NEUROPSYCHOLOGICAL REHABILITATION
https://doi.org/10.1080/09602011.2025.2559911

Routledge
Taylor & Francis Group

REVIEW ARTICLE

OPEN ACCESS Check for updates

Prevalence and moderators of apathy after traumatic brain injury: A systematic review and meta-analysis

Jessica Lynch[a], Leila Sarih[c], Joseph Mole[d,e], Grace Revill[a] and Vaughan Bell[a,b]

[a]Research Department of Clinical, Educational and Health Psychology, University College London, London, UK; [b]Department of Neuropsychiatry, South London and Maudsley NHS Foundation Trust, London, UK; [c]West London NHS Trust, London, UK; [d]Oxford University Hospitals NHS Foundation Trust, Oxford, UK; [e]Institute of Neurology, University College London, London, UK

ABSTRACT

Apathy is a recognized neuropsychiatric syndrome in individuals with traumatic brain injury (TBI) with far-reaching consequences, including reduced independence, meaningful activities and quality of life. However, previous studies have reported variable prevalence rates and no meta-analysis has synthesized prevalence findings and identified moderators of apathy in clinical populations. We conducted a pre-registered meta-analysis (PROSPERO CRD42024552306), searching three databases (MEDLINE, EMBASE, and APA PsycInfo) for primary studies assessing apathy in individuals with TBI. 18 studies met inclusion criteria, and data were extracted for meta-analysis to estimate the pooled prevalence of apathy. Subgroup analyses and meta-regressions explored the influence of potential moderating factors including demographic characteristics, injury-related factors, and methods of apathy assessment. The meta-analysis found the prevalence of apathy following TBI to be 37.6% [95% CI 28.5–47.2%]. Key moderators included cause of injury, TBI severity, sex and population type. Specifically, transport accidents were associated with higher apathy prevalence, while mild TBI, male sex, and veteran status were associated with lower apathy prevalence. Apathy is a prevalent and significant symptom following TBI, affecting over one-third of individuals in the reviewed studies. These findings highlight the need for increased clinical focus on apathy as an important aspect of TBI recovery.

ARTICLE HISTORY
Received 12 March 2025
Accepted 6 September 2025

KEYWORDS
Neuropsychiatry; Brain injury; Neurology; Psychiatry; Amotivation

Introduction

Traumatic brain injury (TBI) is a significant public health concern. It occurs when an external force damages the brain, which can result in a range of physical,

CONTACT Vaughan Bell Vaughan.Bell@ucl.ac.uk University College London, Gower Street, London WC1E 6BT, UK

Supplemental data for this article can be accessed online at https://doi.org/10.1080/09602011.2025.2559911.

cognitive, emotional, and behavioural impairments (Menon et al., 2010). It is the leading cause of disability and mortality among individuals aged 1–45, with only 25% of those who have had a serious TBI gaining long-term functional independence (Ahmed et al., 2017). The consequences of TBI extend beyond the individual, often causing significant distress for families and contributing to broader societal and economic challenges (Faul et al., 2010; Rubiano et al., 2015). In 2019, there were 27.16 million new cases of TBI worldwide, with 48.99 million people living with TBI (Guan et al., 2023). In the UK, a report by the Centre for Mental Health estimated the annual cost of TBI to be £15 billion (Parsonage, 2016). Importantly, while some of the symptoms or TBI may be immediately apparent, other, predominantly neuropsychiatric, symptoms, may be less so. It is because of this that TBI is often referred to as the "silent epidemic."

Apathy is a well-recognized neuropsychiatric outcome in individuals with TBI, with significant impact on functioning and recovery (Azouvi et al., 2017; Ciurli et al., 2011; Worthington & Wood, 2018). Marin (1991) first defined apathy as a neuropsychiatric syndrome characterized by a persistent lack of motivation that cannot be explained by diminished consciousness, cognitive deficits, or emotional distress. It is considered to be a multidimensional construct involving reduced motivation, goal-directed behaviour, and emotional indifference (Marin, 1996). These characteristics make apathy a critical focus in clinical assessment and intervention, given its substantial impact on daily functioning and overall quality of life.

Apathy has been consistently linked to significant impairments in psychosocial functioning. Individuals with apathy face difficulties in activities of daily living (Green et al., 2022; Tierney et al., 2018), reduced independence after hospital discharge (Arnould et al., 2015), and limited community integration (Cattelani et al., 2008). Apathy has also been associated with less progress in rehabilitation (Resnick et al., 1998), increased reliance on caregivers (Landes et al., 2001) and significant caregiver distress which can strain family dynamics (Marsh et al., 1998). Moreover, apathy has been associated with passive coping strategies (Finset & Andersson, 2000), poorer employment outcomes such as reduced working hours and financial independence (Bull et al., 2016; Funayama et al., 2022). These findings highlight the pervasive and multifaceted impact of apathy, reinforcing its importance as a focus for clinical assessment and intervention.

Apathy is prevalent across various other neurological conditions. A meta-analysis found that apathy affects 33% of individuals post-stroke (Zhang et al., 2023), and that the prevalence is approximately three times higher than depression (Caeiro et al., 2013). Similarly, 39.8% of individuals with Parkinson's disease experience apathy (den Brok et al., 2015), and it was reported as the most common neuropsychiatric symptom in Alzheimer's disease (Mega et al., 1996; Nobis & Husain, 2018; Zhao et al., 2016). However, our understanding of the prevalence of apathy following TBI is limited.

A recent review by Quang et al. (2024) explored factors associated with apathy in moderate-to-severe TBI and reported the limited role of injury severity and demographics. Instead, they highlighted the influence of factors like caregiver burden and self-efficacy. While this review emphasized the need for a multifaceted biopsychosocial approach to understanding apathy, it did not meta-analyse apathy prevalence, leaving the overall rate across studies unclear. Additionally, their focus on moderate-to-severe TBI limited insight into how apathy and its moderators vary across the full spectrum of injury severity.

Thus, despite recognition of its seriousness, the prevalence of apathy after TBI remains unclear and a robust meta-analysis addressing this is needed. Estimates of the prevalence of apathy in TBI vary widely, ranging from 16% (van Zomeren & van den Burg, 1985) to 71% (Kant et al., 1998), making it difficult to estimate the scale of the problem and plan services accordingly. The extent of this variability also hints at the existence of factors moderating the relationship between TBI and apathy, whether this is the case and which factors may be relevant remains unclear. Potentially contributing to this inconsistency are definitional challenges. Apathy has been conceptualized as a symptom, a syndrome, or a distinct disorder (Levy & Dubois, 2006; Robert et al., 2018) and often co-occurs with related conditions such as depression and fatigue, which complicates differential diagnosis (Worthington & Wood, 2018). In addition, the lack of a gold-standard apathy measure validated for TBI populations (Clarke et al., 2011) further limits comparability across studies.

This systematic review and meta-analysis aimed to address these important issues by providing a comprehensive estimate of apathy prevalence across mild, moderate, and severe TBI populations while identifying potential moderators influencing variability in reported rates.

Methods

Search strategy

The protocol was pre-registered on PROSPERO (CRD42024552306). We performed comprehensive searches on the Ovid platform across three databases: APA PsycINFO, MEDLINE, and EMBASE. The search was conducted in August 2024 with no date restrictions. Exact search terms are provided in supplementary material 1. The search strategy included terms such as “traumatic brain injury,” “head injury,” “apathy,” “amotivation” and “disinterest.” A wide-ranging selection of apathy-related terms was used (e.g., “loss of motivation,” “indifference”). References of included papers were searched to identify additional studies.

Eligibility criteria and screening

Eligibility criteria were defined using the Population, Intervention, Comparison, Outcomes, and Study (PICOS) framework:

- Population: Adults (≥18 years) with a history of TBI, assessed at least once for apathy.
- Intervention: Apathy assessed through clinical evaluation, structured interviews, or validated questionnaires.
- Comparison: Studies with or without comparison groups were eligible.
- Outcome: Prevalence of apathy reported as cases per sample.
- Study Design: Peer-reviewed primary research articles.

We included studies published in English only due to resource limitations but imposed no restrictions on publication date, geographic location, or care setting. We did not include studies which did not differentiate between TBI and other neurological conditions or acquired brain injury.

Search results were imported into Rayyan, an online screening platform. Two authors (JL and LHS) independently screened titles and abstracts for eligibility. Studies passing this initial screening underwent full-text review for final inclusion by the two authors (JL and LHS). Any disagreements were resolved through discussion or consultation with a third author (VB) when necessary.

Data extraction

Data were extracted independently by two authors (JL and LHS), with discrepancies resolved through discussion and consensus. A third author (VB) was consulted if necessary. Data were extracted into a pre-designed spreadsheet, capturing the following:

1. Study characteristics: Authors, publication year, study design, population and setting.
2. Sample demographics: Age, sex distribution, percentage of non-white participants and sample size.
3. Clinical characteristics: TBI severity, time since injury, and cause of TBI.
4. Apathy assessment: Measurement tool and rater (e.g., clinician, self-report, caregiver/informant).
5. Outcome: Prevalence of apathy (number of cases and sample size).

In cases where multiple apathy prevalence estimates were reported within a study ($k = 3$), reviewers (JL and VB) selected the most appropriate estimate on a case-by-case basis. When both self-report and caregiver-report measures were available ($k = 1$), the caregiver rating was used to align with the most common method across studies. When two validated measures were used within the same sample ($k = 1$), the scale with stronger psychometric support was selected. Where prevalence was reported at multiple timepoints ($k = 1$), the mid-point estimate was chosen to ensure consistency across studies.

These instances are discussed in the narrative review and sensitivity analyses were conducted where appropriate.

Quality assessment

Risk of bias was evaluated using the JBI Critical Appraisal Checklist for Prevalence Studies which assesses various aspects of study validity such as measurement reliability, sample size and sampling methods (see supplementary material 2 for criteria). Assessments were conducted independently by two authors (JL and LHS), with disagreements resolved through consensus.

The average score for study quality across all 18 studies was 8.6/10. Ten studies scored full marks for study quality and one scored below five. Full details of the quality assessment scores for each study can be found in supplementary material 3.

Statistical analysis

The meta-analysis was carried out using *R* (version 4.4.2) with the *meta* and *metafor* packages. Random-effects models were used to calculate the pooled prevalence of apathy after TBI. Heterogeneity was assessed using I^2 statistics to quantify the proportion of variability due to heterogeneity rather than sampling error. Heterogeneity is typical among prevalence studies and therefore a random effects model accounts for $I^2 \geq 50\%$. Prevalence rates were transformed using a Freeman-Tukey double arcsine transformation to stabilize variance. All data and analysis code are available in the open online archive: https://github.com/lynchjess/Apathy-TBI-meta.

To assess potential publication bias, we constructed a Doi plot and calculated LFK index (Furuya-Kanamori et al., 2018) which are recommended in place of funnel plots and Egger's test which are inappropriate for meta-analyses of prevalence (Cheema et al., 2022). Sensitivity analyses were completed using a leave-one-out procedure, wherein each study was sequentially removed to examine its impact on the overall effect size.

Subgroup analyses were conducted to explore variations in prevalence based on study design, study location, setting, apathy measure and apathy rater. Meta-regressions were used to assess whether age, gender, study quality, TBI severity, length of time since TBI and cause of injury moderated the prevalence of apathy.

Results

Search results

Out of 710 studies screened, 18 met the final inclusion criteria. The full screening and study selection process is detailed in the PRISMA flowchart (Figure 1). There

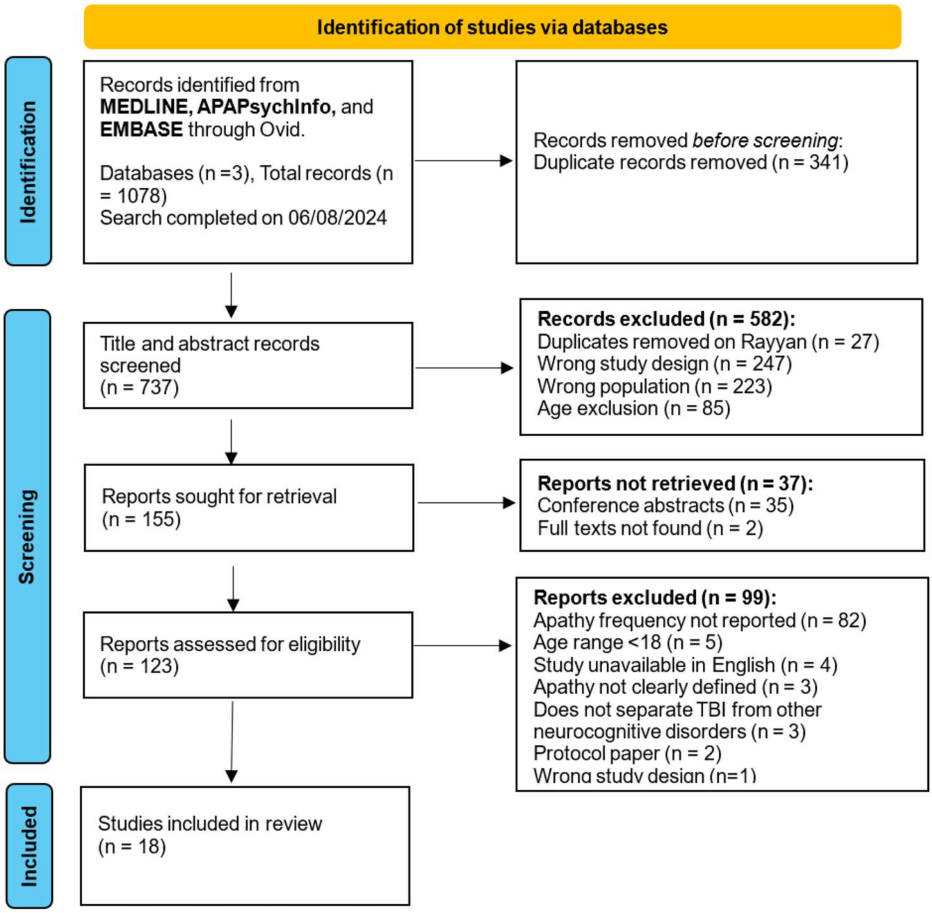

Figure 1. PRISMA flowchart for identification of included studies.

was substantial agreement between both reviewers for the title and abstract screening (Cohen's kappa = 0.72).

Study characteristics

Eighteen studies were included in the analysis, spanning publication years from 1991 to 2024, Table 1 outlines basic characteristics of each included study. The studies were conducted across five continents, with the majority based in North America (k = 6), Asia (k = 5) and Europe (k = 5). Only two of the studies (both in North America) reported details on the proportion of non-white participants, limiting our ability to assess how representative the included samples were or explore potential differences in apathy prevalence by ethnicity. A total of 1136 participants with a TBI were included, with a mean of 63 participants per study. The mean age of participants was 37.8 years, and males comprised 79% of the sample, reflecting the well-documented gender imbalance in reported TBI rates (Bruns & Hauser, 2003).

Table 1. Characteristics of 18 included studies. GCS = Glasgow Coma Scale; NA = Not reported; Other factors = Length of post traumatic amnesia, length of loss of consciousness, trauma-related intracranial neuroimaging abnormalities.

Study authors	Year	Country	TBI N	Severity categorization method	Apathy measure	Rater	Apathy N
Venkatesan & Rabinowitz	2024	USA	106	GCS + other factors	Frontal Systems Behaviour Scale	Self-report	53
Nguyen et al.	2023	Vietnam	75	GCS	Neuropsychiatric Inventory	Caregiver	46
Quang et al.	2023	Vietnam	45	GCS	Dimensional Apathy Scale	Caregiver	20
Ubukata et al.	2022	Japan	88	GCS	Apathy Scale	Self-report	51
Balan et al.	2021	Brazil	41	NA	Apathy Evaluation Scale	Caregiver	12
Devi et al.	2020	India	50	GCS	Neuropsychiatric Inventory	Caregiver	5
Huang et al.	2020	USA	25	GCS + other factors	Head Injury Symptom Checklist – adapted	Self-report	1
Nygren DeBoussard et al.	2017	Sweden	81	GCS	Clinical interview	Clinician	26
Arnould et al.	2015	France	68	NA	Apathy Inventory	Caregiver	14
Lengenfelder et al.	2015	USA	33	NA	Frontal Systems Behaviour Scale	Caregiver	11.55
Knutson et al.	2014	USA	176	NA	Neuropsychiatric Inventory	Caregiver	28
Wiart et al.	2012	France	47	Glasgow Outcome Scale	Clinical interview	Clinician	20
Lane-Brown & Tate	2010	Australia	34	NA	Apathy Evaluation Scale	Caregiver	23.46
Kilmer et al.	2006	USA	51	Other factors	Neuropsychiatric Inventory	Caregiver	19
Al-Adawi et al.	2004	Oman	80	GCS	Apathy Evaluation Scale	Self-report	16
Cantagallo & Dimarco	2002	Italy	53	GCS	Neuropsychiatric Inventory	Caregiver	25
Pąchalska et al.	2001	Poland	15	NA	Frontal Behavioural Inventory	Caregiver	13
Dunlop et al.	1991	USA	68	NA	Neuropsychiatric scale devised for the study	Clinician	28.56

One study (Nygren DeBoussard et al., 2017) provided demographic data for a larger sample (n = 114) than the 81 that were assessed for apathy, limiting the demographic details we could report for this study. Sixteen studies reported the TBI severity of their sample, which overall was found to be 13.2% mild, 34.0% moderate-to-severe and 52.8% severe. Seven of the studies used the Glasgow Coma Scale (GCS) to categorize severity: mild (score 13–15), moderate (9–12), and severe (3–8). Two studies used the GCS alongside other factors, such as the duration of loss of consciousness, post-traumatic amnesia, and intracranial neuroimaging abnormalities. One study combined these factors without relying on the GCS, while another used the Glasgow Outcome Scale. Seven studies did not specify their method of categorization.

Eleven studies reported TBI causes: transport accidents (74.5%), falls (11.36%), combat (4.3%), assaults (4.5%), and other causes (3.8%). Seventeen studies reported a mean or median time since TBI, with a pooled average of 43.4 months. The average time since injury across studies ranged from 3 to 133.2 months (SD = 44.3), based on study-level summary values. One study (Nygren DeBoussard et al., 2017) reported apathy prevalence at 3 weeks (35%), 3 months (32%), and 1 year (37%) post-injury; the 3-month estimate was selected for inclusion in the meta-analysis. Fourteen studies did not specify whether participants had a single or multiple TBIs. Of the four that did, two included only single TBI cases, while the other two included participants with varying numbers of TBIs.

Apathy was assessed using a variety of measures, including the Neuropsychiatric Inventory (NPI; k = 5), Apathy Evaluation Scale (AES; k = 3), Frontal Systems Behavior Scale (FrSBe; k = 2), Dimensional Apathy Scale (DAS; k = 1), Apathy Scale (k = 1), Head Injury Symptom Checklist (k = 1), Frontal Behavioural Inventory (k = 1), and Apathy Inventory (k = 1).

For the purposes of this review, the AES and FrSBe were considered validated measures of apathy in TBI, based on psychometric evidence in this population. The AES and NPI have also been identified as the most psychometrically robust apathy measures across neurological populations (Clarke et al., 2011). Preliminary evidence supports the NPI's validity in TBI populations specifically (Kilmer et al., 2006), and it was therefore also included, with caution, as a TBI-validated measure. Several other tools such as the DAS, Apathy Inventory and Frontal Behavioural Inventory lack validation in TBI populations, though have been validated in other neurological populations (Kertesz et al., 2000; Radakovic, Gray, et al., 2020; Radakovic, McGrory, et al., 2020). In total, ten studies used TBI-validated measures and eight used non-validated ones.

Most measures were caregiver-rated (k = 10), with four self-reported and three clinician-rated. One study (Lengenfelder et al., 2015) reported both self-reported (43%) and caregiver-reported (35%) apathy prevalence; the caregiver-reported estimate was included in the meta-analysis to align with the dominant reporting method across studies. Reported apathy prevalence ranged widely, from 4% to 87%.

Main findings

The pooled prevalence of apathy after TBI was 37.58% (95% CI: 28.45–47.15%) using a random-effects model (Figure 2). Heterogeneity was high ($I^2 = 90.3\%$, 95% CI: 86.2–93.2%), with a significant test of heterogeneity ($Q = 174.88$, $p < .001$) and between-study variance ($\tau^2 = 0.037$, 95% CI: 0.021–0.098). Study weights ranged from 4.4% to 6.1%, indicating no single study disproportionately influenced the estimate. A Freeman-Tukey double arcsine transformation and Clopper-Pearson method were applied to address extreme values and calculate confidence intervals.

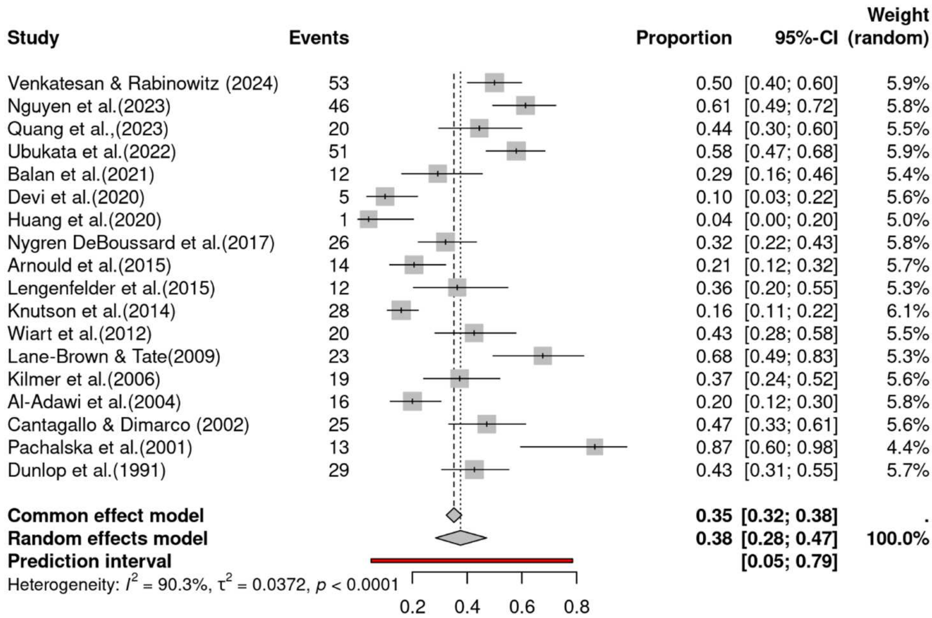

Figure 2. Forest plot of overall apathy prevalence across 18 included studies.

Subgroup analyses

We conducted subgroup analyses for study design, setting, population, continent, apathy measure, validated measures and apathy rater (Table 2). Groups with single studies only were excluded. The only significant difference was found was in population subgroups, where veterans had a lower apathy prevalence than the general public ($p < .001$). No other subgroups were found to significantly moderate the apathy prevalence. One study (Lengenfelder et al., 2015) included both self and caregiver-reported apathy. We ran a sensitivity analysis using the self-report measure in place of the caregiver rated measure, although the subgroup comparison for rater remain non-significant ($p = .876$).

Meta regression analyses

We also ran several meta-regressions to explore the impact of further demographic factors (age and sex), TBI factors (severity, time since TBI and cause of TBI) and study factors (year published and study quality) on apathy prevalence.

Demographic factors

A mixed-effects meta-regression model found no significant relationship between mean age and apathy prevalence ($\beta = 0.001$, $p = .930$). An analysis of 17 studies revealed a significant effect of sex, with males showing a lower prevalence of apathy ($\beta = -0.90$, $p = .03$). The model explained 10.56% of the heterogeneity, but residual heterogeneity remained high ($I^2 = 90.03\%$).

Table 2. Subgroup analyses of apathy prevalence in TBI populations.

Subgroup	Category (k)	Prevalence (%)	95% CI	p
Study design	Cross-sectional (14)	40.09	28.97–51.72	.306
	Other designs (4)	29.66	15.20–46.46	
Setting	Outpatient (8)	43.23	29.24–57.78	.600
	Inpatient (5)	40.45	24.30–57.69	
	Study registry database (3)	30.69	13.46–51.21	
Population	General public (16)	41.52	32.77–50.54	<.001
	Veterans (2)	10.92	2.47–23.56	
Continent	Europe (5)	43.18	26.89–60.22	.513
	Asia (5)	37.46	17.94–59.30	
	North America (6)	29.87	15.95–45.90	
Apathy measure	Frontal Systems Behaviour Scale (2)	45.12	32.63–57.92	.672
	Apathy Evaluation Scale (3)	37.66	13.20–65.91	
	Clinical Interview (2)	36.23	26.47–46.58	
	Neuropsychiatric Inventory (5)	32.71	14.47–54.09	
Validated measures	Validated (10)	36.21	23.83–49.55	.740
	Non-validated (8)	39.39	25.82–53.80	
Apathy rater	Caregiver (11)	39.60	26.45–53.52	.836
	Self-report (4)	31.49	11.61–55.60	
	Clinician (3)	38.27	31.12–45.67	

TBI factors – severity

Three meta-regression analyses were conducted to examine whether TBI severity moderated the relationship between TBI and apathy prevalence. Fifteen studies were included, with three excluded due to missing data.

A significant negative association was found between mild TBI and apathy prevalence ($\beta = -0.40$, $p = .044$), suggesting that individuals with mild TBI experience lower apathy prevalence compared to other severity levels. The model explained a modest proportion of variability ($R^2 = 5.16\%$), though residual heterogeneity remained high ($I^2 = 87.79\%$). No significant associations were found for moderate-to-severe TBI ($\beta = 0.10$, $p = .469$) or severe TBI ($\beta = 0.09$, $p = .473$) with apathy prevalence.

TBI factors – time since TBI and cause of TBI

A meta-regression analysis investigating the relationship between the mean months since TBI and apathy prevalence revealed no significant association ($\beta = 0.002$, $p = .130$). Regarding the cause of TBI, additional meta-regression analyses were conducted to assess how specific causes influenced apathy prevalence. For transport accidents, an analysis of 11 studies demonstrated a significant positive association, indicating that individuals with TBI resulting from transport accidents exhibited higher apathy prevalence ($\beta = 0.417$, $p = .028$). This model explained 26.02% of the variability and residual heterogeneity remained high ($I^2 = 89.56$).

When exploring the same 11 studies, no significant relationship was identified between falls as a cause of TBI and apathy prevalence ($\beta = 0.125$, $p = .908$). Similarly, an analysis focusing on assault as a cause of TBI, which included nine studies where this was reported, found no significant association with apathy prevalence ($\beta = 1.150$, $p = .397$).

Study factors

A meta-regression analysis found no significant relationship between the year of study publication and apathy prevalence ($\beta = -0.004$, $p = .428$). Similarly, no significant effect was found for study quality ($\beta = -0.014$, $p = .601$).

Publication bias and sensitivity analysis

The LFK index was 0.4 and so below the threshold for asymmetry suggesting no significant evidence of publication bias in the Doi plot (Figure 3).

Outlier and influence analysis

Outlier analysis identified seven studies (Devi et al., 2020; Huang et al., 2020; Knutson et al., 2014; Lane-Brown & Tate, 2010; Nguyen et al., 2023; Pąchalska et al., 2001; Ubukata et al., 2022) as outliers. After excluding these outliers, the random-effects model was based on 11 studies with 673 observations and 246 events although the pooled apathy prevalence estimate was similar at 36.11% (95% CI: 29.37–43.13) although with reduced heterogeneity ($I^2 =$ 70.4%, $\tau^2 = 0.009$). Sensitivity analysis using leave-one-out diagnostics showed minor fluctuations in the pooled prevalence (ranging from 33.34% to 39.23%), with similarly minor fluctuations in overall heterogeneity ($I^2 =$ 87.9% to 90.8%), indicating the robustness of the meta-analytic results.

Similarly, the influence diagnostics (supplementary material Figure S1) did not identify any studies as having an effect on the pooled effect size and heterogeneity. Baujat diagnostics identified Pąchalska et al. (2001) and Huang et al. (2020) as potentially influential studies (supplementary material Figure S2).

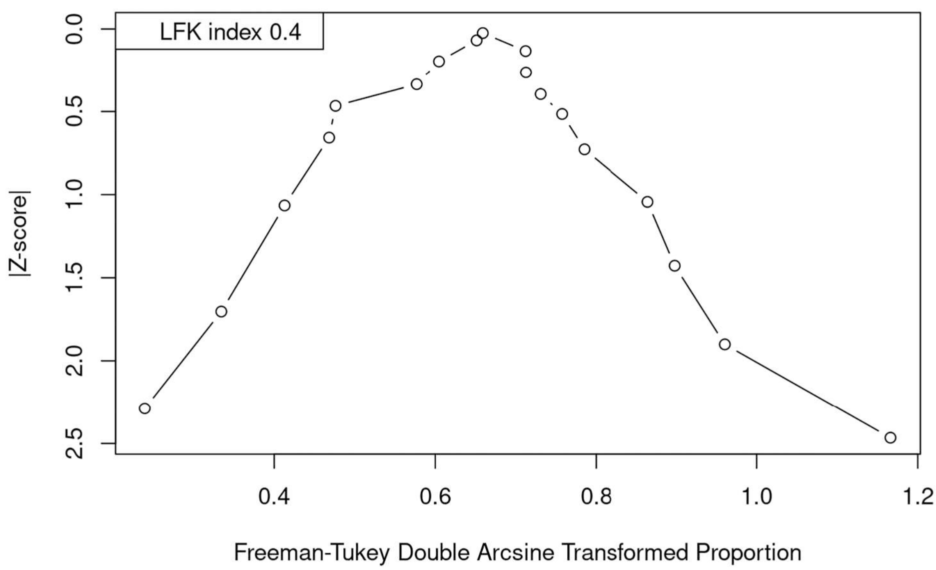

Figure 3. Doi plot.

However, a sensitivity analysis omitting these studies indicated a similar prevalence estimate although with slightly improved heterogeneity (38% CIs 29%–47%; $I^2 = 89.4\%$), similarity indicating robustness.

Discussion

To our knowledge, this is the first review to meta-analyse the pooled prevalence of apathy in individuals with a history of TBI. We also examined potential moderators, including demographic characteristics, TBI-related factors, and methods of apathy assessment. Drawing on data from 18 studies published between 1991 and 2024, we found an overall prevalence of 37.6%, emphasizing the high occurrence of apathy in this population. The prevalence estimate remained robust with little change in the overall estimate in subsequent sensitivity analyses.

This prevalence rate is comparable to other neurological conditions, such as 33% in stroke (Zhang et al., 2023) and 39.8% in Parkinson's disease (den Brok et al., 2015), although it is lower than the 49% prevalence found in Alzheimer's disease (Zhao et al., 2016). These findings indicate that over a third of individuals with TBI are likely to experience apathy. Given its significant negative impact on psychosocial functioning, rehabilitation outcomes, and family well-being, this underlines the need for greater clinical attention to apathy as a critical issue in TBI recovery.

Significant heterogeneity was observed across studies, with apathy frequency ranging from 4% to 87%. This wide variability suggests the influence of various moderating factors. Our subgroup analyses and meta-regressions identified four factors that significantly influenced apathy prevalence: cause of injury, TBI severity, sex and population type. Specifically, transport accidents were associated with higher apathy prevalence, while mild TBI, male sex, and veteran status were associated with lower apathy prevalence. We will consider each of these in turn.

We found that males had a significantly lower prevalence of apathy compared to females. Previous studies, including a large cohort study and meta-analysis, have found that females reported a higher symptom burden and more mental health difficulties following TBI (Farace & Alves, 2000; Mikolić et al., 2021). This difference was more pronounced after mild TBI than after severe TBI (Mikolić et al., 2021; Starkey et al., 2022). The mechanisms underlying these disparities in sex remain unclear, with some clinical opinions contrasting this and suggesting that females tend to experience better outcomes after TBI. While biological factors may contribute to these differences, an additional explanation could be that females are more likely to self-report symptoms or have greater self-awareness of TBI-related deficits (Barsky et al., 2001; Niemeier et al., 2014). Interestingly, a review on apathy after TBI (Quang et al., 2024) found no significant sex differences. However, this review focused only on moderate-to-severe TBI and may not reflect differences that emerge more clearly in mild TBI, which our study includes. Given the male predominance in TBI cases (79% in our sample), further research is needed to explore sex-specific differences in apathy and their clinical implications. No significant impact of other demographic factors, such as age, was found on apathy prevalence in this review.

Regarding TBI severity, we conducted three meta-regressions to examine whether the severity of TBI (mild, moderate-to-severe, and severe) moderated the relationship between TBI and apathy prevalence. Our results indicated that only mild TBI had a significant moderating effect, suggesting that individuals with mild TBI may be less likely to experience apathy. However, this effect was small, and substantial heterogeneity remained, indicating that additional factors may contribute to apathy in this group. The lack of significant findings for moderate-to-severe and severe TBI suggests that apathy prevalence may not increase in direct proportion to injury severity alone. Neuropsychiatric outcomes after mild TBI are influenced by a complex, multifactorial aetiology, with psychological mechanisms such as coping styles or pre-injury mental health difficulties potentially playing a significant role in this group (Mooney et al., 2005; Ponsford et al., 2000; van der Horn et al., 2020). Given that mild TBI accounted for only 10% of the participants in this review, these findings should be interpreted with caution and further research on apathy in mild TBI is needed.

Road traffic accidents were found to moderate the relationship between TBI and apathy, suggesting that individuals with traffic accident-related TBIs may be more likely to experience apathy. One potential explanation for this finding is that road traffic accidents may lead to more complex neurological damage or additional injury-related factors that influence apathy. In high-income countries, road traffic accidents account for the highest proportion of TBI-related hospitalizations (Hyder et al., 2007), indicating that these injuries often necessitate more intensive medical intervention. Furthermore, TBIs resulting from road traffic accidents tend to be more severe than those caused by other incidents (Rahman et al., 2025). The increased severity of injury and the heightened burden of hospitalization following road traffic accidents may contribute to the higher prevalence of apathy observed in this group.

Veterans had a significantly lower prevalence of apathy (10.9%) compared to the general population (41.5%). However, this result should be interpreted cautiously, given the small number of studies on veterans ($k = 2$). Notably, both veteran cohorts were composed entirely of males. Given that we found males had a significantly lower prevalence of apathy than females, one possibility is that this difference is explained entirely by sex. Alternatively, the lower prevalence in veterans could be attributed to other factors, such as distinct TBI aetiologies, the effects of military training or rehabilitation, or differences in symptom reporting. One of these studies used self-report measures, while the other relied on caregiver ratings. Some research suggests that veterans may underreport psychological symptoms due to cultural influences such as military norms around emotional resilience and concerns about stigma (Hoge et al., 2004; Vogt et al., 2014). If underreporting is a factor, the true prevalence of apathy in veterans may be underestimated.

Further research using clinician-rated measures is needed to determine whether the lower prevalence reflects a genuine difference or is influenced by reporting biases. Additional studies with larger and more diverse veteran cohorts, including female participants, are essential to clarify and expand upon these findings. This result also underscores the broader importance of contextual influences such as cultural norms, motivational issues, identity-related factors, and psychosocial context, in shaping how apathy is experienced and reported across populations. For instance, a review by Quang et al. (2024) concluded that apathy was associated with increased loneliness and lower self-efficacy, highlighting complex interactions between environmental and individual-level factors. These influences may contribute to variability in prevalence estimates and warrant greater attention in future research.

We found no evidence that the length of time since injury influenced apathy prevalence, suggesting that apathy may persist over time. This might indicate that apathy is a chronic symptom, possibly driven by neurobiological changes affecting brain regions involved in motivation and emotion. The lack of significant change over time may also reflect insufficient clinical focus on apathy post-TBI. Notably, a systematic review on interventions for post-TBI apathy identified only one randomized controlled trial addressing this symptom (Lane-Brown & Tate, 2009). This study examined cranial electrotherapy stimulation but lacked between-group analyses, preventing conclusions on effectiveness. This highlights both the potential persistence of apathy and the scarcity of evidence on effective treatments. However, there was substantial variability in the time since injury across included studies, with a range of 3–133.2 months, which may have limited our ability to detect consistent associations. Future research should use longitudinal designs with repeated assessments to clarify the trajectory of apathy over time and identify key windows for intervention.

Our analysis found that apathy prevalence remained consistent across study designs, settings, and continents, and was not influenced by the type of apathy measure used or whether it was validated. This suggests our pooled estimate may be robust across assessment approaches. However, there are some important issues to bear in mind. Validated apathy measures for use in TBI populations are limited, and even these appear to capture different characteristics of the construct (Lane-Brown & Tate, 2010). Additionally, the lack of a clear consensus on how apathy is defined complicates efforts to compare prevalence estimates across studies. Together, these limitations highlight important gaps in the literature and point to the need for greater conceptual and measurement clarity in future research.

The study has several methodological strengths. By pooling data from multiple studies and using meta-analytic techniques, we achieved high statistical power, which allowed for more precise and reliable estimates of apathy prevalence. The use of subgroup analyses and meta-regressions further enabled us to explore potential moderating factors, helping to address the considerable variability in reported apathy rates. Moreover, the inclusion of studies spanning different TBI severities strengthens the generalisability of our findings across a wide range of patient populations.

Despite these strengths, several limitations warrant consideration. While the review included studies from five continents, no studies from Africa and only one from Oceania were identified, narrowing the global applicability of the findings. We also only included studies published in English. Moreover, most studies failed to report the ethnicity of their samples, which limits the ability to explore whether apathy prevalence may differ across ethnic groups or cultural contexts. The findings are further constrained by the underrepresentation of certain groups, such as females and individuals with mild TBI, hindering the understanding of sex-specific differences and limiting the applicability to milder forms of TBI. Furthermore, the categorization of TBI severity was not consistently reported across studies, and variability in classification systems could have impacted the results.

In addition, our search strategy focused on peer-reviewed empirical studies and included three key databases. The extent to which including additional databases improves article identification for any particular topic is debated in the literature. Our review complies with recommendations to select databases based on their coverage of the topic (Dhippayom et al., 2023) and to include at least three databases in systematic reviews related to clinical neurology (Vassar et al., 2017). However, although we included backward citation searching we did not include forward citation searching which can improve article identification and grey literature was excluded, which may have missed prevalence estimates published in theses, pre-prints and other sources outside the peer-reviewed literature.

Lastly, while our meta-analysis identified several factors that are likely to explain some of the variability in prevalence estimates, it is notable that these estimates were still extremely wide (ranging from 4% to 87%). Comparing prevalence across studies is challenging, as apathy can be conceptualized as both a symptom and a syndrome, and different measures may capture distinct dimensions (e.g., emotional, behavioural, cognitive). Contextual influences such as cultural norms, rehabilitation engagement, incentives, and individual differences, may also shape how apathy is experienced and reported. Future research should investigate these factors to support a more biopsychosocial understanding of apathy. Additionally, apathy scores are typically accepted at face value, with no symptom validity measures included. Future research may benefit from incorporating independent assessments – such as clinician ratings or objective behavioural indicators – to strengthen the validity of apathy measurement.

Our findings highlight the high prevalence of apathy following TBI, yet treatment options remain limited. There is little research investigating how pharmacological or rehabilitative interventions might influence apathy in this population, which limits understanding of how best to support recovery. In dementia, acetylcholinesterase inhibitors have shown the strongest evidence for reducing apathy (Berman et al., 2012), while motivation-based behaviour therapy has demonstrated benefits in a single-case experimental study (Lane-Brown & Tate, 2010). Multi-sensory stimulation and music therapy have also shown promise in dementia populations (Holmes et al., 2006; Verkaik et al., 2005). Given the multifaceted nature of apathy, clinical research should prioritize developing and evaluating pharmacological, psychological, and rehabilitative interventions tailored to TBI-related apathy.

In conclusion, this meta-analysis is the first to systematically quantify the prevalence of apathy in individuals with TBI and identify the influence of moderating factors. Our findings demonstrate that apathy is prevalent following TBI, affecting over one-third of individuals in the reviewed studies. However, this pooled estimate should be interpreted with appropriate caution given the substantial heterogeneity between studies, the limited representation of individuals with mild TBI and females, and the absence of studies from non-Western contexts. The review identified several factors that may contribute to variability in prevalence: specifically, transport accidents were associated with higher apathy rates, while mild TBI, male sex, and veteran status were linked to lower prevalence. Further research is needed to clarify how apathy manifests across diverse populations and settings. These findings highlight the importance of recognizing apathy as a key aspect of TBI recovery and underscore the need for greater clinical attention to its assessment and management.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

References

Ahmed, S., Venigalla, H., Mekala, H. M., Dar, S., Hassan, M., & Ayub, S. (2017). Traumatic brain injury and neuropsychiatric complications. *Indian Journal of Psychological Medicine*, *39*(2), 114–121. https://doi.org/10.4103/0253-7176.203129

Al-Adawi, S., Dorvlo, A. S. S., Burke, D. T., Huynh, C. C., Jacob, L., Knight, R., Shah, M. K., & Al-Hussaini, A. (2004). Apathy and depression in cross-cultural survivors of traumatic brain injury. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *16*(4), 435–442. https://doi.org/10.1176/jnp.16.4.435

Arnould, A., Rochat, L., Azouvi, P., & Van der Linden, M. (2015). Apathetic symptom presentations in patients with severe traumatic brain injury: Assessment, heterogeneity and relationships with psychosocial functioning and caregivers' burden. *Brain Injury*, *29*(13–14), 1597–1603. https://doi.org/10.3109/02699052.2015.1075156

Azouvi, P., Arnould, A., Dromer, E., & Vallat-Azouvi, C. (2017). Neuropsychology of traumatic brain injury: An expert overview. *Revue Neurologique*, *173*(7), 461–472. https://doi.org/10.1016/j.neurol.2017.07.006

Balan, A. B., Walz, R., Diaz, A. P., & Schwarzbold, M. L. (2021). Return to work after severe traumatic brain injury: Further investigation of the role of personality changes. *Brazilian Journal of Psychiatry*, *43*(3), 340–341. https://doi.org/10.1590/1516-4446-2020-1660

Barsky, A. J., Peekna, H. M., & Borus, J. F. (2001). Somatic symptom reporting in women and men. *Journal of General Internal Medicine*, *16*(4), 266–275. https://doi.org/10.1046/j.1525-1497.2001.016004266.x

Berman, K., Brodaty, H., Withall, A., & Seeher, K. (2012). Pharmacologic treatment of apathy in dementia. *The American Journal of Geriatric Psychiatry*, *20*(2), 104–122. https://doi.org/10.1097/JGP.0b013e31822001a6

Bruns, J., Jr., & Hauser, W. A. (2003). The epidemiology of traumatic brain injury: A review. *Epilepsia*, *44*(s10), 2–10. https://doi.org/10.1046/j.1528-1157.44.s10.3.x

Bull, H., Ueland, T., Lystad, J. U., Evensen, S., Martinsen, E. W., & Falkum, E. (2016). Vocational functioning in schizophrenia spectrum disorders: Does apathy matter? *Journal of Nervous & Mental Disease*, *204*(8), 599–605. https://doi.org/10.1097/NMD.0000000000000504

Caeiro, L., Ferro, J. M., & Costa, J. (2013). Apathy secondary to stroke: A systematic review and meta-analysis. *Cerebrovascular Diseases*, *35*(1), 23–39. https://doi.org/10.1159/000346076

Cantagallo, A., & Dimarco, F. (2002). *Prevalence of neuropsychiatric disorders in traumatic brain injury patients – ProQuest*. https://www.proquest.com/openview/7e70dc4e0c64028c73f94f8a0572ac2b/1?pq-origsite=gscholar&cbl=39738

Cattelani, R., Roberti, R., & Lombardi, F. (2008). Adverse effects of apathy and neurobehavioral deficits on the community integration of traumatic brain injury subjects. *European Journal of Physical and Rehabilitation Medicine*, *44*(3), 245–251.

Cheema, H. A., Shahid, A., Ehsan, M., & Ayyan, M. (2022). The misuse of funnel plots in meta-analyses of proportions: Are they really useful? *Clinical Kidney Journal*, *15*(6), 1209–1210. https://doi.org/10.1093/ckj/sfac035

Ciurli, P., Formisano, R., Bivona, U., Cantagallo, A., & Angelelli, P. (2011). Neuropsychiatric disorders in persons with severe traumatic brain injury: Prevalence, phenomenology, and relationship with demographic, clinical, and functional features. *Journal of Head Trauma Rehabilitation*, *26*(2), 116–126. https://doi.org/10.1097/HTR.0b013e3181dedd0e

Clarke, D. E., Ko, J. Y., Kuhl, E. A., van Reekum, R., Salvador, R., & Marin, R. S. (2011). Are the available apathy measures reliable and valid? A review of the psychometric evidence. *Journal of Psychosomatic Research*, *70*(1), 73–97. https://doi.org/10.1016/j.jpsychores.2010.01.012

den Brok, M. G. H. E., van Dalen, J. W., van Gool, W. A., Moll van Charante, E. P., de Bie, R. M. A., & Richard, E. (2015). Apathy in Parkinson's disease: A systematic review and meta-analysis. *Movement Disorders*, *30*(6), 759–769. https://doi.org/10.1002/mds.26208

Devi, Y., Khan, S., Rana, P., Dhandapani, M., Ghai, S., Gopichandran, L., & Dhandapani, S. (2020). Cognitive, behavioral, and functional impairments among traumatic brain injury survivors: Impact on caregiver burden. *Journal of Neurosciences in Rural Practice*, *11*(4), 629–635. https://doi.org/10.1055/s-0040-1716777

Dhippayom, T., Rattanachaisit, N., Wateemongkollert, A., Napim, R., & Chaiyakunapruk, N. (2023). Should CINAHL be used as one of the main databases for evidence synthesis of health services intervention? *Cochrane Evidence Synthesis and Methods*, *1*(5), e12019. https://doi.org/10.1002/cesm.12019

Dunlop, T. W., Udvarhelyi, G. B., Stedem, A. F., O'Connor, J. M., Isaacs, M. L., Puig, J. G., & Mather, J. H. (1991). Comparison of patients with and without emotional/behavioral deterioration during the first year after traumatic brain injury. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *3*(2), 150–156. https://doi.org/10.1176/jnp.3.2.150

Farace, E., & Alves, W. M. (2000). Do women fare worse: A metaanalysis of gender differences in traumatic brain injury outcome. https://doi.org/10.3171/jns.2000.93.4.0539

Faul, M., Wald, M. M., Xu, L., & Coronado, V. G. (2010). *Traumatic brain injury in the United States: Emergency department visits, hospitalizations, and deaths, 2002–2006*. https://stacks.cdc.gov/view/cdc/5571

Finset, A., & Andersson, S. (2000). Coping strategies in patients with acquired brain injury: Relationships between coping, apathy, depression and lesion location. *Brain Injury*, *14*(10), 887–905. https://doi.org/10.1080/026990500445718

Funayama, M., Nakagawa, Y., Nakajima, A., Kawashima, H., Matsukawa, I., Takata, T., & Kurose, S. (2022). Apathy level, disinhibition, and psychiatric conditions are related to the employment status of people with traumatic brain injury. *The American Journal of Occupational Therapy*, *76*(2), 7602205060. https://doi.org/10.5014/ajot.2022.047456

Furuya-Kanamori, L., Barendregt, J. J., & Doi, S. A. R. (2018). A new improved graphical and quantitative method for detecting bias in meta-analysis. *International Journal of Evidence-Based Healthcare*, *16*(4), 195–203.

Green, S. L., Gignac, G. E., Watson, P. A., Brosnan, N., Becerra, R., Pestell, C., & Weinborn, M. (2022). Apathy and depression as predictors of activities of daily living following stroke and traumatic brain injuries in adults: A meta-analysis. *Neuropsychology Review*, *32*(1), 51–69. https://doi.org/10.1007/s11065-021-09501-8

Guan, B., Anderson, D. B., Chen, L., Feng, S., & Zhou, H. (2023). Global, regional and national burden of traumatic brain injury and spinal cord injury, 1990–2019: A systematic analysis for the global burden of disease study 2019. *BMJ Open*, *13*(10), e075049. https://doi.org/10.1136/bmjopen-2023-075049

Hoge, C. W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., & Koffman, R. L. (2004). Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *New England Journal of Medicine*, *351*(1), 13–22. https://doi.org/10.1056/NEJMoa040603

Holmes, C., Knights, A., Dean, C., Hodkinson, S., & Hopkins, V. (2006). Keep music live: Music and the alleviation of apathy in dementia subjects. *International Psychogeriatrics*, *18*(4), 623–630. https://doi.org/10.1017/S1041610206003887

Huang, M.-X., Huang, C. W., Harrington, D. L., Nichols, S., Robb-Swan, A., Angeles-Quinto, A., Le, L., Rimmele, C., Drake, A., Song, T., Huang, J. W., Clifford, R., Ji, Z., Cheng, C.-K., Lerman, I., Yurgil, K. A., Lee, R. R., & Baker, D. G. (2020). Marked increases in resting-state MEG gamma-band activity in combat-related mild traumatic brain injury. *Cerebral Cortex*, *30*(1), 283–295. https://doi.org/10.1093/cercor/bhz087

Hyder, A. A., Wunderlich, C. A., Puvanachandra, P., Gururaj, G., & Kobusingye, O. C. (2007). The impact of traumatic brain injuries: A global perspective. *NeuroRehabilitation*, *22*(5), 341–353. https://doi.org/10.3233/NRE-2007-22502

Kant, R., Duffy, J. D., & Pivovarnik, A. (1998). Prevalence of apathy following head injury. *Brain Injury*, *12*(1), 87–92. https://doi.org/10.1080/026990598122908

Kertesz, A., Nadkarni, N., Davidson, W., & Thomas, A. W. (2000). The frontal behavioral inventory in the differential diagnosis of frontotemporal dementia. *Journal of the International Neuropsychological Society*, *6*(4), 460–468. https://doi.org/10.1017/S1355617700644041

Kilmer, R. P., Demakis, G. J., Hammond, F. M., Grattan, K. E., Cook, J. R., & Kornev, A. A. (2006). Use of the neuropsychiatric inventory in traumatic brain injury: A pilot investigation. *Rehabilitation Psychology*, *51*(3), 232–238. https://doi.org/10.1037/0090-5550.51.3.232

Knutson, K. M., Dal Monte, O., Raymont, V., Wassermann, E. M., Krueger, F., & Grafman, J. (2014). Neural correlates of apathy revealed by lesion mapping in participants with traumatic brain injuries. *Human Brain Mapping*, *35*(3), 943–953. https://doi.org/10.1002/hbm.22225

Landes, A. M., Sperry, S. D., Strauss, M. E., & Geldmacher, D. S. (2001). Apathy in Alzheimer's disease. *Journal of the American Geriatrics Society*, *49*(12), 1700–1707. https://doi.org/10.1046/j.1532-5415.2001.49282.x

Lane-Brown, A., & Tate, R. (2009). *Interventions for apathy after traumatic brain injury – Lane-Brown, A – 2009 | Cochrane Library*. https://www.cochranelibrary.com/cdsr/doi/10.100214651858.CD006341.pub2/full

Lane-Brown, A., & Tate, R. (2010). Evaluation of an intervention for apathy after traumatic brain injury: A multiple-baseline, single-case experimental design. *The Journal of Head Trauma Rehabilitation*, *25*(6), 459–469. https://doi.org/10.1097/HTR.0b013e3181d98e1d

Lengenfelder, J., Arjunan, A., Chiaravalloti, N., Smith, A., & DeLuca, J. (2015). Assessing frontal behavioral syndromes and cognitive functions in traumatic brain injury. *Applied Neuropsychology: Adult*, *22*(1), 7–15. https://doi.org/10.1080/23279095.2013.816703

Levy, R., & Dubois, B. (2006). Apathy and the functional anatomy of the prefrontal cortex – Basal ganglia circuits. *Cerebral Cortex*, *16*(7), 916–928. https://doi.org/10.1093/cercor/bhj043

Marin, R. S. (1991). Apathy: A neuropsychiatric syndrome. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *3*(3), 243–254. https://doi.org/10.1176/jnp.3.3.243

Marin, R. S. (1996). Apathy: Concept, syndrome, neural mechanisms, and treatment. *Seminars in Clinical Neuropsychiatry*, *1*(4), 304–314. https://doi.org/10.1053/scnp00100304

Marsh, N. V., Kersel, D. A., Havill, J. H., & Sleigh, J. W. (1998). Caregiver burden at 1 year following severe traumatic brain injury. *Brain Injury*, *12*(12), 1045–1059. https://doi.org/10.1080/026990598121954

Mega, M. S., Cummings, J. L., Fiorello, T., & Gornbein, J. (1996). The spectrum of behavioral changes in Alzheimer's disease. *Neurology*, *46*(1), 130–135. https://doi.org/10.1212/WNL.46.1.130

Menon, D. K., Schwab, K., Wright, D. W., & Maas, A. I. (2010). Position statement: Definition of traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *91*(11), 1637–1640. https://doi.org/10.1016/j.apmr.2010.05.017

Mikolić, A., van Klaveren, D., Groeniger, J. O., Wiegers, E. J. A., Lingsma, H. F., Zeldovich, M., von Steinbüchel, N., Maas, A. I. R., Roeters van Lennep, J. E., Polinder, S., & the CENTER-TBI Participants and Investigators. (2021). Differences between men and women in treatment and outcome after traumatic brain injury. *Journal of Neurotrauma*, *38*(2), 235–251. https://doi.org/10.1089/neu.2020.7228

Mooney, G., Speed, J., & Sheppard, S. (2005). Factors related to recovery after mild traumatic brain injury. *Brain Injury*, *19*(12), 975–987. https://doi.org/10.1080/02699050500110264

Nguyen, M.-N., Pham, R., Nguyen, T.-V., Lam-Nguyen, N.-T., McDonald, S., & Quang, H. (2023). Neuropsychiatric symptoms after moderate-to-severe traumatic brain injury in Vietnam: Assessment, prevalence, and impact on caregivers. *Journal of the International Neuropsychological Society*, *29*(10), 984–993. https://doi.org/10.1017/S1355617723000644

Niemeier, J. P., Perrin, P. B., Holcomb, M. G., Rolston, C. D., Artman, L. K., Lu, J., & Nersessova, K. S. (2014). Gender differences in awareness and outcomes during acute traumatic brain injury recovery. *Journal of Women's Health*, *23*(7), 573–580. https://doi.org/10.1089/jwh.2013.4535

Nobis, L., & Husain, M. (2018). Apathy in Alzheimer's disease. *Current Opinion in Behavioral Sciences*, *22*, 7–13. https://doi.org/10.1016/j.cobeha.2017.12.007

Nygren DeBoussard, C., Lannsjö, M., Stenberg, M., Stålnacke, B.-M., & Godbolt, A. K. (2017). Behavioural problems in the first year after severe traumatic brain injury: A prospective multicentre study. *Clinical Rehabilitation*, *31*(4), 555–566. https://doi.org/10.1177/0269215516652184

Pąchalska, M., Kiejna, A., Frańczuk, B., Talar, J., Silverman, F. H., Grochmal-Bach, B., & MacQueen, B. D. (2001). Post-coma paraschizophrenia and quality of life in patients with closed-head injuries. *Ortopedia Traumatologia Rehabilitacja*, *3*(3), 401–411.

Parsonage, M. (2016). *Traumatic brain injury and offending: An economic analysis*. Centre for Mental Health. https://www.centreformentalhealth.org.uk/wp-content/uploads/2018/09/Traumatic_brain_injury_and_offending.pdf

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Kelly, A.-M., Nelms, R., Curran, C., & Ng, K. (2000). Factors influencing outcome following mild traumatic brain injury in adults. *Journal of the International Neuropsychological Society*, *6*(5), 568–579. https://doi.org/10.1017/S1355617700655066

Quang, H., Le Heron, C., Balleine, B., Nguyen, T.-V., Nguyen, T.-Q., Nguyen, M.-N., Kumfor, F., & McDonald, S. (2023). Reduced sensitivity to background reward underlies apathy after traumatic brain injury: Insights from an ecological foraging framework. *Neuroscience*, *528*, 26–36. https://doi.org/10.1016/j.neuroscience.2023.07.026

Quang, H., Wearne, T., Filipcikova, M., Pham, N., Nguyen, N., & McDonald, S. (2024). A biopsychosocial framework for apathy following moderate to severe traumatic brain injury: A systematic review and meta-analysis. *Neuropsychology Review*, *34*(4), 1213–1234. https://doi.org/10.1007/s11065-023-09620-4

Radakovic, R., Gray, D., Dudley, K., Mioshi, E., Dick, D., Melchiorre, G., Gordon, H., Newton, J., Colville, S., Pal, S., Chandran, S., & Abrahams, S. (2020). Reliability and validity of the brief dimensional apathy scale. *Archives of Clinical Neuropsychology*, *35*(5), 539–544. https://doi.org/10.1093/arclin/acaa002

Radakovic, R., McGrory, S., Chandran, S., Swingler, R., Pal, S., Stephenson, L., Colville, S., Newton, J., Starr, J. M., & Abrahams, S. (2020). The brief dimensional apathy scale: A short clinical assessment of apathy. *The Clinical Neuropsychologist*, *34*(2), 423–435. https://doi.org/10.1080/13854046.2019.1621382

Rahman, F. N., Das, S., Kader, M., & Mashreky, S. R. (2025). Epidemiology, outcomes, and risk factors of traumatic brain injury in Bangladesh: A prospective cohort study with a focus on road traffic injury-related vulnerability. *Frontiers in Public Health*, *13*, 1514011. https://doi.org/10.3389/fpubh.2025.1514011

Resnick, B., Zimmerman, S. I., Magaziner, J., & Adelman, A. (1998). Use of the apathy evaluation scale as a measure of motivation in elderly people. *Rehabilitation Nursing*, *23*(3), 141–147. https://doi.org/10.1002/j.2048-7940.1998.tb01766.x

Robert, P., Lanctôt, K. L., Agüera-Ortiz, L., Aalten, P., Bremond, F., Defrancesco, M., Hanon, C., David, R., Dubois, B., Dujardin, K., Husain, M., König, A., Levy, R., Mantua, V., Meulien, D., Miller, D., Moebius, H. J., Rasmussen, J., Robert, G., … Manera, V. (2018). Is it time to revise the diagnostic criteria for apathy in brain disorders? The 2018 international consensus group. *European Psychiatry*, *54*, 71–76. https://doi.org/10.1016/j.eurpsy.2018.07.008

Rubiano, A. M., Carney, N., Chesnut, R., & Puyana, J. C. (2015). Global neurotrauma research challenges and opportunities. *Nature*, *527*(7578), S193–S197. https://doi.org/10.1038/nature16035

Starkey, N. J., Duffy, B., Jones, K., Theadom, A., Barker-Collo, S., Feigin, V., & BIONIC8 Research Group. (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

Tierney, S. M., Woods, S. P., Weinborn, M., & Bucks, R. S. (2018). Real-world implications of apathy among older adults: Independent associations with activities of daily living and quality of life. *Journal of Clinical and Experimental Neuropsychology*, *40*, 895–903. https://www.tandfonline.com/doi/abs/10.108013803395.2018.1444736

Ubukata, S., Ueda, K., Fujimoto, G., Ueno, S., Murai, T., & Oishi, N. (2022). Extracting apathy from depression syndrome in traumatic brain injury by using a clustering method. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *34*(2), 158–167. https://doi.org/10.1176/appi.neuropsych.21020046

van der Horn, H. J., Out, M. L., de Koning, M. E., Mayer, A. R., Spikman, J. M., Sommer, I. E., & van der Naalt, J. (2020). An integrated perspective linking physiological and psychological consequences of mild traumatic brain injury. *Journal of Neurology*, *267*(9), 2497–2506. https://doi.org/10.1007/s00415-019-09335-8

van Zomeren, A. H., & van den Burg, W. (1985). Residual complaints of patients two years after severe head injury. *Journal of Neurology, Neurosurgery & Psychiatry*, *48*(1), 21–28. https://doi.org/10.1136/jnnp.48.1.21

Vassar, M., Yerokhin, V., Sinnett, P. M., Weiher, M., Muckelrath, H., Carr, B., Varney, L., & Cook, G. (2017). Database selection in systematic reviews: An insight through clinical neurology. *Health Information & Libraries Journal*, *34*(2), 156–164. https://doi.org/10.1111/hir.12176

Venkatesan, U. M., & Rabinowitz, A. R. (2024). Apathy and depression among people aging with traumatic brain injury: Relationships to cognitive performance and psychosocial functioning. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *36*(4), 306–315. https://doi.org/10.1176/appi.neuropsych.20230082

Verkaik, R., van Weert, J. C. M., & Francke, A. L. (2005). The effects of psychosocial methods on depressed, aggressive and apathetic behaviors of people with dementia: A systematic review. *International Journal of Geriatric Psychiatry*, *20*(4), 301–314. https://doi.org/10.1002/gps.1279

Vogt, D., Fox, A. B., & Di Leone, B. A. L. (2014). Mental health beliefs and their relationship with treatment seeking among U.S. OEF/OIF veterans. *Journal of Traumatic Stress*, *27*(3), 307–313. https://doi.org/10.1002/jts.21919

Wiart, L., Richer, E., Destaillats, J.-M., Joseph, P.-A., Dehail, P., & Mazaux, J.-M. (2012). Psychotherapeutic follow up of out patients with traumatic brain injury: Preliminary results of an individual neurosystemic approach. *Annals of Physical and Rehabilitation Medicine*, *55*(6), 375–387. https://doi.org/10.1016/j.rehab.2012.04.002

Worthington, A., & Wood, R. L. (2018). Apathy following traumatic brain injury: A review. *Neuropsychologia*, *118*, 40–47. https://doi.org/10.1016/j.neuropsychologia.2018.04.012

Zhang, H., Feng, Y., Lv, H., Tang, S., & Peng, Y. (2023). The prevalence of apathy in stroke patients: A systematic review and meta-analysis. *Journal of Psychosomatic Research*, *173*, 111478. https://doi.org/10.1016/j.jpsychores.2023.111478

Zhao, Q.-F., Tan, L., Wang, H.-F., Jiang, T., Tan, M.-S., Tan, L., Xu, W., Li, J.-Q., Wang, J., Lai, T.-J., & Yu, J.-T. (2016). The prevalence of neuropsychiatric symptoms in Alzheimer's disease: Systematic review and meta-analysis. *Journal of Affective Disorders*, *190*, 264–271. https://doi.org/10.1016/j.jad.2015.09.069