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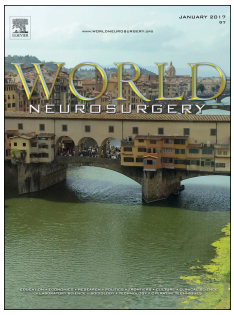

Mechanism of Pediatric Traumatic Brain Injury in Southwestern Uganda: a Prospective Cohort of 100 patients

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Mechanism of Pediatric Traumatic Brain Injury in Southwestern Uganda: a Prospective Cohort of 100 patients

Maria Punchak, MSc[1,2*], Jihad Abdelgadir, MD, MSc[1,3*], Oscar Obiga, MMed[4], Martha Itait, BSN[4], Josephine N Najjuma, BSN, PGD[4], Michael M. Haglund, MD, PhD, MACM[1,3,5], David Kitya, MMed.[4]

[1]Duke University Division of Global Neurosurgery and Neuroscience, Durham, NC, USA; [2]David Geffen School of Medicine at UCLA, Los Angeles, CA, USA; [3]Department of Neurosurgery, Duke University Medical Center, Durham, NC, USA; [4]Department of Neurosurgery, Mbarara Regional Referral Hospital, Mbarara, Uganda; [5]Duke University Global Health Institute, Durham, NC, USA.

[*]co-first authors

Corresponding Author:

Michael M. Haglund, M.D., Ph.D., M.A.C.M
Division of Global Neurosurgery and Neurology, Duke University
310 Trent Drive
Durham, North Carolina 27710, United States
Email: Michael.haglund@duke.edu

ABSTRACT

Background

RTIs, falls and violence contribute to more than two thirds of pediatric TBIs in SSA. In this study, we sought to assess mechanisms of pediatric TBI in an effort to propose interventions for more effective pediatric head injury prevention.

Methods

A cohort of 100 patients who were <18 years treated at MRRH between November 2016 and June 2017 were enrolled in the study. Information on etiology of injury was obtained via a questionnaire administered to patient caretakers at the time of admission.

Results

The mean age was found to be 7.5 years (SD 5.2) and 38% were female. In our sample, 61% had CT imaging done, of which 88.5% had a positive finding. A majority of patients presented with a mild head injury (55%). RTIs were the predominant mechanism of injury across age groups (75%). Across all age groups, falls were responsible for a greater proportion of injuries in children aged 10-14 years (13.3%), while the highest proportion of intentional injuries was reported in age group 10-14 and 15-17 years, 20% and 31.3%, respectively. Patients involved in pedestrian RTIs were significantly younger compared to those injured in non-pedestrian RTIs. Most parents (87.9%) were not with their children at the time of a pedestrian RTI.

Conclusion

In Southwestern Uganda, the majority of pediatric neurotrauma patients are injured pedestrians, with no adult supervision at the time of the injury. Conducting a public awareness and education campaign on the necessity of child supervision is critical to decreasing pediatric head injuries in Uganda.

INTRODUCTION

Traumatic brain injury (TBI) is the leading cause of death and disability in children and young adults around the world.[1] Moreover, TBIs are involved in nearly half of all trauma deaths, and account for more than 10% of total global disability adjusted life years. TBI incidence is on the rise due to due to increased use of motor vehicles—especially in low and middle income countries—which results in road traffic incidents (RTIs).[2] While the current incidence in Europe is 235 per 100,000 per year, incidence is thought to be even higher in Africa, although reliable data is not available for the entirety of the region.[2]

Among all children, head trauma, most commonly as a result of RTIs, stands out as the leading cause of long term disability, affecting both motor and cognitive abilities.[2–4] This subsequently negatively affects a child's educational performance and lifelong access to opportunities that stem from that education. Oftentimes, the poorest children are those that are the most negatively affected. Children from a low socioeconomic status are more likely to be street hawkers as well as walk and play at roadsides or man roadside shops.[5]

The mechanism of pediatric head trauma varies across geographic regions. For instance, in the United States, falls constitute the most frequent mechanism for children aged under 12 years, while adolescents are more prone to assaults, RTIs and sports injuries.[5] In a cohort from Nepal, falls were the most common causes of pediatric head injuries, followed by RTIs, most of which involved pedestrians hit by vehicles.[6] In Taiwan and Iran, the most common etiology was RTIs, followed up falls and assaults.[7,8] Data on the mechanism of pediatric head trauma in low- and middle-income countries (LMICs) is severely lacking. In fact, only one study from Nigeria addressed the mechanism and outcomes of pediatric head trauma in sub-Saharan Africa (SSA), concluding that RTIs accounted for more than two thirds of all pediatric head trauma, followed by falls and violence.[5] In adult studies from Uganda, TBI was determined to be the predominant cause of neurosurgical admissions and deaths, accounting for 87% of all neurosurgical admissions and resulting in an overall mortality rate of 13%.[9,10]

In order to create and institute preventive public health interventions to decrease the incidence, morbidity and mortality of pediatric head injuries in Uganda, a better understanding of why these injuries are happening is necessary. By interviewing the mothers of pediatric patients presenting to Mbarara Regional Referral Hospital (MRRH) with head injury, we sought to assess

mechanisms of pediatric head injuries presenting to this referral hospital and their associations with patient outcomes in an effort to propose interventions for more effective pediatric head injury prevention.

METHODS

Study Population and Setting

The study was conducted at MRRH, one of the 14 government referral hospitals in Uganda, and the only one serving Mbarara District.[11] The majority of the population of Mbarara District is less than 40 years of age (84%) – 29% are the below the age of 10, 23% between the ages of 10 and 19, and 31% between the ages of 20 and 39 years.[12] The hospital serves a population of over four million people in Southwestern Uganda, and has a capacity of 600 beds, 8 ICU beds.[13,14] The staff consists of 410 persons, only one of whom is a neurosurgeon.[13,15] Within Southwestern Uganda, Mbarara Regional Referral Hospital is the only hospital with a staff neurosurgeon.[15] At MRRH, all neurological patients are admitted either through the accident & emergency department (A&E) or through the neurosurgical outpatient department (OPD).

Study Design

We carried out a prospective cohort study, which captured the first 100 pediatric head trauma patients <18 years of age who presented MRRH between November 2016 and June 2017. This study was nested inside a larger MRRH Neurological Database study. The database captures variables on patient demographics, patient risk factors, diagnostic and laboratory results, management, delays in care, complications and outcomes. Information on etiology of injury was obtained via a questionnaire administered to patient caretakers at the time of admission. Injury etiology was stratified into several causes – road traffic incidents (RTI), falls, sports injuries, non-intentional trauma, defined as accidental trauma that is preventable, and intentional trauma, more commonly referred to as assault.[16]

Patient Selection

All pediatric patients (<18 years of age) admitted to the neurosurgical ward through A&E or OPD for head trauma were included in this study regardless of whether they are managed

medically or surgically. This also includes patients who are admitted to the A&E department and subsequently discharged there with CT done or pending.

Data Collection

All data on the mechanism of injury was gathered via direct interaction between the patient caregiver and the researcher or the trained research assistant (MP, MI). Additional data, including demographics, user/provider delays as well as clinical data on the patient comorbidities, physical exam assessment, and diagnostic results were reviewed and documented on standardized templates by research assistants and subsequently entered into a password protected database, stored on researchers' encrypted devices and then uploaded to a HIPAA-compliant Duke surgery servers.

Data Analysis

Variables from the data collection tools were entered into the REDCap (Research Electronic Data Capture, https://projectredcap.org/) platform and analyzed using Stata software version 14.0. Descriptive statistics were used to calculate the patient demographics, injury etiology, injury severity, CT findings, patient treatment and outcome data for all patients. Association between injury etiology and mortality in pediatric TBI patients were determined using Mantel-Haenszel odds ratios. Variables found with a significant association with the outcome of interest with a p-value of <0.05 were considered statistically significant.

Ethical Approval

Ethical approval was obtained from Mbarara University of Science and Technology Research Ethics Committee (Protocol No. 160130) and the Duke University Health System Institutional Review Board (Protocol No. 00069190).

RESULTS

Demographics, Clinical Characteristics and Disposition

A total of 100 patients were included in the study. The mean age was found to be 7.5 years (SD 5.2) with 38% of the patient population being female. When stratified by age group, the gender ratio was 1M:1F in patients in age groups 0-4 years and 5-9 years. Among patients in age groups

10-14 and 15-17, the ratio was 6.5M:1F (**Figure 1**). The vast majority of patients presented with mild (55%) and moderate head injury (30%), while 11% presented with severe injury (GCS <= 8) and data on GCS was missing for 4% of the patients. In our sample, 61% had CT imaging done, of which 88.5% had a positive finding. A total of 24 patients had multiple CT findings. The majority of CT scan findings were skull fractures (38.5% of all CT findings), and contusions (30.8%). Other findings included subdural hematoma (SDH) (6.4%), epidural hematoma (EDH) (9.0%), intraventricular hemorrhage (IVH) (2.6%), subarachnoid hemorrhage (SAH) (1.3%), pneumocephalus (3.7%), and brain edema (7.7%). Most lesions were small and did not necessitate surgical intervention. A total of 8 patients underwent neurosurgical intervention, with the most common procedure being skull fracture elevation and/or duroplasty. Mortality among the patient cohort was 4%, with 1 patient initially presenting with mild head, 2 with moderate and 1 with severe head injury. Further details are depicted in **Table 1**.

Mechanism of Injury

RTIs represented the most common mechanism of head injury. 75% of all patients and 70% of children aged 2 years or less suffered a head injury secondary to this mechanism. Other causes of head injury were intentional injury (10%), fall (6%), non-intentional injury (5%) and sports injury (2%). We were not able to identify the cause of injury for two patients. Further details are provided in **Table 2**.

When assessing mechanism of injury by age group, RTIs predominated across all age groups. In age group 0-2 years, RTIs were responsible for 70% of TBIs, and non-intentional and intentional injuries combined were responsible for around 30% of TBIs. A similar statistic was noted in the age group 3-9 years old, where RTIs is were responsible for 83.93% of TBIs; however, falls were responsible for a greater proportion of injuries in this age group (7.14%), intentional injuries accounted for 4% while non-intentional injuries made up 1.79%. In older children, age groups 10-14 and 15-17 years, RTIs were still the most common cause of injury. Nevertheless, these groups had the highest proportion of intentional injuries, 20% and 31.3% in age groups 10-14 and 15-17 years, respectively. Falls were responsible for 13.3% of TBIs in age group 10-14 years, but no falls were reported in age group 15-17 years. **Figure 2** provides further details.

Interviewees reported that the majority of injuries took place on the street (60%), while 22% took place at home. With regards to location of the child's caregiver at the time of the injury, the

caregiver was with the child at the time of injury in 12% of the cases, while they were home when the injury occurred in 52% of the cases. **Table 2** contains further information on location of parents or guardians during the patient's head injury.

Pedestrian Injuries

Of those injured in RTIs, 79% were pedestrians, 12% were motorcycle passengers and others were cyclists or car passengers (**Figure 3**). The mean age of patients involved in pedestrian RTIs was significantly younger compared to those injured in non-pedestrian RTIs - 5.9 years and 10.7 years, respectively ($p<0.001$, **Figure 4**). Most parents (87.9% of all pedestrian injuries) were not with their children at the time of a pedestrian RTI (**Figure 3**). When the severe outcome was defined as death or need for neurosurgical intervention, all patients who suffered a head injury secondary to an RTI were found to be pedestrians ($p=0.083$).

DISCUSSION

Around the world, traumatic brain injury is the leading cause of death and disability among children.[1] The rise in urbanization across low and middle income countries has further led to a significant increase in trauma across those nations.[2] In an effort to seek solutions for combating the rise of pediatric head injuries in developing countries, this study sought to determine the primary causes of these injuries and to study the circumstances around which these incidents occurred. This prospective study used caregiver interviews in combination with hospital encounter data to report the mechanism and outcomes of TBI in children under 18 years of age who were admitted to a regional referral hospital in Mbarara, Uganda. Only a minority of children presented with severe head injury and more than half presented with mild head injury. The vast majority of patients with a CT scan had a positive finding, with the main findings were skull fracture and contusion. Most injuries were secondary to RTIs with most victims, particularly those of younger ages, being pedestrians. In only a few cases, caregivers were present at the time of the child's injury.

The distribution of patient ages, genders and severity of injury found within our patient cohort was similar to those reported in previously published literature. We noted a bimodal peak in patient age distributions, with patients under 5 years and those >15 years suffering the greatest

number of head injuries. Younger children have been noted to be more susceptible to head injuries due to their larger head sizes, weaker neck musculature and support and thinner calvarium.[17] Meanwhile, older pediatric patients tend to suffer from increased head injuries secondary to RTIs and non-incidental trauma.[18]

The majority of the patients in our study, especially those 10 years of age and older, were males which is similar to previously reported frequencies.[19] Males' propensity for risky behaviors and tendency to start manual work in adolescence could explain this finding. However, the gender ratio was equivalent for patients under 10 years of age. Given most patients of that age group were found to be injured when walking to/from school and the population of Mbarara district has an equivalent sex ratio and is nearly uniformly split in terms of a rural vs urban population, this finding could potentially suggest children in southwestern Ugandan attend primary school in equal proportion. However, the questionnaire used for this study did not capture the location of patient injuries. If most injuries among children < 10 years of age are occurring in urban settlements, then we cannot subsequently extrapolate the same is true for rural areas. Thus, further studies are useful to further assess this association.

Similar to findings from Nepal who reported 65% patients with mild head injuries, we found that 55% of our patient cohort suffered from mild head injuries.[19] Meanwhile, the low incidence of severe head injuries seen within our study is representation of findings in the current literature.[20] It is possible that absence of transportation, low socioeconomic status or lack of prehospital care could be contributing to the lower cases of severe head injury in our population, as these children probably die before reaching the hospital.[21]

Beyond understanding the epidemiology of the pediatric patient population who suffers head injuries, recognizing the conditions and circumstances under which these instances occur is a vital step for creating future interventions to decrease the rate of TBI. Similar to previous studies, this study found that while RTIs dominated as the leading cause of head injuries in children,[22] more significantly, most children who suffered a head injury secondary to an RTI in our cohort were pedestrians. Similarly, a hospital based study from the United States previously reported a high incidence of pedestrian RTIs, although no such data has previously been reported from LMICs.[23] Interestingly, in that study, the highest incidence of pedestrian RTIs occurred among children aged 6-10 years.[23,24] Within our study, the highest incidence was seen among children

under 5 years; however, the incidence continued to be almost similarly high in children aged 5-9 years. Perhaps the most striking finding within our study was that almost 90% of children involved in pedestrian RTIs were not with a parent or guardian at the time of the incident and pedestrian RTIs were more likely to suffer an unfavorable outcome.

Lack of adult supervision of children is a major risk factor for burns and other childhood injuries.[25] However, lack of child supervision is particularly pronounced in LMICs where children often walk to school without their adult guardians, perhaps accompanied by only a slightly older sibling. Children may also play on the sides of streets or busy marketplaces unsupervised while their guardians are busy at work. This study demonstrates that the majority of our pediatric patient population presenting with head injuries are young unsupervised pedestrians. Increasing supervision may be a method for increasing pedestrian safety. Barton, et al. has demonstrated that children behave more cautiously when crossing the street supervised.[26] Studies by psychologists have shown that children judge their physical abilities more cautiously when parents are present.[27] The findings suggest supervising parents or adults could intervene to prevent children from attempting dangerous activities given that children are more likely to overestimate their abilities than parents.[27] Future studies should be geared towards implementing such interventions in the region and assessing their impact.

Given the findings of our study, increasing public awareness on the increased risk of pedestrian RTI head injuries among unsupervised children is necessary. Public awareness and education campaigns have been shown to improve outcomes in other LMICs. In Mexico, an awareness campaign in conjunction with a law enforcement campaign targeting seat belt and child restraint use led to a reduction in road traffic collisions.[28] Another study from Brazil which carried out educational training in health centers and schools as well as conducted a public awareness campaign with media distribution of videos, souvenirs and pamphlets, resulted in a 26% decrease in mortality as well moderate and severe trauma secondary to RTIs.[28,29] Thus, conducting a public awareness and education campaign on the necessity of child supervision is critical for decreasing pediatric head injuries in Uganda.

Limitations

There are several limitations to our study. Most notably, we obtained data from a sample size of only 100 pediatric patients, thus making it difficult to determine whether our findings over- or

underestimated the frequencies of various injury mechanisms. Moreover, this study was limited to one referral hospital located in Southwestern Uganda, thus making it difficult to extrapolate the conclusions made to other populations that are more urbanized or more rural. However, it is important to note that all data was collected prospectively, either from patient charts during admission or from patient caretakers.

CONCLUSION

This was the first prospective study from an LMIC to investigate the circumstances surrounding pediatric head injury. We found that in Southwestern Uganda, most pediatric head injuries occur secondary to RTIs with most victims, particularly those of younger ages, being pedestrians. In most cases, caregivers were notably absent at the time of the child's injury. Increasing pediatric supervision is a necessary step to decrease the incidence of pediatric head injuries in Uganda.

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Table 1. Patient characteristics, patient demographics and clinical outcomes	
Patient age, mean (SD)	7.5 (5.19)
Gender (females), n (% of patients)	38 (38%)
CT of the brain performed, n (% of patients)	61 (61%)
Admission GCS	100 (100%)
13-15	55 (55%)
9-12	30 (30%)
3-8	11 (11%)
unknown	3 (3%)
Patients with positive finding on CT of the brain, n (% of patients)	54 (54%)
CT Findings, n (% of all CT findings)	78 (100%)
Subdural hematoma (SDH)	5 (6.4%)
Epidural hematoma (EDH)	7 (9.0%)
Intraventricular hemorrhage (IVH)	2 (2.6%)
Subarachnoid hemorrhage (SAH)	1 (1.3%)
Pneumocephalus	3 (3.7%)
Skull Fracture	30 (38.5%)
Contusion	24 (30.8%)
Brain edema	6 (7.7%)
Neurosurgical intervention, n (%)	8 (8%)
Elevation of depressed skull fracture	2 (2%)
Duroplasty	2 (2%)
Elevation of depressed skull fracture + duroplasty	1 (1%)
Cranioplasty	1 (1%)
Craniectomy	1 (1%)
Burr holes	1 (1%)
Disposition, n (%)	97 (3%)
Discharged	82 (82%)
Died	4 (4%)
Transferred	2 (2%)
Absconded	12 (12%)

Table 2. Mechanism and location of pediatric head trauma presenting to MRRH.

	All patients (n= 100)	Children </=2 years (n= 10)
Primary causes of injury		
RTI	75 (75%)	7
Fall	6 (6%)	0
Sports injury	2 (2%)	0
Intentional trauma	10 (10%)	1
Non-intentional Trauma	5 (5%)	2
Unknown	2 (2%)	0
Location of injury		
Home	22 (22%)	6
School/Childcare center	4 (4%)	0
Street	60 (60%)	4
Other	3 (3%)	0
Unknown	11 (11%)	0
Location of parents/guardian		
Home	52 (52%)	4
Garden/farm	4 (4%)	1
With child	12 (12%)	5
Other	9 (9%)	0
Unknown	23 (23%)	0
Role if RTI		
Pedestrian	58 (77.3%)	4
Cyclist	5 (6.7%)	0
Motorbike passenger	9 (12.0%)	3
Car passenger	1 (1.3%)	0
Unknown	1 (1.3%)	3

Figure 1. Gender of pediatrics patients presenting to MRRH, stratified by age group.

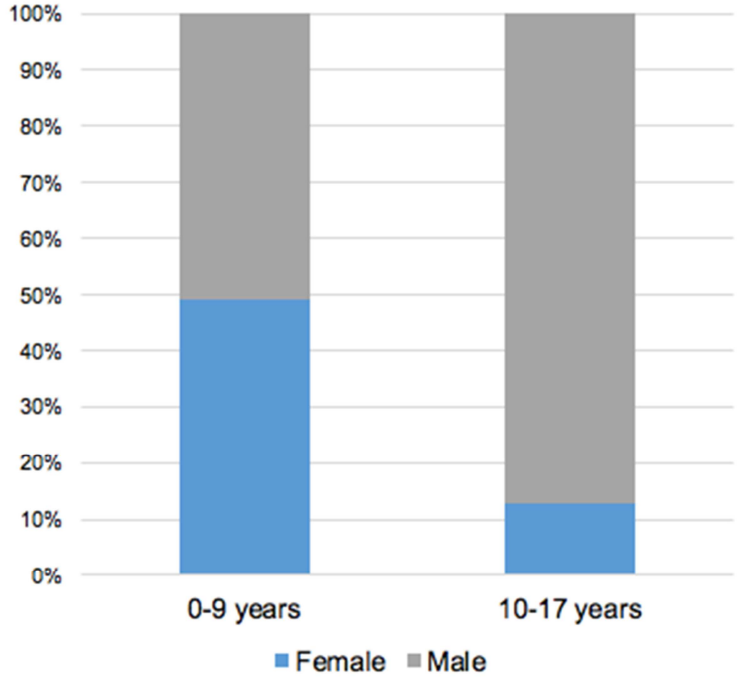


Figure 2. Mechanism of head injury among pediatrics patients presenting to MRRH, stratified by age group.

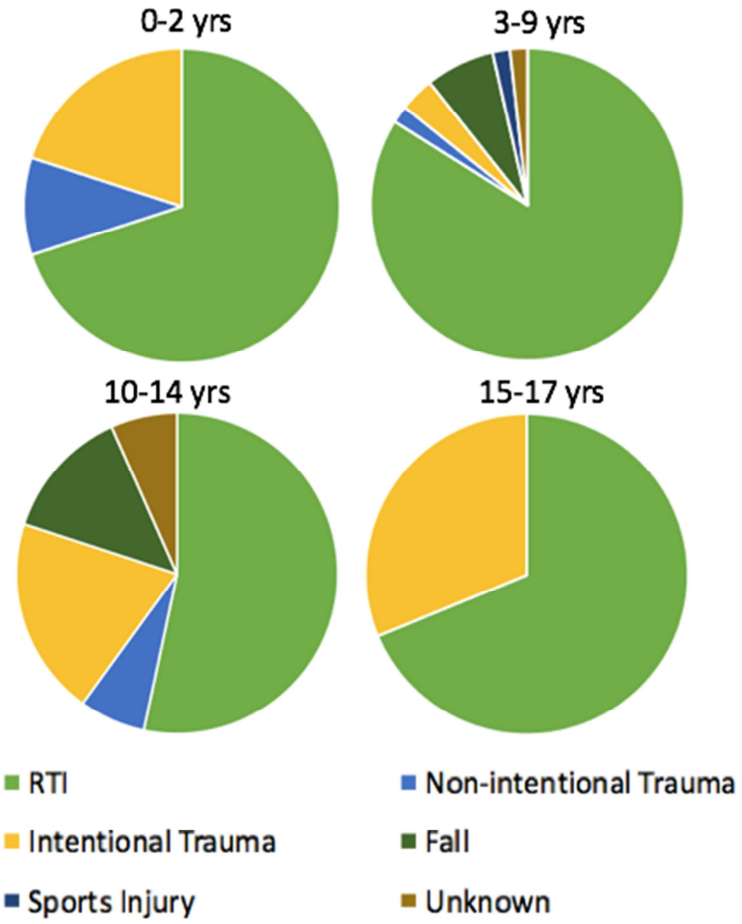


Figure 3. Patient role within road traffic incident and adult supervision status.

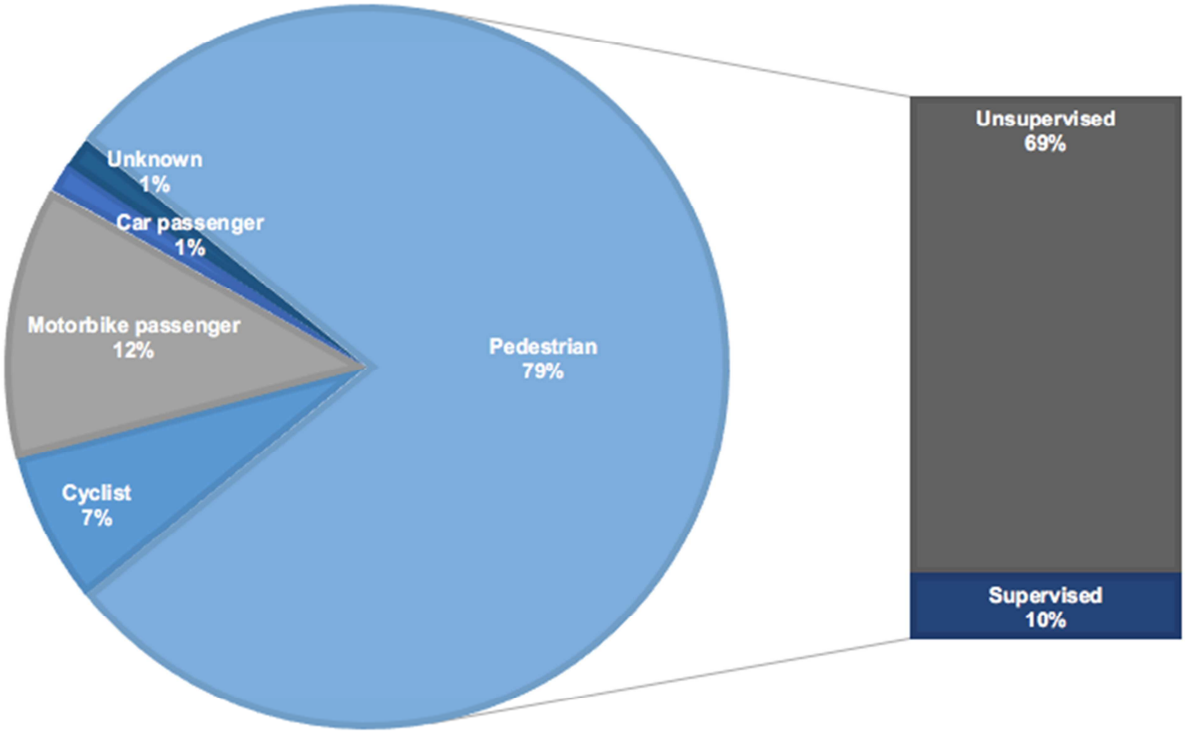
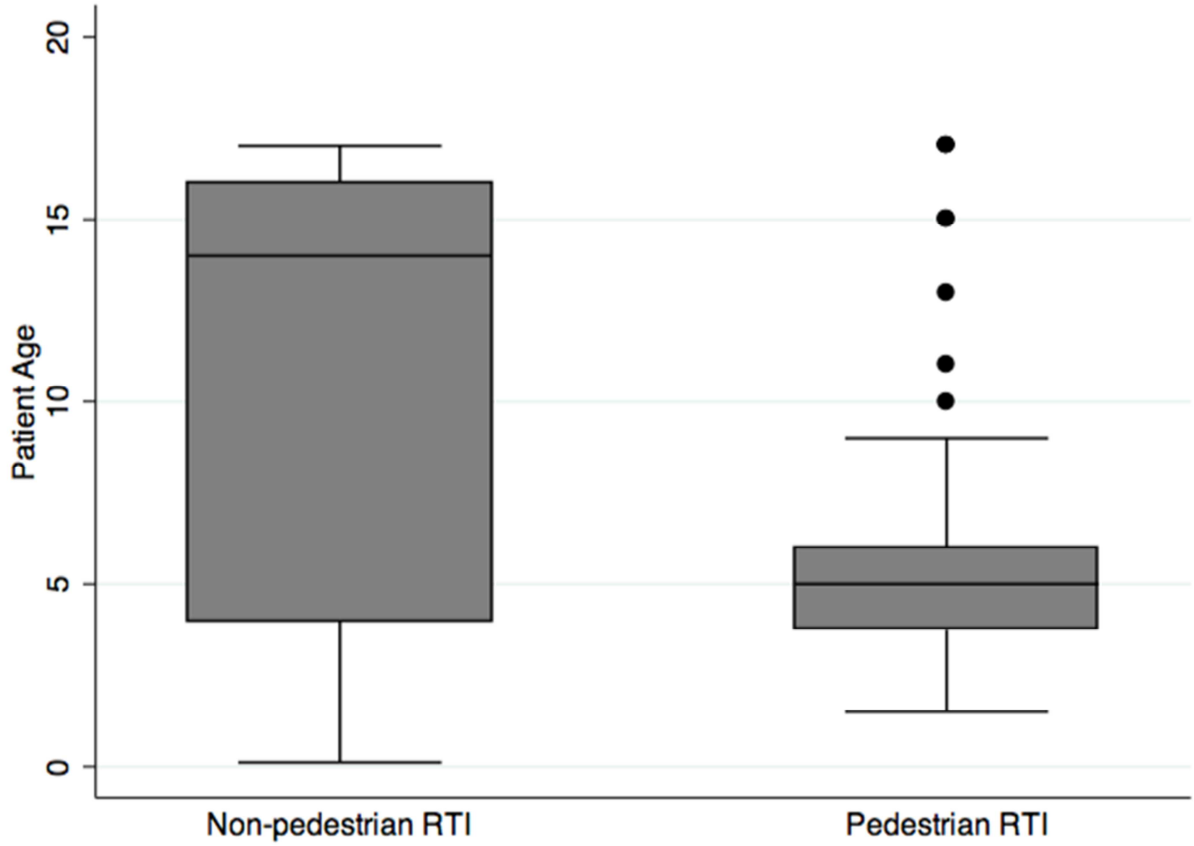


Figure 4. Distribution of patient ages after pedestrian vs non-pedestrian RTIs.



HIGHLIGHTS

- First LMIC study to investigate the circumstances surrounding pediatric head injury.
- The majority of pediatric neurotrauma patients are injured pedestrians.
- Caregivers were notably absent at the time of the child's injury.

ABBREVIATIONS

Accident & Emergency department (A&E)
Epidural hematoma (EDH)
Intraventricular hemorrhage (IVH)
Low- and middle-income country (LMIC)
Mbarara Regional Referral Hospital
Outpatient department (OPD)
Research Electronic Data Capture (REDCap)
Road traffic incident (RTI)
Subarachnoid hemorrhage (SAH)
Subdural hematoma (SDH)
Sub-Saharan Africa (SSA)
Traumatic brain injury (TBI)