

Enhancing Recovery in Traumatic Brain Injury: An Analysis of Systemic Care Procedures, Injury Severity, and Neurological Functional Outcomes in Bangladesh

Md Ali Yousuf^{*1a}, Md Sirajul Islam,^{1b} Mahdy I.B Farooq,^{1c} Fatima T. Younis,^{1d} Md Asadul islam Rahman,^{1e} zainab ali Misbah,^{1f} Habibah W. bilal,^{1g} Md Suliman Miah,^{1h}

Extended author information available on the last page of the article**

* Corresponding Author: Md Ali Yousuf, mad_yusuf48@student.just.edu.bd

DOI: <https://doi.org/10.64440/IBNSINA/SINA0031>

ARTICLE INFO

Article history

Received July 06, 2026

Revised July 19, 2026

Accepted Oct 22, 2026

Keywords

Bangladesh,
Traumatic Brain Injury
(TBI),
Cognitive Retraining (CR),
Glasgow Coma Scale
(GCS),
NIMHANS
Neuropsychology Battery.



This is an open-access
article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/)
license.

ABSTRACT

Aims: The principal cause of chronic disability and mortality worldwide is Traumatic Brain Injury (TBI). This research is confined to a case study of Bangladesh. It evaluates the effects of Cognitive Retraining (CR) on symptom reporting, neuropsychological function, and health status among patients with different TBI presentations. **Material and methods:** The researchers used a pre-post design in a single-group intervention study, including 33 patients diagnosed with occult TBI within 7–27 months after surgery. The Researchers administered the instruments at the National Institute of Mental Health, Sher-e-Bangla Nagar, Dhaka. It is a specialized government hospital that provides mental health services. The Researchers used the NIMHANS Neuropsychology Battery, the Rivermead Post-Concussion Symptoms Questionnaire, the Perceived Stress Scale, the World Health Organization Quality of Life Scale—Brief, the Visual Analog Scale, and the Intervention Program: Cognitive Retraining. All patients completed 21 hospital-based CR sessions over three months. CR tasks targeted processing speed, attention, executive function, learning, and memory. The Researchers assessed outcomes at baseline and immediately after the intervention. **Statistical Analysis:** The researchers used standard deviation, mean percentage, and frequency as descriptive statistics and compared course-related pre- and post-intervention data, also using the Wilcoxon signed-rank test in the Glasgow CS. **Results:** The researchers found that post-intervention improvements in working memory, visual-spatial construction, planning, visual memory, processing speed, and verbal encoding are associated with perceived stress, reporting, and quality of life in the psychological domain, which can be improved through the implementation of the objectives explained. **Conclusion:** We found that CR interventions and the Glasgow Coma Scale (GCS) can improve cognitive symptoms and quality of life in moderate to severe TBI.

1. Introduction

Traumatic brain injury (TBI) in Bangladesh presents a high burden largely driven by road traffic accidents (RTAs) and physical trauma, with clinical outcomes heavily influenced by pre-hospital care delays, injury severity, and timely surgical or neurocritical intervention. This is a serious

global public health challenge, as about 1.35 million deaths result from road traffic injuries each year across the globe, and it is the leading cause of death among children and young adults[1]. Bangladesh has the third-highest death rate due to road traffic accidents among SAARC countries, as Head injury was the most common fatal injury (56.8%), followed by multiple injuries (24.0%). Most accidents (62.4%) occurred in the evening and nighttime[2]. Road traffic injuries commonly result in traumatic brain injury (TBI), and survivors experience chronic disability. Epidemiology and Injury Causes note that most TBI patients in Bangladeshi tertiary care cohorts are male (approx. 76.1%) and predominantly between 18 and 50 years old. Such Leading Causes also include road traffic accidents (RTAs), which account for the vast majority of cases (ranging from 67.9% to higher proportions depending on the center), followed by falls and physical assaults. The Associated Injuries cover nearly 30% of TBI patients present with polytrauma or associated injuries, with limb/locomotor injuries being the most common (68.5%), alongside spinal, thoracic, abdominal, and facial trauma[3].

Approximately one million people are severely disabled due to TBI in Bangladesh annually, as 47% of patients with TBI continue to experience disability at one year[4]. Bangladesh shares a similar scenario, where RTI also plays a major role in causing TBI. Due to the increasing incidence of mortality among TBI resulting from road traffic crashes, effective and prompt pre-hospital care is vital in this regard. Studies depict that a comprehensive post-crash response system, including rapid resuscitation and transport, can significantly improve outcomes and reduce TBI-related mortality[5].

Bangladesh is experiencing a surge in TBI; according to the WHO Global Status Report on Road Safety, every day, sixty-plus people succumb to head injuries through TBI in Bangladesh. It subsequently causes a substantial number of brain injuries, the combination of which is among the most vulnerable to mortality among all types of injuries. It has also largely affected Generation Z and their successors, Gen Alpha, and thus incapacitates a large portion of the nation's productive population. Frequent anecdotal evidence is found in the newspapers and electronic media that focus on individual incidents of TBI in Bangladesh, portraying inadequate pre-hospital care and transport delivery system; because a reliable post-crash response is vital to reducing TBI mortality, empirical, research-based evidence is urgently needed[6]. However, despite the rising TBI burden, research on TBI in Bangladesh remains grossly inadequate, as evidenced by publications in scientific journals. No studies in Bangladesh have evaluated the publishing strength of medical departments and institutes, the number of articles published by researchers from related disciplines,

or the scientific impact of these articles. This study aims to understand Bangladesh's scientific contribution to published TBI research[7].

1.1 Background and Global Burden of Traumatic Brain Injury

Systemic Care Procedures and Pre-Hospital Factors include pre-hospital gaps, as delays between injury and first aid or formal treatment initiation remain a primary barrier in regional settings due to a shortage of specialized trauma facilities and transport infrastructure. The Surgical Interventions include a range between 24.3% and 56.8% of hospitalized TBI cohorts requiring emergency neurosurgical procedures—such as craniotomy, decompressive craniectomy, burr hole drainage, surgical toileting, and elevation of depressed skull fractures, depending on the severity of intracranial hemorrhage and as deemed necessary. Furthermore, comparative studies (such as those in Chittagong) are examining the decompressive craniectomy vs. craniotomy debate by evaluating early decompressive craniectomy versus standard craniotomy for managing refractory intracranial hypertension, balancing survival benefits against long-term neuropsychological and functional outcomes[8].

Posttraumatic chronic disability results from a wide range of physical, cognitive, emotional, and behavioral difficulties in survivors, as blood tests to monitor evolving brain injury in ischemic stroke could be a cost-effective and fast alternative to currently used non-invasive approaches such as MRI. The Researchers used a single-molecule detection assay on blood samples, as it was found that brain-derived tau abundance was associated with the severity of brain injury in three cohorts of patients with ischemic stroke[9]. Brain-derived tau in blood can track the trajectory of brain injury (including treatment effects of the neuroprotectant intervention nerinetidN42, O30) andd reperfusion) and predict functional outcomes for up to 36 months. Nerinetide slows ischemic brain injury by targeting PSD-95 (postsynaptic density 95 protein)- dependent signaling pathways, uncoupling GluN2B-containing NMDA receptors from neuronal nitric oxide synthase and attenuating downstream neurotoxic cascades[10].

1.2 Epidemiology of Traumatic Brain Injury in Bangladesh

Injury Severity and Neurological Functional Outcomes are determined by the severity distribution, which shows that a substantial portion of admitted patients present with moderate to severe TBI (with severe cases often marked by low Glasgow Coma Scale [GCS] scores ≤ 8 and altered consciousness). The mortality Rates: In-hospital and cohort mortality rates for TBI in major Bangladeshi teaching and combined military hospitals hover around 10.3%, influenced heavily by

the speed of surgical decompression and access to intensive care. Functional Prognosis: Using the Glasgow Outcome Scale (GOS), more than half of surviving patients achieve a good recovery, while roughly 19.5% experience poor outcomes (classified as severe disability, vegetative state, or mortality). Persistent post-surgical seizures, delayed consciousness recovery, and baseline CT scan findings (such as mass effect or intracranial bleeds) significantly elevate the risk of long-term functional impairment[11]

1.3 Injury Severity and Neurological Recovery: Current Evidence

The cognitive sequelae of TBI include impaired attention, memory, processing speed, and executive functions. There can be emotional and behavioral problems, which include irritability, agitation, aggression, impulsivity, anxiety, stress, and delinquent social judgment, along with psychiatric syndromes such as depression, mania, psychosis, and posttraumatic stress disorder. These deficits, especially cognitive ones, can disrupt a person's activities of daily living, occupational functioning, social stability, and active participation in their lives. The health-related quality of life in survivors of TBI has been documented to be adversely affected. People with moderate to severe TBI can experience a delinquent quality of life even a decade after injury. Delinquent quality of life after TBI is commonly associated with chronic stress, somatic symptoms, and post-traumatic psychiatric disorders[12].

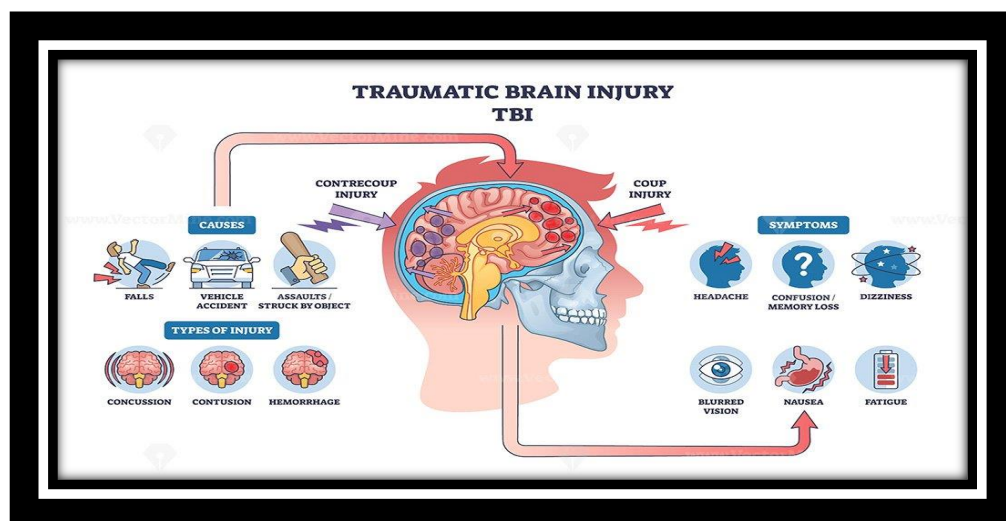


Figure 1- TBI Explained[13]

The physical, cognitive, emotional, and behavioral disturbances result in impaired activities of daily living, chronic disability, and diminished quality of life; hence, neuropsychological

rehabilitation plays an imperative role as it focuses on reducing disability and improving quality of life. Cognitive rehabilitation is the major constituent of a neuropsychological rehabilitation program and aims at remediation of posttraumatic cognitive impairments. Mild Cognitive Impairment (MCI) [14] represents a clinically heterogeneous transition state between physiological aging and overt dementia, typified by objective decline—most often in episodic memory—without substantial loss of everyday autonomy; various cognitive rehabilitation techniques, such as direct training, strategy training, metacognitive training, functional communication skills training, and external memory compensation, are effective and recommended for patients with TBI[15].

1.3.1 Mild, Moderate, and Severe Traumatic Brain Injury

The Bangladesh public sector declares DBI as endemic, driven by road traffic accidents, and care centers in Dhaka have managed it largely as tertiary care. DBI severity, evaluated through the GCS score upon admission, ranges from brief or no loss of consciousness to mild cognitive impairment or minor deficits. Our study at a facility in Dhaka found that a significant proportion of patients were admitted in the mild category and may experience lingering physical and cognitive effects[16]. Moderate TBI, which is GCS 9:00 to 12:00, significantly accounts for hospitalization, as TBI is roughly 35 to 78% of trauma cohorts studied, depending on our own patients who have presented with cerebral hemorrhagic conditions, hematomas, and traumatic subarachnoid hemorrhage. The other aspect is severe TBI, where the GCS scale showed that scores of 3 to 8 indicate a critical condition, with significantly greater risks of long-term disability and mortality. In our cohort, severe TBI accounted for 29% of admitted traumatic cases[17].

1.3.2 Determinants of Functional Recovery

In our study, the leading causes of TBI in Bangladesh were RTIs, accounting for 67 to 70% of cases. But there are other areas where our patients came in. We called these the secondary causes, including falls from apparent heights, which accounted for 16%. Physical assaults, which are a common domestic violence issue in Bangladeshi society, accounted for 17%, and many of these people were women; the fall-from-height patients were mostly those who had tried to commit suicide but failed in their attempt. The patient demographics were predominantly male; because Bangladesh's population is predominantly male, our cohort included 80% males aged 18 to 50, and vehicle drivers were a considerable portion of TBI cases[18].

1.4 Role of Systemic Care Procedures in Recovery Outcomes

The systematic care procedures adopted at the National Institute of Neurosciences, Dhaka Medical College Hospital, included non-contrast CT scans, Burr hole drainage, and hematoma evacuations for surgical interventions, which accounted for at least 56% of patients. Post-injury management is totally dependent on pre-hospital care, and treatment delays have worsened patient prognosis[19].

1.4.1 Prehospital Care

Prehospital care accounts for a significant contribution, as mortality rates in hospital-based cohorts normally range around 10.3%, with a strong correlation between low admission GCS scores and treatment delays over 9 hours and adverse long-term functional outcomes. Prehospital care also includes how patients receive medical help immediately after an accident or incident[20].

1.4.2 Acute Hospital Management

Hospitals are overcrowded, as cognitive rehabilitation proves to be behavioral, amyloid cognitive, and emotional disturbances after occurrence of TBI; nonetheless, scientific evidence eludes from the developed world, which is quite relevant to the cohort study in Bangladesh, as cross-cultural research in this area often is limited and neuropsychological interventions consisted of cultural underpinnings as explicitly determined through neurophysiological functions through neutralization of functioning and were influenced by tumor cultures, neurons and macro macros. Nonetheless, Olfactory Groove Schwannomas (OGSs) [21] are exceptionally rare intracranial tumors and definitely a surgical challenge for which Bangladesh is not well equipped as OGS removal often requires a combined transcranial-interhemispheric and endoscopic endonasal approach for which Bangladeshi hospitals and clinical centers are not well equipped with but this must be supported by the fact that, to achieve total resection ensuring skull base reconstruction is absolutely important; furthermore, postoperative testing can intricately improve Olfactory function[22].

1.4.3 Critical Care and Neurosurgical Interventions

The scientific literature accumulated proves that post-acute TBI rehabilitation led to delinquent outcomes in patients from cultural and linguistic minorities, independent of socioeconomic background, participation, and motivation in rehabilitation. Therefore, directly importing established neuropsychological rehabilitation methods from one culture to the Bangladeshi culture was not entirely justified. Nonetheless, the substantial variation that existed in healthcare system organization, service delivery models, and funding structures has influenced access to rehabilitation

and long-term functional outcomes for adults with chronic moderate to severe traumatic brain injury.

1.4.4 Rehabilitation Services

The rehabilitation services play a key role as Bangladesh reviews protocols that are systematically aimed at characterizing systematic management practices, and this only happened lately during the time of Dr. Yunus's interim government, where rehabilitation access, recovery outcomes, and continuity of care went as far as the European health care system through a generic culture-specific evaluation of neuropsychological intervention, which proved to be quite imperative.

1.5 Research Gaps in Low- and Middle-Income Countries

The lower- and middle-income countries are denoted with the acronym LMICs and bear over 90% of global trauma-related fatalities from TBI, yet critical research gaps remain unaddressed compared to the Arab Gulf Cooperation Council countries (AGCC), Western Europe, and the United States of America (USA). Key research gaps in LMIC TBI treatment stem from the lack of resource-stratified guidelines, as most clinical management guidelines are built on HIC assumptions, such as advanced intracranial pressure (ICP) monitoring, immediate availability, and continuous neuroimaging. Validated protocols are scarce because cost-effective management tailored to resource-constrained environments is lacking. Prehospital care and transport deficiencies also contribute to the problem, as research remains limited or nonexistent due to a lack of data on optimizing prehospital triage, emergency medical services, and rapid transport.

Our study proves that 74% of TBI patients in Bangladesh, through LMIC assessments, arrived at definitive care more than three hours after injury, which led to compounding mortality. Another aspect is the epidemiological and registry that avoids TBI incidence is dependent on large scale prospective registries through reliability of injuring mechanisms through higher prevalence of RTAs versus the suicide attempts through falls and in this regard the real time acute tracking is definitely across Bangladesh have created a lot of trouble as a matter of fact the African countries have a better track record than Bangladesh due to non-investment in medical arena furthermore long term rehabilitation and socioeconomic outcomes are dependent on post accurate functional recovery deduced from personal data call my cognitive rehabilitation ability physical outcomes, household financial catastrophic risk which is in Bangladesh including wage losses a vast majority

of the population gets a wage on a per day basis and then the caregiver burden are severely under researched in the case of Bangladesh.

1.6 Study Objectives

Study objectives are divided into two sections; primarily, the objective is to evaluate the impact of pre-hospital referrals and interfacility stabilization on non-functional outcomes among TBI patients admitted to tertiary care centers in Bangladesh, using 30-day mortality as the outcome. The secondary objective is to quantify exact time-to-treatment intervals and identify specific systemic and clinical bottlenecks at secondary and primary healthcare tiers, for example, Upazila Health Complexes. Secondary objective B is to assess the prevalence and predictors of clinical deterioration among transiting patients who receive no pre-referral active medical stabilization.

1.7 Conceptual Framework

Under The primary hypothesis for this conceptual theorem work included interfacility referral delay which exceeded data awards on TBI patients in Bangladesh from the time of injury to tertiary neurosurgical admission and hold it a significant higher risk of 30 day mortality compared to the other patients who arrived within the “golden hour” or as the medical scientist declare it 8 hours were highly privileged as they were adjusting for baseline injuries severity through the Glasgow, scale GCS. The secondary hypothesis was that patients who arrived at primary and secondary rural health facilities without documentation, and who received active medical stabilization, airway management, and fluid resuscitation, exhibited significantly higher rates of secondary brain injury, hypertension, and hypoxia upon tertiary arrival than stabilized patients. Furthermore, the demographic vulnerability were geriatric TBI patients 860 plus experienced disproportionality higher 30 day mortality rate than the socioeconomic burden, where families of young economically counterproductive male dbi patients and faced A significantly higher rate of immediate high school household catastrophic financial risk, exceeding 40% of capacity to pay due to combination of medical costs and certain wage losses.

2. Methods

2.1 Study Design and Sample

This prospective, single-group pre–post experimental study was conducted at a tertiary care hospital at the National Institute of Mental Health, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The

Researchers screened thirty-three patients aged 21 to 55 years with moderate to severe TBI (Glasgow Coma Scale score 5-9). The Researchers included right-handed individuals with corrected vision or hearing and a post-injury period of 7-21 months. The researchers excluded patients if they had mild TBI, a history of any psychiatric, neurological, or neurosurgical illness, mental retardation, or substance use (except nicotine, alcohol, and vaping), or if they had undergone any structured psychological intervention in the past 1 year.

2.2 Procedure

The Institute Ethics Committee approved the study under the auspices of the World Medical Association (WMA), which has developed the Declaration of Helsinki as a statement of ethical principles for medical research involving human participants, including research using identifiable human material or data. All participants who met the inclusion criteria provided written informed consent, and The Researchers obtained sociodemographic and clinical details[23]. All patients underwent a baseline assessment, including a comprehensive neuropsychological assessment and assessments of symptom reporting and quality of life; caregivers also reported the patient's overall functioning. All participants underwent a hospital-based CR intervention for 21 sessions over a quarter (3 months). After completing the CR intervention, the researchers re-administered the outcome assessments. The outcome measures used in the current study are described below.

2.3 Tools

2.3.1. NIMHANS Neuropsychology Battery

The Researchers assessed cognitive functioning using the NIMHANS Neuropsychology Battery. The Battery consisted of nine tests and covered the cognitive domains of motor speed, processing speed, focused attention, semantic fluency, working memory, planning, visuo-spatial construction, verbal and visual learning, and memory[24]. The Battery has been standardized on the Bangladeshi population and is widely used for clinical and research purposes. The current study used raw scores for analysis[25].

2.3.2. The Rivermead Post-Concussion Symptoms Questionnaire

This scale is a widely used self-report tool to assess commonly reported post-concussion symptoms. The scale consists of 16 items; each is rated on a Likert scale from 0 (never experienced at all) to 7 (a severe problem). The total score is obtained by adding the scores on all items, with a higher total score indicating more severe post-concussive symptoms[26].

2.3.3. Perceived Stress Scale

Scholars and practitioners widely use the Perceived Stress Scale (PSS-10) to measure an individual's perceived stress. However, its factor structure remains contested, with concerns about whether it is unidimensional or multidimensional. This study aims to evaluate the PSS-10's factor structure. This 10-item self-report measure assesses perceived stress. Each item is rated on a Likert scale ranging from 0 (negligible) to 7 (quite often). The total score is obtained by adding the scores on all items; a higher total score indicates higher perceived stress.

2.3.4. World Health Organization Quality of Life Scale—Brief

World Health Organization Quality of Life Scale—Brief is a 26-item self-report measure. Each item is rated on a Likert scale ranging from 0 to 5. The scale assesses quality of life in four domains: physical, psychological, social, and environmental. Total scores are obtained for each domain, with higher scores indicating better quality of life. This investigation scrutinizes the psychometric qualities of the Bangla version of the Older People's Quality of Life-Brief (OPQOL-brief) scale in a sample of Bangla-speaking older adults to support culturally appropriate assessment of lived experience and person-centered care in later life and to strengthen gerontological nursing assessment and evaluation across settings.

2.3.5. Visual Analog Scale

While the Visual Analog Scale (VAS) revealed gradient perception in segmental speech sounds, it has not been applied to lexical tones, a critical yet understudied suprasegmental feature[27]. This study investigated lexical tone categorization using VAS and directly compared it with traditional two-alternative forced-choice (2AFC) [28]. This scale assessed the caregiver's perception of the patient's overall dysfunction. The Researchers rated it on a scale of 0 to 100, where 0 represented adequate functioning and 100 represented complete dysfunction. This provides converging evidence that gradient aspects of perception are also observable at the suprasegmental level and illustrates how VAS can serve as a sensitive tool for probing lexical tone categorization[29].

2.3.6. Intervention Program: Cognitive Retraining

The hospital-based CR intervention used in the current study was adapted from the home-based CR developed by Prof. Dr. Md. Shafiul Alam, MBBS, FCPS (Surgery), MS (Neurosurgery), FICS, FACS (America), MRCPS (Glasgow), for patients with head injury. The CR intervention was based on restoration principles and aimed to improve impaired cognitive functions through intensive, repetitive practice and drills. The CR intervention included five tasks targeting various cognitive domains such as processing speed, attention, response inhibition, working memory, learning, and memory. Each task encountered four difficulty levels arranged in ascending order.

Participants practiced each level for five sessions before moving to the next level. The description of the CR intervention is provided in Table 1. Participants completed 21 CR sessions three times a week with the researchers on an outpatient basis. Before initiating CR, each participant and caregiver received one session with the therapist focused on psychoeducation about TBI and its sequelae, the need for cognitive rehabilitation, and an overview of the CR intervention.

S. no.	Target functions	Task	Description
1	Processing speed; sustained attention	Grain sorting	The patient is exposed to a predefined quantity of a mix of two grains and must sort them separately, one grain at a time, within a limited time.
2	Focused attention; response inhibition	Encountering	The patient is administered a simple geometrical shape printed on plain white paper and encountered it evenly without crossing the boundaries within a limited time.
3	Working memory	Digit span	The therapist recites a string of numbers to the patient, and the patient repeats it forward or backward, as instructed: five items forward and five backward. The researchers stop after each session.
4	Verbal learning and memory	Temporal encoding	A list of unrelated words was read aloud, and the subject repeated the first one-third of the list; the same procedure was done for the last one-third and middle one-third of the list; free recall learning was done for five trials.
5	Visual learning and memory	Spatial encoding	Three to six small daily-use objects, such as a coin, a key, and an eraser, are placed on the table in a predefined spatial arrangement; after 10 seconds of exposure, the patient must rearrange the jumbled objects into the same spatial arrangement.

Table 1. A brief description of the cognitive retraining intervention.

3. Results

Using the Covidence systematic review software (Veritas Health Innovation), the researchers (NZ, JG) independently screened, as in duplicate, the titles and abstracts of all identified references. The same reviewers assessed the full texts of potentially relevant articles for inclusion[30]. The researchers resolved conflicts through discussion and consensus[31]. The main outcome was neurologic deterioration, as defined by the study authors. Neurological deterioration was defined as a focal neurological deficit, abnormal pupillary examination, or a GCS score of 12 or less, based on the original BIG derivation. Secondary outcomes were the researchers' neurosurgical intervention and death. Two independent reviewers extracted study characteristics (country, number of sites, prospective/retrospective, BIG variant used, and total patients) and outcome data, divided into large

categories, from the included studies using a standardized form. The Researchers then entered all data into the Statistical Package for the Social Sciences (IBM-SPSS) software, version 2.0[32]. The Researchers used appropriate descriptive statistics, such as frequencies, percentages, means, and standard deviations (SD), to describe the sociodemographic and clinical data and the outcome measures. To compare average scores on various outcome measures at baseline and post-intervention, the Researchers used the Wilcoxon signed-rank test. The Researchers set the significance level at 5%.

Table 2 shows the sample's sociodemographic and clinical characteristics. Patient age ranged from 18 to 52 years (mean $\pm$ SD = 33.33 ± 9.8). The mean age in the current study is similar to findings from another epidemiological study conducted at a Level I trauma center in Dhaka, where the authors reported a mean age of 32.15 years among patients with moderate to severe TBI.²⁷ The majority of the participants encountered studied up to graduation. The years of education ranged from 7 to 21 years (mean $\pm$ SD = 17.5 ± 7.12). Most participants were male (71%), and more than half were married (61%). Most were gainfully employed before the injury (91%), and the rest were students.

Variables	Mean $\pm$ standard deviation, or n (%)
Age in years	32.33 $\pm$ 7.8
Years of education	14.5 $\pm$ 4.12
Gender	
Male	9 (75)
Female	3 (25)
Marital status	
Married	7 (58)
Single	4 (33)
Separated	1 (9)
Employment status	
Employed	10 (83)

Student	2 (17)
Duration of illness in months	11.37 ± 6.04
Injury severity	
Moderate	4 (33)
Severe	8 (67)
Currenting complaints	
Memory	6 (50)
Language and speech	5 (41)
Behavior	1 (9)

Table 2. Sociodemographic and clinical characteristics of the sample (n = 12).

All the patients sustained TBI due to road traffic accidents, and two-thirds of the patients encountered sustained a severe TBI (77%). At recruitment, illness duration ranged from 3.1 to 30.3 months (mean ± SD = 13.37 ± 7.03). Half of the patients presented with complaints of forgetfulness and slowness of thinking, whereas the other 41% presented with speech-language complaints such as expressive aphasia and anomia.

3.1. Effect of CR on Results

The Researchers compared scores on various outcome measures at baseline and post-intervention to assess immediate post-intervention changes. The Researchers found a congruent effect of CR on Complex post-traumatic stress disorder (cPTSD), a clinical condition that features not only PTSD symptoms, but also disturbances in self-organization[33]. Patients with cPTSD consists of a higher incidence of psychiatric comorbidities, including suicidality. A key construct closely related to suicidality is hopelessness, described as a feeling of despair and a state of mind characterized by low or negative expectancies about an individual's future. Since there is a paucity of studies investigating the link between cPTSD and hopelessness as a risk factor for suicidality, this study aimed to examine the role of post-traumatic symptomatology as the primary driver of suicidality, as measured by hopelessness.

3.1.1. Cognitive Functions

The Researchers assessed cognitive functions using various cognitive tests. Table: The table shows that patients encountered significant changes at post-intervention in the domains of processing speed (Digit Symbol Substitution Test), working memory (Spatial Span) [34], planning (Tower of London), visuo-spatial construction (Complex Figure Test—Copy), visual memory (Complex Figure Test—Delayed Recall), and verbal memory (Rey's Auditory Verbal Learning Test—Total Learning). On Rey's Auditory Verbal Learning Test (RAVLT), only Total Learning scores changed, with no significant difference observed on Delayed Recall. Total Learning scores on RAVLT reflect the individual's capacity to learn information over trials. They are considered measures of memory encoding, whereas the Recall trials are traditionally considered measures of memory retention[35]. The RAVLT findings show changes in memory encoding but not in memory retention. The significant difference on the test of processing speed (Digit Symbol Substitution Test) [36], in the absence of any significant difference on the test of motor speed (Finger Tapping Test) [37], suggests that changes in processing speed are independent of changes in motor speed.

	10	35.98	11.96	40.9	8.954	-1.201	0.240
FTT—Right hand							
DSST—Time	12	457.58	193.82	355.83	172.68	-2.824	0.005a
Color Trails Test 1—Time	12	155.75	70.12	143.00	55.14	-0.471	0.638
Color Trails Test 2—Time	11	309.73	204.94	270.09	140.77	-1.245	0.213
Animal Names test	11	7.55	3.05	8.27	2.45	-0.9	0.368
Verbal 2 Back Hits	11	5.82	2.32	6.73	1.10	-1.278	0.201
Spatial Span	12	14.25	2.63	15.25	2.90	-1.916	0.050a
The Researchers of London	12	7.92	1.98	10.08	1.78	-2.591	0.010a
CFT_Copy	11	29.00	8.05	32.82	3.79	-2.507	0.012a
CFT_Delayed Recall	11	10.45	8.38	16.36	8.43	-2.368	0.018a
AVLT_Total Learning	12	31.42	13.12	37.00	12.85	-2.134	0.033a
AVLT_Delayed Recall	12	4.83	4.04	7.00	5.10	-1.838	0.066

Table 3. Comparison of cognitive functions at baseline and post-intervention.

3.1.2. Symptom Reporting, Quality of Life, and Overall Functionality

Table: Post-intervention, patients reported significantly lower perceived stress (Perceived Stress Scale), lower post-concussive symptoms (Rivermead Post-Concussion Symptoms Scale), and higher psychological quality of life. Caregivers corroborated these subjective improvements, reporting significantly lower overall dysfunction in patients (Visual Analog Scale).

Variables	n	Baseline		Post CR		z-value	p-value
		Mean	SD	Mean	SD		
Abbreviations: CR, cognitive retraining; RPCSQ, Rivermead Post-Concussion Symptom Questionnaire; SD, standard deviation; WHOQoL, World Health Organization Quality of Life Scale—Brief.							
^a p-value significant at the 0.05 level.							
Perceived Stress Scale	9	14.89	9.25	8.89	7.99	−2.203	0.028a
RPCSQ	10	9.00	5.81	4.30	3.77	−2.136	0.033a
WHOQoL—Physical	9	28.89	4.48	30.22	4.49	−1.130	0.258
WHOQoL—Psychological	9	21.44	3.88	25.22	3.19	−2.120	0.034a
WHOQoL—Social	9	12.33	2.06	12.89	1.36	−0.641	0.521
WHOQoL—Environmental	9	31.56	6.60	33.56	5.10	−1.190	0.234
Visual Analog Scale	12	56.25	23.85	29.58	18.52	−3.103	0.002a

Table 4. Comparison of symptom reporting, quality of life, and overall functionality at baseline and post-intervention.

4. Discussion

4.1 Principal Findings

The current study investigated the effects of CR intervention in patients with moderate to severe TBI. The findings reveal significant improvements in the trained cognitive domains: processing speed, working memory, visual memory, and verbal memory[38]. These findings are in line with previous research where participants with acquired brain injury showed significant improvements in the trained cognitive domains, that is, attention, working memory, executive functions, and memory following 8 -12 weeks of hospital-oriented digitized cognitive training[39]. In addition, planning and visuospatial construction improved. Planning and visuospatial construction are higher cognitive functions, and basic cognitive functions such as processing speed, attention, working memory, and visual-perceptual abilities serve as building blocks. The improvements observed in planning and visuospatial construction in the current study can be attributed to the improvements in basic cognitive functions. Since the focus was on improving attention, this may also affect higher cognitive functions. Attention training interventions after TBI improve overall cognitive function and have strong scientific support, as higher cognitive functions indicate the generalization or transfer of learning from trained to untrained domains[40].

Consistent with the previous literature, the findings further reveal that patients experienced a significant reduction in subjectively reported symptoms, that is, post-concussive symptoms and

perceived stress, after CR. A recent Randomized Controlled Trial (RCT) of four CR interventions in military service members with mild TBI reported similar findings, where reduced functional cognitive-behavioral difficulties were found in those receiving therapist-administered CR in addition to a combination of psychoeducation and medical management compared with those receiving only the combination of psychoeducation and medical management[41]. The association between the researchers' subjectively reported symptoms and cognitive functions in TBI appears bidirectional. The persisting cognitive deficits may be a cause of subjective distress for many individuals with TBI, whereas for others, stress and subjective post-concussive symptoms can cause difficulties in cognitive functioning. Somatic symptoms and chronic stress are significantly associated with subjective memory complaints after mild to moderate TBI. Consequently, post-traumatic stress disorder and depression in war veterans with mild TBI are associated with more enduring cognitive compromise. The CR intervention used in the current study focused exclusively on cognitive functions. Therefore, improvements in subjective post-concussive symptoms and perceived stress after CR intervention can be understood as a cascading effect of improved cognitive function.

4.2 Injury Severity as a Determinant of Recovery

Cognitive functions are essential to every aspect of human functioning and form the basis of adaptive behavior and holistic functioning. Cognitive impairments have been shown to negatively affect activities of daily living in brain-injured patients. The current study found a significant reduction in overall dysfunction, as reported by caregivers, after CR intervention. Another study found that patients with moderate to severe TBI who underwent an intensive cognitive rehabilitation program encountered better community integration and satisfaction with functioning than those who underwent a standard rehabilitation program[42]. An RCT reported that working memory training, in addition to standard neurorehabilitation, improved everyday functioning and reduced fatigue in patients with brain injury. The CR intervention used in the current study has also improved functional recovery in patients with TBI.

4.3 Influence of Systemic Care Procedures on Neurological Outcomes

People with TBI experience diminished health-related quality of life, which is commonly associated with chronic stress, somatic symptoms, and psychiatric disorders with an onset after TBI. In the current study, the CR intervention significantly improved the psychological domain of quality of life. In contrast, other domains, such as physical, social, and environmental, remained

unchanged. The improvement seen only in the psychological domain may reflect the nature of the tool's questions. Questions in the psychological domain address intrapersonal factors such as mood, concentration, meaning in life, self-acceptance, and self-appearance. In contrast, questions in the remaining domains address factors such as physical problems, interpersonal relationships, gender, rigorous physical safety, environment, and the availability of resources beyond one's direct control. These findings align with previous literature, which also shows that cognitive rehabilitation improves quality of life in patients with brain injury[43].

4.5 Health System Challenges in Bangladesh

Primarily, in Bangladesh, with 33% of the population still illiterate, who did not clear matriculation, it is difficult to train caregivers to function as co-therapists at home for patients. Therefore, the cognitive rehabilitation plan may not be implemented as systematically as in hospital-based rehabilitation[44]. Secondly, measuring homework compliance in a home-based approach is challenging. Thirdly, it is noteworthy that Bangladesh has high rates of misconceptions toward brain damage and brain injury sequelae even among the upcoming health-care professionals. Behavioral and neuropsychiatric disturbances commonly experienced by the survivors of severe TBI may resemble the behavioral disturbances seen in patients with mental illnesses. Abnormal behavior and after-effects of mental illness are a major source of stigma in family caregivers of people with mental illnesses. Therefore, misconceptions regarding TBIs and behavioral disturbances after TBI may lead to increased stigma among family caregivers of patients with TBI. This stigma may prevent the caregivers from carrying out the cognitive rehabilitation tasks effectively at home and thereby hamper the outcomes of cognitive rehabilitation. Lastly, therapist-mediated hospital-based CR intervention may also foster a therapeutic alliance between the researcher and the patient, which is considered a major mechanism of change in most psychological interventions[45].

4.5.1 Emergency Response Limitations

To our knowledge, this is the first systematic study to explore the effects of hospital-based cognitive rehabilitation on patients with moderate to severe TBI in Bangladesh. The study's major strengths are its structured, intensive rehabilitation program and its use of objective and subjective outcome measures. Major limitations include the small sample size, the lack of a control group, and the short duration of the CR intervention. Moreover, the findings may not generalize to older patients with TBI, as the sample consisted of relatively young patients. Further large-scale studies

with robust study designs are required to assess the effectiveness of this CR intervention in Bangladesh. Future studies should also explore the long-term effects of this intervention at follow-up[46].

4.6 Clinical and Public Health Implications

The current study investigated a hospital-based CR intervention. In contrast, the literature suggests that home-based cognitive rehabilitation is as good as in-hospital cognitive rehabilitation after moderate to severe TBI. Home-based cognitive rehabilitation is cost-effective. However, home-based cognitive rehabilitation has a few major limitations in Bangladesh[47].

4.7 Policy Recommendations for Bangladesh

Bangladesh has emerged as a leading global destination for clinical research. The number of higher education institutions has increased significantly since 2017. Bangladesh ranks ninth in research output in Asia, after India, China, and Japan. Since 2021, publications on brain injury research have increased rapidly nationally and through international collaborations. At the current pace, Bangladesh is expected to rise globally in the coming years. This communication is expected to motivate many neurosurgeons and allied specialists to pursue TBI research and share their findings in high-impact journals. This study aimed to determine region-wise publication patterns of TBI studies from institutions, departments, and journals publishing head injury research from Bangladesh. In PubMed, we found 371 research articles related to TBI from Bangladesh during the study period. Institutes from all 8 Divisions across Bangladesh contributed to TBI research. Chittagong Division had the highest number of institutes (27) contributing to TBI research publications, followed by Dhaka (26), Mymensingh Division (23), Rangpur Division (14), and Khulna Division and Barishal Division (12). In terms of publications, Dhaka leads with 144 papers, followed by Barishal Division (73) and Chittagong Division (63) [48].

Of the mentioned Divisions, 3 Divisions have published in association with other countries. Researchers from Dhaka, Chittagong Division, and Khulna Division have published more papers with international collaboration than those from other Divisions. Sixteen departments published research related to or in association with TBI; of these, neurosurgery leads with 41.9%, followed by forensic medicine (7.3%), neurology (3.3%), etc. Although most published studies were original articles (65.7%), they were primarily clinical observations (69.1%), generating low-level scientific

evidence. Reviews and longitudinal studies are published occasionally. Animal studies are the least common (3.7%)[49].

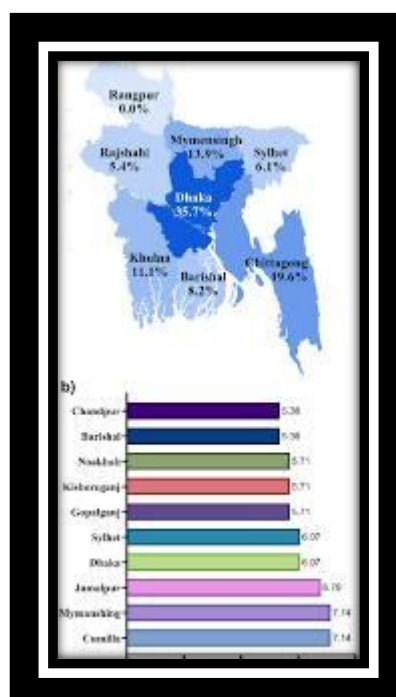


Figure 2-TDI distribution amongst Bangladesh districts[50]

Of the researchers from 29 Divisions and Dhaka Capital Territory, only those from 8 Divisions have contributed to brain injury research so far. Bangladesh has around 333 medical colleges, both government and private. Of them, only 37 consists neurosurgical departments recognized for MC Neurosurgery training programs. Institutes with neurosurgical training are approved for only 190 candidates' intake per year. Bangladesh has approximately 1,500 neurosurgeons, with one neurosurgeon for every 27-31 thousand people, a very low doctor-patient ratio compared with developed countries (one neurosurgeon per 2.5 thousand) [51]. Almost all major cities in Bangladesh have facilities to treat TBI patients. Bangladesh has nearly 90 biological science Research Institutes that mainly focus on basic research. Of them, only a few biological research institutes are involved in brain injury research. Translational research from experiments to humans is still insufficient[52].

This manuscript reports that Bangladesh's contribution to published research that adds knowledge and bridges gaps in the brain injury area is grossly sparse, accounting for as little as 1% of published research articles in PubMed. Bangladeshi authors publishing with foreign authors

strengthen scientific papers by exchanging new ideas and integrating multiple departments. Our research shows that the Department of Neurosurgery leads brain injury publications, accounting for 47.9% of total TBI publications. This is because, in Bangladesh, the Department of Neurosurgery manages initial treatment of brain injury cases and later refers them to specialized departments. Most head injury cases involve a medico-legal angle because they are road traffic injuries regulated by law. Hence, the forensic medicine department contributes to scientific publications, accounting for 5.1% of research papers. There is a dearth of research studies with a prospective design that could lead to a better understanding of the etiology of brain injuries in Bangladeshi conditions[53].



Figure 3-Effects of TBI[54]

4.7.1 Strengthening Trauma Care Systems

Brain injury research articles from Bangladesh were published in 92 indexed journals: 15 Bangladeshi journals and 79 international journals with high impact factors. The study observed an increasing trend in publications over the last 5 years, with about two-thirds of the retrieved papers published between 2021 and 2026. Most of these articles are published in national journals. The number of publications in international journals has also increased over the last five years; however, very few articles are published compared with contributions from developed countries[55].

4.7.2 Improving Neurorehabilitation Infrastructure

The number of people injured per million has doubled from 1990 to 2021 in Bangladesh. From 1990 to 2021, road accident injuries increased 9.3-fold. Consequently, a large number of individuals with TBI endure lifelong impairment and disability. The sudden occurrence of brain injury places a phenomenal burden on day-to-day activities, affecting survival and income. The total cost of road traffic injuries alone is estimated at 57,000 million a year in Bangladesh[56]. Despite rising TBI cases, research has not increased commensurately at any level. Possible causes include limited funding, low interest among neurosurgeons and other TBI providers, and limited time, as the neurosurgeon-to-population ratio is skewed. The neurosurgeon takes more pride in demonstrating his surgical skills for removal of a complex skull base or vascular lesions, the incidence of which is very rare, but does not translate into interest in improving care of victims of TBI, the incidence of which is high[57].

4.7.3 Future Research Directions

This preliminary study investigated the effectiveness of a hospital-based, therapist-mediated CR intervention based on the restorative approach to rehabilitation in patients with moderate to severe TBI. The findings are promising, as the CR intervention resulted in significant improvements in cognitive function after 21 sessions. The CR intervention also reduced subjective symptom reporting and improved functionality and quality of life. Though the home-based CR interventions are more cost-effective, they may not serve the purpose in patients with severe TBI. The behavioral disturbances and complex disability in survivors of severe TBI may render a home-based CR intervention nonviable, and a structured hospital-based CR intervention may be useful. TBI research in Bangladesh highlights a critical transition from basic epidemiological tracking to targeted clinical interventions. This is a long road, through which the leading drivers of TBI disproportionately impact economically productive young adults and vulnerable elderly populations, as future research directions have to concentrate on addressing resource allocation constraints and systemic care gaps.

Critical future research priorities for TBI in Bangladesh can span five major areas primarily the large scale standardized data infrastructure has to be upgraded to a level where the national TBI registries and the community based tracking and the CDEs of the common data elements should be acquired through substantial authenticity furthermore the pre hospital care and post-crash logistics need to be identified through pre referral interventions transportation and triage models and trauma scoring customization the long term outcomes and economic impacts include that like as the

current literature heavily emphasizes on 30 day post-injury survival or immediate discharge outcomes the longitudinal data is severely lacking hence the extended follow-up needs to be implemented through tracking cohorts until three years post-surgery where cognitive decline cohort disability and post-traumatic stress PTS and long term mortality should be examined socioeconomic economic burden needs to be quantified through the household economic collapse joblessness and the wage issue which has led to lost productivity resulting from TBI in particularly when the patient is the primary breadwinner.. Furthermore, precision diagnostics and management protocols needs to be surgically implemented versus conservative trials and advanced prognostic tools should be included in the referral and feasibility of cost effectiveness incorporating neurobiomarkers, advanced neuroimaging and the Glasgow, scale GCS has to be implemented The caregiver infrastructure and rehabilitation needs to be through preparedness of developing and evaluating structured nursing interventions which equip family members with the exact technical and knowledgeable skills required for post-discharge home care then the social support interventions measuring the direct impact of localized community networks, economic assistance, implement patients ultimate transition and quality of life scores.

5. Conclusion

5.1 Summary of Findings

TBI definitely escalates public health and represents a severe economic crisis in Bangladesh. Recent evidence synthesis showed that TBI predominantly affects economically active young males and is driven largely by structural falls and RTIs. The healthcare response is profoundly challenged by systematic pre-hospitalization delays, concentration of advanced trauma care, and a severe shortage of neurosurgical infrastructure in urban tertiary facilities like our facility and the Dhaka Medical College Hospital. Furthermore, current research is highly fragmented, relying on short-term, cross-sectional institutional data rather than centralized registries; the lack of standard prehospital triage protocols and long-term longitudinal tracking suggests that the true national burden of long-term socioeconomic collapse and chronic disability rates affects households and remains vastly underreported.

5.2 Implications for Traumatic Brain Injury Management

Furthermore, our findings emphasize an urgent need to transition from reactive to proactive crisis management in neurosurgery as a systems-level trauma framework in order to optimize TBI

management within Bangladesh's resource-constrained landscape. Systematic interventions should target 3 distinct tiers of organizations:

First, develop data-driven hospital systems through a formalized first-responder network integrated with trauma scoring that prioritizes Primary Health complexes, optimizing rural-to-urban referral pathways and eliminating critical-treatment delays. Then come the hospital protocols as evidence-based guidelines, establishing national conservative management versus surgical intervention, supported by the implementation of the unified common data element CDEs to track clinical metrics. The third and most important aspect is the post-discharge continuum, which shifts from absolute survival metrics towards long-term functional recovery through the development of an institutionalized new role for rehabilitation capacity and structured caregiver training programs to mitigate the profound socio-economic shock to families.

5.3 Concluding Remarks

In conclusion, we must address the TBI epidemic in Bangladesh so it doesn't become a pandemic-like disease, shifting from an isolated surgical emergency to a multifaceted chronic public health priority. Dual expansion of neurosurgical operating theaters is imperative; nonetheless, it is ultimately insufficient without investments in preventive infrastructure, Traffic Safety laws, and strict enforcement. Decentralized emergency care is needed. Navigating this crisis demands sustained collaboration between government policymakers, local clinical researchers, and international health.

Ethical Considerations

Ethical approval was obtained from the Institute Ethics Committee (Approval No. **just-2026-NDF485.BD**) before the commencement of the study. The study was conducted in accordance with the ethical principles of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from all participants before baseline assessment and participation in the hospital-based cognitive retraining intervention at the National Institute of Mental Health, Sher-e-Bangla Nagar, Dhaka, Bangladesh.

List of Abbreviations:

(TBI): Traumatic Brain Injury; **(CR):** Cognitive Retraining; **(GCS):** Glasgow Coma Scale; **(RTAs):** road traffic accidents; **[GCS]:** Glasgow Coma Scale; **(GOS):** Glasgow Outcome Scale; **(MCI):** Mild Cognitive Impairment; **(OGSs):** Olfactory Groove Schwannomas; **(AGCC):** Arab Gulf Cooperation Council countries; **(USA):** United States of America; **(ICP):** intracranial pressure; **(WMA):** World Medical Association; **(VAS) :** Visual Analog Scale ; **(SD):** standard deviations; **(cPTSD):** Complex post-traumatic stress disorder; **(RAVLT):** Rey's Auditory Verbal Learning Test; **(RCT):** Randomized Controlled Trial;

Acknowledgment:

The authors express their sincere gratitude to **Noor Al-Ilm for Publishing and Distribution**, through the **Ibn Sina Journal of Medical Science, Health & Pharmacy**, for fully funding this study under Grant No. **SINA-BANGLADESH-2026-KKS-663H**. This financial support enabled the implementation and completion of the research.

The authors also thank Noor Al-Ilm for Publishing and Distribution and the journal's Editorial Office for providing publication support and granting a **full waiver of the article processing charges (APCs)**, enabling the article to be published free of charge to the authors.

The authors gratefully acknowledge the participants and their caregivers for their cooperation throughout the study.

Author Contribution:

All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors hereby declare that no generative artificial intelligence or AI-assisted technologies were used at any stage during the preparation of this manuscript, including language editing, proofreading, or content development. The authors take full responsibility for the originality and integrity of the work presented in this publication.

Funding:

This research received a full research grant from Noor Al-Ilm for Publishing and Distribution, through the Ibn Sina Journal of Medical Science Health & Pharmacy, under Grant No. ****SINA-BANGLADESH-2026-KKS-663H****. The grant provided comprehensive financial support for the implementation and completion of the study. In addition to supporting the research activities, Noor Al-Ilm for Publishing and Distribution and the Editorial Office of the Ibn Sina Journal of Medical Science Health & Pharmacy provided full publication support for this article. The article processing charges (APCs) were ****fully waived****, and the manuscript was published ****free of charge to the authors**** as part of the journal's research and publication support program. The funding organization had no role in the study design, data collection, data analysis, interpretation of the findings, manuscript preparation, or the decision to publish. The authors retained full scientific independence and responsibility for the methodology, analysis, interpretation, and conclusions presented in this article.

Conflicts of Interest:

“The authors declare no conflict of interest.”

References

- [1] Zou, S., Lv, F., Qian, Y., Han, C., & Zhu, J. (2026). Halving global road traffic deaths through targeted mitigation practices by 2050. *Scientific Reports*. <https://doi.org/10.1038/s41598-026-42076-z>
- [2] Naher, L. ., Begum, J. ., Begum, H. ., & Rahman, M. J. . (2026). Death Due to Road Traffic Accidents: A Forensic Study in Bangladesh. *Community Based Medical Journal*, 15(2), 239-245. <https://doi.org/10.3329/cbmj.v15i2.91495>
- [3] Rahman FN, Das S, Kader M and Mashreky SR (2025) Epidemiology, outcomes, and risk factors of traumatic brain injury in Bangladesh: a prospective cohort study with a focus on road traffic injury-related vulnerability. *Front. Public Health* 13:1514011. doi: <https://doi.org/10.3389/fpubh.2025.1514011>
- [4] Arif, A., Islam, S., Akter, M. T., Hasan, S. M., Siddique, T., Biswas, S., & Mojumdar, T. H. (2026). Comparison between Early Post-Operative Outcome of Two Surgical Techniques of In- window Craniotomy with or without Duroplasty for the Management of Traumatic Brain Injury Patients. *The Insight*, 9(01), 18-21. <https://doi.org/10.5281/>
- [5] Rahman FN, Das S, Kader M and Mashreky SR (2025) Epidemiology, outcomes, and risk factors of traumatic brain injury in Bangladesh: a prospective cohort study with a focus on road traffic injury-related vulnerability. *Front. Public Health* 13:1514011. doi: <https://doi.org/10.3389/fpubh.2025.1514011>
- [6] Biswas, R., Kabir, E. & King, R. Effect of sex and age on traumatic brain injury: a geographical comparative study. *Arch Public Health* 75, 43 (2017). <https://doi.org/10.1186/s13690-017-0211-y>
- [7] Rahman FN, Das S, Chowdhury MRK, Kader M and Mashreky SR (2025) Health outcomes and health-seeking behaviour following traumatic brain injury among older people: a prospective cohort study in Bangladesh. *Front. Aging* 6:1513137. doi: <https://doi.org/10.3389/fragi.2025.1513137>
- [8] Dr. Mst. Maksuda Khatun, Dr. Mohammad Shahin Akter, Dr. Salma Shah Nawaz Parvin, Dr. Md. Towrit Reza. Traumatic Brain Injury And Its Findings On Computed Tomography; A Tertiary Care Hospital Experience. *Journal of Radiology and Clinical Imaging*. 6 (2023): 123-126. <https://doi.org/10.26502/jrci.2809079>
- [9] Rahman FN, Das S, Kader M and Mashreky SR (2025) Epidemiology, outcomes, and risk factors of traumatic brain injury in Bangladesh: a prospective cohort study with a focus on road traffic injury-related vulnerability. *Front. Public Health* 13:1514011. doi: <https://doi.org/10.3389/fpubh.2025.1514011>
- [10] Adams, C., Heard, K., Kohli, Y., Vatanpour, S., Berrouschot, J., Buck, B., ... & ESCAPE-NEXT Investigators. (2026). Safety and Efficacy of Nerinetide at Year 1 in Participants Enrolled in ESCAPE-NEXT: A Multicenter, Double-Blind, Randomized Controlled Trial. *Journal of the American Heart Association*, 15(13), e044080. <https://doi.org/10.1161/JAHA.125.044080>
- [11] Oishi, A. R., Ahsan, M. J., Sejuti, A., & Anik, B. M. (2024). Evaluating Traumatic Brain Injury Outcomes in Road Traffic Crashes. *arXiv preprint arXiv:2411.01771*. <https://arxiv.org/abs/2411.01771>
- [12] Henriksen, J. S., E. Lauridsen, S. S. Jensen, and N. V. Hermann. (2026). “ Patient-Reported Outcomes Following Loss of Permanent Incisors due to Traumatic Dental Injuries: A Retrospective Cross-

- Sectional Pilot Cohort Study.” *Clinical and Experimental Dental Research* 12: e70328. <https://doi.org/10.1002/cre2.70328>
- [13] Diagrams and Infographics / Traumatic brain injury is shown with a side-view head, brain impact zones, and labeled symptoms and causes. Outline diagram, vectormine. <https://vectormine.com/item/traumatic-brain-injury-is-shown-with-a-side-view-head-brain-impact-zones-and-labeled-symptoms-and-causes-outline-diagram/?v=85d1a9c488d7>
- [14] Uddin, M. S., Mamun, A. A., Takeda, S., Sarwar, M. S., & Begum, M. M. (2019). Analyzing the chance of developing dementia among geriatric people: a cross-sectional pilot study in Bangladesh. *Psychogeriatrics*, 19(2), 87-94. <https://doi.org/10.1111/psyg.12368>
- [15] Micarelli, A., Mrakic-Sposta, S., Malacrida, S., Vezzoli, A., Micarelli, R. X., Micarelli, B., Granito, I., & Alessandrini, M. (2026). Olfactory and Cognitive Performance Improvement After Oxygen–Ozone Major Autohemotherapy in Mild Cognitive Impairment: A Retrospective Cohort Study. *Neurology International*, 18(3), 41. <https://doi.org/10.3390/neurolint18030041>
- [16] Imran, J. A., Saha, P. K., Ria, M. A., Sarwar, S. S., & Konok, J. F. (2024). Level of cognitive functioning among elderly patients in urban area of Bangladesh: A cross-sectional study. *Plos one*, 19(12), e0309850. <https://doi.org/10.1371/journal.pone.0309850>
- [17] Hossain, Z., Das, J.K., Fahim, N.F. et al. Prevalence and predictors of cognitive impairment among the elderly in Bangladesh. *J Public Health (Berl.)* 31, 529–537 (2023). <https://doi.org/10.1007/s10389-021-01569-z>
- [18] Mozi, N.E., Monju, I.H., Sharmin, S. et al. Evaluating the association of physical frailty with cognitive impairment: a clinical perspective in older adults of Bangladesh. *BMC Geriatr* 26, 172 (2026). <https://doi.org/10.1186/s12877-026-06971-4>
- [19] Koipapi, S., Mmbaga, B. T., Chilonga, K., Msuya, D., Rabi, H., Nkoronko, M., ... & Chugulu, S. (2024). Outcomes of traumatic brain injury patients with acute epidural and subdural hematoma who underwent burr hole surgery: A two-year study at Kilimanjaro Christian Medical Centre, Tanzania. *World neurosurgery*: X, 21, 100257. [10.1016/j.wnsx.2023.100257](https://doi.org/10.1016/j.wnsx.2023.100257)
- [20] Tasnim, Z., Tune, S. N. B. K., Islam, B. Z., Naher, N., & Ahmed, S. M. (2026). Ambulance services for road traffic injury (RTI) victims in Bangladesh: a cross-sectional study on the ground realities and the way forward. *Injury Prevention*, 32(4), 597-603. <https://injuryprevention.bmj.com/content/32/4/597.abstract>
- [21] Tyagi, G., Madhusudan, N., & Konar, S. (2025). Olfactory Groove Schwannomas: A Single-Center Experience of 15 Cases with a Comprehensive Review of Clinical Presentation and Surgical Outcomes. *Journal of Neurological Surgery Part B: Skull Base*, 86(S 01), S224. <https://doi.org/10.1055/s-0045-1803238>
- [22] Hossain MM, Kroeger A, Pervin K, Norwood G, Be-Nazir A, et al. (2022) Emergency Medical Rescue Services in Dhaka City, Bangladesh: A Situational Analysis and Needs Assessments. *Int J Crit Care Emerg Med* 8:138. <https://doi.org/10.23937/2474-3674/1510138>
- [23] Nashwan, A. J., & Joy, G. V. (2026). The 2024 Declaration of Helsinki revision: Relevance to nursing research. *Journal of Advanced Nursing*, 82(4), 3986-3996. <https://doi.org/10.1111/jan.70082>
- [24] Arain, S., Thanvi, S. U., Shah, N., Farid, M. D., Raza, A., Ishaque, I., ... & Haider, S. M. A. (2025). EVALUATING THYROID HORMONE INFLUENCE ON CARDIOVASCULAR RISK AMONG PATIENTS WITH SUBCLINICAL AND CLINICAL HYPOTHYROIDISM. *IJHR-Journal of Health and Rehabilitation*, 3(8), i1282-i1282. <https://insightsjhr.org/index.php/home/article/view/1282>
- [25] Prajapati, A., Rastogi, P., Mathur, R., Choudhary, R., & Mudgal, V. (2026). Prevalence of Clinically Significant Neurocognitive Deficits in Unaffected First-degree Relatives of Bipolar Disorder Patients: A

- Cross-sectional Study using an Indian Standardized Battery. *Annals of Indian Psychiatry*, 10-4103. https://doi.org/10.4103/aip.aip_378_25
- [26] Summer N Rolin, Jeremy J Davis, Preliminary examination of symptom validity in veterans using the Rivermead post-concussion symptoms questionnaire, *Archives of Clinical Neuropsychology*, Volume 41, Issue 4, June 2026, acag037, <https://doi.org/10.1093/arclin/acag037>
- [27] Calvo Pascual, L.Á., Castro Corredor, D., Collantes-Estévez, E. and López-Medina, C. (2026), Impact of Social Factors on Visual Analog Scale Pain in Patients With Spondyloarthritis: A Propensity Score Matching Analysis. *Arthritis Care Res*, 78: 96-105. <https://doi.org/10.1002/acr.25675>
- [28] Li, Z. K., Gong, J. X., Fang, J., Huang, C. Z., Pu, Y. J., Xie, P., & Zhou, A. B. (2026). Reduced action-related modulation of visual contrast perception in schizophrenia: Evidence from a 2-AFC paradigm. *Vision Research*, 249, 108912. [10.1016/j.visres.2026.108912](https://doi.org/10.1016/j.visres.2026.108912)
- [29] Elmer, S., Lemke, U. & Giroud, N. Auditory and executive determinants of phonetic processing and lexical acquisition in older adults with mild hearing impairment and cognitive decline. *GeroScience* (2026). <https://doi.org/10.1007/s11357-026-02401-w>
- [30] Kayekjian, D., Gandra, N., Nguyen, S. A., Twardus, S. W., & Schlosser, R. J. (2026, September). Correlation of Local Nasal Biomarkers and Olfactory Dysfunction in Chronic Rhinosinusitis: A Systematic Review and Meta-Analysis. In *International Forum of Allergy & Rhinology* (Vol. 16, No. 9, pp. 1012-1023). <https://doi.org/10.1002/alar.70223>
- [31] Atilas, L., Schwam, B., Mehta, D. (2026). VERITAS™ Vision System. In: Armia, A., Sandali, O., Tahiri, R. (eds) *Cataract Surgery*. Springer, Cham. https://doi.org/10.1007/978-3-031-98572-0_22
- [32] Barrett, K. C., Leech, N. L., & Morgan, G. A. (2026). *IBM SPSS for intermediate statistics: Use and interpretation*. Taylor & Francis. [https://books.google.jo/books?hl=en&lr=&id=GDyxEQAAQBAJ&oi=fnd&pg=PT11&dq=%5B32%5D%09++Barrett,+K.+C.,+Leech,+N.+L.,+%26+Morgan,+G.+A.+\(2026\).+IBM+SPSS+for+intermediate+statistics:+Use+and+interpretation.+Taylor+%26+Francis.&ots=8MWyOtpTiu&sig=IzKjW6e7YnxqleoilYjSamplOYo&redir_esc=y#v=onepage&q&f=false](https://books.google.jo/books?hl=en&lr=&id=GDyxEQAAQBAJ&oi=fnd&pg=PT11&dq=%5B32%5D%09++Barrett,+K.+C.,+Leech,+N.+L.,+%26+Morgan,+G.+A.+(2026).+IBM+SPSS+for+intermediate+statistics:+Use+and+interpretation.+Taylor+%26+Francis.&ots=8MWyOtpTiu&sig=IzKjW6e7YnxqleoilYjSamplOYo&redir_esc=y#v=onepage&q&f=false)
- [33] Bi, Y., Cao, C., Chen, W., Liu, Y., Liu, P., Luo, S., ... Wang, L. (2026). A comparison between dissociative subtypes of PTSD and CPTSD among trauma-exposed adolescents. *European Journal of Psychotraumatology*, 17(1). <https://doi.org/10.1080/20008066.2026.2675867>
- [34] Li, Y., & Chen, S. (2026). Span entropy: A novel time series complexity measurement with a redesigned phase space reconstruction. *Advanced Engineering Informatics*, 74, 104631. [10.1016/j.aei.2026.104631](https://doi.org/10.1016/j.aei.2026.104631)
- [35] Orleans, N. A., Finley, J. C. A., Ortiz, B. L., Springer, J. G., Dumett Torres, E., Gribble, M. E., ... & Soble, J. R. (2026). Evaluating the independent and combined accuracy of Rey Auditory Verbal Learning Test (RAVLT) Effort Score and Forced Choice embedded performance validity tests. *Applied Neuropsychology: Adult*, 1-9. <https://doi.org/10.1080/23279095.2026.2731170>
- [36] Heggenberger, A., Leisge, K., & Schaefer, S. (2026). Differential Effects of Age and Simulated Sensory-Motor Constraints on Digit Symbol Substitution Test Performance. *Experimental Aging Research*, 1-18. <https://doi.org/10.1080/0361073X.2026.2703931>
- [37] Farias, Flávia Monteiro, Pereira Furtado, Victória Barros, Pinheiro, Elizabeth Nery, Couto da Costa, Kassiane, da Silva, Alícia Maciel, Moraes, Josileide Nobre, Xavier, Marília Brasil, Souza, Givago Silva, Characterizing Studies Using Mobile-Based Finger Tapping Test: A Scoping Review, *Human Behavior and Emerging Technologies*, 2026, 6388999, 20 pages, 2026. <https://doi.org/10.1155/hbe2/6388999>
- [38] Smits, P., Domensino, A. F., Ponds, R., & van Heugten, C. M. (2026). Predictors and moderators of outcomes on activities, participation, and quality of life following outpatient comprehensive

- neuropsychological rehabilitation for individuals with acquired brain injury: A systematic review. *Neuropsychological Rehabilitation*, 36(6), 1278–1320. <https://doi.org/10.1080/09602011.2025.2587787>
- [39] Najam, M., Parveen, S., Khan, Z., Baloch, F., Noor Ul Ain, Zaman, S., & Umme Habiba. (2026). Sequencing Primary Healthcare Reform for Universal Health Coverage: Lessons from China's Health System Transformation for Pakistan. *Pakistan Journal of Clinical Research*, 3(9), 6-13. <https://doi.org/10.65761/pjcr.2026.319>
- [40] Alashram, A. R. (2026). Computerized cognitive rehabilitation for patients with traumatic brain injury: A systematic review of randomized controlled trials. *Applied Neuropsychology: Adult*, 33(2), 578–587. <https://doi.org/10.1080/23279095.2024.2350607>
- [41] Darr AJ, Kirilin LK, Lopez J, Caswell M, Ananthanarayanan M, Robb J, et al. Evaluating the efficacy of a personalised sub-symptomatic exercise treatment programme for rehabilitation of military service members with persistent symptoms following mild traumatic brain injury: a randomised controlled trial. *BMJ Open Sport & Exercise Medicine*. 2026;12:e003065. <https://doi.org/10.1136/bmjsem-2025-003065>
- [42] Solomou, I., & Constantinidou, F. (2026). Feasibility and Efficacy of a Hybrid Delivery Model of the Categorization Program for Individuals With Chronic Traumatic Brain Injury: A Pilot Study. *American Journal of Speech-Language Pathology*, 1-13. https://doi.org/10.1044/2026_AJSLP-26-00065
- [43] Dua, S., Kumar, R., Prasannanshu, & Narang, K. S. (2026). Impact of acquired brain injury on quality of life. *Annals of Neurosciences*, 33(3), 278-282. <https://doi.org/10.1177/09727531241263670>
- [44] Banik, P., Roy, P. B., & Kumar, B. (2026). Information literacy skills among Bangladeshi undergraduates: measurement, determinants and the role of libraries. *Performance Measurement and Metrics*, 1-29. Banik P, Roy PB, Kumar B (2026;), "Information literacy skills among Bangladeshi undergraduates: measurement, determinants and the role of libraries". *Performance Measurement and Metrics*, Vol. ahead-of-print No. ahead-of-print. <https://doi.org/10.1108/PMM-03-2026-0025>
- [45] Saishree, S., Ranjan, J. K., Pandey, N., & Asthana, H. S. (2026). Cognitive Rehabilitation to Remediate Attention and Memory in Patients with Complicated Mild Traumatic Brain Injury: A Case Series. *Indian Journal of Neurotrauma*, 23(02), 167-176. <https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0045-1802588>
- [46] Apolinario, K., Nataliansyah, M. M., Haines, K. L., Murphy, P., Rao, S., De Moya, M., ... & Morris, R. S. (2026). Quality of life following traumatic brain injury among older adults. *JAMA Network Open*, 9(2), e2558087. doi: <https://doi.org/10.1001/jamanetworkopen.2025.58087>
- [47] Dal Pra, S., Ponsford, J., Munyard, R., Zayna, A., & Trevena-Peters, J. (2026). Cognitive rehabilitation following Traumatic Brain Injury: an international survey of current clinician practice. *Disability and Rehabilitation*, 48(16), 5366–5380. <https://doi.org/10.1080/09638288.2026.2621122>
- [48] Vanova, M., Patel, A. M. R., Scott, I., Gilpin, G., Manning, E. N., Ash, C., ... & Suarez-Gonzalez, A. (2026). Cognitive Rehabilitation and Functional Outcomes in Long COVID–Related Cognitive Impairment: A Randomized Clinical Trial. *JAMA Network Open*, 9(7), e2620687. doi: <https://doi.org/10.1001/jamanetworkopen.2026.20687>
- [49] Khan, S. I., Karim, R., Khan, S. I., Chowdhury, M. A. K., Shill, M. C., Pasha, F. M., ... Reza, H. M. (2024). Factors affecting severity and prognosis of traumatic brain injury among Bangladeshi patients: An institution based cross-sectional study. *Traffic Injury Prevention*, 25(8), 1072–1080. <https://doi.org/10.1080/15389588.2024.2363470>
- [50] Khan, S. I., Karim, R., Khan, S. I., Chowdhury, M. A. K., Shill, M. C., Pasha, F. M., ... Reza, H. M. (2024). Factors affecting severity and prognosis of traumatic brain injury among Bangladeshi patients: An institution based cross-sectional study. *Traffic Injury Prevention*, 25(8), 1072–1080. <https://doi.org/10.1080/15389588.2024.2363470>

- [51] Haque, M. R., Moslem, M., & Hossain, M. A. (2024). Traumatic brain injuries and its outcome at a tertiary Care Hospital in Northwest Part of Bangladesh. *Mymensingh Med J*, 33(4), 1230-1237. <https://mmjmmc.com/uploads/sgCxyr8C32hl.htm>
- [52] Rahman FN, Das S, Kader M and Mashreky SR (2025) Epidemiology, outcomes, and risk factors of traumatic brain injury in Bangladesh: a prospective cohort study with a focus on road traffic injury-related vulnerability. *Front. Public Health* 13:1514011. doi: <https://doi.org/10.3389/fpubh.2025.1514011>
- [53] Manik, A. H., Chowdhury, R. U., Chowdhury, A. U. M., Salek, A. A., & Ali, A. (2025). Outcomes of Traumatic Brain Injury in a Tertiary Care Hospital in Bangladesh. *TAJ: Journal of Teachers Association*, 38(2), 181-187. DOI: <https://doi.org/10.70818/taj.v038i02.0267>
- [54] How to Overcome The Effects of Traumatic Brain Injuries (TBIs)?, Sri Ramakrishna Hospital, 16 Dec 2023. <https://www.sriramakrishnahospital.com/blog/neurosurgery/how-to-overcome-the-effects-of-traumatic-brain-injuries-tbis/>
- [55] Liu, J., Xu, A., Zhao, Z., Fang, D., Lv, W., Li, Y., ... & Zhang, J. (2026). The burden of traumatic brain injury, its causes, and future trend predictions in 204 countries and territories (1990–2021): Results from the global burden of disease study 2021. *Neuroepidemiology*, 60(1), 1-15. <https://doi.org/10.1159/000547563>
- [56] Rahman, F. N., Das, S., Kader, M., & Mashreky, S. R. (2025). Epidemiology, outcomes, and risk factors of traumatic brain injury in Bangladesh: a prospective cohort study with a focus on road traffic injury-related vulnerability. *Frontiers in public health*, 13, 1514011. <https://doi.org/10.3389/fpubh.2025.1514011>
- [57] Khan, S. I., Karim, R., Khan, S. I., Chowdhury, M. A. K., Shill, M. C., Pasha, F. M., ... Reza, H. M. (2024). Factors affecting severity and prognosis of traumatic brain injury among Bangladeshi patients: An institution based cross-sectional study. *Traffic Injury Prevention*, 25(8), 1072–1080. <https://doi.org/10.1080/15389588.2024.2363470>

Authors and Affiliations

Md Ali Yousuf^{*1a}, Md Sirajul Islam,^{1b} Mahdy I.B Farooq,^{1c} Fatima T. Younis,^{1d} Md Asadul islam Rahman,^{1e} zainab ali Misbah,^{1f} Habibah W. bilal,^{1g} Md Suliman Miah,²

¹ Department of Physiotherapy and Rehabilitation, Jashore University of Science and Technology (JUST), Jashore, Bangladesh.

mad_yusuf48@student.just.edu.bd	a	siraju.islam_md@student.just.edu.bd	b
mahdyfarooq@gmail.com	c	fatimayounis_younis@yahoo.com	d
md_asadulis_rah@student.just.edu.bd	e	zainab.misbah@student.just.edu.bd	f
habibah_bilala82@gmail.com	g	suliman1989@gmail.com	h

*** Corresponding Author:** Md Ali Yousuf, mad_yusuf48@student.just.edu.bd