadequately documented. In a study by Osei-Kwame et al.[8] at KATH, the author identified that 20% of 504 TBIs presenting to this tertiary hospital in Ghana are children aged 0-14 years old. The outcomes of these patients were unknown beyond 48 hours of their admission to the emergency department. Indeed, given that sequelae may not be fully evident for months and possibly years, it is not surprising that outcomes and predictors in patients with paediatric TBI are not well understood in Ghana.

1.3.2 Conceptual Framework



1.3.3 Research Questions

1. What are the socio-demographic characteristics of children less than 15 years of age presenting to KATH ED with TBIs?

2. What are the injury characteristics of TBIs in the less than 15-year-old children presenting to KATH ED with TBIs?
3. What definitive management do children less than 15 years of age with TBIs receive after presenting at the KATH ED?
4. What are the final hospital outcomes of children under 15 years of age presenting to the KATH ED with TBIs?
5. What are the three-month post-TBI outcomes of children under 15 years of age who presented with TBI and were managed and discharged from the ED or the hospital?
6. What are the predictors of TBI outcomes among the under 15-year-old children who present to the KATH ED?

1.3.4 Aims of the Study.

The study sought to determine the characteristics and outcomes of children presenting with TBIs to the KATH ED and assessed the potential prognostic value of various characteristics of the child and the injury.

1.3.4.1 Specific Objectives

1. To describe the injury characteristics causing TBIs in less than 15-year-old children presenting to KATH ED.
2. To describe the definitive management children less than 15 years of age with TBIs receive after presenting to the KATH ED.
3. To determine the final hospital outcomes of children under 15 years of age presenting to the KATH ED with TBIs.
4. To determine the three-month post-TBI outcomes of children under 15 years of age with TBI after they have been managed and discharged from the KATH ED or the hospital.
5. To determine the predictors of TBI outcomes among the under 15-year-old children who present to the KATH ED with TBIs.

1.4 Flow of the presentation

The relevant literature regarding paediatric TBI is reviewed in the next chapter, Chapter Two. Chapter Three follows with a description of the study design, materials used for the study and the analytic methods. The results of the study are presented in Chapter Four, with complimentary tables and figures. A summary of the results of the study aims, and a discussion of study findings and limitations are presented in Chapter Five. Conclusions and recommendations follow in Chapter Six. Lastly, the references and appendices will end this dissertation.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter provides a review of the pertinent literature relative to this study. After defining the burden of injury among children, the material is presented, starting from injury event to outcome at discharge from the hospital and rehabilitation. Specific topics included in this chapter are injury rates in children, causes of injuries in children, head injury rates in children, Emergency Medical Systems (EMS), head injury characteristics in children, trauma severity scoring in children, TBI management and outcomes measurement and rehabilitation.

2.2 Injury Rates in Children

One measurement unit used to quantify the burden of diseases, injuries, and risk factors on human populations is Disability Adjusted Life Years (DALYs). It is the years of healthy life lost to premature death and disability.[34] The measure considers premature death and in case of illness, the physical impairment due to ill health and the duration of illness. It is the sum of years of life lost (YLLs) and years lived with disability (YLDs).[34]

The Global Burden of Disease 2017 Report categorises injuries as follows: transport injuries; unintentional injuries, which include falls, drowning, poisonings, foreign body and fire, heat and hot substances; and lastly self-harm and interpersonal violence.[35] Globally, the percentage DALYs attributable to all injuries for the age groups less than 5, 5-9 and 10-14 are 11%, 15%, and 15% respectively.[35] Western Sub-Saharan African countries have a similar percentage of DALYs attributable to injuries. Figure 2. 1 shows the percentage DALYs attributable to all injuries by age-groups in different regions of the world compared to Ghana.

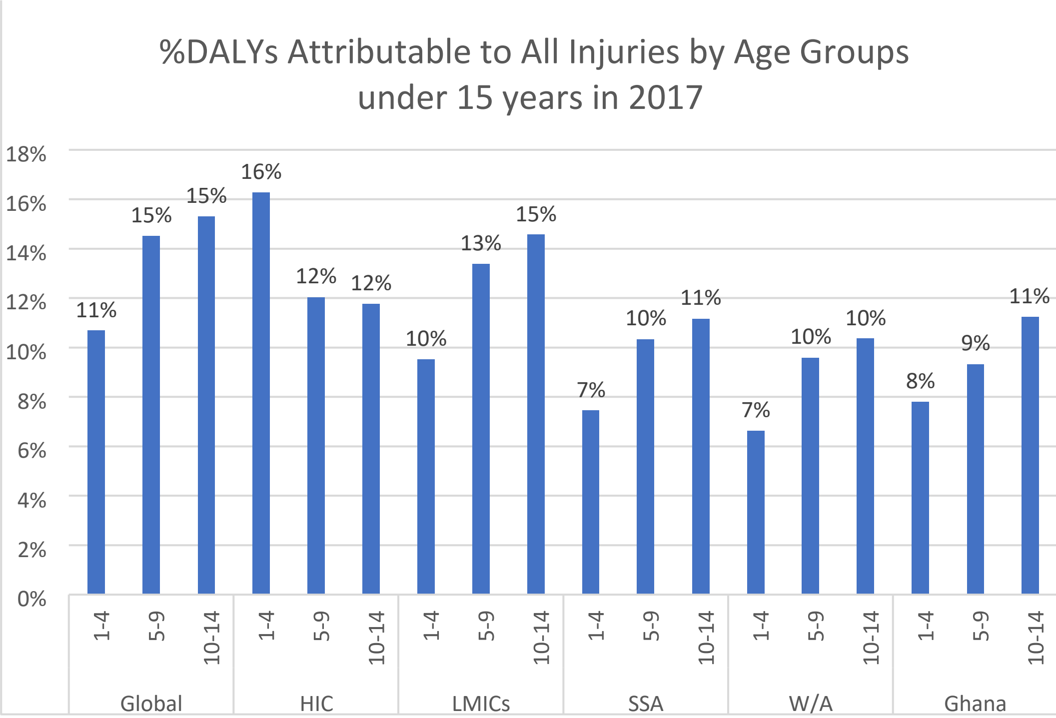


Figure 2. 1:Percentage DALYs attributable to all injuries in children under 15 years in different regions of the world compared to Ghana.

Source: Global Burden of Disease Study 2017 (GBD 2017) Results. Available from http://ghdx.healthdata.org/gbd-results-tool

According to the World Report on Child Injury Prevention,[30] in each year, hundreds of thousands of children die from injuries or violence, and millions of others suffer from disabilities acquired from injuries. As per the World Health Organisation (WHO), one of the emerging priorities for children's health are injuries.[36] Injury was ranked among the top 3 causes of death and lifelong disability among children aged 5-15 years. The GSRRS corroborates this finding by attributing injuries arising from road traffic crashes as the leading cause of death for children between 5 and 14 years of age.[3] In 2012, violence and unintentional injuries killed an estimated 740,000 children under the age of 15 worldwide, with the latter accounting for 90% of these deaths.[36]

Globally, 40% of all childhood mortalities are attributable to injuries, and more than 95% of children under 15 years of age die each year in LMICs from injuries.[37]

Injury death rates among children under the age of 5 years are about the same for males and females.[30] However, from age five years, males are at significantly higher risk of dying as a result of injury compared to females. Also, WHO reported that in children aged 5-9 years, the death rate in males is a third higher than that of females, a difference that worsens to 60% among those aged 10-14 years.[30]

Abantanga et al.[9] reported an annual injury rate among children below 15 years of age to be 230/100,000. Boys had an overall injury rate of 136/100,000 compared to 92/100,000 of girls, and this is the trend in other studies in Ghana,[38] as well as other African countries.[14,29] Apart from several thousands of injury deaths occurring each year, many more injury survivors live with a temporary or permanent disability. Mock et al.[39] found hat in a rural hospital in Ghana, more than 24% of children less than 19 years old survived with various degrees of disability after sustaining an injury.

2.3 Causes of Injury in Children

In several countries, the leading causes of injuries in children include RTI, drowning, burns, falls, and poisoning.[30] The rank order of the significant mechanisms of childhood injuries can vary within the same country and across different countries.[9,29,40] In Ghana, while Abantanga et al.[9] ranked RTIs as the most frequent mechanism followed by falls and then burns, an earlier study by Mock et al.[39] found burns, followed by RTIs and then falls in that order.. A recent population-based survey conducted in Ghana, found that falls, cuts/lacerations and burns were the three leading causes of household injuries in decreasing order.[41] The subsequent subsections will address the following causes of injury; road traffic injuries, falls, assaults, drowning, and burns.

2.3.1 Road traffic injuries

Construction of road infrastructure in many places does not take children into consideration; the result is that children are usually forced to share transport spaces with cars, motorcycles, and cycles increasing the likelihood of being involved in road traffic crashes.[30,42]

A road traffic crash is defined as "a collision or incident that may or may not lead to injury, occurring on a public road and involving at least one moving vehicle". A road traffic injury is defined as "fatal or non-fatal injury incurred as a result of a road traffic crash".[43] Death occurring within 30 days of a road traffic crash is termed, road traffic fatality.[44]

According to the Global Status Report on Road Safety, road traffic fatalities claimed 1.35 million lives in 2016.[3] This translates into approximately

3,700 people being killed on the world's roads every day. The report also states that LICs have just one percent of the world 's vehicles and still suffer 13% of road traffic deaths; this contrasts with 40% of the world's vehicles and 7% road traffic deaths in HICs. The road traffic death rates were highest in LMICs, specifically those in Africa (26.6/100,000 people) and SouthEast Asia (20.7/100,000 people).

Pedestrians, which include children, cyclists, and motorcyclists, are classified as vulnerable road users.[3] This group of road users is at a higher risk of death. Globally, they represent more than 50% of all road traffic deaths. More than one-quarter of all road traffic deaths are pedestrians and cyclists. Africa has the highest percentage of pedestrian and cyclist mortalities, accounting for 44% of deaths.[3]

Some critical behavioural risk factors such as speeding, drink-driving, and failing to use motorcycle helmets, seatbelts and child restraints have been identified to be associated with road traffic crashes.[45] To help deal with these challenges globally, the UN launched in 2010 the Decade of Action for Road Safety, 2011-2020.[46] This campaign aims to save millions of lives through five main actions. The five objectives included: building road safety management capacity, improving the road safety infrastructure, further developing the safety of cars, enhancing the behaviour of road users, and improving post-crash response. The anticipated progress was slow; the GSRRS report of 2015 cited 1.25 million people killed on the world's roads.[47]

In 2015, world leaders agreed on a new set of global priorities called the Sustainable Development Goals (SDGs). Targets 3.6 and 11.2 of the SDGs aim at halving road traffic deaths and injuries by 2020 as well as providing access to safe, affordable, accessible, and sustainable transport systems for all by 2030. Notwithstanding these interventions, road traffic crashes have remained high, as governments and policy makers in LMICs have been unable to achieve all the proposed road safety initiatives.[48] A document, Save LIVES: a road safety technical package was developed in 2017.[48] Developed to assist road safety decision makers and practitioners, this package details key measures to reduce road traffic deaths and injuries. The measures are evidence-based and recognised by many of the world's road safety policymakers and their agencies. The core components of Save LIVES are Speed management, Leadership on road safety, Infrastructure design and improvement, Vehicle safety standards, Enforcement of traffic laws and Survival after a crash.

Worldwide, one in every five road traffic deaths is a child, and road traffic mortality rates among children are 10.7 per 100,000 population.[30] Children, as well as pedestrians, cyclists and older people, are among vulnerable road users.[45] Fifty-four percent of road traffic deaths occur among these road users.[3] In many global studies, as well as others conducted in several African countries, including Ghana, children are mostly involved in road traffic crashes as pedestrians, being struck down.[9,10,29,40] Population studies done in Ghana show that the rate of paediatric RTIs is increasing. The rate in the year 1999, according to Mock et al.[25] was 22 per 1,000 compared to 32 per 1,000 in 2009, according to Guerrero,[49] roughly ten years later. Figure 2. 2 shows the percentage of DALYs due to RTIs by age group below 15 years in different regions of the world compared to Ghana.

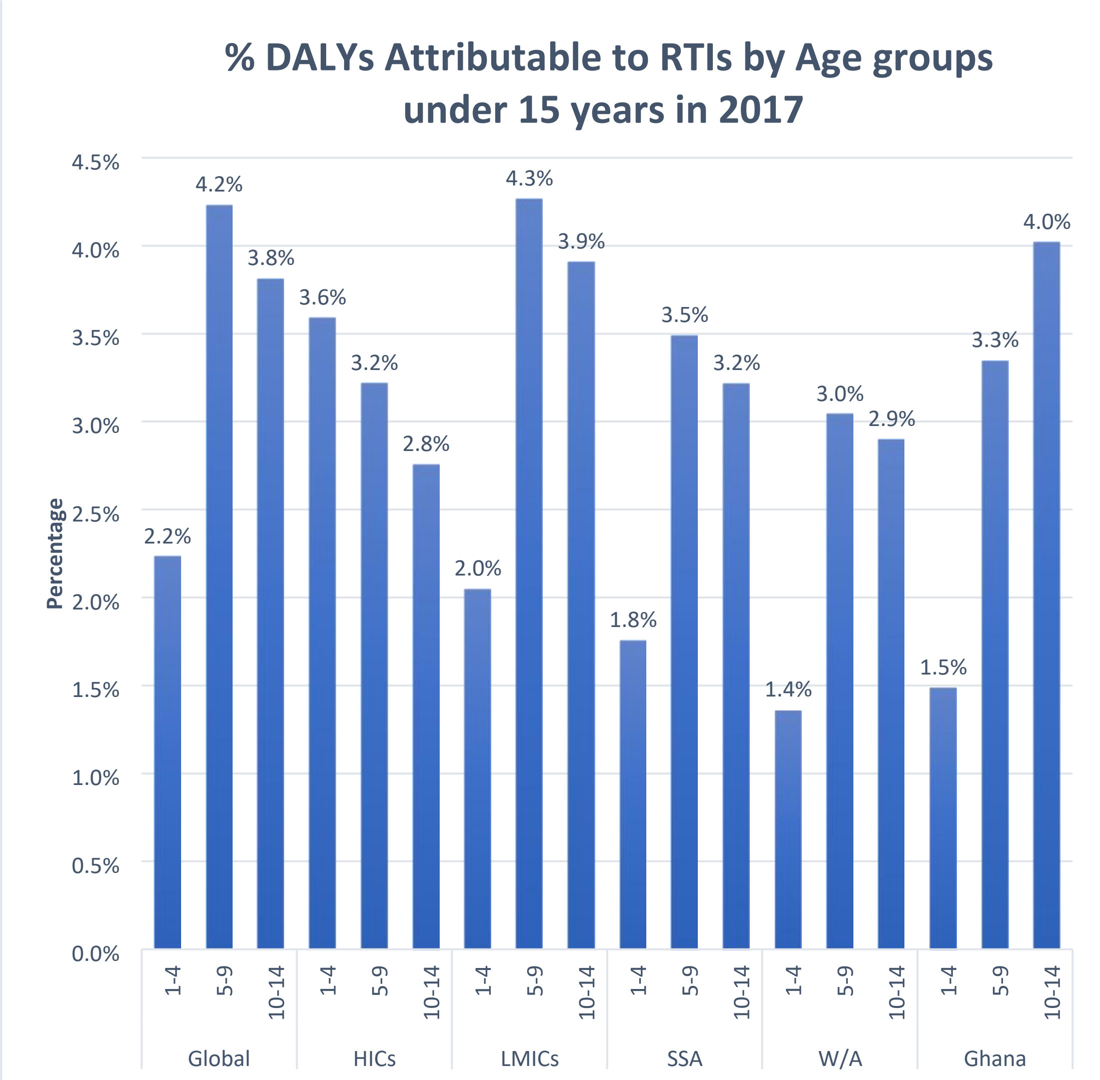


Figure 2. 2: DALYs attributable to RTIs in different regions of the world compared to Ghana.

Source: Global Burden of Disease Study 2017 (GBD 2017) Results. Available from http://ghdx.healthdata.org/gbd-results-tool

2.3.2 Fall injuries.

Falls from various heights also contribute significantly to injuries in children, although it relatively causes fewer fatalities compared to RTIs. It is the second leading cause of unintentional injury mortality globally, after RTIs.[50]

A fall is an event that results in a person coming to rest inadvertently on the ground or floor or other lower level.[50] As part of childhood development, children fall as they learn to walk, run, jump, climb and explore their physical environment. Luckily, many of these falls are of no or little consequence. Children fall many times whiles growing without sustaining damage, except for a few bruises and cuts.[30]

Children account for the most substantial morbidity, and almost one-half of the total number of DALYs lost universally to falls occur in children under 15 years of age.[50]

It is the most important mechanism of childhood injuries in most HICs such as the United States[51] and also the leading cause of injuries in some African countries, including South Africa and Mozambique.[29,40] The 5-14-year-old age group was most affected, and male children were in the majority. The falls occurred mostly at home. Children usually fell from trees and high walls, playground equipment, during sporting activities, and even from ground level.[9,40] Some also fell from storey buildings and roofs.[52]

Figure 2. 3 below shows the percentage of DALYs due to falls by age group under 15 years in different regions of the world compared to Ghana.

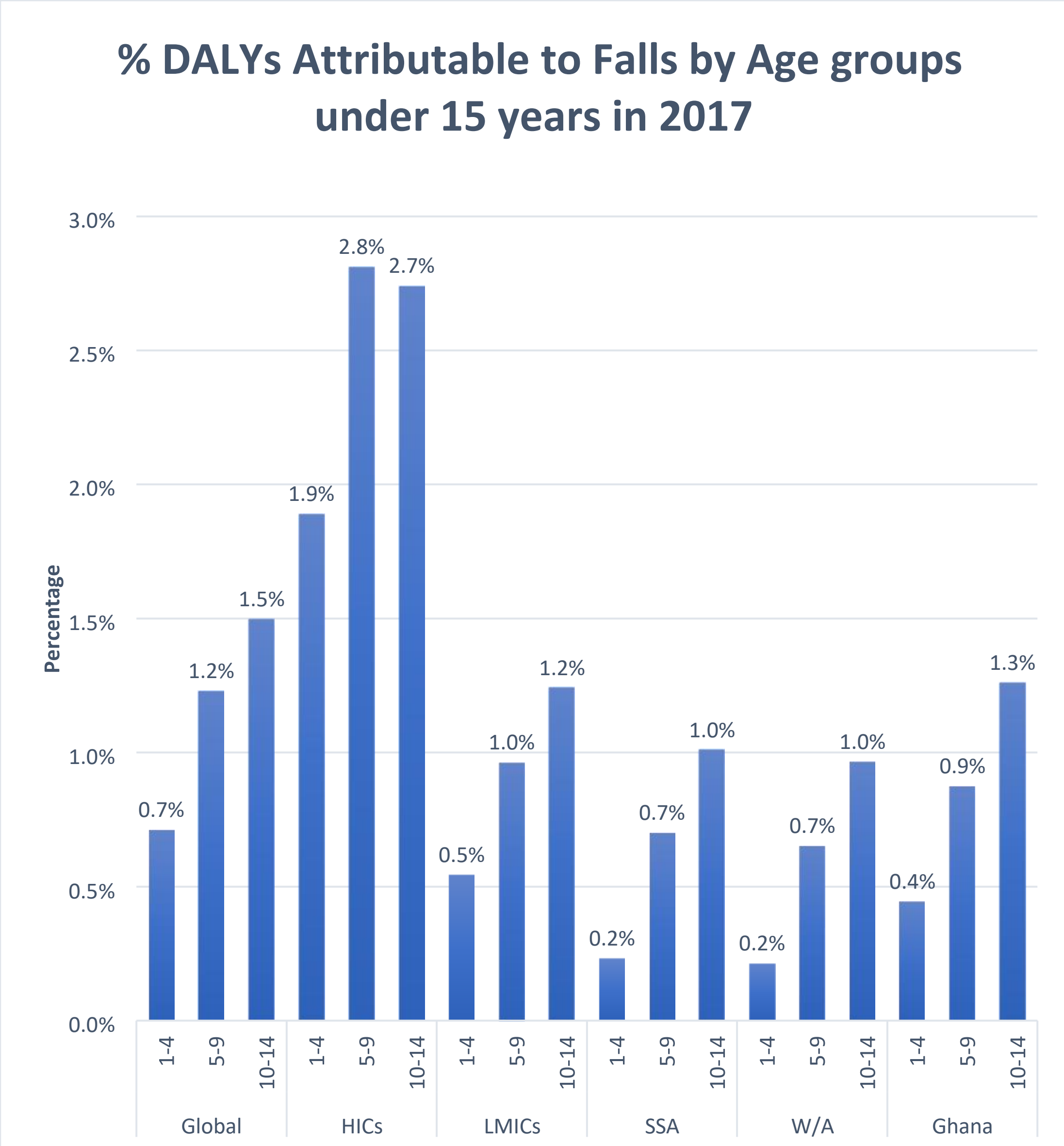


Figure 2. 3: DALYs attributable to falls in different regions of the world compared to Ghana.

Source: Global Burden of Disease Study 2017 (GBD 2017) Results. Available from http://ghdx.healthdata.org/gbd-results-tool

2.3.3 Drowning

Drowning is identified as a significant cause of injury-related deaths in LMICs.[53] Children under the age of 5 years are at a higher risk, and males are 2 to 3 times as likely to drown compared to females.[53,54] Susceptibility to falling into water bodies such as buckets, bathtubs, swimming pools, ditches, and ponds is attributable to lack of coordination, inquisitiveness and overactivity of children.[55] This injury mechanism is mostly reported in

Bangladesh and South Africa.[53] Though data on drowning are scarce in Ghana, one study identified that 15% of injury deaths for children under 15 years of age were attributable to drowning.[56] Figure 2. 4 shows the percentage DALYs attributable to drowning in different regions of the world compared to Ghana.

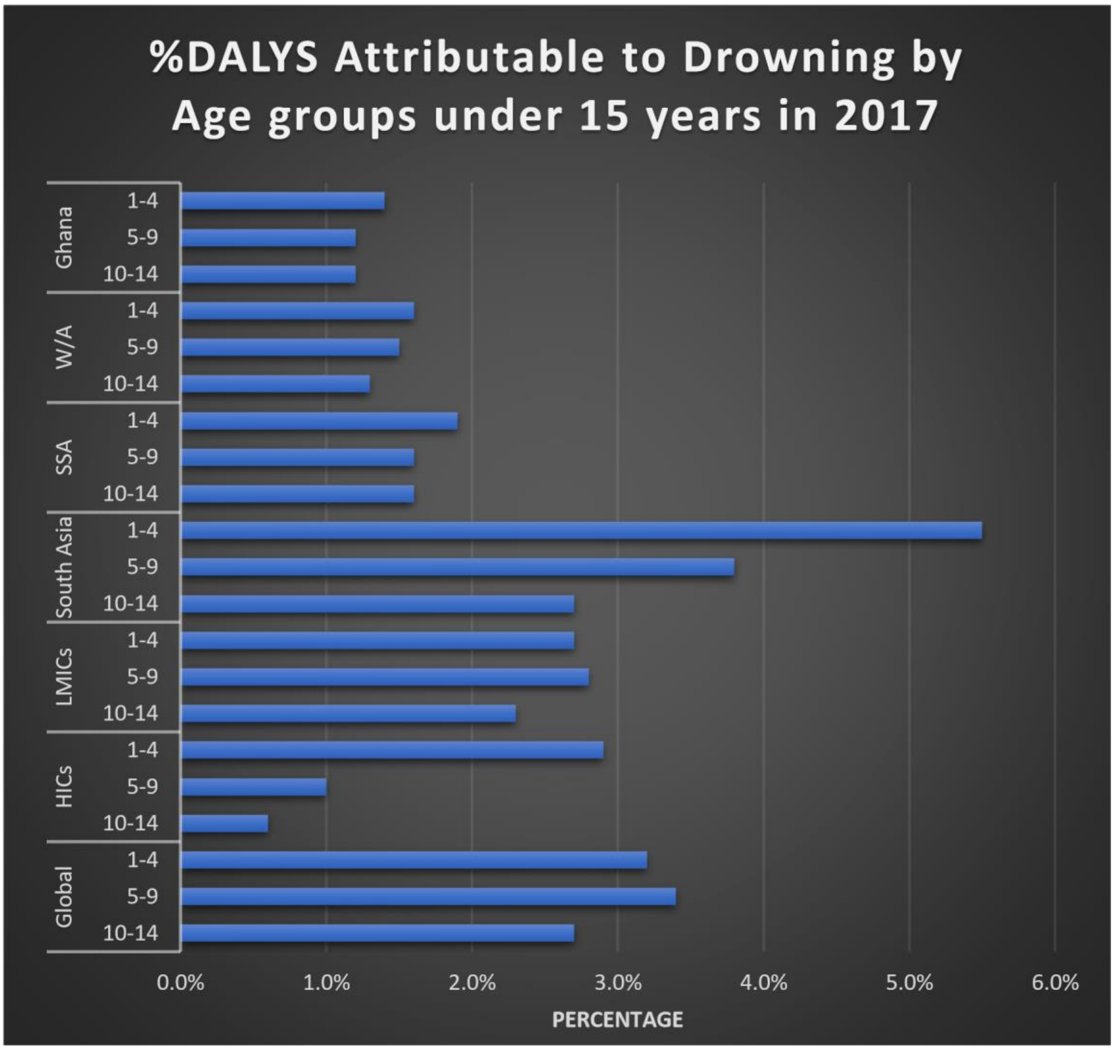


Figure 2. 4: DALYS attributable to Drowning in different regions of the World compared to Ghana.

Source: Global Burden of Disease Study 2017 (GBD 2017) Results. Available from http://ghdx.healthdata.org/gbd-results-tool

2.3.4 Burns

Burns are a significant cause of injuries in all age groups, especially children. Fatalities resulting from unintentional injuries due to fire, heat, and hot substances globally were over 120,000 in 2017.[35] Almost 15% of these mortalities occurred in children under 15 years of age. Percentage DALYs attributable to these injuries in the same year were 0.72, 0.55, 0.52 for the 1-4, 5-9, and 10-14 age groups, respectively. According to a recent study in Ghana by Agbenorku et al.,[57] children less than 15 years old were the most affected by burns with a male preponderance. The primary cause of paediatric burns was scalds compared to open fires in adults. A review study by Bayuo et al.[58] identified the home as the place for most burns. Toddlers with under-developed cognitive functions are usually with their primary caregiver, mothers, in the kitchen while cooking.[57] They unintentionally hurt themselves with hot liquids. Mortality was also highest in the under 15 years age group.[57] A review article on burns in sub-Saharan Africa corroborated these findings.[59]

2.3.5 Assault

Globally, about one billion children aged 2-17 years, experience violence.[60] The violence meted out to children was either physical, sexual, emotional or multiple types. In Ghana, although an earlier hospital-based study found assault to be rare among children,[9] a recent population-based research reported an assault incidence rate of 27.1 per 1,000 children per year.[41] Assault and other intentional injuries are not reported for fear of police arrest and therefore are usually underestimated.[14]

2.4 Traumatic Brain Injury Rates in Children.

Menon et al.[61] defined TBI as an alteration in brain function, or other evidence of brain pathology, caused by an external force. Three main phrases from the definition were further defined. Firstly, “alteration in brain function” was defined to include the following clinical signs: any period of loss of or a decreased level of consciousness (LOC); any loss of memory for events immediately before (retrograde) or after the injury (Post Traumatic Amnesia); neurological deficits (weakness, loss of balance, change in vision, dyspraxia, paresis/ plegia, sensory loss, aphasia); and any alteration in mental state at the time of the injury (confusion, disorientation, slowed thinking). Secondly, “other evidence of brain pathology” included evidence of visual, neuroradiologic, or laboratory confirmation of damage to the brain. Lastly, "caused by an external force" included any of the following events: the head being struck by an object, the head striking an object, the brain undergoing an acceleration/deceleration movement without direct external trauma to the head, a foreign body penetrating the brain, forces generated from events such as a blast or explosion, or other force yet to be defined.

Head injury is described as the single most common and potentially most severe type of injury sustained by children.[30] Globally, 3 million children are affected by TBI annually. The incidence, however, varies significantly from country to country and ranges between 47-280 per 100,000 children.[10] In the United States of America, rates of TBI-related ED visits increased for all age groups from the year 2001 to 2010, but children 0-4 years of age had the highest rates of any age group.[5] Falls accounted for the primary mechanism of TBI-related ED visits and hospitalisation in this age group. Assault was the primary cause of TBI-related deaths in children aged 0-4 years, followed by motor-vehicle traffic-related crashes while the latter was the primary cause of death in the 5-14-year-old age group. In most LMICs where RTIs dominate as the primary cause of injury,[10] head injuries in children are predominantly caused by pedestrian RTIs.[11]

Worldwide, the TBI death rate ranges from 2.8-3.75 per 100,000 children annually or between 1 to 7% of all paediatric TBIs.[10] In a hospital-based study in Ghana,[9] more than 40% of injury deaths were attributable to head injuries. However, it was slightly lower than what was observed in a similar study in South Africa where it was over 50%.[29] Paediatric head injury accounted for over ten percent of all head injuries managed over five years in Nigeria.[11]

2.5 Emergency Medical Systems (EMS)

One of the five critical actions proposed in the Decade of Action for Road Safety is improving post-crash response.[46] When an injury has occurred, it is critical for these victims to get effective care, which begins with the activation of the emergency care system. It is followed by care at the scene, transport, and hospital-based emergency care. For activating the emergency care system, it is ideal to have a single, valid, easy to remember, national telephone number which is free to call.[3] Globally, more than a hundred countries have such a number. Ghana's National Ambulance Service (NAS) toll-free numbers are 193 and 112.[3,62]. Another component of an effective and efficient EMS is personnel who are formally trained and certified with a specialty training pathway in emergency medicine and trauma surgery.[3] Ghana has a formal training programme for emergency medical technicians (EMTs), emergency nurses as well as emergency physicians.[63] Even though trainees from such programmes are distributed across the country, several hospitals in Ghana still do not have such trained emergency nurses and doctors. The inadequate numbers of such cadre of health personnel nationwide will impact on the care of the injured child.

An earlier study by Nee-Kofi et al. demonstrated that a few of the ED attendance in Ghana was by an ambulance.[16] The majority of the patients arrived in taxis and other private cars. The ambulance usually did interfacility transfer. Trained professions do not manage most injured patients at the scene of the incident.

2.6 Head Injury Characteristics in Children.

Children are vulnerable to distinct head injury patterns compared to adults.[64] The differences in size and shape between children and adults are usually obvious. There are differences in anatomical development and physiologic characteristics. Most importantly, there are also differences in age-specific properties of the skull, face, brain, and neck muscles. These differences combine to make children prone to develop specific types of head injuries. Human tissues have viscoelastic properties because they can deform when forces act on them in ways comparable to both fluids (viscosity) and solids (elasticity). For a given strain (change in length due to a force) placed on a tissue, there is corresponding stress (force over an area) on the tissue.

Breaking points of tissues differ based on the amount of stress they can withstand for a given strain. Based on this, tissue may be brittle (adult skull) or flexible (infant skull). Because of this, external forces to a child's head are absorbed differently compared to that of an adult.[64]

The cranium of a child has loose and highly mobile sutures, which allow for some degree of movement in response to mechanical stress. The calvarium, which is soft and rich in bone marrow, is strongly connected with the periosteum to the bone cortex. The continuity of the skull is well-maintained, which makes bone fragments less likely to happen. The brain and nerve fibres of children have undeveloped myelin sheaths with a high-water content per unit volume of brain tissue. These plastic fibres are less prone to rupture. With a direct external force, cerebral contusions are common.[64]

For infants, inappropriate childcare practices or non-accidental injury may be the cause of TBI. For toddlers and school children, with developing motor ability, TBIs are caused by falls and pedestrian injuries. Adolescents, on the other hand, have motorcycle-related and sports-related TBIs.[64] Pathophysiologically, TBI is divided into two separate but related categories: primary and secondary brain injury.

2.6.1 Primary Brain Injury (PBI)

Common mechanisms of PBI include direct external impact, rapid acceleration/deceleration, penetrating injury, and blast waves. PBI comprises intra-parenchymal injury [cerebral contusions, diffuse axonal injury (DAI), and intracerebral haemorrhage]; extra-parenchymal injury [epidural haematoma (EDH), subdural haematoma (SDH), subarachnoid haemorrhage (SAH), and intraventricular haemorrhage (IVH)]; vascular injury as well as skull fractures.[64] These injuries occur immediately after the impact, and the treatment is prevention.

Generally, skull fractures involve either the vault or the skull base. The fracture may be depressed or not. For paediatric skull fractures, the parietal bone is most commonly involved.[65] However, there is an age variation whereby the parietal skull fracture is prevalent in younger children (0-5 years) whiles frontal and temporal bone fractures are predominant in older children (5-11 years and above 11 years, respectively).

EDH is relatively infrequent in children because the dura mater is firmly attached to the inner surface of the skull.[66,67] The frequency of this haematoma increases with age. The source of EDH is mostly venous in children.[64,66] Veins involved include the dural venous sinuses and emissary veins. There is, however, the likelihood of an acute arterial EDH, which can rapidly increase in size leading to cerebral herniation and death. EDH which is characteristically lenticular in shape on CT scans does not cross suture lines.[64]

SDH is found between the arachnoid membrane and the dura mater. Widening of the subdural space in older individuals may make bridging veins more prone to rupture from traction forces. In the paediatric population, however, subdural haemorrhage more commonly results either from direct external force or when the skull in motion collides with a stationary object; the impact causes vascular rupture with haemorrhage into the subdural space. A distinguishing feature of subdural haematoma is that it crosses suture lines. Subdural haematomas tend to be thinner in the paediatric population.[64]

Cerebral contusions are relatively common in children with TBI. It usually occurs beneath the site of impact of external force (coup injury) or opposite the site of impact (contrecoup injury). The frontal and temporal lobes are the sites for cerebral contusions due to the irregular surface of the cranial base, and the anatomical contiguity of the crista galli and the petrous bone to the cortex. The primary contusions result in cerebral swelling, which may quickly develop into an extensive hypoxic area surrounding the original lesions. Cerebral ischaemia may be the outcome if this progress.[64]

DAI is defined as the occurrence of diffuse damage to axons in the cerebral hemispheres. Traumatic axonal damage in the corpus callosum, brainstem and the cerebellum is also classified as DAI.[68] Shearing mechanisms such as traumatic acceleration/deceleration and rotational injuries are noted to cause DAI. It appears on neuroimaging studies, preferably MRI, as multiple small (1-15mm) lesions within white matter tracts in a characteristic distribution.[69] It has been graded histologically according to the anatomic distribution of injury and this grading correlates with mortality.[68,69] Three grades of DAI in increasing severity have been identified. Grade 1 has focal lesions in the cerebral hemispheres, whereas in grade 2, the lesions are in the corpus callosum. In the grade 3 DAI, the focal lesions are located both in the corpus callosum and the brainstem.

2.6.2 Secondary Brain Injury (SBI)

SBI is characterized by a series of biochemical, cellular, and molecular events initiated at the instance of the injury with delayed clinical manifestation.[70] Two well-documented determinants of secondary brain injury are hypoxia and hypovolemia.[71,72] Hypotension has been identified as an independent determinant of outcome from a severe head injury. Other causes of secondary TBI are seizures and hyperthermia.[73]

2.7 Traumatic Brain Injury Severity Scoring in Children

Determining the severity of paediatric traumatic brain injury is essential in predicting outcomes and helps in resource allocation during the management of the injury. There are many injury severity scales for assessing children with traumatic brain injury.

Clinically, the severity of TBI is usually classified according to the level of consciousness of the patient as measured with the Glasgow Coma Scale (GCS).[74] The GCS is a measure of neurologic dysfunction and is calculated based on the best motor response, best verbal response, and eye-opening. The least score is 3, representing a comatose patient and 15 is the maximum score, representing a normal neurological function. A score of 3-8 is classified as a severe TBI; 9-12 is a moderate TBI, and 13-15 is a mild TBI. Paediatric versions of the GCS have been developed.[75,76] Lately, Borgialli et al.[77] identified that a modified GCS which caters for preverbal children

(2 years and below) was equally accurate for identifying children with clinically-important TBIs compared to the standard GCS used for children older than two years. The GCS and its paediatric versions are among the triage scales commonly used to assess the neurological status of patients with head injuries rapidly. The GCS with paediatric modification is shown in Appendix 3.

In the recent past, another scale, Eppendorf-Cologne Scale (ECS), has been found to better predict the presence of TBI and its outcome compared to the GCS.[78] According to Hoffmann et al.,[78] pupil reactivity was coded into three subgroups: brisk, sluggish, and fixed. Pupil size was likewise coded into three subgroups: normal, anisocoric, and bilaterally dilated pupils. The modified motor response subscale was derived from the original GCS motor component data and was coded into four subgroups: normal, specific, nonspecific and none. The ECS is calculated by summing the value of each sub-score. Scores are from a minimum of zero for a patient showing brisk reactive normal-sized pupils, and normal motor response to a maximum of 8 for a patient presenting with fixed and bilaterally dilated pupils and no motor response.[78] The scoring of the ECS is shown in Appendix 4.

Unlike the GCS, another trauma severity scale, Injury Severity Score (ISS), is an "anatomic" rather than a "triage" measure, and it uses specific pathological descriptions. ISS ranges from 1 to 75, and higher scores denote greater injury severity while lower scores represent less severity.[17] It is most useful in head injury severity prediction when there is multiple trauma in addition to a head injury. It, therefore, gives a better representation of the overall trauma severity.[79] In determining the ISS score, an Abbreviated Injury Scale (AIS) score is assigned to the most severe injury in each of the six body systems shown in Table 2. 1. The AIS score ranges from 1 "Minor" to 6 "Unsurvivable." ISS is calculated by summing the squares of the three most severe injuries in three different body systems. An injury assigned an AIS of 6 (Unsurvivable injury) is automatically assigned an ISS score of 75.[17] Some studies have categorised the ISS into "minor trauma" with ISS less than 15 and "major trauma" with ISS of more than 15.[80] For children, this ISS 15 threshold has been challenged with a “serious” or “major” trauma starting from an ISS of 8 according to Palmer et el.[81] or 9 according to Emami et al.[82] The AIS score for the head gives an idea of the severity of the head injury. An AIS score of 1-2 is classified as a mild, 3 as moderate, and 4-6 as severe TBI.[83] Both the head AIS and the ISS are better predictors of outcome of TBI than the GCS.[79] The AIS can only be assigned after complete diagnostic work-up or thorough surgical evaluation.[84]

Table 2. 1: Abbreviated Injury Scale (AIS) Body systems.

Number	**Body Region**	**Organs involved and associated injuries.**
1	Head or Neck	Brain or cervical spine; skull or cervical spine fractures and asphyxia.
2	Face	Mouth, ears, eyes, nose, and facial bones.
3	Chest	All internal organs in the chest, including the diaphragm, rib cage, thoracic spine, and drowning.
4	Abdominal or pelvic contents	All internal organs in the abdominal and pelvic cavities, including lumbar spine lesions.
5	Extremities or pelvic girdle	Injuries include sprains, fractures, dislocations, and amputations. The shoulder girdle is also here.
6	External	Injuries include lacerations, contusions, abrasions, and burns, independent of their location on the body surface. Penetrating injuries, hypothermia, electric injury, frostbite, and whole-body injury.

TBI can also be classified according to morphological criteria based on computed tomographic (CT) or magnetic resonance imaging (MRI) investigations. However, in the acute phase, a CT examination is the preferred investigation of choice. Radiologically, two currently used CT-based grading scales for TBI are the Rotterdam and Marshall scales. The Marshall scale, which uses the findings of CT to classify injuries into six different categories, has not been validated for use in the paediatric population.[85]

The Rotterdam CT score which was developed by Mass et al.[86] to categorize TBI type and severity in adults was validated to be used in paediatric studies as one measure of TBI severity by Bratton et al.[18] A normal head CT scan will have a Rotterdam CT score of 2 whiles an isolated epidural bleed without enough mass effect to result in midline shift or compression of the basilar cisterns will score 1. Table 2. 2 below shows the composition of the Rotterdam CT score.

Even though Marshall score has been found to have a good predictability for assessing TBI-related mortality, Rotterdam score with its individual CT parameters is found to be a better prognostic model.[87] Table 2. 2: Rotterdam CT score.

Rotterdam Score Element	**Score**
Basal Cisterns	
Normal	0
Compressed	1
Absent	2
Midline shift	
No shift/ 5mm or less	0
Shift more than 5mm	1
Epidural Mass lesion	
Present	0
Absent	1
Intraventricular blood or traumatic SAH	
Absent	0
Present	1
Sum score	+1
Total Score	1-6

In limited-resource settings, investigation using a CT scanner may not be readily available, or where available, it may not be affordable. As such, depending on the head CT scan to assess injury severity scores such as the head AIS, ISS or the Rotterdam CT score may not be feasible. To address this limitation, the Kampala Trauma Score (KTS) was developed as a triage tool for use in LMICs. The KTS does not require a head CT scan or any investigation for injury characterisation.[88] It has been used in both adults and children. The score ranges from 5 to 16, the worse to the least severity of injury. KTS less than 11 are classified as severe injury, 11-13 as moderate and 14-16 as mild. The components of the KTS is shown in Table 2. 3. In a recent study by Gardner et al., the KTS was found to predict prognosis and ED outcomes adequately among trauma patients presenting to an ED in Ghana.[89]

Table 2. 3: The Kampala Trauma Score.

Component	Score
Age (years)	
5-55	2
Less than 5 or more than 55	1
Systolic Blood Pressure (mmHg)	
More than 89	4
50-89	3
1-49	2
Undetectable	1
Respiratory rate (per minute)	
10-29	3
More than 30	2
Less than 9	1
Neurologic status	
Alert	4
Responds to verbal stimuli	3
Responds to painful stimuli	2
Unresponsive	1
Number of serious injuries	
None	3
1	2
2 or more	1

Total score	5-16

2.8 Traumatic Brain Injury Management in Children

As with all trauma patients, managing children with TBI involves the rapid, early assessment and management of the ABCDEs according to ATLS principles.[73] In the primary survey, in addition to maintaining oxygenation, ventilation, cardiovascular support, and managing immediately life-threatening injuries, there should be a focus on preventing secondary brain injury, hypoxia, and hypotension. Cervical spine motion restriction must be maintained throughout evaluation until serious spine, and spinal cord injury has been excluded by examining the patient and, for a severe TBI patient, imaging. The secondary survey, which involves a head-to-toe examination, should be done with a complete neurologic evaluation. Appropriately involving neurosurgery from the onset of treatment is also advocated in the management of such patients.

Subsequent management of traumatic brain injury is usually based on the severity of the injury. There are management guidelines for mild-to-moderate, as well as for severe paediatric TBI.[90,91] Globally, most paediatric TBIs are managed conservatively.[10]

2.8.1 Severe Traumatic Brain Injury

Since 2003, there have been published guidelines for the management of paediatric severe TBI.[92] The third edition of this guideline, published in 2019, focused on three specific categories in the management of severe paediatric TBI.[93] These include monitoring, thresholds, and treatments. Monitoring involves intracranial pressure (ICP) and advanced neuromonitoring as well as neuroimaging. There are thresholds for ICP and cerebral perfusion pressure (CPP). Lastly, treatment includes hyperosmolar therapy, analgesics, sedatives, neuromuscular blockade, cerebrospinal fluid (CSF) drainage, seizure prophylaxis, ventilation therapies, temperature control, barbiturates, decompressive craniectomy (DC), nutrition and corticosteroids. Another management algorithm formulated by the same authors, Kochanek et al., described two tiers of therapy for severe paediatric TBI.[90] The focus of the first tier includes preventing and or treating intracranial hypertension, optimising cerebral perfusion pressure, and optimising partial pressure of the brain tissue oxygen ($PbtO_2$). The second tier emphasises decompressive craniectomy surgery, barbiturate infusion, late application of hypothermia, induced hyperventilation, and hyperosmolar therapies. ICP, CPP as well as $PbtO_2$ monitoring are unlikely to be available in the ED or low-resource settings.[73]

2.8.1.1 Baseline care

As part of the baseline care, the paediatric severe TBI guideline recommends the maintenance of an appropriate level of sedation and analgesia with initial benzodiazepine-opioid combination therapy.[90]

The guideline further recommends controlled mechanical ventilation with a Fraction of inspired Oxygen (FiO_2) titrated to an arterial partial pressure of oxygen (PaO_2) of 90-100mmHg. The minute ventilation should be adjusted to achieve a target of an arterial partial pressure of carbon dioxide ($PaCO_2$) between 35mmHg and 40mmHg.[90]

Normothermia is recommended with the prevention and treatment of fever, in order to maintain patient temperatures below 38°C.[90]

Central venous pressure monitoring, urine output assessment, blood urea nitrogen and serum creatinine measurements, as well as clinical examination should be performed to ensure appropriate intravascular volume status.[90] The initial fluid recommendation is normal saline (NS) intravenous (IV) infusion for older children. However, 5% dextrose in NS IV infusion is recommended in younger children to prevent hypoglycaemia. The initial target sodium concentration [Na^+] should be greater than 140mEq/L. Starting nutritional support within 72 hours should also be the goal. The haemoglobin concentration for children with severe TBI should be more than 7.0g/dL.[90]

Neutral head positioning with a 30 degrees head-of-bed elevation is suggested as another baseline care to be provided for such patients.[90]

Seizure prophylaxis is suggested to reduce the occurrence of early (within seven days) post-trauma seizure (PTS).[93]

Children presenting with severe TBI have a significant risk of intracranial hypertension. However, there are no specific determinants of increased ICP in this population without monitoring. Unfortunately, an initial (0-6hours) normal CT scan cannot rule out elevated ICP in comatose paediatric patients with severe TBI.[93] As such non-invasive means to monitor ICP is currently unavailable. In cases of increased ICP, ICP monitoring is associated with improved neurologic and survival outcomes; this is the basis of the level III recommendation to monitor ICP in paediatric TBI patients.[93] However, signs of acute herniation such as pupillary dilatation, bradycardia, bradypnea, hypertension, hemiplegia, decorticate and decerebrate rigidity are considered a medical emergency with or without ICP monitoring.[90] In such patients, hyperosmolar therapy with 2-5 mL/kg of 3% hypertonic saline over 10–20 minutes is recommended.

2.8.2 Mild-to-Moderate Traumatic Brain Injury

Mild head injury constitutes about 70-90% of all paediatric TBIs, and it also accounts for the majority of the burden of disability caused by TBIs.[94,95]

In terms of investigations, neuroimaging is recommended for all children with moderate TBI with GCS below 13.[91] The need for neuroimaging in patients with mild paediatric TBI, however, may not always be clear cut. Given that over the long-term head CT in children may increase risk of radiation induced malignancy, it is helpful to identify children at very low risk of clinically-important traumatic brain injuries (ciTBI). The rationale is that if a child presents with mild TBI then further risk stratification into very low risk for ciTBI would make a head CT scan unnecessary. Clinically important TBI is defined as hospital admission for two or more nights, intubation for more than 24 hours, neurosurgery, or death from TBI. In patients with ciTBI, head CT scan is more likely to show one or more of the following pathologies: intracranial haemorrhage or contusion, cerebral oedema, traumatic infarction, DAI, midline shift of intracranial content, or signs of brain herniation, diastasis of the skull, pneumocephalus and depressed skull fracture of at least the width of the table of the skull.[96] Several clinical decision rules (CDRs) have been developed to identify those with clinically important TBI (ciTBI) and to assist in predicting the need for brain imaging.[96–98]

The three CDRs which include the Children's Head Injury Algorithm for the Prediction of Important Clinical Events Rule (CHALICE), Paediatric Emergency Care Applied Research Network (PECARN) and the Canadian Assessment of Tomography for Childhood Head Injury (CATCH) were found to have high sensitivities when used as designed.[99] However, the cost-effectiveness of these CDRs compared to usual care has been questioned.[100]

Definitive management of patients with mild-to-moderate paediatric TBI after the initial stabilisation may be conservative or neurosurgical. As with all paediatric TBIs, majority of the patients are managed non-operatively.[10] Nonetheless, some neurosurgical intervention for TBI involves ICP monitoring, the elevation of depressed skull fracture, haematoma evacuation, tissue debridement and dura repair.[96]

Skull fractures are usually managed conservatively.[65,101] For the very few patients who require surgical intervention, additional indications are: open fracture debridement, fracture repair on account of fracture displacement, frontal sinus repair and cosmetic repair, mass effect, evidence of dural penetration.[102]

For extradural bleeds, several case series over the years have demonstrated excellent outcomes with non-operative management for patients with mild TBI.[103–106] However, such patients should be monitored closely in a facility with 24-hour emergency access to head CT and a functioning theatre. In this way patients developing adverse neurologic change can be identified and adequately managed with prompt neurosurgical intervention. Children with mild TBI and epidural haematoma who may need emergency craniotomy include those with a large hematoma thickness, the closeness of the bleed to the transverse sinus, and multilobar location.[106] When craniotomy is indicated, early (less than 24 hours) is better than later.[107]

The definitive management of children with acute subdural hematoma frequently requires rapid evacuation and care by a neurosurgeon. This may not be the case if neurosurgical evacuation of the SDH would not significantly improve outcomes. For example, whereas urgent surgery is often required to treat comatose patients with EDH, a conservative approach is adopted in children with SDH with severe brain swelling and infarction. Acute bilateral SDH is managed nonoperatively for the same reason that evacuation may not improve outcomes significantly. Other indications for nonoperative management of SDH include a small SDH with minimal symptoms.[108]

2.9 Outcome Measurement

Death is the worst outcome of TBI among children. It has been documented that children surviving from a head injury may have various functional disabilities.[109] Post head injury, there are validated scales that help determine the functional outcomes of TBI survivors. One such scale is the Glasgow Outcome Scale, Extended (GOSE) (1 = dead, 8 = good recoveryupper),[74] which is used as a rating scale grounded in functional ability. A GOS-Extended, paediatric version (GOSE Peds), was later developed for children, and this is a modification of the 8-point adult GOSE scale.[24] Because the GOSE lacks the developmental specificity necessary to evaluate children, toddlers, and infants, the adult version was modified to create the GOSE Peds (1 = upper good recovery, 8 = death). The GOSE Peds an age-appropriate interview to classify TBI outcome in younger patients (from birth to 16 years).[24] This study showed a strong correlation between the GOSE Peds and the GOS and a similar level of association with the functional and cognitive outcome at 3- and 6-month time points.

Another recognised functional assessment is the use of the Quality of Life in Neurological Disorders (Neuro-QoL) Measures. Paediatric Neuro-QoL includes measures for children aged 8-17. As with adult Neuro-QoL, paediatric Neuro-QoL measures the functions, symptoms, behaviours, and feelings identified as necessary by people with neurological conditions and their caregivers. Paediatric Neuro-QoL measures include item banks that can be administered as computer adaptive tests (CATs) or as fixed length short forms. All measures are self-reported. The Neuro-QoL paediatric framework is shown in Figure 2. 5 below.

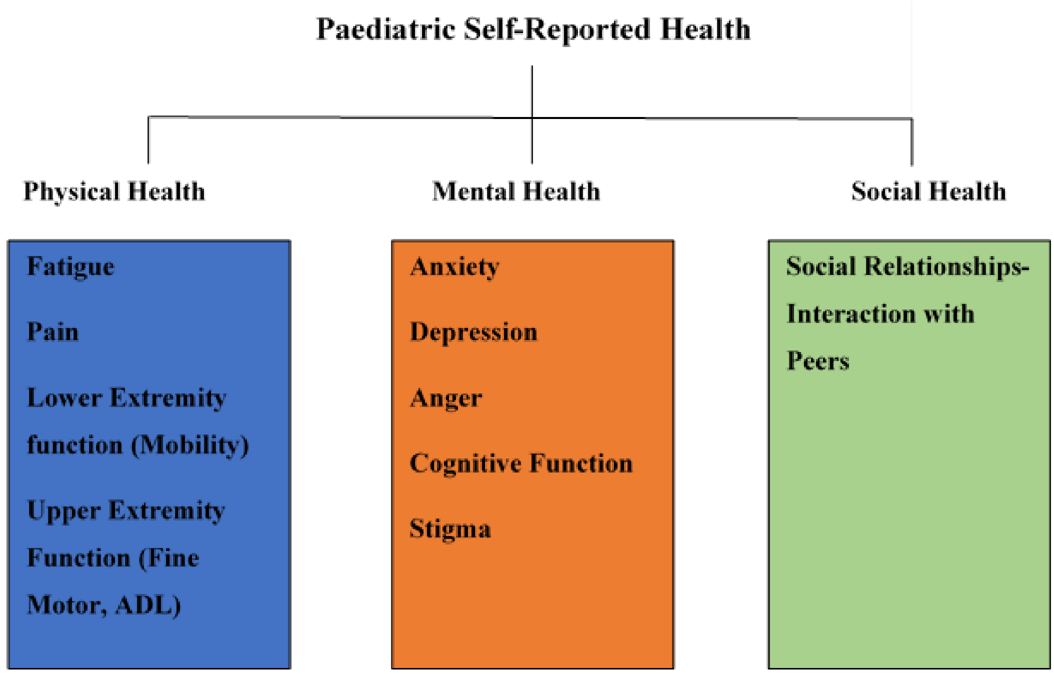


Figure 2. 5: Neuro-QoL Paediatric framework.

Source: Adapted from Neuro-QoL.
http://www.healthmeasures.net/explore-measurement-systems/neuroqol/intro-to-neuro-qol

2.10 Rehabilitation.

Significant disabilities may result from paediatric TBIs. After hospital discharge, such children with any disability should have access to a set of interventions that are required when a person is experiencing or is likely to experience limitations in everyday functioning due to injuries.

Rehabilitation tends to minimise the impact of the disability suffered as well as helps in restoring the individual to his or her pre-injury state as much as possible. There are several types of rehabilitation therapy including, among others, physical, occupational, speech, and cognitive. According to WHO, the rehabilitation needs in most LMICs are unmet.[33,110] It is estimated that more than two-thirds of rehabilitation needs in Africa are not met. The typical rehabilitation service available in Ghana is physiotherapy, with the physiotherapy units mainly located in regional government hospitals. Government physiotherapy services may be variably complemented by private facilities. Unfortunately, the cost of physiotherapy may deter patients from utilising this service beyond a few days. The cost of service is only reimbursed by the National Health Insurance Scheme if the patient is a client of the scheme. Other rehabilitation therapy services are not commonly provided in Ghana. Trained personnel in speech and occupational therapy are few.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Introduction

This chapter describes the methodological approaches employed in carrying out this research. It covers the profile of the study area, the study type, and design, the population involved, as well as the inclusion and exclusion. Chapter Three also presents a detailed description of the study tools and sampling techniques used in the study. In addition, the chapter describes how the study sample size was calculated; the population identified as well as selected. Finally, it gives an overview of how data was collected, stored, analysed, and presented in this final report.

3.2 Profile of Study Area

Komfo Anokye Teaching Hospital (KATH) is the second largest tertiary hospital after Korle-Bu Teaching Hospital in Ghana. It was established in 1954 and became a Teaching Hospital in 1975. The hospital has a capacity of 1,200 beds. The hospital serves the population of the Kumasi metropolis which stood at 2,035,064 according to the 2010 Population and Housing Census.[111,112]

Being in the middle belt of Ghana, it receives referrals from 12 out of the 16 administrative regions in Ghana. These include the Ashanti, Bono, Bono East, Ahafo, Western North, Savannah, Northern, North East, Upper East, Upper West, and some parts of the Central and Eastern regions of Ghana.[111] As the only tertiary hospital in the Ashanti Region, a total population of about 4,780,380 falls within its catchment area.[111,112]

The hospital also serves as a teaching hospital for the School of Medical Sciences of the Kwame Nkrumah University of Science and Technology and is accredited for training specialists and fellows of the Ghana College of Physicians and Surgeons (GCPS) as well as the West African College of Physicians and Surgeons (WACPS).

The study was conducted at the KATH Emergency Medicine Directorate, which is one of the thirteen clinical directorates in the hospital. This centre is the only accredited facility for the training of emergency physicians and nurses in West Africa at the time of the study. It provides a 24-hour service with a current bed capacity of 111 from the original bed capacity of 35.[113] Annual patient volume to this department is approximately 30,000, which includes trauma and non-trauma emergencies.

The service is run by trained emergency physicians and nurses as well as residents. Most trauma patients, including children with TBI, present to this department directly from the accident scene or are referred from other health facilities.

Patients are triaged using the South African Triaging Scale (SATS) to Yellow, Orange, and Red zones (in increasing level of acuity) for management.[114] Patients are resuscitated by the emergency physicians and then admitted to the appropriate admitting service if admission is indicated or discharged after complete negative work-up with follow-up consultation.

As part of radiological services provided by the hospital, there are two computed tomographic (CT) scanners with one in the emergency department. Qualified radiologists and radiology residents provide head CT scan reports within 24 hours of performing the study. However, not all patients who need this service can afford it because it is operated on a cashand-carry basis.

There are two private CT scanners outside the hospital, with the nearest one within approximately five minutes' drive from the ED. Patients must fall back on using the private CT scanners whenever there is a problem with the hospital CT scanners. During the period of this study, the KATH CT scanner was only functional in the first week, and the last week of participant recruitment. Patients requiring CT scan investigation, including children with TBI, were transported to a nearby private CT scanner in a hospital ambulance; these patients were accompanied by a nurse to ensure that a safe service would be provided. Though transportation was free, it was more expensive to do the CT scan investigation at a private facility.

Most of the neuroimaging was done at the nearest private facility, from where images were usually readily available to the Emergency Physician for patient care. A trained radiologist reported on the CT scan within 24-48 hours irrespective of whether the head CT scan was done within the hospital or at a private facility.

The hospital also offers neurosurgical services. Emergency neurosurgical intervention is free for all members of the National Health Insurance Scheme (NHIS).

There is a Paediatric Intensive Care Unit (PICU), which is run by a paediatric intensivist, paediatric residents, and critical care nurses. Due to the limited bed space and resources, most children with moderate to severe TBI who otherwise would have benefited from intensive care are not admitted there. Such children are admitted to the general paediatric surgery ward (B3) or to the neurosurgical ward (C1) depending on the age of the child. On the wards, the neurosurgeons continue to manage them until discharge from the hospital or death.

Some children admitted to the hospital may spend a couple of days at the Clinical Decision Unit (CDU) of the Emergency Department when there is no bed space at B3 or C1. The neurosurgical team continues to provide care for these patients at the CDU until they are transferred to the ward or are fit enough to be discharged from the CDU. Usually, general nurses care for the patients at the CDU, B3, and C1. The nurses at the CDU regularly involve the emergency physicians and their residents when patients in their care have any medical concerns. Patient flow is shown in the flowchart in Figure 3. 1 below.

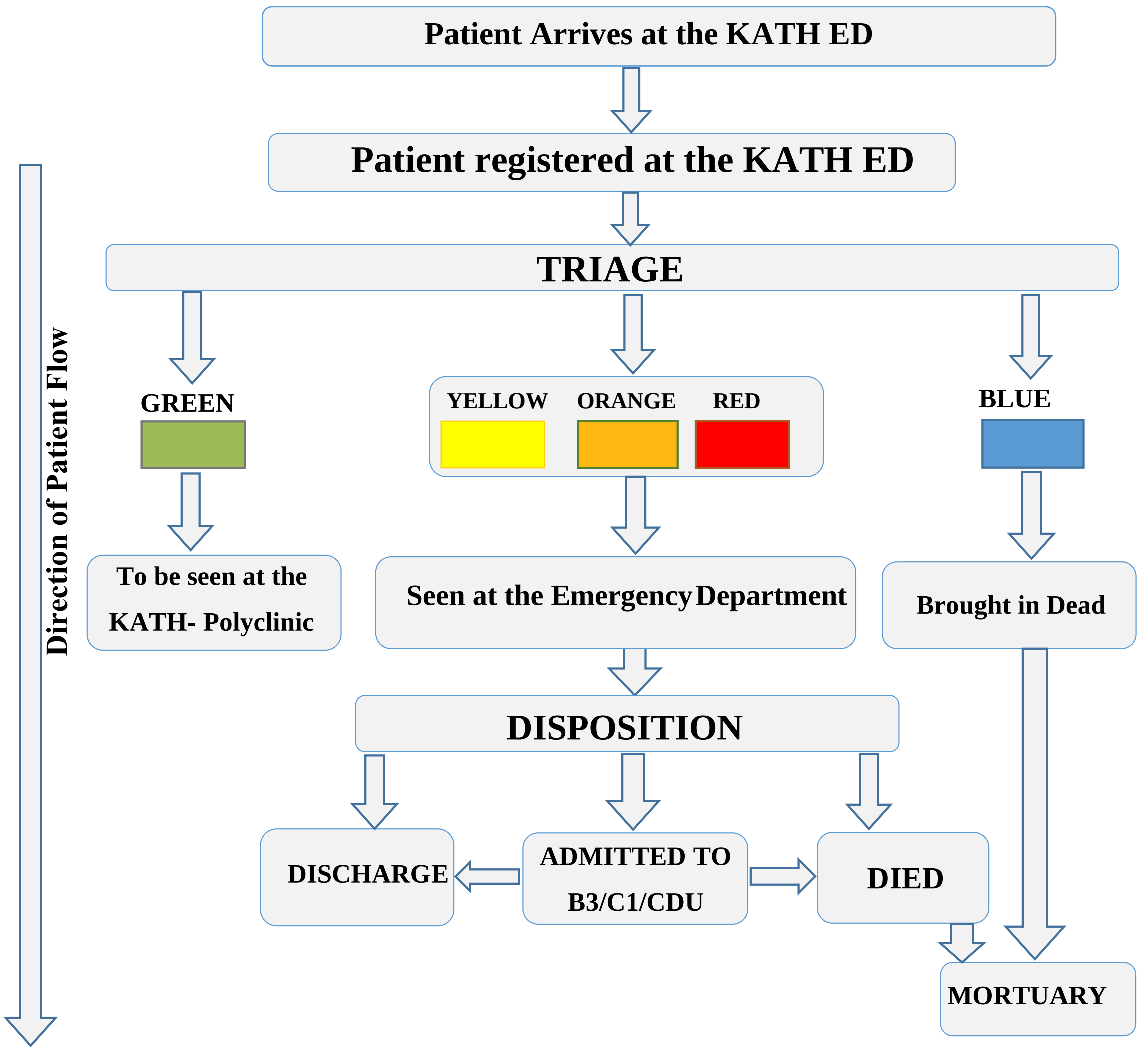


Figure 3. 1: Flowchart of Processes at the KATH ED.

(Adapted and modified from Bonney J, 2015)

Figure 3. 2: Administrative map of Ghana showing KATH.

Source:https://citinewsroom.com/wp-content/uploads/2019/02/16-regionsof-GhanaCiti FM[115]

3.3 Study type and design

The study was a hybrid design consisting of a prospective cross-sectional study for six months with an embedded three-month cohort follow-up study. This design was appropriate for the generation of both descriptive and analytic data to determine and provide an in-depth understanding of the relationship between predictors (child characteristics and injury characteristics) and outcome factors (mortality and GOSE).

3.4 Study Population

The study population was children, less than 15 years old, who presented within the study period following a traumatic event with a history or finding of altered level of consciousness or referred with TBI from another facility and had no missing variable(s) of interest.

3.4.1 Inclusion Criteria

1. All children who were less than 15 years of age presenting to KATH ED within the study period.
2. All children who presented with a traumatic event with a history or finding of altered level of consciousness or referred with TBI from another facility to KATH ED.

3.4.2 Exclusion Criteria

1. All children with TBI who were 15 years and older.
2. All children with a traumatic event without a brain injury.
3. All children with a brain injury without an antecedent traumatic event.
4. All children with suspected TBI who were pronounced dead on arrival.
5. All children with TBI who presented to KATH but not through the ED.
6. All children with TBI whose caregivers were unwilling to participate in the study.

3.5 Sample Size and Power

The sample size calculation considered one of the outcome measures for the study, the Paediatric GOSE. The sample size for this study needed to be enough to produce a margin of error of at most 0.05 (5%) for the percentage subjects with a Paediatric GOSE of 2 or less (95% confidence level). We took a conservative approach to estimate this sample size by assuming the true prevalence was 50% (the point at which the variance used to estimate sample size is maximised). The sample size was calculated using the formula for a descriptive study of a dichotomous variable.

$$S = \frac{4Z\alpha^2 * P\,(1-P)}{W^2}$$

Where

S = required size

With α=0.05 for 0.95 Confidence Interval, $Z\alpha$ = 1.96.

P = the population proportion

W = desired total width

At 0.95 Confidence Interval of +/- 10% and if 50% of the participants will have a GOSE peds of 2 or less,

P = 0.5

W = 0.2 (0.10 below and 0.10 above)

$$S = \frac{4*(1.96)^2*0.5(1-0.5)}{(0.20)^2}$$

$$S = \frac{4*3.8416*0.2500}{0.0400}$$

S=96

The study, however, aimed at an additional 20% more enrolments to cater for non-response and missing data for some of the participants.

A sample size of 115 was therefore estimated for the study.

3.6 Training of Research Assistants

The PI trained three research assistants (RAs) after the development of the questionnaire. They were involved in the pre-testing of the questionnaire before actual data collection started. By so doing, we were able to clarify questions and make modifications to the questionnaire where appropriate. One of the three RAs had experience in assessing the Glasgow Outcome Scale, Extended (GOSE), in an earlier TBI study. She was further trained on how to use the paediatric GOSE (shown in Appendix 5) to prospectively assess children both at discharge and at three months post-TBI. To ensure she was blinded to the severity of the TBI, she only did the paediatric GOSE assessment without being involved in the day-to-day data entry.

3.7 Pre-testing of data collection tool

Pre-testing of the questionnaire was initially done by PI and later by the trained RAs. After each pre-testing, ambiguous questions, as well as inappropriate branching logics in the REDCap, were rephrased or corrected to ensure clarity to elicit the required responses from the participants.

3.8 Data collection tools and techniques

A structured questionnaire was developed by the PI to describe the injury characteristics causing TBIs in children less than 15 years old as well as describe the definitive management, final hospital outcomes and determine the three months post-TBI outcomes of these children. Lastly, the tool was used to determine the predictors of TBI outcomes among children below 15 years old.

Informed consent was obtained by two trained research assistants from the child's legally authorised representative. For those cases where the child was mature and capable, he or she provided assent. The patient was followed from the time of arrival in the ED to the time of discharge. Caregivers were interviewed to collect data on socio-demographic characteristics of the child. Data was also collected on socio demographic characteristics of the primary caregiver who was in the hospital with the child. Phone numbers of caregivers, preferably two different contact numbers, were recorded. A phone call was made immediately to the caregiver to ascertain that the number was correct. The numbers confirmed as correct were stored to be used for post TBI follow-up at three months. Additionally, information on injury characteristics, ED and neurosurgical managements, and complications developed during ward management was abstracted from the participants' medical records. Further information gathered from the participants' chart included vital signs at presentation and GCS score. The PI determined the KTS for each participant using the age, systolic BP, respiratory rate, neurologic status, and the number of serious injuries (assessed by the PI). Using an integrated software package in the Trauma Registry at KATH created by Digital Innovation Incorporated,[116] the ISS coding was done by the PI.

Additionally, the Rotterdam CT score for each participant who obtained a CT scan of the head was calculated by the PI. The PI was trained by a radiologist for a week on assessing the Rotterdam CT score. The outcomes measured were mortality at hospital disposition and paediatric GOSE which was assessed by one trained RA within 24 hours of hospital discharge. The same RA contacted the caregivers at 3 months $\pm$ 1 week via phone calls and the paediatric GOSE was repeated. The three months paediatric GOSE assessment was done in person for participants who had returned to the hospital for review by the neurosurgeons within the follow-up period. The data were entered electronically into a password secured database using REDCap.

3.9 Study Variables

Variables collected included: demographic characteristics (age, sex, previous disability, health insurance coverage, socioeconomic status of parents); injury mechanism (i.e., road traffic injuries, falls, assault); place of injury (home, roadside, playing grounds); time of injury; use of safety devices (such as child car restraint, seatbelt, helmet) and status in the injury event (i.e., pedestrian, passenger, rider). Additional data on patient care (pre-hospital and ED care, definitive management), disposition (ED and hospital), and complications developed during management were gathered. Other measures collected included the participants' vital signs after resuscitation (including GCS, oxygen saturation, systolic blood pressure). Injury severity scores assessed included the ISS, and KTS, as well as the Rotterdam CT score for patients who obtained the CT scan of the head, were calculated. The outcome measures were mortality, and GOSE. The GOSE was determined within 24 hours of discharge for all patients and repeated at three months post-injury.

3.10 Data management and analysis

The Principal Investigator (PI) developed a password secured electronic database using Research Electronic Data Capture (REDCap). To reduce missing variables, most fields in the database were made "required." This demanded that such fields ought to be filled before proceeding. Trained Research Assistants (RAs) used the structured questionnaire developed on REDCap to collect data. Data were checked for completeness and internal errors at the end of each day by the PI. The database was revised on three occasions to enhance accurate and complete data. At the end of participant recruitment, the data was exported to Microsoft Excel ®for data cleaning.

Further data cleaning and data analysis were done with STATA 13.1 (StataCorp. 2013. *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP). Descriptive analysis of data included frequencies, percentages, means with standard deviation, and median with interquartile range. Some continuous variables were converted into categories to calculate percentages. Bivariate analysis was conducted comparing patient and injury characteristics between survivors and those who died and those with good outcomes versus poor outcomes. Bivariate categorical analyses were performed using the Chi square or Fisher's exact tests. Student's t-test was used to determine significant differences in time between groups. Timelines including injury-to-KATH ED arrivals, door-to-head CT scan, length of stay were presented with their 95% Confidence Intervals (CI.). Trauma severity scores including GCS, Kampala Trauma Score, Rotterdam CT, and Eppendorf-Cologne Scale scores with their 95% confidence intervals were calculated. Glasgow Outcome Scale Extended (GOSE) at discharge and 3 months post-TBI were determined and presented with their 95% CIs. Both hospital mortality and three months post-TBI GOSE were used as dependent variables in separate bivariate models. The predictor variables for mortality were age, sex, mechanism of injury, mode of ED arrival, triage category, GCS, and whether complication was developed whilst on admission. The predictor variables for a good recovery at three months post-TBI as assessed by the paediatric GOSE were age, sex, caregiver staying with the child, GCS, mode of ED arrival, triage category, anti-seizure therapy, and whether complication was developed on the ward. Odds ratios of the final model are presented together with their corresponding 95% confidence intervals. Multiple logistic regression was conducted to determine the most useful variables for predicting the outcomes. Statistical significance for all testings was p-value < 0.05.

3.11 Ethical and legal considerations

3.11.1 Clearance

Permission was sought from the Research and Development Unit of KATH, and ethical clearance was approved from the School of Medical Sciences/ Komfo Anokye Teaching Hospital Committee on Human Research, Publication, and Ethics with a reference number CHRPE/AP/128/19.

3.11.2 Consent process

The legally authorised representatives or guardians of participants were engaged in a detailed discussion on the purpose and relevance of the study. Written informed consent was obtained from the legally authorised representatives or guardians of participants. Children who were mature enough to understand the study assented to participate in it.

3.11.3 Anonymity

Patients who consented to participate in the study were de-identified in the database and were assigned a unique numeric identifier. The code key for these identifiers was kept separate from the database and stored in a secure place. Access was under the total control of the PI.

3.11.4 Risk

The main risk of loss of confidentiality was addressed by using de-identified data. No intervention was tested, and the methods used to collect the data posed no physical or mental risk to the participants.

3.11.5 Benefits to participants

Participants who were identified to have motor disabilities were referred to consult a physiotherapist. The follow-up phone calls offered the caregivers the opportunity to clarify any management plan, which was not clear at the time of discharge.

3.11.6 Compensation to participants

Participants did not receive any form of compensation. To minimise any cost to the patient and their caregivers, the follow-up was done through a phone call unless the follow-up also coincided with their neurosurgery review date. This approach prevented participants from travelling to the study site solely for the purpose of participating in the study.

CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter describes the findings on the socio-demographic characteristics of children sustaining TBI. Other results will be presented based on the specific objectives; injury characteristics causing TBIs, definitive management, final hospital outcomes, three-month post-TBI outcomes, and predictors of TBI outcomes in children less than 15-year-old.

A total of 369 paediatric trauma related patients were admitted to the ED over the period of the study. Out of this, 141 patients reported with TBI within the six months of the study. Three caregivers declined to allow their children to participate in the study. At the end of participant enrolment, 138 children were recruited. However, after the neuroimaging, it was identified that two children had increased intracranial pressure from a brain tumour, and that resulted in them falling whiles walking. These children were excluded from the data, and therefore, the final participants for this study were 136, as shown in Figure 4.1 below. The prevalence rate of paediatric TBI was 36.86%.

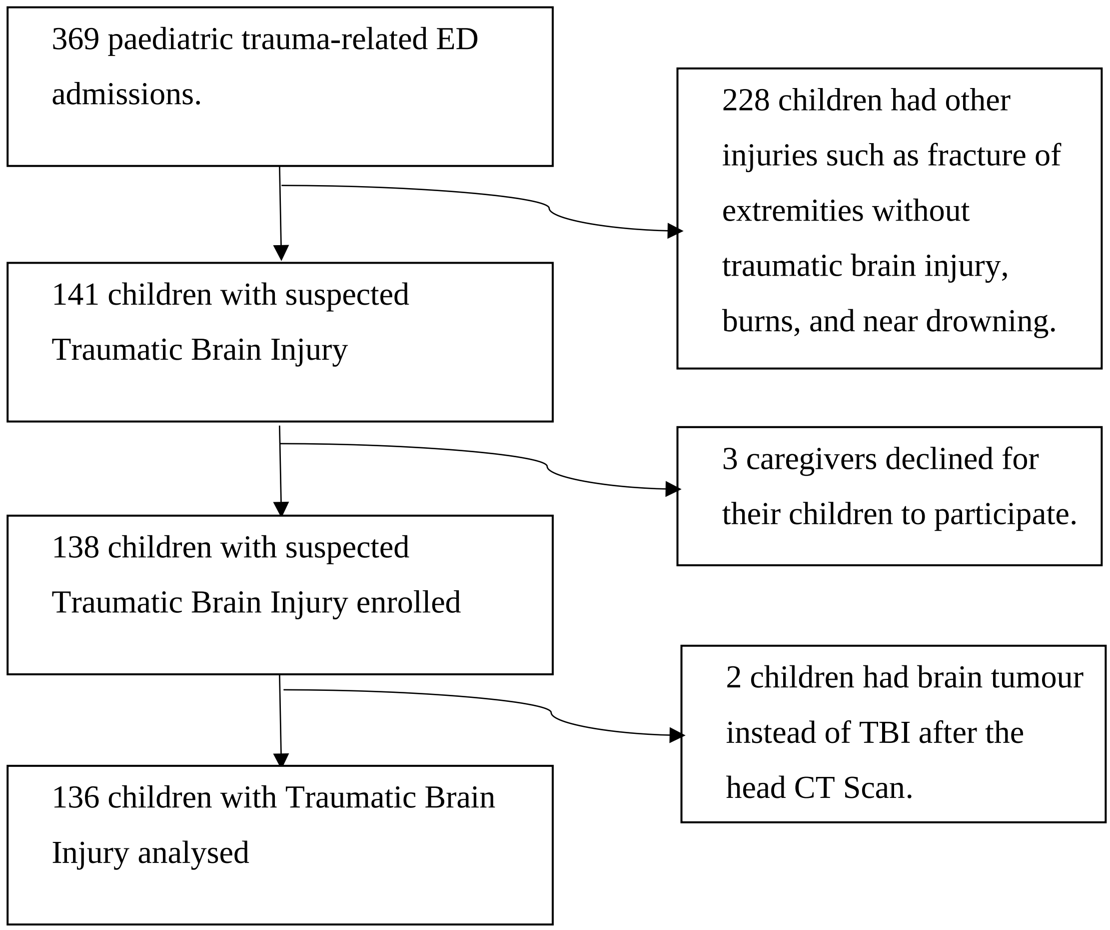


Figure 4. 1: Paediatric Traumatic Brain Injury Recruitment.

4.2 Socio-demographic characteristics of participants and their primary caregivers.

The average age of the children was 6.82 $\pm$ 3.84 years, with 41.91% (57/136) in the 5-9-year age group. Males constituted 63.24% (86/136) of the children with TBI with a male-to-female ratio of 1.7:1. Three children had a disability before the TBI and these disabilities were speech impairment, seizure disorder and a deformed right arm. Sixty percent of the participants were members of the National Health Insurance Scheme (NHIS). Fifty-eight percent (80/136) of children were staying with both parents. Mothers were the primary caregivers with the child in the ED for 59.56% (81/136) of the children.

Ninety-three percent (126/136) of primary caregivers of children with TBI were employed with 74 (58.73%) belonging to the ISCO categories 4-6, which consist of clerical support workers, services, and sales workers and skilled agricultural, forestry and fishery workers. The median monthly salary of primary caregivers was GH250.00 (IQR, GH200.00-400.00). Table 4. 1 shows the socio-demographic characteristics of the child and the caregiver.

Table 4. 1: Socio demographic characteristics of the Child and the Caregiver.

Variables	Frequency	Percentage
Age group 0-		
4	43	31.62
5-9	57	41.91
10-14	36	26.47
Sex		
Female	50	36.76
Male	86	63.24
Disability No		
	133	97.79
Yes	3	2.21
NHIS member No		
	55	40.74
Yes	81	59.56
Triage category Yellow		
	59	43.38
Orange	49	20.59
Red	28	36.03
Caregiver of the child Both		
parents	80	58.82
Single parent	40	29.41
Guardian	16	11.76
Primary caregiver Mother		
	81	59.56
Father	39	28.68
Guardian (Relative)	16	11.76
Educational level of primary caregiver No		
formal education	26	19.12
Primary	16	11.76
Junior/ Senior Secondary	78	57.36
Pre-tertiary/Tertiary	16	11.76
Employment status of primary caregivers		
Unemployed	10	7.35
Employed	126	92.65
ISCO (n=126) 1-3	20	15.87
4-6	74	58.73

7-9	32	25.40

Source: Field Data

4.3 Injury characteristics of Paediatric Traumatic Brain Injury.

The mechanisms of paediatric traumatic brain injuries were mainly road traffic crashes (69.12%), falls (18.38%), and being struck by a falling object (11.03%). 69.12% (94/136) of paediatric TBIs occurred at the roadside, and another 21.32% (29/136) occurred at home. Seventy-six percent (19/25) of the falls occurred at home. The main activities at the time of the TBI were travelling (34.56%) and playing (33.82%). Children were travelling to or from school (46.81%) or to another town (34.04%).

Of those involved in road traffic crashes, 67.02% (63/94) were pedestrian, 18.09% (17/94) were riders or pillion riders and 14.89% (14/94) were passengers. Riders or pillions riders were using a 3-wheeler such as a rickshaw (called “Yellow Yellow”) or in the bucket of a tricycle called “Aboboya” in 13.83% (13/94) of the cases. The cars involved in 61 motor vehicle-pedestrian collisions were taxis (26.23%), minibuses (“trotro”) (18.03%), private sedan cars (16.39%) and SUVs (9.84). 96.77% (30/31) of road users did not use a safety device.

Twenty-five children fell from various heights. 32% of them fell from a storey building, 24% on level ground, and 20% from a flight of stairs. The median height of fall was 250 centimetres (IQR 0-415 centimetres) and the median number of flights of stairs was seven stairs (IQR 4-15 stairs).

Forty-nine percent (46/94) of those who were involved in RTCs were aged 5-9 years old whiles 48.00% (12/25) of those who fell from various heights were under five years of age (p=0.026) and 50% of them fell from a storey building (p=0.002). Seventy-one percent (10/14) of passengers and 52.38% (33/63) of pedestrians were aged 5-9 years old, while 58.82% (10/17) of riders/ pillion riders were aged 10-14 years old (p=0.006). Males dominated all the mechanisms of paediatric TBIs; 55.32% (52/94) of RTC, 80.00% (20/25) of falls, and 82.35% (14/17) of other mechanisms (p=0.018). 78.95% (15/19) of the children with TBI who had major trauma, according to the Injury Severity Score, were males (p=0.102) Also, 68.42% (26/38) of children with TBI who had severe injury according to the Kampala Trauma Score were males (p=0.425). Table 4. 2 to Table 4. 5 show the injury characteristics of children with TBI.

Table 4.

Injury characteristic	**Frequency**	**Percentage (%)**
Mechanism of injury		
Others (Assault, attack by a cow)	2	1.47
Struck by a falling object	15	11.03
Falls	25	18.38
Road traffic crash	94	69.12
Place of injury		
Other places (church, playground)	3	2.21
Parent’s workplace	4	2.94
School	6	4.41
Home	29	21.32
Roadside	94	69.12
Activity at the time of TBI		
Others (being carried by a caregiver, during a seizure activity)	7	5.15
On errands	13	9.56
Hawking	23	16.91
Playing	46	33.82
Travelling	47	34.56
Destination of Travel (n=47)		
Unknown	1	2.13
Parent’s workplace	4	8.51
To church	4	8.51
To another town	16	34.04
To or from School	22	46.81
Type of road user (n=94)		
Passenger	14	14.89
Rider/ Pillion rider	17	18.09
Pedestrian	63	67.02
Means of transportation (n=94)		
Pedal cycle	2	2.13
2-wheeler motorcycle	2	2.13
3-wheeler motorcycle	13	13.83
Car	14	14.89
Walking	63	67.02
Vehicle or motorcycle which struck child (n-94)		
Pedal cycle	1	1.06

Table 4.

3-wheeler motorcycle	4	4.26
2-wheeler motorcycle	14	14.89
None	14	14.89
Car	61	64.89

2: Injury characteristic of paediatric Traumatic Brain Injury.

Source: Field Data

3: Injury characteristic of paediatric Traumatic Brain Injury.

Injury characteristic	**Frequency**	**Percentage (%)**
Type of car involved in		
Cargo truck (tipper truck)	2	3.28
Big bus (>20-seater)	5	8.20
Unknown	5	8.20
4x4/ SUV	6	9.84
Pick-up truck	6	9.84
Private sedan car	10	16.39
Minibus (trotro/sprinter)	11	18.03
Taxi	16	26.23
Type of safety device used (n=31)		
Helmet	1	3.23
None	30	96.77
Objects fell from (n=25)		
Bed	3	12.00
Tree	3	12.00
Stairs	5	20.00
Ground level	6	24.00
Storey building	8	32.00

Source: Field Data

Table 4.

4: Injury characteristics by age.

Injury Characteristics	Age			p-value
	0-4 row % col %	5-9 row %, col %	10-14 row %, col %	
Mechanism of injury				**0.026**
Other mechanisms	7 41.18, 16.28	7 41.18, 12.28	3 17.65, 8.33	
Falls	12, 48.00, 27.91	4 16.00, 7.02	9 25.00, 36.00	
RTCs	24 25.53, 55.81	46 48.94, 80.70	24 25.53, 66.67	
Road user type				**0.006**
Passenger	3 21.43, 12.50	10 71.43, 21.74	1 7.14, 4.17	
Rider/ Pillion rider	4 23.53, 16.67	3 17.65, 6.52	10 58.82, 41.67	
Pedestrian	17 26.98, 70.83	33 52.38, 71.74	13 20.63, 54.17	
Object from which the child fell from				**0.002**
Flight of Stairs	3 60.00, 25	0 0.00, 0.00	2 40.00, 22.22	
Storey building	6 75.00, 50.00	2 25.00, 50.00	0 0.00, 0.00	
Tree	0 0.00, 0.00	1 33.33, 25.00	2 66.67. 22.22	
Bed/Chair/table	3 100.00, 25.00	0 0.00, 0.00	0 0.00, 0.00	
Ground level	0 0.00, 0.00	1 16.67, 25.00	5 83.33, 55.56	

row%= row percentage col% = column percentage

Source: Field Data.

Table 4. 5: Injury characteristics by sex.

Injury characteristic	Sex		p-value
	Female row % col %	**Male** row % col %	
Mechanism of injury			**0.018**
Other mechanisms	3 17.65, 6.00	14 82.35, 16.28	
Falls	5 20.00, 10.00	20 80.00, 23.26	
RTCs	42 44.68, 84.00	52 55.32, 60.47	
Injury Severity Score			0.102
Minor trauma, ISS <15	45 39.13, 91.84	70 60.87, 82.35	
Major trauma, ISS >15	4 21.05, 8.16	15 78.95, 17.65	
Kampala Trauma Score Categories			0.425
Mild injury	14 46.67, 28.57	16 53.33, 19.28	
Moderate injury	23 35.94, 46.94	41 64.06, 49.40	
Severe injury	12 31.58, 24.49	26 68.42, 31.33	

row%= row percentage col% = column percentage
Source: Field Data.

4.3.1 Pre-hospital care and referral characteristics

Ninety-three percent (126/136) of children did not receive any form of care at the scene of the injury. Of the ten children who received pre-hospital care at the scene, water was poured on 70% of them. Parents were the providers of the care at the scene in 7 out of 10 (70%) of the cases.

Eighty-eight percent (120/136) of children with TBIs were referred from another facility to the KATH ED, with 55.00% of the referred children coming from a metropolis outside Kumasi. Apart from the Ashanti Region, 15.00% (18/120) of the children were referred from the Brong Ahafo

Region, 3.33% (4/120) from the Central Region, 1.66% (2/120) from the Western Region and 0.83% (1/120) from the Eastern Region.

The ambulance was the mode of arrival at KATH ED for 60.29% (82/136) of the children with TBI. The median time from injury to KATH ED arrival was 4.78 hours (IQR 2.54-13.06 hours), with 8.09% (11/136) of the children with TBI arriving within an hour of injury. Another 49.26% (67/136) reached KATH ED within 1-6 hours and 42.65% (58/136) made it to the ED after 6 hours. Looking at the cohort who were not referred, all of them arrived at the ED in non-ambulances, 87.50% (14/16) taxis and 12.50% (2/16) private cars. 93.75% (15/16) of children with severe TBI, according to the GCS, arrived at the ED in an ambulance compared to 49.40% (41/83) of those with mild TBI (p=0.016). Table 4. 6 shows the pre-hospital care and referral characteristics of children with TBI.

The median scores for GCS and GOSE at discharge were 14 (Range 3-15) and 5 (Range: 1-8), respectively. The median GOSE at three months post-TBI was 1 (range 1-6).

Table 4. 6: Pre-hospital care and referral characteristics of children with Traumatic Brain Injury.

Injury characteristic	Frequency	Percentage (%)
Provision of care at the scene No		
	126	92.65
Yes	10	7.35
Care provided at the accident scene (n=10)		
Digital pressure to a bleeder	1	10.00
Chest compression	2	20.00
Water poured on child	7	70.00
Care provider (n=10)		
Paramedic	1	10.00c

Bystander	2	20.00
Parent	7	70.00

Source: Field Data.

4.3.2 Emergency Department vital signs

Using the SATS triaging, 43.38% (59/136) of the children presenting to the ED were triaged Yellow, 20.59% (28/136) triaged Orange, and 36.03% (49/136) triaged Red in increasing order of acuity.

Blood pressure measurements were within the 50th percentile of the age for 81.06% (107/132) of the children. 4.55% (6/132) had hypotension and 14.39% (19/132) had hypertension. Sixty-seven percent (4/6) of children with TBI who had hypotension died (p=0.001)

Seven percent (10/136) of the children had hyperthermia, a temperature of 38.0^{o}C and above. Thirty percent of those with hyperthermia compared to nine percent of those with normothermia died, however it did not reach statistical significance (p=0.068).

Hypoxia, oxygen saturation (SpO_2) of 90% and below, was recorded in 3.68% (5/136) of the children with TBI. Twenty percent (1/5) of those with hypoxia died compared to 9.92% (13/131) of those without hypoxia, although not statistically significant (p=0.424). Table 4. 7 shows the initial ED vital signs.

Table 4. 7: Initial Emergency Department Vital Signs.

Emergency department	**Frequency**	**Percentage**
Triage category		
Yellow	59	43.38
Orange	28	20.59
Red	49	36.03
Systolic Blood Pressure		

Hypotension	6	4.55		
Normotension	107	81.06		
Hypertension	19	14.39		
Temperature at Triage				
Normothermia (35ºC to less than 38ºC)	126	92.65		
Hyperthermia (38ºC and above)	10	7.35		
Initial Oxygen				
90% and below	5	3.68		
Above 90%	131	96.32		
Severity of TBI			**Mean GCS Score (SD)**	**95% CI**
Mild (GCS=13-15)	83	61.03	14.71 (0.57)	14.59-14.84
Moderate (GCS=9-12)	37	27.21	10.03 (1.12)	9.65-10.40
Severe (GCS<=8)	16	11.76	6.06 (1.91)	5.04-7.08

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4.3.3 Emergency Department management

The overall intubation rate was 2.94%. However, 25% (4/16) of children with severe TBI were intubated.

The head end of the bed (HOB) was elevated for 7 children with TBI. Five of these children (5/7 = 71.43%) had moderate-to-severe TBI according to the GCS (p=0.109).

Thirteen children with TBI (9.56%) received antiseizure medication whiles in the ED and of these, 92.31% had moderate-to-severe TBI according to the GCS (p<0.001).

Eleven percent (15/136) of the children with TBI were given hyperosmolar fluids and 80.00% of these had moderate-to-severe TBI according to the GCS score (p=0.001). Mannitol was used in 73.33% (11/15) of the cases.

Oxygen was administered to 16.18% (22/136) of paediatric TBI patients and 81.82% of them had moderate-to-severe TBI (p<0.001).

Antibiotics and analgesics were administered in 48.53% (66/136) and 58.82% (80/136) of the children with TBI, respectively.

Seventy percent (95/136) of the children with TBI received intravenous fluids. Eighty-one percent of those with moderate-to-severe TBI received IV fluids compared to 62.65% of those with mild TBI ($p=0.023$). The specific ED management received by children with TBI is shown in Figure 4. 2 below.

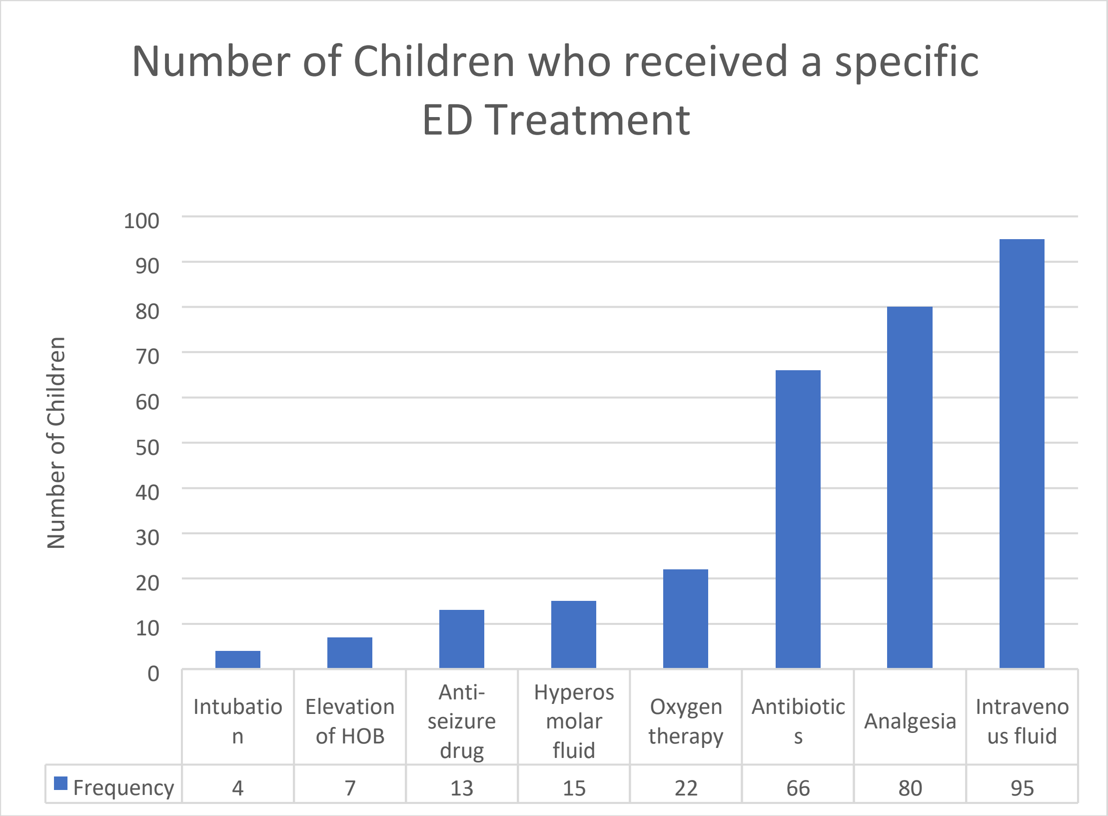


Figure 4. 2: A Bar Chart showing the number of children who received a specific Emergency Department Management.

4.3.4 Neuroimaging and Rotterdam CT scan score.

After primary survey and resuscitation, a head CT scan was indicated in 90.44% (123/136) of the children who presented to KATH ED with a history and physical examination findings of a TBI. A head CT scan was done for 86.18% (106/123) of children with a suspected TBI in whom the CT scan was indicated. Neuroimaging was requested and done in 85.71% (60/70) of children with mild TBI (p=0.005); 75.00% (45/60) of these had a GCS score of 15 (p=0.395). Of the 17 children who did not have a head CT scan, 6 (35.29%) died before the investigation could be done and 10 (58.82%) had no funds for the imaging study.

The median door-to-head CT scan time was 17.58 hours (IQR 8.76-25.08 hours). 95.28% (101/106) of the paediatric TBI patients were unable to obtain the CT scan of the head within an hour of presentation.

The head CT scan identified abnormal findings in 63.21% (67/106) of those who obtained the investigation. Of the patients with mild TBI according to the GCS, 58.33% (35/60) of them had abnormal findings on the head CT scan (p=0.028) and 71.43% (25/35) of those with abnormal CT findings had a GCS score of 15 (p=0.587). Table 4. 8 and Table 4. 9 show the characteristics of neuroimaging for paediatric TBI.

The median Rotterdam CT score was 2 (Range 1-4). All children with a Rotterdam CT score of 1 had epidural haemorrhage (p<0.001). All the children with a Rotterdam CT score of 1, had a moderate TBI while all those with a score of 4 had a severe TBI (p=0.023). Figure 4. 3 below shows the distribution of the Rotterdam CT score by the GCS.

Table 4. 8: Neuroimaging characteristics of children with TBI.

Neuroimaging	Frequency	Percentage
Head CT scan was indicated No	13	9.56
Yes	123	90.44

Head CT scan was done (n=123)		
No	17	13.82
Yes	106	86.18
Reason Head CT was not done when indicated (n=17)		
Doctors later changed their minds	1	5.88
Child died before investigation	6	35.29
No funds for investigation	10	58.82
Gross findings of Head CT scan (n=106)		
Abnormal	67	63.21
Normal	39	36.79
Rotterdam CT score (n=106)		
1	8	7.55
2	89	83.96
3	6	5.66
4	3	2.83

Table 4. 9: Neuroimaging characteristics of children with TBI.

Neuroimaging	**Presence of Epidural Bleed**		**p-value**
	No (row% col%)	**Yes (row% col%)**	
Rotterdam CT category			<0.001
Rotterdam CT score 1	0 (0.00, 0.00)	8 (100.00, 80.00)	
Rotterdam CT scores 2-3	94 (98.95, 97.92)	1 (1.05, 10.00)	
Rotterdam CT score 4	2 (66.67, 2.08)	1 (33.33, 10.00)	
	Head CT Scan done when indicated		
	No n (row%, col%)	**Yes n (row%, col%)**	**p-value**
GCS (n=123)			0.005
Mild	10 (14.29, 58.82)	60 (85.71, 56.60)	
Moderate	1 (2.70, 5.88)	36 (97.30, 33.96)	
Severe	6 (37.50, 35.29)	10 (62.50, 9.43)	
Mild GCS score (n=70)			0.395
13	1 (20.00, 10.00)	4 (80.00, 6.67)	
14	3 (21.43, 30.00)	11 (78.57, 18.33)	
15	6 (11.76, 60.00)	45 (88.24, 75.00)	

	Overall Head CT Scan finding		p-value
	Abnormal n (row%, col%)	Normal n (row%, col%)	
GCS			0.028
Mild	35 (58.33, 52.24)	25 (41.67, 64.10)	
Moderate	22 (61.11, 32.84)	14 (38.89, 35.90)	
Severe	10 (100.00, 14.93)	0 (0.00, 0.00)	
GCS score (mild)			0.587
13	2 (50.00, 5.71)	2 (50.00, 8.00)	
14	8 (72.73, 22.86)	3 (27.27, 12.00)	
15	25 (55.56, 71.43)	20 (44.44, 80.00)	

Source: Field Data

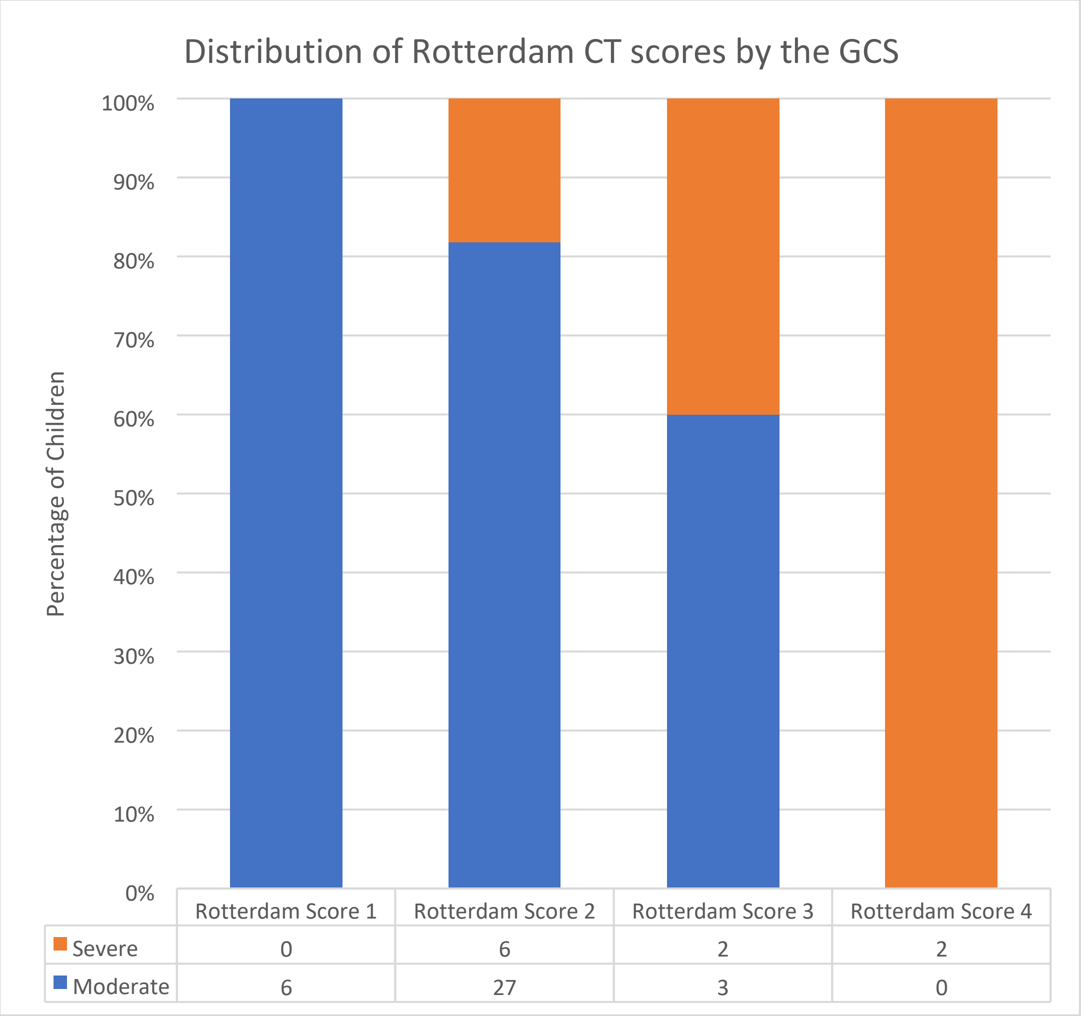
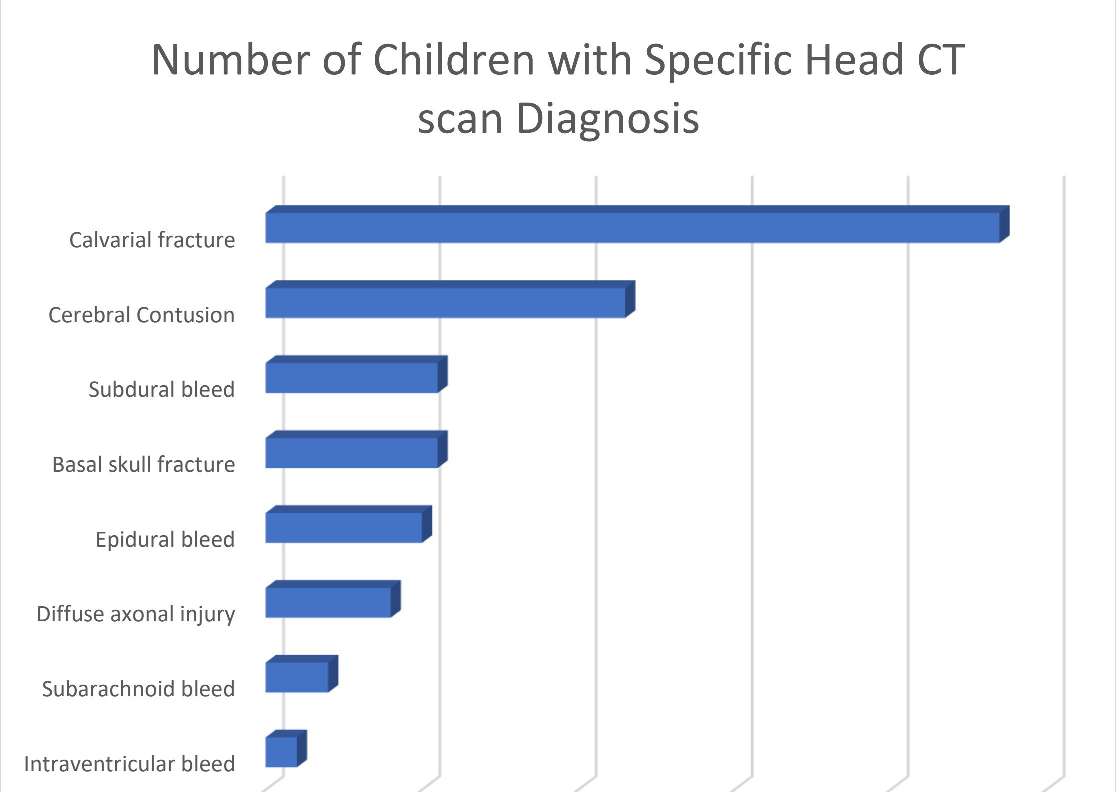


Figure 4. 3: Distribution of the Rotterdam CT score by Glasgow Coma Scale.

Forty-seven percent (50/106) of children with TBI who obtained the head CT scan had skull fractures. Seventy-eight percent of children with skull fracture had a purely Calvarial fracture, six percent had a basal skull fracture and 16% had both Calvarial as well as basal skull fractures. Thirty-six percent (17/47) of Calvarial fractures were depressed.

Twenty-three percent (24/106) of TBI children had extra-axial haemorrhage with some children having multiple extra-axial haemorrhages. Subdural haemorrhage was diagnosed in 10.38% (11/106) of the children with TBI who underwent neuroimaging, EDH in 9.43% (10/106), SAH in 3.77% (4/106) and intraventricular haemorrhage in 1.89% (2/106). All children with EDH had a Calvarial fracture ($p<0.001$).

Cerebral contusion and DAI were diagnosed in 21.70% (23/106) and 7.55% (8/106), respectively, of paediatric TBI patients with head CT scans. Figure 4. 4 below shows the specific head CT scan diagnosis for children presented with TBI.

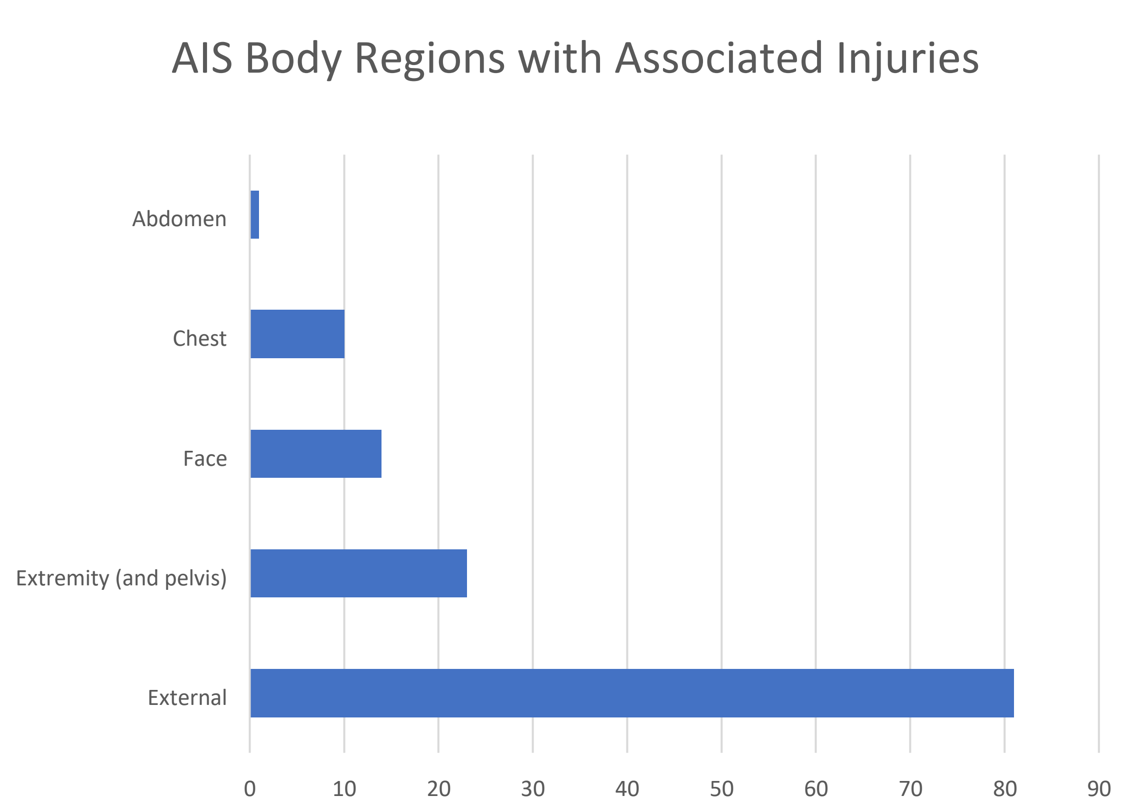


	Intraventricular bleed	Subarachnoid bleed	Diffuse axonal injury	Epidural bleed	Basal skull fracture	Subdural bleed	Cerebral Contusion	Calvarial fracture
frequency	2	4	8	10	11	11	23	47

Figure 4. 4: A Bar Chart showing the number of children with specific Computed Tomographic diagnosis.

4.3.5 Associated injuries

Sixty percent (81/136) of the children with TBI also had an injury to the external body region according to the AIS. External injuries included abrasion/ bruises (41.91%, 57/136), lacerations/avulsions (33.82%,46/136) and scalp contusions (2.94%, 4/136). Paediatric TBI was also associated with extremity fracture in 16.91% (23/136) of cases, facial injuries in 10.29% (14/136), chest injuries 7.35% (10/136) and abdominal injury in 0.74% (1/136). Twenty-one percent (28/136) of the children presented with an isolated traumatic brain injury. Injuries associated with TBI in children presenting to KATH ED are shown in Figure 4. 5 below.



	External	Extremity (and pelvis)	Face	Chest	Abdomen
Frequency	81	23	14	10	1

Figure 4. 5: A Bar Chart showing Abbreviated Injury Scale Body Regions with other injuries associated with paediatric TBI.

4.3.6 Trauma Severity Scores

Apart from the GCS and the Rotterdam CT scores described above, the results of other trauma severity scores used in this study will be presented here.

Using the Abbreviated Injury Scale of the head (Head AIS), 43.40% (46/106) and 13.21% (14/106) of the children who underwent head CT scan had scores of 3 (serious injury) and 4 (severe injury) respectively as shown in Table 4. 10 below. For the ISS, 68.87% (73/106) of the children with TBI had major trauma.

The Kampala Trauma Score (KTS), on the other hand, identified 28.79% (38/132) of the paediatric TBI patients to have a severe injury. None of the children with mild injury according to the KTS had a severe TBI according to the GCS, and none of those with severe injury according to the KTS had a mild TBI according to the GCS ($p<0.001$). For children with TBI between 5 and 9 years of age, the Kampala Trauma Score categorised 30.36% (17/56) as severe injury compared with 27.50% (11/40) for the 0-4-year age group and 27.78% (10/36) for those aged 10-14 years ($p<0.001$). Children who were triaged to Yellow had a KTS between 11 and 14 whiles that of those triaged to Red was between 6 and 13. The average difference in KTS for children with TBI who triaged Ye1low (urgent) compared to those who triaged Red (emergent) was 3.20 (95% CI 2.75-3.66, $p<0.001$). The KTS range for passengers was 10 to 14 compared to 8 to 14 for pedestrians. The mean difference in KTS for children who were passengers compared to pedestrians was 1.19 (95% CI 0.06-2.32, $p=0.039$)

Majority (60.50%) of the patients had an Eppendorf-Cologne Scale (ECS) score of zero with over 90% having scores of 0-3. About 95% of the patients with a mild TBI had ECS score of zero whiles none of these patients had a score of 8. On the other hand, none of the patients with severe TBI had ECS score of zero whiles seven percent had a score of 8 ($p<0.001$).

There was a strong positive correlation between the KTS and the GCS score ($r=0.8$, $p<0.001$). There was a moderate negative correlation between head AIS score and GCS score ($r= -0.3$, $p=0.004$) and between ISS and GCS score ($r= -0.4$, $p<0.001$)

Table 4. 10: Trauma Severity Scores.

Trauma Severity Score	Frequency	Percentage
Head Abbreviated Injury Scale (n=106)		
1 (minor)	38	35.85
2 (moderate)	8	7.55
3 (Serious)	46	43.40
4 (Severe)	14	13.21
Injury Severity Score (n=106) Minor trauma (ISS <8)	33	31.13
Major trauma (ISS 8 and above)	73	68.87
Kampala Trauma Score (n=132)		
Mild	30	22.73

Moderate	64	48.48
Severe	38	28.79
Eppendorf-Cologne Scale Score (119) 0		
	72	60.50
1	27	22.69
2	13	10.92
3	3	2.52
4	1	0.84
7	2	1.68
8	1	0.84

4.3.7 Emergency Department Disposition

The admission rate for children with TBI was 68.38% (93/136), and in 94.62% of the time, it was to the paediatric ward of the Clinical Decision Unit, as shown in Figure 4. 6 below. The ED discharge rate for paediatric TBI patients was 23.53% (32/136). Of these, 87.50% of them presented with mild TBI according to the GCS, 12.50% with moderate and none with severe TBI ($p<0.001$). One percent (2/136) of the children with TBI were sent from the ED to the theatre for orthopaedic intervention.

None of the four children with TBI who was intubated at the ED got admitted to the PICU. Also, none of the fifty-three children with moderate-to-severe TBI according to the Glasgow Coma Scale was initially admitted to PICU.

In total, 6.62% (9/136) of the children with TBI died in the ED with 4.41% (6/136) dying within 48 hours of admission. The median ED length of stay (LOS) for children with TBI was 21.02 hours (IQR 13.53-33.52 hours). Children with mild TBI according to the GCS, spent an average of 36.17 hours less in the ED compared to those with moderate-to-severe TBI (95% CI -67.88 to -4.47, p=0.026). Children with TBI who were not intubated spent an average of 8.89 hours less time in the ED compared to their counterparts who were intubated (95% CI -102.12 - 84.34, p=0.851). Also, compared to the patients who died, those who were admitted spend an average of 2.99 hours less time in the ED (95% CI -80.46 - 74.47, p=0.939).

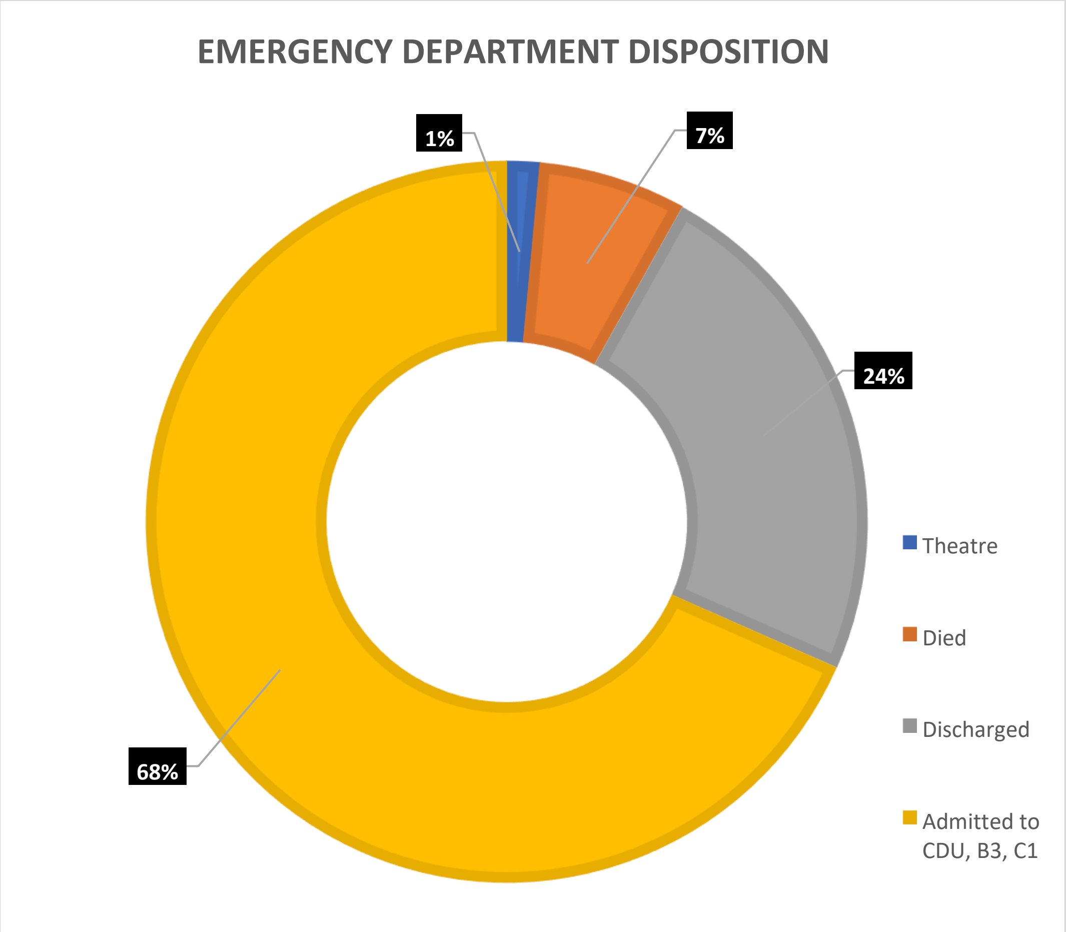


Figure 4. 6: Emergency department disposition for Children with Trauma Brain Injury.

4.4 Definitive management of paediatric Traumatic Brain Injury

4.4.1 Management plan

Children with TBI were managed conservatively 94.12% (128/136) of the time, as shown in Figure 4. 7 below. Six children (4.41%) with TBI died before the neuro-investigation could be done and as a result, the definitive management could not be determined. Ninety-six percent (45/47) of children with Calvarial fractures were managed non-operatively (p=0.129) including 88.24% (15/17) of those with depressed Calvarial fractures (p=0.129). None of the children with epidural haemorrhage and nine percent (1/11) of those with subdural haemorrhage had a neurosurgical intervention. The neurosurgical operation rate for children with TBI was one percent (2/136). However, for those with abnormal head CT scans, the rate was three percent (2/67). Both craniotomy and skull elevation were performed for one of the children who underwent surgery. His head CT diagnosis was a depressed left parietal Calvarial fracture with a subacute subdural hematoma. Additionally, there was an adjoining mixed haemorrhagic and non-haemorrhagic contusion of the left parietal cortex causing a masseffect. The second skull elevation was performed for another child who had a depressed right parieto-occipital skull fracture with underlying contusional bleed.

The mean time from KATH ED arrival to the neurosurgical intervention was 97.17 hours (SD 31.23 hours). With an average time of 25.78 hours (SD 33.60 hours) from KATH ED arrival to obtaining head CT scan for these two patients, it took an average time of 71.39 hours (approximately three days) after obtaining the head CT scan to have a neurosurgical intervention.

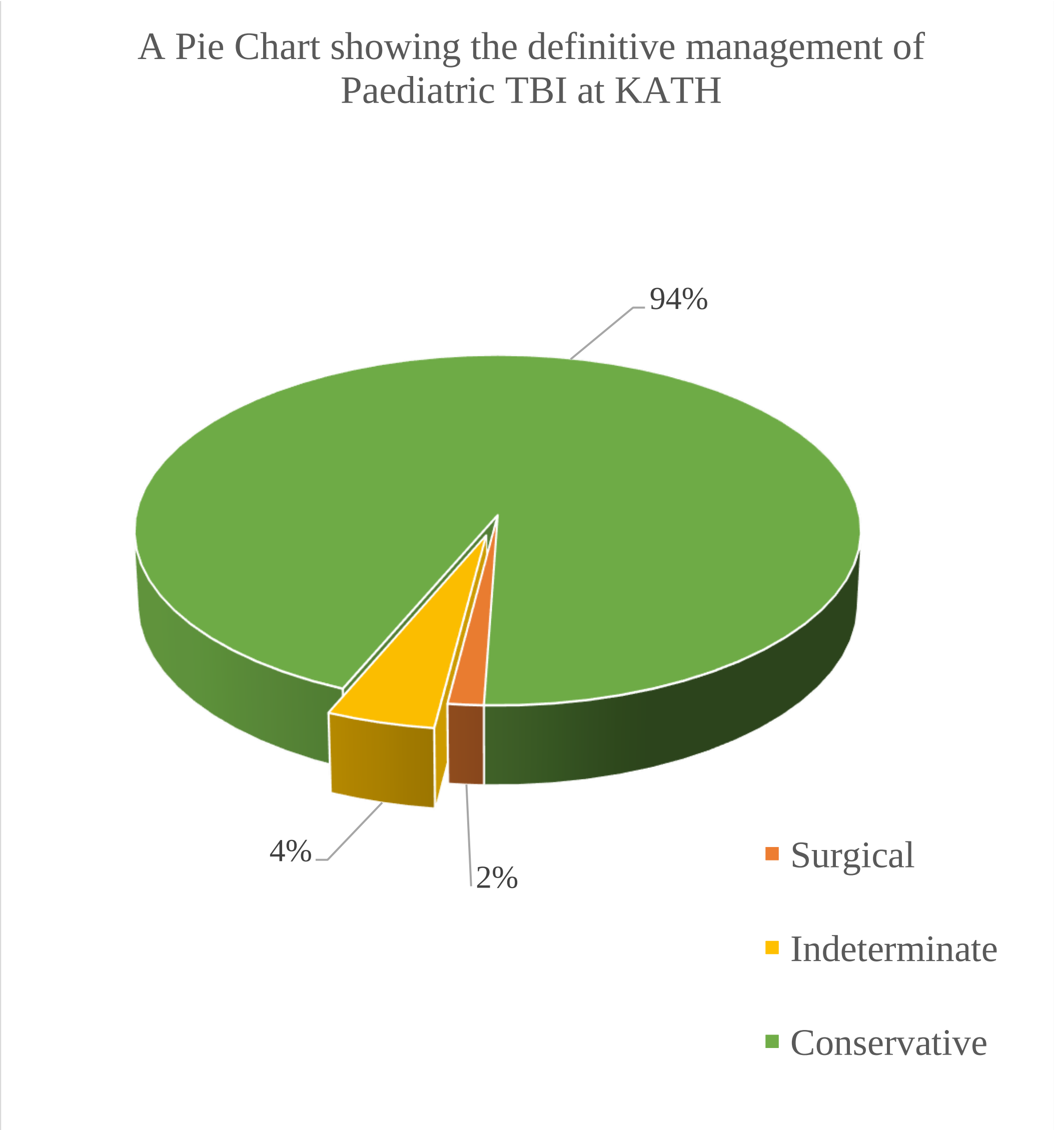


Figure 4. 7: A Pie Chart showing the definitive management of Children with TBI at KATH.

4.4.2 Complications developed by Children with Traumatic Brain Injury whiles on the wards.

Ninety-three percent (126/136) of the children had no complications on admission. The remaining 10 children with TBI developed 13 complications whiles on the ward. One child developed malaria, meningitis, shock and eventually died at the PICU. Another had status epilepticus and died. The others had just one complication. Figure 4. 8 below shows the complications developed whiles on the ward.

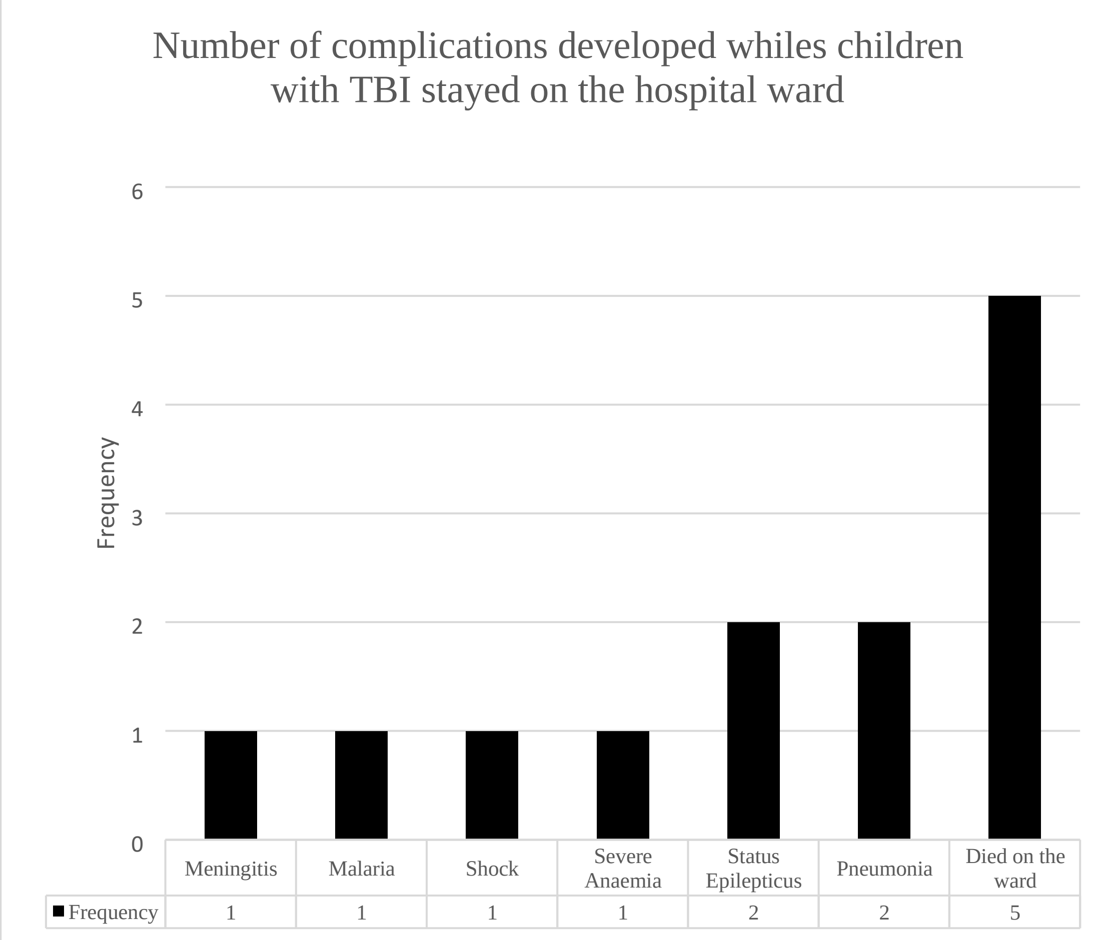


Figure 4. 8: A Bar Chart showing the complications developed by Children with TBI whiles on the ward.

4.5 Final hospital outcomes of children with Traumatic Brain Injuries.

This section will describe the overall outcome of children presenting to the KATH ED with traumatic brain injuries, dead or alive. It will also describe the outcome as assessed by the paediatric GOSE at discharge for children who were discharged alive. The median length of hospital stay for children with TBI was 71.75 hours (IQR 28.43-158.50 hours) which included a median ED LOS of 21.02 hours (IQR 13.53-33.53 hours).

4.5.1 Mortality outcomes

A total of 14 out of the 136 (10.29%) children with TBI who presented to the KATH ED died at the end of their hospital stay. The overall ED mortality rate was 6.62%. Mortality as it relates to the socio-demographic characteristics of the children with TBI and their injury characteristics is described below.

4.5.1.1 Mortality outcomes and socio-demographic characteristics.

Eight out of the 14 (57.14%) children with TBI who died were females ($p=0.095$). Using the different trauma severity scores, the average scores for the females with TBI who died were better compared to their male counterparts (all p-values >0.05). Of the fourteen children who died, those within the 5-9-year age group constituted 57.14% ($p=0.557$). 57.14% of paediatric TBI mortality was among children who were not members of the NHIS ($p=0.179$). 78.57% of those who died were triaged Red (Emergent), with none of those triaged Yellow (Urgent) dying ($p<0.001$). 6.25% (1/16) of children with TBI who stayed with a guardian died compared to 12.50% (5/40) and 10.00% (8/80) of those who stayed with single and both parents respectively ($p=0.845$). Other mortality outcomes by socio-demographic characteristics are shown in Table 4. 11 below.

11: Mortality outcomes by Socio demographic characteristics of children with TBI.

Demographic	Mortality Outcome	p-value	Alive (row%, col%) Dead
Sex			0.095
Female	(84.00, 34.43)	(16.00, 57.14)	
Male	(93.02, 65.57)	(6.98, 42.86)	
Age group			0.557
0-4	(93.02, 32.79)	(6.98, 21.43)	
5-9	(85.96, 40.16)	(14.04, 57.14)	
10-14	(91.67, 27.05)	(8.33, 21.43)	
Disability			1.000
No	(89.47, 97.54)	(10.53, 100)	
Yes	(100, 2.46)	(0,0)	
NHIS member			0.179
No	(85.45, 38.52)	(14.55, 57.14)	
Yes	(92.59)	(7.41, 42.86)	
Triage category			<0.001
Yellow	(100, 48.46)	(0,0)	
Orange	(89.29, 20.49)	(10.71, 21.43)	
Red	(77.55, 31.15)	(22.45, 78.57)	
Caregiver of the child			0.845
Both parents	(90.00, 59.02)	(10.00, 57.14)	
Single parent	(93.75, 12.30)	(6.25, 7.14)	
Guardian	(87.50, 28.69)	(12.50,35.71)	
Educational level of primary caregiver			0.732
No formal education	(96.15, 20.49)	(3.85, 7.14)	
Primary	(87.50, 11.48)	(12.50, 14.29)	
Junior/ Senior	(88.46, 56.56)	(11.54, 64.29)	
Pre-tertiary/Tertiary	(87.50, 11.48)	(12.50, 14.29)	
ISCO (n=126)			0.776
1-3	(90.00, 15.79)	(10.00, 33.33)	
4-6	(91.89, 59.65)	(8.11, 50.00)	
7-9	(87.50, 24.56)	(12.50, 16.67)	

(row%, col%)

row%= row percentage col% = column percentage

Source: Field data.

4.5.1.2 Mortality outcomes by pre-hospital care of children with TBI.

For 92.86% of the children with TBI who died, no prehospital care was provided at the scene of the injury (p=1.000). Compared to children with TBI who lived, children who died spent 92.22 more hours from the time of the injury to KATH ED arrival (95% CI -151.55 to -32.88, p=0.003)

Table 4.

4.5.1.3 Mortality outcome and injury characteristics

Seventy-nine percent of the children with TBI who died were involved in road traffic crashes as the mechanism of the injury, although not statistically significant (p=0.155). Paediatric TBI mortality attributable to falls was 14.29%. Of those who died, one was due to an assault that occurred during a fight with a colleague while returning from school. No death was accounted for by an object striking a child's heads. The roadside was the place where 78.57% injuries resulting in paediatric TBI mortalities occurred, followed by the home (14.29%) and then the school (7.14%) (p=0.798). Thirty-six percent of children with TBI who died were hawking by the roadside at the time of the injury and 28.57% were travelling (p=0.146). Half (2/4) of those who sustained paediatric TBI while travelling and died were going to or from school (p=0.706). Of the 11 children who were road users and died from TBI, 81.82% were pedestrians (p=0.707). Mortality rate for children with isolated mild TBI was 2.14% (95% CI, 0.29-8.43%) compared to 62.50% (95% CI, 35.43-84.80%) for children with severe TBI as in Table 4. 12.

12: Mortality outcomes by injury characteristic of children with TBI.

Injury characteristic	**Mortality outcome**		**p-value**
	Alive (row%, col%)	**Dead (row%, col%)**	
Mechanism of injury			0.155
Falls	23 (92.00,18.85)	2 (8.00,14.29)	
Road traffic crash	83 (88.30,68.03)	11 (11.70, 78.57)	
Struck by a fall object	15 (100, 12.30)	0 (0.00, 0.00)	
Others (Assault and attack by a cow)	1 (50.00,0.82)	1 (50.00,7.14)	
Place of injury			0.798
Home	27 (93.10,22.13)	2 (6.90, 14.29)	
Roadside	83 (88.30,68.03)	11 (11.70,78.57)	
School	5 (83.33, 4.10)	1 (16.67,7.14)	
Parent's workplace	4 (100, 3.28)	0 (0.00,0.00)	
Other places (church,	3 (100, 2.46)	0 (0.00,0.00)	
Activity at the time of injury			0.146
Playing	44 (95.65,36.07)	2 (4.35,14.29)	

Travelling	43 (91.49,35.25)	4 (8.51,28.57)	
Hawking	18 (78.26,14.75)	5 (21.74,35.71)	
On errands	11 (84.62,9.02)	2 (15.38,14.29)	
Others (being carried by	6 (85.71,4.92)	1 (14.29,7.14)	
Destination of Travel (n=47)			0.706
To or from School	20 (90.91,46.51)	2 (9.09,50.00)	
To another town	15 (93.75,34.88)	1 (6.25,25.00)	
To church	4 (100, 9.30)	0 (0.00,0.00)	
Parent's workplace	3 (75.00,6.98)	1 (25.00,25.00)	
Unknown	1 (100, 2.33)	0 (0.00,0.00)	
Type of road user (n=94)			0.707
Passenger	13 (92.86,15.66)	1 (7.14,9.09)	
Pedestrian	54 (85.71,65.06)	9 (14.29,81.82)	
Rider/ Pillion rider	16 (94.12,19.28)	1 (5.88,9.09)	
Severity of TBI	**Frequency**	**Mortality rate (%)**	**95% CI**
Mild	83	2.41	0.29-8.43
Moderate	37	5.41	0.66-18.19
Severe	16	62.50	35.43-84.80

row%= row percentage col% = column percentage

Source: Field data

Ninety-one percent (10/11) of those who died after sustaining paediatric TBI from road traffic crashes were because of pedestrian-vehicle collision (p=0.502). The cars involved in such collisions included minibus (trotro) (20%), private sedan car (20%) and pick-up truck (20%) (p=0.452). Of the road users in whom a safety device usage was indicated, two of them died after sustaining a paediatric TBI and none of them used the device (p=1.000). Two children who fell from a height died after suffering from TBI (p=0.513) as shown in Table 4. 13. One child fell from a storey building, and the other was a 1-year-old girl who fell from a bed of about 50 centimetres high hitting her head on a concrete floor.

Table 4.

13: Mortality outcomes by injury characteristic of children with TBI.

Mortality outcome Injury characteristic	Alive (row%, col%)	Dead (row%, col%)	p-value
Traffic counterpart (n=94)			0.502
Car	51 (83.61,61.45)	10 (16.39,90.91)	
3-wheeler motorcycle	4 (100,4.82)	0 (0.00,0.00)	
2-wheeler motorcycle	13 (92.86,15.66)	1 (7.14,9.09)	
Pedal cycle	1 (100,1.20)	0 (0.00,0.00)	
None	14 (100,16.87)	0 (0.00,0.00)	
Type of car involved in vehicle-pedestrian collision (n=61)			0.452
Minibus (trotro/sprinter)	9 (81.82,17.65)	2 (18.18,20.00)	
Private sedan car	8 (80.00,15.69)	2 (33.33,20.00)	
Taxi	15 (93.75,29.41)	1 (6.25,10.00)	
4x4/ SUV	6 (100,11.76)	0 (0.00,0.00)	
Big bus (>20-seater)	4 (80.00,7.84)	1 (20.00,10.00)	
Cargo truck (tipper truck)	1 (50.00,1.96)	1 (50.00,10.00)	
Pick-up truck	4 (66.67,7.84)	2 (33.33,20.00)	
Unknown	4 (80.00,7.84)	1 (20.00,10.00)	
Type of safety device used (n=31)			1.000
Helmet	1 (100,3.45)	0 (0.00,0.00)	
None	28 (93.33,96.55)	2 (6.67,100)	
Objects fell from (n=25)			0.513
Stairs	5 (100,21.74)	0 (0.00,0.00)	
Storey building	7 (87.50,30.43)	1 (12.50,50.00)	
Tree	3 (100, 13.04)	0 (0.00,0.00)	
Bed	2 (66.67,8.70)	1 (33.33,50.00)	
Ground level	6 (100,26.09)	0 (0.00,0.00)	
Provision of care at the scene			1.000
No	113 (89.68,92.62)	13 (10.32,92.86)	
Yes	9 (90.00,7.38)	1 (10.00,7.14)	
Care provider (n=10)			0.100
Parent	7 (100,77.78)	0 (0.00,0.00)	
Bystander	2 (100, 22.22)	0 (0.00,0.00)	
Paramedic	0 (0.00,0.00)	1 (100,100)	

row%= row percentage col% = column percentage Source: Field Data.

4.5.1.4 Mortality outcomes by ED treatment

All the children with TBI who were intubated in the ED died compared to 7.58% (10/132) of those who were not intubated ($p<0.001$). Forty-one percent (9/22) of the children who received oxygen therapy died compared to 4.39% (5/114) of their counterparts who were not administered oxygen ($p<0.001$). Although not statistically significant, 25.00% (1/4) of the children who were treated with 3% hypertonic died compared to 45.45% (5/11) of those treated with mannitol ($p=0.604$). Five percent (3/66) of the children with TBI who received antibiotics died compared with 15.71% (11/70) of those who did not receive the antibiotics ($p=0.046$).

4.5.1.5 Mortality outcomes by trauma severity scores

Seventy-one percent (10/14) of the children with TBI who died had severe TBI, according to the Glasgow Coma Scale ($p<0.001$). All children with severe TBI with a GCS score of less than 7 died ($p<0.001$). Again, 5.41% (2/37) of those with moderate TBI died compared to 2.41% (2/81) of those with mild TBI ($p<0.001$). Children who died had a GCS score which was 6 points lower than those who survived (95% CI 4.63 to 7.61, $p<0.001$).

None of the children with TBI who died had mild injury according to the Kampala Trauma Score compared to 78.5% of those with severe injury ($p<0.001$). None of the children with a Rotterdam CT score of 1 died. The death rate for each Rotterdam CT score increased as the score increased from 1 through 4 ($p=0.023$). Four percent of those with a Rotterdam CT score of 2 died and 33.33% with a score of 4 died.

Compared to the patients who survived, those who died had Eppendorf-Cologne Scale (ECS) scores which were 2.80 higher (95% CI 2.19-3.41, $p<0.001$).

The head AIS and the ISS had no association with mortality with $p=0.378$ and $p=0.096$ respectively as shown in Table 4. 14 below.

14: Mortality outcomes by trauma severity scores.

	Mortality Outcome		
Trauma severity score	**Alive (row% col %)**	**Dead (row% col%)**	**p-value**
Glasgow Coma Scale			<0.001

Table 4.

Mild (GCS 3-8)	81 (97.59, 66.39)	2 (2.41,14.29)	
Moderate (GCS 9-12)	35 (94.59,28.69)	2 (5.41,14.29)	
Severe (GCS 13-15)	6 (37.50, 4.92)	10 (62.50,71.43)	
Kampala Trauma Score (n=132)			<0.001
Mild (KTS 14-16)	30 (100,0)	0 (0.00,0.00)	
Moderate (11-13)	61 (95.31,51.69)	3 (4.69,21.43)	
Severe (5-10)	27 (71.05,22.88)	11 (28.95,78.57)	
Rotterdam CT Scan Score (n=106)			0.023
1	8 (100.00, 8.80)	0 (0,0)	
2	85 (95.51,85.86)	4 (4.49,57.14)	
3	4 (66.67, 4.04)	2 (33.33,28.57)	
4	2 (66.67,2.02)	1 (33.33,14.29)	
Head AIS score (n=104)			0.378
1	35 (97.22, 36.08)	1 (2.78, 14.29)	
2	8 (100,8.25)	0 (0.00, 0.00)	
3	42 (91.30, 43.30)	4 (8.70, 57.14)	
4	12 (85.71, 12.37)	2 (14.29, 28.57)	
Injury Severity Score (n=106)			0.096
Minor trauma (ISS <8)	33 (100, 33.33)	0 (0.00, 0.00)	
Major trauma (ISS 8 and above)	66 (90.41, 66.67)	7 (9.59, 100.00)	

row%= row percentage col% = column percentage

Source: Field Data.

4.5.2 Paediatric GOSE at Discharge

Using the paediatric GOSE at discharge, acquired disability at the time of discharge will be described for those who could be contacted. Association between GOSE at discharge and both socio-demographic and injury characteristics will be presented.

Paediatric GOSE assessment could be done for 99.18% (121/122) of the children with TBI who were alive at the time of discharge. Eighty-seven percent (106/122) of the paediatric GOSE assessment at discharge was done over a phone call. The mean paediatric GOSE score was 3.64 (SD 2.11) with 61.98% (75/121) of them having a moderate-to-severe disability classified as a poor recovery at the time of discharge. None of the children with TBI was discharged in a vegetative state, as shown in Table 4. 15 below.

The overall median length of stay in the hospital for children with TBI was 71.75 hours (IQR 28.43-158.50 hours).

Table 4. 15: Glasgow Outcome Scale Extended (GOSE) at discharge assessment.

Source of information for GOSE assessment (n=122)		**Frequency**	**Percentage**
Could not be contacted		1	0.82
From Charts		2	1.64
In-person		13	10.66
Phone call		106	86.89
GOSE at Discharge (n=121)	**Score**	**Frequency**	**Percentage**
Upper Good Recovery (Upper GR)	1	38	31.40
Lower Good Recovery (Lower GR)	2	8	6.61
Upper Moderate Disability (Upper MD)	3	10	8.26
Lower Moderate Disability (Lower MD)	4	4	3.31
Upper Severe Disability (Upper SD)	5	25	20.66
Lower Severe Disability (Lower SD)	6	36	29.75

Source: Field Data.

4.5.2.1 GOSE at discharge by Socio-demographic characteristics

Forty-eight percent (36/75) of the children who were discharged alive and had a poor recovery were within the 5-9-age group (p=0.006). The percentage of females who had a poor recovery was 68.29% compared to 58.75% of males, although not statistically significant (p=0.330). Eighty percent (20/25) of paediatric TBI patients who were triaged Orange had a poor recovery at discharge compared to 70.27% (26/37) of those triaged Red and 49.15% (29/59) of Yellow (p=0.014). Sixty-six percent (23/35) of children with TBI who stayed with a guardian had a poor recovery at the time of discharge compared to 53.52% (38/71) of their counterparts who lived with both parents (p=0.010). Eighty-three percent (20/24) of children with TBI who stayed with a primary caregiver who had no formal education had poor recovery at discharge compared to 71.43% (10/14) of those who stayed with a caregiver who had primary education. Fifty-five percent (38/69) of participants stayed with caregivers who had junior or senior secondary education. Another, 50.00% (7/14) of the children stayed with caregivers who had either vocational or tertiary education (p=0.053). The association between GOSE at discharge and socio-demographic characteristics is shown in Table 4. 16 below.

Table 4. 16: Association between GOSE at discharge and socio demographic characteristics.

	GOSE at Discharge		
Socio-demographic characteristics	**Good Recovery (row%, col%)**	**Poor Recovery (row%, col%)**	**p-value**
Age Group (n=121)			0.006
0-4	23 (57.50, 50.00)	17 (42.60, 22.67)	
5-9	12 (25.00, 26.09)	36 (75.00, 48.00)	
10-14	11 (33.33, 23.91	22 (66.67, 29.33)	
Sex (n=121)			0.330
Female	13 (31.71, 28.26)	28 (68.29, 37.33)	
Male	33 (41.25, 71.74)	47 (58.75, 62.67)	
Disability (n=121)			1.000
No	45 (38.14, 97.83)	73 (61.86, 97.33)	
Yes	1 (33.33, 2.17)	2 (66.67, 2.67)	

NHIS (n=121)			1.000
No	18 (38.30, 39.13)	29 (61.70, 38.67)	
Yes	28 (37.84, 60.87)	46 (62.16, 61.33)	
Triage category (n=121)			0.014
Yellow	30 (50.85, 65.22)	29 (49.15, 38.67)	
Orange	5 (20.00, 10.87)	20 (80.00, 26.67)	
Red	11 (29.73, 23.91)	26 (70.27, 34.67)	
Caregiver of the child (n=121)			0.010
Both parents	33 (46.48, 71.74)	38 (53.52, 50.67)	
Single parent	1 (6.67, 2.17)	14 (93.33, 18.67)	
Guardian	12 (34.29, 26.09)	23 (65.71, 30.67)	
Educational level of primary Caregiver (n=121)			0.053
No formal education	4 (16.67, 8.70)	20 (83.33, 26.67)	
Primary	4 (28.57, 8.70)	10 (71.43, 13.33)	
Junior/ Secondary	31 (44.93, 67.39)	38 (55.07, 50.67)	
Vocational/ Tertiary	7 (50.00, 15.22)	7 (50.00, 9.33)	
ISCO (n=113)			0.257
1-3	8 (44.44, 18.18)	10 (55.56, 14.49)	
4-6	22 (32.84, 50.00)	45 (67.16, 65.22)	
7-9	14 (50.00, 31.82)	14 (50.00, 20.29)	

row%= row percentage col% = column percentage
Source: Field Data.

4.5.2.2 GOSE at discharge by injury characteristics

Seventy-four percent (61/82) of children who had TBI from road traffic crash had poor recovery at discharge compared to 39.13% (9/23) of those who sustained TBI from falls (p<0.001).

Additionally, children who suffered from TBI on the road had 74.39% likelihood of a poor recovery at discharge compared to 75.00% for those who got injured at the parent’s workplace and 25.93% of those who sustained the TBI at home (p<0.001). Eighty-one percent (34/42) of those who were travelling and sustained TBI were discharged with poor recovery compared to 72.73% (8/11) of those children who were on errands and 66.67% (12/18) of those who were hawking (p=0.002). Eighty-four percent (16/19) of children who were travelling to or from school and sustained TBI had a poor recovery at discharge compared to 80.00% (12/15) of those who were travelling to another town (p=0.940). Eighty-eight percent (14/16) of riders or pillion riders who suffered from TBI had poor recovery at discharge compared to 84.62% (11/13) of passengers (p=0.241). All children who sustained TBI after being hit by a pick-up truck had a poor recovery at discharge compared to 77.78% (7/9) of those hit by a minibus ("trotro"). Of the children with TBI who had poor recovery at discharge according to the GOSE, 96.00% (24/25) of them did not use any safety device (p=1.000).

Sixty-seven percent (2/3) of children who sustained TBI after falling from a tree had a poor recovery at discharge compared to 50.00% (1/2) of those who fell from a bed and 20.00% (1/5) of those who fell from a flight of stairs (p=0.833). Of the 75 children with TBI who had poor recovery at discharge, 97.33% of them did not receive any prehospital care at the scene of the injury (p=0.026). Table 4. 17 shows the association between GOSE at discharge and injury characteristics of children with TBI.

Table 4. 17: Association between GOSE at discharge and injury characteristics of children with TBI.

GOSE at Discharge Injury Characteristics	Good Recovery (row%, col%)	Poor Recovery (row%, col%)	p-value
Mechanism of injury (n=121)			<0.001
Falls	14 (60.87, 30.43)	9 (39.13, 12.00)	
Road traffic crash	21 (25.61, 45.65)	61 (74.39, 81.33)	
Struck by a falling object	11 (73.33, 23.91)	4 (26.67, 5.33)	
Others (Assault, hit by cow)	0 (0.00, 0.00)	1 (100.00, 1.33)	
Place of injury (n=121)			<0.001
Home	20 (74.07, 43.38)	7 (25.93, 9.33)	
Roadside	21 (25.61, 45.65)	61 (74.39, 81.33)	
School	3 (60.00, 6.52)	2 (40.00, 2.67)	
Parent's workplace	1 (25.00, 2.17)	3 (75.00, 4.00)	
Others (church, playing	1 (25.00, 2.17)	2 (66.67, 2.67)	
Activity at the time of injury (n=121)			0.002
Playing	25 (56.82, 54.35)	19 (43.18, 25.33)	
Travelling	8 (19.05, 17.39)	34 (80.95, 45.33)	
Hawking	6 (33.33, 13.04)	12 (66.67, 16.00)	
On errands	3 (27.27, 6.52)	8 (72.73, 10.67)	
Others (being carried, during a	4 (66.67, 8.70)	2 (33.33, 2.67)	

Destination of Travelling (n=42)			0.940
To or from School	3 (15.79, 37.50)	16 (84.21, 47.06)	
To another town	3 (20.00, 37.50)	12 (80.00, 35.29)	
To church	1 (25.00, 12.50)	3 (75.00, 8.82)	
Parent's workplace	1 (33.33, 12.50)	2 (66.67, 5.88)	
Unknown	0 (0.00, 0.00)	1 (100.00, 2.94)	
Type of road user (n=82)			0.241
Passenger	2 (15.38, 9.52)	11 (84.62, 18.03)	
Pedestrian	17 (32.08, 80.95)	36 (67.92, 59.02)	
Rider/ Pillion rider	2 (12.50, 9.52)	14 (87.50, 22.95)	
Means of transportation (n=82)			0.588
Car	2 (15.38, 9.52)	11 (84.62, 18.03)	
2-wheeler	0 (0.00, 0.00)	2 (100.00, 3.28)	
Pedal cycle	0 (0.00, 0.00)	2 (100.00, 3.28)	
3-Wheeler	2 (16.67, 9.52)	10 (83.33, 16.39)	
Walking	17 (32.08, 80.95)	36 (67.92, 59.02)	
Traffic counterpart (n=82)			0.315
Car	14 (28.00, 66.67)	36 (72.00, 59.02)	
3-wheeler motorcycle	0 (0.00, 0.00)	4 (100.00, 6.56)	
2-wheeler motorcycle	4 (30.77, 19.05)	9 (69.23, 14.75)	
Pedal cycle	1 (100.00, 4.76)	0 (0.00, 0.00)	
GOSE at Discharge Injury Characteristics	**Good Recovery (row%, col%)**	**Poor Recovery (row%, col%)**	**p-value**
None	2 (14.29, 9.52)	12 (85.71, 19.67)	
Type of car involved in			0.661
Minibus ("trotro"/sprinter)	2 (22.22, 14.29)	7 (77.78, 19.44)	
Private sedan car	2 (25.00, 14.29)	6 (75.00, 19.44)	
Taxi	4 (28.57, 28.57)	10 (71.43, 27.78)	
4x4/ SUV	3 (50.00, 21.43)	3 (50.00, 8.33)	
Big bus (>20-seater)	1 (25.00, 7.14)	3 (75.00, 8.33)	
Cargo truck (tipper truck)	1 (100.00, 7.14)	0 (0.00, 0.00)	
Pick-up truck	0 (0.00, 0.00)	4 (100.00, 11.11)	
Unknown	1 (25.00, 7.14)	3 (75.00, 8.33)	
Type of safety device used (n=29)			1.000
Helmet	0 (0.00, 0.00)	1 (100.00, 4.00)	
None	4 (14.29, 100.00)	24 (85.71, 96.00)	
Objects fell from (n=23)			0.833
Stairs	4 (80.00, 28.57)	1 (20.00, 11.11)	
Storey building	4 (57.15, 28.57)	3 (42.86, 33.33)	
Tree	1 (33.33, 7.14)	2 (66.67, 22.22)	
Bed	1 (50.00, 7.14)	1 (50.00, 11.11)	

Ground level	4 (66.67, 28.57)	2 (33.33, 22.22)	
Provision of care at the scene (n=121)			0.026
No	39 (34.82, 84.78)	73 (65.18, 97.33)	
Yes	7 (77.78, 15.22)	2 (22.22, 2.67)	
Care provided at the accident scene (n=9)			0.417
Digital pressure to a bleeder	1 (100.00, 14.29)	0 (0.00, 0.00)	
Chest compression	0 (0.00, 0.00)	1 (100.00, 50.00)	
Water poured on child	6 (85.71, 85.71)	1 (14.29, 50.00)	
Care provider (n=9)			0.417
Parent	1 (50.00, 114.29)	1 (50.00, 50.00)	
Bystander	6 (85.71, 85.71	1 (14.29, 50.00)	

row%= row percentage col% = column percentage Source: Field Data.

4.6 Three months post-TBI outcomes of children with Traumatic Brain Injuries.

This section will describe the GOSE assessment at three months post-TBI and its association with both the socio-demographic and injury characteristics of children with TBI.

4.6.1 Paediatric GOSE at three months post-TBI.

Paediatric GOSE assessment could be done for 90.98% (111/122) of the children with TBI who were alive at the time of discharge. Ninety percent (110/122) of the paediatric GOSE assessment at three months post-TBI was done over a phone call. The mean paediatric GOSE at three months post-TBI score was 1.37 (SD 0.95). 91.89% of them had a good recovery at three months post-TBI. The average GOSE at three months post-TBI was 1.13 (95% CI, 1.06-1.19) for those with good recovery and 4.22 (95% CI, 3.22-5.22) for those with poor recovery. None of the children with TBI who was discharged died or was in vegetative state at three months post-TBI as shown in Table 4. 18 below.

There was a significant improvement in the GOSE assessment at discharge and at three months post-TBI. There was a mean decrease of 3.51 points on the GOSE assessment (SD 1.68) (95% CI, 3.20 to 3.83, p<0.001). There was a 57.82% improvement in the percentage of the children with TBI who had good recovery at discharge (34.07%) compared to at three months post-TBI (91.89%) (95% CI 48.34 to 67.29%, p<0.001)

Table 4. 18: GOSE at three months post-TBI.

Source of information for GOSE assessment (n=122)	**Freq**	**%**		
From Charts	1	0.82		
Could not be contacted	11	9.02		
Phone call	110	90.16		
GOSE at 3 months (n=111)				
Upper Good Recovery (Upper GR)	89	80.18		
Lower Good Recovery (Lower GR)	13	11.71		
Upper Moderate Disability (Upper MD)	4	3.60		
Lower Moderate Disability (Lower MD)	1	0.90		
Upper Severe Disability (Upper SD)	2	1.80		
Lower Severe Disability (Lower SD)	2	1.80		
			Mean GOSE (95% CI)	**Mean GCS (95% CI)**
GOSE at 3 months (n=111)				
Good recovery	102	91.89	1.13 (1.06-1.19)	13.10 (12.61-13.59)
Poor recovery	9	8.11	4.22 (3.22-5.22)	11.78 (9.51-14.04)

Source: Field Data.

4.6.2 Paediatric GOSE at three months post-TBI by socio-demographic and injury characteristics of children with TBI.

There was no significant association between socio-demographic characteristics and good recovery at three months post-TBI as shown in table 4.18. In terms of injury characteristics, the only significant association was with anti-seizure therapy. Ninety-four percent (95/101) of the children with TBI who did not receive anti-seizure therapy had a good recovery at three months post-TBI compared to 70.00% (7/10) of their counterparts who received it (p=0.034). Other associations between paediatric GOSE at three months post-TBI and socio-demographic as well as injury characteristics are shown in Table 4. 19 and Table 4. 20 respectively.

Table 4. 19: Association between GOSE at three months post-TBI and socio-demographic characteristics.

Socio-demographic characteristics	GOSE at three-month post-TBI Good Recovery (row%, col%)	 Poor Recovery (row%, col%)	p-value
Age Group (n=111)			0.616
0-4	34 (94.44, 33.33)	2 (5.56, 22.22)	
5-9	41 (93.18, 40.20)	3 (6.82, 33.33)	
10-14	27 (87.10, 26.47)	4 (12.90, 44.44)	
Sex (n=111)			0.717
Female	33 (94.29, 32.35)	2 (5.71, 22.22)	
Male	69 (90.79, 67.65)	7 (9.21, 77.78)	
Disability (n=111)			1.000
No	99 (91.67, 97.06)	9 (8.33, 100.00)	
Yes	3 (100.00, 2.94)	0 (0.00, 0.00)	
NHIS (n=111)			1.000
No	40 (93.02, 39.22)	3 (6.98, 33.33)	
Yes	62 (91.18, 60.78)	6 (8.82, 66.67)	
Triage category (n=111)			0.255
Yellow	51 (96.23, 50.00)	2 (3.77, 22.22)	
Orange	20 (86.96, 19.61)	3 (13.04, 33.33)	
Red	31 (88.57, 30.39)	4 (11.43, 44.44)	
Caregiver of the child (n=111)			0.482
Both parents	58 (89.23, 56.86)	7 (10.77, 77.78)	
Single parent	13 (92.86, 12.75)	1 (7.14, 11.11)	
Guardian	31 (96.88, 30.39)	1 (3.13, 11.11)	
Educational level of primary Caregiver (n=111)			0.300
No formal education	18 (81.82, 17.65)	4 (18.18, 44.44)	
Primary	12 (100.00, 11.76)	0 (0.00 0.00)	

Junior/ Secondary	59 (93.65, 57.84)	4 (6.35, 44.444)	
Vocational/ Tertiary	13 (92.86, 12.75)	1 (7.14, 11.11)	
ISCO (n=106)			0.156
1-3	17 (100.00, 17.35)	0 (0.00, 0.00)	
4-6	59(93.65, 60.20)	4 (6.35, 50.00)	
7-9	22 (84.62, 22.45)	4 (15.38, 50.00)	

row%= row percentage col% = column percentage Source: Field Data.

Table 4. 20: Association between GOSE at three months post-TBI and injury characteristics.

Injury characteristics	GOSE at three months post-TBI Good Recovery (row%, col%)	 Poor Recovery (row%, col%)	p-value
Mechanism of injury (n=111)			0.167
Falls	22 (100.00, 21.57)	0 (0.00, 0.00)	
Road traffic crash	64 (87.67, 62.75)	9 (12.33, 100.00)	
Struck by a falling object	15 (100.00, 14.71)	0 (0.00, 0.00)	
Others (Assault, hit by cow)	1 (100.00, 0.98)	0 (0.00, 100.0)	
Place of injury (n=111)			0.350
Home	26 (100.00, 25.49)	0 (0.00, 0.00)	
Roadside	64 (87.67, 62.75)	9 (12.33, 100.00)	
School	5 (100.00, 4.90)	0 (0.00, 0.00)	
Parent's workplace	4 (100.00, 3.92)	0 (0.00, 0.00)	
Others (church, playing ground)	3 (100.00, 2.94)	0 (0.00, 0.00)	
Activity at the time of injury (n=111)			0.093
Playing	43 (97.73, 42.16)	1 (2.27, 11.11)	
Travelling	35 (92.11, 34.31)	3 (7.89, 33.33)	
Hawking	11 (78.57, 10.78)	3 (21.43, 33.33)	
On errands	9 (81.82, 8.82)	2 (18.18, 22.22)	
Others (being carried, during a seizure activity)	4 (100.00, 3.92)	0 (0.00, 0.00)	
Destination of Travelling (n=38)			1.000
To or from School	15 (88.24, 42.86)	2 (11.76, 66.67)	
To another town	13 (92.86, 37.14)	1 (7.14, 33.33)	
To church	4 (100.00, 11.43)	0 (0.00, 0.00)	
Parent's workplace	3 (100.00, 8.57)	0 (0.00, 0.00)	
Type of road user (n=73)			0.252
Passenger	10 (90.91, 15.63)	1 (9.09, 11.11)	
Pedestrian	39 (82.98, 60.94)	8 (17.02, 88.89)	
Rider/ Pillion rider	15 (100.00, 23.44)	0 (0.00, 0.00)	
Means of transportation (n=73)			0.740

Car	10 (90.91, 15.63)	1 (9.09, 11.11)	
2-wheeler	2 (100.00, 3.13)	0 (0.00, 0.00)	
Pedal cycle	2 (100.00, 3.13)	0 (0.00, 0.00)	
3-Wheeler	11 (100.00, 17.19)	0 (0.00, 0.00)	
Walking	39 (82.98, 60.94)	8 (17.02, 88.89)	
Traffic counterpart (n=73)			0.424
Car	36 (81.82, 56.25)	8 (18.18, 88.89)	
3-wheeler motorcycle	10 (90.91, 15.63)	1 (9.09, 11.11)	
2-wheeler motorcycle	13 (100.00, 20.31)	0 (0.00, 0.00)	
Pedal cycle	1 (100.00, 1.56)	0 (0.00, 0.00)	
None	4 (100.00, 6.25)	0 (0.00, 0.00)	

	GOSE at 3 months post-TBI		
Injury characteristics	**Good Recovery (row%, col%)**	**Poor Recovery (row%, col%)**	**p-value**
Type of car involved in vehicle-pedestrian collision (n=44)			0.125
Minibus (“trotro”/sprinter)	8 (88.89, 22.22)	1 (11.11, 12.50)	
Private sedan car	5 (71.43, 13.89)	2 (75.00, 19.44)	
Taxi	13 (92.86, 36.11)	1 (71.43, 27.78)	
4x4/ SUV	5 (100.00, 13.89)	0 (50.00, 8.33)	
Big bus (>20 seaters)	1 (50.00, 2.78)	1 (75.00, 8.33)	
Cargo truck (tipper truck)	1 (100.00, 2.78)	0 (0.00, 0.00)	
Pick-up truck	1 33.33, 2.78)	2 (66.67, 25.00)	
Unknown	2 (66.67, 5.56)	1 (33.33, 12.50)	
Type of safety device used (n=26)			1.000
Helmet	1 (100.00, 4.00)	0 (0.00, 0.00)	
None	24 (96.00, 96.00)	1 (4.00, 100.00)	
Provision of care at the scene (n=111)			1.000
No	93 (91.18, 91,18)	9 (65.18, 97.33)	
Yes	9 (100.00, 8.82)	0 (0.00, 0.00)	
Glasgow Coma Scale			0.167
Mild	68 (94.44, 66.67)	4 (5.56, 44.44)	
Moderate	30 (88.24, 29.41)	4 (11.76, 44.44)	
Severe	4 (80.00, 3.92)	1 (20.00, 11.11)	
Rotterdam CT score (n=111)			0.061
Rotterdam CT score 1	4 (66.67, 12.12)	2 (33.33, 40.00)	
Rotterdam CT scores 2-3	28 (93.33, 84.85)	2 (6.67, 40.00)	
Rotterdam CT scores 4-6	1 (50.00, 3.03)	1 (50.00, 20.00)	
Anti-seizure prophylaxis/ therapy (n=111)			0.034
No	95 (94.06, 93.14)	6 (5.94, 66.67)	
Yes	7 (70.00, 6.86)	3 (30.00, 33.33)	

row%= row percentage col% = column percentage Source: Field Data.

4.7 Predictors of paediatric traumatic brain injury outcomes.

4.7.1 Predictors of outcomes for children with TBI

This will determine the socio-demographic and injury characteristics which predict both mortality and GOSE at three months post-injury for children with traumatic brain injury. Both bivariate and multiple logistic regressions were used to determine the predictors of the outcomes. Apart from age and sex, variables that had significant associations with outcomes of interest (mortality and good recovery at three months post-TBI) were used in the model.

4.7.2 Predictors of mortality for children with TBI

Table 4. 21 presents the bivariate and multivariate logistic analysis of predictors of mortality for children with TBI. Children within the age groups of 5-9 years (OR 2.18; 95% CI, 0.54 to 8.75) and 10-14years (OR 1.21; 95% CI, 0.23 to 6.41) were more likely to die compared to those aged 0-4 years old in the bivariate logistic regression, although not statistically

significant.

Despite not reaching statistical significance, females were twice as likely to die from paediatric TBI compared to their male counterparts (OR 2.54, 95% CI 0.83 to 7.80). RTCs were more likely to result in a paediatric TBI death compared to falls, albeit not statistically significant (OR 1.52, CI 0.32 to 7.37).

Children with severe TBI according to the GCS were significantly more likely to die compared to their counterparts with mild TBI (OR 67.50, 95% CI 11.97 to 380.70). Also, in the bivariate analysis, children with TBI who arrived at the KATH ED in ambulances had a significant chance of death compared to those who arrived in taxis (OR 8.29, 95% CI 1.04 to 65.62). Significantly, there was a higher chance of death for children with TBI who developed any complication whiles on the ward compared to those who had no complications (OR 23.40, 95% CI 5.90 to 92.82).

In the multivariate analysis, severe TBI (adjusted OR [AOR] 136.02, 95% CI 2.76 to 6,706.22), and the development of complication whiles on the ward (AOR 29.03, 95% CI 2.44 to 344.91) were independent positive predictors of mortality for children with TBI.

Table 4. 21: Bivariate and multiple logistic regressions of variables associated with mortality outcome in children with traumatic brain injury.

Demographic, injury, and hospital	**Bivariate**		**Multivariate**	
variables	**OR**	**95% CI**	**AOR**	**95% CI**
Age (years)				
0-4	Ref		Ref	
5-9	2.18	0.54 to 8.75	4.59	0.29 to 73.42
10-14	1.21	0.23 to 6.41	6.78	0.20 to 234.25
Sex				
Male	Ref		Ref	
Female	2.54	0.83 to 7.80	41.22	1.80 to 943.09*
Mechanism of injury				
Fall	Ref		Ref	
Road Traffic Crash	1.52	0.32 to 7.37	2.56	0.133 to 49.11
Other mechanism	0.72	0.06 to 8.62	14.10	0.23 to 847.18
Glasgow Coma Scale				
Mild	Ref		Ref	
Moderate	2.31	0.31 to 12.09	1.02	0.06 to 16.13
Severe	67.50	11.97 to 380.70*	136.02	2.76 to 6,706.22*
Mode of ED arrival				
Taxis	Ref		Ref	
Ambulance	8.29	1.04 to 65.62*	3.94	0.20 to 79.27
Triage category				
Orange	Ref		Ref	
Red	2.41	0.61 to 9.52	0.46	0.04 to 5.09
Developed complications whiles on the ward				
No	Ref		Ref	
Yes	23.40	5.90 to 92.82*	29.03	2.44 to 344.91*

* p-value <0.05; OR Odds Ratio; AOR Adjusted Odds Ratio.
Source: Field Data.

4.7.3 Predictors of good recovery at three months post-TBI for children with TBI

Table 4. 22 shows the bivariate and multivariate logistic analysis of predictors of good recovery at three months post-TBI for children with TBI.

In the bivariate analysis, even though not statistically significant, children with TBI within the 0-4-year age group had a 24% likelihood of having a good recovery at three months post-TBI compared to their counterparts within the 5-9-year age group (OR, 1.24; 95% CI, 0.20 to 7.88). Three months following TBI, males with paediatric TBI had a 40% less chance of good recovery compared to the females, notwithstanding not reaching statistical significance (OR, 0.60; 95% CI, 0.11 to 3.03).

Children with TBI who stayed with single parents had an increased likelihood of a good recovery at three months post-TBI by almost 4-fold compared to colleagues who stayed with both parents (OR, 3.74; 95% CI, 0.44 to 31.80). Three months after TBI, there was a 4-fold chance of a good recovery for children who had mild TBI compared to those who had severe TBI according to the GCS (OR, 4.25; 95% CI, 0.38 to 47.42).

Despite not reaching statistical significance, children with TBI who arrived at the ED in taxis had close to 6-fold likelihood of having a good recovery at three months post-TBI (OR, 5.79; 95% CI, 0.69 to 48.10). Children with TBI who received anti-seizure medications had a significant 85% reduced chance of good recovery after three months of TBI (OR, 0.15; 95% CI, 0.03 to 0.72).

In the multivariate analysis, only anti-seizure therapy was a significant independent negative predictor of good recovery at three months post-TBI (AOR, 0.02; 95% CI, 0.00 to 0.35).

Table 4. 22: Bivariate and multiple logistic analysis of variables associated with good recovery at 3 months post TBI for children with traumatic brain injury.

Demographic, injury, Bivariate Multivariate and hospital variables OR 95% CI AOR 95% CI

Age (years)

5-9	Ref		Ref	
0-4	1.24	0.20 to 7.88	3.07	0.25 to 37.56
10-14	0.49	0.10 to 2.38	0.26	0.04to 1.88
Sex				
Female	Ref		Ref	
Male	0.60	0.11 to 3.03	1.14	0.16 to 8.35
Caregiver staying with child				
Both parents	Ref		Ref	
Single parent	3.74	0.44 to 31.80	0.39	0.02 to7.50
Guardian	1.57	0.18 to 13.88	29.15	0.89 to 956.87
Glasgow Coma Scale				
Severe	Ref		Ref	
Moderate	1.88	0.17 to 21.233	0.55	0.02 to 12.49
Mild	4.25	0.38 to 47.42	0.40	0.01 to 13.96
Mode of ED arrival				
Ambulance	Ref		Ref	
Taxis	5.78	0.69 to 48.10	15.38	1.12 to 212.13*
Triage category				
Red	Ref		Ref	
Orange	0.41	0.11 to 1.63	2.19	0.20 to 24.34
Anti-seizure prophylaxis/ therapy				
No	Ref		Ref	
Yes	0.15	0.03 to 0.72*	0.02	0.00 to 0.35*
Developed complications whiles on the ward				
Yes	Ref		Ref	
No	4.13	0.38 to 44.35	11.21	0.45 to 280.65

* p-value <0.05; OR Odds Ratio; AOR Adjusted Odds Ratio. Source: Field Data.

CHAPTER FIVE: DISCUSSION

5.1 Introduction

There is a paucity of research describing paediatric traumatic brain injuries in Ghana. This study describes the characteristics of injuries causing paediatric traumatic brain injuries, the definitive management of paediatric TBIs, the hospital outcomes of paediatric TBI management as well as the three months post-injury outcomes of these children. Lastly, the predictors of mortality and that of the three months post-injury outcome will be described.

5.2 Socio-demographic characteristics of paediatric traumatic brain injury.

Male children were affected more commonly than their female counterparts in 1.7:1 ratio. The male preponderance is similar to what is found in most injury studies, including that of TBIs in Ghana, the sub-region and the world.[9–11] Some reasons for this difference are that boys tend to have a higher activity level than girls and these activities are usually risky. In addition, due to the difference in gender socialization, boys are permitted to explore without much parental control. That makes them roam and play alone without adequate adult supervision.[30]

The average age of the children who presented with traumatic brain injury in our study was 6.82years (SD 3.84 years), with majority of them in the 5-9-year age group. It was similar to what Abantanga et al.[9] described in their earlier study at this facility, where injury rates were highest in this particular age group. Again, the average age of 6.82 years was similar to the 7.4 years Udoh et al.[11] found among children with TBI in Nigerian. Also, our mean age was within the range of 3.2-10.4 years identified by Dewan et al.[10] in a study on the epidemiology of global paediatric TBI. Nevertheless, our age group contrasted with what Dewan et al.[10] found where the incidence of the injury was lowest in the 5-13 year age group compared to the under 2 and 15-18 year age groups. The reason for this difference is that our study excluded children who were 15 years and above.

Three children had a pre-existing disability prior to sustaining the traumatic brain injury. The premorbid status was taken into account when the paediatric GOSE was assessed as suggested by Beers et al.[24]

Most of the children with TBI were registered members of the NHIS. This corroborates with an earlier unpublished study at the same facility which identified 64% of the ED attendants to be NHIS members.[117] Most of the children stayed with both parents and as often is the case, the mother was the primary caregiver who stayed with the child in the hospital. Most of the primary caregivers who stayed with the children were employed. Many of them belonging to the International Standard Classification of Occupations categories 4-6 (clerical support workers, services, and sales workers and skilled agricultural, forestry and fishery workers). Fifty percent of those employed earned a monthly salary of GH250.00. With traders dominating this group, it meant that absence from their jobs resulted in reduced family income. It was also possible that caregivers going out to work as “traders” limited parental supervision of vulnerable children.

5.3 Injury characteristics of paediatric traumatic brain injury.

5.3.1 Mechanisms of paediatric traumatic brain injury.

Road traffic crash was the commonest mechanism of paediatric traumatic brain injury with many of the children being pedestrians. Abantanga et al.[9] indicated 20 years ago that the trend of pedestrian collisions was increasing in Ghana. In Ghana and many other developing countries, vulnerable road users such as pedestrians, cyclists, and motorcyclists are worse affected by road traffic crashes.[3,10] In most developed countries, occupants of vehicles are involved in road traffic crashes more than pedestrians.[10] The road traffic crashes usually occurred when children were going to or from school. The possible explanations for this include bad road user habits, poor speed management, poor road design and infrastructure, poorly maintained older vehicles contributing to inadequate vehicle safety standards, and the lack of compliance with traffic laws.[30]

Behavioural risk factors associated with road traffic crashes such as speeding, drink-driving and failing to use motorcycle helmets, seatbelts and child restraints are pervasive in Ghana.[3] Although there are national laws on speed limits, the law and its enforcement are not always applied..[3] Local authorities cannot modify the speed limits to suit the local needs. Also, a national drink-driving law exists, however, this legislation is inadequate according to WHO standards.[3] Whiles the World Health Organisation considers legislation of a Blood Alcohol Concentration (BAC) of less than 0.05g/dl for the general population to be a good law, Ghana’s law permits BAC of up to 0.08g/dl. In a recent study by Forson et al.,[118] 42% of drivers injured in a road traffic crash tested positive for alcohol. It appears that the enforcement of the drink-drive law is unable to deter such drivers who continue to drive and injure children on the roads.

An overwhelming majority of children who were supposed to use safety equipment failed to do so. Only one child riding a bicycle used a helmet. There is a good national motorcycle helmet law; however, its enforcement is poor with a pillion helmet-wearing rate of 16.9%.[3] According to the GSRRS, Ghana has a good seat-belt legislation that is poorly enforced, however, no child restraint law exists.[3] It is not surprising that none of the children involved in the road traffic crash as passengers used any restraints.

As part of activities to ensure safer vehicles, the Global Plan for the Decade of Action for Road Safety, 2011-2020, stipulates that all new motor vehicles have to be equipped with seat-belts and anchorages that meet regulatory requirements and pass applicable crash test standards as the minimum safety features.[119] Many commercial vehicles that use the roads in Ghana do not have such standards, and yet have been certified by the relevant authority to be roadworthy. Although the Driver and Vehicle Licensing Authority (DVLA) of Ghana requires a vehicle to be presented along with vehicle registration certificate for vehicle examination and verification respectively,[120] there is anecdotal evidence that commercial vehicles, especially the minibus ("trotro") and taxis, are not examined before they are issued a roadworthiness certificate.

A developing trend in Ghana is the increasing use of 3-wheeled motorised vehicles such as the rickshaw (called "Yellow Yellow") or the tricycle (called "Aboboya") as a means of commercial transportation. Often, these 3-wheelers do not obey traffic rules and endanger the lives of occupants as well as pedestrians.

The huge numbers of paediatric TBIs occurring on the streets of Ghana and many parts of the world buttress the fact that streets are not designed with the child in mind.[30] Attending school should not be a risky activity. As aptly captured by Janette Sadik-Khan,[121] "If you design a street that works for kids, you've designed a street that works for everyone." Our streets are unsafe for our children. It is in the light of this that there is a global initiative to design streets for kids which is a program to develop new technical guidance and advance street designs that create safe public spaces for children of all ages and abilities to learn, play, and move around a city.[121]

The second mechanism of paediatric TBIs was falls. Falls being the second leading cause of paediatric injuries presenting to KATH has not changed over the past two decades.[9] A Nigerian study also identified falls as the second mechanism of paediatric TBIs after RTCs.[11] This finding was however in contrast to what pertains in some other African countries such South Africa where falls were twice as many as RTCs in causing paediatric injuries.[29] Again, in Mozambique, falls were the commonest cause of paediatric injuries followed by burns and then RTCs.[40] In many HICs where there is better law enforcement,[3] road traffic crashes are less common than in LMICs, and as such falls are usually the leading cause of paediatric injuries including TBIs.[10,51] Almost fifty percent of the children who sustained a traumatic brain injury after falling from various heights were less than five years old and half of them fell from a storey building. The age group most affected by falls in our study was similar to what Herbert et al.[29] found in South Africa. It however contrasted with the 5-9-year age group Abantanga et al.[9] found earlier in Ghana and the 5-14-year age group found by De Sousa Petersburgo et al.[40] in Mozambique. Lallier et al.[52] identified that almost eighty percent of children fell from a height equivalent to at least two storeys. In our study, the falls usually occurred at home or in school whiles these children were playing which was similar to other studies.[9,29,40] The probable reason for this high number of falls as a cause of paediatric TBIs may be a result of poor parental and teacher supervision when children are playing.

Males significantly dominated all mechanisms of paediatric traumatic injuries; however, the severity of their injuries according to both the Injury Severity Score and the Kampala Trauma Scores were not statistically different from that of their female counterparts.

5.3.2 Prehospital care and referral characteristics.

Post-crash response is the fifth pillar in the actions stipulated by the Global Plan for the Decade of Action for road safety, 2011-2020.[46] Most children received no treatment for the injury at the scene after the incident. The few injured children who received bystander "support" had water poured on them. This type of traditional care is not only inappropriate but may be deleterious to the child. The water poured on the injured child may result in hypothermia and lead to a lethal triad of hypothermia, acidosis, and trauma-induced coagulopathy.[73] This form of "care" was usually administered by the parents or bystanders. The reason for the nonprofessionals resorting to providing this improper care is that, in the event of an injury, in as much as they want to assist, they do not have any training in first aid provision as such do what they think will help. Mostly, the "help" or "care" is inappropriate. The other reason is that they prefer to offer their "care" rather than activate the underdeveloped and inefficient EMS system in Ghana which is underutilised.[32,122] Two children received cardiopulmonary resuscitation (CPR) where a parent performed one and the other was performed by a paramedic. The child who received the CPR from the parent survived whiles the other child died. The reason the children died may be accounted for by the severity of their injuries. The GCS score for the child who survived was 12 compared to 8 for the child who died. The parent, in this case, had tertiary education and was probably trained in Basic Life Support (BLS).

Most children with TBI presenting to the KATH ED were referred from another health facility, with more than half of the referrals coming from outside the Kumasi metropolis. Apart from the Ashanti Region, children with TBIs were also referred from the Brong Ahafo, Central, Western and Eastern regions of Ghana. These four regions are relatively close to KATH, lack neurosurgical services, and therefore refer all TBI patients to KATH. This finding was comparable to what Osei Kwame et al.[8] found except that there were referrals from four additional regions. Within the period of the current study, there was no referral from the regions in the Northern part of Ghana as was the case in the earlier study.[8] The only neurosurgeon might have been absent during the period of the Osei Kwame study accounting for referrals from the northern regions of the country.

An ambulance was the mode of arrival for many of the children with TBI presenting to the KATH ED. ED attendance by ambulance has increased over the years from 14.8% in 2011[16] to 41.5% in 2016[8] and is currently 60.3%. The probable reason for the increase in ED ambulance attendance is that most hospitals are acquiring their own ambulances and there is an emerging private ambulance service to complement the ambulances operated by the NAS. With the government of Ghana procuring 307 state-of-the-art ambulances for the NAS,[123] the patronage of ambulances may yet improve further. Half of the children with TBI arrived within five hours of the injury. However, it was noted that many ambulances performed inter-facility transfers. Of the cohort who were not referred, none arrived at the ED in an ambulance but instead in taxis mainly and private cars. It was evident that the likelihood of transporting a child with TBI in an ambulance increased as the severity of the injury increased. It buttresses the point that it is not the public who are activating the EMS.

5.3.3 Emergency Department initial vital signs

There was a significant association between the acuity of the injury as assigned by the SATS score and the severity of the traumatic brain injury, according to the Glasgow Coma Scale. Majority of the children with severe TBI were triaged emergent (Red) while those with mild TBI were triaged urgent (Yellow)

5.3.4 Emergency Department management

Children with TBI were quickly assessed, and their ABCDEs managed according to the ATLS principles of trauma management.[73] Three percent of the patients studied required definitive airway management in the form of intubation; this compares to the 6% intubation rate found in an earlier study at the same facility about three years prior to this current study.[8] Only a quarter of the children with severe TBI according to the Glasgow Coma scale in this current study were intubated. This contrasted the 100% intubation rate for Nigerian children with severe TBI.[11] It was also at variance with the airway management recommended for children with severe TBI.[93] Early intubation, when required with adequate oxygenation and ventilation, can aid in preventing further brain injury.[73] The likely reason for this variance was that it was very cumbersome to do the neuroimaging after the patient had been intubated. Patients frequently had to be transported outside the hospital for the head CT scan in those instances where both hospital CT scanners were non-functional. There was a significant association between intubation and whether the head CT scan was done when indicated. Only one child with TBI who was intubated had the investigation done and even for him, the neuroimaging preceded the intubation. It clearly showed that once intubated, the head CT scan, which is required to determine the definitive management of TBI, was not done. Additionally, with none of the intubated patients being admitted to PICU and all dying at the ED, it appeared there was no drive to intubate other children with severe TBI.

About ten percent of the children with TBI were administered antiseizure medications, and a significant number of them had moderate to severe TBI according to the GCS. However, considering the numerous risk factors (depressed skull fracture, SDH, EDH, severe TBI) associated with the occurrence of post-traumatic seizures, many more of the children with TBI should have received antiseizure medication.[93] The reason for this disparity is that there is no institutional protocol for the management of children with TBI and as such the initial ED management is at the call of the individual emergency physician who first attends the child. A little over one-tenth of children with TBI were given hyperosmolar fluids and mannitol was preferred over 3% hypertonic saline. The hypertonic saline was not readily available but had to be purchased by caregivers from community pharmacies before it could be administered. When available at the hospital, the concentration is usually 20% which must be reconstituted to the 3%. The above reasons made the mannitol the preferred hyperosmolar fluid in our setting. There was however no significant mortality outcome difference between the two hyperosmolar fluids in our facility. Although the recommendation preferred 3% hypertonic saline (Level II recommendation, given as 2 5mL/Kg over 10 20 minutes), it also indicated that there was no difference in mortality outcomes between mannitol and 3% hypertonic saline for intracranial hypertension.[93]

Almost half of the children with TBI received antibiotics. They were mainly indicated for the accompanying soft tissue injuries such as skin lacerations, abrasions, and bruises these children had. It was significantly different from the almost 40% antibiotic usage identified in a previous study.[8] The administration of antibiotics to children with TBI was significantly associated with better outcomes.

Sixty percent of children with TBI were administered analgesics. This number was twice as many as was found in the Osei Kwame et al. study.[8] A probable reason for the increased in analgesia usage may be that there has been an improvement in pain management by emergency physicians over the period.

Over two-thirds of the children with TBI received intravenous crystalloids with a significant number of them having moderate to severe TBI. Adequate fluid resuscitation is recommended to prevent hypoperfusion which is a well-known risk factor for secondary brain injury.[71,72] Again, more of the children in our study received IV fluids compared to what was identified in an earlier study.[8] What may have accounted for the difference was that to improve data quality, the PI reviewed all available patient charts. By so doing the PI identified instances where medications including IV fluids were administered but was not obvious to the RAs.

5.3.5 Neuroimaging and Rotterdam CT score.

Head CT scan was indicated in over ninety percent of the children with TBI. For the remaining patients, the emergency physicians decided that the investigation was not warranted based on available clinical decision rules.[99] The neuroimaging rate was close to ninety percent. However, half had the investigation done within 18 hours of ED presentation. Less than 5% of them were able to undergo this critical investigation within the recommended 1 hour of requesting for the investigation.[124] The likely reasons for the delay in obtaining the head CT scan are numerous. Caregivers did not readily have the requisite amount of money for the investigation, which is done on a cash-and-carry basis. With sixty percent of the children being members of the NHIS, caregivers expected that CT brain would be covered by NHIS and so did not come to hospital prepared to make co-payment for this investigation. Another reason was that the private CT scanners outside the hospital did not work during the night and any patient who needed the investigation during that time of the day had to wait till the morning to access the facility. Unaffordability of the investigation was the primary reason given for not obtaining the head CT scan when it was indicated. Another significant reason was that death preceded the investigation. Children with TBI who died before neuroimaging had a median LOS of less than 18 hours for ED, just about the average time it took for those patients who received it to complete this investigation.

The head CT scan was requested and done in several children with mild TBI according to the GCS, which was worrying because of the radiation exposure. Of much concern was that, of the sixty children with mild TBI who did the investigation, two-thirds of them had a GCS score of 15. Surprisingly, almost sixty percent of the children with mild TBI and more than half of those with a GCS score of 15 had abnormal findings on the head CT scan. Even more intriguing was the fact that the only two children with TBI who had an abnormal head CT scan finding and received neurosurgical interventions had a GCS score of 15. Clinicians at the Komfo Anokye Teaching Hospital Emergency Department (KATH ED) seemed to be more efficient at determining which patients with mild TBI needed CTs compared to their counterparts in High-Income Countries (HICs). This could reflect a selection bias because most of the subjects were referred and perhaps their GCS on arrival at KATH ED had improved from their initial GCS. On the other hand, it could reflect a more clinically astute appraisal by KATH physicians relative to HIC doctors. The head CT scan rate for mild TBI in this current study was not different from what had been documented in an earlier study at this facility.[8] Alert children having such a high percentage of abnormal head CT findings was in sharp contrast with what Udoh et al.[11] found in Nigeria, and Dewan et al.[10] reported globally.

Among paediatric TBI patients with positive imaging findings, skull fracture (47%) and cerebral contusions (22%) were the most frequent structural pathologies. Our findings conform to the global trend.[10] The third and fourth common CT findings were extra axial haemorrhages and DAIs respectively. Majority of the skull fractures were Calvarial fractures with over one third being depressed.

Although the original study which validated the Rotterdam CT score in children included those with moderate and severe TBI,[18] the current study included patients with mild TBI because 60% of these patients with CT scans had abnormal findings. Most of the children with TBI scored 2 on the Rotterdam score and majority of them with this score had a mild TBI. As the score represents no positive findings, some head CT scans scored as 2 were normal comparable to what Bratton et al.[18] identified. Our mortality rate for those with a Rotterdam scores of 2 and 4 were 4 and 33% respectively. When compared to the Rotterdam CT scores for adults (a score of 2 =7% mortality rate; 4=26%),[86] the children had lower mortalities at lower scores and higher mortalities at higher scores similar to what was identified earlier.[18] None of the children with TBI had a Rotterdam CT scores 5 or 6 in our study.

5.3.6 Associated injuries

The commonest body region with associated injury for children with TBI was the skin (soft tissue) (77%), followed by the extremities (17%), face (10%), chest (7%) and abdomen (less than 1%). Many of the skin injuries were abrasion, bruises, lacerations, and contusions. Adetayo et al. also identified a similar pattern of non-neurologic concomitant injuries.[65] This was different from what was found earlier at this facility.[8] The main reason was that no skin injury was considered in the earlier study.

None of the children in whom a suspected cervical spine injury (CSI) was investigated with a CT scan or X-ray demonstrated any abnormality. Children with their unique cervical spine anatomy are less prone to cervical spine injury (CSI). Since X-rays have a 100% sensitivity in diagnosing CSI,[125] we did not think that CSIs were missed in those who were investigated with this modality. Almost three percent of children who had skull fractures had a concomitant CSI in a previous study.[65] The probable reason for the difference is that majority of the children in our study presented with mild TBI and there were no concerns for a CSI. Fewer children were therefore investigated for a concomitant CSI.

Only one-fifth of the children had an isolated TBI which was in agreement with a study done in the US.[65] It however contrasted what was found in an earlier study done at KATH.[8] The difference in the earlier study resulted from the fact that it did not include soft tissue injuries.

5.3.7 Trauma severity Score

Different trauma severity scores were determined for children with TBI. These included the AIS, ISS, KTS, and ECS scores. Several studies have defined TBI with a head AIS score of 3 or more.[78,82,126] Using the head AIS score of 3 to define TBI would have resulted in excluding several of the children with TBI in our study. Reasons were that a couple of children with TBI could not do the head CT scan, which was required to score the head AIS. In addition, more than 40% of those with moderate TBI according to the GCS had a head AIS score of less than 3. Most of the referenced studies used secondary data with available head CT scan findings which made it relatively easy to identify the study population of interest. The head AIS score moderately correlated with the GCS score in this study but was not an efficient predictor of mortality compared to GCS score and KTS in our study.

The ISS categorised with a threshold of 8 in our study had a better association with the GCS than with a threshold of 15.[80,81] Again, the ISS, which incorporates the AIS scores of three different body regions,[17] did not include more than one fifth of the participants in our study in computation because the head CT scan was not done. The ISS also had a weak relationship with the GCS score in our study.

The KTS and ECS scores did not require a head CT scan to assign the scores. The KTS could not be determined in less than three percent of the study participants due to missing systolic blood pressure recordings. At this rate, the KTS was more useful than both the head AIS score and the ISS in injury severity scoring. Children aged 5-9 years suffered more KTS-defined severe TBI than other age groups. The KTS also correlated well with the GCS scores and predicted mortality relatively well too.

Eppendorf Cologne Scale score could not be calculated for 13% of the children with TBI due to the inability to assess pupil size and reactivity because of severe periorbital swelling in those participants. It however did better compare to the head AIS score and ISS in assigning injury severity to the participants. It also correlated much better with the GCS score compared to the head AIS score and the ISS. It also predicted mortality well.

5.3.8 Emergency Department Disposition

Many of the children with TBI presenting to the KATH ED were admitted. Most of them were admitted to the paediatric ward of the Clinical Decision Unit of the Emergency Department. Apart from the fact that in most instances there were no bed spaces for the children to be admitted to the neurosurgical ward, the CDU looked more child friendly than the neurosurgical ward so preferably the surgeons admitted here. Only two children with TBI were taken to the operating theatre for surgical management; they were sent to the theatre for the management of associated orthopaedic injury and not for the TBI.

While children who were intubated in the ED were usually reviewed by the PICU team, none of these patients were admitted to the PICU during the study period. A lack of bed space in the PICU and patient evaluation that indicated a poor prognosis were the reasons why these intubated patients were not transferred to the PICU. Due to limited resources, patients who were assessed to have a poor outcome by the paediatric intensivist usually did not get admitted to the PICU. No non-intubated patient was admitted initially to PICU either. One patient who was admitted later to PICU was initially admitted to CDU and when conditions deteriorated there, the child was then admitted to PICU through Red without intubation. Generally, very few critically ill ED patients in Ghana get intensive care unit admissions.[8] Although intubation was indicated for children with severe TBI,[93] 75% of them were not intubated. Some reasons given for not intubating these children included lack of bed space at PICU and poor prognosis. All intubated children with TBI died at the ED and one of the reasons is that they were more severely injured compared to their non-intubated counterparts. The average Kampala Trauma Score was significantly lower for those intubated compared to the non-intubated patients. Another reason could be that there was suboptimal intubation and ventilation which has been found to be associated with worse outcomes.[127]

Close to a quarter of the children with TBI were discharged home from the ED with a significant number of them being those with mild TBI. As expected, no child with severe TBI according to the GCS was discharged home. The median ED LOS for children with TBI was 21 hours with those with mild TBI according to the GCS spending significantly less time than those with moderate to severe TBI.

At the end of ED stay, the mortality rate for children with TBI was 7% with two-thirds dying within 48 hours of admission. The 48 hour mortality rate was significantly lower than what was found earlier at this facility.[8] The reason for this could be that since the early study had a mixed population of adults and children, the relatively higher percentage of adults may have influenced the mortality. Several studies have documented that adults have worse mortality outcomes compared to children.[18,82]

5.4 Definitive management of paediatric traumatic brain injury.

5.4.1 Management plan

The overwhelming majority (94%) of the children with TBI presenting to KATH were managed conservatively which is similar to the global picture.[10] Our facility neurosurgical operation rate of 1% was significantly lower than the 21% in Nigeria,[11] and 15% in Australia.[128] The likely reason for this difference is that the Nigerian study had more patients with severe TBI (40%) compare to that of this current study (12%).

Most children with skull fractures were managed conservatively. This approach appears consistent with two studies done in a Level 1 trauma centre in the US.[65,101] Evidence from the literature supports the conservative management of non-depressed skull fractures.[65,101] In the current study, 90% of patients with depressed skull fractures were managed conservatively. This contrasts with near 100% operative approach for American children with displaced skull fractures.[101] One study suggests conservative treatment for a depressed skull fracture without associated intracranial hematoma and bone depressed less than 1 centimetre.[129] Two children in the present study had neurosurgery for depressed skull fractures. Both children had intracranial haemorrhage. Other children with similar pathology on neuroimaging were not offered operative treatment. This makes it difficult to assess what the indications were at KATH for the operative management of depressed skull fractures. Despite the low operative rate, the 3 months post-TBI outcomes compares favourably with studies in High-Income Countries (HICs).[130] Perhaps if a more conservative approach if adapted by HICs, it will lead to a substantial save on resources and surgical morbidity.

In terms of extra-axial bleeds, one child with SDH and associated depressed skull fracture had craniotomy and skull elevation done. Again, others with similar injuries were managed non-operatively. Rapid evacuation is what has been prescribed but for a conservative approach, there should either be severe brain swelling and infarction or small SDH with minimal symptoms or acute bilateral SDH.[108] It was not the case that all the children in our study population with SDH met the conservative management approach criteria. None of the children with epidural bleeds, irrespective of whether it was causing mass effect or not, had neurosurgical intervention. With epidural haemorrhage, the conservative approach was acceptable, but the caveat is that, there should be an all-time emergency access to head CT and an operational theatre so that any neurologic change could be identified and managed expeditiously.[103–106] As alluded to earlier, the CT scanner at the hospital was non-functional during most part of the study and less than five percent of the children with TBI were able to obtain this critical investigation within an hour. These limitations beg the question whether conservative approach was the best definitive management plan for children with epidural bleed in our setting. The average time from obtaining the head CT scan to operative management of over 70 hours (3 days) for the two children was long. At least for the one with the SDH, immediate evacuation is the recommendation.[108]

For all patients who could not obtain the head CT scan, the definitive plan could not be determined. Blind (without neuroimaging) neurosurgical procedure was not an option at this facility because the head CT scan was needed to stratify the injuries and provide targeted therapy.[131]

5.4.2 Complications developed whiles on the wards.

Over ninety percent of the children with TBI who were admitted had no complications on admission to the wards. For those who had complications, the major one was death (50%), followed by pneumonia, about one-fifth. One patient from the neurosurgical ward was admitted to the adult ICU (on account of her age of 14 years) when she deteriorated whiles on the ward. As mentioned earlier, another child who was at the CDU and deteriorated was later admitted to PICU through Red.

5.5 Final hospital outcomes of Children with TBI

5.5.1 Mortality outcomes

The overall mortality rate for children with TBI in our study was 10.29%, which was similar to the 48-hour mortality rate (10.31%) identified earlier at this facility.[8] It was, however, lower than what pertains to South Africa, 14.6%, but the studied population was only children with severe TBI.[132] Our mortality rate was slightly higher than the 8.66% reported by Udoh et al.[11] in Nigeria and significantly higher than the 1-7% reported globally.[10] More than 40% of the children with TBI who died in our study did not have a head CT scan to inform definitive management which may have changed their management and mortality outcomes. All the patients in the Nigerian study had head CT scans done.

5.5.1.1 Mortality outcome by Socio-demographic characteristics

Although most of the children with TBI were males, close to sixty percent of the children who died were females; however, it was not statistically significant. There was no statistical difference in terms of injury severity in the sexes to account for the higher female mortality percentage. The higher death rate in females with TBI in our study was contrary to many local and international studies.[8–11] For now, since there is no obvious explanation and the difference was not statistically significant, we will attribute the observed difference to chance.

More than half of the children with TBI who died were between the 5-9-year age group, albeit not statistically significant. The reason may be attributable to the relatively more severe injury according to the KTS in this age group compared to the others.

Although we thought that children with TBI who were subscribers of the NHIS would have a better mortality outcome than those who were not, that was not the case. A relatively higher number of those who died were without members of the NHIS; however, the difference was not statistically significant. What accounted for this was that the rate-limiting step in TBI management, which is the head CT scan, is done on a cash-and-carry basis.

Half of the children with TBI who died without doing the head CT scan were members of the NHIS, and the same proportion was in the group without NHIS. Without crossing the neuroimaging barrier, the free emergency neurosurgical intervention for members of the NHIS could not be enjoyed since, as alluded to earlier, the procedure is not performed blindly.

Children with TBI who lived with both parents did not have a better mortality outcome compared with those who stayed with either single parent or a guardian. Although the proportion of those who stayed with a guardian were severely injured compared to their counterparts who stayed with both parents, the proportion of the former group who died compared to the latter was not significantly different. There is limited research into how caregivers' characteristics influenced paediatric TBIs and its outcomes.

Significantly, most of the children with TBI who died were triaged Red (emergent) with none of those who triaged Yellow (urgent) dying. All the different trauma severity scores significantly demonstrated that patients who triaged Red were severely injured compared to the Yellow patients. However, the trauma severity scores did not show any difference in injury severity for the patients who were triaged Orange (very urgent) from those triaged Red. Even though SATS was good indicator of TBI severity, there was no difference in overall injury severity for patients triaged to Orange and Red. Same treatment resources were required for both patients.

5.5.1.2 Mortality outcomes by injury characteristics of children with TBI

Patients presenting with traumatic brain injuries from road traffic crashes had a higher mortality compared to those presenting with injuries from other causes. It is estimated that more than half of road traffic deaths globally occur in vulnerable road users such as pedestrians, cyclists and motorcyclists.[3] Among this group, the majority of deaths happens in Africa.

In the present study 82% of road traffic crashes resulting in death resulted mainly from pedestrian collisions with commercial minibuses locally called “trotro”. Other vehicles included private sedan cars, pick-up trucks, taxis, big buses (> 20-seater), and cargo trucks. Taken together this list of vehicles caused more than 90% of pedestrian deaths from road traffic crashes. It is of some interest that this list of vehicles contributing to paediatric TBI and deaths, is similar to that identified a decade ago, and has not changed in that time.[133]

Morbidity and mortality rates found in this study are considerably higher even among similar LIMCs. Determinants for a worse outcome for vulnerable road users includes the lack of protection during the crash and the consequent severity of the injury sustained. These factors remain prevalent because several important safety recommendations have not been implemented, including those resulting from the seminal studies by Damsere-Derry et al.[133]

Understandably, most of the children with severe TBI were statistically more likely to die. The mortality rate rose to 100% for all children with GCS less than 7. Increasing mortality was also associated with worsening severity of TBI. The KTS was also a good predictor of severity and outcomes for the patients in our study sample.

Most of the children in this study who died were pedestrians. The study identified two main groups of pedestrians. The first high-risk group comprised roadside hawkers, as identified by Damsere-Derry et al.[133] The second group were children going to or from school. This study underlines how vulnerable paediatric road users are among the population served by KATH.

By contrast, the Korean government developed a national strategy in response to the recognition that paediatric pedestrian fatalities were increasing.[3] A national road safety policy was vigorously implemented over a 12-year period. The result was a 95% reduction in traffic deaths among the under the 14-year age group. Active governmental commitment to road safety can reduce paediatric pedestrian mortality; the absence of such commitment unfortunately means that childhood deaths on our roads will not stop.

5.5.2 Paediatric GOSE at Discharge

Paediatric GOSE assessment was done for all the children with TBI who were alive at discharge except for one child who could not be contacted, nor could her chart be located. The assessment was mainly done over a phone call to minimise inconveniences to the children and their caregivers. Also, this approach of follow-up was adopted to cut down on the potential cost of paying for their transportation.

The mean paediatric GOSE was 4 with most (60%) of the children being discharged with moderate-to-severe disability classified as poor recovery. The findings contrasted with a study done in the US where less than 25% of the children were discharged with unfavourable outcomes.[130] It was not surprising because our patients had a long ED stay with delays in access to CT scanning and neurosurgical care as well as no access to PICU.

Again, most of the children who were discharged with poor recovery were between the 5-9-year age group with females in the majority (not significant statistically). There is a paucity of paediatric TBI data comparing status at discharge with demographic characteristics. In a study by Slovis et al.,[130] which involved children aged from 0-17 years, they identified that unfavourable outcomes were associated with younger age, with most of them being males. There was no reason why females in our study again had a poor recovery at discharge compared to males. A larger sample size is required to confirm these findings.

There was a significant difference between those triaged Orange to those triaged Red in terms of poor recovery. A higher percentage of the former were discharged with a moderate-to-severe disability compared to the later. As noted earlier, children who were triaged Orange had similar injury severity to those triaged Red. Wrong triaging and not up-triaging when patients condition deteriorated at Orange may account for this finding.

The injury characteristics which were significantly associated with poor recovery at discharge included road traffic crashes and lack of prehospital care at the scene of injury. As alluded to, children who were involved in RTCs had severer injuries compared to their counterparts with other mechanisms of TBI which may have contributed to their worse outcome.[3]

5.6 Three months post-TBI outcomes of children with Traumatic Brain Injuries.

Majority (91%) of the children with TBI were assessed three months after the TBI which was comparable to an earlier study where 93% assessment was completed at three months follow-up.[24] Most (90%) of the assessment of the paediatric GOSE at three months post-TBI was done over a phone call. The highly successful three months follow-up rate was possible because of a high cell phone penetration in Ghana.[134] Additionally, the method used whereby two phone numbers were collected from caregivers and immediately called to ensure it was correct enhanced the phone follow-up. A significant number (92%) of the children who were discharged had a good recovery after three months of the traumatic brain injury. Slovis et at.[130] identified that over 80% of the children in their study had a favourable outcome after six months of paediatric TBI. A higher percentage of our participants had a good recovery at three months post-TBI compared to the study by Slovis et at. Unlike their study which included only complicated mild or moderate and severe TBI, the current study included all mild, moderate, and severe TBI children. Two-thirds of the children with good recovery at three months post-TBI had mild TBI according to the GCS. No child died or was in a vegetative state within three months after the traumatic brain injury.

5.7 Predictors of outcomes of paediatric traumatic brain injury.

5.7.1 Predictors of mortality for paediatric traumatic brain injury.

In the bivariate logistic analysis, severe TBI, ED attendance in an ambulance, and the development of complication whiles on admission on the wards were associated with an increased chance of paediatric TBI death.

However, in the multiple logistic regression, severe TBI and the presence of complications remained significant positive predictors of mortality among children with TBI.

5.7.2 Predictors of good recovery at three months post-TBI

The only variable which was significantly associated with a good recovery at three months post-TBI in the bivariate logistic regression was anti-seizure therapy. It was also significant in the multivariate logistic analysis as well.

5.8 Limitations

Since contemporaneous data was not collected during the night, we could have missed children with TBI who presented during that period. However, the RAs crosschecked from the triage records to update their data every morning and by so doing, participants were not missed.

Fourteen percent of the patients were unable to have the head CT scan, and that may have influenced the number of children who would have had operative management.

The study was limited by time and money to follow the children with TBI for six months and 12 months. However, the three months follow-up using the paediatric GOSE has been found to correlate very well with the six months follow-up.[24]

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1. Introduction

This section summaries the major findings according to the objectives of the study, and recommendations from this study will be targeted at the hospital, other agencies such as the Road Safety Commission, DVLA, Ministry of Health. Recommendations for future research will be made here.

6.2. Conclusions

Paediatric traumatic brain injury at KATH is common affecting 1 in 3 children (36.86%) presenting with paediatric injuries. It occurred predominantly in males aged 5 - 9 years and RTCs were a leading mechanism of injury followed by falls. Definitive management was conservative with a high mortality of 10.29% which was associated with severe TBI and delays at KATH arrival. However, there was good recovery at 3 months post TBI. The findings of this study have implications on management of paediatric TBI and interventions to curb paediatric TBI must focus especially on road traffic injury prevention. Successful long-term follow-up of paediatric trauma, and specifically paediatric TBI, is feasible in LMICs such as Ghana. The paediatric TBI care in Ghana could inform such care in High-Income Countries.

6.3. Recommendations

From the study, the following recommendations are made to key stakeholders.

6.3.1.1. The public, including caregivers of children.

At home and in schools, caregivers should adequately supervise children when they play and should ensure that the play area for children is devoid of things that can trip these children such as rocks and tree stumps.[135] To prevent children from falling from stairs, caregivers should also use safety gates at the top and bottom of stairs when young children are around.[135]

Caregivers should use appropriate safety devices such as child safety seats and booster seats that are correct for the age and weight of the child.[135]

With the procurement and commissioning of over 300 ambulances by the government, first responders to an accident should activate the emergency medical systems by dialling 1-1-2 on all networks. This practice will minimise the time spent before getting to a definitive care facility.

6.3.1.2.Komfo Anokye Teaching Hospital (KATH).

KATH should ensure that its CT scanners, especially the one located at the ED, are functional 24 hours a day throughout the year. This service should be provided for all patients who presents with an emergency and payment made later.

KATH should ensure that the emergency pharmacy stocks all emergency medications in their right concentrations.

The hospital, in conjunction with other nearby hospitals, should liaise with the Ghana Private Road Transport Union (GPRTU) to train drivers on the initial care of an injured patient including children.

6.3.1.3.National Health and Insurance Authority.

The health insurance authority should revise the emergency services provided by the National Health Insurance Scheme. As a matter of urgency, emergency investigations, including emergency CT scans, should be covered under the NHIS. This will facilitate rapid diagnosis and enhance prompt interventions.

6.3.1.4.Ministry of Transport.

The ministry should insist that vehicles imported into the country meet the priority UN vehicle safety standards.[136]

6.3.1.4.1. Driver and Vehicle Licensing Authority.

The authority should ensure that every vehicle which is given a roadworthiness certificate, is physically examined. The vehicles should meet all standards including the presence of appropriate and functional safety devices such as seatbelts and anchorages for child restraints.

6.3.1.5. Ministry of Roads and Highways.

The ministry must ensure that safety is considered during the planning, designing, and operation of all roads in Ghana.

Specifically, the incorporation of specific infrastructure features which will safeguard the safety of pedestrians, particularly children, need to be a priority. Children should be engaged in the road design process to build roads suitable for them to minimise TBI resulting from RTCs.[121]

6.3.1.6. Law enforcement agency.

6.3.1.6.1. Motor Traffic and Transport Department (MTTD) of the Ghana Police Service (GPS).

The MTTD of the GPS should enforce the usage of safety devices whiles children use the road. By so doing much more people will comply with the laws and minimise the impact of traumatic brain injury if it occurs. Also, Ghana's average rating on enforcement will improve.[3]

6.3.1.7. Government of Ghana

The government of Ghana should work at achieving the Global Voluntary Performance Targets for Road Safety Risk Factors and Service Delivery Mechanisms, 2017.[3]

The government should also adopt a national strategy aimed at improving road safety through investments in school zone programmes, regulation of school buses, imposing fines for violations within school zones, clamping down on unregulated school transport, supporting civil society organisations in road safety advocacy and continuously amending and improving road safety legislation as was done in Korea.[3]

As a matter of urgency, the government through parliament should enact a national child restraint (child car seats or boosters) law which is currently missing in our legislation.[3]

6.3.1.8. Future Research

1. A multicentred paediatric TBI study should be conducted to enhance generalisability.
2. A process research to reduce time to definitive treatment, access to CT scan, access to ICU and their possible effects on morbidity and mortality should be studied.
3. With most of the children being discharged home without rehabilitation, such as physiotherapy, a study which compares the outcome of children with TBI who receives physiotherapy and those who do not will help in the management of such patients.
4. The current study followed children for 3 months. A future research in Ghana should follow children up for 6 and 12 months.
5. Our study considered a few characteristics of the caregiver of the child. The influence of caregiver characteristics on paediatric TBI should be the focus another research.
6. Socio-economic and cultural determinants of paediatric TBI should also be studied in Ghana.
7. A high-powered study should be conducted to confirm or reject the high female mortality compared to males with TBI.
8. With the relatively low operative rate in our study, there should be a study to compare the outcomes of children with TBI who are managed at the peripheral hospitals compared to those managed at KATH.

REFERENCE

1. Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington. Published 2016. Accessed January 17, 2019. https://vizhub.healthdata.org/gbd-compare/

2. Wang H, Naghavi M, Allen C, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*. 2016;388(10053):14591544.

3. WHO. Global status report on road safety 2018. *WHO*. Published online 2019.

4. Dewan MC, Rattani A, Gupta S, et al. Estimating the global incidence of traumatic brain injury. *Journal of Neurosurgery*. Published online 2018:1-18. doi:10.3171/2017.10.JNS17352

5. Taylor CA, Bell JM, Breiding MJ, Xu L. Traumatic Brain Injury–Related Emergency Department Visits, Hospitalizations, and Deaths — United States, 2007 and 2013. *MMWR Surveillance Summaries*. 2017;66(9):1-16. doi:10.15585/mmwr.ss6609a1

6. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. *NeuroRehabilitation*. 2007;22(5):341-353. doi:http://iospress.metapress.com/content/103177/?sortorder=asc

7. Bruns J, Hauser WA. The epidemiology of traumatic brain injury: a review. *Epilepsia*. 2003;44(s10):2-10.

8. Osei-Kwame D. The Burden of Traumatic Brain Injury (TBI) at an Urban Emergency Department in Kumasi, Ghana. *Emergency Medicine*. 2016;Fellowship.

9. Abantanga FA, Mock CN. Childhood injuries in an urban area of Ghana a hospital-based study of 677 cases. *Pediatric surgery international*. 1998;13(7):515-518. doi:10.1007/s003830050387

10. Dewan MC, Mummareddy N, Wellons JC, Bonfield CM. Epidemiology of global pediatric traumatic brain injury: qualitative review. *World neurosurgery*. 2016;91:497-509. e1. doi:10.1016/j.wneu.2016.03.045

11. Udoh DO, Adeyemo AA. Traumatic brain injuries in children: A hospital-based study in Nigeria. *African Journal of Paediatric Surgery*. 2013;10(2):154. doi:10.4103/0189-6725.115043

12. Pham C V., Luong AM, Bachani AM, Nguyen T V., Tran NT, La QN. Injury mortality in Vietnam: patterns and trends, 2005-2013. *Journal of public health management and practice*. 2018;24(2):S44S51. doi:10.1097/PHH.0000000000000718

13. Guerrero JL, Thurman DJ, Sniezek JE. Emergency department visits associated with traumatic brain injury: United States, 1995–1996. *Brain injury*. 2000;14(2):181-186. doi:10.1080/026990500120827

14. Simon R, Gilyoma JM, Dass RM, Mchembe MD, Chalya PL. Paediatric injuries at Bugando Medical Centre in Northwestern Tanzania: a prospective review of 150 cases. *Journal of trauma management & outcomes*. 2013;7(1):10. doi:10.1186/1752-2897-710

15. Mahama M-N, Kenu E, Bandoh DA, Zakariah AN. Emergency response time and pre-hospital trauma survival rate of the national ambulance service, Greater Accra (January – December 2014). *BMC Emergency Medicine 2018 18:1*. 2018;18(1):33. doi:10.1186/s12873-018-0184-3

16. Nee-Kofi Mould-Millman C, Rominski S, Oteng R. Ambulance or taxi? High acuity prehospital transports in the Ashanti region of Ghana. *African Journal of Emergency Medicine*. 2014;4(1):8-13. doi:10.1016/j.afjem.2013.04.004

17. Baker SP, o'Neill B, Haddon Jr W, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *Journal of Trauma and Acute Care Surgery*. 1974;14(3):187-196.

18. Bratton SL, Liesemer K, Tran H, et al. Use of Rotterdam CT scores for mortality risk stratification in children with traumatic brain injury. *Pediatric critical care medicine: a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies*. 2014;15(6):554. doi:10.1097/PCC.0000000000000150

19. Prasad MR, Swank PR, Ewing-Cobbs L. Long-term school outcomes of children and adolescents with traumatic brain injury. *The Journal of head trauma rehabilitation*. 2017;32(1):E24.

20. Feigin VL, Theadom A, Barker-Collo S, et al. Incidence of traumatic brain injury in New Zealand: a population-based study. *The Lancet Neurology*. 2013;12(1):53-64. doi:10.1016/S1474-4422(12)70262-4

21. Kraus JF, Fife D, Conroy C. Pediatric brain injuries: the nature, clinical course, and early outcomes in a defined United States' population. *Pediatrics*. 1987;79(4):501-507.

22. Schneier AJ, Shields BJ, Hostetler SG, Xiang H, Smith GA. Incidence of pediatric traumatic brain injury and associated hospital resource utilization in the United States. *Pediatrics*. 2006;118(2):483-492. doi:10.1542/peds.2005-2588

23. Luerssen TG, Klauber MR, Marshall LF. Outcome from head injury related to patient'age: A longitudinal prospective study of adult and pediatric head injury. *Journal of Neurosurgery*. 1988;68(3):409-416. doi:10.3171/jns.1988.68.3.0409

24. Beers SR, Wisniewski SR, Garcia-Filion P, et al. Validity of a pediatric version of the Glasgow Outcome Scale–Extended. *Journal of neurotrauma*. 2012;29(6):1126-1139. doi:10.1089/neu.2011.2272

25. Mock CN, Abantanga F, Cummings P, Koepsell TD. Incidence and outcome of injury in Ghana: a community-based survey. *Bulletin of the World Health Organization*. 1999;77(12):955.

26. Buitendag JJP, Kong VY, Bruce JL, Laing GL, Clarke DL, Brysiewicz P. The spectrum and outcome of paediatric traumatic brain injury in KwaZulu-Natal Province, South Africa has not changed over the last two decades. *SAMJ: South African Medical*

Journal. 2017;107(9):777-780. doi:10.7196/SAMJ.2017.v107i9.12394

27. Mwita CC, Muthoka J, Maina S, Mulingwa P, Gwer S. Early management of traumatic brain injury in a Tertiary hospital in Central Kenya: A clinical audit. *Journal of neurosciences in rural practice*. 2016;7(1):97.

28. Odebode TOO, Abubakar AMM. Childhood head injury: causes, outcome, and outcome predictors. *Pediatric surgery international*. 2004;20(5):348-352. doi:10.1007/s11104-015-2600-8

29. Herbert HK, Van As AB, Bachani AM, et al. Patterns of pediatric injury in South Africa: an analysis of hospital data between 1997 and 2006. *Journal of Trauma and Acute Care Surgery*. 2012;73(1):168-174. doi:10.1097/TA.0b013e31824d67c3

30. Peden M, Oyegbite K, Ozanne-Smith J, et al. *World Report on Child Injury Prevention*. Vol 14. World Health Organization; 2008. doi:10.1136/ip.2007.018143

31. Mould-Millman N-K, Rominski SD, Bogus J, et al. Barriers to Accessing Emergency Medical Services in Accra, Ghana: Development of a Survey Instrument and Initial Application in Ghana. *Global health, science and practice*. 2015;3(4):577-590. doi:10.9745/GHSP-D-15-00170

32. Otec102.9fm. Emergency Health Service collapses in Ashanti Region - Dr. Osei Ampofo - Otec FM Online. Published 2018. Accessed April 29, 2019. https://otecfmghana.com/2018/06/emergency-health-servicecollapses-in-ashanti-region-dr-osei-ampofo/

33. World Health Organization. Rehabilitation. Key Facts. Published 2019. Accessed June 20, 2019. https://www.who.int/news-room/fact-sheets/detail/rehabilitation

34. IHME. *Findings from the Global Burden of Disease Study 2017*.; 2018.

35. IHME. Global Burden of Disease Study 2017 (GBD 2017). Results., Global Burden of Disease Study 2017 (GBD 2017). Published 2018. http://ghdx.healthdata.org/gbd-results-tool

36. Organisation WH. Children: Reducing Mortality. *http://www.who.int/mediacentre/factsheets/fs178/en/*. (Accessed.

37. Organization WH. Child and adolescent injury prevention: a global call to action. Published online 2005.

38. Whiteside LK, Oteng R, Carter P, et al. Non-fatal injuries among pediatric patients seeking care in an urban Ghanaian emergency department. *International journal of emergency medicine*. 2012;5(1):36. doi:http://dx.doi.org/10.1186/1865-1380-5-36

39. Mock CN, Denno D, Adzotor ES. Paediatric trauma in the rural developing world: low cost measures to improve outcome. *Injury*. 1993;24(5):291-296. doi:10.1016/0020-1383(93)90047-A

40. De Sousa Petersburgo D, Keyes CE, Wright DW, et al. The epidemiology of childhood injury in Maputo, Mozambique. *International journal of emergency medicine*. 2010;3(3):157-163. doi:10.1007/s12245-010-0182-z

41. Gyedu A, Nakua EK, Otupiri E, Mock C, Donkor P, Ebel B. Incidence, characteristics and risk factors for household and neighbourhood injury among young children in semiurban Ghana: a population-based household survey. *Injury prevention*. 2014;21(E1):injuryprev-2013-040950. doi:10.1136/injuryprev2013-040950

42. Toroyan T, Peden M (eds). *Youth and Road Safety*.; 2007.

43. Peden M, Scurfield R, Sleet D, Mohan D, Hyder AA, Jarawan E. *WHO | World Report on Road Traffic Injury Prevention*. World Health Organization; 2004.

44. Economic Commission for Europe. *Glossary of Transport Statistics, 3rd Ed. New York, NY, United Nations Economic and Social Council (TRANS/WP.6/2003/6)*.; 2003.

45. WHO | Road traffic injuries. *WHO*. Published online 2019.

46. WHO. WHO | Decade of Action for Road Safety 2011-2020. *WHO*. Published online 2018.

47. Toroyan T. Global status report on road safety. *Injury Prevention*. 2015;15(4):286. doi:10.1136/ip.2009.023697

48. World Health Organization (WHO). *A Road Safety Technical Package*.; 2017.

49. Guerrero A, Amegashie J, Obiri-Yeboah M, Appiah N, Zakariah A. Paediatric road traffic injuries in urban Ghana: a population-based study. *Injury prevention*. 2011;17(5):ip. 2010.028878. doi:10.1136/ip.2010.028878

50. WHO. Falls. *World Health Organization*. Published online 2014.

51. Borse N, Sleet DA, Moffett DB. CDC childhood injury report: Patterns of unintentional injuries among 0-to 19-year olds in the united states, 2000–2006. *Family & community health*. 2009;32(2):189. doi:10.1097/01.FCH.0000347986.44810.59

52. Lallier M, Bouchard S, St-Vil D, Dupont J, Tucci M. Falls from heights among children: A retrospective review. *Journal of Pediatric Surgery*. 1999;34(7):1060-1063. doi:10.1016/S0022-3468(99)90564-X

53. Tyler MD, Richards DB, Reske-Nielsen C, et al. The epidemiology of drowning in low- and middle-income countries:

a systematic review. *BMC Public Health*. 2017;17(1):1-7. doi:10.1186/s12889017-4239-2

54. Organization WH. *Global Report on Drowning: Preventing a Leading Killer*. World Health Organization; 2014.

55. Hyder AA, Borse NN, Blum L, Khan R, El Arifeen S, Baqui AH. Childhood drowning in low-and middle-income countries: Urgent need for intervention trials. *Journal of paediatrics and child health*. 2008;44(4):221-227. doi:10.1111/j.1440-1754.2007.01273.x

56. Adofo K, Donkor P, Boateng KA, Afukaar F, Mock C. Sustainable improvements in injury surveillance in Ghana. *International journal of injury control and safety promotion*. 2010;17(2):79-85. doi:10.1080/17457301003786948

57. Agbenorku P, Agbenorku M, Effah AT, Adamu Bukari A-R, Asare NYO. Descriptive epidemiological study of burn admissions to the Burns Intensive Care Unit of the Komfo Anokye Teaching Hospital, Kumasi-Ghana, 2009–2016. *Journal of Acute Disease*. 2017;6(3):112-119. doi:10.12980/jad.6.2017JOAD_2016_76

58. Bayuo J, Agyei FB, Baffour PK. Burns in the middle belt of Ghana:
A systematic review. *Burns Open*. 2018;2(2):85-89. doi:10.1016/J.BURNSO.2018.02.001

59. Nthumba PM. Burns in sub-Saharan Africa: A review. *Burns*. 2016;42(2):258-266. doi:10.1016/j.burns.2015.04.006

60. Hillis S, Mercy J, Amobi A, Kress H. Global Prevalence of Pastyear Violence Against Children: A Systematic Review and Minimum
Estimates. *Pediatrics*. 2016;137(3):e20154079. doi:10.1542/peds.2015-4079

61. Menon DK, Schwab K, Wright DW, Maas AI. Position statement: definition of traumatic brain injury. *Archives of physical medicine and rehabilitation*. 2010;91(11):1637-1640. doi:10.1016/j.apmr.2010.05.017

62. Emergency Numbers - Government of Ghana. Accessed July 27, 2019. http://www.ghana.gov.gh/index.php/emergency-numbers

63. Osei-Ampofo M, Oduro G, Oteng R, Zakariah A, Jacquet G, Donkor P. The evolution and current state of emergency care in Ghana. *African Journal of Emergency Medicine*. 2013;3(2):52-58. doi:10.1016/J.AFJEM.2012.11.006

64. Araki T, YOKOTA H, MORITA A. Pediatric traumatic brain injury: characteristic features, diagnosis, and management. *Neurologia medico-chirurgica*. 2017;57(2):82-93. doi:10.2176/nmc.ra.2016-0191

65. Adetayo OA, Naran S, Bonfield CM, et al. Pediatric Cranial Vault Fractures: Analysis of Demographics, Injury Patterns, and Factors Predictive of Mortality. *Journal of Craniofacial Surgery*. 2015;26(6):1840-1846. doi:10.1097/SCS.0000000000001982

66. Rocchi G, Caroli E, Raco A, Salvati M, Delfini R. Traumatic Epidural Hematoma in Children. *Journal of Child Neurology*. 2017;20(7):569-571. doi:10.1177/08830738050200070501

67. Choux M, Grisoli F, Peragut J-C. Extradural Hematomas in Children. *Pediatric Neurosurgery*. 1975;1(6):337-347. doi:10.1159/000119585

68. Adams JH, Doyle D, Ford I, Gennarelli TA, Graham DI, Mclellan DR. Diffuse axonal injury in head injury: Definition, diagnosis and grading. *Histopathology*. 1989;15(1):49-59. doi:10.1111/j.1365-2559.1989.tb03040.x

69. Wasserman JR, Feldman JS, Koenigsberg RA. Diffuse Axonal Injury Imaging: Overview, Radiography, Computed Tomography.

Published 2016. Accessed August 5, 2019. https://emedicine.medscape.com/article/339912-overview

70. Kochanek PM, Clark RSB, Ruppel RA, et al. Biochemical, cellular, and molecular mechanisms in the evolution of secondary damage after severe traumatic brain injury in infants and children: Lessons learned from the bedside. *Pediatric Critical Care Medicine*.
2000;1(1):4-19. doi:10.1097/00130478-200007000-00003

71. Ghajar J. Traumatic brain injury. *The Lancet*. 2000;356(9233):923929.

72. Chesnut RM, Marshall LF, Klauber MR, et al. The Role of Secondary Brain Injury in Determining Outcome from Severe Head Injury. *The Journal of Trauma*. 1993;34(2):216-222. doi:10.1097/00005373-199302000-00006

73. Stewart R, Rotondo M, Henry S. *Advanced Trauma Life Support. ATLS 10th Edition*.; 2018.

74. Jennett B, Snoek J, Bond MR, Brooks N. Disability after severe head injury: observations on the use of the Glasgow Outcome Scale.
Journal of Neurology, Neurosurgery & Psychiatry. 1981;44(4):285293.

75. Reilly PL, Simpson DA, Sprod R, Thomas L. Assessing the conscious level in infants and young children: a paediatric version of the Glasgow Coma Scale. *Child's Nervous System*. 1988;4(1):30-33.
doi:10.1007/BF00274080

76. James HE. Neurologic Evaluation and Support in the Child with an Acute Brain Insult. *Pediatric Annals*. 1986;15(1):16-22. doi:10.3928/0090-4481-19860101-05

77. Borgialli DA, Mahajan P, Hoyle JD, et al. Performance of the Pediatric Glasgow Coma Scale Score in the Evaluation of Children With Blunt Head Trauma. *Academic Emergency Medicine*. 2016;23(8):878-884. doi:10.1111/acem.13014

78. Hoffmann M, Lehmann W, Rueger JM, Lefering R, Surgery TR of the GS for T. Introduction of a novel trauma score. *Journal of Trauma and Acute Care Surgery*. 2012;73(6):1607-1613. doi:10.1097/TA.0b013e318270d572

79. Foreman B, Caesar R, Parks J, et al. Usefulness of the Abbreviated Injury Score and the Injury Severity Score in Comparison to the Glasgow Coma Scale in Predicting Outcome After Traumatic Brain Injury. *The Journal of Trauma: Injury, Infection, and Critical Care*. 2007;62(4):946-950. doi:10.1097/01.ta.0000229796.14717.3a

80. MacLeod JBA, Kobusingye O, Frost C, Lett R, Kirya F, Shulman C. 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: Is Equal Performance Achieved with Fewer Resources? *European Journal of Trauma*. 2003;29(6):392-398. doi:10.1007/s00068-003-1277-5

81. Palmer C, Dip G, Epi C. *MAJOR TRAUMA AND THE INJURY SEVERITY SCORE-WHERE SHOULD WE SET THE BAR?*; 2007.

82. Emami P, Czorlich P, Fritzsche FS, et al. Impact of Glasgow Coma Scale score and pupil parameters on mortality rate and outcome in pediatric and adult severe traumatic brain injury: a retrospective, multicenter cohort study. *Journal of Neurosurgery*. Published online 2017. doi:10.3171/2016.1.JNS152385

83. Thurman D, Guerrero J. Trends in Hospitalization Associated With Traumatic Brain Injury. *JAMA*. 1999;282(10):954-957. doi:doi:10.1001/jama.282.10.954

84. Morris JA, Auerbach PS, Marshall GA, Bluth RF, Johnson LG, Trunkey DD. The Trauma Score as a Triage Tool. *JAMA: The Journal of the American Medical Association*. 1986;256(10):1319-1325. doi:10.1001/jama.1987.03390040100016

85. Marshall LF, Marshall SB, Klauber MR, et al. The diagnosis of head injury requires a classification based on computed axial tomography. *Journal of neurotrauma*. 1992;9 Suppl 1:S287-92.

86. Maas AIR, Hukkelhoven CWPM, Marshall LF, et al. Prediction of outcome in traumatic brain injury with computed tomographic characteristics: A comparison between the computed tomographic classification and combinations of computed tomographic predictors: Commentary. *Neurosurgery*. 2005;57(6):1181-1182. doi:10.1227/01.NEU.0000186013.63046.6B

87. Munakomi S. A comparative study between Marshall and Rotterdam CT scores in predicting early deaths in patients with traumatic brain injury in a major tertiary care hospital in Nepal. *Chinese Journal of Traumatology*. 2016;19(1):25-27. doi:10.1016/J.CJTEE.2015.12.005

88. Macleod JBA, Kobusingye O. Kampala Trauma Score (KTS): Is it a new triage tool? 2007;12(1):74-82.

89. Gardner A, Forson PK, Oduro G, et al. Diagnostic accuracy of the Kampala Trauma Score using estimated Abbreviated Injury Scale scores and physician opinion. *Injury*. 2017;48(1):177-183. doi:10.1016/j.injury.2016.11.022

90. Kochanek PM, Tasker RC, Bell MJ, et al. Management of Pediatric

Severe Traumatic Brain Injury: 2019 Consensus and GuidelinesBased Algorithm for First and Second Tier Therapies. *Pediatric Critical Care Medicine*. 2019;20(3):269-279. doi:10.1097/PCC.0000000000001737

91. Astrand R, Rosenlund C, Undén J, et al. Scandinavian guidelines for initial management of minor and moderate head trauma in children. *BMC Medicine*. 2016;14(1). doi:10.1186/s12916-0160574-x

92. Kochanek PM, Chair V, Carney N, et al. Guidelines for the Acute Medical Management of Severe Traumatic Brain Injury in Infants, Children, and Adolescents-Second Edition Author Affiliations of the Brain Trauma Foundation Project Management External Peer Reviewers. *Pediatr Crit Care Med*. 2012;13(1). doi:10.1097/PCC.0b013e31823f437e

93. Kochanek PM, Tasker RC, Carney N, et al. *Guidelines for the Management of Pediatric Severe Traumatic Brain Injury, Third Edition*. Vol 20.; 2019. doi:10.1097/pcc.0000000000001736

94. Cassidy DJ, Carroll LJ, Peloso PM, et al. Incidence, risk factors and prevention of mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *J Rehabil Med*. 2004;43:28-60. doi:10.1080/16501960410023732

95. Rivara FP, Koepsell TD, Wang J, et al. Incidence of disability among children 12 months after traumatic brain injury. *American journal of public health*. 2012;102(11):2074-2079. doi:10.2105/AJPH.2012.300696

96. Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *The Lancet*. 2009;374(9696):1160-1170. doi:10.1016/S0140-6736(09)61558-0

97. Osmond MH, Klassen TP, Wells GA, et al. CATCH: a clinical decision rule for the use of computed tomography in children with minor head injury. *CMAJ : Canadian Medical Association journal = journal de l’Association medicale canadienne*. 2010;182(4):341348. doi:10.1503/cmaj.091421

98. Dunning J, Daly JP, Lomas J-P, Lecky F, Batchelor J, Mackway-Jones K. Derivation of the children’s head injury algorithm for the prediction of important clinical events decision rule for head injury in children. *Archives of Disease in Childhood*. 2006;91(11):885-891. doi:10.1136/adc.2005.083980

99. Babl FE, Borland ML, Phillips N, et al. Accuracy of PECARN, CATCH, and CHALICE head injury decision rules in children: a prospective cohort study. *The Lancet*. 2017;389(10087):2393-2402. doi:10.1016/S0140-6736(17)30555-X

100. Dalziel K, Cheek JA, Fanning L, et al. A Cost-Effectiveness Analysis Comparing Clinical Decision Rules PECARN, CATCH, and CHALICE With Usual Care for the Management of Pediatric Head Injury. *Annals of Emergency Medicine*. 2019;73(5):429-439. doi:10.1016/j.annemergmed.2018.09.030

101. Bonfield CM, Naran S, Adetayo OA, Pollack IF, Losee JE. Pediatric skull fractures: The need for surgical intervention, characteristics, complications, and outcomes: Clinical article. *Journal of Neurosurgery: Pediatrics*. 2014;14(2):205-211. doi:10.3171/2014.5.PEDS13414

102. Stein SC. The Evolution of Modern Treatment for Depressed Skull Fractures. *World Neurosurgery*. 2019;121(July 2018):186-192. doi:10.1016/j.wneu.2018.10.045

103. Jamous MA, Abdel Aziz H, Al Kaisy F, Eloqayli H, Azab M, AlJarrah M. Conservative management of acute epidural hematoma in a pediatric age group. *Pediatric Neurosurgery*. 2009;45(3):181-184.

doi:10.1159/000218200

104. Bullock R, Smith RM, van Dellen JR. Nonoperative Management of Extradural Hematoma. *Neurosurgery*. 1985;16(5):602-606. doi:10.1227/00006123-198505000-00003

105. Balmer B, Boltshauser E, Altermatt S, Gobet R. Conservative management of significant epidural haematomas in children. *Child's Nervous System*. 2006;22(4):363-367. doi:10.1007/s00381-0051254-x

106. Bounajem MT, Samples DC, Wallace DJ, Tavakoli S, Liao L, Tarasiewicz I. Management of epidural hematomas in pediatric patients presenting with a GCS of 14 or better. *Journal of Clinical Neuroscience*. Published online August 14, 2019. doi:10.1016/J.JOCN.2019.08.056

107. Salam MA, Rahman MM, Uddin K, et al. Surgical Outcome between Early and Delayed Surgery of Extradural Haematoma (EDH) in Closed Head Injury. *Journal of National Institute of Neurosciences Bangladesh*. 2019;5(1):24-28. doi:10.3329/jninb.v5i1.42164

108. Proctor MR, Bachur RG, Wiley JF. Intracranial subdural hematoma in children: Clinical features, evaluation, and management. UpToDate. Published 2019. Accessed August 21, 2019. https://www.uptodate.com/contents/intracranial-subduralhematoma-in-children-clinical-features-evaluation-andmanagement?topicRef=93336&source=related_link

109. Frieden TR, Houry D, Baldwin G. Report to congress on traumatic brain injury in the United States: Epidemiology and rehabilitation. Atlanta, GA: Centers for Disease Control and Prevention. *National Center for Injury Prevention and Control*. Published online 2015.

110. Stephenson B. 7 Types of Rehabilitation Therapy. Published 2018. Accessed August 22, 2019. https://blog.rehabselect.net/7-types-ofrehabilitation-therapy

111. KATH. About Us | Komfo Anokye Teaching Hospital. Published 2019. Accessed October 23, 2019. http://www.kathhsp.org/about-us/

112. Service GS. *2010 Population and Housing Census: Summary Report of Final Results.* (Service GS, ed.). Ghana Statistical Service ; 2012.

113. KATH-EMD. Emergency Medicine Directorate | Komfo Anokye Teaching Hospital. Published 2019. Accessed October 23, 2019. http://www.kathhsp.org/emergency-medicine-directorate/

114. Paediatric Triage Working Group (PTWG) and South Africa Triage Group. The South African Triage Scale Training Manual 2012. *South African Triage Scale Training Manual 2012*. Published online 2012:1-34.

115. citifm. 16 Regions of Ghana. Published 2019. Accessed December 18, 2019. https://citinewsroom.com/wp-content/uploads/2019/02/16-regions-of-Ghana-1024x862.jpeg

116. Digital Innovation I. Medical Registry and Case Management Software Experts. Published 2019. Accessed December 12, 2019. https://www.dicorp.com/

117. Ekremet K, Opare-Addo M, Botchey MI, et al. Patient or Caregiver Satisfaction at a Tertiary Emergency Department in Ghana. Published online 2019.

118. Forson PK, Gardner A, Oduro G, et al. Frequency of Alcohol Use Among Injured Adult Patients Presenting to a Ghanaian Emergency Department. *Annals of Emergency Medicine*. 2016;68(4):492-500.e6. doi:10.1016/j.annemergmed.2016.04.033

119. Collaboration UNRS. Global plan for the Decade of Action for Road Safety 2011–2020. *Geneva: WHO*. Published online 2011:25.

120. DVLA G. DVLA | News. Published 2019. Accessed November 30, 2019.

http://www.dvla.gov.gh/single_service.php?service=OUNzQXFYTDhnSXdSczBXNHovbWtldz09

121. NACTO-GDCI. Streets for Kids City Awards | Global Designing Cities Initiative. Published 2019. Accessed November 30, 2019. https://globaldesigningcities.org/2019/09/09/streets-for-kids-cityawards/

122. Mould-Millman NK, Oteng R, Zakariah A, et al. Assessment of Emergency Medical Services in the Ashanti Region of Ghana. *Ghana medical journal*. 2015;49(3):125-135.

123. Sackey K. President Commissions 307 ambulances. Ghana News Agency (GNA). Published 2020. Accessed January 30, 2020. https://www.ghanamma.com/2020/01/28/president-commissions-307-ambulances-ghana-news-agency-gna/

124. NICE. *NICE Pathways: Investigation for Clinically Important Brain Injuries in Patients with Head Injury*.; 2019.

125. Cui LW, Probst MA, Hoffman JR, Mower WR. Sensitivity of plain radiography for pediatric cervical spine injury. *Emergency Radiology*. 2016;23(5):443-448. doi:10.1007/s10140-016-1417-y

126. Hoffmann M, Lefering R, Rueger JM, et al. Pupil evaluation in addition to Glasgow Coma Scale components in prediction of traumatic brain injury and mortality. *British Journal of Surgery*. 2012;99(SUPPL. 1):122-130. doi:10.1002/bjs.7707

127. Dinsmore J. Traumatic brain injury: an evidence-based review of management. *Continuing Education in Anaesthesia Critical Care & Pain*. 2013;13(6):189-195. doi:10.1093/bjaceaccp/mkt010

128. Stephens S, Campbell R, Chaseling R, Ma N. Traumatic brain injuries in a paediatric neurosurgical unit: A Queensland experience. *Journal of Clinical Neuroscience*. 2019;70(xxxx):27-32. doi:10.1016/j.jocn.2019.09.008

129. Ersahin Y, Mutluer S, Mirzai H, Palali I. Pediatric depressed skull fractures: analysis of 530 cases. *Child's Nervous System*. 1996;12(6):323-331. doi:10.1007/BF00301021

130. Slovis JC, Gupta N, Li NY, Kernie SG, Miles DK. Assessment of recovery following pediatric traumatic brain injury. *Pediatric Critical Care Medicine*. 2018;19(4):353-360. doi:10.1097/PCC.0000000000001490

131. Kochanek PM, Adelson PD, Ashwal S, et al. Chapter 7. Neuroimaging. *Pediatric Critical Care Medicine*. 2012;13:S33-S35. doi:10.1097/PCC.0b013e31823f65e2

132. Schrieff LE, Thomas KGF, Dollman AK, Rohlwink UK, Figaji AA. Demographic profile of severe traumatic brain injury admissions to Red Cross War Memorial Children's Hospital, 20062011. *South African Medical Journal*. 2013;103(9):616-620. doi:10.7196/SAMJ.7137

133. Damsere-Derry J, Ebel BE, Mock CN, Afukaar F, Donkor P. Pedestrians' injury patterns in Ghana. *Accident Analysis and Prevention*. 2010;42(4):1080-1088. doi:10.1016/j.aap.2009.12.016

134. O'Dea S. Mobile subscription penetration rate in Ghana from 2010 to 2020. Statista. Published 2020. Accessed April 3, 2021. https://www.statista.com/statistics/779697/mobile-cellularsubscriptions-penetration-rate-ghana/

135. CDC. Graphics and Infographics | HEADS UP | CDC Injury Center. Published 2020. Accessed March 6, 2020. https://www.cdc.gov/headsup/resources/graphics.html

136. Ward D. Automotive Safety in the UN Decade of Action Presentation by. 2013;(December).

137. ILO. *Resolution Concerning Updating the International Standard Classification of Occupations*.; 2013.

APPENDIX Appendix 1: PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

<u>This leaflet must be given to all prospective participants to enable them to know enough about the research before deciding to or not to participate.</u>

Title of Research: Characteristics and outcomes of paediatric traumatic brain injuries presenting to Komfo Anokye Teaching Hospital.

Name(s) and affiliation(s) of researcher(s): Co-investigators include Dr Kwame Ekremet from Komfo Anokye Teaching Hospital, Dr Rockefeller Oteng from University of Michigan/ Komfo Anokye Teaching Hospital, Professor Ronald Maio from University of Michigan Medical School.

Background (Please explain simply and briefly what the study is about): Traumatic Brain Injury (TBI) in children is a major cause of morbidity and mortality in many countries. Children constitute a significant percentage of the TBI population, and this is of public health concern globally. Most studies of paediatric TBIs and its outcomes are conducted in HighIncome Countries (HICs) where the burden is relatively low compared to LMICs with its huge burden of road traffic injuries. In Ghana, studies which characterise and determine the outcomes of children who sustain a traumatic brain injury are lacking.

It is expected that this study will lead to a better understanding of the characteristics and the determinants of outcomes of paediatric TBIs. The findings will help improve the acute care of children presenting to the ED with TBI and inform primary prevention of TBI among children.

Purpose of the research: This study seeks to examine the characteristics and outcomes of children presenting with traumatic brain injuries to the emergency department of Komfo Anokye Teaching Hospital and to assess the potential prognostic value of various characteristics of the child and the injury.

Procedure of the research, what shall be required of each participant and approximate total number of participants that would be involved in the research: The procedure will involve interviewing caregivers of children with TBI with an electronic data collection sheet during the child's hospital stay. There will be another interview at discharge and three months after the injury in person or over the phone. The approximate total number of participants will be 115.

Risk(s): The design of this study is prospective and observational. No intervention is being tested. No methods used to collect data pose a physical or mental risk to the subject.

Benefit(s): There is no direct benefit to participants from this research. However, subjects who are identified to have disabilities will be linked to available rehabilitation services, such as physiotherapy or speech therapy as their disability may require.

Confidentiality: All information collected in this study will be given code numbers. Names will not be recorded. Data collected cannot be linked to the participant whatsoever. No name or identifier will be used in any publication from this study.
Voluntariness: Taking part in this study will be entirely out of your free will. This research is voluntary.
Alternatives to participation: Choosing not to participate in this study will not affect the care that will be given to you in this hospital in any way. Withdrawal from the research: You may choose to exit from the study at any stage without having to explain. Again, this will not affect the treatment that will be given you.
Consequences of Withdrawal: There will be no consequences, loss of benefit or care to you if you choose to withdraw from to study.

Costs/Compensation: There is no compensation related to participation in this study.

Contacts: If you need any further information about the study or have concerns, please contact Dr Kwame Ekremet of Komfo Anokye Teaching Hospital on 0242230912.
Further, if you have any concern about the conduct of this study, your welfare, or your rights as a research participant, you may contact:

The Office of the Chairman
Committee on Human Research and Publication Ethics
Kumasi
Tel: 0322063248 or 0205453785

CONSENT FORM

Statement of person obtaining informed consent:

I have fully explained this research to ______________________________________ and have given sufficient information about the study, including that on procedures, risks and benefits, to enable the prospective participant make an informed decision as to or not to participate.

DATE:______________________

NAME: __________________________________

Statement of person giving consent:

I have read the information on this study/research or I have had it translated into a language I understand. I have also talked it over with the interviewer to my satisfaction.

I understand that my participation is voluntary.

I know enough about the purpose, methods, risks, and benefits of the research study to decide that I want to take part in it.

I also understand that I may freely stop being part of this study at any time without having to explain myself and that there will be no consequences for my ward in any way.

I have received a copy of the information leaflet and this consent form to keep for myself.
NAME: ____

DATE: ____________

SIGNATURE/THUMB PRINT: ___________________ Statement of person witnessing consent (Process for Non-Literate Participants):

I ____________________________ (Name of Witness) certify that the information given to

______________________________ (Name of Participant), in the local language, is a true reflection of what l have read from the study Participant Information Leaflet attached.

WITNESS' SIGNATURE/THUMB PRINT (maintain if participant is non-literate): ____________________

CAREGIVER'S SIGNATURE/THUMB PRINT _____________________________

CAREGIVER'S NAME: ____

RELATION OF CAREGIVER TO PATIENT: ______________________________ Appendix 2: DATA COLLECTION TOOL

Patient ID: A/E ________ Contact Number: 1. ________ 2. ________

Date and Time of ED Arrival______________ 1.

Age: ________

2. Sex:
   a. Male
   b. Female
3. Previous disability:
   a. Yes
   b. No
4. If "Yes" in question 3 above, indicate the type of disability. ____________
5. Health insurance coverage:
   a. Yes
   b. No

6. If “Yes” to health insurance coverage, indicate the type (multiple choice)
    a. NHIS
    b. Private
    c. Corporate
    d. Not applicable
7. Who does the child stay with?
    a. Single parent
        i. Mother
        ii. Father
    b. Both parents
    c. Guardian
        i. Relative
        ii. Not a relative
8. Educational level of primary caregiver
    a. No education
    b. Primary
    c. JHS/Middle
    d. Secondary/ Form 4
    e. Pre-tertiary/ Vocational
    f. Tertiary
9. Occupation of caregiver
    a. Artisan
    b. Trader
    c. Student
    d. Farmer
    e. Service/ Sales worker
    f. Professional (e.g., teacher, accountant, engineer, nurse, doctor, lawyer)
    g. Retired/ Pensioner
    h. Unemployed
    i. Others, specify________________________
10. Monthly income of caregiver (in Ghana Cedis) _______________
11. Date injury occurred: _________ 12. Time injury occurred (24h): _________
13. Place of injury:

a. Roadside
b. Home
c. School
d. Farm
e. Playing ground/ Recreational centre
f. Unknown
g. Other, specify _________

14. Activity at the time of injury:
    a. Travelling to or from school
    b. Hawking by the roadside
    c. Sports
    d. Playing
    e. Unknown
    f. Other, specify _________

15. What was the mechanism of the injury?
    a. Road traffic injury
    b. Fall
    c. Child abuse
    d. Assault
    e. Struck by a falling object
    f. Gunshot
    g. Stab injury
    h. Unknown
    i. Other, specify _________

If the mechanism of injury was due to "road traffic injury", answer the next four (4) questions, otherwise, skip to the question 20.

16. What type of road user was the patient?
    a. Passenger
    b. Pedestrian
    c. Rider (co-rider)
    d. Unknown
    e. Other, specify _________

17. What was the mode of transportation?

a. Walking
b. Car
c. Motorcycle
d. Three-wheel motorcycle (Aboboya/Yellow Yellow)
e. Pedal cycle (bicycle)
f. Unknown
g. Other, specify ________

18. What was the traffic counterpart?
    a. Car
    b. Motorcycle
    c. Three-wheel motorcycle (Aboboya/Yellow Yellow)
    d. Pedal cycle (bicycle)
    e. Unknown
    f. Other, specify ________
19. What was the safety equipment used?
    a. None
    b. Child car seat
    c. Seatbelt
    d. Helmet
    e. Unknown
    f. Other, specify ________

If the mechanism of injury was due to a fall, then answer the next two (2) questions, otherwise, skip to question 22.

20. From what did the patient fall?
    a. Ground level
    b. From bed/table/chair/stool
    c. From a tree
    d. From a wall
    e. From a storey building
    f. From being carried by caregiver.
21. What is the estimated height from which the patient fell? (in centimetres) ________
22. Was care provided at the scene of the injury?

a. Yes
b. No
c. Do not know.

23. If “Yes” to above, what care was provided?
    a. Poured water on the patient
    b. Applied C-collar
    c. Others, specify________
    d. Not applicable
24. Who provided the care?
    a. Bystanders
    b. Parents
    c. Paramedic
    d. Other, specify ________
    e. Not applicable
25. Was the patient referred from another health facility?
    a. Yes
    b. No (patient was brought from accident scene)
    c. Unknown
26. If the patient was referred, from which facility was he/she referred?
    a. Public
    b. Private
    c. Not applicable
27. Mode of arrival at KATH ED:
    a. Ambulance
    b. Taxi
    c. Private car
    d. Minibus
    e. Walked in/carried in
    f. Unknown
    g. Other, specify________
28. Date of arrival at KATH ED: ________
29. Time of arrival at KATH ED (24h): ________

Initial Vital Signs

30. As per the triage recording.

a. Mobility _________
b. Respiratory rate _________
c. Heart rate _________
d. Blood pressure _________
e. Temperature _________
f. AVPU _________
g. Trauma _________
h. Oxygen saturation at room air _________
i. Triage Early Warning (TEW) Score

____

j. Final Triage Category:

i. Yellow ii.

Orange

iii. Red

31. Glasgow Coma Scale Score:

a. Motor _________
b. Verbal _________
c. Eye _________
d. Total GCS score _________

Post resuscitation

32. Vital Signs

a. Blood pressure _________
b. Heart Rate _________
c. Respiratory rate _________
d. Temperature _________
e. Oxygen saturation _________

33. Glasgow Coma Scale Score:

a. Motor _________
b. Verbal _________

c. Eye _________

d. Total GCS score _________

34. What were the other injuries sustained anatomically?
    a. No other injury
    b. Maxillofacial
    c. Cervical spine
    d. Chest
    e. Abdomen
    f. Pelvis
    g. Thoracic/ Lumbar Spine
    h. Upper extremity
    i. Lower extremity
    j. Unknown
35. Was head CT scan indicated?
    a. Yes
    b. No
36. If head CT scan was indicated, was it done?
    a. Yes
    b. No
37. If it was indicated but was not done, why was it not done?
    a. No funds
    b. Faulty CT scanner
    c. No ambulance to transport patient outside the ED
    d. Other, Specify, _________
38. If head CT scan was done, what was the finding? (Multiple options allowed)
    a. Skull fracture (calvarium)
        i. Depressed
        ii. Non-depressed
    b. Basal skull fracture
    c. Epidural haematoma
    d. Subdural haematoma
    e. Intraparenchymal bleed (contusional haemorrhage)
    f. Subarachnoid haemorrhage (SAH)

g. Intraventricular haemorrhage (IVH)
h. Diffuse axonal injury
i. Cerebral oedema
j. Midline shift, _____________mm
k. Rotterdam CT scan Classification
    i. Basal cistern ________
    ii. Midline shift ________
    iii. Epidural bleed ________
    iv. SAH/IVH ________
    + 1
    v. Total Score ________
l. Injury Severity Score (ISS) ________

39. Emergency department treatment (multiple options allowed)
    a. No treatment
    b. Intubation
    c. Oxygen therapy
    d. Intravenous fluids
    e. Hyperosmolar therapy (indicate which type, Mannitol or Hypertonic saline)
    f. Anti-seizure prophylaxis or treatment
    g. Antibiotics
    h. Unknown
    i. Other, specify, ________

40. Emergency Department Disposition
    a. Discharged home
    b. Admitted
    c. Theatre
    d. Discharge Against Medical Advice (DAMA)
    e. Died

41. If admitted, indicate to which ward/unit patient was initially admitted to.
    a. Paediatric Intensive Care Unit (PICU)
    b. Neurosurgery ward (B3)
    c. Clinical Decision Unit (CDU) – paediatric ward
    d. Not applicable

42. Emergency department length of stay (LOS)
    a. Date of ED disposition ________
    b. Time of ED disposition ________
    c. LOS ________ (hours)
43. Definitive management
    a. Surgery
    b. Conservative

If surgery was done, then answer the next three (3) questions, otherwise skip to question 47.

44. Date of surgery ________
45. Time of surgery ________
46. Type of surgery (multiple options allowed)
    a. Craniotomy
    b. Skull elevation
    c. Decompressive craniectomy
    d. Unknown
    e. Other, specify, ________

47. Indicate any complication developed while on admission. (Multiple options allowed)
    a. No medical complications
    b. Meningitis
    c. Intracranial abscess
    d. Pneumonia
    e. Urinary tract infection
    f. Malaria
    g. Decubitus ulcer
    h. Septic shock
    i. Unplanned surgery
    j. Missed injury
    k. Surgical site infection
    l. Cardiac arrest but was resuscitated
    m. Died on admission
    n. Unknown

o. Other, specify, ________

p. Not applicable

48. Hospital disposition

a. Discharged home

b. DAMA

c. Absconded

d. Died in hospital

e. Unknown

f. Not applicable

49. Total Hospital LOS

a. Date of discharge ________

b. Time of discharge ________

c. Total hospital LOS ________

50. Extended Glasgow Outcome Scale at discharge: ________

51. Extended Glasgow Outcome Scale at 3 months: ________

Appendix 3: STUDY VARIABLES

Variable	Measurement	Definition/ Options
Child Demographic Characteristics		
Age	Continuous Categorical	Child's age at last birthday measured in years. Later categorised into three age groups (0-4,5-9,10-14)
Sex	Dichotomous	The gender of the child, either Male or Female
Pre-existing disability	Dichotomous	Yes, if the child had any disability before the injury. No, otherwise.
Health insurance membership	Dichotomous	Yes, if the child was a member of a health insurance scheme. No, otherwise.
Caregiver of child socio-demographic characteristics		
The caregiver who stays with the child	Categorical	The caregiver, the child, stays with at home: both parents, single parent, and guardian.

The primary caregiver with the child in the hospital.	Categorical	The primary who stays with the child during the hospital stay: mother, father, guardian.
The educational level of the primary caregiver.	Categorical	The level of education of the primary caregiver: no formal education, Primary, Junior/Secondary, pre-tertiary, and tertiary.
The caregiver's class of occupation.	Categorical	Three categories collapsed from the ten classes of occupation according to the International Standard Classification of Occupations (ISCO):[137] 1-3-

Variable	Measurement	Definition/ Options
		managers, professionals, technicians and associate professionals 4-6- clerical support workers, services, and sales workers and skilled agricultural, forestry and fishery workers 7-9- Craft and related trades workers; plant and Machine operators, and assemblers, elementary Occupations.
Injury Characteristics		
The mechanism of injury.	Categorical	Road traffic crash; falls; struck on the head by an object, Others (assault, attack by a cow).

Variable	Measurement	Definition/ Options
The place of injury.	Categorical	The site where the injury occurred: Roadside, home, school, others (church, playground).
The activity at the time of injury.	Categorical	Traveling, playing, hawking, on errands.
The destination of travel.	Categorical	To or from school, to another town, to church, to parent’s workplace.
The type of road user.	Categorical	Passenger, rider/ pillion rider, pedestrian.
The means of transportation.	Categorical	Pedal cycle, 2-wheeler, 3-wheeler, car, walking.
The traffic counterpart.	Categorical	The motorcycle or vehicle which collided with the child or the motorcycle or vehicle the child was using. Pedal cycle,
		3-wheeler, 2-wheeler, car, and none.
The type of vehicle involved in pedestrian-vehicle collision.	Categorical	Cargo truck, big bus (more than 20 seaters), SUV, pick-up truck, private sedan car, minibus (“trotro”), Taxi and unknown.
The type of safety device used.	Categorical	Child car seat, seatbelt, helmet, None, unknown, others.

The object from which the child fell.	Categorical	The object the children fell from: Bed/table/chair/stool, tree, wall, storey building, caregiver, into a pit, ground level, and unknown.
The estimated height of fall	Continuous	Caregivers estimated the height of the object from which the patient fell from in centimetres (cm).
Prehospital care		
Care provision at the scene of the injury	Dichotomous	Yes, if the child received prehospital care at the scene. No, otherwise.
Type of prehospital care provided at the scene	Categorical	Water poured on the child, cervical collar application, others to be specified.
On-scene prehospital care provider	Categorical	The person who provided the prehospital care at the scene of injury. Bystander, parents, paramedics, others to be specified.
Referral details		

Variable	**Measurement**	**Definition/ Options**
Whether the child was referred	Dichotomous	Yes, if the child was referred from another facility to the KATH ED. No otherwise.

Region of referral	Categorical	The region of the facility from where the child was referred. Ashanti, Western, Brong Ahafo, Central, Eastern, Greater Accra, Volta, Northern, Upper East, and West regions.
Mode of referral	Categorical	The mode of arrival of the patient to KATH ED. Ambulance, taxi, private car, walked in, others to be specified.
Date and time of KATH ED arrival	Numerical	The date and time as recorded on the triage sheet.
The vital signs at presentation	Continuous Categorical	Systolic Blood pressure, measured with an electronic sphygmomanometer (CONTEC^{TM}, model: CONTEC08A, CONTEC MEDICAL SYSTEMS CO, LTD), was categorised into below 50th percentile for age or above that. Temperature was measured by a non-contact infrared thermometer. It was categorised into hypothermia (less than 35^{o}C), normothermia (35 to less than 38^{o}C) and hyperthermia (38^{o}C and above).

Variable	**Measurement**	**Definition/ Options**

		Oxygen saturation was determined by a finger pulse oximeter (SANTAMEDICAL, Gurin Products, LLC). It was categorised into below 90% and 90% and above.
Triage category	Categorical	The category patient was triaged according to the SATS[114]: Yellow (urgent), Orange (very urgent) and Red (emergent)
Glasgow Coma Scale (GCS) score.	Discrete Categorical	The GCS score was recorded from 3-15. It was categorised into mild (GCS scores of 13-15), moderate (9-12), and severe (3-8).
Associated injuries.	Categorical	Other injuries associated with the TBI. It was organised according to the body regions of the Abbreviated Injury Scale (AIS): Head/neck, face, chest, abdomen, extremity, eternal (skin).
Neuroimaging		
Whether the head CT scan was indicated.	Dichotomous	Yes, if the head CT scan was indicated. No, otherwise.
The head CT was done if indicated.	Dichotomous	Yes, if the head CT scan was done. No, otherwise.
The reasons for not doing the head CT scan if indicated.	Categorical	No funds, faulty CT scanner, no ambulance to transport the patient outside the hospital if faulty CT scanner.

Variable	**Measurement**	**Definition/ Options**

The overall findings of the head CT scan	Categorical	The general findings of the head CT scan: Normal or abnormal.
The specific findings if the head CT scan was abnormal	Categorical	The findings as reported by the radiologist. Calvarial fracture (depressed or non-depressed), basal skull fracture, EDH, SDH, contusional bleed, SAH, IVH, DAI, cerebral oedema.
The Rotterdam CT score	Discrete Categorical	The Rotterdam CT score was determined by the PI. It ranged from 1-6. It was categorised into category 1 (Rotterdam CT score of 1), category 2 (2-3), and category 3 (4-6).
ED Management		
The ED treatment provided	Categorised	Options for ED treatment included no treatment, endotracheal intubation, oxygen therapy, IV fluids, hyperosmolar therapy, anti-seizure prophylactic, antibiotics, the elevation of HOB.
Type of Hyperosmolar initiated	Categorical	Options included Mannitol, 3% hypertonic saline or both
The ED disposition	Categorical	Discharge home, Ward admission, theatre, discharge against medical advice (DAMA), death.

Variable	Measurement	Definition/ Options
The ward/unit to which child was initially admitted	Categorical	PICU, neurosurgical ward, paediatric CDU.
ED length of stay (LOS)	Continuous	The time from ED arrival to ED disposition.
Trauma Severity Scores		
The Injury Severity Score (ISS)	Discrete Categorical	The ISS was calculated for patients who had head CT scans done. A software package created by Digital Innovation Incorporated.[116] was employed for the ISS coding. This package is integrated into the Trauma Registry at KATH. The ISS which ranges from 1-75 was categorised into minor injury (less than 8) and major (8 and above)
The Kampala Trauma Score (KTS)	Discrete Categorical	The KTS was calculated using the child's age, SBP, respiratory rate, level of consciousness given by Alert, Verbal, Pain, Unresponsive (AVPU) and the number of serious injuries (determined by the PI) as shown in figure 2.4 It ranges from 5-16 which was categorised into mild (14-16), moderate (11-13), and severe (less than 11) injuries.
Definitive Management		

Variable	Measurement	Definition/ Options
The definitive management provided to the child	Categorical	Surgery (craniotomy, skull elevation, decompressive craniectomy), conservative
The complications developed on the ward	Categorical	No complication, meningitis, pneumonia, urinary tract infection, malaria, circulatory shock, surgical site infection, Cardiac arrest but resuscitated, died, intensive care admission.
The overall hospital disposition	Categorical	Discharged home, DAMA, absconded, died in hospital.
Overall length of hospital stay	Numerical	Length of hospital stay from ED arrival to discharge from the ED or the hospital ward.
Outcome Measurements		
The final hospital outcome	Dichotomous	The options were dead or alive.
The paediatric GOSE at discharge	Discrete Categorical	The paediatric GOSE at discharge was assessed using the scale at Appendix 5. The scale which ranges from 1-8 was categorised into good recovery (1-2) and poor recovery (3-8).

The paediatric GOSE at 3 months post-TBI	Discrete Categorical	The paediatric GOSE at three months post-TBI was assessed using the scale at Appendix 5. The scale which ranges from 1-8 was categorised into good recovery (1-2) and poor recovery (3-8).

Appendix 4: GLASGOW COMA SCALE FOR PAEDIATRIC PATIENTS

Eye-Opening Response		
Score	>1 year	<1 year
4	Spontaneous	Spontaneous
3	To verbal command	To shout
2	To pain	To pain
1	None	None

Motor Response		
Score	>1 year	<1 year
6	Obeys commands	Spontaneous
5	Localizes pain	Localizes to pain
4	Withdraws to pain	Withdraws to pain
3	Abnormal flexion to pain (decorticate)	Abnormal flexion to pain (decorticate)
2	Abnormal extension to pain (decerebrate)	Abnormal extension to pain (decerebrate)
1	None	None

Verbal Response			
Score	>5 years	2-5 years	0-2 years
5	Oriented and converses	Appropriate words and phrases	Babbles, coos appropriately
4	Confused conversion	Inappropriate words	Cries but is consolable
3	Inappropriate words	Persistent crying or screaming to pain	Persistent crying or screaming to pain
2	Incomprehensible sounds	Grunts or moans to pain	Grunts or moans to pain
1	None	None	None

Appendix

5: EPPENDORF-COLOGNE SCALE

Eppendorf-Cologne Scale			
Category	Findings	Score	
Pupil Reactivity			
Both pupils constrict identically with light shone into either eye alone	Brisk	0	
Delayed pupil constriction in reaction to light	Sluggish	1	
No response to a light stimulus regardless of which eye is being stimulated	Fixed	3	
Pupil size			
Bilaterally, equally, nondilated pupil size	Normal	0	
Unequal pupil size	Anisocoria	1	
Bilaterally dilated pupils	Bilaterally dilated	2	
Motor response			Corresponding GCS (Motor Component)
Obeys command	Normal	0	6
Localises pain or withdraws to pain	Specific	1	4-5
Abnormal flexion or extension to pain	Nonspecific	2	2-3
No motor response	None	3	1
TOTAL			

6: PAEDIATRIC GLASGOW OUTCOME SCALE- EXTENDED

GLASGOW OUTCOME SCALE-EXTENDED PAEDIATRIC VERSION (GOSE PEDS) (SUE R. BEERS, Ph.D., ANNA SKOLD, MS, THOMAS HAHNER, & P. DAVID ADELSON, MD, CHILDREN'S HOSPITAL OF PITTSBURGH)

Information obtained (select one):

○ In person ○ By phone ○ From records

1

NOTE: Only problems that have **developed or become markedly worse** since the head injury should be considered when completing the GOSE Peds. That is, the child's premorbid status must be weighed when answering all questions.

Appendix

1**. CONSCIOUSNESS**

1a) Is the head-injured person able to obey simple commands or say any words?

Or for younger patients.

Can he or she act/react/interact beyond reflexes?

- No
- Yes (Skip to 2.)

Vegetative State (VS)

Skip to end of form and record GOSE Peds

Score=7.

An individual who shows the ability to obey even simple commands or utter any word or communicate specifically in any other way is no longer considered to be in a vegetative state. Eye movements are not reliable evidence of meaningful responsiveness; corroborate with nursing staff and the child's parents when possible. Confirmation of VS requires full assessment as in the Royal College of Physician Guidelines. However, for infants, actively following the movement of a parent or people/object with eyes, grasping for objects, making faces, etc. are interactions; breastfeeding and crying continuously can be reflexes.

2. INDEPENDENCE IN THE HOME

2a) Is the assistance of another person at home essential every day for some activities of daily living?

Or for younger patients.

Is the child dependent upon a caretaker more so than is expected based on age?

○ Yes (Go to 2b.) ○

No (Skip to 3.)

2

For an older child, complete independence and a 'no' answer should mean that the person can get washed, put on clean clothes without prompting, prepare food for themselves, deal with callers, and handle minor domestic crises. The person should be able to carry out activities without needing prompting or reminding and should be capable of being left alone for an age-appropriate period. Young children should be able to accomplish age-appropriate developmental milestones without assistance (see Vineland Daily Living Skills). If a child compensates for physical disability to the point where developmental milestones are only mildly compromised, question parents to determine the level of independence (i.e., A child with hemiparesis who is still able to complete tasks that other children of that age can be rated as independent).

2b) Does the child need frequent help or for someone to be around at home most of the time?

Or for younger patients.

Does the child need frequent help from a caretaker to accomplish tasks that a child this age should be able to accomplish (If child sometimes functions at an age-appropriate level, then answer 'no')?

Yes → Lower Severe Disability Skip to end of form and record GOSE Peds Score =6

No

Upper Severe Disability Skip to end of form and record GOSE Peds

Score = 5

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3. INDEPENDENCE OUTSIDE THE HOME

3a) Is the child able to shop and travel without assistance?

Or for younger patients.

Does the child behave age appropriately outside the home?

Yes (Skip to 4.)

No → Upper Severe Disability Skip to end of form and record GOSE Peds Score = 5

This item considers activities such as shopping and traveling, always in the context of age-appropriate behaviours. This includes being able to plan what to buy, take care of money, and behave appropriately in public. The individual needs not normally shop but must be able to do so. A younger child must behave age appropriately in public. An older child may drive or use public transit to get around. Ability to use a taxi is sufficient, provided the person can phone for it themselves and give instruction to the driver. Older children who sometimes could travel independently before the injury should be able to walk to a neighbour's house, take a school bus, ride a bike, or take public transportation.

4. SCHOOL/WORK

4a) Can the child function at work or in school at his or her **previous** capacity?

○ Yes (Skip to 5.) ○ No (Go to 4b.)

If an adolescent was working before the injury, then his or her current capacity for work should be at the same level. If the individual was seeking work before, then the injury should not have adversely affected chances of obtaining work or the level of work for which he or she is eligible. If the patient was in preschool or a student before the injury, then capacity for school work and school activities should not be adversely affected.

4b) Level of restriction:

i. Able to work only in a sheltered workshop or non-competitive job, in a school setting for severely impaired children or tutored at home, or currently unable to work or go to school.

Yes No (Go to 4b ii.)

Lower Moderate Disability Skip to end of form and record GOSE Peds Score = 4

ii. Reduced work or school capacity.

Yes

Upper Moderate Disability Skip to end of form and record GOSE Peds Score = 3

5. SOCIAL & LEISURE ACTIVITIES

5a) Is the child able to resume regular social and leisure activities?

Yes (Skip to 6.) No (Go to 5b.)

The individual may not have resumed all previous leisure activities but should not be prevented from doing so by physical or mental impairment. If he or she has stopped most activities because of loss of interest or motivation, then this is considered a disability. For younger children, social and leisure activities can include games and toys played with caretakers, siblings, or other children as well as the ability to interact in a playful manner with others.

5b) What is the extent of restrictions on social and leisure activities?

i. Unable to participate: Rarely, if ever, takes part.

Yes No (Go to 5b ii.)

Lower Moderate Disability Skip to end of form and record GOSE Peds Score = 4

ii. Participate much less: Less than half as often.

Yes No (go to 5b iii.)

Upper Moderate Disability Skip to end of form and record GOSE Peds Score = 3

iii. Participate a bit less: At least half as often as before the injury.

Yes | No (Skip to 6.)

Lower Good Disability Skip to end of form and record GOSE Peds Score = 2

6. FAMILY & FRIENDSHIPS

6a) Are there psychological problems that have resulted in ongoing disruption with respect to either family or friendships?

Yes (Go to 6b.) | No (Skip to 7.)

Typical post-traumatic personality changes: quick temper, irritability, anxiety, aggressive acts, insensitivity to others, mood swings, depression, and unreasonable or childish behaviour that is not age appropriate.

6b) What is the extent of disruption or strain?

- Constant – daily and intolerable → Lower Moderate Disability Skip to end of form and record GOSE Peds Score = 4
- Frequent – once a week or more, but tolerable → Upper Moderate Disability Skip to end of form and record GOSE Peds Score = 3
- Occasional – less than weekly and → Lower Good Recovery Skip to end of form record GOSE Peds Score = 2

7. RETURN TO NORMAL LIFE

7a) Are there any other problems relating to the injury that affect daily life?

Yes → Lower Good Recovery Skip to end of form and record GOSE Peds Score = 2

No → Upper Good Recovery Skip to end of form and record GOSE Peds Score = 1

Typical problems reported after head injury: headaches, dizziness, tiredness, sensitivity to noise or light, slowness, memory failures, concentration problems, or other problems.

RECORD GOSE PEDS Score <u>SCORE</u>:

Scoring caveat: Remember to consider premorbid status when assigning category scores to an outcome of injury; problems in functioning should have deteriorated from premorbid level.

8 - Death

7 - Vegetative State (VS)

6 - Lower Severe Disability (Lower SD)

5 - Upper Severe Disability (Upper SD)

4 - Lower Moderate Disability (Lower MD)

3 - Upper Moderate Disability (Upper MD)

2 - Lower Good Recovery (Lower GR)

1 - Upper Good Recovery (Upper GR)

GOSE Peds Score: _______

Appendix

7: GCPS APPROVAL TO COMMENCE ETHICAL PROCESSES

GHANA COLLEGE OF PHYSICIANS AND SURGEONS

OUR REF:
Tel: +233-(0)302-238650/238703
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P. O. Box MB 429
Ministries-Accra
Ghana

8th February 2019

The Head
Emergency Unit
KATH
Kumasi

Dear Sir,

REQUEST FOR ETHICAL APPROVAL

Dr. Kwame Ekremet, a Senior Resident in Emergency Medicine, Komfo Anokye Teaching Hospital has submitted the revised proposal for his dissertation after comments by the Dissertation Review Dissertation Review Committee.

I, forward the proposal to you to arrange submission to the Research and Ethics Committee of the Komfo Anokye Teaching Hospital for ethical approval to enable him start his research work which is a requirement for the award of the Fellowship of the College.

Attached is a copy of the Research Proposal.

Counting on your usual cooperation.

Yours Sincerely

Prof. Jacob Plange-Rhule
Rector

cc: The Chairman, Faculty of Emergency Medicine
Dr. Kwame Ekremet

8: KATH RESEARCH AND DEVELOPMENT CERTIFICATE OF REGISTRATION

KOMFO ANOKYE TEACHING HOSPITAL

RESEARCH AND DEVELOPMENT UNIT (R & D)

CERTIFICATE OF REGISTRATION

REG. NO: RD/CR19/027...

This is to certify that

Prof/Dr/Mrs/Mr/Ms. Ekremet Kwame ....

has registered his/her proposed study titled . Characteristics and ....

Outcomes of Traumatic Brain Injury Presenting to Komfo Anokye ....

Teaching Hospital........

.... with the Research and Development Unit.

Date: 18-February-2019.......

Name of issuing officer

Mr. Isaac Boakye........

K/17/0550868 *

*Receipt number must tally with pay-in slip from the bank

Signature

....

Note

This certificate does not constitute ethical clearance for the conduct of the study but proof of registration of study with KATH. Ethical clearance from the Committee of Human Research, Publications and Ethics (CHRPE) is required to conduct the study in KATH. Copies of all relevant regulatory approvals including CHRPE **must** *be submitted to the R&D Unit prior to commencement of the study.*

Version RD/REG-01st JUNE, 2018
Please note: All previous versions of the certificate of registration becomes obsolete

Form expires 30TH JUNE, 2019

9: CHRPE ETHICAL APPROVAL

Appendix

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF HEALTH SCIENCES
SCHOOL OF MEDICAL SCIENCES / KOMFO ANOKYE TEACHING HOSPITAL
COMMITTEE ON HUMAN RESEARCH, PUBLICATION AND ETHICS

Our Ref: CHRPE/AP/128/19 2nd April, 2019.

Dr. Kwame Ekremet
Department of Emergency Medicine
Komfo Anokye Teaching Hospital
Post Office Box 1934
KUMASI.

Dear Sir,

LETTER OF APPROVAL

Protocol Title: ***"Characteristics and Outcome of Paediatric Traumatic Brain Injury Presenting to Komfo Anokye Teaching Hospital."***

Proposed Site: ***Emergency Medicine Department, Komfo Anokye Teaching Hospital, Kumasi.***

Sponsor: ***Principal Investigator.***

Your submission to the Committee on Human Research, Publications and Ethics on the above-named protocol refers.

The Committee reviewed the following documents:

- A notification letter of 18th February, 2019 from the Komfo Anokye Teaching Hospital (study site) indicating approval for the conduct of the study at the Hospital.
- A Completed CHRPE Application Form.
- Participant Information Leaflet and Consent Form.
- Research Protocol.
- Questionnaire.

The Committee has considered the ethical merit of your submission and approved the protocol. The approval is for a fixed period of one year, beginning 2nd April, 2019 to 1st April, 2020 renewable thereafter. The Committee may however, suspend or withdraw ethical approval at any time if your study is found to contravene the approved protocol.

Data gathered for the study should be used for the approved purposes only. Permission should be sought from the Committee if any amendment to the protocol or use, other than submitted, is made of your research data.

The Committee should be notified of the actual start date of the project and would expect a report on your study, annually or at the close of the project, whichever one comes first. It should also be informed of any publication arising from the study.

Yours faithfully,

Rev. Prof. John Appiah-Poku.
Honorary Secretary
FOR: CHAIRMAN