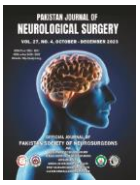

PAKISTAN JOURNAL OF NEUROLOGICAL SURGERY (QUARTERLY) – OFFICIAL JOURNAL OF PAKISTAN SOCIETY OF NEUROSURGEONS

Original Research

Assessment of Neuropsychological Impairment among Individuals with a History of Head Trauma – A Case-Control Analysis

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ABSTRACT

Objective: To determine the frequency of different neuropsychological impairments in traumatic head injury survivors compared to those without a history of head trauma.

Materials and Methods: A case-control study was done in Karachi, Pakistan, during February 2023 and March 2023, with participants aged 18 and above, of both genders, with or without a history of head trauma forming the case and control groups, respectively. Individuals with a history of head trauma or congenital neurological impairment were not included. Screening tools included the ESS, UNS, GAD-7 scale, and PHQ-9.

Results: A total of 303 participants were enrolled, out of these 128 (42.2%) were in the case group and 175 (57.8%) were in the control group. The most common source of head injury was Road Traffic Accidents (53.9%, n = 69). 143 (63.8%) out of 224 males had a positive history of head trauma in their lifetime, making the male gender more susceptible. The majority who had a history of head trauma lie in the age group < 21 years (52.6%, n = 110). No significant association was found between the interpretations of screening scales and history of head trauma.

Conclusion: Traumatic head injuries and their long-term consequences can predispose a person to experience any cognitive impairment in their life. However, in this study, we could not find significant neuropsychiatric deficits in patients with a history of head trauma. Therefore, it is crucial to conduct further large-scale, multi-center, and controlled studies to explore the cognitive and psychological impairment associated with head trauma.

Keywords: Head trauma, Traumatic brain injury, Neuropsychological tests, Head injury, Psychological side effects, Brain trauma.

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Date of Submission: 09-09-2023
Date of Revision: 15-11-2023
Date of Acceptance: 02-12-2023
Date of Online Publishing: 31-12-2023
Date of Print: 31-12-2023

DOI: 10.36552/pjns.v27i4.910

INTRODUCTION

The leading cause of head trauma is road traffic accidents (RTA), involving motorcycle riders, passengers, and pedestrians.[1] Other causes including sports injuries, falls (almost equal or more cases than RTA for traumatic brain injury), violence, or more, predict a larger number of individuals who come across this incidence.[2] Head injuries often result in brain trauma if classified under moderate or severe injury. According to a recent study, the most commonly seen type of head injury based on severity was a mild head injury.[3] If injuries impact internally, the brain being a vital part of the human body, does not precisely come under the category of completely recovering organs and reversible injuries, that is why head trauma resulting in traumatic brain injury (TBI) is likely to leave its side effects behind, that are seen in the form of neuropsychological impairments such as amnesia, cognitive functions disturbances, disturbed sleep patterns (narcolepsy, etc.), depression, anxiety, effects on IQ and intelligence, language skills, attention deficits, etc.[4]

Olfactory disturbances are also marked as a common side effect after TBI.[5] There is proof of exacerbated cognitive decline and risk of developing Alzheimer's disease in older adults with a history of TBI.[6] Also, evidently strong associations have been assessed between selective and sustained attention, and acute posttraumatic stress and pain, following mild TBI.[7] In another assessment, the studied population had a greater subset manifesting Acute Stress Disorder (ASD) who had suffered mild TBI as opposed to those who did not prove it.[8] Suicidal ideation (SI) is another highly observed factor among a population with a history of mild traumatic brain injury (mTBI), even both attention/processing speed and memory were burdened as a result of mTBI, and a history of three or more mTBIs was associated with poorer performance in these domains and a greater probability of SI. A noticeable assessment was also made in slower processing speed and/or memory difficulties, which may further result in hopelessness and SI in the studied population with a history of three or more mTBIs.[9] Demographic studies suggest the adult/middle-aged population to be more predisposed to traumatic head injury whereas the pediatric population tends to progress to complete recovery and have better outcomes of head trauma.[10,11] There is a worldwide need for such assessments/surveys for head trauma victims which might provide a better prognostic view of head trauma rehabilitation to maximize the normal return to biopsychosocial activities of individuals and minimize the diagnosis of later occurring neuropsychological impairments.

MATERIALS AND METHODS

Study Setting and Duration

A retrospective case-control study was conducted in the Department of Neurosurgery and Trauma, Jinnah Postgraduate Medical Center, Karachi, Pakistan from February 2023 to March 2023 after obtaining approval from the Institutional Review Board of Jinnah Postgraduate Medical Center.

Sampling Technique and Sample Size

Data was collected by a non-probability convenience sampling technique. Using the Open EPI electronic calculator, keeping the incidence of traumatic brain injury (TBI) at 34%, the confidence level at 95%, and the population size (N) of more than one million, the sample size obtained was 310.[12]

Inclusion Criteria:

Individuals of age 18 and above from both genders and with a history of mild head trauma with GCS not below 14 and danger signs not more than 1 (such as seizures, vomiting, ENT bleed, etc) and those who had experienced head

trauma in a window of fewer than two years to almost 3 months back were included in this study.

Exclusion Criteria: We excluded any participant with degenerative age-related brain diseases, hereditary/congenital psychological impairments, handicapped individuals with bedridden lifestyle pre-trauma, patients with any post-traumatic neurological deficits or those who underwent surgical intervention post head trauma as an emergency or elective procedure.

Data Collection Tool

A self-administered questionnaire was used, compiled from four validated scales; Epworth Sleepiness Scale (ESS), Ullanlinna Narcolepsy Scale (UNS), Generalized Anxiety Disorder-7 (GAD-7) scale, and Patient Health Questionnaire – 9 (PHQ-9) for data collection after approval from the Institutional Review Board. Epworth's sleepiness scale is a valid tool to measure subjective sleepiness in participants and bears a reliability coefficient of 0.71. Ullanlinna Narcolepsy scale assesses the narcoleptic syndrome with 100% sensitivity and 98.8% specificity at the cutoff point (score-14). The GAD-7 scale is a highly sensitive, valid, and reliable tool to assess the severity of generalized anxiety disorder. PHQ-9 is a novel tool for making diagnoses of depression and other mental disorders seen in basic care settings. The questionnaire was developed after an extensive literature review using PubMed and Google Scholar as reliable review sources. It comprised multiple-choice, open, and close-ended questions.

Data Analysis

Collected data were analyzed using SPSS software version 25.0. Descriptive statistics were calculated for mean standard deviation whereas the categorical variables were expressed in the frequency of Chi-square stages. The Chi-square/ Fisher Exact test was applied to determine any association between the neuropsychological impairments, gender, recovery period, etc. Cross-tabulations were done for suitable corresponding variables for their percentages. Odds ratio and regression analysis were done to determine if any neuropsychological scores are associated with head trauma history with justification for gender. The statistical analysis was conducted with a 95% confidence interval and a p-value of <0.05 as a threshold of statistical significance.

Ethical Considerations

All ethical measures were considered and followed after approval from the Institutional Review Board/Ethical Committee. Individuals participated voluntarily after obtaining informed consent from them and the results were calculated in a generalized form that did not reflect the identity of any participant.

RESULTS

Demographic Details of Study Participants

A total of 303 participants were included in this study from a sample size of 310, remaining seven responses were excluded due to incomplete questionnaire responses. The age range of the study population was 18 to 45 years old, while the mean age of the study population was found to be 22.15 (Standard Deviation $\pm$ 3.871). A total of 224 (73.9%) participants were males and 79 (26.1%) were females. Out of 303, 18 (5.9%) were from rural populations while the rest of 285 (94.1%) participants resided in urban areas. Moreover, 216 (71.3%) participants had a monthly family/personal income of PKR 50,000 above**. (Table 1).**

Table 1: Characteristics of study participants (n = 303).

Characteristics		Case n(%)	Control n(%)	P-value
Age Groups	< 21 years	110 (52.6%)	99 (47.3%)	0.286
	≥ 21 years	18 (19.1%)	76 (80.8%)	
Gender	Female	47 (59.5%)	32 (40.5%)	**<0.001 (significant result)**
	Male	143 (63.8%)	81 (36.2%)	
Residence	Urban	118 (41.4%)	167 (58.6%)	0.175
	Rural	10 (55.6%)	8 (44.4%)	
Education Status	Secondary High School	68 (46.3%)	79 (53.7%)	0.368
	Bachelors	56 (38.9%)	88 (61.1%)	
	Postgraduate	4 (33.3%)	8 (66.7%)	
Monthly Income	Less than 60$	10 (45.5%)	12 (54.5%)	0.672
	61 to 100$	9 (45.0%)	11 (55.0%)	
	101 to 140$	11 (55.0%)	9 (45.0%)	
	141 to 180$	12 (48.0%)	13 (52.0%)	
	181$ above	86 (39.8%)	130 (60.2%)	

Spectrum of Head Trauma and Related Variables in Both Study Groups

A division of 128 (42.2%) and 175 (57.8%) participants formed the case and control groups, with a history of head trauma and with no history of head trauma, respectively. A total of 143 males (63.8%) out of 224, experienced head trauma, making the male gender more susceptible to head injuries. The following result percentages based on details of head injury are calculated out of 128 i.e. the individuals who had a positive history of head trauma. Majority i.e. 98 (76.5%) participants faced head injury less than 2 years ago **(Table 2)**.

Moreover, the most common source of head injury was found to be Road Traffic accidents in a total of 69 (53.9%) participants followed by blunt Fall in 21.9% **(Table 3)**. Out of these 128 participants, 67 (52.3%) did not visit a hospital for any assessment while 61 (47.6%) did. Out of these 61, only 15 (24.6%) participants got admitted and out of these 15, the majority i.e. 10 (66.6%) got discharged within 12 hours of admission. Out of

Table 2: Time since head trauma (n=128).

Time since Head Trauma	Participants from Case Group (%)
More than 3 months	10 (7.8%)
Less than 6 months	4 (3.1%)
More than 6 months	9 (7.0%)
Less than a year	3 (2.3%)
More than a year	4 (3.1%)
Less than 2 years	98 (76.6%)

Of all those who had a positive history of head trauma, 90.6% of individuals (n = 116) did not experience any post-traumatic amnesia.

In further analysis, the demographics were then compared to our case and control groups **(Table 1).** This correlation also showed that the majority i.e. 110 (52.6%) participants of the age group less than 21 had a positive history of head trauma, while in the age group greater than 21, the majority i.e. 76 participants (80.8%) had no history of head trauma. Moreover, urban residents being dominant in the study population had 167 (56.8%) participants with no history of head trauma, while 10 (55.6%) out of 18 participants from rural populations suffered a head injury at some point in their life. The majority of participants who were secondary high

school graduates showed a total of 79 (53.7%) individuals with no prior incident of head trauma. Lastly, the dominant study population with a monthly family/personal income of 181$ above showed a total of 130 (60.2%) individuals who never suffered a head injury at any point in their life while the incidence of head trauma history positive or negative was nearly equal in the individuals with monthly income lower than 180$.

Table 3: Source of Head Trauma (n=128).

Mechanism/Source of Head Trauma	Participants from Case Group (%)
Road Traffic Accident	69 (53.9%)
Fall	28 (21.9%)
Sports	13 (10.2%)
Blunt object trauma	7 (5.5%)
Violence	6 (4.7%)
Got hit as a pedestrian	5 (3.9%)

We further stratified the data to assess correlations and associations between groups of two variables. The correlation between positive history of head trauma and gender was found to be significant (p-value < 0.001).

Analysis of Neuropsychiatric Deficits in Both Study Groups

Every participant was screened with the Epworth sleepiness scale (ESS), Ullanlinna Narcolepsy scale (UNS), Generalized Anxiety Disorder – 7 (GAD-7) scale, and Patient Health Questionnaire – 9 (PHQ-9). The responses from both groups were graded according to the standard scoring system of each screening tool and then correlated to find any association. Interpretations from all four scales were compared to study groups, and none was found significant **(Table 4).** Hence, a positive history of head injury did not increase the incidence of neuropsychological disturbances any more than it is already found in people with no history of head trauma.

Due to gender differences between patients with and without head trauma history, a binary logistic regression was used to determine if any neuropsychological scores are associated with head trauma history with justification for gender. As shown, there was no significant association between any scale and head trauma (P>0.05) (**Table 5).**

In patients with a history of head trauma, age had a significant reverse correlation with PHQ, GAD, ES scale, and UNS (p-value < 0.05); the most powerful correlation with GAD, followed by PHQ, ES and UNS. However, interpretations from all 4 scales showed significant association with the source of head injury. In our analysis, the association of source of head injury was also found significant with the Epworth sleepiness scale (p-value = 0.017), Ullanlinna Narcolepsy scale (p-value = 0.009), Generalized Anxiety Disorder 7-item scale (p-value = 0.02), and Patient Health Questionnaire (PHQ-9) (p-value = 0.01). To establish an association between age and neuropsychiatric scales, a correlation matrix was used **(Figure 1)**.

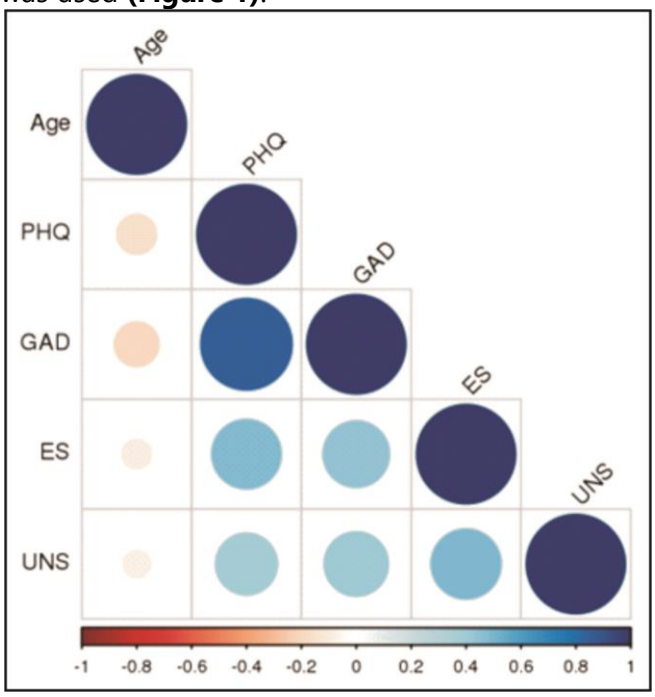

Figure 1: Correlation matrix of age and neuropsychiatric scales. **Key**: GAD-7 (Generalized Anxiety Disorder 7-item Scale), PHQ-9 (Patient Health Questionnaire - 9), UNS (Ullanlinna Narcolepsy Scale), ESS (Epworth Sleepiness Scale). Red bubbles show the reverse correlation and blue ones are positive correlations. Color density shows the value of the power of correlation.

Table 4: Association between neuropsychiatric deficits with a history of head injury (n=303).

		Group of Study		p-value
		Case n(%)	Control n(%)	
Grading of ESS (score range)	Normal Range of Sleepiness (0-10)	89 (69.5%)	122 (69.7%)	0.573
	Mild Sleepiness (11-14)	25 (19.5%)	41 (23.4%)	
	Moderate Sleepiness (15-17)	11 (8.6%)	9 (5.1%)	
	Severe Sleepiness (18-24)	3 (2.3%)	3 (1.7%)	
Total		128 (42.2%)	175 (57.7%)	303
		Case	**Control**	**p-value**
Grading of UNS (score range)	Normal symptoms not suggestive of Narcolepsy (1-14)	110 (85.9%)	142 (81.1%)	0.271
	Suggestive of Narcolepsy with Cataplexy (14 above)	18 (14.1%)	33 (18.8%)	
Total		128 (42.2%)	175 (57.7%)	303
		Case	**Control**	**p-value**
Grading of GAD-7 (score range)	Normal (0-5)	37 (28.9%)	47 (26.8%)	0.682
	Mild Anxiety (6-10)	38 (29.7%)	60 (34.3%)	
	Moderate Anxiety (11-15)	23 (17.9%)	35 (20%)	
	Severe Anxiety (15 above)	30 (23.4%)	33 (18.8%)	
Total		128 (42.2%)	175 (57.7%)	303
		Case	**Control**	**p-value**
Grading of PHQ-9 (score range)	No Depression (0)	12 (9.3%)	11 (6.3%)	0.329
	Minimal Depression (1-4)	25 (19.5%)	25 (14.3%)	
	Mild Depression (5-9)	27 (21.1%)	54 (30.8%)	
	Moderate Depression (10-14)	24 (18.7%)	36 (20.6%)	
	Moderately Severe Depression (15-19)	18 (14.1%)	26 (14.8%)	
	Severe Depression (20-27)	22 (17.2%)	23 (13.1%)	
Total		128 (42.2%)	175 (57.7%)	303

Key: GAD-7 (Generalized Anxiety Disorder 7-item Scale), PHQ-9 (Patient Health Questionnaire – 9), UNS (Ullanlinna Narcolepsy Scale), and ESS (Epworth Sleepiness Scale)

Table 5: Binary logistic regression of association of neuropsychological scores and head trauma history.

Scale	B	OR	95% CI		P-value
			Lower	Upper	
GAD-7	0.01	1.01	0.95	1.07	0.75
PHQ-9	0.02	1.02	0.97	1.08	0.41
UNS	-0.04	0.96	0.91	1.01	0.09
ESS	0.01	1.01	0.95	1.08	0.68

Key: GAD-7 (Generalized Anxiety Disorder 7-item Scale), PHQ-9 (Patient Health Questionnaire – 9), UNS (Ullanlinna Narcolepsy Scale), and ESS (Epworth Sleepiness Scale)

The association of the source of head injury with each one of the variables individually, including loss of consciousness, hospital visit, hospitalization, duration of hospitalization, and post-traumatic amnesia was found to be significant (p-value < 0.001). Another association of loss of consciousness (LOC) with a hospital visit, hospitalization, duration of hospitalization, and post-traumatic amnesia, individually, also turned out to be significant (p-value < 0.001). Of the participants who experienced post-traumatic

amnesia, a positive association was recorded with hospital admission post-trauma (p-value < 0.001).

DISCUSSION

Head trauma leading to traumatic brain injury (TBI) is a prominent source of long-term neuropsychological sequelae. A major subset of the literature is devoted to assessing the incidence of impairments and related factors in neuropsychological domains among individuals with a history of head trauma.

Our analysis highlights the vulnerability of age groups less than 21 to head injuries. A study by Adeolu et al. supports the fact that young students suffer head trauma more than others.[13] Lan et al. also surveyed regarding the safe transportation of neuro-trauma patients and it also showed that the majority of participants were young adults[14] while pedestrians, cyclists, or motorcyclists suffering head trauma in lower-middle-income countries are also generally young adults.[15]

Out of all the participants included in this study, the ones with a fair monthly income (i.e. more than PKR 50,000) were least likely to experience any head trauma in their life. In the existing literature, Kisser J et al, suggest that generally, individuals with lower socioeconomic status are more exposed to a variety of negative determinators of mental and physical health with susceptibility extending to TBI.[16] This propensity could explain why most of our well-off subjects primarily bore no history of head trauma.

Our study attributes Road traffic accidents as the leading cause of head trauma followed by falls and highlights the dominance of the male gender in bearing the positive history of head trauma, reinforced by the findings of Tiret L et al, which also recorded falls as the second most common cause of head trauma.[17] With gender disparities in TBI being extensively recognized, none of the epidemiological studies to date have countered the prospect of male predisposition in this domain.

Previous literature by Frankowski et al, shows that two-thirds of deaths after a head injury occur before hospitalization thereby rendering this duration critical for preventing any future neuropsychological dysfunction.[18] Whereas, our study indicates that more than half of our participants who suffered head trauma did not visit any hospital for assessment and of those who did, only a small number of people were admitted for observation and treatment.

The interpretations of all four screening scales showed no association with a positive or negative history of head trauma, thereby defying any influence of head trauma in inducing neuropsychological deficits. In contradiction to the current findings, a vast body of work by Rosenbaum PE et al identifies TBI as a complicated disorder, and that patients with moderate-to-severe TBI are associated with an elevated risk of long-term cognitive impairments and behavioral abnormalities that may hamper their social and vocational rehabilitation and negatively the quality of life.[19]

An extensive analysis done on the reasons for hospitalization in the USA revealed almost 0.2 million admissions for TBI only, in the year 2004, with road traffic accident and fall being the core culprits of these admissions, which aligns with our significant finding of source of head injury being directly associated with factors such as hospital visits, hospitalization and increased duration of hospital stay.[20]

Given the findings derived from this study and the existing body of literature, it is evident that there exists an imperative requirement for enhanced evaluation protocols for individuals presenting with head injuries in emergency rooms or trauma departments. These protocols should include comprehensive neuropsychological assessments, well-structured follow-up

procedures, and the provision of expert psychological counseling.

CONCLUSION

With Road Traffic Accidents attributable as the most common source of head injury, our analysis suggests that the incidence of neuropsychological impairment is not determined by a history of head trauma, relative to individuals without a history of head trauma.

LIMITATIONS

This study was limited due to its cross-sectional study design that did not allow age-sex matched analysis; while we justified our analysis based on gender. The unavailability of documentation related to head trauma on follow-up affecting the initial analysis and grading of injury, is another limitation. Further studies with a higher number of patients and longer follow-ups would be beneficial.

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Additional Information

Disclosures: Authors report no conflict of interest.
Ethical Review Board Approval: The study was conformed to the ethical review board requirements.
Human Subjects: Consent was obtained by all patients/participants in this study.
Conflicts of Interest:
In compliance with the ICMJE uniform disclosure form, all authors declare the following:
Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.
Funding: his study received no specific donation from any funding association in the public, commercial, or not-for-profit sectors.
Data Availability Statement: The data supporting the results of this study are offered at the request of the corresponding author.

AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1..	Javeria Khan	1. Conceptualization, study design, methodology, manuscript writing and data analysis.
2.	Zainab Shamim	2. Manuscript writing and data collection.
3.	Khudija Tehreem	3. Manuscript writing and data collection.
4.	Kiran Abbas	4. Data analysis and interpretation of results.
5.	Moiz Ahmed	5. Literature review and referencing.
6.	Farrukh Javeed	6. Editing and quality insurer.