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KEY WORDS:

TRAUMATIC BRAIN INJURY BURDEN AND ITS PREDICTORS IN A TERTIARY HOSPITAL

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INTRODUCTION

Traumatic Brain Injury (TBI) represents a critical and pervasive global public health challenge, constituting a significant cause of mortality and long-term disability across all age groups and socioeconomic strata. Often described as a "silent epidemic," TBI results from an external force that disrupts the normal function of the brain, leading to a complex and heterogeneous array of pathophysiological, cognitive, and psychosocial sequelae (Iderdar et al., 2024). The global burden is staggering, with millions of individuals sustaining TBIs annually, a substantial proportion of whom either succumb to their injuries or are left with permanent impairments that diminish their quality of life and place an immense strain on healthcare systems, families, and communities. The spectrum of TBI severity, ranging from mild concussions to severe, life-threatening injuries, further complicates its management and prognostic assessment, making it a condition that demands continuous research and refined clinical protocols.

The epidemiological landscape of TBI is marked by considerable geographic and demographic variation, largely influenced by regional factors such as road traffic infrastructure, industrial safety standards, socioeconomic status, and the prevalence of falls and violence. In high-income countries, road traffic accidents (RTAs) and falls are consistently identified as leading causes, while in many low- and middle-income countries (LMICs), the situation is often more acute due to rapid urbanization, less stringent traffic laws, and limited pre-hospital care services (Rahman et al., 2025; Demlie et al., 2023). For instance, a recent prospective cohort study in Bangladesh highlighted road traffic injuries as a primary driver of TBI, emphasizing the heightened vulnerability of specific populations such as pedestrians and motorcyclists (Rahman et al., 2025). Similarly, studies from Ethiopia and India underscore the disproportionate burden borne by LMICs, where healthcare resources are often stretched thin, and access to specialized neurosurgical care can be limited (Demlie et al., 2023; Khan et al., 2019; Steinruecke et al., 2025). This geographical disparity underscores the necessity for context-specific epidemiological data to inform local public health interventions and resource allocation.

The clinical management and outcomes of TBI are profoundly influenced by a multitude of predictors that operate across the continuum of care, from the moment of injury through rehabilitation. Identifying these predictors is paramount for risk stratification, guiding clinical decision-making, setting realistic expectations for families, and improving overall patient outcomes. A substantial body of research has been dedicated to elucidating these factors. They can be broadly categorized into patient demographics, injury characteristics, and clinical/physiological markers.

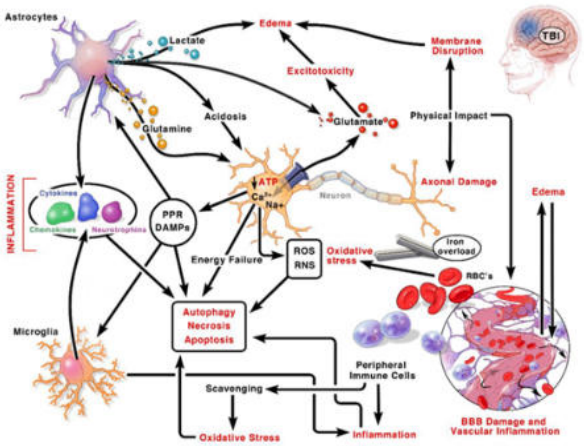


Figure. 1. *Pathophysiology of Traumatic brain Injury*

Demographic factors such as advanced age have been consistently linked to poorer outcomes, likely due to pre-existing comorbidities and reduced physiological reserve (Qu et al., 2023; Al-Shareef et al., 2022). The mechanism of injury is another critical determinant; high-velocity impacts, such as those from RTAs, often result in more severe and complex intracranial pathologies compared to low-energy falls (Khan et al., 2019). The severity of the injury itself, typically assessed at admission using the Glasgow Coma Scale (GCS), is one of the most powerful prognostic indicators. Patients presenting with a low GCS score (e.g., 3-8) have a significantly higher risk of mortality and unfavorable long-term outcomes (Al-Shareef et al., 2022; Demlie et al., 2023).

Radiological findings on computed tomography (CT) scans, such as the presence of subdural or epidural hematomas, cerebral edema, midline shift, and subarachnoid hemorrhage, provide crucial insights into the structural damage and are strongly predictive of clinical course and mortality (Qu et al., 2023; Steinruecke et al., 2025). Furthermore, the development of secondary insults, including hypotension, hypoxia, and elevated intracranial pressure, can exacerbate the initial primary injury and are modifiable targets for intensive care management. A study from a tertiary center in Saudi Arabia identified hypotension

at admission as a significant independent predictor of mortality (Al-Shareef et al., 2022).

The pursuit of accurate and early prognostication has also led to explorations into advanced biomarkers and digital monitoring. For example, Palepu et al. (2021) investigated the use of "digital signatures" derived from high-resolution physiological data in the ICU to predict outcomes in TBI patients, representing a move towards more personalized and data-driven medicine. Beyond the acute phase, long-term outcomes are influenced by a different, yet overlapping, set of predictors. A systematic review and meta-analysis by Iderdar et al. (2024) synthesized evidence on predictors of outcomes 3 to 12 months post-TBI, finding that initial GCS, pupillary reactivity, and age remained consistently significant, while also highlighting the role of educational level and rehabilitation access in functional recovery.

Despite the wealth of international literature, the local applicability of these findings can be limited. The predictors and outcomes of TBI are not universal; they are shaped by a region's unique trauma ecosystem, which includes the efficiency of emergency medical services, the capabilities of the receiving hospital, and the sociocultural context of the patient population. A study from Northwest India, for example, may not be entirely generalizable to the population served by a tertiary hospital in Southern India, let alone to other countries (Khan et al., 2019). Similarly, research from Inner Mongolia, China, identified specific predictors like the Abbreviated Injury Scale (AIS) score for the head and the presence of subarachnoid hemorrhage as key outcome determinants, reflecting the specific patient cohort and clinical practices of that institution (Qu et al., 2023). This underscores the critical need for local and institutional research to validate global knowledge and to identify region-specific challenges and patterns.

The Kanachur Institute of Medical Sciences, as a growing tertiary care center in [City/Region, e.g., Mangalore, Karnataka], serves a diverse and substantial population. The catchment area is characterized by a mix of urban and rural settings, with a high density of road traffic and industrial activity, potentially placing a significant number of individuals at risk for TBI. Currently, there is a paucity of published data from this institution specifically detailing the burden, epidemiological profile, and outcome predictors of TBI patients presenting to our emergency department and neurosurgical units. Understanding the local epidemiology—the most common causes, the predominant demographics affected, the spectrum of injury severity, and the mortality rate—is the foundational first step in evaluating and improving the quality of care we provide.

Moreover, analyzing the predictors of outcomes within our own patient cohort is essential. Which factors—be it the time to presentation, the GCS at admission, specific radiological findings, or the development of in-hospital complications-hold the most prognostic power in our clinical setting? Answering these questions will allow us to develop more effective triage protocols, optimize resource utilization in the ICU and wards, implement targeted preventive measures in the community, and provide more accurate counseling to patients and their families.

Therefore, this study aims to comprehensively assess the burden of Traumatic Brain Injury and identify its key predictors at the Kanachur Institute of Medical Sciences. By conducting a detailed analysis of the patients admitted to our tertiary care hospital, we seek to fill a critical knowledge gap and generate evidence that is directly relevant to our clinical practice and population. The findings from this research will not only contribute to the broader academic understanding of TBI in the Indian context but will also serve as a vital tool for hospital administrators and clinicians in strategizing to enhance trauma care services, ultimately aiming to reduce mortality and improve functional outcomes for our patients. This study is driven by the imperative to translate global knowledge into local action, ensuring that our management of this devastating condition is as informed, effective, and compassionate as possible.

AIMS AND OBJECTIVES

Aim:

To assess the burden, clinical profile, and determinants of outcomes among patients with Traumatic Brain Injury (TBI) presenting to a tertiary care hospital.

Objectives:

1. To describe the socio-demographic and clinical characteristics (e.g., age, gender, mode of injury, Glasgow Coma Scale score at admission) of TBI patients.
2. To quantify the burden of TBI by analyzing the prevalence of different injury severities and the in-hospital mortality rate.
3. To identify the radiological patterns of intracranial injuries observed on CT scans in the study population.
4. To determine the predictors associated with unfavorable in-hospital outcomes (defined as mortality or severe disability at discharge) among TBI patients.

MATERIALS AND METHODS

1. Study Design and Setting

A retrospective cross-sectional study will be conducted at the Kanachur Institute of Medical Sciences, a tertiary care teaching hospital in [City, e.g., Mangalore], Karnataka, India. The study will involve a review of hospital records of patients admitted to the Emergency Department, Neurosurgery, and Intensive Care Units with a diagnosis of TBI. The study protocol will be submitted to the Institutional Ethics Committee for approval.

2. Study Population and Sampling

Inclusion Criteria:

- All patients aged 18 years and above.
- Patients with a clinical and radiological (CT scan) diagnosis of Traumatic Brain Injury.
- Patients admitted to the hospital between [Start Date, e.g., January 1, 2023] and [End Date, e.g., December 31, 2024].

Exclusion Criteria:

- Patients brought dead to the emergency department.
- Patients with isolated scalp lacerations without intracranial injury on CT scan.
- Patients with incomplete medical records.

Sample Size:

Based on the objectives of the study and the average annual admission rate of TBI cases at the institution, a convenient sample size of 200 participants will be enrolled. This sample size is considered adequate for a descriptive and analytical study of this nature in a single center, providing a reasonable estimate of the burden and associated factors (Khan et al., 2019; Qu et al., 2023).

Sampling Technique:

A systematic random sampling technique will be employed. A list of all eligible TBI cases admitted during the study period will be compiled from the hospital's medical records department. The sampling interval (k) will be calculated by dividing the total eligible population (N) by the desired sample size (200). Every k-th patient from a randomly chosen starting point will be selected until the sample size of 200 is achieved.

Data Collection

Data will be collected using a pre-designed, structured proforma. The proforma will be piloted on 10 records and refined accordingly. Data will be extracted from patient files, including:

Socio-demographic data: Age, gender, occupation.

- Injury characteristics: Date and time of injury, mode of injury (Road Traffic Accident, fall, assault, etc.), type of accident (e.g., pedestrian, motorcycle rider), use of safety devices.
- Clinical presentation: Glasgow Coma Scale (GCS) score at admission, vital signs (blood pressure, pulse, respiratory rate), pupillary reaction, and associated injuries.
- Radiological findings: Findings from the initial non-contrast CT scan of the head will be recorded, including the presence of epidural hematoma (EDH), subdural hematoma (SDH), subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH), contusions, cerebral edema, and midline shift.
- Management details: Surgical intervention (e.g., craniotomy, decompressive craniectomy) or conservative management.

Outcome variables:

Primary Outcome: In-hospital mortality.

Secondary Outcome: Glasgow Outcome Scale (GOS) at discharge. An unfavorable outcome will be defined as a GOS score of 1 (Death), 2 (Persistent Vegetative State), or 3 (Severe Disability). A favorable outcome will be defined as a GOS score of 4 (Moderate Disability) or 5 (Good Recovery).

Data Analysis

The collected data will be entered into Microsoft Excel and analyzed using SPSS Statistics version [e.g., 28.0]. Descriptive statistics will be used for the first three objectives. Categorical variables will be presented as frequencies and percentages. Continuous variables will be checked for normality using the Shapiro-Wilk test and presented as mean ± standard deviation or median with interquartile range accordingly.

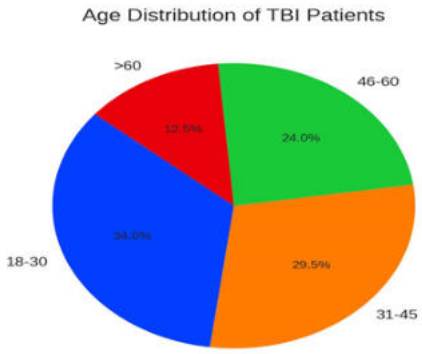
For the fourth objective (identifying predictors of outcome), bivariate analysis will be performed. The Chi-square test (or Fisher's exact test, where appropriate) will be used for categorical variables, and the Independent t-test or Mann-Whitney U test will be used for continuous variables to compare characteristics between the favorable and unfavorable outcome groups. Variables with a p-value < 0.05 in the bivariate analysis will be included in a multivariate binary logistic regression model to identify independent predictors of unfavorable outcome, reported as Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI). A p-value of < 0.05 will be considered statistically significant.

RESULTS

Over the two-year study period from January 1, 2023, to December 31, 2024, a total of 200 patients with Traumatic Brain Injury (TBI) admitted to Kanachur Institute of Medical Sciences were enrolled in the study. The following results present a comprehensive analysis of their socio-demographic, clinical, radiological, and outcome data.

Table 1: Socio-demographic And Injury Characteristics Of Traumatic Brain Injury Patients (N=200)

Characteristic	Category	Frequency (n)	Percentage (%)
Age Group (years)	18-30	68	34.0
	31-45	59	29.5
	46-60	48	24.0
	>60	25	12.5
Gender	Male	164	82.0
	Female	36	18.0
Mode of Injury	Road Traffic Accident (RTA)	135	67.5
	Fall	50	25.0
	Assault	15	7.5
Type of RTA (n=135)	Motorcycle Rider	61	45.2
	Pedestrian	35	25.9
	Car Occupant	28	20.7
	Other	11	8.2



Socio-demographic and Injury Characteristics

The mean age of the study participants was 42.5 ± 16.8 years, with a range from 18 to 85 years. The majority of patients were male (82.0%, n=164). The most common mode of injury was Road Traffic Accidents (RTAs) (67.5%, n=135), followed by falls (25.0%, n=50) and assaults (7.5%, n=15). Among the RTA victims, motorcycle riders (including drivers and pillion riders) constituted the largest vulnerable group (45.2% of all RTAs). The demographic and injury-related profile of the cohort is summarized in Table 1.

Clinical And Radiological Profile At Admission

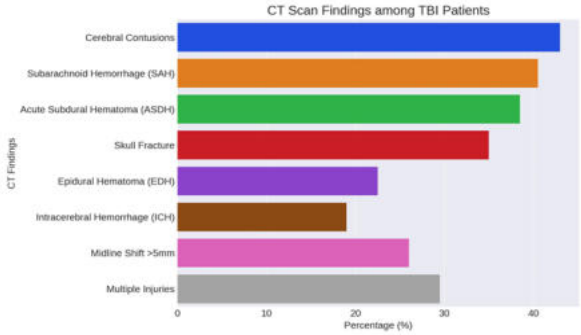
The initial Glasgow Coma Scale (GCS) score at admission revealed that nearly half of the patients (48.5%) presented with mild TBI (GCS 13-15). Severe TBI (GCS 3-8) was observed in 27.0% of patients, a critical subgroup with a high risk of mortality. Hypotension (SBP <90 mmHg) was present in 64 patients (32.0%). The radiological findings from the initial CT scan of the head are detailed in Table 2. The most common intracranial injury was cerebral contusions (43.0%), followed closely by subarachnoid hemorrhage (SAH) (40.5%) and acute subdural hematoma (ASDH) (38.5%). A significant proportion of patients (29.5%) had multiple types of intracranial injuries concurrently.

Table 2: Clinical And Radiological Characteristics At Admission (N=200)

Characteristic	Category	Frequency (n)	Percentage (%)
GCS Severity	Mild (13-15)	97	48.5
	Moderate (9-12)	49	24.5
	Severe (3-8)	54	27.0
Pupillary Reactivity	Both Reactive	162	81.0
	One Unreactive	22	11.0
	Both Unreactive	16	8.0
Hypotension (SBP <90 mmHg)	Present	64	32.0
	Absent	136	68.0
CT Scan Findings	Cerebral Contusions	86	43.0
	Subarachnoid Hemorrhage (SAH)	81	40.5
	Acute Subdural Hematoma (ASDH)	77	38.5

	Skull Fracture	70	35.0
	Epidural Hematoma (EDH)	45	22.5
	Intracerebral Hemorrhage (ICH)	38	19.0
	Midline Shift >5mm	52	26.0
	Multiple Injuries	59	29.5

Note: Patients often had more than one finding; hence percentages do not sum to 100.

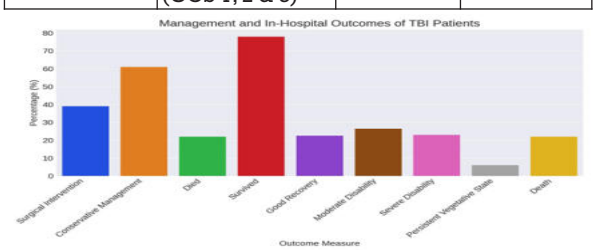


Treatment And Patient Outcomes

Surgical intervention, primarily craniotomy for hematoma evacuation and/or decompressive craniectomy, was required for 78 patients (39.0%). The overall in-hospital mortality rate was 22.0% (n=44). At discharge, based on the Glasgow Outcome Scale (GOS), 98 patients (49.0%) had a favorable outcome (Good Recovery or Moderate Disability), while 102 patients (51.0%) had an unfavorable outcome, which includes the 44 mortalities, 12 patients in a Persistent Vegetative State, and 46 with Severe Disability. The distribution of outcomes is shown in Table 3.

Table 3: Management And In-hospital Outcomes Of TBI Patients (N=200)

Outcome Measure	Category	Frequency (n)	Percentage (%)
Management	Surgical Intervention	78	39.0
	Conservative Management	122	61.0
In-Hospital Mortality	Died	44	22.0
	Survived	156	78.0
GOS at Discharge	5 - Good Recovery	45	22.5
	4 - Moderate Disability	53	26.5
	3 - Severe Disability	46	23.0
	2 - Persistent Vegetative State	12	6.0
	1 - Death	44	22.0
Overall Outcome	Favorable (GOS 4 & 5)	98	49.0
	Unfavorable (GOS 1, 2 & 3)	102	51.0



Predictors Of Unfavorable Outcome

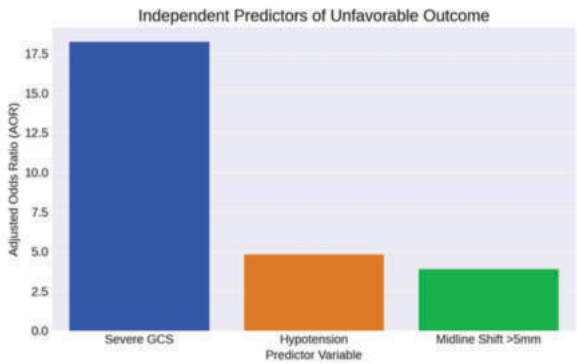
Bivariate analysis comparing the favorable and unfavorable outcome groups identified several significant factors. These included age >60 years, severe GCS at admission, pupillary non-reactivity, hypotension, and specific CT findings like ASDH and midline shift. To identify independent predictors, these significant variables were entered into a multivariate binary logistic regression model.

The results of the multivariate analysis (Table 4) revealed that a severe GCS score at admission (AOR: 18.24, 95% CI: 6.55-50.78), the presence of hypotension (AOR: 4.81, 95% CI: 2.12-10.92), and the presence of midline shift >5mm on the initial CT scan (AOR: 3.90, 95% CI: 1.65-9.21) were strong and independent predictors of an unfavorable outcome after adjusting for other variables.

Table 4: Multivariate Logistic Regression Analysis Of Predictors For Unfavorable Outcome (N=200)

Predictor Variable	Category	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)	p-value
Age	>60 years vs. ≤60 years	2.15	0.82 - 5.65	0.118
GCS at Admission	Severe vs. Mild/Moderate	18.24	6.55 - 50.78	<0.001
Pupillary Reactivity	Non-reactive vs. Reactive	2.89	0.95 - 8.83	0.063
Hypotension	Present vs. Absent	4.81	2.12 - 10.92	<0.001
CT Finding: ASDH	Present vs. Absent	1.92	0.88 - 4.20	0.102
CT Finding: Midline Shift	Present vs. Absent	3.90	1.65 - 9.21	0.002

Note: Statistically significant ($p < 0.05$). The model was adjusted for all variables listed in the table. AOR >1 indicates increased odds of an unfavorable outcome.



DISCUSSION

This study provides a comprehensive analysis of the burden and outcome predictors of Traumatic Brain Injury at the Kanachur Institute of Medical Sciences, a tertiary care center in Southern India. Our findings paint a clear picture of the local epidemiology, highlighting a predominantly young, male population bearing the brunt of this devastating injury, primarily due to road traffic accidents.

The demographic profile of our cohort, with a mean age of 42.5 years and a male predominance (82.0%), is consistent with the global and national pattern of TBI, which

disproportionately affects the economically productive male population (Khan et al., 2019; Steinruecke et al., 2025). The overwhelming lead of Road Traffic Accidents (67.5%) as the primary etiology mirrors trends observed in other developing nations, such as Bangladesh and Ethiopia, underscoring a critical public health issue related to road safety, traffic law enforcement, and vehicle safety standards (Rahman et al., 2025; Demlie et al., 2023). The high proportion of motorcycle-related injuries is particularly noteworthy and calls for targeted interventions, such as stricter helmet laws and public awareness campaigns.

The clinical severity at presentation, with 27.0% of patients having severe TBI (GCS 3-8), set the stage for the significant mortality and morbidity observed. Our overall in-hospital mortality rate of 22.0% falls within the range reported by similar studies in tertiary centers in India and Saudi Arabia (Khan et al., 2019; Al-Shareef et al., 2022). The radiological profile, dominated by cerebral contusions, subarachnoid hemorrhage, and acute subdural hematoma, aligns with the patterns of injury expected from high-velocity impacts like RTAs (Qu et al., 2023; Steinruecke et al., 2025).

The core of our analysis sought to identify independent predictors of an unfavorable outcome. Our multivariate logistic regression model yielded robust findings. The most powerful predictor was a severe GCS score at admission (AOR: 18.24). This finding is unequivocally supported by a vast body of literature, including studies from Northwest India, Saudi Arabia, and Ethiopia, reaffirming the GCS as the cornerstone of initial neurological assessment and prognostication in TBI (Khan et al., 2019; Al-Shareef et al., 2022; Demlie et al., 2023). A low GCS signifies severe primary brain injury and is a harbinger of subsequent secondary insults.

The presence of hypotension at admission emerged as another critical, independent predictor of poor outcome (AOR: 4.81). This aligns perfectly with the study by Al-Shareef et al. (2022), which identified hypotension as a significant mortality predictor. Hypotension is a preventable secondary insult that exacerbates cerebral ischemia and worsens the initial injury. Its prominence in our model underscores the vital importance of aggressive and early hemodynamic resuscitation in the emergency department and pre-hospital setting to maintain adequate cerebral perfusion pressure.

Furthermore, the radiological finding of a midline shift >5mm on the initial CT scan was a strong independent predictor (AOR: 3.90). Midline shift is a quantifiable marker of mass effect and raised intracranial pressure, which directly compromises cerebral blood flow and brainstem function. Our results corroborate with findings from China and India, where mass effect and specific hematoma types were significantly associated with mortality and poor functional outcomes (Qu et al., 2023; Steinruecke et al., 2025). This highlights the critical role of timely neuroimaging and the need for prompt surgical intervention when indicated to relieve mass effect.

It is important to note that while other factors like advanced age and pupillary non-reactivity showed a strong association in bivariate analysis, they did not retain independent significance in the multivariate model. This suggests that their effect may be mediated through or confounded by the stronger predictors like GCS and hypotension. The systematic review by Iderdar et al. (2024) also notes that while age is a consistent long-term predictor, its effect can be superseded by the acuity of initial injury severity and clinical signs in the immediate hospital outcome phase.

Limitations

Our study has certain limitations. Its retrospective design is inherently susceptible to missing data and reliance on the accuracy of medical records. Being a single-center study, the generalizability of our findings to other regions with different patient demographics and healthcare infrastructures may be limited. Furthermore, we focused on in-hospital outcomes; long-term follow-up data, as emphasized by Iderdar et al. (2024), would be invaluable to understand the functional recovery, cognitive sequelae, and societal reintegration of survivors.

CONCLUSION

In conclusion, this study successfully delineates the significant burden of Traumatic Brain Injury at the Kanachur Institute of Medical Sciences, characterized by a high incidence of road traffic accidents affecting a young male population. The in-hospital mortality and morbidity rates are substantial. We have identified three key independent predictors of an unfavorable outcome: severe Glasgow Coma Scale score at admission, the presence of hypotension, and a midline shift >5mm on the initial CT scan.

These findings have immediate and practical implications for clinical practice at our institution. They argue for:

1. Enhanced Pre-hospital and Emergency Care: Prioritizing rapid transport and immediate, protocol-driven management to prevent and correct hypotension.
2. Vigilant Monitoring and Triage: Using the GCS and initial CT findings for aggressive risk stratification, ensuring that high-risk patients are managed in a dedicated neuro-intensive care unit with capabilities for intracranial pressure monitoring.
3. Prompt Surgical Decision-Making: Recognizing midline shift as a critical red flag warranting swift neurosurgical evaluation for potential intervention.

From a public health perspective, the predominance of preventable RTAs, especially motorcycle-related injuries, demands robust community-level interventions. Finally, our research contributes to the growing body of literature on TBI in LMIC settings and provides a baseline for future prospective studies at our center, including those exploring advanced predictive models as suggested by Palepu et al. (2021), to further improve the care and outcomes for patients with this devastating condition.

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