REVIEW ARTICLE

Psychosocial Consequences of Mild Traumatic Brain Injury in Children: Results of a Systematic Review by the International Collaboration on Mild Traumatic Brain Injury Prognosis

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Abstract

Objective: To synthesize the best available evidence regarding psychosocial consequences of mild traumatic brain injury (MTBI) in children.

Data Sources: MEDLINE, Embase, CINAHL, PsycINFO, and SPORTDiscus were searched (2001–2012). Inclusion criteria included published peer-reviewed reports in English, French, Norwegian, Spanish, Swedish, and Danish. References were also identified from relevant reviews and meta-analyses, and the bibliographies of eligible articles.

Study Selection: This article presents an update of a previous review with a much larger scope, of which this topic is a small subset of the questions addressed by that review. Controlled trials and cohort and case-control studies were selected according to predefined criteria. Two independent reviewers used modified Scottish Intercollegiate Guidelines Network criteria to critically appraise eligible studies. A total of 77,914 records were screened; 101 of these articles were deemed scientifically admissible, of which 6 investigated the psychosocial consequences of MTBI in children.

Data Extraction: Two reviewers independently extracted data from accepted studies into evidence tables.

Data Synthesis: We conducted a best-evidence synthesis by linking our conclusions to the evidence tables. Most accepted studies were exploratory rather than confirmatory. Preliminary evidence suggests that most children recover within 3 months post-MTBI. After 1 year, the prevalence of postconcussion symptoms and syndrome is similar between children with MTBI and children with orthopedic injuries. The

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Mild traumatic brain injury (MTBI), or concussion, is a prevalent injury in children and youth younger than 19 years (see case definition of MTBI below). Determining the true incidence of pediatric MTBI has historically proven difficult; however, it is estimated that 1 in 220 pediatric emergency department visits is the result of an MTBI. Recent statistics from the Centers for Disease Control and Prevention (CDC) indicate that an estimated 3.8 million concussions occur annually in the United States, the majority in children and young adults.

Similar to adults, youth may experience a range of neurobehavioral deficits after concussion that can include combinations of somatic, cognitive, and emotional/behavioral postconcussion symptoms. These deficits can affect psychosocial functioning via participation restrictions in daily activities (eg, sport, school, family, social). Because childhood and adolescence are the periods during which the greatest plasticity and growth occurs in the brain, it is thought that the young brain may be more vulnerable to the effects of MTBI, resulting in delayed recovery and the potential for persisting functional deficits that may influence psychological outcomes. While it has been suggested that individuals with MTBI typically recover within 1 to 2 weeks, symptoms and related performance deficits persisting for several weeks to months postinjury have been reported. Similarly, adolescents have been reported to be more susceptible to short-term neuropsychological and neurophysiological deficits after concussion than younger children and adults. However, the long-term impact of MTBI in children remains to be examined, in particular, how short-term MTBI-related psychological deficits influence long-term psychosocial outcomes.

In its 2004 systematic review of MTBI prognosis, the World Health Organization (WHO) Collaborating Centre for Neurotrauma Prevention, Management, and Rehabilitation Task Force reported that the prognosis is favorable for children with MTBI. The WHO Collaborating Centre Task Force found that postconcussion symptoms were generally transient, usually resolving within 3 months, and resembled symptoms experienced by children who had sustained other types of injuries (ie, orthopedic). The evidence available at the time also suggested that few children experienced short- or long-term cognitive deficits and that children with MTBI did not subsequently have higher rates of behavioral or school problems than children with other types of injuries.
published peer-reviewed research reports in English, French, Swedish, Norwegian, Danish, and Spanish. To be included in this report on psychosocial outcomes of MTBI in children, studies had to have a minimum of 30 MTBI pediatric cases and had to assess childhood psychosocial outcomes such as psychiatric illness, family functioning, or broad indicators of childhood behavior, health, and quality of life. Thus, this article presents a subset of the results from the larger review on MTBI prognosis, which appears in this same journal supplement.

Eligible study designs were controlled trials and cohort and case-control studies. Exclusion criteria included cross-sectional studies, case reports and series, cadaveric studies, biomechanical studies, and laboratory studies. While we screened all relevant reviews and meta-analyses to locate primary studies, we did not critically review them, and they are not included in this best-evidence synthesis.

**Case definition**

MTBI was defined according to the definitions endorsed by the WHO Collaborating Centre Task Force and the CDC. The WHO Task Force defines MTBI as “an acute brain injury resulting from mechanical energy to the head from external physical forces. Operational criteria for clinical identification include: (i) one or more of the following: confusion or disorientation, loss of consciousness for 30 minutes or less, post-traumatic amnesia for less than 24 hours, and/or other transient neurological abnormalities

![Flow diagram of literature search](https://wwwarchives-pmrorg/Fig1.png)
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<td><strong>Course of recovery</strong></td>
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<td>Anderson et al, 2001; Australia</td>
<td>Pediatric admissions to Royal Children's Hospital, Victoria, Australia, because of TBI (n = 42) F/U: 30mo</td>
<td>Age of injury 3 &lt; 13 plus subgroup of children aged &lt; 3y at time of injury; admission to hospital; ability to complete cognitive evaluations; completion of acute, 12-mo and 30-mo evaluations Exclusions: penetrating head injury, previous TBI; TBI as a result of abuse; preexisting physical, neurologic, psychiatric, or developmental disorder</td>
<td>Admission GCS score, 13–15; documented evidence of TBI including period of altered consciousness; no CT/MRI abnormality, no neurologic deficits</td>
<td>Course of recovery</td>
<td>Improvement was observed in all outcome measures at 30mo post-MTBI. At admission, 83.3% had no deficits, 14.3% had 1 deficit, and 2.4% had 2 deficits in functional domains. At 30mo, 90.5% had no deficits, 9.5% had 1 deficit, and no individuals had 2 deficits.</td>
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<td>Hajek, et al, 2010; United States</td>
<td>Children (aged 8–15y) recruited from 2 Ohio EDs MTBI: eligible (n = 393); 48% participated (n = 186); only analyzed those who completed all F/U assessments (n = 167) Unexposed: OI group—eligible (n = 286); 35% participated (n = 99); 84 were analyzed. F/U: 2wk, 3mo, 12mo</td>
<td>Inclusion for MTBI group: MTBI. Inclusion for unexposed (OI): fracture with AIS ≤ 3 with no head injury Exclusion for exposed and unexposed: injury-related surgery, hypoxia or shock postinjury, previous TBI with admission, prior neurologic disorder, severe psychiatric disorder requiring hospitalization; associated injuries with AIS &gt; 3; injuries hindering neuropsychological assessment; injuries related to child abuse or drug/alcohol use</td>
<td>LOC &lt; 30min, GCS score 13–14, ≥ 2 symptoms of MTBI reported by ED physicians. Evidence of CT skull fracture or intracranial lesion still included</td>
<td>Course: postconcussive symptoms, assessed by PCS-I, HBI, posttraumatic stress symptoms as assessed by PCL-C/PR Psychosocial outcome: posttraumatic stress symptoms</td>
<td>Prevalence of PTSD among patients with MTBI decreased from 8% at baseline to 2% at 12mo. Prevalence of PTSD remained stable at 7% in patients with OIs. Prevalence of postconcussive symptoms among patients with MTBI and OI decreased from baseline to 12mo: 51% to 19% (for MTBI) and 30% to 19% (for OI), respectively. No clinically important difference in postconcussive symptoms and PTSD between MTBI and OI groups.</td>
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<td>Kenardy et al, 2012; Australia</td>
<td>Children and adolescents (aged 6–15y) assessed in the ED of 3 tertiary hospitals for MTBI (n = 94). F/U: 2, 3, 6, 12, and 18mo</td>
<td>Inclusion: childhood TBI with documented LOC; consent from parents; and for children aged ≥ 10y, assent to participate</td>
<td>GCS score between 13 and 15; absence of neurologic or radiologic abnormalities</td>
<td>Course: Parent Report Child Health Questionnaire (CHQ-PF50), Physical (CHQ-Ph50) and psychological (CHQ-PsS)</td>
<td>Children with MTBI recovered within the first 3mo post-MTBI.</td>
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<td>AbdelMalik et al,24 2003; Canada</td>
<td>Phase I case-control study</td>
<td>Cases: Canadian adults with schizophrenia (n=67) (diagnosed using the DSM-III-R [SCID-1]) Controls: (n=102) without schizophrenia</td>
<td>Inclusion (cases): a proband and at least 1 relative with schizophrenia, and if multiple affected and unaffected family members were willing to participate. In subjects with schizophrenia, only head injuries preceding the onset of psychosis were considered. Exclusion for cases: subjects with no unaffected siblings, subjects and unaffected subjects with insufficient information regarding head injury, subjects with schizophrenia who had onset of psychosis at an age &gt;50y</td>
<td>Graded severity of TBI from none to most severe; grades 3–4 were consistent with MTBI. Childhood head injury was defined as that occurring at ≤10y of age.</td>
<td>Prognostic factors: childhood head injury (SCID-1, medical records, information from family members)</td>
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<td>Luis and Mittenberg,26 2002; United States</td>
<td>Phase I cohort study</td>
<td>Children (aged 6–15y) hospitalized in a general hospital Exposed: n=42 children with MTBI Unexposed: n=35 children with skeletal fractures but</td>
<td>Exclusion: documented history of neurologic disorder such as epilepsy or cerebral palsy and/or reported history of abuse or neglect</td>
<td>GCS scores of 13–15, normal CT scans and neurologic exams, and absence of depressed skull fracture</td>
<td>Outcomes: module A (anxiety disorders) and module C (mood disorder) of the DISC-IV</td>
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<td>Massagli et al, 2004; United States Phase III cohort study</td>
<td>no head trauma</td>
<td>Exposed: children (aged ≤14y) with MTBI assessed in ED, hospital and outpatient clinics in a large health maintenance organization (n = 490) Unexposed: children matched by sex, age, and enrollment at the time of injury (n = 1470) F/U: 6mo</td>
<td>Inclusion: enrolled in Group Health Cooperative of Puget Sound on the reference date, with an ICD-9-CM diagnosis of TBI Exclusion: ICD-9-CM TBI diagnosis in the year prior</td>
<td>CDC criteria: ICD-9-CM codes indicate brief (&lt;1h) LOC or no LOC; no intracranial lesions</td>
<td>Outcomes: psychiatric diagnoses, psychiatric medication prescription, and utilization of psychiatric services</td>
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**Abbreviations:** AIS, Abbreviated Injury Scale; CHQ, Child Health Questionnaire; CT, computed tomography; DISC-IV, Diagnostic Interview Schedule for Children—Fourth Edition; DSM-III-R, Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition; ED, emergency department; F/U, follow-up; GCS, Glasgow Coma Scale; HBI, Health and Behavior Inventory; ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical Modification; LOC, loss of consciousness; MRI, magnetic resonance imaging; OI, orthopedic injury; OR, odds ratio; PCL-C/PR, PTSD Checklist for Children/Parent Report; PCS-I, Postconcussive Symptom Interview; PTA, posttraumatic amnesia; RR, relative risk; SCID, Structured Clinical Interview.
such as focal signs, seizure, and intracranial lesion not requiring surgery; and (ii) Glasgow Coma Scale score of 13–15 after 30 minutes postinjury or later upon presentation for healthcare. These manifestations of MTBI must not be due to drugs, alcohol, medications, caused by other injuries or treatment for other injuries, (eg, systemic injuries, facial injuries or intubation), caused by other problems (eg, psychological trauma, language barrier or coexisting medical conditions) or caused by penetrating cranio-cerebral injury. 13 Persons with fractured skulls were included if they fit this case definition. The CDC provides an additional definition that can be derived from clinical records. According to the CDC, MTBI is present if an Abbreviated Injury Severity Scale score of 2 for the head region is documented. 18 An administrative data definition for surveillance or research is also provided. 18 Specifically, cases of MTBI are recognized among persons who are assigned certain International Classification of Diseases, Ninth Revision, Clinical Modification diagnostic codes. 16

Assessment of methodological quality

The critical appraisal process is reported in detail elsewhere. Briefly, all eligible articles were critically appraised using a modification of the Scottish Intercollegiate Guidelines Network (SIGN) criteria. 19 Two reviewers performed independent, in-depth reviews of each eligible study to appraise the methodological quality of the articles and assess the impact of selection bias, information bias, and confounding on the results. A third reviewer was consulted for disagreements. Similarly, 2 reviewers independently extracted data from scientifically admissible articles into evidence tables to inform our results.

Synthesis of evidence

We performed a best-evidence synthesis by extracting data from accepted studies (ie, those with a low risk of bias) into evidence tables and linking these to our findings. 16 The steps include searching the literature, evaluating the quality of the studies, extracting findings from the low-risk-of-bias articles into tables, and synthesizing this best evidence into conclusions about the topic. Our assessment of bias was completed before tabling the evidence, and data extracted into the evidence table included author, year and country of publication; source population, study size, participation, and follow-up; inclusion/exclusion criteria; MTBI case definition (as originally published); prognostic factors/outcomes; and findings. 16 We used evidence that was restricted to psychosocial consequences after MTBI in children. The data from studies that included a range of severity of TBI were excluded unless the results were stratified to present MTBI-specific findings. We also categorized the evidence on relevant prognostic factors as exploratory or confirmatory, using the phases of study framework described by Côté et al. 20 Phase I studies are hypothesis-generating investigations that explore the associations between potential prognostic factors and disease outcomes in a descriptive or univariate way. Phase II studies are extensive exploratory analyses that focus on particular sets of prognostic factors, or attempt to discover which factors have the highest prognostic value. Phase I and phase II studies provide preliminary evidence. Lastly, phase III studies are large confirmatory studies of explicit prestated hypotheses that allow for a focused examination of the strength, direction, and independence of the proposed relationship between a prognostic factor and the outcome of interest. Information from accepted phase III studies is considered the strongest evidence, followed by evidence from accepted phase II studies. Phase I studies do not consider confounding factors and are considered more limited evidence.

Results

This article reports on the subset of articles of MTBI prognosis that relate to psychosocial outcomes in children after MTBI. For the larger entire ICoMP review addressing MTBI prognosis, a total of 77,914 records were screened, and 299 met the eligibility criteria. Of these, 101 were accepted as scientifically admissible (ie, low risk of bias according to SIGN criteria) (fig 1). 17 Of the 101 accepted articles for the entire MTBI prognosis review, 6 were related to psychosocial prognosis in children after MTBI and were included in this article (table 1).

Most of the evidence on the psychosocial consequences of MTBI in children is preliminary. Of the 6 accepted studies, 5 were phase I studies and 1 was a phase III study. 21-26 Three studies 23-26 were conducted in the United States, 2 studies were conducted in Australia, 23,22 and 1 study 24 was conducted in Canada. Most participants were younger than 15 years and recruited from hospital emergency departments. Follow-up periods varied from 12 to 30 months.

Course of recovery of psychosocial outcomes after MTBI

Three studies, all phase I exploratory studies, report on recovery of psychosocial functioning after MTBI. One study suggests that according to parents’ reports, most children aged 6 to 15 years with MTBI recruited from emergency departments in Australia recover their physical, psychological, and social functioning within 3 months of their injury. 25 In the United States, the point prevalence of postconcussion symptoms was assessed at baseline (within 3 wk of injury), at 3 months, and again 1 year after the injury in children (aged 8–15 y) with MTBI and in children with orthopedic injuries. 23 At baseline, the prevalence of these symptoms was higher in the MTBI group (52% vs 30%), but by 3 months the prevalence was no different between groups, and at 1 year the prevalence of postconcussion symptoms was 19% in both groups. However, in the same population, posttraumatic stress disorder (PTSD) developed in a small number of children; the point prevalence of PTSD assessed 1 year after the injury was higher in children with orthopedic injuries (7%) than those with MTBI (2%). 23 Finally, 2 studies 23,22 of Australian children recruited from hospitals suggest that the functional status of children with MTBI improves steadily over the first 6 to 12 months postinjury and does not appear to deteriorate over a 30-month follow-up.

Risk of psychiatric illness and utilization of psychiatric services

Three studies (2 phase I studies and 1 phase III cohort study) investigated the association between MTBI and subsequent psychiatric illness. 24-26 AbdelMalik et al 25 studied the association between MTBI and schizophrenia in a family-matched case-control study of families with a strong genetic disposition for schizophrenia (phase I study). The authors found a positive association (odds ratio, 2.35; 95% confidence interval [CI], 1.03–5.36) between MTBI and schizophrenia (diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition [Structured Clinical Interview] criteria). However, the majority of participants
were reporting on an MTBI that had occurred decades earlier, which may have compromised the validity of the study.

Luas and Mittenberg\textsuperscript{26} compared 42 children with MTBI and 35 children with skeletal fractures without head trauma who were admitted to a general hospital (phase I cohort study). The prevalence of mood disorders assessed 6 months after onset was higher in the MTBI group (35.7\%) than in the orthopedic group (11.4\%), as was the prevalence of anxiety disorders (21.4\% for MTBI vs 2.8\% for the orthopedic group).

Another study of U.S. children (phase III cohort) investigated the incidence of psychiatric diagnoses, psychiatric medication prescription, and utilization of psychiatric services for children (age $\leq 14$y) with diagnosed MTBI compared with unexposed sex- and age-matched children from the same health maintenance organization.\textsuperscript{25} Children with a prior history of psychiatric illness, regardless of whether they had sustained an MTBI, were at increased risk for a subsequent psychiatric disorder, and MTBI did not increase that risk. However, for those children with no prior psychiatric diagnosis during the year before their injury, those children with MTBI were more likely to have a psychiatric illness diagnosed in the 3 years postinjury compared with the non-MTBI-injured controls (relative risk, 1.62; 95\% CI, 1.0–2.7).\textsuperscript{25} This increased risk in children with MTBI was observed especially for a diagnosis of hyperactivity during the first year postinjury compared with controls (relative risk, 7.59; 95\% CI, 2.7–21.6).\textsuperscript{25} However, that association was no longer present by the second year postinjury.

**Discussion**

Clearly, there is a lack of attention to the psychosocial consequences after MTBI in children within the available literature. Despite such limited evidence, our review is the first of its kind to focus uniquely on psychosocial outcomes after MTBI in children. The best available evidence from our review suggests that for children with MTBI, most symptoms resolve within 3 months of the injury,\textsuperscript{22,23} and their functional status improves steadily over the first 6 to 12 months postinjury without obvious deterioration over a 30-month follow-up period.\textsuperscript{21,22} In 2004, the WHO Collaborating Centre Task Force on MTBI found that the prognosis for most children after MTBI is good, with quick resolution of symptoms and little evidence of residual cognitive, behavioral, or academic deficits.\textsuperscript{13} However, we also found 3 studies\textsuperscript{24–26} (1 phase III, 2 phase I) that focused on psychiatric illness and utilization of psychiatric services, and all indicated a positive association between childhood MTBI and subsequent psychiatric diagnoses, including mood and hyperactivity disorders within the following 3 years postinjury. Only 1\textsuperscript{25} of these studies was a phase III study, and although it was a large study with a strong design, the age- and sex-matched control group did not have an injury. However, 1\textsuperscript{24} of the other phase I studies, which did include controls with other injuries, also found an MTBI-related increased risk of psychiatric illness. Although these findings need to be confirmed in future research, they suggest increased concern about MTBI exposures in children. We recommend that more, better-designed, confirmatory studies be done in the very near future.

We were disappointed to find so few high-quality studies addressing this important topic. The reviewed literature was small, and several methodological issues limit its validity. For instance, most study participants were recruited from hospital emergency departments that may have included a select group of patients with more severe injuries. This limits the generalizability of the findings, given that many youth who experience a milder MTBI may not present to a hospital. In addition, because of the limited number of studies, the findings reflect a fairly narrow scope of psychosocial outcomes. Psychosocial health in children represents a much broader realm of function, and the lack of studies focusing on other important outcomes, such as overall childhood quality of life, represents a significant limitation. Future studies should measure different psychosocial factors in a hierarchical fashion, combining specific family and childhood indicators and history with persisting posttrauma symptomatology, psychiatric behaviors, and diagnoses with quality-of-life outcomes in order to better understand their interactions with outcomes. Furthermore, the longest time frame for follow-up was 30 months, and this should be expanded, especially given the broad age ranges captured in most MTBI participant samples. For example, it would be worthwhile to systematically evaluate how sex or age at onset might influence psychosocial outcomes in early adulthood and beyond. Finally, the research did not address the possibility for early intervention (ie, within the first year) for those youth with a pre-morbid psychiatric disturbance or vulnerability, as well as MTBI-related PTSD, in order to influence outcome.\textsuperscript{27} Although speculative at this point, research could certainly be conducted to investigate the value of cognitive behavioral or trauma-specific therapies with this subset of the MTBI pediatric population.

To summarize, there is a great need for well-designed, long-term confirmatory studies that consider potential confounders, to better understand psychosocial outcomes after childhood MTBI. Potential confounders that were not well explored across the studies include sex, age at onset of injury, family socioeconomic status, prior health and functioning, and the general impact of injuries in children. Furthermore, future studies should consider the impact of MTBI on broader measures of psychosocial function such as childhood quality of life.

**Study limitations**

Our review has limitations.\textsuperscript{27} Publication bias is possible since we only reviewed studies that were published in peer-reviewed journals and in specific languages. Therefore, potentially relevant studies may have been missed. Several different review teams assessed studies for eligibility and quality. There is a certain amount of subjectivity involved with this process. As such, some teams may have rejected articles that others would have deemed admissible and vice versa. Similarly, certain studies could have been excluded that other teams may have deemed eligible. However, we tried to guard against these problems by having 2 reviewers independently assess studies using explicit criteria for inclusion and exclusion, as well as review the evidence using the SIGN criteria. Furthermore, it should be noted that the articles reviewed on MTBI in children sometimes included intracranial lesions, as long as the other criteria for MTBI (usually Glasgow Coma Scale, loss of consciousness, and posttraumatic amnesia) were satisfied. This was not our case definition, but those from the best available studies.\textsuperscript{16} Our findings are also limited by the quality of studies available in the literature.

Biases could still exist in the studies we accepted for our best-evidence synthesis. Selection bias is a major concern and refers to differences in the baseline characteristics of individuals in different groups such as can occur when the groups being studied are not selected from the same source population and are thus not comparable. Ascertaining a study’s risk for selection bias was at times difficult because of inadequate reporting. Selection bias is also a major threat if differential and nonrandom attrition occurs.
in a study. Information bias is also a major concern, especially when participants are asked to recall a past exposure of MTBI that may have occurred decades before data collection.

Conclusions

Overall, there is a dearth of literature focusing on psychosocial outcomes after MTBI in children and youth. Those studies that were reviewed contained a number of methodological weaknesses and biases. Furthermore, the shortage of confirmatory studies (phase III) regarding prognosis after pediatric MTBI prevents firm conclusions. Three studies described a positive association between childhood MTBI and the risk of subsequent psychiatric diagnoses, but this finding needs to be confirmed in additional, well-designed phase III studies. Future research in this area needs to improve to address the shortcomings that we have identified. This will help to develop better evidence-based guidelines for follow-up care and treatment in children and youth with MTBI, and could have particular importance for those youth with pre-morbid psychiatric, familial, and behavioral dysfunction.

Keywords

Brain injuries; Craniocerebral trauma; Pediatric; Psychological outcomes; Recovery of function; Rehabilitation

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References