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Persistent Post-Concussive Symptoms after Mild Traumatic Brain Injury: Prevalence and Clinical Characteristics

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ABSTRACT

Mild traumatic brain injury is often considered a transient condition; however, a substantial proportion of survivors experience persistent physical, cognitive, emotional, and sleep-related symptoms. This study aimed to determine the prevalence and clinical characteristics of persistent post-concussive symptoms among adults following mild traumatic brain injury. A multicenter cross-sectional study was conducted among adults assessed 3–12 months after mild traumatic brain injury. Participants were recruited using consecutive sampling from hospital medical records. Persistent post-concussive symptoms were assessed using the Rivermead Post-Concussion Symptoms Questionnaire and were defined as the presence of at least three symptoms rated as mild, moderate, or severe. Demographic, premorbid, and injury-related characteristics were collected through structured interviews and medical-record review. Modified Poisson regression with robust variance estimation was used to identify factors associated with persistent symptoms. A total of 387 participants were included, with a mean age of 38.6 ± 13.7 years, and 43.4% were female. Persistent post-concussive symptoms were identified in 141 participants, corresponding to a prevalence of 36.4% (95% CI: 31.8–41.3). Headache was the most frequently reported symptom, followed by dizziness, fatigue, sleep disturbance, poor concentration, and forgetfulness. In the adjusted analysis, persistent symptoms were independently associated with age ≥40 years (aPR 1.29; 95% CI: 1.01–1.65), female sex (aPR 1.34; 95% CI: 1.05–1.71), previous mild traumatic brain injury (aPR 1.45; 95% CI: 1.11–1.91), premorbid headache or migraine (aPR 1.37; 95% CI: 1.06–1.78), an initial Glasgow Coma Scale score of 13–14 (aPR 1.30; 95% CI: 1.01–1.67), and acute headache or dizziness (aPR 1.57; 95% CI: 1.20–2.05). More than one-third of adults experienced persistent post-concussive symptoms 3–12 months after mild traumatic brain injury. Structured discharge education, risk-based follow-up, and standardized symptom screening may help identify individuals requiring further clinical assessment and rehabilitation.

ARTICLE DETAILS

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I. INTRODUCTION

Traumatic brain injury (TBI) is a major global health problem and one of the most common causes of neurological morbidity across the life course (Maas et al., 2022). Mild traumatic brain injury (mTBI), commonly defined by an initial Glasgow Coma Scale score of 13–15, accounts for more than 90% of patients with TBI presenting to hospitals. Despite being classified as "mild," the condition should not be regarded as clinically insignificant or uniformly self-limiting. Although many patients recover

within the first several weeks, a substantial proportion do not return to their pre-injury level of health and functioning. Contemporary evidence indicates that approximately half of adults presenting to hospital with mTBI may experience incomplete recovery six months after injury, challenging the traditional assumption that mTBI is predominantly an acute and transient condition (Haarbauer-Krupa et al., 2021; Maas et al., 2017).

One of the most clinically important consequences of mTBI is the persistence of post-concussive symptoms beyond the expected period of neurological recovery. These symptoms may involve physical, cognitive, emotional, and sleep-related domains, including headache, dizziness, fatigue, sensitivity to light or noise, sleep disturbance, irritability, forgetfulness, slowed thinking, and difficulty concentrating (Biagianti et al., 2020; Hadanny & Efrati, 2025; Suwaryo, Kadir, Omar, & Singh, 2024). Current literature increasingly favors the term persistent post-concussive symptoms rather than post-concussion syndrome, because symptom presentations are heterogeneous, may occur in different combinations, and do not always constitute a single uniform clinical syndrome (Rickards et al., 2022; Waladani et al., 2023). Persistent symptoms can interfere with daily activities, occupational participation, social relationships, and psychological well-being, even when conventional neuroimaging shows no major structural abnormality and the patient appears neurologically stable during the acute phase (Leddy et al., 2021; Santoso et al., 2023).

Estimates of the prevalence of persistent post-concussive symptoms vary considerably across studies because of differences in study populations, follow-up periods, measurement instruments, symptom thresholds, and operational definitions. A systematic review and meta-analysis reported that approximately 31% of adults experienced at least mild post-concussive symptoms three to six months after mTBI, whereas approximately 18% met a more stringent symptom definition (Cancelliere et al., 2023). Longitudinal studies have also demonstrated that post-concussive symptoms may remain evident for at least one year after injury and that symptom burden among individuals with mTBI is substantially greater than that observed among individuals with non-head orthopedic injuries (Rytter et al., 2021). These findings emphasize that persistent symptoms are neither rare nor necessarily explained by normal symptom experiences in the general population.

Recovery after mTBI is heterogeneous and is influenced by interactions among biological, psychological, social, and injury-related factors. Previous studies have suggested that persistent symptoms may be associated with sex, age, pre-existing physical or mental health conditions, previous concussion, loss of consciousness, post-traumatic amnesia, injury mechanism, acute headache or dizziness, sleep disturbance, and greater initial symptom burden (Polinder et al., 2018; Quinn et al., 2018). However, the contribution of individual clinical characteristics has not been entirely consistent across populations. Moreover, symptom occurrence cannot always be predicted from the apparent severity of the initial injury or the presence of abnormalities on computed tomography. Identifying the demographic, clinical, and injury-related characteristics of patients with persistent symptoms is therefore important for improving discharge education, follow-up planning, early symptom screening, and timely referral to rehabilitation services (Abdel Aziz & Qassem, 2025).

The burden of persistent symptoms may be particularly relevant in low- and middle-income countries, where TBI frequently results from road traffic incidents involving motorcyclists and other vulnerable road users (Baker et al., 2022; Jiang et al., 2023; S.-C. Kim et al., 2019). In these settings, post-acute monitoring and rehabilitation services may be less accessible than acute trauma services, and patients classified as having mild injuries may be discharged without structured follow-up. Evidence from Indonesia remains limited and has primarily been derived from single-center studies. One retrospective study reported persistent post-concussive symptoms in 35.4% of adults after mTBI, with concentration problems, sensitivity to light, and headache among the most frequently reported symptoms (Devlin et al., 2019; Sayyed Hoseinian et al., 2019; Suwaryo, Kadir, Omar, Singh, et al., 2024). A subsequent small observational study found that approximately one-third of patients experienced post-concussive symptoms one month after injury (Adeleye et al., 2019; Banson et al., 2025; Rahman et al., 2025). Although these studies provide important preliminary evidence, differences in follow-up timing, sampling methods, and study populations limit the generalizability of their findings. A broader assessment using a standardized symptom measure is needed to clarify the magnitude and clinical presentation of persistent symptoms among mTBI survivors.

Therefore, this study aimed to determine the prevalence of persistent post-concussive symptoms and describe their physical, cognitive, emotional, and sleep-related profiles among adult survivors of mTBI. It also aimed to compare selected demographic, injury-related, and clinical characteristics between participants with and without persistent symptoms. We hypothesized that a clinically meaningful proportion of mTBI survivors would continue to experience post-concussive symptoms beyond three months after injury and that the occurrence of persistent symptoms would differ according to selected demographic and clinical characteristics.

II. METHODS

Study Design and Setting

This multicenter cross-sectional study was conducted to determine the prevalence and clinical characteristics of persistent post-concussive symptoms among adult survivors

of mild traumatic brain injury (mTBI). Participants were recruited from three secondary and tertiary hospitals providing emergency and trauma care between January and July 2026. The participating hospitals served patients from both urban and rural communities and received traumatic injury cases through direct emergency department presentations and interhospital referrals.

Potential participants were identified through emergency department and inpatient medical records. Each participant underwent a single follow-up assessment between 3 and 12 months after the index injury. This follow-up interval was selected to ensure that the symptoms assessed had persisted beyond the usual acute recovery period while limiting the variability that could arise from excessively long intervals after injury. The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology statement for cross-sectional studies.

Study Population

The study population consisted of adults who had received acute assessment or treatment for mTBI at one of the participating hospitals. Mild traumatic brain injury was determined from the documented clinical diagnosis, neurological examination, and injury-related information recorded during the acute phase.

Participants were eligible when they were aged 18 years or older, had sustained a traumatic injury to the head caused by an external force, and had an initial or post-resuscitation Glasgow Coma Scale score of 13–15 within 24 hours of injury. Participants were also required to have at least one documented clinical indicator of acute brain function disturbance, such as loss of consciousness lasting less than 30 minutes, post-traumatic amnesia lasting less than 24 hours, transient confusion or disorientation, or a transient neurological abnormality. Additional eligibility criteria included being assessed between 3 and 12 months after the index injury, being able to communicate in Indonesian, and providing informed consent.

Individuals were excluded when they had a history of moderate or severe TBI, penetrating brain injury, spinal cord injury, or a major neurological condition that could independently produce symptoms similar to those associated with mTBI. Participants with severe cognitive or communication impairment that prevented valid completion of the study questionnaire were also excluded. Individuals whose acute injury information could not be verified from hospital records were not included in the study.

Previous mTBI, pre-existing headache, sleep disorders, anxiety, depression, and other relevant comorbidities were not treated as exclusion criteria because these factors may contribute to the persistence of post-concussive symptoms. Instead, these characteristics were documented and considered in the statistical analysis.

Sample Size

The minimum sample size was estimated using the single-population proportion formula, with a 95% confidence level, an anticipated prevalence of persistent post-concussive symptoms of 35.4%, and an absolute precision of 5% [7]. Based on these assumptions, the minimum required sample was 352 participants. To account for an estimated 10% rate of non-response, incomplete questionnaires, or unavailable clinical information, the recruitment target was increased to at least 387 participants.

When participants were recruited from more than one hospital, the number allocated to each study site was determined proportionally according to the number of eligible mTBI cases recorded at the respective hospital during the prespecified study period.

Sampling and Recruitment

Participants were recruited using consecutive sampling. Trained research assistants screened emergency department and inpatient medical records to identify adults who had received treatment for mTBI and met the eligibility criteria.

Potential participants were contacted using the telephone numbers recorded in their hospital records. During the initial contact, the research team explained the purpose of the study, the data-collection procedures, the voluntary nature of participation, and the measures used to protect confidentiality. Individuals who agreed to participate were invited to complete the study assessment through a face-to-face interview at the hospital or another mutually agreed location. Where permitted by the ethics committee, participants who were unable to attend an in-person assessment completed the questionnaire through a standardized telephone interview. Potential participants who could not be reached during the first contact attempt were contacted on a maximum of three occasions on different days and at different times.

Primary Outcome

The primary outcome was the presence of persistent post-concussive symptoms between 3 and 12 months after mTBI. Symptoms were assessed using the Rivermead Post-Concussion Symptoms Questionnaire (RPQ). For the primary analysis, persistent post-concussive symptoms were operationally defined as the presence of at least three RPQ symptoms that were rated as mild, moderate, or severe, corresponding to an item score of 2–4. This symptom-based definition was used for epidemiological classification and was not intended to represent a formal clinical diagnosis of post-concussion syndrome.

To evaluate whether the prevalence estimate was influenced by the selected symptom threshold, sensitivity analyses were conducted using alternative definitions. These included the presence of at least one symptom rated 2–4, the presence of at least one moderate-to-severe symptom rated 3 or 4, and the total RPQ symptom-severity score.

Rivermead Post-Concussion Symptoms Questionnaire

The RPQ is a 16-item questionnaire designed to assess symptoms commonly experienced after traumatic brain injury [11]. It can be completed independently by participants or administered through a structured interview. The questionnaire evaluates headache, dizziness, nausea or vomiting, noise sensitivity, sleep disturbance, fatigue, irritability, depression or tearfulness, frustration or impatience, forgetfulness, poor concentration, slowed thinking, blurred vision, sensitivity to light, double vision, and restlessness.

Participants were asked to compare each symptom experienced during the preceding 24 hours with their condition before the injury. Each symptom was rated on a five-point scale ranging from 0 to 4. A score of 0 indicated that the symptom was not experienced, whereas a score of 1 indicated that the symptom was present but was no more problematic than before the injury. Scores of 2, 3, and 4 represented mild, moderate, and severe problems, respectively.

In accordance with the conventional RPQ scoring procedure, responses scored as 1 were recoded as 0 because they indicated that the symptom had not worsened compared with its pre-injury level. The remaining item scores were summed to produce a total score ranging from 0 to 64, with higher scores indicating a greater post-concussive symptom burden.

For descriptive purposes, individual symptoms were categorized into physical, cognitive, emotional or behavioral, and sleep or fatigue domains. Physical symptoms included headache, dizziness, nausea or vomiting, noise sensitivity, blurred vision, light sensitivity, and double vision. Cognitive symptoms included forgetfulness, poor concentration, and taking longer to think. Emotional and behavioral symptoms included irritability, depression or tearfulness, frustration or impatience, and restlessness, whereas sleep or fatigue symptoms included sleep disturbance and fatigue. These categories were used only to facilitate the clinical presentation of symptom patterns and were not interpreted as independently validated RPQ subscales.

The validated Indonesian-language version of the RPQ was used in this study. Before the primary data collection, the questionnaire was reviewed for linguistic and conceptual clarity and pilot-tested among 30 adults with characteristics similar to those of the study population. These participants were not included in the final analysis. The internal consistency of the RPQ in the main study sample was evaluated using Cronbach's alpha, with a coefficient of at least 0.70 considered acceptable.

Demographic and Clinical Characteristics

Demographic, premorbid, injury-related, and post-injury characteristics were collected using a standardized case-report form. Demographic information included age, sex, marital status, educational attainment, employment status, occupation, area of residence, and health insurance status.

Premorbid characteristics included a history of previous TBI or concussion, headache or migraine, sleep disorders, anxiety, depression, hypertension, diabetes mellitus, neurological disorders, psychotropic medication use, and alcohol or substance use when such information was available.

Injury-related variables included the mechanism and date of injury, initial Glasgow Coma Scale score, loss of consciousness and its documented duration, post-traumatic amnesia, confusion or disorientation, vomiting, seizure, acute headache, acute dizziness, computed tomography findings, extracranial injuries, hospital admission, length of hospital stay, and acute surgical or nonsurgical interventions.

The interval since injury was calculated from the date of the index injury to the date of the RPQ assessment and expressed in months. Injury mechanisms were categorized as motorcycle collisions, other road traffic incidents, falls, assaults, occupational injuries, sports-related injuries, or other mechanisms.

Computed tomography findings were classified as normal, showing a traumatic intracranial abnormality, or imaging not performed. Participants with a traumatic intracranial abnormality but an acute clinical presentation consistent with mTBI were categorized as having complicated mTBI. Participants without an identified intracranial abnormality were categorized as having uncomplicated mTBI.

Data Collection Procedures

Data were obtained from participant interviews and hospital medical records. Demographic information, premorbid health conditions, current symptoms, and post-injury status were collected directly from participants. Acute neurological findings, injury characteristics, imaging results, treatment information, and hospitalization data were extracted from emergency department and inpatient medical records.

Data collection was performed by trained research assistants with a health-professional background. Before recruitment commenced, all research assistants received standardized training on participant eligibility assessment, informed-consent procedures, RPQ administration, medical-record abstraction, data documentation, and confidentiality.

A standardized data-collection manual was used across all participating sites. Research assistants were instructed to read each questionnaire item verbatim and avoid influencing participant responses. When clarification was required, a standardized explanation was provided without suggesting a particular answer.

The study questionnaire and case-report form were pilot-tested among the same 30 participants. Ambiguous wording, inconsistent response options, and practical difficulties

identified during the pilot phase were reviewed and corrected before the main data collection commenced.

Data Quality Control

Completed questionnaires and case-report forms were reviewed by the site coordinator to identify missing, inconsistent, or implausible responses. Medical-record information from a random sample of at least 10% of participants was independently re-extracted by a second researcher. Any discrepancies were resolved through discussion and verification against the original medical record.

Study data were entered into a password-protected electronic database using unique participant identification codes. Personal identifiers were stored separately from the analytical dataset. Range checks, logical consistency checks, and duplicate-record checks were performed before the database was finalized for analysis.

The internal consistency of the RPQ was evaluated using Cronbach's alpha. When medical-record abstraction was performed by more than one researcher, inter-rater agreement was assessed in a subsample using Cohen's kappa for categorical variables and the intraclass correlation coefficient for continuous variables.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 30. All statistical tests were two-sided, and a p-value of less than 0.05 was considered statistically significant.

Categorical variables were summarized using frequencies and percentages. Continuous variables were summarized using means and standard deviations when approximately normally distributed and medians with interquartile ranges when distributions were skewed. The distributions of continuous variables were examined using histograms, Q–Q plots, and the Shapiro–Wilk test.

The prevalence of persistent post-concussive symptoms was calculated by dividing the number of participants who met the prespecified symptom criterion by the total number of participants included in the analysis. Prevalence estimates were presented with 95% confidence intervals calculated using the Wilson method.

The frequency and severity of each RPQ symptom were reported. The proportions of participants experiencing physical, cognitive, emotional or behavioral, and sleep or fatigue symptoms were also described. Total RPQ scores were presented for the overall sample and according to selected demographic and clinical characteristics.

Participants with and without persistent post-concussive symptoms were compared using the independent-samples t-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Standardized differences were additionally calculated to describe the magnitude of differences between the groups.

Modified Poisson regression with robust variance estimation was used to identify demographic and clinical characteristics independently associated with persistent post-concussive symptoms. The findings were presented as crude and adjusted prevalence ratios with 95% confidence intervals. Variables considered for inclusion in the multivariable model were determined a priori based on clinical relevance and previous evidence. These variables included age, sex, time since injury, previous TBI, pre-existing headache, anxiety or depression, sleep disorder, initial Glasgow Coma Scale score, loss of consciousness, post-traumatic amnesia, acute headache or dizziness, computed tomography findings, injury mechanism, and hospital admission.

The number of variables included in the final model was restricted according to the number of participants who experienced the primary outcome to reduce the risk of model overfitting. Multicollinearity was examined using variance inflation factors, with values below 5 considered acceptable. Clinically plausible interactions, including interactions between sex and premorbid mental health conditions and between time since injury and acute symptom burden, were examined in exploratory analyses.

Sensitivity analyses were performed using alternative definitions of persistent symptoms, including the presence of at least one RPQ symptom rated 2–4 and at least one symptom rated 3 or 4. When participants were recruited from multiple hospitals, robust standard errors were used to account for clustering by study site. Descriptive analyses stratified by study site were also conducted to evaluate potential differences in participant characteristics and symptom prevalence.

The extent and pattern of missing data were evaluated before the main analysis. Complete-case analysis was performed when missing data represented less than 5% of observations and no systematic pattern was identified. When a larger proportion of covariate data was missing, multiple imputation by chained equations was considered under the assumption that the data were missing at random. Participants without complete RPQ outcome data were excluded from the primary prevalence analysis.

Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee of Universitas Muhammadiyah Gombong under approval number 109.6/II.3.AU/F/KEPK/I/2026. Administrative permission was also obtained from each participating hospital before participant recruitment and medical-record review commenced.

All participants received written and verbal information regarding the study and provided written informed consent before data collection. For assessments conducted remotely, consent was documented using procedures approved by the ethics committee. Participation was entirely voluntary, and

participants were informed that they could decline or withdraw from the study at any time without affecting their access to healthcare services.

All study procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki. Participant confidentiality was maintained by removing names and direct identifiers from the analytical dataset. Study documents and electronic data were accessible only to authorized members of the research team.

Participants who reported severe or worsening neurological symptoms, substantial emotional distress, or symptoms requiring further clinical evaluation were advised to seek medical attention and were referred to an appropriate healthcare service in accordance with the established referral procedure.

III.RESULT

Participant Recruitment and General Characteristics

A total of 462 medical records of patients with a history of mild traumatic brain injury were screened for eligibility. Of these, 31 individuals were excluded because they did not meet the eligibility criteria, including an unverifiable acute injury history, a documented moderate or severe traumatic brain injury, or age below 18 years. Among the remaining eligible individuals, 31 could not be contacted and 13 declined to participate. Consequently, 387 participants completed the assessment and were included in the final analysis.

The mean age of the participants was 38.6 ± 13.7 years, and 168 participants (43.4%) were female. Most participants were married, had completed secondary education or lower, and were employed at the time of assessment. Motorcycle-related road traffic incidents were the most common mechanism of injury, accounting for 62.5% of the cases. The median interval between the index injury and the study assessment was 6.3 months.

Persistent post-concussive symptoms, defined as at least three RPQ symptoms rated as mild, moderate, or severe, were identified in 141 participants. Participants with persistent symptoms were older and included a higher proportion of women compared with those without persistent symptoms. Previous mTBI, premorbid headache or migraine, premorbid anxiety or depression, an initial Glasgow Coma Scale score of 13–14, loss of consciousness, post-traumatic amnesia, acute headache or dizziness, abnormal computed tomography findings, and hospital admission were more frequent among participants with persistent symptoms.

Prevalence and Severity of Persistent Post-Concussive Symptoms

The prevalence of persistent post-concussive symptoms was 36.4% (141/387; 95% CI: 31.8–41.3). At least one RPQ symptom rated as mild or greater was reported by 211 participants (54.5%), whereas 104 participants (26.9%) reported at least one symptom of moderate or severe intensity.

The median RPQ total score in the overall sample was 4.0 (IQR: 0.0–12.0). Participants who met the persistent symptom criterion had a median score of 15.0 (IQR: 10.0–23.0), compared with 0.0 (IQR: 0.0–2.0) among those without persistent symptoms. The difference in RPQ scores between the two groups was statistically significant ($p < 0.001$). The RPQ demonstrated high internal consistency in the study sample, with a Cronbach's alpha coefficient of 0.92.

Headache was the most frequently reported symptom, affecting 30.0% of the participants, followed by dizziness, fatigue, sleep disturbance, poor concentration, and forgetfulness. Double vision and nausea or vomiting were the least frequently reported symptoms. Physical symptoms were experienced by 154 participants (39.8%), followed by sleep or fatigue symptoms in 120 participants (31.0%), cognitive symptoms in 112 participants (28.9%), and emotional or behavioral symptoms in 91 participants (23.5%).

Table 1. Demographic and clinical characteristics according to persistent post-concussive symptom status

Characteristics	Overall, n = 387	Persistent symptoms, n = 141	No persistent symptoms, n = 246	p-value
Age, years, mean ± SD	38.6 ± 13.7	41.3 ± 13.8	37.1 ± 13.4	0.004
Female sex	168 (43.4)	75 (53.2)	93 (37.8)	0.003
Married	270 (69.8)	105 (74.5)	165 (67.1)	0.127
Secondary education or lower	240 (62.0)	98 (69.5)	142 (57.7)	0.022
Currently employed	274 (70.8)	92 (65.2)	182 (74.0)	0.069

Characteristics	**Overall, n = 387**	**Persistent symptoms, n = 141**	**No persistent symptoms, n = 246**	**p-value**
Previous mTBI	48 (12.4)	27 (19.1)	21 (8.5)	0.002
Premorbid headache or migraine	57 (14.7)	31 (22.0)	26 (10.6)	0.002
Premorbid anxiety or depression	36 (9.3)	20 (14.2)	16 (6.5)	0.012
Motorcycle-related injury	242 (62.5)	90 (63.8)	152 (61.8)	0.690
Initial GCS score of 13–14	72 (18.6)	38 (27.0)	34 (13.8)	0.001
Loss of consciousness	176 (45.5)	80 (56.7)	96 (39.0)	0.001
Post-traumatic amnesia	108 (27.9)	54 (38.3)	54 (22.0)	0.001
Acute headache or dizziness	215 (55.6)	101 (71.6)	114 (46.3)	<0.001
Traumatic intracranial abnormality on CT	72 (18.6)	35 (24.8)	37 (15.0)	0.017
Hospital admission	221 (57.1)	94 (66.7)	127 (51.6)	0.004
Time since injury, months, median (IQR)	6.3 (4.5–9.1)	5.8 (4.1–8.2)	6.6 (4.8–9.5)	0.032

Data are presented as n (%) unless otherwise indicated. Comparisons were performed using the independent-samples t-test or Mann–Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. CT, computed tomography; GCS, Glasgow Coma Scale; IQR, interquartile range; mTBI, mild traumatic brain injury; SD, standard deviation.

Table 2. Frequency and severity of post-concussive symptoms measured using the RPQ

RPQ symptom	Mild, n (%)	Moderate or severe, n (%)	Any symptom, n (%)
Headache	69 (17.8)	47 (12.1)	116 (30.0)
Dizziness	64 (16.5)	37 (9.6)	101 (26.1)
Fatigue	56 (14.5)	38 (9.8)	94 (24.3)
Sleep disturbance	50 (12.9)	38 (9.8)	88 (22.7)
Poor concentration	49 (12.7)	33 (8.5)	82 (21.2)
Forgetfulness	48 (12.4)	30 (7.8)	78 (20.2)
Taking longer to think	41 (10.6)	25 (6.5)	66 (17.1)
Irritability	39 (10.1)	23 (5.9)	62 (16.0)
Noise sensitivity	36 (9.3)	22 (5.7)	58 (15.0)
Light sensitivity	33 (8.5)	19 (4.9)	52 (13.4)
Frustration or impatience	31 (8.0)	18 (4.7)	49 (12.7)
Depression or tearfulness	25 (6.5)	16 (4.1)	41 (10.6)
Blurred vision	25 (6.5)	14 (3.6)	39 (10.1)
Restlessness	24 (6.2)	13 (3.4)	37 (9.6)
Nausea or vomiting	16 (4.1)	8 (2.1)	24 (6.2)
Double vision	11 (2.8)	6 (1.6)	17 (4.4)

Table 3. Factors associated with persistent post-concussive symptoms

Characteristics	Crude PR (95% CI)	Adjusted PR (95% CI)	p-value
Age ≥40 years	1.51 (1.16–1.97)	1.29 (1.01–1.65)	0.042
Female sex	1.48 (1.14–1.93)	1.34 (1.05–1.71)	0.019
Previous mTBI	1.67 (1.25–2.24)	1.45 (1.11–1.91)	0.007
Premorbid headache or migraine	1.63 (1.23–2.16)	1.37 (1.06–1.78)	0.016
Premorbid anxiety or depression	1.61 (1.16–2.23)	1.29 (0.95–1.74)	0.102
Initial GCS score of 13–14	1.61 (1.23–2.11)	1.30 (1.01–1.67)	0.043
Loss of consciousness	1.57 (1.20–2.05)	1.18 (0.94–1.49)	0.156
Post-traumatic amnesia	1.60 (1.24–2.07)	1.24 (0.99–1.56)	0.061
Acute headache or dizziness	2.02 (1.49–2.74)	1.57 (1.20–2.05)	0.001
Traumatic intracranial abnormality	1.44 (1.09–1.92)	1.15 (0.88–1.50)	0.302
Hospital admission	1.50 (1.13–2.00)	1.12 (0.87–1.44)	0.384
Time since injury, per one-month increase	0.96 (0.92–1.00)	0.95 (0.91–0.99)	0.018

The adjusted model simultaneously included all variables shown in the table. Modified Poisson regression with robust variance estimation was used. No evidence of problematic multicollinearity was identified, with variance inflation factor values ranging from 1.11 to 1.84. CI, confidence interval; GCS, Glasgow Coma Scale; mTBI, mild traumatic brain injury; PR, prevalence ratio.

Characteristics Associated With Persistent Post-Concussive Symptoms

In the crude analysis, persistent post-concussive symptoms were significantly associated with age of 40 years or older, female sex, previous mTBI, premorbid headache or migraine, premorbid anxiety or depression, an initial Glasgow Coma Scale score of 13–14, loss of consciousness, post-traumatic amnesia, acute headache or dizziness, traumatic intracranial abnormalities on computed tomography, and hospital admission.

After adjustment for demographic, premorbid, and injury-related characteristics, female participants had a 34% higher prevalence of persistent symptoms than male participants. Age of 40 years or older, previous mTBI, premorbid headache or migraine, an initial Glasgow Coma Scale score of 13–14, and acute headache or dizziness remained independently associated with the outcome. Acute headache or dizziness showed the strongest association, with an adjusted prevalence ratio of 1.57.

A longer interval since injury was associated with a modest reduction in the prevalence of persistent symptoms. Premorbid anxiety or depression, loss of consciousness, post-traumatic amnesia, abnormal computed tomography findings, and hospital admission were no longer statistically significant after adjustment for the other covariates.

IV. DISCUSSION

This study found that more than one-third of adults continued to experience persistent post-concussive symptoms between 3 and 12 months after mild traumatic brain injury. Headache, dizziness, fatigue, sleep disturbance, poor concentration, and forgetfulness were the most frequently reported symptoms. Persistent symptoms were more common among older participants, women, individuals with a previous history of mild traumatic brain injury or premorbid headache, those presenting with a lower initial Glasgow Coma Scale score, and those who experienced headache or dizziness during the acute phase. These findings reinforce that mild traumatic brain injury is not invariably a transient condition and that a clinically important proportion of survivors may experience prolonged physical, cognitive, emotional, and sleep-related difficulties (Hereford, 2013; Kalaria et al., 2024; Warren et al., 2024).

The observed prevalence of 36.4% indicates that persistent post-concussive symptoms represent a substantial post-acute burden among adults with mild traumatic brain injury. This estimate is broadly consistent with previous evidence showing that approximately one-third of patients report persistent symptoms several months after injury. Differences in prevalence across studies may reflect variation in follow-up periods, case definitions, clinical settings, patient characteristics, and symptom thresholds. The use of a symptom-based definition in the present study may have captured clinically relevant problems without assuming that all participants fulfilled the diagnostic criteria for a uniform post-concussion syndrome (Eapen et al., 2022; Jennings & Islam, 2023).

Headache and dizziness were the most common symptoms, suggesting that physical complaints remain

prominent beyond the acute injury period. However, fatigue, sleep disturbance, poor concentration, and forgetfulness were also frequently reported, demonstrating that persistent symptom burden extends beyond neurological complaints alone. These symptoms may interact with one another. Sleep disturbance and fatigue may worsen attention and memory, while persistent headache and dizziness may limit daily activity and delay return to work. Therefore, post-mTBI follow-up should not focus solely on isolated physical symptoms but should include broader assessment of cognitive, emotional, and sleep-related difficulties (Chan et al., 2025; Holte, 2024; Mavroudis et al., 2023; Nielsen et al., 2022).

The association between female sex and persistent symptoms is consistent with evidence suggesting that women may report a greater post-concussive symptom burden than men. Possible explanations include biological differences, hormonal influences, differences in premorbid migraine prevalence, psychosocial factors, and variation in symptom recognition or reporting. Older age was also associated with persistent symptoms, which may reflect reduced neurological resilience, a greater burden of comorbidity, or slower functional recovery. However, these findings should not be interpreted as evidence of direct causation because the study was observational (Karr & Logan, 2024; Starkey et al., 2022).

Previous mild traumatic brain injury and premorbid headache or migraine remained independently associated with persistent symptoms. A history of previous injury may increase vulnerability to prolonged recovery, while pre-existing headache may be exacerbated by the index injury or may complicate the attribution of symptoms specifically to mTBI. These findings support the importance of documenting premorbid conditions during acute assessment and follow-up. Clinical interpretation of persistent symptoms should distinguish newly developed complaints from symptoms that were already present before the injury (Löwe et al., 2024; Michels et al., 2022).

Acute headache or dizziness showed the strongest independent association with persistent symptoms. These early manifestations may represent a higher initial symptom burden and could serve as practical indicators for identifying patients who require closer follow-up. Although loss of consciousness, post-traumatic amnesia, abnormal computed tomography findings, and hospital admission were associated with persistent symptoms in the crude analyses, these associations were attenuated after adjustment. This suggests that prolonged symptom burden may not be fully explained by conventional markers of acute injury severity. Patients with apparently uncomplicated mTBI and normal neuroimaging may still develop clinically important persistent symptoms (Asturias et al., 2023; S. Y. Kim et al., 2023; Shim et al., 2026).

The findings have several clinical implications. Adults treated for mTBI should receive clear discharge education regarding the possibility of persistent symptoms, expected recovery trajectories, warning signs, and indications for further assessment (Sergeyenko et al., 2025). Brief follow-up screening using the RPQ may help identify patients who continue to experience multiple or moderate-to-severe symptoms. Particular attention should be given to women, older adults, individuals with previous mTBI or premorbid headache, and patients presenting with acute headache or dizziness. Early identification may facilitate timely referral for neurological evaluation, rehabilitation, headache management, psychological support, sleep interventions, and occupational guidance (Ray et al., 2024).

From a healthcare-system perspective, the findings support the development of structured post-mTBI follow-up pathways. Mild injury classification should not automatically lead to the assumption that follow-up is unnecessary. Integrating symptom screening into outpatient, primary care, or telephone follow-up services may be particularly valuable in settings where access to specialized neurorehabilitation is limited. A standardized referral pathway could also reduce fragmentation of care for patients experiencing overlapping physical, cognitive, emotional, and sleep-related symptoms (Ji et al., 2025; Sýkorová et al., 2025).

This study has several limitations. First, the cross-sectional design did not permit evaluation of symptom trajectories or causal relationships between participant characteristics and persistent symptoms. Second, the RPQ is a self-reported measure and may be influenced by recall, current emotional state, health expectations, and reporting behavior. Third, some symptoms assessed by the RPQ are nonspecific and may also occur in individuals without traumatic brain injury or may reflect premorbid health conditions. Although participants were asked to compare their current symptoms with their pre-injury condition, residual misclassification may have remained.

Fourth, participants who could not be contacted or who declined participation may have differed from those who completed the assessment, introducing potential selection bias. Fifth, variation in the interval between injury and assessment may have influenced symptom prevalence, although time since injury was considered in the adjusted analysis. Sixth, clinical information obtained from medical records may have been affected by incomplete documentation, particularly for loss of consciousness, post-traumatic amnesia, and acute symptoms. Finally, although recruitment from multiple hospitals may improve the diversity of the sample, the findings may not be generalizable to individuals with mTBI who did not seek hospital care. Despite these limitations, the study provides clinically relevant evidence regarding the prevalence and presentation of persistent post-concussive symptoms after mild traumatic brain injury. The use of a standardized symptom instrument, inclusion of premorbid and injury-related characteristics, and estimation of adjusted prevalence

ratios strengthen the interpretation of the findings. Prospective longitudinal studies are needed to examine symptom trajectories, functional consequences, healthcare utilization, and the effectiveness of early screening and follow-up interventions.

V. CONCLUSION

Persistent post-concussive symptoms affected more than one-third of adults between 3 and 12 months after mild traumatic brain injury. Headache, dizziness, fatigue, sleep disturbance, poor concentration, and forgetfulness were the most frequently reported symptoms, indicating that the post-injury burden involved physical, cognitive, and sleep-related domains. Persistent symptoms were more prevalent among older adults, women, individuals with previous mild traumatic brain injury or premorbid headache, patients with an initial Glasgow Coma Scale score of 13–14, and those who experienced acute headache or dizziness.

These findings demonstrate that mild traumatic brain injury may be followed by clinically important and prolonged symptoms, even when the initial injury appears uncomplicated. Structured discharge education, early identification of patients at greater risk, and standardized follow-up screening should therefore be incorporated into post-mTBI care. Further prospective studies are needed to examine symptom trajectories and determine whether early multidisciplinary interventions can reduce persistent symptom burden and improve long-term recovery.

REFERENCES

I. Abdel Aziz, K., & Qassem, T. (2025). From Trauma to Recovery: Assessing and Managing the Neuropsychiatric Impact of Traumatic Brain Injury. Annals of Clinical Psychiatry, 36(1–2), 2–14. https://doi.org/10.1177/10401237251344099

II. Adeleye, A. O., Clark, D. J., & Malomo, T. A. (2019). Trauma demography and clinical epidemiology of motorcycle crash–related head injury in a neurosurgery practice in an African developing country. Traffic Injury Prevention, 20(2), 211–215. https://doi.org/10.1080/15389588.2018.1553085

III. Asturias, A., Knoblauch, T., Rodriguez, A., Vanier, C., Le Tohic, C., Barrett, B., Eisenberg, M., Gibbert, R., Zimmerman, L., Parikh, S., Nguyen, A., Azad, S., Germin, L., Fazzini, E., & Snyder, T. (2023). Diffusion in the corpus callosum predicts persistence of clinical symptoms after mild traumatic brain injury, a multi-scanner study. Frontiers in Neuroimaging, 2. https://doi.org/10.3389/fnimg.2023.1153115

IV. Baker, C. E., Martin, P., Wilson, M. H., Ghajari, M., & Sharp, D. J. (2022). The relationship between road traffic collision dynamics and traumatic brain injury pathology. Brain Communications, 4(2), fcac033. https://doi.org/10.1093/braincomms/fcac033

V. Banson, M., Ametefe, M. K., Darko, K., Dakubo, J. C. B., Iddrisu, M., & Dakurah, T. (2025). Comparative Analysis of Traumatic Brain Injury Severity in Motorcycle and Car Accident Victims Treated at Korle-Bu Teaching Hospital. Journal of the West African College of Surgeons, 15(1), 75–82. https://doi.org/10.4103/jwas.jwas_188_23

VI. Biagianti, B., Stocchetti, N., Brambilla, P., & Van Vleet, T. (2020). Brain dysfunction underlying prolonged post-concussive syndrome: A systematic review. Journal of Affective Disorders, 262, 71–76. https://doi.org/10.1016/j.jad.2019.10.058

VII. Cancelliere, C., Verville, L., Stubbs, J. L., Yu, H., Hincapié, C. A., Cassidy, J. D., Wong, J. J., Shearer, H. M., Connell, G., Southerst, D., Howitt, S., Guist, B., & Silverberg, N. D. (2023). Post-Concussion Symptoms and Disability in Adults With Mild Traumatic Brain Injury: A Systematic Review and Meta-Analysis. Journal of Neurotrauma, 40(11–12), 1045–1059. https://doi.org/10.1089/neu.2022.0185

VIII. Chan, Y., Thorne, P. R., & Taylor, R. L. (2025). Self-reported dizziness, balance, and multisensory impairment following mild traumatic brain injury: An exploratory study. Journal of the Royal Society of New Zealand, 55(3), 451–465. https://doi.org/10.1080/03036758.2024.2412095

IX. Devlin, A., Beck, B., Simpson, P. M., Ekegren, C. L., Giummarra, M. J., Edwards, E. R., Cameron, P. A., Liew, S., Oppy, A., Richardson, M., Page, R., & Gabbe, B. J. (2019). The road to recovery for vulnerable road users hospitalised for orthopaedic injury following an on-road crash. Accident Analysis & Prevention, 132, 105279. https://doi.org/10.1016/j.aap.2019.105279

X. Eapen, B. C., Bowles, A. O., Sall, J., Lang, A. E., Hoppes, C. W., Stout, K. C., Kretzmer, T., & Cifu, D. X. (2022). The management and rehabilitation of post-acute mild traumatic brain injury. Brain Injury, 36(5), 693–702. https://doi.org/10.1080/02699052.2022.2033848

XI. Haarbauer-Krupa, J., Pugh, M. J., Prager, E. M., Harmon, N., Wolfe, J., & Yaffe, K. (2021). Epidemiology of Chronic Effects of Traumatic Brain Injury. Journal of Neurotrauma, 38(23), 3235–3247. https://doi.org/10.1089/neu.2021.0062

XII. Hadanny, A., & Efrati, S. (2025). Persistent post-concussion syndrome: Pathophysiology, diagnosis, current and evolving treatment strategies. Expert Review of Neurotherapeutics, 25(8), 959–971. https://doi.org/10.1080/14737175.2025.2515061

XIII. Hereford, J. M. (2013). Sleep and Other Medical and Psychiatric Disorders. In Sleep and Rehabilitation. Routledge.

XIV. Holte, K. E. (2024). Characterizing Clinical Presentations following Mild Traumatic Brain Injury: Mechanisms of Injury and Dizziness Subtypes. https://doi.org/10.11575/PRISM/42896

XV. Jennings, T., & Islam, M. S. (2023). Examining the interdisciplinary approach for treatment of persistent post-concussion symptoms in adults: A systematic review. Brain Impairment, 24(2), 290–308. https://doi.org/10.1017/BrImp.2022.28

XVI. Ji, K.-H., Kim, D.-K., Kim, E.-H., & Chung, S. (2025). The Missing Link in Patient Recovery: Hospital Sleep Medicine. Sleep Medicine Research, 16(1), 7–17. https://doi.org/10.17241/smr.2025.02782

XVII. Jiang, M., Li, C., Zhang, S., Gao, X., & Yang, X. (2023). The incidence of brain trauma caused by road injuries: Results from the Global Burden of Disease Study 2019. Injury, 54(12), 110984. https://doi.org/10.1016/j.injury.2023.110984

XVIII. Kalaria, R. N., Akinyemi, R. O., Paddick, S.-M., & Ihara, M. (2024). Current perspectives on prevention of vascular cognitive impairment and promotion of vascular brain health. Expert Review of Neurotherapeutics, 24(1), 25–44. https://doi.org/10.1080/14737175.2023.2273393

XIX. Karr, J. E., & Logan, T. K. (2024). Post-Concussion Symptoms in Women With Head Injury Due to Intimate Partner Violence. Journal of Neurotrauma, 41(3–4), 447–463. https://doi.org/10.1089/neu.2023.0101

XX. Kim, S. Y., Yeh, P.-H., Ollinger, J. M., Morris, H. D., Hood, M. N., Ho, V. B., & Choi, K. H. (2023). Military-related mild traumatic brain injury: Clinical characteristics, advanced neuroimaging, and molecular mechanisms. Translational Psychiatry, 13(1), 289. https://doi.org/10.1038/s41398-023-02569-1

XXI. Kim, S.-C., Lee, H.-J., Kim, J.-M., Kong, S.-Y., Park, J.-S., Jeon, H.-J., In, Y.-N., Kim, H., Lee, S.-W., & Kim, Y.-T. (2019). Comparison of epidemiology and injury profile between vulnerable road users and motor vehicle occupants in road traffic fatalities. Traffic Injury Prevention, 20(6), 581–587. https://doi.org/10.1080/15389588.2018.1539840

XXII. Leddy, J. J., Haider, M. N., Noble, J. M., Rieger, B., Flanagan, S., McPherson, J. I., Shubin-Stein, K., Saleem, G. T., Corsaro, L., & Willer, B. (2021). Clinical Assessment of Concussion and Persistent Post-Concussive Symptoms for Neurologists. Current Neurology and Neuroscience Reports, 21(12), 70. https://doi.org/10.1007/s11910-021-01159-2

XXIII. Löwe, B., Toussaint, A., Rosmalen, J. G. M., Huang, W.-L., Burton, C., Weigel, A., Levenson, J. L., & Henningsen, P. (2024). Persistent physical symptoms: Definition, genesis, and management. The Lancet, 403(10444), 2649–2662. https://doi.org/10.1016/S0140-6736(24)00623-8

XXIV. Maas, A. I. R., Menon, D. K., Adelson, P. D., Andelic, N., Bell, M. J., Belli, A., Bragge, P., Brazinova, A., Büki, A., Chesnut, R. M., Citerio, G., Coburn, M., Cooper, D. J., Crowder, A. T., Czeiter, E., Czosnyka, M., Diaz-Arrastia, R., Dreier, J. P., Duhaime, A.-C., … Zumbo, F. (2017). Traumatic brain injury: Integrated approaches to improve prevention, clinical care, and research. The Lancet Neurology, 16(12), 987–1048. https://doi.org/10.1016/S1474-4422(17)30371-X

XXV. Maas, A. I. R., Menon, D. K., Manley, G. T., Abrams, M., Åkerlund, C., Andelic, N., Aries, M., Bashford, T., Bell, M. J., Bodien, Y. G., Brett, B. L., Büki, A., Chesnut, R. M., Citerio, G., Clark, D., Clasby, B., Cooper, D. J., Czeiter, E., Czosnyka, M., … Zemek, R. (2022). Traumatic brain injury: Progress and challenges in prevention, clinical care, and research. The Lancet Neurology, 21(11), 1004–1060. https://doi.org/10.1016/S1474-4422(22)00309-X

XXVI. Mavroudis, I., Ciobica, A., Luca, A. C., & Balmus, I.-M. (2023). Post-Traumatic Headache: A Review of Prevalence, Clinical Features, Risk Factors, and Treatment Strategies. Journal of Clinical Medicine, 12(13), 4233. https://doi.org/10.3390/jcm12134233

XXVII. Michels, F., Wastyn, H., Pottel, H., Stockmans, F., Vereecke, E., & Matricali, G. (2022). The presence of persistent symptoms 12 months following a first lateral ankle sprain: A systematic review and meta-analysis. Foot and Ankle Surgery, 28(7), 817–826. https://doi.org/10.1016/j.fas.2021.12.002

XXVIII. Nielsen, K. J., Carstensen, O., Kærgaard, A., Vestergaard, J. M., & Biering, K. (2022). Neurological symptoms and disorders following electrical injury: A register-based matched cohort study. PLOS ONE, 17(3), e0264857. https://doi.org/10.1371/journal.pone.0264857

XXIX. Polinder, S., Cnossen, M. C., Real, R. G. L., Covic, A., Gorbunova, A., Voormolen, D. C., Master, C. L., Haagsma, J. A., Diaz-Arrastia, R., & von Steinbuechel, N. (2018). A Multidimensional Approach to Post-concussion Symptoms in Mild Traumatic Brain Injury. Frontiers in Neurology, 9. https://doi.org/10.3389/fneur.2018.01113

XXX. Quinn, D. K., Mayer, A. R., Master, C. L., & Fann, J. R. (2018). Prolonged Postconcussive Symptoms.

American Journal of Psychiatry, 175, 103–111. https://doi.org/10.1176/appi.ajp.2017.17020235

XXXI. 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. https://doi.org/10.3389/fpubh.2025.1514011

XXXII. Ray, S., Luke, J., & Kreitzer, N. (2024). Patient-centered mild traumatic brain injury interventions in the emergency department. The American Journal of Emergency Medicine, 79, 183–191. https://doi.org/10.1016/j.ajem.2024.02.038

XXXIII. Rickards, T. A., Cranston, C. C., & McWhorter, J. (2022). Persistent post-concussive symptoms: A model of predisposing, precipitating, and perpetuating factors. Applied Neuropsychology: Adult, 29(2), 284–294. https://doi.org/10.1080/23279095.2020.1748032

XXXIV. Rytter, H. M., Graff, H. J., Henriksen, H. K., Aaen, N., Hartvigsen, J., Hoegh, M., Nisted, I., Næss-Schmidt, E. T., Pedersen, L. L., Schytz, H. W., Thastum, M. M., Zerlang, B., & Callesen, H. E. (2021). Nonpharmacological Treatment of Persistent Postconcussion Symptoms in Adults: A Systematic Review and Meta-analysis and Guideline Recommendation. JAMA Network Open, 4(11), e2132221. https://doi.org/10.1001/jamanetworkopen.2021.32221

XXXV. Santoso, E. B., Suwaryo, P. A. W., & Asti, A. D. (2023). Post Concussion Syndrome Detection in Post Traumatic Brain Injury Patients. Babali Nursing Research, 4(1), 22–33. https://doi.org/10.37363/bnr.2023.41136

XXXVI. Sayyed Hoseinian, S. H., Ebrahimzadeh, M. H. ., Peivandi, M. T., Bagheri, F., Hasani, J., Golshan, S., & Birjandinejad, A. (2019). Injury Patterns among Motorcyclist Trauma Patients: A Cross Sectional Study on 4200 Patients. Archives of Bone and Joint Surgery, 7(4), 367–372.

XXXVII. Sergeyenko, Y., Andreae, M. E., & Segal, M. (2025). Diagnosis and Management of Mild Traumatic Brain Injury (mTBI): A Comprehensive, Patient-centered Approach. Current Pain and Headache Reports, 29(1), 19. https://doi.org/10.1007/s11916-024-01333-4

XXXVIII. Shim, Y., Kim, M., Yoon, H. G., Lee, J. J., Hong, J. B., Chung, Y., Oh, J. K., & Won, Y. S. (2026). Mild Traumatic Brain Injury as a Heterogeneous Neurological Disorder: Definition, Epidemiology, Neurobiology, and Clinical Course. Korean Journal of Neurotrauma, 22(2), 78–88. https://doi.org/10.13004/kjnt.2026.22.e18

XXXIX. Starkey, N. J., Duffy, B., Jones, K., Theadom, A., Barker-Collo, S., Feigin, V., & Group, on behalf of the B. R. (2022). Sex differences in outcomes from mild traumatic brain injury eight years post-injury. PLOS ONE, 17(5), e0269101. https://doi.org/10.1371/journal.pone.0269101

XL. Suwaryo, P. A. W., Kadir, F., Omar, A., & Singh, S. K. D. (2024). Prevalence of Persistent Post-Concussion Syndrome in Adults After Mild Traumatic Brain Injury. Nurse Media Journal of Nursing, 14(2), 199–209. https://doi.org/10.14710/nmjn.v14i2.56529

XLI. Suwaryo, P. A. W., Kadir, F., Omar, A., Singh, S. K. D., & Bolong, M. F. (2024). The impact of interpersonal support on quality of life in traumatic brain injury patients – a one-month post-treatment analysis. European Journal of Clinical and Experimental Medicine, 22(3), 538–542. https://doi.org/10.15584/ejcem.2024.3.8

XLII. Sýkorová, M., Nolte, E., Martineau, F., Miller, M. A., Eriksson, S. H., Smith, I. E., & Strongman, H. (2025). Barriers and facilitators to specialist service referrals for sleep disorders from healthcare professionals' perspective: A scoping review of qualitative research evidence (p. 2025.01.20.25320835). medRxiv. https://doi.org/10.1101/2025.01.20.25320835

XLIII. Waladani, B., Suwaryo, P. A. W., Yuniar, I., Yuwono, P., & Setianingsih, E. (2023). Predictive Value of Non-Invasive Intracranial Pressure Monitoring in Profoundly Impaired Traumatic Brain Injury Patients. Babali Nursing Research, 4(4), 714–722. https://doi.org/10.37363/bnr.2023.44281

XLIV. Warren, J., Collinge, J., Fox, N., Mead, S., Mummery, C., Rohrer, J., Rossor, M., Schott, J., & Weil, R. (2024). Cognitive Impairment and Dementia. In Neurology (pp. 319–367). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119715672.ch11