ARSI UNIVERSITY

COLLEGE OF HEALTH SCIENCE

DEPARTMENT OF PEDIATRICS AND CHILD HEALTH

TRAUMATIC BRAIN INJURY OUTCOME AND ASSOCIATED FACTORS AMONG PEDIATRIC PATIENTS TREATED AT ASELLA REFERRAL AND TEACHING HOSPITAL: A 4-YEAR RETROSPECTIVE STUDY

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A THESIS RESULT TO BE SUBMITTED TO ARSI UNIVERSITY, COLLEGE OF HEALTH SCIENCES, ASELLA REFERRAL AND TEACHING HOSPITAL, DEPARTMENT OF PEDIATRIC AND CHILD HEALTH, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR A SPECIALTY CERTIFICATE IN PEDIATRICS AND CHILD HEALTH.

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ABBREVIATIONS AND ACRONYMS

AEDH----------Acute Epidural Hemorrhage

AOR- ----------Adjusted Odd Ratio

ARTH----------Asella Referral and Teaching Hospital

CT Scan ---------Computed Tomography Scan

COR----------Crude odd ratios

CSA----------Central Statistical Agency

CPGs----------Clinical Practice Guideline

ED- ----------Emergency Department

EOPD- ----------Emergency Outpatient Department

ETAT----------Emergency Triage Assessment and Treatment

FMOH----------Federal Ministry of Health

GCS- ----------Glasgow Coma Scale

GOS----------Glasgow Outcome Scale

ICU- ----------Intensive Care Unit

ICP----------Intracranial Pressure

IERB----------Institutional Ethical Review Board

LMIC----------Low and Middle Income Countries

MVCs----------Motor Vehicles Collisions

RTA----------Road Traffic Accident

TBI----------Traumatic Brain Injury

WHO----------World Health Organization

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ABSTRACT

Background: Traumatic brain injury is a brain injury that occurs following a blow to the head, a fall, a bullet, a high-speed crash, or an explosion that disrupt physiologic and anatomic function of the brain. Despite the significant burden of Traumatic Brain Injury, there is a lack of comprehensive, data-based studies in this area, particularly in low-resource settings, limiting the development of effective prevention and management strategies.

Objective: To assess treatment outcome and associated factors of traumatic brain injury among pediatric patients treated at Asella Referral and Teaching Hospital, Asella, Southeast Ethiopia.

Methods: An institution-based retrospective cross-sectional study was conducted on 282 pediatric patients with traumatic head injury treated at Asella Referral Hospital from 2021 to 2024. Data were analyzed using SPSS version 27. Bivariate and Multivariable logistic regression were performed to identify factors independently associated with unfavorable outcomes. Adjusted odds ratios with 95% CI were used to measure the strength of associations, and statistical significance was declared at $p < 0.05$.

Results: In this study of 282 patients, 49 (17.4%) of pediatric traumatic brain injury patients had an unfavorable outcome. Lower Glasgow Coma Scale(AOR = 2.96 (95 % CI 1.36 - 8.91)), the presence of increased intracranial pressure(AOR=3.61(95%CI 1.71-7.62)), and the need for Intensive Care Unit(AOR= 6.04(95%CI, 2.02-17.58)) were found to be significantly associated with unfavorable outcomes.

Conclusion: A significant proportion of pediatric patients with traumatic brain injury experienced unfavorable outcomes. Severe brain injury, increased intracranial pressure, and intensive critical care requirements were independently associated with adverse outcomes. Early identification of high-risk patients and prompt management may improve pediatric TBI outcomes.

Key words: Traumatic brain injury, Associated Factors, Pediatrics, ARTH, Treatment Outcome

1. INTRODUCTION

1.1 Background

Traumatic brain injury (TBI) is defined as a brain injury that occurs following a blow to the head, a fall, a bullet, a high-speed crash, or an explosion that disrupts physiologic and anatomic function of the brain. It can be an open (penetrating) or closed type(1). Low- and middle-income countries (LMICs) have three times higher TBI burden than high-income countries. Road traffic-related head injury was reported to be common in LMICs. Globally, TBI is projected to be the third leading cause of death and injury by the World Health Organization in 2030(2,3).

The incidence and severity are significantly rising as a result of the rapid growth of industrial activity and the expansion of transportation modalities(4). TBI is the leading cause of death and disability in children(5). Over 80% of injuries and deaths in children occur in LMIC. Globally, the road traffic death rate among children is 10.7 per 100,000, while in the African region it is almost double at 19.9 per 100,000(6,7).

The pattern of TBI varies with age and country. In the U.S, the leading causes of TBI-related emergency department (ED) visits, hospitalizations, and deaths for those < 15 years of age were unintentional falls and being struck by or against an object, whereas for those 15-24 years of age, the leading causes were motor vehicle crashes and falls. Another common cause of TBI is sports and recreational activities among TBI-related ED-visited children and teens in 2012(5).

Pediatric TBI is a devastating disease that affects all countries in the world. Adherence to pre-hospital Clinical Practice Guidelines (CPGs) can prevent secondary brain injury and subsequently reduce morbidity and mortality. A strategy for LMICs may be to adapt high-quality CPGs with deliberate effort to ensure local applicability and feasibility on multiple levels(8).

Some recent studies report that the burden of head injury in developed countries is slowly decreasing due to the strong implementation of the strategy of prevention(9,10). WHO strongly recommends educating people about the ways TBI occurs and is prevented. Information about TBI prevention can be included in school health education programs. To solve these problems,

the World Health Organization recommends the establishment of first-responder training programs in LMICs(9,11) and Emergency Triage, Assessment, and Treatment plus (ETAT+) training(12). Considering the burden of injury in our country, FMOH adopted the ETAT for primary emergency care in our health system. Even though the strategic plan was launched, the incidence of injury has still not significantly changed (13).

Pediatric TBI has several distinctive features that differ from those in adults and are due to age-related anatomical and physiological differences, injury patterns based on the child's physical development, and challenges in neurological assessment in children (7). The cause, or mechanism, of TBI is crucial for understanding its epidemiology because injury mechanisms indicate the types of events that should be prevented. The mechanisms of TBI vary by age (10).

While moderate to severe injuries are thought to lead to greater impairment, there has been considerable interest given to mild injuries, which are often referred to as concussions. The vast majority of all brain injuries are mild (57 million)(14) and tend to resolve in days or weeks with no long-term negative consequences. However, approximately 10–15% of mild injuries are thought to lead to long-term deficits. Research has shown that potential serious consequences of concussion and brain injury are poorly understood by members of the public, educators, and healthcare professionals (10).

Institution-based research done in southern Ethiopia found that the main cause of TBI was RTA (road traffic accidents). Followed by falls and predominantly affecting males more than females. Concerning the outcome at discharge, 95.6% study subjects recovered from the injury. Good recovery without neurologic deficit, focal neurologic deficit, and depressed mentation were documented in 267 (84.2%), 30 (9.5%), and 10 (3.2%) of study subjects, respectively. Ten (3.2%) deaths were documented, and 2 cases were referred to another hospital, and 2 left against medical advice(15).

The Ethiopian Federal Ministry of Health (FMoH) has been working to reduce the burden of pediatric trauma by implementing ETAT + strategies (13), and the Ethiopian health sector program provides great attention to injuries and violence prevention(11). Despite the above-mentioned programs and trials, there are still numerous children with trauma problems in Ethiopia. TBI is varied among different age groups, place-to-place, and time-to-time due to

different characteristics(10). There limited study done in Ethiopia concerning outcomes and associated factors of pediatric traumatic brain injury(14). Besides, as far as our knowledge is concerned, there is no sufficient information in this study area. Assessing treatment outcomes and associated factors of pediatric trauma is essential for informing policy decisions and implementing effective preventive measures.

1.2 Statement of The Problem

Traumatic brain injury (TBI) is a growing contributor to childhood death, disability, and years lived with disability worldwide(16). The global incidence of pediatric traumatic brain injury (TBI) varies significantly across countries, with most reporting incidence rates ranging from 47 to 280 cases per 100,000 children (17). In LMICs, injuries are a public health crisis, with TBI ranking as the third highest cause of death(2–4)**.** More than 90% of injury deaths occur in LMICs (2)**.** Asia contributes a large share of the world's pediatric traumatic brain injury burden because of population size, high road traffic injury rates, and variable health-system capacity(18).

In Sub-Saharan Africa (SSA), pediatric traumatic brain injuries affects a sizeable proportion of injured children with case-fatality rates higher than global averages(19). In Ethiopia, injuries were responsible for an estimated 25,000 deaths among children aged 0–14 years in 2015, a figure that is more than twice the number projected by global burden of disease estimates(20)**.** Projections of pediatric trauma-related mortality in Ethiopia indicate a rising trend, with annual deaths due to injuries estimated at 26,463 in 2015, increasing to 27,807 in 2020, and expected to reach 30,364 by 2030(14)**.**

The socioeconomic impact of injury-related disabilities is particularly severe in low-income countries, where trauma care and rehabilitation services are often underdeveloped, and social welfare systems are limited or entirely lacking(20)**.** The major contributors to trauma-related challenges in low- and middle-income countries (LMICs) include the absence of effective prehospital care systems and formal triage protocols, inadequate staffing levels, overwhelming patient loads in emergency departments, and limited access to basic surgical services(21,22).

Although several studies in Ethiopia have examined head injuries, there is limited pediatric studies on outcomes. Pediatric TBI constitutes a common cause of admission to ARTH;

however, there is no comprehensive local study assessing treatment outcomes and the factors associated with these outcomes.

This study is essential to fill the existing knowledge gap by assessing treatment outcomes and associated factors of traumatic brain injury among pediatric patients at Asella Referral and Teaching Hospital (ARTH). The findings are expected to inform clinical practice, guide public health policy, and support efforts to improve both preventive and rehabilitative care for injured children in Ethiopia and similar settings.

1.3 Significance of the study

This study provides important evidence on treatment outcomes and associated factors among pediatric patients with traumatic brain injury (TBI) at our setup. Unlike previous studies that primarily reported overall mortality or combined adult and pediatric populations, this study provides pediatric specific evidence on outcomes and their determinants. By identifying key predictors of unfavorable outcomes, the findings contribute to a better understanding of the burden and determinants of pediatric TBI, which is essential for improving the quality and effectiveness of care. The results generate locally relevant evidence that can support informed clinical decision-making and guide improvements in pediatric neurotrauma management.

From a health policy and planning perspective, the findings of this study offer valuable information for healthcare administrators, planners, and policymakers. Evidence on outcome patterns and associated risk factors can inform priority setting, efficient allocation of limited healthcare resources, and strengthening of pediatric trauma and critical care services. The study also highlights areas where targeted preventive strategies and early intervention programs may reduce adverse outcomes, thereby contributing to improved child health outcomes.

Furthermore, this study serves as an important reference for strengthening health systems by providing baseline data on pediatric TBI outcomes in the study setting. The findings can be used to support the development or revision of local-specific clinical guidelines and institutional protocols for pediatric TBI management. In addition, the study contributes to the existing body of knowledge and provides a foundation for future research, monitoring, and evaluation efforts aimed at improving pediatric traumatic brain injury care and outcomes.

2. LITERATURE REVIEW

2.1 Overall Prevalence of Head Injury

The Global Burden of Disease (GBD) Study demonstrated that injuries accounted for millions of deaths and a substantial proportion of disability adjusted life years globally, underscoring their persistent impact on population health. The study also shows the absolute number of injury cases and deaths increasing due to population growth and demographic transitions, particularly in low- and middle-income countries(23)**.**

The worldwide incidence of pediatric TBI varies greatly by country, with most reporting a range between 47 and 280 per 100,000 children. The World Health Organization (WHO) estimates that TBI accounts for nearly 50% of all trauma-related deaths in children globally (WHO, 2023). Studies in high-income countries such as the United States and the United Kingdom report an annual incidence of 200–500 per 100,000 children(24)**.**

In Africa and Asia, pedestrians were most commonly injured in motor vehicle collisions (MVCs), while vehicle occupants were more likely involved among Australian, European, and US populations. For children, non-accidental trauma was prevalent in developing and developed nations alike. It concludes TBI is a relatively common entity stretching across traditional geographic and demographic boundaries and affecting pediatric populations worldwide. Continued civil infrastructure development and public health policy reforms may help to reduce the societal burden of pediatric TBI**.** More than 90% of injury deaths occur in low- and middle-income countries, where preventive efforts are often nonexistent and health-care systems are least prepared to meet the challenge. The socioeconomic impact of injury-related disability is magnified in low-income countries, where there are often poorly developed trauma care and rehabilitation systems and little or no social welfare infrastructure(17,20).

Other systematic review research brought together in this special issue highlights the need for improved provision for children and training for those who care for their needs. The hidden nature of brain injury means that deficits are often not immediately apparent, which can lead to unrealistic expectations and a lack of consideration. The long-term negative consequences of pediatric ABI have been shown to lead to reduced quality of life, poor educational outcomes,

greater reliance on state support, and in some cases, involvement with the criminal justice system beyond that extremely affected with psychosocial and economic burden throughout their life(25).

2.2 Associated Factors Related to Head Injury

2.2.1 Socio-demographic factor

Sociodemographic characteristics strongly influence both the risk of sustaining pediatric traumatic brain injury (pTBI) and the clinical outcomes after injury(26). Geospatial and large-database analyses done in US shows that clustering of pediatric head injuries in socioeconomically disadvantaged neighborhoods, with higher rates of severe injuries and lower preventive-safety uptake (helmet, seatbelt)(27).

Study done at one of the tertiary hospitals of Kenya the average age in this study was six years old but the majority of patients were under ten years old, and male. Most injuries (68.2%) also occurred in a place of residency, such as a home or apartment building. A large majority did not arrive by ambulance, and almost all received only analgesia or no pre- hospital intervention at all. Majority of the injuries were due to falls, and just under half of the injuries resulted in closed fractures with, not surprisingly, the most frequent location of injury being the extremities or bony pelvis. Head injuries and burns occur more frequently amongst zero- to four-year-olds. Additionally, out of the 144 charts included in the study, 138 were deemed accidental, one as non-accidental (i.e. assault), and five were undetermined(28).

Over the age of 3, male children suffered higher rates of TBI than females. A bimodal age distribution is often described, with very young children (0-2 years) and adolescents (15-18) more commonly injured(10). Students with mild injury typically recover within a few weeks, and most of them return to their pre-injury classrooms. However, in a large study following children younger than 18 years of age, 14% of children who experienced an moderate TBI needed educational support services at school 12 months later(9,10). Study conducted in southwest Uganda, the mean age was found to be 7.5 years (standard deviation 5.2) and 38% were female. In our sample, 61% had computed_tomography imaging done, of whom 88.5% had a positive finding. A majority of patients presented with a mild head injury (55%)(29).

Study published in 2020 done at Aabet hospital Addis Ababa, 8,520 patients seen in the emergency department. Of these, 6,700 were seen for traumatic injuries where 594 of the trauma patients were <18 years of age. 284 (69.8%) were males. The mean age was 11.7 ± 5.1 years. While most of the patients arrived at the hospital within 24 hours of injury, 134 (33%) presented more than a day after the injury. Males accounted for the majority of injuries in all categories of injury The patient's arrival from distances (out of Addis Ababa), ages between 5 to 12 years [AOR = 1.91, 95% CI (1.123.24)] and head injury [AOR= 1.82, 95%CI(1.06, 3.12)] are more likely to be admitted than those who are not(30)**.**

Study done at southwest Ethiopia on a total of 405 study participants, 271 (66.9%) of injured children were male. The majority 167 (41.2%) of children age group of five to twelve years were more affected by trauma and their mean age was found to be 9.26±4.95(31)**.**

2.2.2 Mechanism of Injury

Systematic reviews and large multi-study done in Africa identify RTIs as the single largest cause overall (particularly for moderate–severe injuries in school-age children an, with falls predominating in the youngest children and contributing a large share of mild injuries(32). Study conducted south west Uganda, 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%), whereas the greatest 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 with those injured in non-pedestrian RTIs. Most parents (87.9%) were not with their children at the time of a pedestrian RTI(33)**.**

Research done southern Ethiopia stated that the main cause of TBI was RTA (road traffic accidents), 144 (45.4%) cases. From RTA, the majority were pedestrians, 120 (83.3%), while 24 (16.7%) were occupants in vehicles. The other TBI causes were falls, 104 (32.8%); fighting/violence, 40 (12.6%); animal bite or kick injury, 28 (8.8%); and one case of assault (child maltreatment). Most preschool falls occurred at home 29 (60.7%), while 94.1% (32) of school aged and 97.6% (41) of adolescent falls happened outdoor. Eighty three (79.8%) of falls and 84 (58.3%) of road traffic accidents occurred in boys(15)**.**

Study published in 2020 done at Aabet Hospital in Addis Ababa, the major mechanisms of injury were road traffic accidents (RTA) 162 (39.8%), falls 105 (25.8%), physical assaults 71 (17.4%) and burn accounts 20 (4.9%). The majority of RTA injuries were 130 (80.2 %) pedestrians, 27 (16.7%) passengers, and 5 (3.1%) on drivers. Around 108 (26.5%) of injured children used an ambulance for transportation to the hospital, but only 27 (6.6%) of the injured children received pre-hospital care at the scene and on the way to the hospital(30**).**

Study done at southwest Ethiopia, trauma caused by falls was the most frequent in the 5–12 years old and the < 5 years old age groups, accounting for 43.7% and 34.4% % of all traumas respectively. Road traffic accidents were the most common cause of trauma among 13–18 years age groups children accounting for 40.8%. An animal bite was the third most common commonly trauma accounting for 50.0% and 33.3% of traumas in the age group of 13–18 and 5–12 years old respectively(31)**.** Retrospective study done at Agaro General Hospital found that falls (37.3%) and road traffic accidents (24.2%) were the top two mechanisms among pediatric trauma presentations(31).

2.2.3 Patient's Clinical Condition

Common presenting symptoms reported across large pediatric cohorts are vomiting, headache, loss of consciousness, altered behavior/mental status, and focal neurologic signs (weakness, cranial nerve deficits). Seizures at presentation occur more often in young children and in those with more severe injuries. Systematic reviews and multinational cohort studies done in developed countries emphasize that initial neurological status, most commonly recorded using the Glasgow Coma Scale (GCS) is the strongest single predictor of immediate outcome. Secondary physiologic derangements, hypoxia and hypotension are consistently associated with worse outcome and are major targets of early resuscitation(34,35).

A TBI of any severity experienced by a child can result in changes that affect a child's daily life. Most children with moderate TBI recover from the initial symptoms within 6 weeks after injury, with approximately 60% having persistent symptoms at one month post-injury,10% at three months post-injury, and less than 5% at one year post-injury(36)**.**

More severe brain injuries carry a range of medical, health, cognitive, motor, emotional, and behavioral issues. The significance of problems might not be realized until years after the injury when higher-level cognitive and behavioral functioning is required to meet typical developmental milestones, especially when the injury occurs at a very young age. Because of this, there is a critical need for follow-up care beyond the acute injury**.** Mild TBI (GCS ≥13) constitutes more than 80% of injuries, and up to 90% of all injuries are associated with negative imaging. Only a small fraction (<10%) requires surgical intervention. Independent of country or region of origin, the vast majority of children suffering TBI achieve a good clinical outcome. Hospital admission rates vary widely, with US patients more commonly admitted than those from other countries. Falls and motor vehicle collisions (MVC) represent the majority of injury mechanisms(10,37,38)**.**

Study published in 2020 done at Aabet Hospital in Addis Ababa, overall, 291 (71.5%) of patients were discharged and 115 (28.2 %) were admitted, with 1(0.2%) patients died in the emergency unit. Only 212 (52.1%) could be scored for Pediatric trauma severity score because of the absence of pediatric blood pressure measurement and only 5 patients identified with PTS score less than 8(30)**.** Study done at southern Ethiopia at one of the University Hospital, the outcome at discharge, 303 (95.6%) study subjects recovered from the injury. Good recovery without neurologic deficit, focal neurologic deficit, and depressed mentation were documented in 267 (84.2%), 30 (9.5%), and 10 (3.2%) of study subjects, respectively. Ten (3.2%) deaths were documented, and 2 cases were referred to another hospital and 2 left against medical advice(15)**.** Studies from Jimma Medical Center document presenting features such as loss of consciousness, vomiting, and neurologic deficits among TBI patients, and identify low GCS and delayed presentation as predictors of poor outcome in regional cohorts(39).

2.2.4 Intracranial and Extra Cranial Injury

Pediatric TBI commonly occurs with concomitant extracranial injuries affecting the face, chest, abdomen, spine and extremities. One study done at one the teritiary hospital of Malaysia found that Extracranial concomitant injuries were seen in 78% of the patients. Three commonest injuries were facial (44%), lower extremity (20%) and upper extremity (12%) injuries(40).

In the study of southern Ethiopia on University hospital study, associated extra-cranial injuries were reported in 256 (80.7%) cases of TBI. From these, soft tissue injury being the most common injury, 179 (56.5%), followed by extremity bone fracture, 70 (22.1%); chest or abdominal injury, 6 (1.9%); and one case of vertebral bone injury(15)**.** Outcome after management 129 (72.2%) TBI cases were managed conservatively, while 88 (27.8%) underwent various surgical interventions within the first (01) week of presentation. Most of the operated cases were aged 5 to 10 years, 48/88 (55%). No death was documented among the operated patients. The common surgical indications were the evacuation of epidural and subdural hematoma, 4(4.5%); wound debridement for compound skull fracture, 19 (21.3%); and depressed skull fracture elevation, 66 (74.2%). Elevation of depressed skull fracture was done for 66 cases with mild (53), moderate (12), and severe (1) TBI categories. Burr hole and evacuation was done for four mild TBI cases. Irrigation and debridement were done for mild (16) and moderate TBI (1) cases(15)**.**

2.3 Conceptual Framework

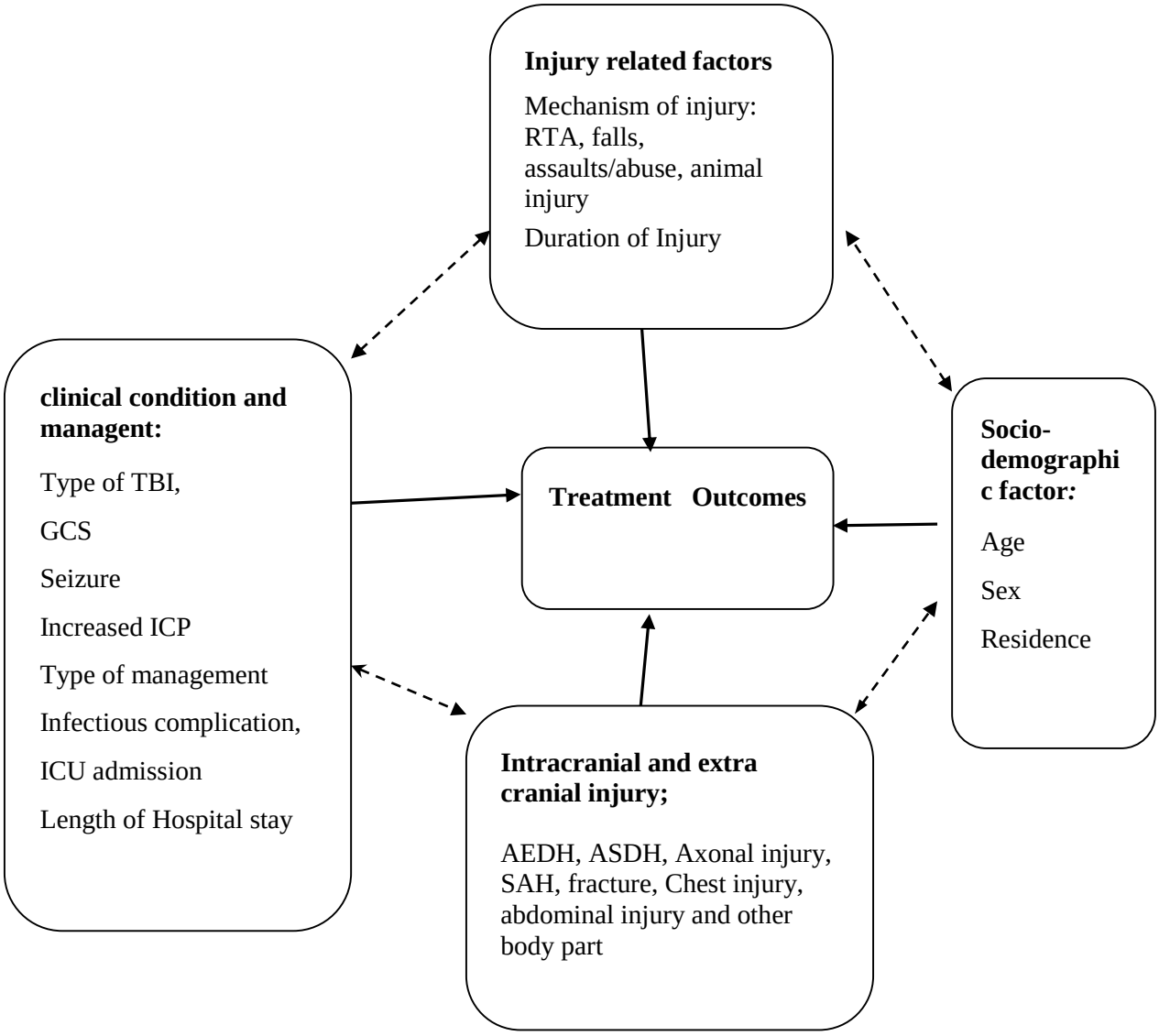

Figure 1: Conceptual framework of variables associated with outcomes of pediatric Traumatic brain injury at ARTH-2025.

(developed by the investigator by reviewing different literature mentioned(1,4,15,30,41))

3. OBJECTIVES

3.1 General Objective

To assess traumatic brain injury outcome and associated factors among pediatric patients treated at Asella Referral Teaching Hospital during 2021-2024, Asella, Ethiopia,

3.2 Specific Objectives

To determine traumatic brain injury clinical outcomes among pediatric patients treated at Asella Referral and Teaching Hospital between 2021-2024, Asella, Ethiopia.

To identify factors associated with outcomes of traumatic brain injury among pediatric patients at Asella Referral and Teaching Hospital between 2021-2024, Asella, Ethiopia.

4. MATERIAL AND METHOD

4.1 Study Area and Period

The study was conducted at Arsi University, CHS, Asella Teaching and Referral Hospital, which is located in the town of Asella. Asella is a town and separate woreda in central Ethiopia, which is located in the Arsi Zone of the Oromia Region about 175 kilometers to the southeast of Addis Ababa, the capital city of Ethiopia. Arsi University is one of the young universities established in 2014. Asella Teaching and Referral Hospital, however, is serving about 3.5 million people in Arsi and the nearby zones since 1964. The hospital is well equipped and has 321 beds, with more than 6 departments, including 100 beds for pediatric departments and 6 ICU beds for critically ill patients (adult and pediatric). The hospital is involved in training undergraduates and postgraduates in four different specialties. In the department of pediatrics and child health, there are 14 pediatricians and 23 residents. Neurosurgical interventions are provided by neurosurgeons, and radiologic images like head CT Scan are read by radiologists. These services are available 24 hours a day, and head CT Scan is acquired upon presentation of TBI cases.

4.2 Study Design and Period

An institution-based retrospective cross-sectional study was conducted from August to December 2025

4.3. Population

4.3.1. Source Population

All pediatric TBI patients presented to ARTH during the study period.

4.3.2. Study Population

All pediatric traumatic brain injury patients who presented to ARTH during 2021-2024, and met the inclusion criteria.

4.3.4 Inclusion Criteria

Pediatric traumatic brain injury patients presented to ARTH during the study period, and with complete medical records

4.3.5 Exclusion Criteria

Pediatric patients with incomplete or missed charts, those who were dead on arrival with no clinical or radiologic data available, patients with cerebral palsy, readmissions for the same event, those who left against medical advice, and those transferred to other facilities.

4.4 Sample Size Determination

All pediatric patients presented to Asella Referral and Teaching Hospital (282) who were diagnosed with traumatic brain injury during the study period was included. Given the relatively small and manageable population, a census sampling approach was used. Therefore, no formal sample size calculation is required, and a census sampling method was applied to maximize data completeness and statistical power.

4.5 **Data Collection Techniques and Tools**

First, the list of all pediatric TBI cases registered at ARTH from January 1, 2021 to December 31, 2024 was obtained from emergency, inpatient, and ICU logbooks. Data was collected using a retrospective chart review method, using a pre-tested (Adama Hospital Medical College) structured questionnaire administered through KoboCollect. Four trained Interns were selected from ARTH for data collection and patient's charts were reviewed manually. Information regarding demographic characteristics, clinical and management-related factors was gathered from the individual patient's card using an English-language structured questionnaire prepared from similar previous literature to address socio-demographic-related factors, clinical factors, and management. Charts not meeting inclusion criteria were excluded from analysis. To ensure data quality, collected forms were checked daily by the investigator for completeness and consistency.

4.6.1 Data Quality Assurance

To assure the quality of the data, the following measures were undertaken. A total of two days of training was given to all data collectors. The questionnaire was pretested on 5% of the total sample size at AHMC, and its clarity, length, completeness, and consistency of language were checked. The investigator closely supervised the data collection activities on a daily basis. At the end of each data collection day, the investigator verified the completeness of the filled questionnaires and ensured that the recorded information was accurate and logical in order to maintain the quality of the collected data. Meetings were held with the data collectors whenever necessary to clarify any ambiguities through discussion.

4.6.2 Data Processing and Analysis

After data collection, the dataset was exported from KoboToolbox in Excel format and checked for completeness using Excel. The cleaned data were then imported into SPSS version 27 for analysis. Descriptive statistics were performed to describe the study population. Bivariate logistic regression was conducted, and independent variables with a P-value of less than 0.25 were considered candidates for the final logistic regression model. Multivariable logistic regression was used to control for confounding effects. The associations were expressed as adjusted odds ratios with 95% confidence intervals, and a P-value of less than 0.05 was used as the cut-off point to declare statistical significance in the final model.

Finally, the obtained results were presented using frequency tables and charts and were described using text.

4.7. **Variables**

4.7.1 Dependent Variable

Treatment outcomes of TBI – Favorable outcomes/Unfavorable outcomes

4.7.2 Independent Variable

Demographic Factors:

Age, Sex Residence (urban vs. rural)

Clinical Factors:

Mechanisms of injury; Time to hospital presentation (duration since trauma); GCS score; Presence of intracranial injury on imaging; Associated extra cranial injury

Management-related Factors:

Surgical vs. conservative treatment; ICU admission; Time to intervention; Infectious complications; Length of hospital stay

4.8. Operational Definitions

Pediatric patient: A child aged 1 month to < 15 years who was diagnosed with TBI(42)

Traumatic brain injury: Alteration in brain function due to external mechanical trauma(43).

Severity of traumatic brain injury: classified based on the admission Glasgow Coma Scale (GCS) score as mild (13–15), moderate (9–12), and severe (≤8)(44).

Outcome: The clinical result of the TBI case at discharge(45).

Favorable Outcome: Includes Good Recovery with no neurologic deficits(45).

Unfavorable Outcome: Includes Disability, Vegetative State, and Death(45)

Associated Injury – Defined as the presence of additional injuries outside the brain (e.g., fractures, abdominal trauma)(46).

Focal Neurologic Deficit - the presence of localized neurologic impairment (e.g., motor weakness, sensory loss, speech disturbance, or cranial nerve deficit) documented at admission or during hospitalization(46).

Depressed Mental Status- Defined as change in responsiveness(decreased level of consciousness); for this study (GCS ≤ 13)(44).

4.9 Ethical Consideration

Ethical clearance was obtained from the Institutional Ethical Review Board of Arsi University to conduct the research. The study was conducted through a review of medical records. To ensure confidentiality, the names and other identifiers of patients, Physicians, and other healthcare professionals who examined the patients were not recorded on the data abstraction format and were not transferred to any other body.

4.10 Dissemination Plan

After research completion and finalizing report, this study will be presented to the department of Pediatrics and Child Health and Public Health, as part of pediatrics and child health specialty thesis at Arsi University and submitted to post graduate programs coordinating office of college of health sciences of Arsi University and other stake holders for possible application and publication of the study.

5. RESULTS

5.1 Socio-demographic characteristics

A total of 282 pediatric patients with traumatic brain injury were included in the study. About 195(69.1%) were males with male to female ratio of 2.24:1 ratio. The majority 116 (41.1%) of TBI occurred among ages 5-10 years old contributed to 41.1%(116). One hundred fifteen (69.1%) of the patients were from rural areas. The majority don't have underlying comorbidities, only 3(%) is known epileptic (see Table 1). Boys were predominantly affected, and they accounted for 58.8%, 67.3%, and 70.3% of TBI in <5 years, 5- 10 years, and adolescent age groups, respectively.

Table 1: Socio-demographic characteristics of pediatric patients with traumatic brain injury treated at ARTH, Oromia, Ethiopia, from 2021- 2024.

Variables	Category	Frequency	Percent%
Age	< 5 Years	84	29.8
	5 – 10 Years	116	41.1
	10 – 14 Years	82	29
Sex	Male	195	69.1
	Female	87	30.9
Residency	Urban	122	43.3
	Rural	160	56.7
Comorbidity	Epilepsy	3	1.1
	Severe Acute Malnutrition	1	0.4

5.2. Mechanisms of traumatic injury and patient's clinical condition

Regarding the mechanism of injury, most patients sustained traumatic brain injury due to falls, which accounted for 112 (39.7%). Most < 5 years falls occurred at home 32 (74.4%), while 86.1% (37) of 5– 10 years and 93.6% (23) of older than 10 years falls happened outdoor. The other major TBI causes were by road traffic accidents(RTA), comprising 89 (31.6%); among them pedestrians accounts for 78%(70). Assault accounted for 39 (13.8%) cases, and animal kick injuries for 33 (11.7%). Other mechanisms of injury, such as animal bites, blast or gunshot injuries, and building collapse, accounted for 9 (3.2%) cases.

Concerning the timing of presentation, most study subjects presented within 24 hours of injury, accounting for 214 (75.9%) cases, while 56 (19.9%) and 9 (3.2%) presented between 24 and 72 hours and after 72 hours of injury, respectively; only 3 patients (1.1%) presented after one week (see table 2). Majority of TBI followed unintentional injuries, 243(86%). Almost all of the intentional injuries, 36 (92.3%), were due to fighting, mainly among > 10 years old.

Regarding TBI severity, majority of our study subjects were conscious at the time of presentation and 184(67.9%) had mild TBI with GCS of 13-15, 65(23%) moderate TBI with GCS of 9-12. Severe TBI accounts for 22 (7.8%) of the study subjects. Mild TBI resulted from all mechanisms of injury, whereas moderate and severe TBI were mainly caused by road traffic accidents. At presentation, 41 (14.5%) of the patients had seizures, and increased intracranial pressure was observed in 32 (11.3%) cases.

Table 2: Patients' condition at admission of traumatic brain injury pediatric patients treated at ARTH, Oromia, Ethiopia, 2021- 2024.

Variable	Category	Numbers	Percent %
Mechanism of injury	Fall down accident	112	39.7
	Road traffic accident	89	31.6
	Assault	39	13.8
	Animal Injury	33	11.7
	Other	9	3.2
Duration of presentation	< 24 hr	214	75.9
	24hr -72hr	56	19.9
	72hr- 1week	9	3.2
	After 1 week	3	1.1
Increased ICP	No	250	88.7
	Yes	32	11.3
GCS at presentation	Mild(13-15)	184	67.9
	Moderate(9-12)	65	23
	Severe(3-8)	22	7.8
Seizure at admission	No	241	85.5
	Yes	41	14.5

5.3. Clinical characteristics and management factors

Among 282 traumatic brain injury patients presented to ARTH, 258(91.5%) sustained blunt injury and 24(8.51%) was penetrating injury. Radiological imaging revealed that 141 (50%) showed skull fracture, depressed skull fracture (DSF) accounting for 94 (33.3%), linear skull fracture 38(13.5%), basal skull fracture observed in 7(2.5%). Common intracranial injury seen in this study were brain contusion 33(11.7%), intracranial bleeding 30(10.6%), Diffuse Axonal Injury (DAI) 26(9.2%).

Concerning associated extra cranial injury of 282 TBI patients, 87 (31%) had associated injuries, of which 49(17.4%) had extremity/long bone fractures, (6.4%) had thoracic injuries, 12(4.2%) had abdominal injuries, and others like pelvic bone or spinal cord injury (see table 3).

In this study One hundred eighty-five (65.6%) traumatic brain injury cases were managed conservatively, while 97 (34.3%) underwent various surgical interventions within the first week of presentation. Most of the operated cases were aged 5 to 10 years. 7 Death was documented among the operated patients. Common surgical indications were DSF elevation 70(68.8%) and evacuation. Elevation of depressed skull fracture was done for mild (16), moderate (40), and severe (14) TBI categories.

Of the 282 TBI patients 32(11.3%) of them admitted to ICU. 35 (12.4%) of traumatic brain injury patients developed infectious complications mainly pneumonia 25(8.9%) and wound site infection. Focal neurologic deficits were documented in 27(9.6%) of pediatric TBI patients. Regarding duration of hospital stay, about 157(55%) discharged within 3 days of hospital presentations. 41(14.5%) discharged after 7 days of hospital stays.

Table 3 : Distribution of clinical and management factors of traumatic brain injury patients treated at ARTH, Oromia, Ethiopia, 2021- 2024.

Variables	Category	Frequency	Percent(%)
Head injury	Blunt	258	91.5
	Penetrating	24	8.5
Skull Fracture	No	143	50.7
	Yes	139	49.3
Type of skull fracture	DSF	94	33.3
	Linear	38	13.5
	Basal	7	2.5
ICU admission	No	250	88.7
	Yes	32	11.3
Extra-cranial Injury	No	195	69
	Yes	87	31
Intracranial finding	No	165	58.5
	Yes	117	41.5
Treatment given	Conservative	185	65.6
	Surgical	97	34.4
Infectious complication	No	247	87.6
	Yes	35	12.4
Conditions on discharge	Full recovery	133	82.6
	Focal neurologic deficits	27	9.5
	Depressed mentation	6	2.1
	Died	16	5.6
Length of Hospital stay	<= 3 Days	157	55.7
	> 3 Days	125	44.3

5.4. Outcomes of traumatic brain injury

Out of the total pediatric TBI patients included in the study, the majority 232(82.6%) had a favorable treatment outcome at discharge, indicating that most children showed clinical improvement or were discharged in stable condition. In contrast, 49(17.4%) of the patients experienced an unfavorable outcome at discharge, which includes death or discharge with neurological deficits or depressed mental status.

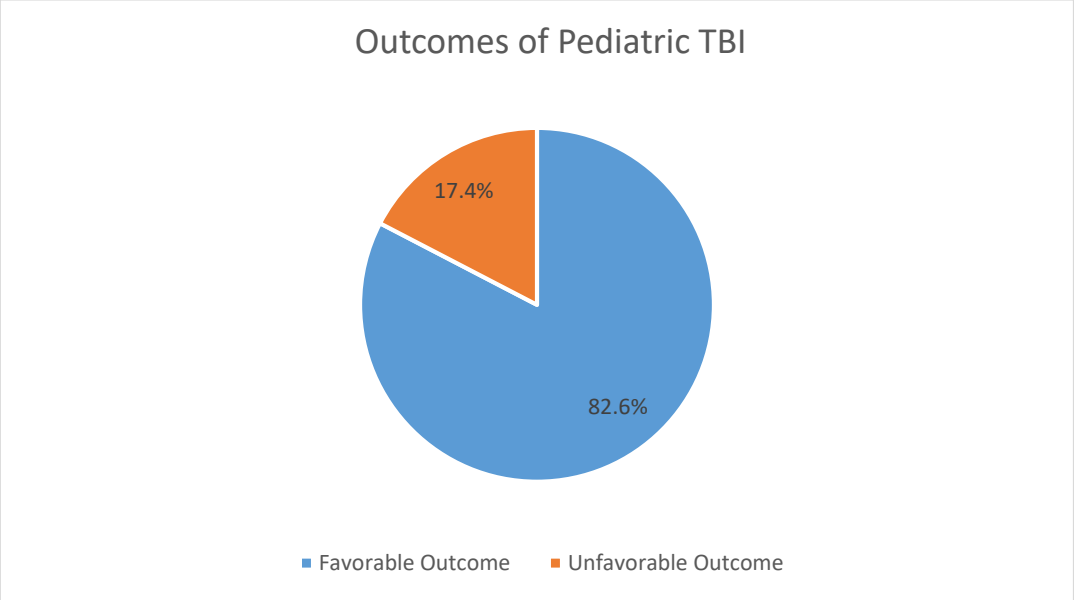

Figure 2: Distribution of Outcomes among pediatric TBI patients treated at ARTH, Oromia, Ethiopia, from 2021 – 2024.

5.6. Factors associated with outcomes

Lower admission GCS, ICU admission, and increased intracranial pressure were significantly associated with unfavorable outcomes among TBI patients.

Table 4 : Bivariate and Multivariable logistic regression Analysis of Factors associated with unsuccessful outcomes of TBI patients treated at ARTH, Oromia, Ethiopia, from 2021 - 2024.

Variables	Categories	Participant's Outcome		COR(95% CI)	AOR(95% CI)
		favorable outcome No(%)	unfavorable outcome No(%)		
Age	< 5 Years	73(31.7)	9(16.3)	1	1
	5 -10 years	93(40.1)	25(46.9)	3.037(.628-14.684)	.103-4.5
	10 -14 years	62(27.5)	20(37.3)	9.939(2.206-44.781)	0.903 - 6.622
Mechanisms of injury	Fall	101(42.4)	11(29.5)	1	1
	RTA	65(23)	24(54)	5.809(2.073-16.273)	.314(.01- 8.408)
	Assault	34(14.3)	4(9)	.605(.064-4.975)	.157(.02-1.483)
	Animal Injury	28(11.8)	5(11.5)	.669(.064-4.975)	1.36(.453-41.17)
Identified head injury	Blunt	225(94.5)	14(31.8)	1	1
	Penetrating	13(5.4)	30(68.2)	.133(.056 -.313)	.284(.033 2.426)
Skull fracture	No	139(54.3)	2(7.7)	1	1
	Yes	117(45.7)	24(92.3)	14.256(3.30-61.591)	2.328(0.81-16.505)
GCS	13-15	172(72.1)	6(13.6)	1	1
	9-12	57(23.9)	12(27.3)	5.025(1.581-15.971	.698(.026-1.896)
	3-8	9(3.7)	26(59.1)	5.171(1.520 -17.656)	2.968(1.363- 8.918)
Increased ICP	No	242(94.5)	8(30.8)	1	1
	Yes	14(5.5)	18(69.2)	4.893(1.424 10.869)	3.611(1.708 – 7.621)
Seizure	No	230(89.8)	11(42.3)	1	1
	Yes	26(10.2)	15(57.7)	.083(.034-.199)	1.677(.136 - 7.674)
Extracranial injury	No	161(62.9)	4(15.4)	1	1
	Yes	95(37.1)	22(84.6)	1.816(1.376-4.210)	.698 (.026 -1.8.946)
ICU admission	No	239(93.4)	11(42.3)	1	1
	Yes	17(6.6%)	15(57.7%)	3.052(1.021-5.131)	6.040(2.021- 17.581)

6. DISCUSSION

The aim of this study was to assess the outcome of traumatic brain injury and associated factors in pediatric patients treated at Asella Referral and Teaching Hospital. The majority patients had favorable outcomes, a while significant proportion experienced unfavorable Outcome.

In our study the overall prevalence of unfavorable outcome of traumatic brain injury among pediatrics patients was found that 17.4% (95% CI: 13.0%–21.8%). This study finding was consistent with study conducted southern Ethiopia (15.6%)(15) and study conducted in Saudi Arabia 14.8%(47). In contrast, it was higher than study conducted in Netherlands 5%(48). This difference may be attributed to study design, variations in healthcare system capacity, availability of prehospital emergency services, and access to advanced neurocritical care in Netherlands. In contrast, limited intensive care resources, and absence of prehospital care may contribute to the higher unfavorable outcomes observed in this study and other study done in Ethiopia. On the other hand, the current study result was lower than study conducted in Mulago National Referral Hospital in Uganda 25.25%(49). The possible discrepancy may be due to differences in study setting, study design and study period it was conducted in a community-based and long term follow up.

According to this study, lowest GCS (<8) at admission was associated with adverse outcomes compared to GCS ≥ 8 (AOR = 0.53, 95% CI: 0.14–0.92, p = 0.035). The study showed similarity with a study done in Hawassa Specialized Comprehensive Hospital, southern Ethiopia, tertiary hospital of Nairobi, Kenya and Nigeria which presented a high correlation between low GCS level and mortality (15,17,29). The study is also consistent with study done in Dutch(50). A low GCS score at admission reflects severe impairment of consciousness due to severe primary brain injury and ongoing secondary insults.

Children who required ICU admission had six times higher odds of unfavorable outcomes compared with those managed in non-ICU settings (AOR = 6.040; 95% CI: 2.02–17.58; p < 0.001). A study from a Tanzanian referral hospital reported that patients admitted to intensive care for TBI had nearly four times higher risk of unfavorable outcome compared with non-ICU patients(51). A multicentered study done in Finland shows that children treated in ICU for TBI often have significantly poorer long-term quality of life and functional outcomes(52)**.** The observed association between ICU admission and

unfavorable outcomes is likely reflective of the severity of injury. Patients admitted to the ICU commonly present with severe TBI, lower GCS scores, raised intracranial pressure, respiratory compromise, or hemodynamic instability, all of which are well-established predictors of adverse outcomes.

Patients with increased intracranial pressure at admission had 3.6 times higher odds of unfavorable outcomes compared to those without increased ICP (AOR = 3.61; 95% CI: 1.71–7.62; p = 0.021). The evidence from trauma cohorts, pediatric series, and high-resolution ICP studies consistently indicates that increased ICP is associated with higher morbidity and mortality**,** poorer functional recovery, and greater risk of neurological complications(53). Fifteen pediatric TBI studies done in US demonstrated that an association between episodes of intracranial hypertension and adverse neurologic outcome or death(54). Increased ICP causes brain damages by reducing CBF, distorting brain structures and triggering secondary injury pathways.

7 STRENGTH AND LIMITATIONS

7.1 Strength

This study utilized recent four-year data from Referral Hospital, providing insight into pediatric traumatic brain injury outcomes in Ethiopia. Focusing on pediatric patients addresses a critical evidence gap in local trauma research. Additionally, the inclusion of well-established prognostic factors such as admission Glasgow Coma Scale, ICU admission, and increased intracranial pressure strengthens the internal validity and comparability of the findings with regional and international studies.

7.2 Limitation

This study was a hospital-based retrospective analysis, which may limit generalizability to the wider population. The relatively small sample size may also reduce the power to detect some associations, and future studies with larger sample sizes are recommended. In addition, the absence of a standardized trauma registry and incomplete patient medical records, posed challenges during data extraction. The discharge neurologic status of patient the patients not clearly documented. Furthermore, the study assessed outcomes only at the time of hospital discharge and did not include post-discharge follow-up, which could have provided additional information on long-term morbidity and mortality among pediatric traumatic brain injury patients.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The finding of this study revealed substantial proportion of unfavorable treatment outcomes among pediatric patients with traumatic brain injury admitted to Asella Referral and Teaching Hospital. Pediatric injuries remain a major public health problem. Based on this study, It's recommended to establish greater supervision and safety measures for children; early identification of severe cases, and timely, appropriate clinical management to reduce morbidity and mortality.

8.2. Recommendations

1. To health care providers

- Early treatment and closer neurological monitoring of TBI cases for secondary brain injury prevention is recommended.
- TBI patients who has GCS less than 8 better managed at ICU with maximum airway protection to prevent aspiration pneumonia

2. To governmental and non- governmental organizations

- Neuro -intensive care unit is better established at ARTH as TBI is cause of major admission in this area.
- The identified determinant factors should be taken under consideration by health care providers, concerned bodies, and policy makers of the trauma centers to plan an optimized management protocol.

3. To researchers

Further research with advanced design covering other range of samples is needed to address the limitations of this study and for more generalizability of this finding.

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ANNEXES QUESTIONNAIRES

Check list to collect data on retrospective analysis of outcomes and associated factors of pediatric traumatic brain injury patient admitted at ARTH from 2021 – 2024, Asella, Southwest, Ethiopia. (adapted and modified from the literature that I used)

ID No:_____		
Part 1 Socio demographic status		
SN	Variables	Response
1	Age	_____
2	Sex	1.male 2.Female
3	Residence	1.Urban 2.Rural
Part II: History of the patient		
4	Duration of presentation after injury	(_____)hours
5	Mechanisms of trauma	1.Road traffic accidents 2.Assault 3.Fall accident 4.Animal Injury 4.other(specify)_____

6	Identified head injury	1.Blunt 2. Penetrating
7	increased ICP	0. No 1. Yes
8	Seizure at admission	0. No 1. Yes
9	Admission GCS	1.3-8 2.9-12 3.13-15 4.not mentioned
10	Presence of Skull Fracture	0. No 1. yes
10:1	If yes	0. Blunt 1. Penetrating
10:2	If yes, Skull fracture	1. Open skull fracture 2. closed skull fracture
10:3	If yes, type of skull fracture	1. linear skull fracture 2. Depressed skull fracture 3. Basal skull fracture
11	ICU admission	0. No 1. yes

12	Is there associated extracranial injury	0. No 1. yes
12.1	If yes, type of associated injury	1.Thoracic injury 2.abdominla injury 3.Extremity injury 4.Neck/spinal injury 5.other_____
13	Additional intracranial finding	1.Acute Epidural hematoma 2.Acute Subdural hematoma 3.Chronic subdural hematoma 4.Diffuse axonal injury 5.Brain contusion 6.Subarachidonic hemorrhage 7.other_____
14	Any comorbidity identified	_____
15	Treatment Given	1.conservative 2.Surgical
16	If surgical, surgery types	1.Burrhole 2.Craniotomy 3.Elevation 4.other_____

18	Infectious complication	0.No 1.yes:___
19	If yes(infection)	Specify_____
20	Hospital stay	_____days
21	Patient on Discharge	1. full recovery 2. Focal neurologic deficits 3. Depressed mentation 4-Died

ANNEXES II DECLARATIONS

Declaration of Investigator

I, the undersigned Pediatric and Child Health Resident, declare that this research paper is my original work in partial fulfillment of the requirement for the specialty certificate in pediatrics and child health for the stated student above to my best knowledge.

Name of investigator: _____

Signature: _____

Date_____

Declaration of Advisors

We, the undersigned Advisors, declare that this paper is the investigator's original work in partial fulfillments of the requirements for specialty certificate in pediatrics and child health for the stated student above to our best knowledge. We confirmed that this Thesis is ready for defense with our approval as the university Advisors.

Date of Submission: _____

Name of Advisors:	Signatures	Date
Dr Tadesse Assefa_____	_____	_____
Mr Firaol Lamessa _____	_____	_____