

# The Impact of Early Pre-Hospital Cognitive Rehabilitation on Quality of Life After Traumatic Brain Injury

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## ABSTRACT:

**Background:** Traumatic brain injury (TBI) is a major global health concern and one of the leading causes of long-term disability and reduced quality of life. Although advances in emergency medicine have improved survival rates, many patients continue to experience persistent cognitive, physical, psychological, and social impairments. Early cognitive rehabilitation has emerged as a promising strategy for enhancing neurological recovery; however, its application during the pre-hospital phase remains insufficiently investigated.

**Aim:** The aim of this systematic review is to evaluate and synthesize the available evidence regarding the impact of early pre-hospital cognitive rehabilitation on health-related quality of life among patients with traumatic brain injury (TBI). The review also aims to examine its influence on cognitive recovery, functional independence, neurological outcomes, and social reintegration.

**Methods:** This systematic review was conducted to evaluate the available evidence regarding the impact of early pre-hospital cognitive rehabilitation on health-related quality of life following traumatic brain injury. Electronic databases including PubMed, Scopus, Web of Science, Cochrane Library, and Google Scholar were searched for studies published between 2020 and 2025. Study selection was performed according to the PRISMA 2020 guidelines. The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Tools, and the findings were synthesized narratively because of the heterogeneity among the included studies.

**Importance of the Study:** This study is important because it addresses a significant gap in the current literature regarding the role of early pre-hospital cognitive rehabilitation in patients with traumatic brain injury. The findings may contribute to a better understanding of the potential value of integrating cognitive

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rehabilitation into the early stages of emergency care. In addition, the study may support the development of integrated trauma care pathways, provide evidence to guide clinical practice and rehabilitation strategies, and inform healthcare policies aimed at improving long-term patient outcomes, functional recovery, and health-related quality of life.

**Keywords:** Traumatic Brain Injury; Cognitive Rehabilitation; Pre-Hospital Care; Emergency Medical Services; Quality of Life; Functional Independence; Neurorehabilitation.

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## Introduction

Traumatic brain injury (TBI) is defined as an alteration in brain function or other evidence of brain pathology caused by an external force, such as a blow, jolt, or penetrating injury to the head. The severity of TBI ranges from mild to severe and may result in temporary or permanent impairments affecting cognitive, physical, emotional, and behavioral functions. TBI is one of the most serious public health problems worldwide because of its high incidence, mortality, and long-term disability rates.

It can affect individuals of all ages and is commonly caused by road traffic accidents, falls, sports-related injuries, workplace accidents, and blast-related trauma. Despite advances in emergency medicine and neurosurgical care, a substantial proportion of survivors continue to experience persistent neurological deficits long after the initial injury. Consequently, the focus of modern healthcare has shifted toward comprehensive rehabilitation interventions aimed at improving long-term functional recovery and health-related quality of life, rather than solely reducing mortality (Dulf et al., 2025; Yuan et al., 2025).

The impact on the brain following a head trauma is not only the immediate trauma but also a complex process with several secondary injury mechanisms, including neuroinflammation, oxidative stress, brain swelling, disruption of the blood brain barrier, excitotoxicity and progressive neuronal damage. These secondary processes are important in the cognitive decline and long-term disability if inadequately controlled during the early stages of treatment. In the last years, however, neurobiological studies

have shown that early rehabilitation plays an integral role in the treatment of TBI and that early intervention after injury can reduce secondary brain damage, enhance neuroplasticity and improve neurological recovery (Yuan et al., 2025).

Traumatic brain injury (TBI) can have numerous outcomes and the most debilitating and enduring is cognitive impairment. Deficits in attention, concentration, memory, executive functioning, information processing speed, language and problem-solving abilities are common outcomes. These disabilities often affect a person's ability to function in daily life, the school, work, relationships, and community. Due to this, cognitive rehabilitation is a part of the multidisciplinary neurorehabilitation programs used to restore cognitive functions, compensate for the remaining deficits, enhance adaptive functioning and optimize reintegration into society (Markovic et al., 2024; Sugianto et al., 2025).

Recent developments in the scientific study of rehabilitation support the early initiation of cognitive rehabilitation, as well as early initiation of rehabilitation treatment after hospital admission. Early rehabilitation takes advantage of the increased neuroplasticity that takes place right after the injury and can stop secondary neurological deficits from developing. In this context the pre-hospital phase has been attracting more and more interest, as a key moment for implementing interventions oriented to rehabilitation, in addition to the emergency stabilizations. The integration of cognitive rehabilitation principles into early trauma care may contribute to optimizing neurological

function before the onset of irreversible damage to function (Wang & Wu 2022; Zeinaddini-Meymand et al., 2025).

Practical pre-hospital care is a crucial component to survival and chronic neurological outcome following a traumatic brain injury. Optimisation of airway management, prevention of hypoxia and hypotension, rapid assessment of the neurological picture and timely transfer to special trauma centres help to limit secondary brain damage and enhance recovery.

Optimised pre-hospital and in-hospital emergency care pathways have been demonstrated to significantly enhance clinical outcomes in acute craniocerebral trauma by decreasing the disease treatment time, and ensuring that pre-hospital and in-hospital care are continuously provided along the trauma management pathway (Wang & Wu, 2022). In addition, recent review of trauma care systems has suggested that improving the quality of the pre-hospital and post-hospital care would not only lead to better outcomes for the patient but would also involve planning for rehabilitation from the early stages of care (Zeinaddini-Meymand et al., 2025).

The current cognitive rehabilitation is not only directed to the cognitive exercise, but also considers comprehensive, multidisciplinary approach combining neuropsychological training, behavioral therapy, psychological counseling, family education, computerized cognitive intervention, and individual compensatory techniques.

Furthermore, cognitive approaches such as psychological interventions, specifically cognitive behavioral therapy (CBT), have been found to be helpful in rehabilitation programs with respect to coping skill, emotional regulation, stress management, and quality of life, showing the importance of these cognitive approaches in the early stages of trauma treatment and their use in rehabilitation programs.

Consistent with this, a large multicenter cohort study from the United States found that adverse physiological events during pre-hospital TBI care were independently associated with worse

outcomes, reinforcing the importance of optimizing every phase of early trauma management, including cognitive and physiological stabilization, to protect long-term recovery potential (Maiga et al., 2025).

Building on this North American evidence base, a randomized-trial follow-up study from Sweden further demonstrated that patients who began structured attention-training rehabilitation earlier after traumatic brain injury or stroke showed better long-term health-related quality of life, daily activity performance, and return-to-work outcomes than those who began later, supporting an international, cross-regional consensus on the value of early cognitive rehabilitation (Markovic et al., 2024).

In the past few years, quality of life has become one of the most pertinent outcome measures to consider in traumatic brain injury (TBI) research, because it is more complete than considering clinical recovery alone, which includes physical, psychological, cognitive, emotional, and social functioning. Neurological stabilization can be achieved, but at the same time, patients have a considerable amount of impairment in daily functioning, mood, labor capacity as well as social functioning and this has the effect on the quality of life. Hence, enhancing the quality of life has emerged as one of the major targets of modern-day rehab programs (Dulf et al., 2025; Mutlucan et al., 2025).

Over the years, international studies have found consistent evidence of the long-term impact of traumatic brain injury on quality of life. A multinational study of adults with traumatic brain injury (TBI) in Armenia, Georgia and Moldova found that survivors had significant improvements on a number of health-related quality of life domains years after their injury (Dulf et al., 2025).

Similarly, a five-year prospective cohort study in Indonesia showed that neurological severity, disability level, social factors and clinical characteristics were important factors that affected patients' long-term quality of life and supported the need for ongoing rehabilitation

interventions during recovery (Sugianto et al., 2025).

In the same way, long-term evaluations of patients who had severe traumatic brain injury have demonstrated that after decompressive craniectomy, patients have enhanced survival, but a significant proportion of them, for several years after injury, remain cognitively impaired, functionally dependent and with diminished health-related quality of life. The results suggest that while these treatments are effective during the acute phase, effective rehabilitation is still necessary for optimal recovery to maximize functional outcomes (Mutlucan et al., 2025).

Accessibility to rehabilitation services has emerged as a growing factor to recovery after a traumatic brain injury (TBI), in addition to the effectiveness of rehabilitation interventions. However, access to specialized rehabilitation may be delayed, geographic variations may limit the opportunity for optimal neurological recovery, a lack of healthcare resources may limit patients' opportunity for optimal neurological recovery, and a lack of coordination between emergency and rehabilitation services may limit patients' opportunity for optimal neurological recovery. Injury Treatment and Rehabilitation Accessibility Queensland Index (iTRAQI) was developed to show the importance of access to rehabilitation as an equity-based measure of trauma system performance, and how rehabilitation access is closely linked to functional outcomes following moderate to severe TBI (Cramb et al., 2025).

Present-day healthcare delivery systems are increasingly promoting a multidisciplinary approach to trauma care that starts at the point of injury and extends into the hospital and long-term rehabilitation. Current data suggests that integrated care pathways between emergency services, doctors, health rehabilitation, psychologists and allied health services improve care continuity, decrease disability and have a positive impact on the outcomes for the patient. In addition, interdisciplinary healthcare reviews have underscored that the rehabilitation process needs to be considered as an ongoing care, which should start from the pre-hospital management

phase of the patient (Zeinaddini-Meymand et al., 2025).

Although the literature on traumatic brain injury (TBI), emergency management, rehabilitation and quality of life has been expanding, there is a great deal of research that needs to be done on the effectiveness of early pre-hospital cognitive rehabilitation. Most previous studies have focused on emergency medical care, accessibility to rehabilitation, cognitive rehabilitation, or quality of life, but not combined in the initial stages of trauma care.

Therefore, there is little evidence to support the use of cognitive rehabilitation as an intervention in the pre-hospital setting to improve the long-term quality of life for people with traumatic brain injury. Based on this, the current study aims to explore the effects of early pre-hospital treatment using cognitive rehabilitation for improving quality of life following TBI and to provide evidence that can be used in the design of integrated models of trauma care that can increase neurological recovery, functional independence and long-term quality of life.

### **Aim of the study**

The aim of this systematic review is to evaluate and synthesize the available evidence regarding the impact of early pre-hospital cognitive rehabilitation on health-related quality of life among patients with traumatic brain injury (TBI). The review also aims to examine its influence on cognitive recovery, functional independence, neurological outcomes, and social reintegration.

### **Study Design**

This study was conducted as a systematic review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. The review aimed to identify, critically appraise, and synthesize the available evidence regarding the effectiveness of early pre-hospital cognitive rehabilitation in improving health-related quality of life and functional outcomes among patients with traumatic brain injury (TBI).

A systematic review design was selected because it provides a rigorous, transparent, and

reproducible approach for evaluating the existing evidence, identifying research gaps, and supporting evidence-based clinical practice.

### Search Strategy

A comprehensive and systematic literature search was conducted across the electronic databases PubMed, Scopus, Web of Science, Cochrane Library, and Google Scholar. The search included studies published in English between January 2020 and December 2025.

Medical Subject Headings (MeSH) and free-text keywords were combined using the Boolean operators AND and OR to maximize search sensitivity and specificity. The primary search terms included Traumatic Brain Injury, TBI, Cognitive Rehabilitation, Early Rehabilitation, Pre-Hospital Care, Emergency Medical Services, EMS, Neurorehabilitation, Quality of Life, Functional Recovery, and Neurological Outcomes. In addition, the reference lists of all eligible studies were manually screened to identify any relevant articles that were not retrieved during the electronic database search.

### Eligibility Criteria

Studies were selected according to predefined inclusion and exclusion criteria. Eligible studies included randomized controlled trials, cohort studies, case-control studies, and observational studies involving adult patients with traumatic brain injury (TBI) who received early cognitive rehabilitation during the pre-hospital or early acute phase of care, or who were exposed to pre-hospital care events with a direct bearing on early neurological and cognitive outcomes.

No geographic restriction was applied; eligible studies originating from Europe, Asia, the Middle East, Australia, and North America were all

considered, in order to capture evidence from a broad range of trauma-care and emergency medical service systems, including the multicenter United States Linking Investigations in Trauma and Emergency Services (LITES) Network. Included studies were required to evaluate at least one of the following outcomes: health-related quality of life, cognitive function, functional independence, neurological recovery, or social reintegration.

Only peer-reviewed articles published in English with full-text availability were included. Studies involving pediatric populations, animal models, conference abstracts, editorials, opinion papers, narrative reviews, systematic reviews, and studies that did not evaluate rehabilitation-related outcomes were excluded from the review.

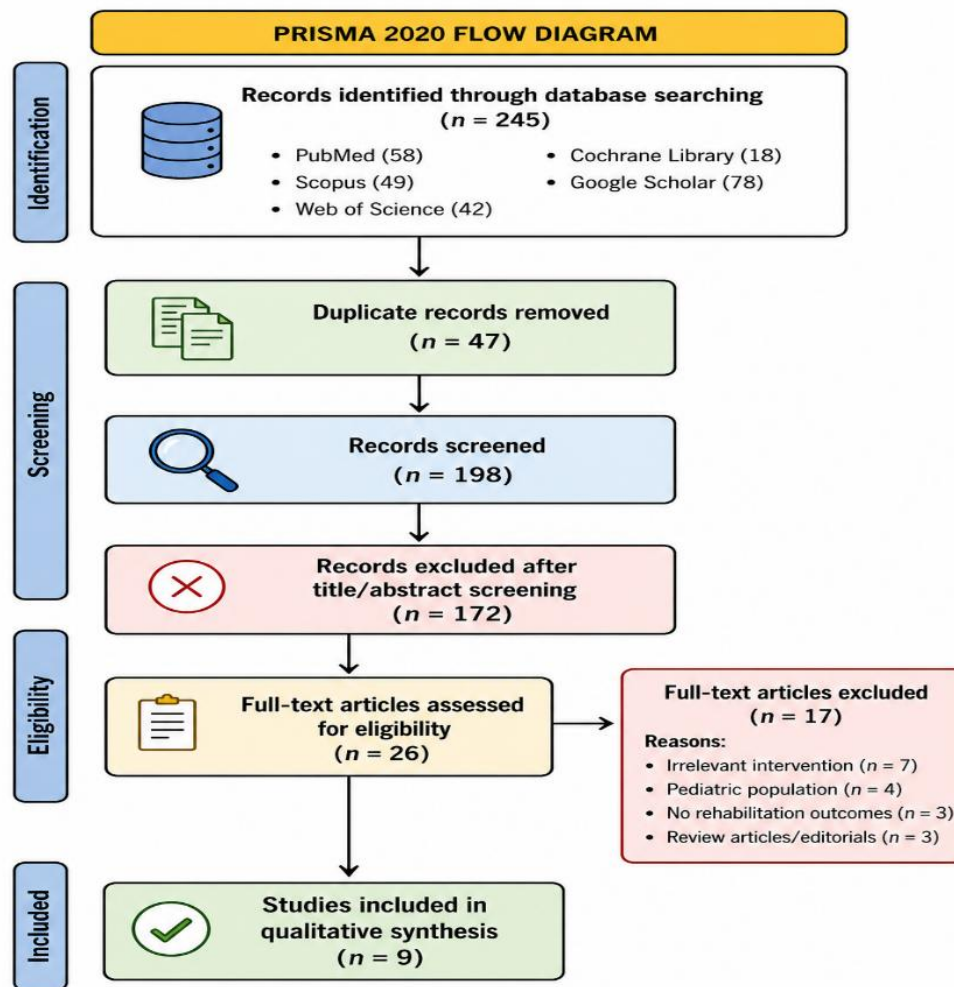
### Study Selection

The study selection process was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. All retrieved records were imported into reference management software, and duplicate records were identified and removed.

Subsequently, the titles and abstracts of the remaining studies were independently screened by two reviewers according to the predefined eligibility criteria. Full-text articles of potentially eligible studies were then independently assessed by both reviewers to determine their final eligibility for inclusion.

Any disagreements regarding study selection were resolved through discussion and consensus, and when necessary, a third reviewer was consulted to reach a final decision. The complete study selection process was documented using a PRISMA 2020 flow diagram.

## PRISMA 2020 Flow Diagram



## Data Extraction

A standardized data extraction form was developed to ensure consistency and accuracy throughout the review process. Data were extracted independently by two reviewers to minimize errors and enhance the reliability of the extracted information. The extracted data included the first author's name, year of publication, country of origin, study design, sample size, participant characteristics, severity of traumatic brain injury, characteristics and timing of the cognitive rehabilitation intervention, outcome measures, duration of follow-up, and the principal findings of each study. Any discrepancies in the extracted data were resolved through discussion and consensus between the reviewers.

## Quality Assessment

The methodological quality and risk of bias of the included studies were critically appraised using the Joanna Briggs Institute (JBI) Critical Appraisal Tools, according to the design of each included study. Methodological quality, selection bias, measurement validity, potential confounding factors, and the overall risk of bias were assessed independently for each study. The results of the quality assessment were summarized in tabular form and were considered during the interpretation of the review findings to ensure that the conclusions were based on the highest-quality available evidence. Where methodological limitations were identified, their potential impact on the overall findings was taken into account during the synthesis and discussion of the evidence.

**Quality Assessment of Included Studies (JBI)**

| Study                           | Design                    | JBI Tool      | Overall Quality |
|---------------------------------|---------------------------|---------------|-----------------|
| Markovic et al., 2024           | RCT Follow-up             | JBI Checklist | High            |
| Wang & Wu, 2022                 | Clinical Study            | JBI Checklist | High            |
| Yuan et al., 2025               | Prospective Observational | JBI Checklist | High            |
| Maiga et al., 2025              | Multicenter Cohort        | JBI Checklist | High            |
| Dulf et al., 2025               | Observational             | JBI Checklist | High            |
| Sugianto et al., 2025           | Cohort                    | JBI Checklist | High            |
| Mutlucan et al., 2025           | Cohort                    | JBI Checklist | High            |
| Cramb et al., 2025              | Technical Report          | JBI Checklist | Moderate        |
| Zeinaddini-Meymand et al., 2025 | Observational             | JBI Checklist | High            |

**Data Synthesis**

Due to the heterogeneity in study designs, rehabilitation protocols, participant characteristics, and outcome measures among the included studies, a narrative synthesis was conducted rather than a meta-analysis. The findings were organized and presented according to the main outcome domains, including health-related quality of life, cognitive recovery, functional independence, neurological outcomes, psychological well-being, and social reintegration. Similarities and differences across the included studies were critically compared, and the strength and consistency of the available evidence were evaluated. This approach facilitated the identification of current evidence trends, existing knowledge gaps, and the implications of the findings for clinical practice and future research.

**Results**

The systematic literature search identified studies investigating the role of early cognitive rehabilitation in improving outcomes following traumatic brain injury (TBI). Following the application of the predefined eligibility criteria, nine studies were included in the final qualitative synthesis. These studies comprised randomized and observational research, prospective cohort studies, and evidence-based reports published between 2022 and 2025.

The included studies consistently emphasized the importance of early rehabilitation interventions in improving patient outcomes after TBI. Most studies reported positive effects on health-related quality of life, cognitive recovery, functional independence, neurological outcomes, and social reintegration. In addition, several studies highlighted the importance of optimized pre-hospital care, multidisciplinary rehabilitation pathways, and timely intervention in minimizing secondary brain injury and enhancing long-term recovery.

Although the overall findings supported the effectiveness of early rehabilitation, considerable heterogeneity was observed among the included studies regarding study design, rehabilitation protocols, participant characteristics, outcome measures, and follow-up duration. Consequently, a narrative synthesis was considered the most appropriate method for integrating the available evidence.

**Discussion****Pre-hospital Cognitive rehabilitation and Quality of Life.**

The findings of this systematic review indicate that early cognitive rehabilitation has the potential to improve health-related quality of life among patients with traumatic brain injury. Across the included studies, early rehabilitation was associated with improvements in cognitive

functioning, functional independence, and social participation, supporting the growing recognition that rehabilitation should begin as early as medically feasible. These findings are consistent with the concept that early intervention promotes neuroplasticity, limits secondary brain injury, and facilitates long-term neurological recovery (Yuan et al., 2025).

Additionally, the quality of life following TBI is not just physical but psychological, cognitive, emotional, and social. Hence, introducing the rehabilitation process in the pre-hospital phase can set an early ground for rehabilitation by mitigating the cognitive deficits before their deep embedment. This encourages a patient-centred trauma care model which aims to achieve the best long-term functioning or functional outcome, not just the lowest mortality rate.

### **Why Early Intervention is important in a Traumatic Brain Injury.**

The biological reaction to the injured brain in the acute phase is one of the major explanations for the effectiveness of early cognitive rehabilitation. After the initial trauma, there are secondary pathological processes that occur and continue to cause damage to the brain: neuroinflammation, oxidative stress, cerebral edema, and neuronal apoptosis. Neural mechanisms that can be pathological can be prevented or reduced if they are stimulated via early rehabilitation interventions, which may increase cerebral plasticity and promote functional reorganization of remaining neural networks (Yuan et al., 2025).

In addition, the pre-hospital period may be a key therapeutic window for which early intervention could make a significant difference in neurological outcome. Today's trauma systems see this as the first step in a continuum of care, not just the time for saving lives. Early rehabilitation can therefore minimize long-term disability and speed up patients' recovery paths.

### **Role of Optimized Pre-Hospital Care**

The available evidence also Highlights the need for quality pre-hospital emergency medical services (EMS) for long-term outcomes after a traumatic brain injury (TBI). Good airway

management, avoidance of hypoxia and hypotension, prompt neurological evaluation and prompt transport to a specialist trauma centre minimizes secondary brain injuries and enhances neurological outcome. If cognitive rehabilitation concepts are included in this stage, the rehabilitation treatment provided can be more comprehensive and have the effect of stabilizing patients in the acute stage and then re-integrating the patients into society in the future (Wang & Wu, 2022).

Furthermore, there may be benefits of implementing trauma pathways that link Emergency Medical Services (EMS), hospital care, and rehabilitation services. Effective communication between emergency physicians, neurologists, rehabilitation specialists, psychologists, and nursing staff helps to plan individualized treatment, reduce rehabilitation delays, and improve patient-centered outcomes throughout the rehabilitation process.

### **Cognitive Rehabilitation and Functional Recovery**

Cognitive rehabilitation is still one of the most successful treatments for chronic cognitive dysfunction following traumatic brain injury. Improvements in attention, memory, executive functioning, information processing speed and problem-solving may greatly improve patients' ability to function independently with activities of daily living. These functional enhancement then boost confidence, lessen caregiver burden and help for successful reintegration into family, occupational and community settings.

Furthermore, modern cognitive rehabilitation is not restricted to cognitive training sessions, but also includes behavioral therapy, computer-based cognitive training, psychological counseling and educating families. This multidisciplinary approach acknowledges the need to treat emotional and psychosocial issues along with cognitive dysfunction to achieve successful recovery. Modern neurorehabilitation research is increasingly lending support to this holistic rehabilitation philosophy.

### **Psychological Well-Being and Social Reintegration**

The positive effect on psychological adjustment may also be the reason for the observed improvement in quality of life after EC-R. Traumatic brain injury often is associated with depression, anxiety, emotional regulation, and decreased self-confidence, which all have a negative impact on the rehabilitation outcome. Early cognitive and behavioral interventions can help improve coping, emotional resilience, stress management, and proactively engage in rehabilitation (Markovic et al., 2024).

Besides, successful rehabilitation facilitates social reintegration as patients are able to go back to educational, work, interpersonal and community activities. Rehabilitation of these social roles is an important factor in improving overall satisfaction with life and one of the most meaningful measures of the success of rehabilitation from the patient's perspective.

### Comparison with Previous Studies

The findings of the present systematic review were generally consistent with previous international studies. Dulf et al. (2025) demonstrated that traumatic brain injury substantially affects long-term health-related quality of life across multiple domains. Similarly, Sugianto et al. (2025) identified neurological severity, disability, and social determinants as significant predictors of long-term quality of life.

### Characteristics of Included Studies

| Author          | Year | Country | Study Design        | Population / Sample                        | Intervention                     | Main Findings                                                                                                                                                                             |
|-----------------|------|---------|---------------------|--------------------------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Markovic et al. | 2024 | Sweden  | RCT Follow-up Study | Adults with mild-to-moderate stroke or TBI | Early attention-process training | Patients who began attention training earlier (subacute, less than 4 months post-injury) showed better long-term quality of life, daily activity performance, and return-to-work outcomes |

Furthermore, Mutlucan et al. (2025) reported that many patients continued to experience reduced quality of life despite successful neurosurgical management, emphasizing that medical stabilization alone is insufficient without comprehensive rehabilitation. Likewise, Wang and Wu (2022) highlighted the effectiveness of optimized emergency care pathways in improving neurological outcomes, while Zeinaddini-Meymand et al. (2025) emphasized the importance of coordinated pre-hospital and post-hospital rehabilitation services.

Overall, the findings of the included studies consistently support the integration of rehabilitation strategies into the early stages of trauma care. This international body of evidence is further reinforced by a large multicenter cohort from the United States (Maiga et al., 2025), which found that adverse physiological events during pre-hospital care independently worsened TBI outcomes, and by a Swedish randomized-trial follow-up study (Markovic et al., 2024), which showed that earlier initiation of structured cognitive rehabilitation produced better long-term functional and quality-of-life outcomes than later initiation, together underscoring the value of early, well-coordinated pre-hospital and rehabilitative care across diverse healthcare systems.

|              |      |               |                                 |                                                |                                                                                               |                                                                                                                                                                                                                                                                                  |
|--------------|------|---------------|---------------------------------|------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|              |      |               |                                 |                                                |                                                                                               | than those starting later.                                                                                                                                                                                                                                                       |
| Wang & Wu    | 2022 | China         | Clinical study                  | Patients with acute craniocerebral trauma      | Optimized pre-hospital and in-hospital emergency care                                         | Early emergency care significantly improved neurological outcomes and reduced treatment delays.                                                                                                                                                                                  |
| Yuan et al.  | 2025 | China         | Prospective Observational Study | TBI patients (training and validation cohorts) | Early predictive risk-score model for cognitive impairment                                    | Developed and validated a predictive risk-score model identifying age, education, pulmonary infection, epilepsy, cerebrospinal fluid leakage, and injury severity as key predictors of early cognitive impairment after TBI, supporting earlier identification and intervention. |
| Maiga et al. | 2025 | United States | Multicenter Cohort Study        | Adults with confirmed TBI transported by EMS   | Optimized pre-hospital physiologic management (avoidance of hypoxia, hypotension, hypocarbia) | Prehospital hypoxia, hypotension, and hypocarbia were each independently associated with higher risk of death and unfavorable discharge disposition, underscoring the importance of optimal early physiological stabilization for neurological outcomes.                         |

|                           |      |                           |                                   |                                                   |                                    |                                                                                                                   |
|---------------------------|------|---------------------------|-----------------------------------|---------------------------------------------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Dulf et al.               | 2025 | Armenia, Georgia, Moldova | Multinational Observational Study | Adults with TBI                                   | Long-term rehabilitation outcomes  | Significant impairment in quality of life persisted after TBI, highlighting the importance of rehabilitation.     |
| Sugianto et al.           | 2025 | Indonesia                 | Prospective Cohort Study          | Patients with TBI                                 | Long-term rehabilitation follow-up | Disability severity and social factors strongly influenced long-term quality of life.                             |
| Mutlucan et al.           | 2025 | Türkiye                   | Long-term Follow-up Study         | Severe TBI patients                               | Post-craniectomy rehabilitation    | Many patients remained functionally impaired despite successful surgery, emphasizing the need for rehabilitation. |
| Cramb et al.              | 2025 | Australia                 | Technical Report                  | Moderate-to-severe TBI                            | Rehabilitation accessibility       | Better access to rehabilitation services was associated with improved functional outcomes.                        |
| Zeinaddini-Meymand et al. | 2025 | Iran                      | National Quality Assessment Study | Patients with traumatic spinal and brain injuries | Integrated trauma care             | Coordinated pre-hospital and post-hospital rehabilitation improved continuity of care and patient outcomes.       |

### Clinical Implications

The findings of this systematic review have important implications for emergency medicine, neurorehabilitation, and healthcare policy. Early cognitive rehabilitation should be considered an integral component of trauma management whenever clinically appropriate. Strengthening

collaboration among emergency medical services, trauma centers, rehabilitation specialists, psychologists, and community rehabilitation providers may improve continuity of care and enhance long-term functional outcomes. Furthermore, expanding access to specialized rehabilitation services may contribute to reducing

disability and improving the quality of life of patients with traumatic brain injury.

### Study Limitations and Future Research

There are a number of drawbacks to be acknowledged. Both injury severity and type of rehabilitation received, socioeconomic status, family support, and healthcare access could affect the quality of life outcomes apart from cognitive rehabilitation. In addition, long-term follow-up is required to see if there is some benefit that lasts for several years following the injury.

Further research is needed using multicenter randomized controlled trials with larger sample sizes to provide more solid causal proof of the effectiveness of early pre-hospital cognitive rehabilitation. Future studies should also determine the most effective timing, treatment duration and components of cognitive rehabilitation programs as well as the cost-effectiveness of the implementation of these programs in the emergency medical system.

### Ethical Considerations

As this systematic review was based exclusively on previously published scientific literature, ethical approval and informed consent were not required. The review was conducted in accordance with internationally accepted standards for research integrity, transparency, and methodological rigor. The review process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines to ensure

transparency, reproducibility, and comprehensive reporting. All included studies were appropriately cited, and their findings were accurately represented without alteration or misinterpretation. Efforts were made to minimize selection bias through systematic database searching, predefined eligibility criteria, independent study screening, standardized data extraction, and methodological quality assessment using the Joanna Briggs Institute (JBI) Critical Appraisal Tools. The limitations of the available evidence were also considered during data interpretation to ensure objective and balanced conclusions.

### Conclusion

Traumatic brain injury remains one of the leading causes of long-term disability worldwide, with profound effects on cognitive, physical, psychological, and social functioning. This systematic review synthesized evidence from nine published studies investigating the impact of early pre-hospital cognitive rehabilitation on patients with traumatic brain injury. Overall, the available evidence suggests that early rehabilitation may improve health-related quality of life, cognitive recovery, functional independence, neurological outcomes, and social reintegration. Despite these promising findings, variations in study design, intervention protocols, and outcome measures indicate the need for additional high-quality multicenter studies to strengthen the current evidence base and guide future clinical practice.

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