

Economic and Financial Burden of Traumatic Brain Injury Care in Low- and Middle-Income Countries: A Scoping Review

Abdikani Ali Hassan

abdikanih33@gmail.com

Kampala International University <https://orcid.org/0009-0006-9272-9529>

Mohamed Abdi dirie

Kampala International University

Yusuf Mohamed heyle

Kampala International University

Mohamed aweis Salah

Kampala International University

Mohamed Saleban Jama

Kampala International University

Abdullahi Ahmed Ali1

Kampala International University

Ahmed Kiswezi

Kampala International University

Systematic Review

Keywords: traumatic brain injury, economic burden, out-of-pocket expenditure, catastrophic health expenditure, low- and middle-income countries, scoping review

Posted Date: October 14th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11352394/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: The authors declare no competing interests.

Abstract

Background

Traumatic brain injury (TBI) places a heavy financial strain on health systems, patients, families, and caregivers, but evidence from low- and middle-income countries (LMICs) remains fragmented. This scoping review mapped the economic and financial burden of TBI across LMICs and identified the main gaps in the evidence.

Methods

We conducted a systematic scoping review reported according to PRISMA-ScR. The protocol was registered on the Open Science Framework on 12 September 2026 (<https://doi.org/10.17605/OSF.IO/4DQC9>). We searched MEDLINE/PubMed, Embase, Scopus, and Google Scholar between July and September 2026, supplemented by citation searching. We included empirical studies from World Bank FY2027 low-, lower-middle-, and upper-middle-income economies reporting direct medical or non-medical costs, out-of-pocket expenditure, catastrophic health expenditure, distress financing, productivity losses, caregiver burden, rehabilitation costs, provider or health-system expenditure, societal costs, or affordability barriers. Monetary estimates were kept in original currencies, with author-reported US dollar equivalents where available.

Results

Twenty studies from 14 LMICs, published between 2008 and 2026, met the inclusion criteria. Hospital or direct costs were reported in 17 studies, indirect or caregiver burden in 7, household financial burden in 5, rehabilitation or post-acute costs in 3, health-system or societal burden in 2, and affordability or access in 1. Greater TBI severity, intensive care, surgery, neuroimaging, complications, and longer hospitalization were generally linked to higher costs. Household studies documented out-of-pocket spending, catastrophic expenditure, income loss, and distress financing. In Tanzania, 15 of 67 patients could not pay for care, and affordability shaped treatment intensity. Evidence on long-term rehabilitation, caregiver productivity loss, and societal costs was limited.

Conclusions

TBI in LMICs drives substantial provider and household costs, including catastrophic expenditure, income loss, and affordability-related barriers to care. More standardized economic studies are needed to inform trauma-system financing, financial protection, and resource allocation.

Background

Traumatic brain injury (TBI) is a leading global cause of death and disability, and its management often demands intensive emergency, neurosurgical, critical-care, and rehabilitation services. Global Burden of Disease estimates for 2019 identified roughly 27.16 million new TBI cases and 48.99 million prevalent cases, accounting for about 7.08 million years lived with disability worldwide ¹. These consequences weigh most heavily on LMICs, where limited health-system resources and household financial vulnerability can intensify the burden of injury ^{2,3}.

The economic consequences of TBI stretch far beyond the initial hospital bill. Costs can include emergency assessment, imaging, surgery, intensive care, hospitalization, medications, rehabilitation, transport, accommodation, and other non-medical expenses. Patients and households may also face lost earnings, caregiver time costs, borrowing, asset sales, and catastrophic health expenditure. At the health-system and societal levels, TBI can drive substantial public expenditure, funding gaps, disability-related productivity losses, and losses from premature mortality. Earlier reviews of injury economics in LMICs have shown that economic evidence is sparse and methodologically heterogeneous ², while analyses of neurosurgical disease more broadly have demonstrated substantial economic consequences in LMIC settings³.

Existing TBI cost reviews leave important gaps for our question. Humphreys et al. synthesized TBI costs in a literature review that was dominated by high-income settings⁴. Van Dijk et al. systematically reviewed acute in-hospital costs after severe TBI and reported

marked variation driven by clinical and methodological heterogeneity⁵. More recently, Crozes et al. mapped healthcare costs in relation to socioeconomic position after TBI, but that review was not designed to comprehensively capture LMIC-specific household, caregiver, provider, health-system, and societal financial burden⁶.

A focused synthesis is therefore needed to show where economic burden arises in LMIC TBI care, how it is distributed across patients, households, caregivers, providers, health systems, and society, and where major evidence gaps remain.

This scoping review maps the available evidence on the economic and financial burden of TBI care in LMICs, with particular attention to direct and indirect costs, financial hardship, affordability-related barriers, rehabilitation expenditure, provider and health-system costs, and implications for resource allocation and financial protection.

Methods.

Study design and protocol registration.

This scoping review followed Joanna Briggs Institute (JBI) methodology for scoping reviews⁷ and was reported in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR)⁸, and the study-selection process is summarized in the PRISMA-ScR flow diagram (Fig. 1). A scoping design was chosen because the aim is to map the breadth, characteristics, methods, and gaps in the heterogeneous evidence on the economic and financial burden of traumatic brain injury rather than estimate a pooled monetary effect.

Protocol development began on 8 July 2026. During this phase, we carried out preliminary feasibility searching, refinement of search terms, source verification, and pilot data charting. The protocol was registered on the Open Science Framework (OSF) on 12 September 2026 (DOI: 10.17605/OSF.IO/4DQC9) before the final reproducible review procedures. Any amendments or deviations from the registered protocol will be reported transparently

Eligibility.

The review question was structured using the Population–Concept–Context framework: What is known about the economic and financial burden of traumatic brain injury on patients, households, caregivers, healthcare systems, and society in low- and middle-income countries?

Population

Studies involving people of any age with TBI were eligible, regardless of injury mechanism or severity. Studies of caregivers or households were eligible when the economic outcome was explicitly attributable to a person with TBI. Studies enrolling broader trauma populations were retained only when TBI or head-injury economic data could be extracted separately.

Concept

Eligible outcomes included direct medical and direct non-medical costs, OOOPE, CHE, distress financing, debt or asset sales, patient income loss, productivity loss, caregiver expenditure or income loss, rehabilitation and post-discharge costs, provider or hospital costs, health-system expenditure or funding gaps, societal economic loss, and affordability-related barriers to receiving care. Studies using quantitative financial-burden scales were eligible even when the outcome was not expressed in monetary units. Pure cost-effectiveness, cost-utility, or cost-benefit analyses were excluded when they did not provide separately extractable empirical TBI burden or resource-cost data.

Context

Eligible studies had to be conducted in economies classified as low, lower-middle, or upper-middle income according to the World Bank FY2027 classification⁹. Multicountry studies were eligible only when data from LMIC settings could be extracted separately.

Evidence sources

Primary empirical studies using observational, costing, administrative, cost-of-illness, household, caregiver, or mixed-method designs were eligible. Reviews, editorials, protocols, case reports, and reports without extractable primary economic or financial outcomes

were excluded.

Information sources and search strategy.

The search strategy was built around three concepts: traumatic brain injury (TBI), economic or financial burden, and low- and middle-income country (LMIC) setting. We searched MEDLINE/PubMed, Embase, Scopus, Web of Science Core Collection, CINAHL, Global Health, EconLit, WHO Global Index Medicus/African Index Medicus, and African Journals Online, supplemented by Google Scholar and backward and forward citation searching. Search terms combined controlled vocabulary and free-text terms for TBI, economic and financial burden, and individual World Bank FY2027 LMIC country names and aliases. The final reproducible database searches were run after protocol registration, with the exact search date for each database documented in Supplementary Table S1. Database-specific search strategies and retrieval counts are also provided in Supplementary Table S1.

Study selection.

Records were screened against the predefined eligibility criteria in two stages: title and abstract screening, followed by full-text assessment. Two reviewers independently assessed records at each stage. Records with insufficient information during title and abstract screening were retained for full-text review. Reasons for full-text exclusion were documented according to the predefined eligibility criteria.

Data charting and economic outcome handling.

We developed a standardized charting form and refined it iteratively. Extracted variables included author and year, country and World Bank income group, study design and setting, sample size, TBI population and severity, follow-up period, economic perspective, costing method, currency and price year, direct medical and direct non-medical costs, OOPe, CHE, distress financing, productivity losses, caregiver burden, rehabilitation costs, provider and hospital costs, health-system funding gaps, societal costs, affordability barriers, and principal cost drivers.

Monetary estimates were kept in original currencies, with author-reported US dollar equivalents where available. No additional conversion or inflation adjustment was performed because price years, costing perspectives, and valuation methods varied widely. Where sources contained inconsistent conversions, we retained the original local-currency estimate and used converted values only when internally consistent, noting the discrepancy explicitly.

Verification: Key numerical estimates and denominators were cross-checked against the cited primary publications. No unreported values were imputed. Where publications contained internal inconsistencies, we used explicit numerator/denominator data and reported the discrepancy in the relevant table note

Critical appraisal.

Two reviewers independently assessed the methodological quality of the included studies using design-appropriate Joanna Briggs Institute (JBI) critical appraisal tools. Analytical cross-sectional studies and cohort studies were evaluated using their corresponding JBI instruments. Any disagreements between the two reviewers were resolved through discussion and consensus. The appraisal was done to contextualize the strengths and limitations of the evidence rather than to determine study eligibility; no study was excluded solely on the basis of methodological quality, and no arbitrary numerical quality threshold was applied. Final consensus appraisal findings are reported in the Results and detailed in Supplementary Table S3.

Synthesis.

Given the substantial heterogeneity in study populations, economic perspectives, costing methods, currencies, price years, healthcare systems, and follow-up durations, a meta-analysis of monetary estimates was not considered appropriate. Findings were therefore summarized descriptively and mapped into six overarching domains: (1) hospital/direct costs; (2) household financial burden; (3) indirect/caregiver burden; (4) rehabilitation/post-acute costs; (5) health-system/societal burden; and (6) affordability/access. A single study could contribute to more than one domain.

Results

Study selection.

The search identified 889 records in total: 835 from bibliographic databases and 54 from other sources. After removing 450 duplicates, 439 records were screened, of which 402 were excluded. Thirty-seven full-text sources were assessed for eligibility; 17 were excluded because of wrong population or context, or non-separable TBI-specific data (n = 8), no extractable economic or financial outcome (n = 5), or ineligible publication type or design (n = 4). Twenty sources of evidence were included in the review (Fig. 1).

Study characteristics.

The 20 included studies were published between 2008 and 2026 and covered Ethiopia, Pakistan, Vietnam, China, Iran, Benin, Tanzania, South Africa, Brazil, Mexico, India, Togo, Malaysia, and Papua New Guinea. Six countries contributed two studies each (China, India, Iran, Pakistan, Papua New Guinea, and South Africa), while the remaining eight contributed one study each. Study designs varied and included cross-sectional cost studies, prospective observational and cost-of-illness studies, household follow-up studies, administrative database analyses, rehabilitation-cost studies, and caregiver-burden studies. Sample sizes ranged from 18 participants in a preliminary Indian cohort to more than 1.5 million TBI-related admissions in a Brazilian national administrative dataset. Characteristics are shown in Table 1.

Economic perspectives differed across studies. Patient or household expenditure, hospital or provider cost, health-system expenditure, caregiver burden, and societal productivity loss were all represented. Acute hospital care was the phase most often examined, whereas long-term rehabilitation and post-discharge economic burden were rarely studied.

Table 1
Characteristics of included studies.

Study	Country (income group)	Study design / setting	N	TBI population	Economic perspective	Follow-up
Asmamaw et al., 2019 ¹⁰	Ethiopia (Low income)	Institution-based cross-sectional cost study; University of Gondar Specialized Referral Hospital ED	387	Mixed	Patient/household	Index ED/hospital episode
Bhatti et al., 2015 ¹¹	Pakistan (Lower-middle income)	Multicenter ED surveillance study; seven teaching-hospital emergency departments	1,787; cost data n = 803	Mixed	Patient/household	ED episode
Hoang et al., 2008 ¹²	Vietnam (Upper-middle income)	Retrospective cross-sectional cost study; Hanoi	35 patients/families	Mild/moderate/severe	Patient/household	1 year post-injury
Yuan et al., 2012 ¹³	China (Upper-middle income)	Prospective multicentre observational cost study; 80 hospitals	13,007	Mixed	Provider/hospital	Acute hospitalization
Kavosi et al., 2015 ¹⁴	Iran (Upper-middle income)	Retrospective cross-sectional cost-of-illness study; Shiraz	279 fatal TBI cases	Fatal TBI	Societal	Fatal hospitalization; 2009–2013
Gheysvandi et al., 2023 ¹⁵	Iran (Upper-middle income)	Prospective 1-year household follow-up; Poursina Hospital	220 households	Mixed	Patient/household	1 year
Hode et al., 2017 ¹⁶	Benin (Lower-middle income)	Prospective direct-cost study; national teaching hospital, Cotonou	297	Mild/moderate/severe	Patient/household	Initial treatment phase
Schenck et al., 2023 ¹⁷	Tanzania (Lower-middle income)	Exploratory observational affordability study; tertiary referral hospital	67	Severe	Patient/household	Acute admission
Kong et al., 2017 ¹⁸	South Africa (Upper-middle income)	Registry-based TBI costing/funding-gap study	3,301	Mixed	Health system	Acute admission
Phaleng & Hardcastle, 2025 ¹⁹	South Africa (Upper-middle income)	Retrospective micro-costing study; Pietersburg Hospital	83	Major TBI; ISS > 16	Provider/hospital	Admission

Table 1
Characteristics of included studies (continued).

Study	Country (income group)	Study design / setting	N	TBI population	Economic perspective	Follow-up
Carteri & da Silva, 2021 ²⁰	Brazil (Upper-middle income)	National administrative database; Brazilian Unified Health System	1,572,178 admissions	Mixed	Health system	2008–2019 hospitalizations
Barragán-Hervella et al., 2016 ²¹	Mexico (Upper-middle income)	Cross-sectional direct-cost study; tertiary care	219	Mild TBI	Provider/hospital	Acute encounter
Arora et al., 2026 ²²	India (Lower-middle income)	Prospective two-centre cohort	18	Mixed isolated TBI	Patient/household	3 months post-discharge
Doleagbenou et al., 2026 ²³	Togo (Lower-middle income)	Cross-sectional economic-burden study; CHU Sylvanus Olympio	219	Mixed	Patient/household	Admission
Yu et al., 2025 ²⁴	China (Upper-middle income)	Retrospective rehabilitation-cost study	44 TBI (total cohort n = 210)	TBI with disorders of consciousness	Provider/hospital	Long-term rehabilitation
You et al., 2018 ²⁵	Malaysia (Upper-middle income)	Costing study; surgically managed isolated TBI	49	Mild/moderate/severe	Provider/health system	1 year
Hussain et al., 2019 ²⁶	Pakistan (Lower-middle income)	Public-sector hospital TBI costing study	70	53 moderate; 17 severe	Provider/hospital	6-month costing period
Umo et al., 2022 ²⁷	Papua New Guinea (Lower-middle income)	Prospective trauma cost-of-illness study with head-injury subgroup	13 head-injury cases; cost data n = 12	7 mild; 2 moderate; 4 severe	Patient/hospital	Index admission
Paka et al., 2025 ²⁸	Papua New Guinea (Lower-middle income)	Prospective TBI cost-of-illness study; Port Moresby General Hospital	77	52 mild; 16 moderate; 9 severe	Patient/hospital	Index admission
Kanmani et al., 2019 ²⁹	India (Lower-middle income)	Descriptive cross-sectional caregiver study; emergency ICU	60 caregivers	Caregivers of TBI patients	Caregiver	During ICU stay

Table note: TBI, traumatic brain injury; ED, emergency department; ICU, intensive care unit; ISS, Injury Severity Score. Income groups use World Bank FY2027 classification.

Distribution of economic-burden domains.

Hospital or direct costs were the most frequently reported domain, appearing in 17 studies. Indirect or caregiver burden followed in seven studies, household financial burden in five, rehabilitation or post-acute costs in three, health-system or societal burden in two, and affordability or access in just one study (Fig. 2). Because many studies addressed more than one component of economic burden, these categories were not mutually exclusive.

Hospital and direct costs.

Direct treatment and provider costs were the outcomes studied most often^{10,12,16,18,28}. Where these were examined, greater TBI severity and more intensive resource use were generally linked to higher expenditure. In Benin, mean direct treatment cost was EUR285.67 per patient, rising from EUR188.19 for mild TBI to EUR522.08 for severe TBI¹⁶. In Malaysia, mean first-year treatment cost among surgically managed isolated TBI cases was RM30,039.18 (US\$7,365.61), with severe TBI averaging RM36,917.86²⁵. A large multicenter Chinese study reported a median acute hospitalization cost of US\$879 and a median daily cost of US\$79; lower Glasgow Coma Scale scores, longer length of stay, ICU care, surgery, polytrauma, and tertiary-level care were all associated with higher costs¹³.

In Mexico, Barragán-Hervella et al. found that the direct cost of managing 219 adults with mild TBI totaled MXN1,032,293.72, with an average expenditure of MXN4,713.66 per patient²¹. In Pakistan, Hussain et al. reported substantial daily hospital expenditure, including PKR42,333 for hospital bills, PKR179,923 for ICU setup, and PKR2,573 for staff salaries; the study reported an overall daily cost of US\$1,409.02²⁶.

Provider-level burden was substantial in South Africa. Kong et al. estimated approximately ZAR62 million in total TBI management costs and modelled ICU funding gaps of ZAR11.24–20.00 million¹⁸. Phaleng and Hardcastle reported average admission costs of R572,925 for ICU-managed major TBI compared with R244,503 forward-managed patients¹⁹. In Brazil, average annual public-hospital expenditure reached approximately US\$43.24 million, with mean expenditure of US\$327.68 per admission²⁰. Two studies from Papua New Guinea also pointed to high direct medical costs. In the head-injury subgroup reported by Umo et al., the cost table included 12 cases with a total direct medical cost of K531,695 and a mean of K44,307.92 (US\$12,849.29) per case²⁷. In a dedicated TBI cost-of-illness study at Port Moresby Gener

al Hospital, mean direct medical cost was K81,127 (US\$20,281.75) per patient, and severe TBI generated the highest mean expenditure²⁸.

Household financial burden and affordability.

Household financial burden was evident across multiple settings. In Pakistan, mean emergency OOOPE was US\$8.39 among patients with available expenditure data; spending rose with admission, ambulance transport, and computed tomography¹¹. In Iran, a one-year household follow-up study found mean monthly direct costs of US\$11.86, indirect costs of US\$87.00, and income loss of US\$73.59, while 45.5% of households faced catastrophic costs¹⁵. In India, mean OOOPE was INR88,485, CHE occurred in 15 of 18 participants (83.3%) at the study's 10% threshold, and 11 of 18 (61.1%) used distress financing²². Affordability also shaped access to care. In the Tanzanian severe-TBI study, 44 of 67 patients (65.7%) could pay upfront, 15 (22.3%) could not, and payment status was undocumented for 8 (11.9%); ability to pay was tied to treatment intensity and access to computed tomography¹⁷.

These findings suggest that financial vulnerability may shape the care pathway itself, not only the consequences of treatment. Non-medical and income-related costs were also prominent. In Ethiopia, mean total cost of traumatic head injury was ETB4,673.43 per patient; direct non-medical costs accounted for ETB1,896.19 (40.57%), direct medical costs ETB1,101.66 (23.58%), and indirect costs ETB1,675.58¹⁰. In Togo, the median total cost was US\$512 (IQR 380–890) and the mean was US\$648 ± 478, roughly 7.1 times the national monthly minimum wage²³.

Indirect, caregiver, and productivity burden.

Indirect costs included patient income loss, caregiver income loss, time away from work, and productivity losses tied to disability or premature mortality. The Vietnamese study showed that both direct and time-loss burden rose with increasing TBI severity over one year¹². The Iranian household cohort found indirect expenditure to exceed direct monthly expenditure¹⁵, while the Ethiopian study documented income losses for both patients and attendants¹⁰. A caregiver-focused Indian study reported a mean financial-burden score of 6.28 ± 2.36 among 60 caregivers of patients with TBI in intensive care²⁹. At the societal level, the most striking productivity estimate came from Iran, where fatal traffic-related TBI generated productivity losses of roughly 506.77 billion IRR (about US\$20 million), far exceeding direct hospital expenditure¹⁴.

This pattern shows how analyses limited to hospital charges can substantially underestimate the wider economic consequences of TBI.

Rehabilitation and post-acute burden

Just three studies looked closely at rehabilitation or post-acute economic burden^{12,22,24}.

The Vietnamese study tracked patients and families for a full year, capturing treatment, rehabilitation, and time-loss costs along the way¹². The Indian OOE cohort followed participants for three months after discharge and recorded their rehabilitation spending²². In China, the TBI subgroup of a rehabilitation cohort faced a median hospitalization cost of US\$57,366.05 and a median stay of 363.5 days a striking illustration of just how resource-intensive prolonged rehabilitation can be for patients with disorders of consciousness²⁴.

Health-system and societal burden.

Explicit health-system or societal burden was quantified less often. Kong et al. showed a substantial critical-care funding gap within a South African trauma system¹⁸. In Iran, fatal traffic-related TBI generated roughly 6.2–6.273 billion IRR in total hospital costs and a mean direct medical cost of about 22 million IRR (around US\$888) per death, while productivity losses reached approximately 506.77 billion IRR¹⁴. Because the source reports inconsistent US-dollar conversions for the total hospital-cost estimate, this review keeps the original IRR total and the internally consistent per-death estimate instead of choosing between conflicting converted totals.

Methodological appraisal.

The appraisal flagged several recurring limitations: small samples, single-centre designs, retrospective or self-reported expenditure, incomplete reporting of costing validity, and limited adjustment for confounding. Studies that used prospective multicentre datasets, standardized hospital costing, or longitudinal household follow-up generally raised fewer concerns. Consensus appraisal classified 13 studies as having low methodological concerns and 7 as having some concerns; none were rated as high concern. Appraisal was not used as an exclusion criterion. Detailed item-level results appear in Supplementary Table S3.

Evidence gaps.

Several gaps stood out. First, only 14 LMICs were represented, and many studies came from single tertiary hospitals, leaving large numbers of countries, rural populations, district facilities, and patients who never reach specialist care underrepresented. Second, the literature leaned heavily toward acute direct costs; CHE, distress financing, caregiver productivity loss, long-term rehabilitation expenditure, and societal burden were examined far less often. Third, costing perspectives, price years, cost categories, and resource-valuation methods were reported inconsistently, which limited direct cross-country comparison.

Finally, few studies connected economic outcomes with long-term neurological recovery, functional disability, employment, or quality of life.

Discussion

Principal findings.

This scoping review maps a heterogeneous but clinically and policy-relevant body of evidence on the economic consequences of TBI in LMICs. Most of the literature focuses on acute hospital and direct treatment costs. Across several settings, greater injury severity, intensive care, surgery, neuroimaging, complications, and prolonged hospitalization went hand in hand with higher expenditure. Yet the burden reached beyond healthcare providers: household OOE, catastrophic costs, distress financing, patient and caregiver income losses, and affordability-related restrictions on access all appeared in multiple settings, while rehabilitation and societal consequences received far less attention.

Three broad pathways of economic burden emerge from the evidence.

The first is direct consumption of healthcare and related non-medical resources.

The second is financial shock to patients and households, including OOE, catastrophic expenditure, and distress financing.

The third is indirect loss through caregiving, disability, work absence, and premature mortality.

These pathways can coexist within the same episode of TBI and may compound one another, especially where financial protection is limited.

Comparison with previous reviews.

Our findings echo prior global TBI cost reviews, which reported substantial expenditure alongside pronounced methodological heterogeneity^{5,30}. Van Dijck et al. found wide variation in severe-TBI in-hospital costs and pinpointed length of stay, surgery, and injury severity as key drivers, while poor reporting of cost-data sources and calculation methods hampered comparability⁵. The LMIC evidence mapped here shows the same methodological challenges but also brings to the fore the importance of patient ability to pay, non-medical expenditure, caregiver time, and catastrophic household costs. This review also complements the 2024 scoping review by Crozes et al., which examined TBI costs in relation to socioeconomic characteristics⁶.

Our review takes a distinctly LMIC-specific, multilevel approach, organizing the evidence across patient/household, caregiver, provider, health-system, rehabilitation, access, and societal perspectives. That distinction matters because several included studies documented OOPe, catastrophic expenditure, distress financing, or affordability-related constraints on care outcomes that sit at the heart of financial protection in LMIC health systems.

More broadly, our findings align with the review by Wesson et al., which identified limited and heterogeneous economic evidence for injury and trauma care in LMICs², and with analyses showing substantial economic consequences of neurosurgical disease in resource-constrained settings³.

Financial protection, equity, and access.

One finding stands out: affordability may reshape the treatment pathway itself. In Tanzania, inability to pay was linked to reduced access to computed tomography and lower therapeutic intensity¹⁷. This creates a dual burden household that seek care may face financial hardship, while those without sufficient resources may receive less complete diagnostic or therapeutic care. TBI economics therefore belongs within the broader agenda of universal health coverage, where financial protection is meant to reduce both catastrophic spending and clinically important forgone care. The Iranian and Indian household studies reinforce this concern. Catastrophic costs affected 45.5% of Iranian households¹⁵, while CHE and distress financing were common in the preliminary Indian cohort²².

Transport and other non-medical costs also loomed large in Ethiopia and Togo^{10,23}. Policies that subsidize hospital charges alone may therefore leave families exposed to substantial transport, food, rehabilitation, wage-loss, and caregiving costs.

Implications for trauma systems and financing.

Provider-level evidence makes clear that the financing problem is not confined to households. South African analyses documented substantial institutional costs, and Kong et al. quantified explicit ICU funding gaps^{18,19}. Brazilian national data showed substantial recurrent public-hospital expenditure²⁰.

These findings speak directly to trauma-system planning, since constrained health systems must weigh investments in emergency assessment, imaging, neurosurgical capacity, critical care, rehabilitation, and financial protection against one another.

The link between greater severity, intensive resource use, complications, and higher costs also points to prevention, timely effective care, and complication reduction as priorities for future economic evaluation. The available evidence does not establish the cost-effectiveness of specific TBI interventions, but it does identify the cost drivers and financial-risk domains that should be built into future cost-effectiveness, budget-impact, and resource-allocation analyses.

Implications for future research.

Future LMIC TBI economic research needs more standardized methods. Studies should report the costing perspective, resource categories, unit-cost sources, currency, price year, time horizon, handling of informal care and productivity loss, and conversion methods. Household studies should define OOPe, CHE, and distress financing clearly and separate direct medical, direct non-medical, and indirect costs. Longitudinal designs are especially needed. Few included studies captured rehabilitation or post-discharge expenditure despite TBI's long-term disability. Future cohorts should link economic outcomes to functional recovery, employment,

quality of life, and caregiver participation. Multicenter and population-based studies are also needed to reduce reliance on single tertiary hospitals and capture rural populations and patients who never reach specialist care. Societal perspectives remain underdeveloped. The Iranian fatal-TBI study shows productivity loss can dwarf direct medical expenditure¹⁴. Future work should quantify premature-mortality losses, long-term disability, informal caregiving, and macroeconomic consequences alongside provider costs to allow more complete comparison of investments in prevention, acute care, rehabilitation, and financial protection.

Strengths and limitations.

This review has several strengths. It focuses specifically on LMICs, uses a broad multilevel definition of economic burden, and includes household and caregiver outcomes alongside provider and societal costs. Original monetary values were preserved rather than standardized across countries without a clear basis. Key estimates and denominators were verified against primary publications, and source inconsistencies in currency conversion or subgroup denominators were documented transparently rather than quietly smoothed over. The review also applies the current World Bank FY2027 income classification, maps studies across clearly defined economic domains.

The review also has limitations. The included studies were methodologically heterogeneous and often lacked standardized price years, costing perspectives, or resource-valuation methods, which precluded meaningful pooling or direct monetary comparison. Several were small, single-centre, or based partly on self-reported costs. Retaining author-reported currencies limits direct numerical comparison across countries but avoids misleading conversions when base-year information is incomplete.

Conclusions

The available evidence points to a substantial and multidimensional economic burden of TBI across LMIC settings. Direct treatment costs generally rose with injury severity and resource intensity, while a smaller body of literature documented catastrophic household costs, distress financing, lost income, caregiver burden, affordability barriers, rehabilitation expenditure, and societal productivity loss.

The evidence base remains geographically sparse and heavily weighted toward acute hospital care.

More standardized, longitudinal, and multicenter economic studies are needed to support valid cross-setting comparison and to inform budget impact, resource allocation, and financial-protection policy. Future evaluations should weigh both health-system efficiency and the risk that access to essential TBI care hinges on household ability to pay.

Abbreviations

CHE, catastrophic health expenditure;

CT, computed tomography;

ED, emergency department;

GCS, Glasgow Coma Scale;

ICU, intensive care unit;

IRR, Iranian rial;

JBI, Joanna Briggs Institute;

LMICs, low- and middle-income countries;

LOS, length of stay;

OOPE, out-of-pocket expenditure;

OSF, Open Science Framework;

PRISMA-ScR, Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews; TBI, traumatic brain injury;

UHC, universal health coverage.

Declarations

Ethics approval and consent to participate

Not applicable. This review synthesizes data from previously published studies and does not involve new human participants, human data collection or human tissue.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding.

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

Authors' contributions.

AAH conceived and designed the study, developed the protocol, and registered it on the Open Science Framework. AAH, MAD, YMH, and MAS conducted the literature searches, performed title and abstract screening, and carried out full-text assessment. AAH and YMH performed data charting and cross-checked all extracted numerical values against the primary publications. MAD and MAS conducted the critical appraisal using the JBI tools, with AAH serving as third reviewer for disagreements. AAH, YMH, and MSJ contributed to the synthesis of findings and mapping of economic-burden domains. AAA and AK provided methodological and clinical input, particularly on the interpretation of cost data and trauma-system implications in LMIC settings. AAH drafted the first version of the manuscript. All authors (AAH, MAD, YMH, MAS, MSJ, AAA, AK) critically revised the manuscript, read and approved the final version, and agree to be accountable for all aspects of the work.

Availability of data and materials.

Data supporting the findings of this review are provided within the manuscript and its supplementary materials. The registered protocol is publicly available on the Open Science Framework (OSF; DOI: <https://doi.org/10.17605/OSF.IO/4DQC9>)

References

1. Guan B, Anderson DB, 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:e075049. 10.1136/bmjopen-2023-075049
2. Wesson HKH, Boikhutso N, Bachani AM, Hofman KJ, Hyder AA (2014) The cost of injury and trauma care in low- and middle-income countries: a review of economic evidence. *Health Policy Plan* 29:795–808. 10.1093/heapol/czt064
3. Rudolfson N, Dewan MC, Park KB, Shrimel MG, Meara JG, Alkire BC (2019) The economic consequences of neurosurgical disease in low- and middle-income countries. *J Neurosurg* 130:1149–1156. 10.3171/2017.12.JNS17281
4. Humphreys I, Wood RL, Phillips CJ, Macey S. The costs of traumatic brain injury: a literature review. *Clin Outcomes Res CEOR*. 2013;5:281–7. doi:10.2147/CEOR.S44625 PubMed PMID: 23836998; PubMed Central PMCID: PMC3699059

5. Van Dijck JTJM, Dijkman MD, Ophuis RH, De Ruiter GCW, Peul WC, Polinder S (2019) In-hospital costs after severe traumatic brain injury: A systematic review and quality assessment. Kerezoudis P, editor. PLOS ONE. ;14:e0216743. 10.1371/journal.pone.0216743
6. Crozes F, Delpierre C, Costa N (2024) Mapping the costs and socioeconomic characteristics involved in traumatic brain injuries: a scoping review. J Rehabil Med 56:jrm18311. 10.2340/jrm.v56.18311
7. Peters MD, Godfrey C, McInerney P, Munn Z, Tricco AC, Khalil H Scoping reviews. In: Aromataris E, Lockwood C, Porritt K, Pilla B, Jordan Z, editors. JBI Manual for Evidence Synthesis [Internet]. JBI; 2024 [cited 2026 Sep 18]. Available from: <https://jbi-global-wiki.refined.site/space/MANUAL/355862497/10.+Scoping+reviews> 10.46658/JBIMES-24-09
8. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D et al (2018) PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med 169:467–473. 10.7326/M18-0850
9. World Bank World Bank Data Help Desk [Internet]. [cited 2026 Sep 11]. World Bank Country and Lending Groups. Available from: <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>
10. Asmamaw Y, Yitayal M, Debie A, Handebo S (2019) The costs of traumatic head injury and associated factors at University of Gondar Specialized Referral Hospital, Northwest Ethiopia. BMC Public Health 19:1399. 10.1186/s12889-019-7800-3
11. Bhatti JA, Stevens K, Mir MU, Hyder AA, Razzak JA (2015) Emergency care of traumatic brain injuries in Pakistan: a multicenter study. BMC Emerg Med 15:S12. 10.1186/1471-227X-15-S2-S12
12. Hoang HT, Pham TL, Vo TT, Nguyen PK, Doran CM, Hill PS (2008) The costs of traumatic brain injury due to motorcycle accidents in Hanoi, Vietnam. Cost Eff Resour Alloc 6:17. 10.1186/1478-7547-6-17
13. Yuan Q, Liu H, Wu X, Sun Y, Yao H, Zhou L et al (2012) Characteristics of acute treatment costs of traumatic brain injury in Eastern China—a multi-centre prospective observational study. Injury 43:2094–2099. 10.1016/j.injury.2012.03.028
14. Kavosi Z, Jafari A, Hatam N, Enaami M (2015) The Economic Burden of Traumatic Brain Injury Due to Fatal Traffic Accidents in Shiraz Shahid Rajaei Trauma Hospital, Shiraz, Iran. Arch Trauma Res 4. 10.5812/at.22594
15. Gheysvandi E, Mohammadi SZ, Amirkiyasar MN, Rad EH, Kouchakinejad-Eramsadati L, Mohtasham-Amiri Z (2023) Measuring Catastrophic Costs in Families Facing Traumatic Brain Injury in Iran. Korean J Neurotrauma 19:53. 10.13004/kjnt.2022.18.e46
16. Hode L, Madougou S, Fatigba HO, Hounnou P, Ebassa K, Hans Moevi AA et al (2017) The Direct Cost of Treatment of Traumatic Brain Injury in a Sub-Saharan African Country (Benin). World Neurosurg 99:210–213. 10.1016/j.wneu.2016.11.083
17. Schenck HE, Joackim P, Lazaro A, Wu X, Gerber LM, Stieg PE et al (2023) Affordability impacts therapeutic intensity of acute management of severe traumatic brain injury patients: An exploratory study in Tanzania. Brain Spine 3:101738. 10.1016/j.bas.2023.101738
18. Kong VY, Odendaal JJ, Bruce JL, Laing GL, Jerome E, Sartorius B et al (2017) Quantifying the funding gap for management of traumatic brain injury at a major trauma centre in South Africa. South Afr J Surg Suid-Afr Tydskr Vir Chir 55:26–30 PubMed PMID: 29227053
19. Phaleng S, Hardcastle T (2025) The economic burden of traumatic brain injury at Pietersburg Hospital, Limpopo Province: a retrospective micro-costing study. S Afr J Surg 63:234–239. 10.36303/SAJS.02492
20. Carteri RBK, da Silva RA (2021) Traumatic brain injury hospital incidence in Brazil: an analysis of the past 10 years. Rev Bras Ter Intensiva 33:282–289. 10.5935/0103-507X.20210036
21. Barragán-Hervella R, Montiel-Jarquín Á, Limón-Serrano I, Escobedo-Sosa V, Loría-Castellanos J (2016) [Direct cost of primary care of mild traumatic brain injury in adults by GRD in third level of care]. Gac Med Mex 152:755–760 PubMed PMID: 27861473
22. Arora H, Patil S, Bhatia P, Khajanchi M, Sarang B, Nathani P et al (2026) Out-of-pocket expenditure in patients with isolated traumatic brain injury: a two center cohort study, a preliminary report. Cost Eff Resour Alloc 24:16. 10.1186/s12962-026-00716-1
23. Doleagbenou AK, Assogba P, Quenum K, Djoubairou B, Essossinam K (2026) Economic burden and cost drivers of traumatic brain injury. Surg Neurol Int 17:390. 10.25259/SNI_573_2025
24. Yu M, Huang Z, Yang Y, Wang Y, Ren H, Tang S (2025) The cost of rehabilitation after critical illness: a comparison of hospitalization costs for traumatic brain injury and non-traumatic brain injury patients with disorders of consciousness. Front Public Health 13:1552162. 10.3389/fpubh.2025.1552162
25. You X, Liew BS, Rosman AK, Dcsn, Musa KI, Idris Z (2018) The estimated cost of surgically managed isolated traumatic head injury secondary to road traffic accidents. Neurosurg Focus 44:E7. 10.3171/2018.1.FOCUS17796

26. Hussain SS, Kamboh UA, Raza MA, Kanwal M, Shahid S, Ashraf N (2019) The Woes of Economic Burden of Traumatic Brain Injury (TBI) Cases Borne by Public Sector Hospital of Pakistan. *Pak J Neurol Surg* 23:176–181. 10.36552/pjns.v23i3.356
27. Umo I, James K, Didilemu F, Sinen B, Borchem I, Inaido D et al (2022) The direct medical cost of trauma aetiologies and injuries in a resource limited setting of Papua New Guinea: A prospective cost of illness study. *Lancet Reg Health - West Pac* 20:100379. 10.1016/j.lanwpc.2021.100379
28. Paka W, Umo I, Apuahe E, Thomas B (2025) The direct medical cost of managing traumatic brain injuries at Port Moresby General Hospital, Papua New Guinea: a prospective cost of illness study. *Collins A, editor. P N G Med J.* ;66: MJ24007. 10.1071/MJ24007
29. Kanmani TR, Thimmappur RM, Birudu R, Reddy KN, Raj P (2019) Burden and Psychological Distress of Intensive Care Unit Caregivers of Traumatic Brain Injury Patients. *Indian J Crit Care Med* 23:220–223. 10.5005/jp-journals-10071-23164
30. Humphreys I, Wood, Phillips C, Macey. The costs of traumatic brain injury: a literature review. *Clin Outcomes Res.* 2013;281. doi:10.2147/CEOR.S44625

Figures

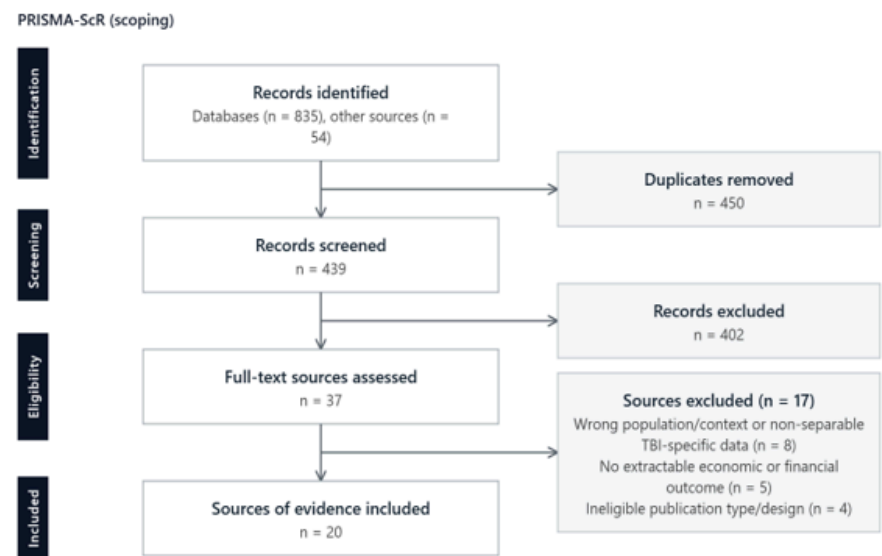


Figure 1

PRISMA-ScR flow diagram of source selection for the scoping review⁸.

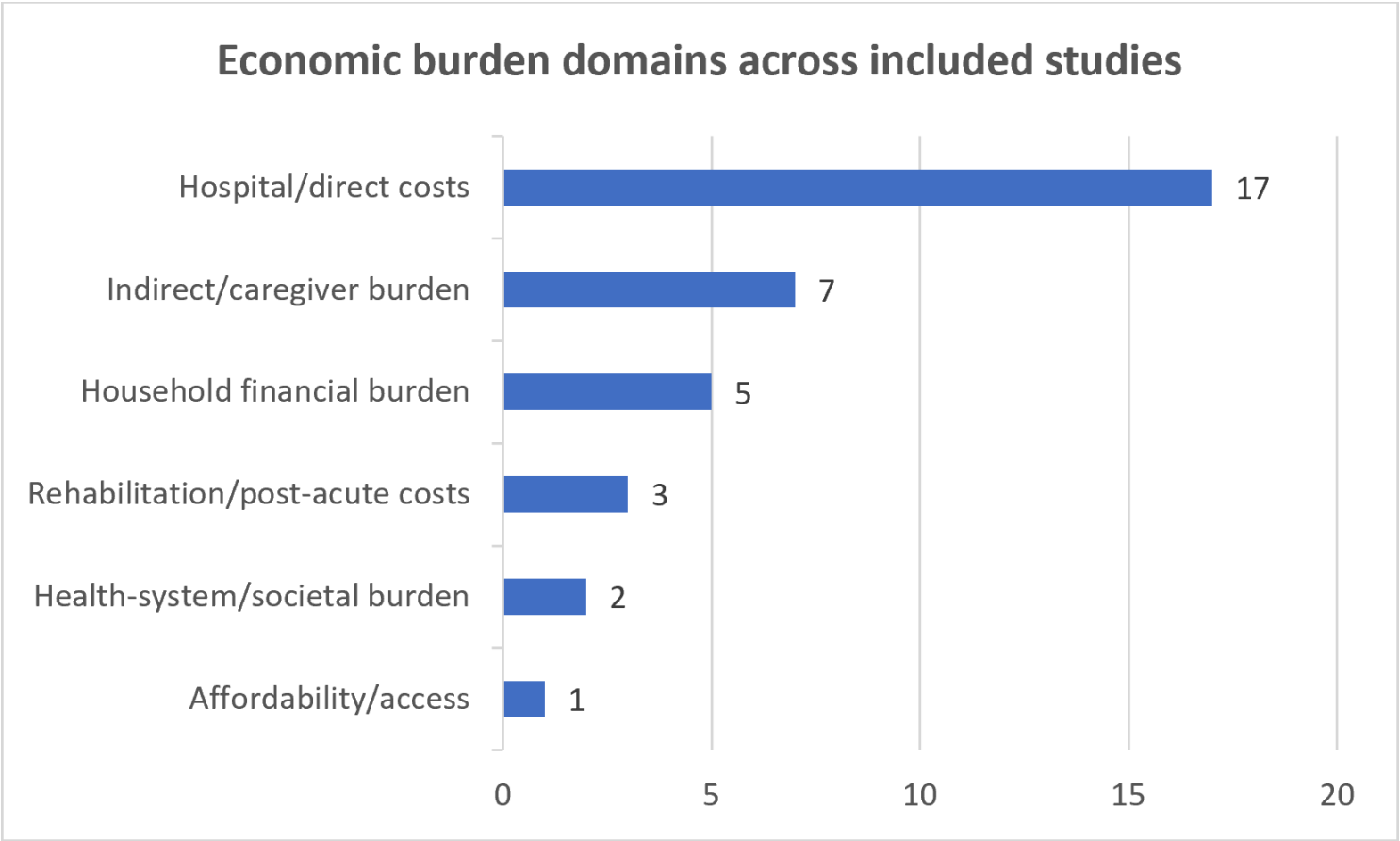


Figure 2

Economic burden domains across included studies. Studies could contribute to more than one domain; therefore, counts are not mutually exclusive.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryMaterialeconomicburdenFULL.docx](#)