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REVIEW

Prevalence of Headache Following Traumatic Brain Injury: A Systematic Review and Meta-Analysis

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Introduction: Post-traumatic headache (PTH) is a common and debilitating consequence of traumatic brain injury (TBI), significantly affecting patients' quality of life. It presents in various forms, including tension-type headaches and migraines, and is influenced by multiple neurological and psychological factors. Due to variability in diagnostic criteria across studies, the term "post-traumatic headache" in this review refers to headaches reported after TBI, not necessarily meeting full clinical diagnostic criteria. This study aims to systematically assess the prevalence of PTH to provide comprehensive data for improved clinical management and future research.

Methods: This systematic review and meta-analysis followed PRISMA guidelines to assess PTH prevalence in TBI patients. A database search (2000–2024) identified eligible observational studies. Data extraction and quality assessment were conducted independently. Statistical analyses, including heterogeneity assessment, subgroup analysis, and meta-regression, were performed using Stata 17. Publication bias was examined via funnel plots and Egger's test.

Results: The pooled prevalence of posttraumatic headache was 49.3% (95% CI: 44.7–53.9%), with sensitivity analysis confirming the stability of the findings. Subgroup analysis showed no significant difference in prevalence based on sample size or continent, though variations were observed across measurement tools, with interviews reporting the highest prevalence (65.2%) and the NRS the lowest (25.2%) ($p < 0.001$). Headache prevalence was higher in military populations (56.1%) than in the general patient group (45.1%) ($p = 0.039$). Meta-regression revealed that prevalence was not significantly influenced by publication year, sample size, or patient age, and no publication bias was detected.

Conclusion: This meta-analysis confirms a high prevalence of post-traumatic headache, particularly among military populations and when assessed via interviews. Variations in prevalence were influenced by assessment methods and follow-up duration, but not by sample size or publication year. Despite methodological differences, the findings were stable, underscoring the need for standardized diagnostic criteria and targeted, population-specific management strategies.

Keywords: meta-analysis, post-traumatic headache, prevalence, traumatic brain injury

Introduction

Traumatic brain injury (TBI) is one of the most significant public health concerns worldwide, affecting millions of people each year and leading to varying degrees of physical, cognitive, and psychological impairments.[1] This injury results from a direct or indirect impact on the head, often caused by motor vehicle accidents, falls, physical assaults, sports-related injuries, and industrial accidents. Based on severity, TBI is classified into mild, moderate, and severe categories, each with different clinical outcomes.[2] While many individuals with mild TBI recover within a short period, others may experience long-term or even permanent complications. Given its high prevalence and wide-ranging consequences, a comprehensive investigation into the clinical and epidemiological effects of TBI is essential.[3]

Patients with TBI present with a broad spectrum of symptoms and complications that vary in severity and duration depending on the extent and location of the injury. Some of the most common issues include cognitive impairments such

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as reduced concentration, memory deficits, and slower information processing, as well as mood disturbances like depression, anxiety, and irritability. Additionally, patients may experience motor dysfunctions, including poor coordination, dizziness, and balance problems, along with sleep disturbances and chronic pain. These symptoms not only disrupt daily life but also significantly impair social and occupational functioning.[4]

One of the most prevalent and debilitating complications of TBI is post-traumatic headache (PTH). Despite its high prevalence and significant impact on daily functioning and quality of life, PTH remains a complex and poorly understood condition. Post-traumatic headache (PTH) is a secondary headache disorder that occurs as a consequence of traumatic brain injury (TBI) and is diagnosed primarily based on clinical criteria. According to the International Classification of Headache Disorders (ICHD-3), acute PTH is defined as a headache that develops within 7 days following the trauma or regaining consciousness. In individuals with a pre-existing headache disorder, the diagnosis of PTH requires a significant worsening of the headache temporally related to the trauma. While most acute cases resolve spontaneously, persistent PTH is diagnosed when the headache continues beyond three months post-injury. This condition can lead to substantial functional impairment and often coexists with other post-TBI symptoms, making accurate identification and classification essential for research and clinical care.[5] Moreover, a considerable number of individuals continue to experience headaches even a year after the injury, highlighting the chronic nature of this condition.[6] PTH typically develops within the first few weeks following the injury but, in some cases, can become chronic and persist for months or even years. Clinically, it can present in different forms, including tension-type headaches, migraines, headaches associated with increased intracranial pressure, and neuropathic headaches. Several mechanisms contribute to its development, such as cranial nerve damage, inflammation from the injury, alterations in cerebral blood flow, and disruptions in central pain processing systems. Additionally, psychological factors, including stress and emotional distress following TBI, can intensify both the severity and duration of headaches.[7]

PTH has a profound impact on both the physical and mental health of patients. This condition not only reduces quality of life but also leads to sleep disturbances, impaired concentration, increased irritability, and emotional problems such as depression and anxiety. Furthermore, persistent headaches can interfere with daily activities, decrease work productivity, and impose substantial healthcare costs.[8] Many patients resort to long-term use of painkillers to manage their headaches, which may result in drug dependence and complications from medication overuse. Therefore, gaining a better understanding of the factors contributing to PTH and developing effective treatment strategies is crucial in reducing the burden of this condition and improving patient outcomes.[9]

Given the high prevalence and serious consequences of PTH in TBI patients, accurately estimating its occurrence is of great importance. A systematic review and meta-analysis of existing studies can provide a clearer understanding of prevalence rates, patterns of occurrence, and associated factors. These findings will not only help guide clinical decision-making in the treatment and management of affected individuals but also serve as a foundation for healthcare policies and preventive strategies. Therefore, this study aims to systematically assess the prevalence of PTH to provide precise and comprehensive data that can facilitate future research and enhance patient care.

Methods

This systematic review and meta-analysis were performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Search Strategy

Relevant articles on the prevalence of post-traumatic headache (PTH) were retrieved from four English databases—Scopus, PubMed, Embase, and Web of Science—covering the period from January 2000 to December 2024. The search was conducted using the following keywords: “Traumatic Brain Injury”, “TBI”, “mTBI”, “mild TBI”, “Head Injury”, “Brain Trauma”, “Chronic Headache(s)”, “Persistent Headache(s)”, “Long-term Headache(s)”, and “Headache(s)”. Titles and abstracts of the retrieved articles were screened to assess eligibility. Irrelevant studies were excluded, and the full texts of the remaining articles were independently reviewed by two authors. Additionally, the references of the selected articles were manually searched to identify further relevant studies.

Inclusion/Exclusion Criteria

The inclusion criteria were as follows: studies published in English between 2000 and 2024, observational studies involving adult patients with traumatic brain injury (TBI), and studies reporting essential data, such as the frequency or prevalence of headaches in these individuals. Studies conducted on other age groups, as well as reviews, qualitative studies, editorials, and interventional studies, were excluded from the analysis. Additionally, studies with a sample size of fewer than 100 participants and those with incomplete or insufficient data were also excluded.

Data Extraction and Quality Assessment

Data were independently extracted by two researchers from the eligible studies, with any disagreements resolved through discussion. The collected data included the first author's name, year of publication, sample size, study location (country and continent), measurement scale, follow-up duration, headache severity, target population, methodological quality score, and headache prevalence.

Quality Assessment

For methodological quality assessment, the Joanna Briggs Institute (JBI) Critical Appraisal Checklist was used to evaluate cross-sectional studies. Two independent reviewers assessed each study across key domains, including sample selection, measurement validity, confounding factors, and statistical analysis. Each study was rated based on the JBI criteria, with higher scores reflecting stronger methodological quality. Disagreements were resolved through discussion or consultation with a third reviewer. Studies meeting ≥70% of the criteria were classified as high quality, while those meeting 50–69% were considered moderate quality. The quality assessment results were incorporated into the subgroup analysis to determine whether study quality influenced the pooled prevalence estimates.[10]

Data Analysis

Statistical analysis was conducted using Stata software version 17. To assess heterogeneity among studies, Cochran's Q test and the I^2 statistic were applied. Heterogeneity was considered significant if the p-value was below 0.05 or if I^2 exceeded 50%. In cases of low heterogeneity, a fixed-effects model was used to estimate the overall prevalence, whereas a random-effects model was applied when substantial heterogeneity was detected. To explore potential sources of heterogeneity, subgroup analysis, sensitivity analysis, and meta-regression were performed. Subgroup analysis examined prevalence differences based on factors such as continent, target population (military vs non-military), headache assessment tools, follow-up duration (<1 year, >1 year, unspecified), sample size (<1,000 vs >1,000 participants), and methodological quality of the studies. Sensitivity analysis assessed the impact of excluding individual studies on overall results. Meta-regression was conducted to investigate factors influencing heterogeneity, including mean patient age and year of publication. To assess publication bias, a funnel plot was used to visually inspect data symmetry, and Egger's test was performed to detect potential bias in the included studies.

Results

Selection Results and Study Characteristics

In the initial search, 4,422 articles were retrieved, of which 2,508 were duplicates. Titles and abstracts were then screened, leading to the exclusion of 1,400 studies due to not meeting the inclusion criteria or being irrelevant. The full texts of 503 studies were reviewed independently by two authors. As a result, 27 studies were excluded due to a sample size of fewer than 100 participants, 396 studies due to insufficient data, and 17 studies due to being conducted on children. Ultimately, 63 studies were included in the final analysis (see Figure 1).

The smallest and largest sample sizes were 100,[12,13] and 102,055[14] respectively. Most studies were published in 2022 (n = 8) and 2012 (n = 7). Also, 62% of selected studies were conducted in USA. The rest of the studies were related to the countries of Colombia (n = 1), Japan (n = 1), Taiwan (n = 1), Finland (n = 1), Denmark (n = 2), Norway (n = 3), Korea (n = 1), Netherlands (n = 1), China (n = 1), France (n = 1), Sweden (n = 1), Canada (n = 2), Ireland (n = 1) and Australia (n = 1). Of the included studies, 13 were classified as having moderate methodological quality, while the

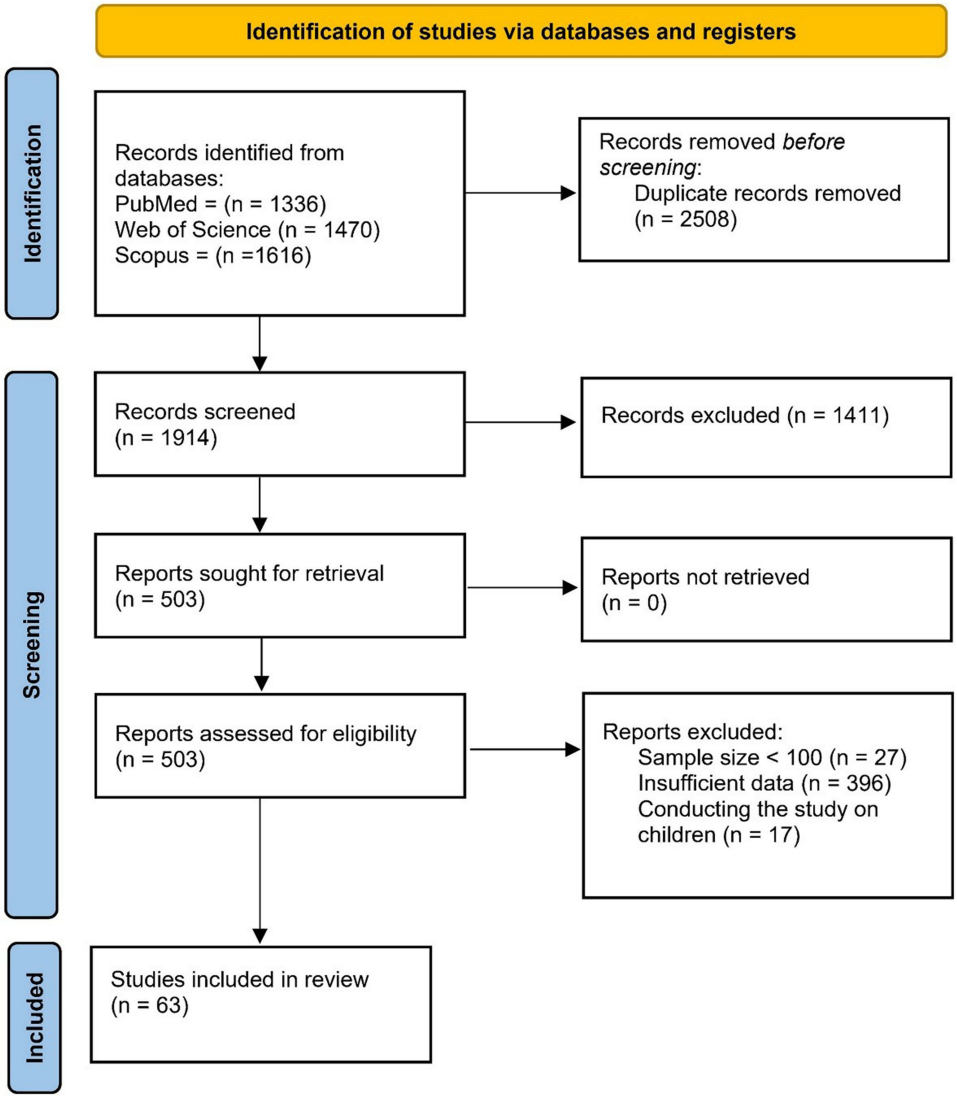

Figure 1 The PRISMA flowchart. Adapted from Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi:10.1136/bmj.n71.[11]

remaining studies were of high quality. These classifications were based on the Joanna Briggs Institute (JBI) Critical Appraisal Checklist, considering factors such as sample selection, measurement validity, confounding factors, and statistical analysis (Table 1).

Table 1 The Characteristics of the Included Papers

First Author	Year	Sample Size	Location	Mean Age	Tools	Follow-Up (Months)	Prevalence (%)	Severity	Quality
Hoffman[15]	2024	1762	USA	46.4	BPI	-	47.3	-	7
Harrison-Felix[16]	2024	3804	-	47	BPI	60	46.3	-	7
Chong[17]	2023	111	USA	41.3	SCAT-5	1	46.86	Mild	8
Ashina[18]	2023	1594	-	-	-	1	60.4	Mild	5

(*Continued*)

Table 1 (Continued).

First Author	Year	Sample Size	Location	Mean Age	Tools	Follow-Up (Months)	Prevalence (%)	Severity	Quality
Flynn[19]	2023	147	USA	45.2	ICHD-3	60	60	-	8
Coffman[20]	2022	377	Columbia	34.22	NSI	-	77.7	Mild	8
Licona[21]	2022	224	USA	-	-	-	75	-	5
Couch[22]	2022	497	USA	-	-	-	95.8	-	5
Leibovit-Reiben[23]	2022	565	Japan	-	ICHD-3	1	25.7	-	5
Karr[24]	2022	291	Taiwan	37.9	CPCS	1	53.95	Mild	7
Kraemer[25]	2022	127	Finland	40	NRS	1	61	Mild	8
Kothari[26]	2022	107	Denmark	22.8	HIT-6	12	44	Mild	8
Bosak[27]	2022	105	USA		NPS	12	41.9	-	8
Meltzer[28]	2021	2862	USA	42.1	BAST	6	23	-	7
Portanova[29]	2021	183	USA	49.2	RPQ	6	78	-	8
Hoffman[30]	2020	189	USA	45.4	HIT-6	1	58	Mild	7
		346		43.1			33	Moderate to severe	
Nordhaug[31]	2019	378	Norway	31.2	SAQ	3	47.3	Mild	8
						12	35.7		
Suri[32]	2019	23703	USA	33.3	CTBIEs	1	69.8	Mild	8
		3080		33.5			77.1	Moderate to severe	
Pugh[33]	2019	93003	USA	29.79	EHR	12	20.4	Mild	8
Howard[34]	2018	122	USA	-	ICHD-3	3	45.9	Mild	6
Nordhaug[35]	2018	294	Norway	48.4	SR	12	81.63	-	6
Kulas[36]	2018	23063	USA	32.83	EHR	12	47.7	Mild	8
		9253		32.14			36		
Walker[37]	2018	414	USA	36	HIT-6	-	70.8	Mild	8
Hong[38]	2017	259	Korea	37.9	NRS	36	13.1	Mild	8
Yilmaz[39]	2017	409	Netherlands	47	HISC	3	23	Mild to Moderate	8
Stacey[40]	2017	316	USA	41.8	HIT-6	1	38	-	8
						6	17		
						12	23		
						60	20		
Suri[41]	2017	1683	USA	36.6	CTBIEs	1	94.1	Mild	8
		379		35.9			95.2	Moderate to severe	
Schwab[42]	2017	358	USA	27	CPGS	3	15	Mild	8
Lucas[43]	2016	212	USA	44.4	SR	1	64	Mild	7

(*Continued*)

Table 1 (Continued).

First Author	Year	Sample Size	Location	Mean Age	Tools	Follow-Up (Months)	Prevalence (%)	Severity	Quality
Xu[44]	2016	543	China	48.4	ICHD-2	3	57.7	Mild	8
						6	53.9		
						12	49.4		
Nordhaug[45]	2016	940	Norway	50.6	HISS, 19	120	41.5	-	8
Jackson[46]	2016	612	USA	37.1	SR	1	33.1	Mild	8
BeswickEscanlar[14]	2016	102,055			EHR	12	15.2	Mild	6
Sawyer[47]	2015	212	USA	44	NRS	3	12	Mild	8
						6	11		
						12	30		
Webb[48]	2015	5065	USA		EHR	6	2.8	Mild	7
						>6	7.32		
Di Tommaso[49]	2014	212	USA	-	ICHD-2	-	78.77	Mild	6
Kjeldgaard[50]	2014	135	Denmark		RPQ	-	66.66	-	6
Laborey[51]	2014	536	France	36	FI	3	37.7	Mild	8
Lucas[52]	2014	212	USA	44.4	FTI	3	62	Mild	8
						6	69		
						12	58		
King[53]	2014	283	USA	31.4	EHR	3	51.2	Mild	7
		421		30.3			38		
Brickell[54]	2014	167	USA	27.6	FTI	6	73.9	Mild	
						12	67.4		
						24	85.2		
						36	83.3		
						48	83.3		
						60	92		
Walker[55]	2013	450	USA	43	SR	3	47.5	Mild	8
						6	41.2		
						12	44.8		
Ahman[56]	2013	163	Sweden	30.8	RPQ	36	50.9	Mild	7
MacGregor[57]	2013	334	-	23.3	PDHA	12	33.2	Mild	8

(*Continued*)

Table 1 (Continued).

First Author	Year	Sample Size	Location	Mean Age	Tools	Follow-Up (Months)	Prevalence (%)	Severity	Quality
Lucas[58]	2012	378	USA	42.6	ICHD-2	1	43.12	-	8
						3	37.83		
						6	35.71		
						12	41		
Tham[59]	2012	171	USA	-	-	24	39.2	Mild	6
Theeler[60]	2012	978	USA	-	SR	3	97.9	Mild	7
Romesser[61]	2012	210	USA	-	SR	1	71.4	Mild	7
		144					80.6		
Wilk[62]	2012	260	USA	-	EHR	1	32.7	Mild	8
Colantonio[63]	2012	435	Canada		RPQ	24	85.1	Mild, moderate, severe	7
Lieba-Samal[13]	2011	100	Austria	34.4	RPQ	3	66	Mild	8
Hoffman[64]	2011	362	USA	43.7	FTI	3	46	-	8
		402		43.7		6	41		
		392		43.7		12	44		
		452		43.7		-	71		
Patil[65]	2011	246	USA	27.9	EHR	1	74	Mild	8
Wilk[66]	2010	587	USA		SR	1	25.6	Mild	7
Chaput[67]	2009	443	Canada	46.9	RPQ	1	46.8	Mild	8
						-	39.9		
Vanderploeg[68]	2009	278	USA		SR	1	27	Mild	7
McCartan[69]	2008	216	Ireland	29		3	32.8	-	8
Faux[12]	2008	100	Australia	33.64	VAS	1	30.4	Mild	7
						3	15.35		
Hoge[70]	2008	375	USA		SR	-	22	Mild	7
Ruff[71]	2008	126	USA	-	NE	-	63.5	Mild	7
Nestvold[72]	2005	249	-	45	-	1	61	-	6
						3	36		
Warden[73]	2005	433	-	-	-	-	47	-	6
Walker[74]	2005	109	USA	28.4	SR	12	38	Moderate to severe	8

Abbreviations, BAST, Behavioral Assessment Screening Tool; BPI, Brief Pain Inventory; CPCS, Checklist of Post-Concussion Symptoms; CPGS, Chronic Pain Grade scale; CTBIEs, comprehensive TBI evaluations; EHR, Electronic Health Record; FI, Follow-up interviews; FTI, Follow-up telephone interviews; HISC, Head Injury Symptom Checklist; HISS; 19, Head Injury Severity Scale; HIT-6, six-item Headache Impact Test; ICHD-3, International Classification of Headache Disorders; NE, Neurological exam; NPS, Numerical Pain Scale; NRS, 0–10 numeric rating scale; NSI, Neurobehavioral Symptom Inventory; PDHA, Post-Deployment Health Assessment; RPQ, Rivermead Post-Concussion Symptoms Questionnaire; SAQ, self-administered questionnaires; SCAT-5, Symptom Evaluation of the Sports Concussion Assessment Tool; SR, self-reported; VAS, Visual analog scores.

The pooled prevalence of posttraumatic headache was 49.3% (95% CI: 44.7–53.9%). Sensitivity analysis showed that removing any single study did not significantly affect the overall prevalence of headache. This finding indicates that the meta-analysis results are stable and not influenced by any specific study.

Subgroup Analysis

Subgroup analysis showed that the prevalence of headache in studies with sample sizes of less than 1000 and more than 1000 participants was 50.4% (95% CI: 45.7–55.2%) and 42.1% (95% CI: 26.8–57.4%), respectively (p = 0.308). The analysis by continent revealed that the prevalence of headache in studies conducted in Asia, Europe, and America was 42.3% (95% CI: 27.5–57%), 48.9% (95% CI: 39.2–58.5%), and 51.4% (45.5–57.2%), respectively, with no significant difference between these three regions (p = 0.515).

Regarding measurement tools, the highest prevalence of headache was reported in studies using interviews (65.2%, 95% CI: 55.9–74.6%), while the lowest prevalence was observed in studies utilizing the NRS (25.2%, 95% CI: 6.7–43.7%) (p < 0.001). The prevalence of headache varied significantly across different measurement scales (p<0.001). In 64 studies, headache was assessed up to one year after trauma, whereas in 12 studies, it was examined beyond one year. The prevalence of headache in one-year and more-than-one-year follow-ups was 45.4% (95% CI: 40.5–50.3%) and 58.3% (95% CI: 42.8–73.8%), respectively (p = 0.005). The prevalence of headache was 45.1% (95% CI: 40.7–49.6%) in the general patient population and 56.1% (95% CI: 46.7–65.3%) in the military population, with significant difference between the two groups (p = 0.039). Additionally, the prevalence of headache in studies with high and moderate methodological quality was largely similar (48.2%, 95% CI: 43.3–53.1 vs 56%, 95% CI: 43.1–69%) (p = 0.270) (Table 2).

Table 2 The Results of the Subgroup Analysis

Categories		No. of Studies	Prevalence	95% CI	I2 (%)	Q	p
Sample size	< 1000	82	49.1	44.5–53.6	98.54	7517.03	< 0.001
	> 1000	13	44.5	30.5–58.6	99.90	6054.06	< 0.001
Continent	Asia	6	42.3	27.5–57	98.62	379.14	< 0.001
	Europe	12	48.9	39.2–58.6	97.48	490.82	< 0.001
	America	68	50.2	44.8–55.7	99.82	55,875.81	< 0.001
Scale	HER	9	35.7	22.4–49.0	99.90	11,629.56	< 0.001
	HIT6	8	37.9	24.6 51.1	98.14	445.67	< 0.001
	ICHD2	8	49.7	40.0–59.3	97.09	198.56	< 0.001
	Interview	14	65.2	55.9–74.6	97.74	709.37	< 0.001
	NRS	5	25.2	6.7–43.7	98.52	136.41	< 0.001
	RPO	7	61.9	49.3–74.5	97.28	344.99	< 0.001
	Self-reported	15	46.3	36.4–56.3	98.30	823.13	< 0.001
	Others	22	48.3	38.3–58.2	99.77	9766.46	< 0.001
Follow-up	Unknown	10	61.9	50.7–73.2	98.42	632.74	< 0.001
	<1 year	73	45	40.4–49.6	99.86	67,881.17	< 0.001
	> 1 year	12	58.3	42.8–73.8	99.47	1770.44	< 0.001

(*Continued*)

Table 2 (Continued).

Categories		No. of Studies	Prevalence	95% CI	I2 (%)	Q	p
Target	Veteran	34	54.6	54.7–63.6	99.92	67,394.28	< 0.001
	Others	61	45	40.5–49.4	98.41	3944.71	< 0.001
Quality	Moderate	13	51.2	39.6–62.8	99.30	3834.82	< 0.001
	Good	82	48	43.3–52.7	99.77	56,273.69	< 0.001

Meta-Regression

The meta-regression results indicated that the pooled prevalence of posttraumatic headache was not influenced by the year of publication (p = 0.345), sample size (p = 0.502), or the mean age of patients (p = 0.219). In other words, variations in these factors did not lead to a significant difference in the reported prevalence of headache across studies.

Publication Bias

The results showed that Egger's test did not provide evidence of publication bias (p = 0.375). In addition, a funnel plot was used for visual assessment. Therefore, the meta-analysis results were not affected by selective publication of studies.

Discussion

The findings of this systematic review and meta-analysis showed that the prevalence of posttraumatic headache (PTH) is 49.3% (95% CI: 44.7–53.9%). This high prevalence highlights PTH as one of the most common and debilitating complications of traumatic brain injury (TBI), with potential long-term effects on patients' physical and mental health. Given the potential for PTH to become chronic and persist for more than a year, accurately estimating its prevalence and patterns is essential for effective treatment and prevention strategies.[19] Our findings are similar to previous findings. Our findings are comparable to those of some previous studies. For example, in another meta-analysis conducted in 2008, the prevalence of post-traumatic headache (PTH) among veterans and civilians was reported to be 57.8%. This study found that the prevalence of PTH in patients with mild traumatic brain injury (75.3%) was unexpectedly higher than in those with moderate/severe traumatic brain injury (32.1%). Several factors may contribute to this difference in prevalence rates. On the one hand, revisions in the diagnostic criteria for mild traumatic brain injury in recent years may have led to changes in case reporting. On the other hand, population aging and the increasing prevalence of traumatic brain injuries among older adults may have influenced the differences observed in study findings. Therefore, further investigations are needed to gain a deeper understanding of the factors affecting PTH prevalence and its implications for different patient groups.[75]

Furthermore, the impact of repetitive head trauma is not limited to military populations. Studies on amateur and retired male boxers have demonstrated that repeated and chronic head trauma in boxing may be associated with pituitary dysfunction and decreased pituitary volume, suggesting endocrine system involvement as a significant consequence of repeated brain injuries.[76] In another meta-analysis conducted on adult civilians, the findings indicated that the overall estimated prevalence of post-traumatic headache (PTH) was 47.1%, which is consistent with the results of the present study. Notably, this prevalence showed little variation across different time intervals (3, 6, 12, and 36 months).[77]

However, sensitivity analyses in our study confirmed that excluding any single study did not significantly affect the overall prevalence, indicating stability and robustness of our findings. However, some cross-sectional studies have reported varying prevalence rates, from lower[23,30,33,38] to higher,[18,20,29,32] which may reflect differences in study design, population characteristics, and diagnostic criteria. Furthermore, sensitivity analyses confirmed that no single study had a disproportionate effect on the overall prevalence estimate, reinforcing the robustness and reliability of our meta-analytic results.[78] One of the key reasons for the significance of these findings is the potential impact of post-traumatic headache (PTH) on patients' neurological and psychological outcomes. Studies have shown that PTH can be associated with

symptoms such as chronic fatigue, sleep disturbances, anxiety, and depression, all of which may reduce patients' quality of life and limit their ability to return to daily activities.[79]

Similarly, a study on soldiers with traumatic brain injury (TBI) identified a wide range of neuropsychiatric symptoms grouped into cognitive impairments, neurobehavioral disorders (including depression, anxiety, and PTSD), and sensory disruptions, somatic symptoms such as chronic headaches and pain, and substance dependence. These symptoms are especially prevalent in soldiers exposed to blast injuries. The study highlighted the importance of using multidimensional diagnostic approaches like the biopsychosocial model to detect and manage psychological and social dysfunction in this population effectively.[78]

Moreover, some research has indicated that the severity and duration of headache following TBI may be linked to the severity of the initial brain injury. Therefore, identifying risk factors and developing effective treatment strategies for managing PTH could play a crucial role in improving outcomes for patients with TBI.[14,55] The findings of this study showed that the prevalence of post-traumatic headache (PTH) varies significantly depending on the assessment tools used. The highest prevalence, at 65.2%, was reported in evaluations based on clinical interviews. This variation may be attributed to several factors. In interview-based methods, evaluators can obtain more detailed information from patients, interpret their responses, and ask follow-up questions if needed for clarification. This is particularly important for patients who may struggle to accurately describe their symptoms or underestimate the severity of their headaches.

Allen (2019) states that clinical interviews allow for a thorough examination of patient symptoms and facilitate a comprehensive assessment.[80] In contrast, standardized questionnaires such as the Numeric Rating Scale (NRS) reported lower prevalence rates (25.2%), possibly due to their limited capacity to capture complex headache features. Due to the inherent limitations of these questionnaires, certain aspects of headache symptoms may not be fully captured. Additionally, variations in reported prevalence may result from differences in how these tools are administered, patients' interpretations of their symptoms, and the diagnostic accuracy of each method. These findings highlight the importance of selecting an appropriate assessment tool for evaluating PTH, suggesting that clinical interviews, due to their greater flexibility and ability to explore symptoms in depth, provide a more comprehensive picture of the disorder's prevalence.

We also found that follow-up duration significantly influenced prevalence estimates: rates were higher beyond one year (58.3%) compared to within one year (45.4%), suggesting persistence or delayed onset of PTH in some cases. Furthermore, military populations exhibited higher prevalence (56.1%) than general patient groups (45.1%), possibly reflecting more frequent head trauma or unique risk factors in these groups. It is important to note that athletes in contact sports such as boxing are also at considerable risk for repeated head trauma, which has been associated with neuroendocrine dysfunctions, including pituitary gland abnormalities, as well as chronic neuropsychiatric conditions. These factors should be considered when interpreting headache prevalence in populations exposed to head injuries. Meta-regression indicated that variables such as publication year, sample size, and mean age did not significantly affect prevalence estimates, which supports the consistency of our results. Moreover, no publication bias was detected based on Egger's test and funnel plot analysis. We acknowledge the considerable heterogeneity in definitions and assessment methods of PTH across studies. To address this, we clarified in the manuscript that "posttraumatic headache" includes all headaches reported after TBI, regardless of whether they meet strict clinical criteria (eg, ICHD-3). This limitation has been explicitly stated to aid interpretation.

Given the high incidence of headaches among TBI patients, special attention to this condition is essential in the care and rehabilitation process. Future studies should investigate the precise mechanisms underlying PTH, associated risk factors, and optimal treatment strategies for managing this condition. Moreover, adopting a multimodal approach—including pharmacological treatments, neurorehabilitation, and behavioral interventions—may be effective in alleviating the burden of PTH.

Limitations

This study has several limitations. First, the included studies may not fully represent the broader target population, which limits the generalizability of our findings. Future research with larger, more diverse samples is needed to improve external validity. Second, the cross-sectional nature of many included studies restricts the ability to infer causality. Longitudinal or experimental designs are needed to explore causal relationships between TBI and PTH. Third, the tools used to assess PTH varied widely, and some—such as the NRS—may underestimate prevalence due to their limited capacity to capture the complexity of symptoms. In contrast, clinical interviews appear to provide a more comprehensive

assessment, as supported by our subgroup analyses. Fourth, substantial heterogeneity existed across studies in how PTH was defined and measured. Although we used an inclusive approach to improve sensitivity, this may have introduced variability that complicates interpretation. Fifth, certain high-risk subgroups, such as military personnel and athletes in contact sports, may experience distinct patterns of injury and symptoms due to repeated trauma and neuroendocrine disruptions. While these populations were included in our analysis, more focused studies are needed to understand their specific risk profiles. Finally, although meta-regression found no significant effects from variables like sample size or mean age, the presence of overall heterogeneity suggests a need for more standardized definitions and assessment methodologies in future research.

Conclusion

This study indicates that the prevalence of post-traumatic headache (PTH) is influenced by multiple factors, including assessment methods, follow-up duration, and study population. Notably, clinical interviews tend to yield higher prevalence estimates than standardized questionnaires, likely due to their greater depth and flexibility. Sensitivity analyses and meta-regression confirmed the robustness of our findings, and no publication bias was detected. However, methodological variability—particularly in diagnostic criteria and assessment tools—may have contributed to differences across studies. Therefore, reported prevalence estimates should be interpreted with caution. These findings underscore the need for careful selection of assessment tools and greater standardization in PTH research. Given the significant burden of PTH on patients with TBI, future research should focus on understanding its underlying mechanisms and developing effective, multimodal treatment strategies tailored to patient subgroups.

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Disclosure

The authors report no conflicts of interest in this work.

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