Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children: Recommendations from the CDC

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Abstract

Importance:

Mild traumatic brain injury (mTBI) in children is a growing public health concern as epidemiologic data indicates a marked increase in the number of ED visits over the past decade. However, no evidence-based clinical guidelines have been developed for diagnosing and managing pediatric mTBI in the United States. Clinical guidance for healthcare providers is critical to improving the health and safety of this vulnerable population.

Objective:

The Centers for Disease Control and Prevention (CDC) National Center for Injury Prevention (NCIPC) and Control's Board of Scientific Counselors (BSC), a federal advisory committee, established the Pediatric Mild TBI Guideline Workgroup. The Workgroup conducted a systematic review of the literature and this review was used to obtain and assess evidence toward developing clinical recommendations for healthcare providers related to the diagnosis, prognosis, and management/treatment of pediatric mTBI. The systematic review and clinical recommendations were reviewed and endorsed by NCIPC's BSC; the BSC recommended that CDC use these findings to create the *Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children*.

Evidence Review:

The Pediatric Mild TBI Workgroup conducted a systematic review and drafted clinical recommendations using the methods developed by American Academy of Neurology. As part of the systematic review, evidence was rated using a modified Grading of Recommendations Assessment Development and Evaluation (GRADE) methodology. The Workgroup drafted recommendations based on the evidence that was obtained and assessed within the systematic review, as well as related evidence, scientific principles, and expert inference.

Findings:

The CDC Guideline includes 19 sets of recommendations that were assigned a level of obligation (i.e., must, should, may) based on confidence in the evidence. Recommendations address imaging, symptom scales, cognitive testing, and standardized assessment for diagnosis; history and risk factor assessment, monitoring, and counseling for prognosis; and patient/family education, rest, support, return to school, and symptom management for treatment.

Conclusion and Relevance:

This guideline identifies best practices based on current evidence; updates may be made as the body of evidence grows. Equally as important is a multifaceted approach to the implementation of the recommendations. In addition to the development of the guideline, the CDC has created user-friendly implementation materials that are concise and actionable. Partner organizations' efforts are critical to ensure sustainability of this effort nationwide. Evaluation of the guideline and implementation materials is crucial in understanding the impact of the recommendations.

Key Points (to be submitted as separate supplemental file; 100 words or less)

Question:

Based on the current evidence, what are the best practices for the diagnosis, prognosis, and management of pediatric mTBI?

Findings:

The Guideline includes 19 sets of recommendations in the areas of diagnosis, prognosis, and management of pediatric mTBI. Each recommendation was assigned a level of obligation (i.e., must, should, may) based on confidence in the evidence.

Meaning:

Clinical guidance for healthcare providers is critical to improving the health and safety of this vulnerable population. The recommendations represent current best practices and comprise the first evidence-based clinical guideline for diagnosing and managing pediatric mTBI in the United States.

Introduction

Mild traumatic brain injury (mTBI) in children is a significant public health concern. From 2005 to 2009, children made more than 2 million outpatient visits and almost 3 million emergency department (ED) visits for mTBI.[1] In a subset of pediatric patients, postconcussive symptoms persist beyond 2 weeks and can continue for longer than 3 months.[2] Pathophysiologic injury and symptomatology (both acute and long term) affect a child's ability to function physically, cognitively, and psychologically following mTBI.[3-5]

Consensus guidelines on the management of mTBI in adults have been developed.[6,7] Evidence-based guidelines related to the management of sports-related concussion in children and adults were published in 2013,[8] and the Ontario Neurotrauma Foundation published an evidence-based guideline for diagnosing and managing pediatric concussion in 2014.[9] No evidence-based clinical guidelines have been developed in the United States related to the diagnosis, prognosis, and treatment/management of pediatric mTBI. Clinical guidance for healthcare providers is critical to improving the health and safety of this vulnerable population.

This guideline provides evidence-based recommendations for healthcare providers that were developed using a rigorous scientific process based on a comprehensive review of pediatric mTBI scientific evidence.[10] Recommendations aim to provide healthcare providers in primary care, outpatient specialty, inpatient, and emergency care settings in the US with evidence-based guidance on the diagnosis and management of mTBI in children 18 years of age and younger.

A wide clinical and functional definition of pediatric mTBI was employed in the development of the systematic review and guideline. Specifically, pediatric patients were included with Glasgow Coma Scale (GCS) scores of 13-15, with or without the complication of intracranial injury on neuroimaging, and regardless of potentially requiring a hospital admission and/or neurosurgical intervention.

Methods

Federal Advisory Committee Process

The CDC National Center for Injury Prevention and Control's (NCIPC) Board of Scientific Counselors (BSC), a federal advisory committee, established the Pediatric Mild TBI Guideline Workgroup to conduct a systematic review and draft clinical recommendations for healthcare providers on the diagnosis and management of mTBI among children ages 18 and younger. Prior to their participation, and again near the end of the process, Workgroup members and ad-hoc experts were asked to disclose activities that could pose possible conflicts of interest. CDC reviewed disclosed activities and no conflicts of interest were identified. Further, members of the BSC completed an Office of Government Ethics (OGE) Form 450 to disclose relevant interests. Activities that did not pose a conflict but pertain to the topic of the guideline are disclosed. More information on the Workgroup's activities can be found in the systematic review[10] and the Pediatric Mild TBI Guideline Workgroup Report ("Workgroup Report").[11]

AAN Guideline Methodology

The Pediatric Mild TBI Workgroup conducted a systematic review and drafted clinical recommendations using the methods developed by American Academy of Neurology (AAN).[12] The process included clinical question identification and a systematic review. The review methods and findings that support the

recommendations are reported in detail in the systematic review accompanying the Guideline.[10] Evidence was rated as part of the systematic review using a modified Grading of Recommendations Assessment Development and Evaluation (GRADE) methodology. The Workgroup drafted recommendations based on the systematic review, as well as related evidence, scientific principles, and expert inference, and categorized recommendations into three topic areas: diagnosis, prognosis, and management/treatment.

Clinical recommendations were collated and distributed among the Workgroup members in sequential rounds of voting to determine consensus. Workgroup members were presented with a series of potential recommendations and a rationale for each recommendation. The rationale was based on the research identified in the systematic review that was relevant to that recommendation (full rationales can be found in the Workgroup Report).[11] After four rounds of voting, the Workgroup achieved consensus on 46 clinical recommendations: 11 pertained to diagnosis, 12 pertained to prognosis, and 23 focused on management and treatment. Box 1 describes how workgroup members assigned a Level of Confidence in the Inference (i.e., High, Moderate, Low, Very Low) and a Strength of Recommendation (e.g., Level A, B, C, R) for each recommendation. A more detailed description of the voting process, and tables displaying the clinical evidence profile for each recommendation, are available in the Appendix A. Using the Workgroup Report, CDC grouped the 46 recommendations into 19 sets of recommendations based on clinical focus (e.g., "General Healthcare Provider Counseling of Prognosis," "Cognitive Impairment Treatment/Management"), and constructed a draft *Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children* ("Guideline"). As co-authors of the Guideline, Workgroup members individually reviewed the full draft Guideline prior to public comment and peer review.

Public Comment and Peer Review

To obtain comments from the public on the draft Guideline, CDC published a notice in the Federal Register (### to be added later) announcing the availability of the Guideline for public comment during a 60-day period. In addition, public comments were received on the Workgroup Report during a BSC meeting open to the public. Because the Guideline provides influential scientific information that could have a clear and substantial impact on public and private sector decisions, the Guideline was peer reviewed per the final Office of Management and Budget information quality bulletin for peer review by three external, independent reviewers. CDC carefully considered comments of the public and peer reviewers when developing and revising the Guideline.

Recommendations

Diagnostic Recommendations

This section contains recommendations for when particular forms of imaging are indicated, as well as recommendations regarding the diagnostic utility of symptom scales, cognitive testing, and serum biomarkers.

Risk factors for intracranial injury and Computed Tomography (CT)

Recommendation #1 1a. Healthcare providers *should not* routinely obtain head CT for diagnostic purposes in children with mTBI **(Moderate Confidence in Inference, Strength of Recommendation: Level B). 1b.** Healthcare providers *should* use validated clinical decision rules to identify children with mTBI at low risk for intracranial injury (ICI), in whom head CT is not indicated, as well as children who

may be at higher risk for clinically important ICI, and therefore may warrant head CT. Existing decision rules combine a variety of factors that, when assessed together, may increase the risk for more serious injury. Such risk factors include the following:

- Age < 2 years old
- Vomiting
- Loss of consciousness
- Severe mechanism of injury
- Severe or worsening headache
- Amnesia
- Nonfrontal scalp hematoma
- Glasgow Coma Score < 15
- Clinical suspicion for skull fracture **(Moderate, Level B).**

1c. For children diagnosed with mTBI, healthcare providers *should* discuss the risks of pediatric head CT in the context of risk factors for ICI with the patient and his/her family **(Moderate, Level B).**

Rationale: Up to 7.5% of children presenting to the ED with mTBI will have intracranial injury.[13-27] Identification of risk factors for ICI in children presenting with possible mTBI in the acute setting is important to the diagnosis of more severe forms of TBI, further directing observation and the possible need for emergent head CT. ICI further influences the prognosis of patients with mTBI (see Prognosis Recommendations). Moderate evidence indicates that several risk factors identify patients with increased risk of ICI.[15,17,28-30] However, risk factors generally are not sufficiently predictive in isolation to guide clinical care. Instead, strong clinical evidence shows that use of clinical decision rules that combine multiple risk factors are more effective in identifying children at low risk for ICI.[15,17,28,30] The use of clinical decision rules may minimize the risk of failure to identify important ICI while avoiding unnecessary radiation exposure from head CT. Head CT is the preferred diagnostic tool in acute care settings to rapidly identify ICI. However, higher doses of radiation attributable to this type of imaging in children have been associated with an increase in the lifetime cancer mortality risk.[31-34] Further, certain pediatric populations will require sedation in order to obtain adequate neuroimaging, increasing the overall risk related to imaging processes.[35] Families require clinical counseling regarding these risks to understand best practices for the clinical care of their child. They should be aware that, following seemingly minor head injuries and mTBI, ICI resulting in clinically important outcomes, such as neurosurgical intervention, is rare.[13-15,20-22,24,28,36-43] Clinical evaluation of the child with possible mTBI includes balancing the likelihood of potentially devastating complications of a more severe injury against the risks associated with head CT (as well as possible concomitant sedation for imaging).

Brain Magnetic Resonance Imaging (MRI)

Recommendation #2: Healthcare providers *should not* routinely use MRI in the acute evaluation of suspected or diagnosed mTBI **(Moderate, Level B).**

Rationale: No study met inclusion criteria addressing the use of brain MRI in the diagnosis of mTBI in children. MRI is more sensitive in identifying structural abnormalities than CT,[44,45] and MRI avoids the use of ionizing radiation associated with CT. Nevertheless, MRI more often requires sedation due to longer imaging acquisition times, and is more expensive than CT; however, the recent employment of rapid sequence MRI in non-sedated patients has been successfully employed in children with suspected acute TBI.[46]

Single Photon Emission Computed Tomography (SPECT)

Recommendation #3: Healthcare providers *should not* use SPECT in the acute evaluation of cases of suspected or diagnosed mTBI **(Moderate, Level B).**

Rationale: The systematic review did not find any study that met our inclusion criteria addressing the use of SPECT in the diagnosis of mTBI in children. Further, SPECT is not commonly used in the clinical setting of TBI in children, may require patient sedation, requires intravenous access in the child with the injection of a radiopharmeceutical, and may be more expensive than head CT alone as it is often employed in conjunction with CT.

Skull X-ray

Recommendation #4: 4a. Skull X-rays *should not* be used in the diagnosis of pediatric mTBI **(High, Level B). 4b.** Skull X-rays *should not* be used in the screening for ICI **(High, Level B).**

Rationale: The systematic review identified two Class III studies evaluating the use of skull X-rays in children following minor head injury. One study identified a possible skull fracture in 7.1% (95% CI, 4.0-10.3%) of patients.[14] X-ray is not the optimal test to diagnose skull fracture with ICI following mTBI for several reasons, specifically: the literature reports that skull X-ray has a 63% sensitivity for diagnosing a single skull fracture in children; X-ray cannot detect intracranial injuries such as hemorrhage, shift from midline, or edema; and X-ray employs radiation for imaging.[47] Clinical suspicion for skull fracture is a risk factor for other ICI following mTBI in children.[17,28-30] Neuroimaging modalities, such as head CT, better detect intracranial injuries, including skull fractures, making it the more appropriate diagnostic imaging choice when imaging is clinically indicated.

Neuropsychological Tools: Symptom Scales, Computerized Cognitive Testing, and Standardized Assessment of Concussion

Recommendation #5. 5a. Healthcare providers *should* use an age-appropriate, validated symptom rating scale as a component of the diagnostic evaluation in children presenting with acute mTBI **(Moderate, Level B). 5b.** Healthcare providers *may* use validated, age-appropriate computerized cognitive testing in the acute period of injury as a component of the diagnosis of mTBI **(Moderate, Level C). 5c.** The Standardized Assessment of Concussion (SAC) *should not* be exclusively used to diagnose mTBI in children 6-18 years of age **(Moderate, Level B).**

Rationale: The consequences of missing a diagnosis of mTBI include failure to recommend appropriate treatment and management. In addition, an undiagnosed mTBI may contribute to the prolongation of symptoms and an increased risk of re-injury. The systematic review concluded that the Graded Symptom Checklist (GSC) is useful in distinguishing children ages 6 years and older with mTBI from those without TBI within the first 2 days after injury.[48] The review concluded that the Post-concussion Symptom Scale used in the ImPACT neurocognitive testing battery distinguishes high school athletes with mTBI from those without TBI within the first 4 days after injury.[49,50] There are several other validated symptom scales that are reliable in the diagnosis of mTBI and have demonstrated validity at ages younger than high school.[51] Symptom inventories can be applied quickly and inexpensively.

Two Class II studies met inclusion criteria related to computerized cognitive testing and the diagnosis of mTBI in children.[49,50] These studies demonstrated that ImPACT cognitive testing probably distinguishes high school athletes with and without mTBI in the first 4 days post-injury and may add sensitivity to use of a symptom rating scale alone.[49,50] While these two studies only reviewed ImPACT testing, related evidence demonstrates that other validated computerized cognitive tests are also able to discriminate between children with and without mTBI.[52,53]

The systematic review demonstrated that cognitive screening using the Standardized Assessment of Concussion was not accurate in distinguishing those children with mTBI from those without mTBI due to lack of statistical significance from a single Class III study.[48]

Serum Markers

Recommendation #6: Healthcare providers *should not* utilize biomarkers outside of a research setting for the diagnosis of children with mTBI **(High, Level R).**

Rationale: There is insufficient evidence to currently recommend any of the studied biomarkers for the diagnosis of mTBI in children. In two Class II studies, S100B was shown to be associated with a low sensitivity but high specificity in severe TBI patients, with no discrimination in mild to moderate TBI.[54,55] In a Class II study, Tau was significantly different across pediatric mTBI patients with normal head CT, abnormal CT, and with non-TBI control subjects.[56] A single Class II study explored the use of autoantibodies against glutamate receptors and oxide metabolites as a marker to discriminate between severe and mild pediatric TBI.[57] There was good discrimination between the two groups; however, further data is needed. A single Class III study examined multiplex bead array biomarkers in a small number of infants with TBI compared to controls and found significant differences in a number of biomarkers.[58] Related studies have demonstrated associations between neuronal ubiquitin C-terminal hydrolase-L1 and glial fibrillary acidic protein biomarker levels and ICI in adults;[59-62] however, a single Class II study of 23 children found insufficient evidence for the use of these biomarkers in distinguishing children with or without mTBI.[63]

Prognostic Recommendations

This section contains recommendations related to counseling on prognosis, assessment of premorbid history and cumulative risk, use of tools to track recovery, and interventions for patients with a poor prognosis.

General Healthcare Provider Counseling of Prognosis

Recommendation #7. 7a. Healthcare providers *should* counsel patients and families that a large majority (70-80%) of children with mTBI do not show significant difficulties that last more than 1-3 months post-injury **(Moderate, Level B). 7b.** Healthcare providers *should* counsel patients and families that although some factors predict an increased or decreased risk for prolonged symptoms, each child's recovery from mTBI is unique and will follow its own trajectory **(Moderate, Level B).**

Rationale: Recovery from pediatric mTBI is variable,[64-66] and no single factor can predict symptom resolution or outcome.[67] Symptoms experienced by the majority of children with mTBI resolve within

1-3 months post-injury.[64] A single Class III study reported that providing informational booklets to families that counseled on symptoms and coping strategies for children with mTBI resulted in improved patient outcomes at 3 months.[68] Related studies in children and adults with mTBI report direct patient benefits of counseling by healthcare providers.[69,70] Public health campaigns have emphasized the importance of parent and family education in mTBI because health outcomes, in general, are optimized through patient health literacy and the resulting behavior modifications.[71-73] Important aspects of healthcare provider counseling are outlined in Recommendation #12.

Prognosis Related to Premorbid Conditions

Recommendation #8: 8a. Healthcare providers *should* assess the premorbid history of children either prior to injury as a part of pre-participation athletic examinations, or as soon as possible post-injury in children with mTBI, to assist in determining prognosis **(Moderate, Level B)**. **8b.** Healthcare providers *should* counsel children and families completing pre-participation athletic examinations and children with mTBI as well as their families that recovery from mTBI might be delayed in those with:

- Premorbid histories of mTBI
- Lower cognitive ability (for children with an intracranial lesion)
- Neurological or psychiatric disorder
- Learning difficulties
- Increased pre-injury symptoms (i.e., similar to those commonly referred to as "postconcussive")
- Family and social stressors **(Moderate, Level B)**.

Rationale: Evidence of varying strength indicates that there is an increased risk of delayed recovery or prolonged symptoms associated with the premorbid conditions listed above in children with mTBI.[74-80]

Assessment of Cumulative Risk Factors and Prognosis

Recommendation #9. 9a. Healthcare providers *should* screen for known risk factors for persistent symptoms in children with mTBI. **(High, Level B) 9b**. Healthcare providers *may* use validated prediction rules, which combine information about multiple risk factors for persistent symptoms, to provide prognostic counseling to children with mTBI evaluated in ED settings **(High, Level C).**

Rationale: Evidence of varying strength indicates that a variety of noninjury (e.g., demographic) and injury-related factors predict outcomes in pediatric mTBI. Specifically, symptoms may last longer among older children/adolescents,[64,81,82] children of Hispanic ethnicity (as compared with White ethnicity),[82] children of lower socioeconomic status,[80,82] children with more severe presentations of mTBI[66,83,84] (including those associated with intracranial injury),[83,85] and children reporting more acute postconcussion symptoms.[65,75,86] Additionally, headaches persist longer in girls.[81] However, no single factor is strongly predictive of outcome.[67] A 2016 study of 3,063 children with mTBI seen in the ED demonstrated that an empirically derived set of risk factors predicted the risk of persistent postconcussion symptoms at 28 days.[87]

Assessment Tools and Prognosis

Recommendation #10. 10a. Healthcare providers *should* use a combination of tools to assess recovery in children with mTBI **(Moderate, Level B). 10b.** Healthcare providers *should* use validated symptom

scales to assess recovery in children with mTBI **(Moderate, Level B). 10c.** Healthcare providers *may* use validated cognitive testing (including measures of reaction time) to assess recovery in children with mTBI **(Moderate, Level C). 10d.** Healthcare providers *may* use balance testing to assess recovery in adolescent athletes with mTBI **(Moderate, Level C).**

Rationale: No single assessment tool is strongly predictive of outcome in children with mTBI.[67] However, multiple tools have shown utility in the assessment of individual patients and their recovery from mTBI.[88-90] Symptom scales and cognitive testing (including measures of reaction time) have the strongest evidence in terms of their contribution to predicting outcomes and assessing recovery.[91] Less evidence supports balance testing as a predictor for prognosis in children, but it has shown utility in older adolescent athletes.[92]

Interventions for mTBI with Poor Prognosis

Recommendation #11. 11a. Healthcare providers *should* closely monitor children with mTBI who are determined to be at high risk for persistent symptoms based on premorbid history, demographics, and/or injury characteristics **(Low, Level B). 11b.** For children with mTBI whose symptoms do not resolve as expected with standard care (i.e., within 4-6 weeks), healthcare providers *should* provide or refer for appropriate assessments and/or interventions **(Moderate, Level B).**

Rationale: The symptoms experienced by the majority of children with mTBI resolve within 1-3 months post-injury,[64] but some children are at risk for persistent symptoms and delayed recovery (i.e., those who demonstrate certain premorbid characteristics and other risk factors; see recommendations 8 and 9). Children with mTBI who are at high risk for persistent symptoms or delayed recovery are more likely to require intervention than children at low risk. Healthcare providers can more effectively counsel patients with mTBI when they have assessed prognostic risk factors.

<u>Recommendations Related to Management and Treatment</u>

This section contains recommendation related to the provision of patient/family education, counseling related to physical/cognitive rest, assessment of patient psychosocial/emotional support, and managing a patient's return to school. In addition, this section contains recommendation related to the treatment/management of headache, vestibulo-oculomotor dysfunction, sleep problems, and cognitive impairment.

Patient/Family Education and Reassurance

Recommendation #12: In providing education and reassurance to the family, the healthcare provider *should* include the following information:

- Warning signs of more serious injury
- Description of injury and expected course of symptoms and recovery
- Instructions on how to monitor postconcussive symptoms
- Prevention of further injury
- Management of cognitive and physical activity/rest
- Instructions regarding return to play/recreation and school
- Clear clinician follow-up instructions **(High, Level A).**

Rationale: There is no definitive evidence to indicate that specific methods of patient and family education and reassurance following pediatric mTBI are associated with clear improvements in patient health outcomes. Regardless, public health campaigns have emphasized the importance of parent and family education in mTBI because health outcomes in general are optimized through health literacy and the resulting behavior modifications.[71-73] Patient and family education and reassurance are key components of mTBI care initiatives and ED discharge instructions.[68-70,93] Standardized processes of evaluation and discharge instruction provide significant benefit with respect to pediatric mTBI patient outcomes.[69]

Cognitive/physical rest and aerobic treatment

Recommendation #13. 13a. Healthcare providers *should* counsel patients to observe more restrictive physical and cognitive activity during the first several days following mTBI in children **(Moderate, Level B). 13b.** Following these first several days, healthcare providers *should* counsel patients and families to resume a gradual schedule of activity that does not exacerbate symptoms, with close monitoring of symptom expression (number, severity) **(Moderate, Level B). 13c.** Following the successful resumption of a gradual schedule of activity (see 13b), healthcare providers should offer an active rehabilitation program of progressive reintroduction of noncontact aerobic activity that does not exacerbate symptoms, with close monitoring of symptom expression (number, severity) **(High, Level B). 13d.** Healthcare providers *should* counsel patients to return to full activity when they return to premorbid performance if they have remained symptom free at rest and with increasing levels of physical exertion **(Moderate, Level B).**

Rationale: Historically, "rest" has been a foundation in the treatment of acute mTBI.[94,95] However, scientific evidence supporting its timing, duration, and efficacy is limited.[96] Related evidence suggests that rest or reduction in cognitive/physical activity is beneficial immediately following mTBI and, for those who are slow to recover, may help accelerate recovery.[97-99] The post-injury period is a posited temporal window of vulnerability for re-injury,[100,101] because the re-injury threshold is lower during recovery and the symptom burden may be greater.[102-104] On the other hand, studies in children and adults with prolonged symptoms beyond 4 weeks demonstrate that physical exercise managed below symptom exacerbation reduced postconcussive symptoms in active rehabilitation models.[105-108]

The optimal timing to initiate an aerobic program following pediatric mTBI has not been established, and only a limited number of studies have applied this treatment to patients with symptoms persisting past 4 weeks.[105-107] Related evidence suggests that early rest (within the first 3 days of injury) may be beneficial,[94,109] but that inactivity beyond this time period for most children may worsen their self-reported symptoms.[110]

Psychosocial/Emotional Support

Recommendation #14: Healthcare providers *may* assess the extent and types of social support (i.e., emotional, informational, instrumental, appraisal) available to children with mTBI and emphasize social support as a key element in the education of caregivers and educators **(Moderate, Level C).**

Rationale: Social support has proven useful in promoting the recovery of persons with TBI, particularly those with cognitive deficits.[104,111] Limited research with those who have suffered aa mTBI

demonstrates similar benefits.[112,113] Direct, ancillary, and extrapolated evidence is strongly suggestive of the utility of social support in the management of mTBI.

Return to School

Recommendation #15: 15a. To assist children returning to school following mTBI, medical and school-based teams *should* counsel the student and family regarding the process of gradually increasing the duration and intensity of academic activities as tolerated, with the goal of increasing participation without significantly exacerbating symptoms **(Moderate, Level B). 15b.** Return to school protocols *should* be customized based on the severity of postconcussion symptoms in children with mTBI as determined jointly by medical and school-based teams **(Moderate, Level B). 15c.** For any student with prolonged symptoms that interfere with academic performance, school-based teams *should* assess the educational needs of that student and determine the student's need for additional educational supports, including those described under pertinent federal statutes (e.g., Section 504, IDEA)[114] **(High, Level B). 15d.** Postconcussion symptoms and academic progress in school *should* be monitored collaboratively by the student, family, healthcare provider(s), and school teams, who jointly determine what modifications or accommodations are needed to maintain an academic workload without significantly exacerbating symptoms **(High, Level B). 15e.** The provision of educational supports *should* be monitored and adjusted on an ongoing basis by the school-based team until the student's academic performance has returned to preinjury levels **(Moderate, Level B). 15f.** For students who demonstrate prolonged symptoms and academic difficulties despite an active treatment approach, healthcare providers *should* refer the child for a formal evaluation by a specialist in pediatric mTBI **(Moderate, Level B).**

Rationale: Return to school following mTBI must be carefully planned given the adverse effects (e.g., headaches and fatigue interfering with learning, greater problems concentrating on schoolwork, difficulty taking notes) that can affect learning and performance.[115,116] Limited evidence exists to guide the timing or progression of return to activity in relation to academic activities.[110] Consensus-based recommendations for returning to school after mTBI attempt to minimize cognitive and physical overexertion.[95] Return to school protocols affirm the need for continued collaboration among medical, school, and family systems to gradually adjust interventions and return the child to full participation without significant worsening of symptoms.[95,115,117-120] The protocols target the student's symptoms as the focus of intervention, linking specific accommodations in efforts to limit symptom expression. Because postconcussive symptoms resolve at different rates in different children after mTBI, individualization of return to school programming is necessary. To protect their legal right to an appropriate education, children with mTBI who have a greater symptom burden and prolonged recoveries may require formal educational planning incorporating protections under federal statutes.[114,121]

Post-traumatic Headache Treatment/Management

Recommendation #16. 16a. Healthcare providers in the ED *should* clinically observe and consider obtaining a head CT in children presenting with severe and worsening headache following mTBI to evaluate for ICI requiring further management in accordance with validated clinical decision making rules **(High, Level B). 16b.** Children undergoing observation periods for headache with acutely worsening symptoms *should* undergo emergent neuroimaging **(High, Level B). 16c.** Healthcare

providers and caregivers *should* offer non-opioid analgesia (i.e., ibuprofen or acetaminophen) to children with painful headache following acute mTBI, but also provide counseling to the family regarding the risks of analgesic overuse, including rebound headache **(Moderate, Level B). 16d.** Healthcare providers *should not* administer 3% hypertonic saline to children with mTBI for treatment of acute headache outside of a research setting at this time **(Moderate, Level R). 16e.** Chronic headache following mTBI is likely to be multifactorial, and, therefore, healthcare providers *should* refer children with chronic headache after mTBI for multidisciplinary evaluation and treatment, with consideration of analgesic overuse as a contributory factor **(High, Level B).**

Rationale: Children presenting with a headache, including worsening or severe headache, following mTBI are probably at moderate risk for ICI reflected by risk difference of 1.9% (95% CI, 0.1%-3.6%) from three Class I studies and one Class II study.[15,17,28,30] This evidence supports that the risk of not identifying more severe forms of TBI presenting with a progressive, severe headache in a child with or without other risk factors outweighs the risk of ionizing radiation. Painful headache in children requires intervention. Non-opioid analgesics such as ibuprofen and acetaminophen are often effective in treating headaches in children, and opioids are not generally recommended as therapy for headaches.[122-124] Non-opioid analgesic overuse carries important risks of toxicity and rebound headache.[125] There is insufficient evidence to currently recommend the administration of 3% hypertonic saline as a treatment for acute headache following mTBI in children. In children in the ED, a single Class I study found that 3% hypertonic saline possibly decreases pain with headache immediately following administration, but not at 3 days post intervention.[126]

Vestibulo-oculomotor Dysfunction Treatment/Management

Recommendation #17: Healthcare providers *may* refer children with subjective or objective evidence of persistent vestibulo-oculomotor dysfunction following mTBI to a program of vestibular rehabilitation **(Moderate, Level C).**

Rationale: A single Class II study reported that vestibular and oculomotor dysfunction may contribute to the diagnosis of mTBI and longer symptom duration.[127] Limited evidence suggests that early vestibular physical therapy may be of benefit for patients presenting with subjective complaints (symptom of dizziness) or objective physical examination findings.[128-131]

Sleep Treatment/Management

Recommendation #18. 18a. Healthcare providers *should* provide guidance on proper sleep hygiene methods to facilitate recovery from pediatric mTBI. **(Moderate, Level B). 18b.** If sleep problems emerge or continue despite appropriate sleep hygiene measures, healthcare providers *may* refer children with mTBI to a sleep disorder specialist for further assessment **(Moderate, Level C).**

Rationale: Receiving adequate sleep has been shown to facilitate health,[132] and when not adequate, adversely affects medical conditions, including TBI.[133-135] While limited evidence supports a recommendation for sleep hygiene specifically in children with mTBI, related evidence in adults with TBI indicates benefits, suggesting that the maintenance of appropriate sleep and management of disrupted sleep may be a critical target of treatment for the child with mTBI.[136-138]

Cognitive Impairment Treatment/Management

Recommendation #19. 19a. Healthcare providers *should* attempt to determine the etiology of cognitive dysfunction, within the context of other mTBI symptoms **(Moderate, Level B). 19b.** Healthcare providers *should* recommend treatment for cognitive dysfunction that reflects its presumed etiology **(High, Level B). 19c**. Healthcare providers *may* refer children with persisting complaints related to cognitive function for a formal neuropsychological evaluation to assist in determining etiology and recommending targeted treatment (**High, Level C).**

Rationale: Cognitive impairment occurs following mTBI and includes the following areas: attention, memory and learning, response speed, and aspects of executive functions.[49,50,139,140] Cognitive impairment may be directly related to the pathology of the brain injury (i.e., impaired neurotransmission) but may also reflect secondary effects of other symptoms (e.g., ongoing headache pain, fatigue/low energy, low frustration tolerance) that may produce a disruption in cognitive processing. Neuropsychological evaluations can assist in determining etiology of cognitive impairment and directing treatment.[140]

Conclusions and Future Directions

The science of managing mTBI in children is rapidly evolving and expanding. This guideline identifies best practices based on current evidence; updates may be made as the body of evidence grows. Suggestions related to key future directions for research are described in the systematic review that informed this guideline.[10]

Equally as important as the development of this guideline is a multifaceted approach to its implementation.[141,142] The CDC created user-friendly implementation materials[143] that are concise and actionable.[142] These materials include a screening tool, online training, fact sheets, and a clinical algorithm. Patient discharge instructions, inclusive of a return to activity protocol, and symptom-based recovery tips were also created.[144] The CDC will leverage its HEADS UP campaign (www.cdc.gov/HEADSUP) to support distribution of the guideline implementation materials through leading organizations and digital platforms (i.e., web, mobile, electronic health records). Partner organizations' efforts are critical to ensure sustainability of this effort nationwide. Finally, examining the effectiveness of the guideline and implementation materials is a research priority of CDC's Injury Center;[145] evaluation is crucial for understanding the impact of the recommendations, both intended and unintended, and for revising future recommendations and implementation materials.

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Conflicts of Interest

CDC authors disclose that they have no conflicts of interest.

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References

1. Mannix R, O'Brien MJ, Meehan WP 3rd. The epidemiology of outpatient visits for minor head injury: 2005 to 2009. *Neurosurgery*. 2013;73(1):129-134. doi:10.1227/01.neu.0000429846.14579.41.
2. Babcock L, Byczkowski T, Wade SL, Ho M, Mookerjee S, Bazarian JJ. Predicting postconcussion syndrome after mild traumatic brain injury in children and adolescents who present to the emergency department. *JAMA Pediatr.* 2013;167(2):156-161. doi:10.1001/jamapediatrics.2013.434.
3. Lee H, Wintermark M, Gean AD, Ghajar J, Manley GT, Mukherjee P. Focal lesions in acute mild traumatic brain injury and neurocognitive outcome: CT versus 3T MRI. *J Neurotrauma.* 2008;25:1049-1056. doi:10.1089/neu.2008.0566.
4. Hessen E, Nestvold K. Indicators of complicated mild TBI predict MMPI-2 scores after 23 years. *Brain Inj.* 2009;23:234-242. doi: 10.1080/02699050902748349.
5. Dikmen S, Machamer J, Fann JR, Temkin NR. Rates of symptom reporting following traumatic brain injury. *J Int Neuropsychol Soc.* 2010;16:401-411. doi:10.1017/S1355617710000196.
6. Jagoda AS, Bazarian JJ, Bruns JJ Jr, et al. Clinical policy: neuroimaging and decisionmaking in adult mild traumatic brain injury in the acute setting. *Ann Emerg Med*. 2008;52(6):714-748. doi:10.1016/j.annemergmed.2008.08.021.
7. Marshall S, Bayley M, McCullagh S, Velikonja D, Berrigan L. Clinical practice guidelines for mild traumatic brain injury and persistent symptoms. *Can Fam Physician*. 2012;58(3):257-267.
8. Sports concussion resources. American Academy of Neurology website. http://www.aan.com/go/practice/concussion. Accessed May 24, 2016.
9. Zemek R, Duval S, Dematteo C, et al. *Guidelines for Diagnosing and Managing Pediatric Concussion: Recommendations for Health Care Professionals.* Toronto, ON: Ontario Neurotrauma Foundation; 2014.
10. MISSING (SR Reference for same JAMA Pediatrics issue).
11. Centers for Disease Control and Prevention. Report from the pediatric mild traumatic brain injury guideline workgroup: systematic review and clinical recommendations for healthcare providers on the diagnosis and management of mild traumatic brain injury among children. https://www.cdc.gov/injury/pdfs/bsc/systemicreviewcompilation_august_2016.pdf. Accessed May 19, 2017.
12. Gronseth GS, Woodroffe LM, Getchius TSD. *Clinical Practice Guideline Process Manual*. St. Paul, MN: American Academy of Neurology; 2011.
13. Fabbri A, Servadei F, Marchesini G, Raggi A, Vandelli A. Analysis of different decision aids for clinical use in pediatric head injury in an emergency department of a general hospital. *J Trauma*. 2011;70(5):E79-83. doi:10.1097/TA.0b013e3181d4885a.
14. Boran BO, Boran P, Barut N, Akgun C, Celikoglu E, Bozbuga M. Evaluation of mild head injury in a pediatric population. *Pediatr Neurosurg*. 2006;42(4):203-207.
15. Osmond MH, Klassen TP, Wells GA, et al. CATCH: a clinical decision rule for the use of computed tomography in children with minor head injury. *CMAJ*. 2010;182(4):341-348.
16. Dietrich AM, Bowman MJ, Ginn-Pease ME, Kosnik E, King DR. Pediatric head injuries: can clinical factors reliably predict an abnormality on computed tomography? *Ann Emerg Med*. 1993;22(10):1535-1540.
17. Palchak MJ, Holmes JF, Vance CW, et al. A decision rule for identifying children at low risk for brain injuries after blunt head trauma. *Ann Emerg Med*. 2003;42(4):492-506.

18. Atabaki SM, Stiell IG, Bazarian JJ, et al. A clinical decision rule for cranial computed tomography in minor pediatric head trauma. *Arch Pediatr Adolesc Med*. 2008;162(5):439-445. doi:10.1001/archpedi.162.5.439.
19. Chan HC, Aasim WA, Abdullah NM, et al. Characteristics and clinical predictors of minor head injury in children presenting to two Malaysian accident and emergency departments. *Singapore Med J*. 2005;46(5):219-223.
20. Schunk JE, Rodgerson JD, Woodward GA. The utility of head computed tomographic scanning in pediatric patients with normal neurologic examination in the emergency department. *Pediatr Emerg Care*. 1996;12(3):160-165.
21. Davis RL, Mullen N, Makela M, Taylor JA, Cohen W, Rivara FP. Cranial computed tomography scans in children after minimal head injury with loss of consciousness. *Ann Emerg Med*. 1994;24(4):640-645. doi:http://dx.doi.org/10.1016/S0196-0644(94)70273-X.
22. Simon B, Letourneau P, Vitorino E, McCall J. Pediatric minor head trauma: indications for computed tomographic scanning revisited. *J Trauma*. 2001;51(2):231-237;discussion 237-238.
23. Fundaro C, Caldarelli M, Monaco S, et al. Brain CT scan for pediatric minor accidental head injury. An Italian experience and review of literature. *Childs Nerv Syst*. 2012;28(7): 1063-1068. doi: 10.1007/s00381-012-1717-9.
24. Bramley H, Mcfarland C, Lewis MM, et al. Short-term outcomes of sport- and recreation-related concussion in patients admitted to a pediatric trauma service. *Clin Pediatr (Phila)*. 2014;53(8):784-790. doi:10.1177/0009922814533403.
25. Gülşen I, Ak H, Karadaş S, Demır I, Bulut MD, Yaycioğlu S. Indications of brain computed tomography scan in children younger than 3 years of age with minor head trauma. *Emerg Med Int*. 2014;1-4. doi:10.1155/2014/248967.
26. Katirci Y, Ocak T, Karamercan MA, et al. Compliance with catch rules in administering computerized tomography scans to children admitted to the emergency department with minor head trauma. *Acta Medica Mediterranea*. 2013;29:717-722.
27. Dunning J, Daly JP, Lomas JP, Lecky F, Batchelor J, Mackway-Jones K. Derivation of the children's head injury algorithm for the prediction of important clinical events decision rule for head injury in children. *Arch Dis Child*. 2006;91(11):885-891. doi:10.1136/adc.2005.083980.
28. Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet*. 2009;374(9696):1160-1170. doi:10.1016/S0140-6736(09)61558-0.
29. Greenes DS, Schutzman SA. Clinical significance of scalp abnormalities in asymptomatic head-injured infants. *Pediatr Emerg Care*. 2001;17(2):88-92.
30. Sun BC, Hoffman JR, Mower WR. Evaluation of a modified prediction instrument to identify significant pediatric intracranial injury after blunt head trauma. *Ann Emerg Med*. 2007;49(3):325-332, 332.e1.
31. Berrington de Gonzalez A, Salotti JA, McHugh K, et al. Relationship between paediatric CT scans and subsequent risk of leukaemia and brain tumours: assessment of the impact of underlying conditions. *Br J Cancer*. 2016;114(4):388-394. doi:10.1038/bjc.2015.415.
32. Journy N, Ancelet S, Rehel JL, et al. Predicted cancer risks induced by computed tomography examinations during childhood, by a quantitative risk assessment approach. *Radiat Environ Biophys*. 2014;53(1):39-54. doi:10.1007/s00411-013-0491-8.
33. Pearce MS, Salotti JA, Little MP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. *Lancet*. 2012;380(9840):499-505. doi:10.1016/S0140-6736(12)60815-0.

34. Miglioretti DL, Johnson E, Williams A, et al. The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. *JAMA Pediatr*. 2013;167(8):700-707. doi:10.1001/jamapediatrics.2013.311.
35. Moro-Sutherland DM, Algren JT, Louis PT, Kozinetz CA, Shook JE. Comparison of intravenous midazolam with pentobarbital for sedation for head computed tomography imaging. *Acad Emerg Med*. 2000;7(12):1370-1375.
36. Halley MK, Silva PD, Foley J, Rodarte A. Loss of consciousness: when to perform computed tomography? *Pediatr Crit Care Med*. 2004;5(3):230-233.
37. Quayle KS, Jaffe DM, Kuppermann N, et al. Diagnostic testing for acute head injury in children: when are head computed tomography and skull radiographs indicated? *Pediatrics*. 1997;99(5):E11.
38. Melo JR, Lemos-Júnior LP, Reis RC, et al. Do children with Glasgow 13/14 could be identified as mild traumatic brain injury? *Arq Neuropsiquiatr*. 2010;68(3):381-384.
39. Bainbridge J, Khirwadkar H, Hourihan MD. Vomiting—is this a good indication for CT head scans in patients with minor head injury? *Br J Radiol*. 2012;85:183-186. doi:http://dx.doi.org/10.1259/bjr/56169980.
40. Bressan S, Steiner IP, Mion T, Berlese P, Romanato S, Da Dalt L. The Pediatric Emergency Care Applied Research Network intermediate-risk predictors were not associated with scanning decisions for minor head injuries. *Acta Paediatr*. 2015;104(1):47-52. doi:10.1111/apa.12797.
41. Schonfeld D, Fitz BM, Nigrovic LE. Effect of the duration of emergency department observation on computed tomography use in children with minor blunt head trauma. *Ann Emerg Med*. 2013;62(6):597-603. doi:10.1016/j.annemergmed.2013.06.020.
42. Zhu H, Gao Q, Xia X, Xiang J, Yao H, Shao J. Clinically-important brain injury and CT findings in pediatric mild traumatic brain injuries: a prospective study in a Chinese reference hospital. *Int J Environ Res Public Health*. 2014;11(4):3493-3506. doi:10.3390/ijerph110403493.
43. Hamilton M, Mrazik M, Johnson DW. Incidence of delayed intracranial hemorrhage in children after uncomplicated minor head injuries. *Pediatrics*. 2010;126(1)e:33-39. doi:10.1542/peds.2009-0692.
44. Currie S, Saleem N, Straiton JA, Macmullen-Price J, Warren DJ, Craven IJ. Imaging assessment of traumatic brain injury. *Postgrad Med J*. 2016;92(1083):41-50. doi:10.1136/postgradmedj-2014-133211.
45. Kim JJ, Gean AD. Imaging for the diagnosis and management of traumatic brain injury. *Neurotherapeutics*. 2011;8(1):39-53. doi:10.1007/s13311-010-0003-3.
46. Young JY, Duhaime AC, Caruso PA, Rincon SP. Comparison of non-sedated brain MRI and CT for the detection of acute traumatic injury in children 6 years of age or less. *Emerg Radiol*. 2016;23(4):325-331. doi:10.1007/s10140-016-1392-3.
47. Mulroy MH, Loyd AM, Frush DP, Verla TG, Myers BS, Bass CR. Evaluation of pediatric skull fracture imaging techniques. *Forensic Sci Int*. 2012;214(1-3):167-172. doi:10.1016/j.forsciint.2011.07.050.
48. Grubenhoff JA, Kirkwood M, Gao D, Deakyne S, Wathen J. Evaluation of the standardized assessment of concussion in a pediatric emergency department. *Pediatrics*. 2010;126(4):688-695. doi:10.1542/peds.2009-2804.
49. Lovell MR, Collins MW, Iverson GL, et al. Recovery from mild concussion in high school athletes. *J Neurosurg*. 2003;98:296-301.
50. Schatz P, Pardini JE, Lovell MR, Collins MW, Podell K. Sensitivity and specificity of the ImPACT Test Battery for concussion in athletes. *Arch Clin Neuropsychol*. 2006;21(1):91-99.
51. Gioia GA, Schneider JC, Vaughan CG, Isquith PK. Which symptom assessments and approaches are uniquely appropriate for paediatric concussion? *Br J Sports Med*. 2009;43(suppl 1):i13-i22. doi:10.1136/bjsm.2009.058255.

52. Nelson LD, LaRoche AA, Pfaller AY, et al. Prospective, head-to-head study of three computerized neurocognitive assessment tools (CNTs): reliability and validity for the assessment of sport-related concussion. *J Int Neuropsychol Soc*. 2016;22(1):24-37. doi: 10.1017/S1355617715001101.
53. Nelson LD, Pfaller AY, Rein LE, McCrea MA. Rates and predictors of invalid baseline test performance in high school and collegiate athletes for 3 computerized neurocognitive tests: ANAM, Axon Sports, and ImPACT. *Am J Sports Med*. 2015;43(8):2018-2026. doi:10.1177/0363546515587714.
54. Berger RP, Pierce MC, Wisniewski SR, Adelson PD, Kochanek PM. Serum S100B concentrations are increased after closed head injury in children: a preliminary study. *J Neurotrauma*. 2002;19(11):1405-1409. doi:10.1089/089771502320914633.
55. Geyer C, Ulrich A, Gräfe G, Stach B, Till H. Diagnostic value of S100B and neuron-specific enolase in mild pediatric traumatic brain injury. *J Neurosurg Pediatr*. 2009;4(4):339-344. doi:10.3171/2009.5.PEDS08481.
56. Güzel A, Karasalihoglu S, Aylanç H, Temizöz O, Hiçdönmez T. Validity of serum tau protein levels in pediatric patients with minor head trauma. *Am J Emerg Med*. 2010;28(4):399-403. doi:10.1016/j.ajem.2008.12.025.
57. Sorokina EG, Semenova ZhB, Bazarnaya NA, et al. Autoantibodies to glutamate receptors and products of nitric oxide metabolism in serum in children in the acute phase of craniocerebral trauma. *Neurosci Behav Physiol*. 2009;39(4):329-334. doi:10.1007/s11055-009-9147-1.
58. Berger RP, Ta'asan S, Rand A, Lokshin A, Kochanek P. Multiplex assessment of serum biomarker concentrations in well-appearing children with inflicted traumatic brain injury. *Pediatr Res*. 2009;65(1):97-102. doi:10.1203/PDR.0b013e31818c7e27.
59. Papa L, Brophy GM, Welch RD, et al. Time course and diagnostic accuracy of glial and neuronal blood biomarkers GFAP and UCH-L1 in a large cohort of trauma patients with and without mild traumatic brain injury. *JAMA Neurol*. 2016;73(5):551-560. doi:10.1001/jamaneurol.2016.0039.
60. Papa L, Lewis LM, Silvestri S, et al. Serum levels of ubiquitin C-terminal hydrolase distinguish mild traumatic brain injury from trauma controls and are elevated in mild and moderate traumatic brain injury patients with intracranial lesions and neurosurgical intervention. *J Trauma Acute Care Surg*. 2012;72(5):1335-1344. doi:10.1097/TA.0b013e3182491e3d.
61. Kou Z, Gattu R, Kobeissy F, et al. Combining biochemical and imaging markers to improve diagnosis and characterization of mild traumatic brain injury in the acute setting: results from a pilot study. *PloS One*. 2013;8(11):e80296. doi:10.1371/journal.pone.0080296.
62. Welch RD, Ayaz SI, Lewis LM, et al. Ability of serum glial fibrillary acidic protein, ubiquitin c-terminal hydrolase-L1, and s100b to differentiate normal and abnormal head computed tomography findings in patients with suspected mild or moderate traumatic brain injury. *J Neurotrauma*. 2016;33(2):203-214. doi:10.1089/neu.2015.4149.
63. Babcock L, McClanahan N, Ho ML. Uchl-1 and Gfap: are these promising acute diagnostic biomarkers for children with mild traumatic brain injury? Paper presented at: American Academy of Pediatrics; October 25, 2013; Orlando, FL.
64. Barlow KM, Crawford S, Stevenson A, Sandhu SS, Belanger F, Dewey D. Epidemiology of postconcussion syndrome in pediatric mild traumatic brain injury. *Pediatrics*. 2010;126(2):e374-381. doi:10.1542/peds.2009-0925.
65. Babikian T, Satz P, Zaucha K, Light R, Lewis RS, Asarnow RF. The UCLA longitudinal study of neurocognitive outcomes following mild pediatric traumatic brain injury. *J Int Neuropsychol Soc*. 2011;17(5):886-895. doi:10.1017/S1355617711000907.

66. Yeates KO, Taylor HG, Rusin J, et al. Longitudinal trajectories of post-concussive symptoms in children with mild traumatic brain injuries and their relationship to acute clinical status. *Pediatrics*. 2009;123(3):735-743. doi:10.1542/peds.2008-1056.
67. Zemek RL, Farion KJ, Sampson M, McGahern C. Prognosticators of persistent symptoms following pediatric concussion: a systematic review. *JAMA Pediatr*. 2013;167(3):259-265. doi:10.1001/2013.jamapediatrics.216.
68. Ponsford J, Willmott C, Rothwell A, et al. Impact of early intervention on outcome after mild traumatic brain injury in children. *Pediatrics*. 2001;108(6):1297-1303.
69. Zuckerbraun NS, Atabaki S, Collins MW, Thomas D, Gioia GA. Use of modified acute concussion evaluation tools in the emergency department. *Pediatrics*. 2014;133(4):635-642. doi:10.1542/peds.2013-2600.
70. Ponsford J, Willmott C, Rothwell A, et al. Impact of early intervention on outcome following mild head injury in adults. *J Neurol Neurosurg Psychiatry*. 2002;73(3):330-332. doi:10.1136/jnnp.73.3.330.
71. Centers for Disease Control and Prevention. HEADS UP. http://www.cdc.gov/headsup. Updated March 14, 2017. Accessed June 16, 2016.
72. Broglio SP, Cantu RC, Gioia GA, et al. National Athletic Trainers' Association position statement: management of sport concussion. *J Athl Train*. 2014;49(2):245-265. doi:10.4085/1062-6050-49.1.07.
73. Adams, RJ. Improving health outcomes with better patient understanding and education. [published online October 14, 2010]. *Risk Manag Healthc Policy*. 2010;3:61-72. doi:10.2147/RMHP.S7500.
74. Castile L, Collins CL, McIlvain NM, Comstock RD. The epidemiology of new versus recurrent sports concussions among high school athletes, 2005-2010. *Br J Sports Med*. 2012;46(8):603-610. doi:10.1136/bjsports-2011-090115.
75. Chrisman SP, Rivara FP, Schiff MA, Zhou C, Comstock RD. Risk factors for concussive symptoms 1 week or longer in high school athletes. *Brain Inj*. 2013;27(1):1-9. doi:10.3109/02699052.2012.722251.
76. Fay TB, Yeates KO, Taylor HG, et al. Cognitive reserve as a moderator of postconcussive symptoms in children with complicated and uncomplicated mild traumatic brain injury. *J Int Neuropsychol Soc*. 2010;16(1):94-105. doi:10.1017/S1355617709991007.
77. Massagli TL, Fann JR, Burington BE, Jaffe KM, Katon WJ, Thompson RS. Psychiatric illness after mild traumatic brain injury in children. *Arch Phys Med Rehabil*. 2004;85(9):1428-1434. doi:10.1016/j.apmr.2003.12.036.
78. Ponsford J, Willmott C, Rothwell A, et al. Cognitive and behavioral outcome following mild traumatic head injury in children. *J Head Trauma Rehabil*. 1999;14(4):360-372.
79. Olsson KA, Lloyd OT, Lebrocque RM, McKinlay L, Anderson VA, Kenardy JA. Predictors of child post-concussion symptoms at 6 and 18 months following mild traumatic brain injury. *Brain Inj*. 2013;27(2):145-157. doi:10.3109/02699052.2012.729286.
80. Max JE, Pardo D, Hanten G, et al. Psychiatric disorders in children and adolescents six-to-twelve months after mild traumatic brain injury. *J Neuropsychiatry Clin Neurosci*. 2013;25(4):272-282. doi:10.1176/appi.neuropsych.12040078.
81. Blume HK, Vavilala MS, Jaffe KM, et al. Headache after pediatric traumatic brain injury: a cohort study. *Pediatrics*. 2012;129(1):e31-e39.

82. Zonfrillo MR, Durbin DR, Koepsell TD, et al. Prevalence of and risk factors for poor functioning after isolated mild traumatic brain injury in children. *J Neurotrauma*. 2014;31(8):722-727. doi:10.1089/neu.2013.3088.
83. Rivara FP, Koepsell TD, Wang J, Temkin N, et al. Disability 3, 12, and 24 months after traumatic brain injury among children and adolescents. *Pediatrics*. 2011;128(5):e1129-e1138. doi:10.1542/peds.2011-0840.
84. Taylor HG, Orchinik LJ, Minich N, et al. Symptoms of persistent behavior problems in children with mild traumatic brain injury. *J Head Trauma Rehabil*. 2015;30(5):302-310. doi:10.1097/HTR.0000000000000106.
85. Levin HS, Hanten G, Roberson G, et al. Prediction of cognitive sequelae based on abnormal computed tomography findings in children following mild traumatic brain injury. *J Neurosurg Pediatr*. 2008;1(6):461-470.
86. Smyth K, Sandhu SS, Crawford S, Dewey D, Parboosingh J, Barlow KM. The role of serotonin receptor alleles and environmental stressors in the development of post-concussive symptoms after pediatric mild traumatic brain injury. *Dev Med Child Neurol*. 2014;56(1):73-77. doi:10.1111/dmcn.12263.
87. Zemek R, Barrowman N, Freedman SB, et al. Clinical risk score for persistent post-concussion symptoms among children with acute concussion in the ED. *JAMA*. 2016;315(10):1014-1025. doi:10.1001/jama.2016.1203.
88. Broglio SP, Puetz TW. The effect of sport concussion on neurocognitive function, self-report symptoms and postural control. *Sports Med*. 2008;38(1):53-67.
89. Davis GA, Iverson GL, Guskiewicz KM, Ptito A, Johnston KM. Contributions of neuroimaging, balance testing, electrophysiology and blood markers to the assessment of sport-related concussion. *Brit J Sports Med*. 2009;43(suppl I):i36-i45. doi:10.1136/bjsm.2009.058123.
90. Ellemberg D, Henry LC, Macciocchi SN, Guskiewicz KM, Broglio SP. Advances in sports concussion assessment: from behavioral to brain imaging measures. *J Neurotrauma*. 2009;26(12):2365-2382. doi:10.1089/neu.2009.0906.
91. Brooks BL, Daya H, Khan S, Carlson HL, Mikrogianakis A, Barlow KM. Cognition in the emergency department as a predictor of recovery after pediatric mild traumatic brain injury. *J Int Neuropsychol Soc*. 2016;22(4):379-387. doi:10.1017/S1355617715001368.
92. Guskiewicz KM. Postural stability assessment following concussion: one piece of the puzzle. *Clin J Sport Med*. 2001;11(3):182-189.
93. Mittenberg JW, Canyock EM, Condit D, Patton C. Treatment of post-concussion syndrome following mild head injury. *J Clin Exp Neuropsychol*. 2001;23(6):829-836.
94. McCrory P, Meeuwisse WH, Aubry M, et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. *Br J Sports Med*. 2013;47(5):250-258. doi:10.1136/bjsports-2013-092313.
95. Halstead ME, Walter KD. American Academy of Pediatrics. Clinical report—sport-related concussion in children and adolescents. *Pediatrics*. 2010;126(3):597-615. doi:10.1542/peds.2010-2005.
96. Silverberg ND, Iverson GL. Is rest after concussion "the best medicine?": recommendations for activity resumption following concussion in athletes, civilians, and military service members. *J Head Trauma Rehabil*. 2013;28(4):250-259. doi:10.1097/HTR.0b013e31825ad658.
97. Moser RS, Schatz P, Glenn M, Kollias KE, Iverson GL. Examining prescribed rest as treatment for adolescents who are slow to recover from concussion. *Brain Inj*. 2015;29(1):58-63. doi:10.3109/02699052.2014.964771.

940 98. Moser RS, Glatts C, Schatz P. Efficacy of immediate and delayed cognitive and physical rest
941 following sports-related concussion. *J Pediatr*. 2012;161(5):922-926.
942 doi:10.1016/j.jpeds.2012.04.012.
943 99. Brown NJ, Mannix RC, O'Brien MJ, Gostine D, Collins MW, Meehan WP 3rd. Effect of cognitive
944 activity level on duration of post-concussion symptoms. *Pediatrics*. 2014;133(2):e299-304.
945 doi:10.1542/peds.2013-2125.
946 100. Prins ML, Alexander D, Giza CC, Hovda DA. Repeated mild traumatic brain injury: mechanisms of
947 cerebral vulnerability. *J Neurotrauma*. 2013;30(1):30-38. doi:10.1089/neu.2012.2399.
948 101. Giza CC, Griesbach GS, Hovda DA. Experience-dependent behavioral plasticity is disturbed
949 following traumatic injury to the immature brain. *Behav Brain Res*. 2005;157(1):11-22.
950 102. Terwilliger VK, Pratson L, Vaughan CG, Gioia GA. Additional post-concussion impact exposure may
951 affect recovery in adolescent athletes. *J Neurotrauma*. 2016;33(8):761-765.
952 doi:10.1089/neu.2015.4082.
953 103. Weinstein E, Turner M, Kuzma BB, Feuer H. Second impact syndrome in football: new imaging and
954 insights into a rare and devastating condition. *J Neurosurg Pediatr*. 2013;11(3):331-334.
955 doi:10.3171/2012.11.PEDS12343.
956 104. Bay E, Hagerty BM, Williams RA, Kirsch N, Gillespie B. Chronic stress, sense of belonging, and
957 depression among survivors of traumatic brain injury. *J Nurs Scholarsh*. 2002;34(3):221-226.
958 doi:10.1111/j.1547-5069.2002.00221.x.
959 105. Leddy JJ, Kozlowski K, Donnelly JP, Pendergast DR, Epstein LH, Willer B. A preliminary study of
960 subsymptom threshold exercise training for refractory post-concussion syndrome. *Clinical J Sport*
961 *Med*. 2010;20(1):21-27. doi:10.1097/JSM.0b013e3181c6c22c.
962 106. Gagnon I, Galli C, Friedman D, Grilli L, Iverson GL. Active rehabilitation for children who are slow
963 to recover following sport-related concussion. *Brain Inj*. 2009;23(12):956-964.
964 doi:10.3109/02699050903373477.
965 107. Gagnon I, Grilli L, Friedman D, Iverson GL. A pilot study of active rehabilitation for adolescents
966 who are slow to recover from sport-related concussion. *Scan J Med Sci Sports*. 2016;26(3):299-306.
967 doi:10.1111/sms.12441.
968 108. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *CMAJ*.
969 2006;174(6): 801–809.
970 109. Thomas DG, Apps JN, Hoffman RG, McCrea M, Hammeke T. Benefits of strict rest after acute
971 concussion: a randomized controlled trial. *Pediatrics*. 2015;35(2):213-223. doi:10.1542/peds.2014-
972 0966.
973 110. Penninx BW, Kriegsman DM, van Eijk JTM, Boeke AJ, Deeg DJH. Differential effect of social support
974 on the course of chronic disease: a criteria-based literature study. *Fam Syst Health.* 1996;14(2):223-
975 244.
976 111. Stålnacke BM. Community integration, social support and life satisfaction in relation to symptoms
977 3 years after mild traumatic brain injury. *Brain Inj*. 2007;21(9):933-942.
978 doi:10.1080/02699050701553189.
979 112. McCauley SR, Boake C, Levin HS, Contant CF, Song JX. Postconcussional disorder following mild to
980 moderate traumatic brain injury: anxiety, depression, and social support as risk factors and
981 comorbidities. *J Clin Exp Neuropsychol*. 2001;23(6):792-808.
982 113. Gioia G. Medical-school partnership in guiding return to school following mild traumatic brain
983 injury in youth. *J Child Neurol*. 2016;31(1):93-108. doi:10.1177/0883073814555604.

114. Gioia GA, Glang AE, Hooper SR, Brown BE. Building statewide infrastructure for the academic support of students with mild traumatic brain injury. *J Head Trauma Rehabil.* 2016;31(6):397-406.
115. Ransom DM, Vaughan CG, Pratson L, Sady MD, McGill CA, Gioia GA. Academic effects of concussion in children and adolescents. *Pediatrics*. 2015;135(6):1043-1050. doi:10.1542/peds.2014-3434.
116. Babikian T, McArthur D, Asarnow RF. Predictors of 1-month and 1-year neurocognitive functioning from the UCLA Longitudinal, Mild, Uncomplicated, Pediatric Traumatic Brain Injury Study. *J Int Neuropsychol Soc*. 2013;19(2):145-154. doi:10.1017/S135561771200104X.
117. Sady MD, Vaughan CG, Gioia GA. School and the concussed youth: recommendations for concussion education and management. *Phys Med Rehabil Clin N Am*. 2011;22(4):701-719. doi:10.1016/j.pmr.2011.08.008.
118. Broglio SP, Collins MW, Williams RM, Mucha A, Kontos AP. Current and emerging rehabilitation for concussion: a review of the evidence. *Clin Sports Med*. 2015;34(2):213-231. doi:10.1016/j.csm.2014.12.005.
119. DeMatteo C, Stazyk K, Giglia L, et al. A balanced protocol for return to school for children and youth following concussive injury. *Clin Pediatr*. 2015;54(8):783-792. doi:10.1177/0009922814567305.
120. Protecting students with disabilities. U.S. Department of Education website. http://www2.ed.gov/about/offices/list/ocr/504faq.html. Updated October 16, 2015. Accessed June 17, 2016.
121. Yeates KO, Luria J, Bartkowski H, Rusin J, Martin L, Bigler ED. Post-concussive symptoms in children with mild closed-head injuries. *J Head Trauma Rehabil*. 1999;14(4):337-350.
122. Gelfand AA, Goadsby PJ. Treatment of pediatric migraine in the emergency room. *Pediatr Neurol*. 2012;47(4):233-241. doi:10.1016/j.pediatrneurol.2012.06.001.
123. Silberstein SD. Practice parameter: evidence-based guidelines for migraine headache (an evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology*. 2000;55(6):754-762.
124. Institute of Medicine and National Research Council. *Sports-Related Concussions in Youth: Improving the Science, Changing the Culture*. Washington, DC: The National Academies Press; 2014. doi:10.17226/18377.
125. Lumba-Brown A, Harley J, Lucio S, Vaida F, Hilfiker M. Hypertonic saline as a therapy for pediatric concussion pain: a randomized controlled trial of symptom treatment in the emergency department. *Pediatr Emerg Care*. 2014;30(3):139-145. doi:10.1097/PEC.0000000000000084.
126. Mucha A, Collins MW, Elbin RJ, et al. A Brief Vestibular/Ocular Motor Screening (VOMS) assessment to evaluate concussions: preliminary findings. *Am J Sports Med*. 2014;42(10):2479-2486. doi:10.1177/0363546514543775.
127. Alsalaheen BA, Mucha A, Morris LO, et al. Vestibular rehabilitation for dizziness and balance disorders after concussion. *J Neurol Phys Ther*. 2010;34(2):87-93. doi:10.1097/NPT.0b013e3181dde568.
128. Alsalaheen BA, Whitney SL, Mucha A, Morris LO, Furman JM, Sparto PJ. Exercise prescription patterns in patients treated with vestibular rehabilitation after concussion. *Physiother Res Int*. 2013;18(2):100-108. doi:10.1002/pri.1532.

129. Ellis MJ, Leddy JJ, Willer B. Physiological, vestibulo-ocular and cervicogenic post-concussion disorders: an evidence-based classification system with directions for treatment. *Brain Inj*. 2015;29(2):238-248. doi:10.3109/02699052.2014.965207.

130. Schneider KJ, Meeuwisse WH, Nettel-Aguirre A, et al. Cervicovestibular rehabilitation in sport-related concussion: a randomised controlled trial. *Br J Sports Med*. 2014;48(17):1294-1298. doi:10.1136/bjsports-2013-093267.

131. Lavigne G, Khoury S, Chauny JM, Desautels A. Pain and sleep in post-concussion/mild traumatic brain injury. *Pain*. 2015;156(suppl 1):S75-S85. doi:10.1097/j.pain.0000000000000111.

132. Stores, G. Children's sleep disorders: modern approaches, developmental effects, and children at special risk. *Devl Med Child Neurol*. 1999;41(8):568-573. doi:10.1111/j.1469-8749.1999.tb00657.

133. Baumann CR, Werth E, Stocker R, Ludwig S, Bassetti CL. Sleep-wake disturbances 6 months after traumatic brain injury: a prospective study. *Brain*. 2007;130(pt 7):1873-1883.

134. Venter, RE. Role of sleep in performance and recovery of athletes: a review article. *South Afr J Res Sport, Phys Ed Recr*. 2012;34(1):167-184.

135. Owens JA, Mindell JA. Pediatric insomnia. *Pediatr Clin North Am*. 2011;58(3):555-569. doi:10.1016/j.pcl.2011.03.011.

136. Mollayeva T, Pratt B, Mollayeva S, Shapiro CM, Cassidy JD, Colantonio A. The relationship between insomnia and disability in workers with mild traumatic brain injury/concussion: Insomnia and disability in chronic mild traumatic brain injury. *Sleep Med*. April 2016;20:157-166.

137. Kemp S, Biswas R, Neumann V, Coughlan A. The value of melatonin for sleep disorders occurring post-head injury: a pilot RCT. *Brain Inj*. 2004;18(9):911-919.

138. Broglio SP, Macciocchi SN, Ferrara MS. Neurocognitive performance of concussed athletes when symptom free. *J Athl Train*. 2007;42(4):504-508.

139. Broshek DK, Kaushik T, Freeman JR, Erlanger D, Webbe F, Barth JT. Sex differences in outcome following sports-related concussion. *J Neurosurg*. 2005;102(5), 856-863.

140. Braun M, Tupper D, Kaufmann P, et al. Neuropsychological assessment: a valuable tool in the diagnosis and management of neurological, neurodevelopmental, medical, and psychiatric disorders. *Cogn Behav Neurol*. 2011;24(3):107-114. doi:10.1097/WNN.0b013e3182351289.

141. Moulding NT, Silagy CA, Weller DP. A framework for effective management of change in clinical practice: dissemination and implementation of clinical practice guidelines. *Qual Health Care.* 1999;8(3):177-183.

142. Francke AL, Smit MC, de Veer AJE, Mistiaen P. Factors influencing the implementation of clinical guidelines for health care professionals: A systematic meta-review. *BMC Med Inform Decis Mak.* 2008;8(38):doi:10.1186/1472-6947-8-38.

143. Titler MG. The evidence for evidence-based practice implementation. In Hughes R, ed. *Advances in Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville, MD: Agency for Healthcare Research and Quality;2008.1-49.

144. Arbogast KB, McGinley AD, Master CL, Grady MF, Robinson RL, Zonfrillo MR. Cognitive rest and school-based recommendations following pediatric concussion: the need for primary care support tools. *Clin Pediatr (Phila).* 2013;52(5):397-402. doi:10.1177/0009922813478160.

145. National Center for Injury Prevention and Control. *CDC Injury Center Research Priorities*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention; 2015. Available at https://www.cdc.gov/injury/researchpriorities/index.html.

Box 1.

Levels of Confidence in Inference

- As part of the systematic review, the American Academy of Neurology Classification of Evidence Scheme was used to assign the risk of bias and assign a Class for each study (e.g., Class I (e.g., high quality RCTs), Class II (e.g., RCTs with significant limitations), Class III (e.g., other controlled studies), and Class IV (e.g., no measures of effectiveness or statistical precision).
- Workgroup members were presented with a series of potential recommendations and a rationale for each recommendation. The rationale was based on the research identified in the systematic review, as well as related evidence that pertained to the recommendation.
- Level of confidence in the inference was based on workgroup members' assessment of the cogency of the rationale supporting each recommendation, and assigned on the basis of five domains rated by workgroup members: rationale is logical; evidence statements are accurate; axioms are true; related evidence is strong and applicable; and internal inferences logically follow.
- Levels include high, moderate, low, and very low

Strength of Recommendation

There is not a direct correspondence between the Class of studies and the Confidence in Inference or in the Strength of Recommendation. While the Class of studies is an important consideration the methodology that was utilized considers a number of additional factors in deriving these judgments. The determination by the Workgroup of the Strength of Recommendation was initially anchored to the level of confidence in the inference but was modified on the basis of Workgroup members' assessment of each recommendation's: benefit relative to harm; importance of the outcome; expected variation in patient preferences; financial burden relative to benefit expected; and the availability of intervention.

- Level A: The recommendation almost always should be followed.
- Level B: The recommendation usually should be followed.
- Level C: The recommendation may sometimes be followed.
- Level U: There is insufficient evidence to make a recommendation.
- Level R: The intervention generally should not be done outside of a research setting (applicable only to recommendations related to interventions).

More detailed information related to how Workgroup members assigned Levels of Confidence in the Inference and a Strength of Recommendation can be found in Appendix A.

Clinical Contextual Profiles

Assigning Strength of Recommendation

As part of the systematic review,[1] the American Academy of Neurology Classification of Evidence Scheme[2] was used to assign the risk of bias and assign a Class for each study (e.g., Class I (e.g., high quality RCTs), Class II (e.g., RCTs with significant limitations), Class III (e.g., other controlled studies), and Class IV (e.g., no measures of effectiveness or statistical precision). Following completion of the systematic review, workgroup members were presented with a series of potential recommendations and a rationale for each recommendation. The rationale was based on the research identified in the systematic review, as well as related evidence that pertained to the recommendation.

Workgroup members' judgments were sought regarding multiple domains pertaining to the recommendation, using a modified Delphi process. The goal was to attain consensus after a maximum of four rounds of voting. Consensus was defined by: > 80% agreement on dichotomous judgments, and 80% agreement, within one point, for ordinal judgments. If consensus was obtained the Strength of Recommendation was assigned at the median. If not, it was assigned at the 10th percentile.

The final strength of recommendation was indicated by a helping verb: "May," "Should" or "Must" corresponding to levels of recommendation of "C," "B" or "A." Workgroup members were given the discretion of using the helping verb "Should" or "Must" for recommendations that attained a strength of Level A.

Draft recommendations were worded with a default "Should" helping verb. Recommendation developers were given the option of changing this helping verb to "May" when recommendations did not attain consensus. In this situation, the finalized recommendation could not have a strength greater than "May."

Steps used to assign final Strength of Recommendation:

1. Level of Confidence in the Inference (High, Moderate, Low, Very Low) was based on an assessment of the cogency of the rationale supporting each recommendation, and assigned on the basis of five domains rated by workgroup members:
    a. Rationale is logical
    b. Evidence statements are accurate
    c. Axioms are true
    d. Related evidence is strong and applicable
    e. Internal inferences logically follow

    Workgroup members voted yes/no on each of these qualities of the rationale, for each candidate recommendation. Consensus on each domain was defined as > 80% agreement. The lowest level of agreement among Workgroup members determined the Level of Confidence in the inference.

2. Strength of Recommendation was modified on the basis of Workgroup members' assessment of each recommendation's benefit relative to harm (large, moderate, small, and similar). Consensus was defined as 80% agreement within one level. Strength of recommendation could be moved up one level based on this assessment or, if it was judged to be lower than the Level of Confidence in the Inference, could be moved down.
3. Strength of Recommendation could then be downgraded based on assessment of the Workgroup on the following domains:
    a. Importance of the outcome: critical, important, mildly important, not important
    b. Expected variation in patient preferences: none, minimal, moderate, large
    c. Financial burden relative to benefit expected: none, minimal, moderate, large
    d. Availability of intervention: universal, usually, sometimes, limited

   Consensus was defined as 80% agreement within one level.

References

1. Placeholder for Systematic Review reference
2. Gronseth GS, Woodroffe LM, Getchius TSD. *Clinical Practice Guideline Process Manual*. St. Paul, MN: American Academy of Neurology; 2011.

Appendix A

Clinical Contextual Profiles

1a. Healthcare providers *should not* routinely obtain head CT for diagnostic purposes in children with mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 2	Benefit >> Harm 4	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very Important 8	Critically Important 9	Yes
Variation in preferences	Large 1	Moderate 1	Modest 12	Minimal 3	Yes
Feasible	Rarely 0	Occasionally 0	Usually 3	Always 14	Yes
Cost relative to net benefit	Very Large 0	Large 1	Moderate 2	Small 14	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

1b. Healthcare providers *should* use validated clinical decision rules to identify children with mTBI at low risk for intracranial injury, in whom head CT is not indicated, as well as children who may be at higher risk for clinically important ICI, and therefore may warrant head CT. Existing decision rules combine a variety of factors that, when assessed together, may increase the risk for more serious injury. Such risk factors include the following:

- Age < 2 years old
- Vomiting
- Loss of consciousness
- Severe mechanism of injury
- Severe or worsening headache
- Amnesia
- Nonfrontal scalp hematoma
- Glasgow Coma Score < 15
- Clinical suspicion for skull fracture

(Moderate Confidence in Inference, Level B)

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 3	Benefit >>> Harm 15	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 7	Critically Important 10	Yes
Variation in preferences	Large 0	Moderate 0	Modest 5	Minimal 13	Yes
Feasible	Rarely 0	Occasionally 0	Usually 6	Always 12	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 3	Small 15	Yes

Strength of recommendation	R/U	C	B	A	

1c. For children diagnosed with mTBI, healthcare providers *should* discuss the risks of pediatric head CT in the context of risk factors for ICI with the patient and his/her family. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 3	Benefit >>> Harm 15	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 6	Critically Important 12	Yes
Variation in preferences	Large 0	Moderate 1	Modest 7	Minimal 10	Yes
Feasible	Rarely 0	Occasionally 0	Usually 8	Always 10	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 7	Small 11	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

2. Healthcare providers *should not* routinely use MRI in the acute evaluation of suspected or diagnosed mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 2	Benefit > Harm 1	Benefit >> Harm 9	Benefit >>> Harm 7	Yes
Importance of outcomes	Not Important or 2	Mildly 1	Very 11	Critically Important 5	Yes
Variation in preferences	Large 0	Moderate 1	Modest 7	Minimal 11	Yes
Feasible	Rarely 0	Occasionally 2	Usually 7	Always 10	Yes
Cost relative to net benefit	Very Large 2	Large 1	Moderate 4	Small 12	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

3. Healthcare providers *should not* use SPECT in the acute evaluation of cases of suspected or diagnosed mTBI. (**Moderate Confidence in Inference, Level B**)

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 2	Benefit >> Harm 3	Benefit >>> Harm 12	Yes
Importance of outcomes	Not Important or 4	Mildly 3	Very 8	Critically Important 3	No
Variation in preferences	Large 1	Moderate 0	Modest 0	Minimal 17	Yes
Feasible	Rarely 0	Occasionally 5	Usually 2	Always 11	No
Cost relative to net benefit	Very Large 1	Large 1	Moderate 2	Small 14	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

4a. Skull X-rays *should not* be used in the diagnosis of pediatric mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 2	Benefit >> Harm 3	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 2	Very 9	Critically Important 7	Yes
Variation in preferences	Large 0	Moderate 0	Modest 3	Minimal 15	Yes
Feasible	Rarely 0	Occasionally 0	Usually 4	Always 14	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 4	Small 14	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

4b. Skull X-rays *should not* be used in the screening for ICI. **(High Confidence in Inference, Level A)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 5	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 8	Critically Important 9	Yes
Variation in preferences	Large 0	Moderate 0	Modest 3	Minimal 15	Yes
Feasible	Rarely 0	Occasionally 0	Usually 3	Always 15	Yes
Cost relative to net benefit	Very Large 0	Large 1	Moderate 3	Small 14	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

5a. Healthcare providers *should* use an age-appropriate, validated symptom rating scale as a component of the diagnostic evaluation in children presenting with acute mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 1	Benefit >>> Harm 17	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 7	Critically Important 11	Yes
Variation in preferences	Large 0	Moderate 3	Modest 4	Minimal 11	Yes
Feasible	Rarely 0	Occasionally 0	Usually 3	Always 15	Yes
Cost relative to net benefit	Very Large 0	Large 1	Moderate 3	Small 14	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

5b. Healthcare providers *may* use validated, age-appropriate computerized cognitive testing in the acute period of injury as a component of the diagnosis of mTBI. **(Moderate Confidence in Inference, Level C)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 2	Benefit >> Harm 9	Benefit >>> Harm 6	Yes
Importance of outcomes	Not Important or 0	Mildly 3	Very 12	Critically Important 3	Yes
Variation in preferences	Large 0	Moderate 5	Modest 7	Minimal 6	No
Feasible	Rarely 0	Occasionally 12	Usually 6	Always 0	Yes
Cost relative to net benefit	Very Large 0	Large 7	Moderate 8	Small 3	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

5c. The Standardized Assessment of Concussion (SAC) *should not* be exclusively used to diagnose mTBI in children 6-18 years of age. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 1	Benefit >> Harm 5	Benefit >>> Harm 10	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 14	Critically Important 2	Yes
Variation in preferences	Large 0	Moderate 0	Modest 4	Minimal 13	Yes
Feasible	Rarely 0	Occasionally 3	Usually 3	Always 11	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 3	Small 14	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

6. Healthcare providers *should not* utilize biomarkers outside of a research setting for the diagnosis of children with mTBI. **(High Confidence in Inference, Level R)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 0	Benefit >> Harm 7	Benefit >>> Harm 9	Yes
Importance of outcomes	Not Important or 2	Mildly 2	Very 9	Critically Important 4	No
Variation in preferences	Large 0	Moderate 1	Modest 1	Minimal 15	Yes
Feasible	Rarely 1	Occasionally 5	Usually 0	Always 11	No
Cost relative to net benefit	Very Large 0	Large 1	Moderate 2	Small 14	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

Note: Strength of recommendation ultimately rated as Level R because the statement recommends against performing the tests outside of a research setting.

7a. Healthcare providers *should* counsel patients and families that a large majority (70-80%) of children with mTBI do not show significant difficulties that last more than 1-3 months post injury. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 5	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 11	Critically Important 5	Yes
Variation in preferences	Large 0	Moderate 0	Modest 2	Minimal 14	Yes
Feasible	Rarely 0	Occasionally 0	Usually 2	Always 14	Yes
Cost relative to net benefit	Very Large 0	Large 1	Moderate 1	Small 14	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

7b. Healthcare providers *should* counsel patients and families that although some factors predict an increased or decreased risk for prolonged symptoms, each child's recovery from mTBI is unique and will follow its own trajectory. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 2	Benefit >>> Harm 14	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 10	Critically Important 5	Yes
Variation in preferences	Large 0	Moderate 0	Modest 1	Minimal 15	Yes
Feasible	Rarely 0	Occasionally 1	Usually 4	Always 11	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 3	Small 13	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

8a. Healthcare providers *should* assess the premorbid history of children either prior to injury as a part of pre-participation athletic examinations, or as soon as possible post injury in children with mTBI, to assist in determining prognosis. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 3	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 11	Critically Important 5	Yes
Variation in preferences	Large 0	Moderate 1	Modest 4	Minimal 11	Yes
Feasible	Rarely 0	Occasionally 0	Usually 5	Always 11	Yes
Cost relative to net benefit	Very Large 0	Large 2	Moderate 2	Small 12	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

8b. Healthcare providers *should* counsel children and families completing pre-participation athletic examinations and children with mTBI as well as their families that recovery from mTBI might be delayed in those with:

- Premorbid histories of mTBI
- Lower cognitive ability (for children with an intracranial lesion)
- Neurological or psychiatric disorder
- Learning difficulties
- Increased pre-injury symptoms (i.e., similar to those commonly referred to as "postconcussive")
- Family and social stressors **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 0	Benefit >> Harm 5	Benefit >>> Harm 9	Yes
Importance of outcomes	Not Important or 1	Mildly 0	Very 10	Critically Important 4	Yes
Variation in preferences	Large 0	Moderate 2	Modest 2	Minimal 11	Yes
Feasible	Rarely 0	Occasionally 0	Usually 5	Always 10	Yes
Cost relative to net benefit	Very Large 0	Large 3	Moderate 1	Small 11	Yes

Strength of recommendation	R/U	C	B	A	

9a. Healthcare providers *should* screen for known risk factors for persistent symptoms in children with mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 7	Benefit >>> Harm 10	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 14	Critically Important 2	Yes
Variation in preferences	Large 0	Moderate 1	Modest 2	Minimal 14	Yes
Feasible	Rarely 0	Occasionally 1	Usually 6	Always 10	Yes
Cost relative to net benefit	Very Large 0	Large 1	Moderate 6	Small 10	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

9b. Healthcare providers *may* use validated prediction rules, which combine information about multiple risk factors for persistent symptoms, to provide prognostic counseling to children with mTBI evaluated in ED settings. **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 0	Benefit >> Harm 6	Benefit >>> Harm 9	Yes
Importance of outcomes	Not Important or 1	Mildly 2	Very 11	Critically Important 2	Yes
Variation in preferences	Large 1	Moderate 1	Modest 4	Minimal 10	Yes
Feasible	Rarely 1	Occasionally 1	Usually 8	Always 6	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 6	Small 10	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

Recommendations did not attain consensus at the "Should" level and so the recommendation developers exercised the option of changing to the "May" wording at which point consensus was reached.

10a. Healthcare providers *should* use a combination of tools to assess recovery in children with mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 5	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 12	Critically Important 3	Yes
Variation in preferences	Large 1	Moderate 0	Modest 4	Minimal 11	Yes
Feasible	Rarely 0	Occasionally 4	Usually 9	Always 3	Yes
Cost relative to net benefit	Very Large 0	Large 1	Moderate 10	Small 5	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

10b. Healthcare providers *should* use validated symptom scales to assess recovery in children with mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 4	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 12	Critically Important 5	Yes
Variation in preferences	Large 0	Moderate 0	Modest 3	Minimal 14	Yes
Feasible	Rarely 0	Occasionally 1	Usually 10	Always 6	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 8	Small 9	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

10c. Healthcare providers *may* use validated cognitive testing (including measures of reaction time) to assess recovery in children with mTBI. **(Moderate Confidence in Inference, Level C)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 1	Benefit >> Harm 7	Benefit >>> Harm 8	Yes
Importance of outcomes	Not Important or 1	Mildly 2	Very 12	Critically Important 1	Yes
Variation in preferences	Large 1	Moderate 2	Modest 6	Minimal 7	Yes
Feasible	Rarely 0	Occasionally 8	Usually 8	Always 0	Yes
Cost relative to net benefit	Very Large 0	Large 4	Moderate 11	Small 1	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

10d. Healthcare providers *may* use balance testing to assess recovery in adolescent athletes with mTBI. (**Moderate Confidence in Inference, Level C**)

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 3	Benefit >> Harm 6	Benefit >>> Harm 6	No
Importance of outcomes	Not Important or 2	Mildly 2	Very 11	Critically Important 1	Yes
Variation in preferences	Large 1	Moderate 1	Modest 7	Minimal 7	Yes
Feasible	Rarely 0	Occasionally 8	Usually 5	Always 3	Yes
Cost relative to net benefit	Very Large 1	Large 3	Moderate 9	Small 3	No
Strength of recommendation	**R/U**	**C**	**B**	**A**	

11a. Healthcare providers *should* closely monitor children with mTBI who are determined to be at high risk for persistent symptoms based on premorbid history, demographics, and/or injury characteristics. **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 3	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 9	Critically Important 6	Yes
Variation in preferences	Large 0	Moderate 2	Modest 7	Minimal 7	Yes
Feasible	Rarely 0	Occasionally 0	Usually 10	Always 6	Yes
Cost relative to net benefit	Very Large 1	Large 1	Moderate 3	Small 11	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

11b. For children with mTBI whose symptoms do not resolve as expected with standard care (i.e., within 4-6 weeks), healthcare providers *should* provide or refer for appropriate assessments and/or interventions (see Recommendations for Treatment and Management). **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 4	Benefit >>> Harm 12	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 9	Critically Important 6	Yes
Variation in preferences	Large 0	Moderate 2	Modest 9	Minimal 5	Yes
Feasible	Rarely 0	Occasionally 5	Usually 10	Always 1	Yes
Cost relative to net benefit	Very Large 0	Large 2	Moderate 11	Small 3	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

12. In providing education and reassurance to the family, the healthcare provider *should* include the following information:

- Warning signs of more serious injury
- Description of injury and expected course of symptoms and recovery
- Instructions on how to monitor postconcussive symptoms
- Prevention of further injury
- Management of cognitive and physical activity/rest
- Instructions regarding return to play/recreation and school
- Clear clinician follow-up instructions. **(High Confidence in Inference, Level A)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 1	Benefit >> Harm 3	Benefit >>> Harm 15	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 7	Critically Important 12	Yes
Variation in preferences	Large 0	Moderate 0	Modest 4	Minimal 15	Yes
Feasible	Rarely 0	Occasionally 0	Usually 8	Always 11	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 6	Small 13	Yes

Strength of recommendation	R/U	C	B	A	

13a. Healthcare providers *should* counsel patients to observe more restrictive physical and cognitive activity during the first several days following mTBI in children. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 2	Benefit >> Harm 3	Benefit >>> Harm 12	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 10	Critically Important 8	Yes
Variation in preferences	Large 0	Moderate 2	Modest 10	Minimal 6	Yes
Feasible	Rarely 1	Occasionally 0	Usually 5	Always 12	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 6	Small 12	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

13b. Following these first several days, healthcare providers *should* counsel patients and families to resume a gradual schedule of activity that does not exacerbate symptoms, with close monitoring of symptom expression (number, severity). **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 1	Benefit >> Harm 5	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 16	Critically Important 2	Yes
Variation in preferences	Large 0	Moderate 1	Modest 10	Minimal 7	Yes
Feasible	Rarely 0	Occasionally 0	Usually 5	Always 13	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 7	Small 11	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

13c. Following the successful resumption of a gradual schedule of activity (see 13b), healthcare providers *should* offer an active rehabilitation program of progressive reintroduction of noncontact aerobic activity that does not exacerbate symptoms, with close monitoring of symptom expression (number, severity). **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 3	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 11	Critically Important 5	Yes
Variation in preferences	Large 0	Moderate 1	Modest 9	Minimal 6	Yes
Feasible	Rarely 0	Occasionally 0	Usually 11	Always 5	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 7	Small 9	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

13d. Healthcare providers *should* counsel patients to return to full activity when they return to premorbid performance if they have remained symptom free at rest and with increasing levels of physical exertion. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 5	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 10	Critically Important 6	Yes
Variation in preferences	Large 0	Moderate 0	Modest 4	Minimal 12	Yes
Feasible	Rarely 0	Occasionally 0	Usually 7	Always 9	Yes
Cost relative to net benefit	Very Large 0	Large 3	Moderate 5	Small 8	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

14. Healthcare providers *may* assess the extent and types of social support (i.e., emotional, informational, instrumental, appraisal) in children with mTBI and emphasize social support as a key element in the education of caregivers and educators. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 9	Benefit >>> Harm 9	Yes
Importance of outcomes	Not Important or 1	Mildly 6	Very 9	Critically Important 2	Yes
Variation in preferences	Large 1	Moderate 2	Modest 8	Minimal 7	Yes
Feasible	Rarely 0	Occasionally 3	Usually 8	Always 7	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 11	Small 7	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

Recommendations did not attain consensus at the "Should" level and so the recommendation developers exercised the option of changing to the "May" wording at which point consensus was reached.

15a. To assist children returning to school following mTBI, medical and school-based teams *should* counsel the student and family regarding the process of gradually increasing the duration and intensity of academic activities as tolerated, with the goal of increasing participation without significantly exacerbating symptoms. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 1	Benefit >> Harm 1	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 6	Critically Important 10	Yes
Variation in preferences	Large 0	Moderate 1	Modest 5	Minimal 10	Yes
Feasible	Rarely 0	Occasionally 0	Usually 7	Always 9	Yes
Cost relative to net benefit	Very Large 0	Large 3	Moderate 4	Small 9	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

15b. Return to school protocols *should* be customized based on the severity of postconcussion symptoms in children with mTBI as determined jointly by medical and school-based teams. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 3	Benefit >>> Harm 12	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 4	Critically Important 11	Yes
Variation in preferences	Large 0	Moderate 2	Modest 6	Minimal 7	Yes
Feasible	Rarely 0	Occasionally 0	Usually 7	Always 8	Yes
Cost relative to net benefit	Very Large 0	Large 2	Moderate 4	Small 9	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

15c. For any student with prolonged symptoms that interfere with academic performance, school-based teams *should* assess the educational needs of that student and determine the student's need for additional educational supports, including those described under pertinent federal statutes (e.g., Section 504, IDEA). **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 6	Benefit >>> Harm 10	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 11	Critically Important 5	Yes
Variation in preferences	Large 0	Moderate 4	Modest 7	Minimal 5	No
Feasible	Rarely 0	Occasionally 2	Usually 13	Always 1	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 16	Small 0	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

15d. Postconcussion symptoms and academic progress in school *should* be monitored collaboratively by the student, family, healthcare provider, and school teams, who jointly determine what modifications or accommodations are needed to maintain an academic workload without significantly exacerbating symptoms. **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 7	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 11	Critically Important 7	Yes
Variation in preferences	Large 1	Moderate 3	Modest 8	Minimal 6	No
Feasible	Rarely 0	Occasionally 4	Usually 11	Always 3	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 17	Small 1	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

15e. The provision of educational supports *should* be monitored and adjusted on an ongoing basis by the school-based team until the student's academic performance has returned to preinjury levels. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 3	Benefit >>> Harm 7	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 6	Critically Important 4	Yes
Variation in preferences	Large 0	Moderate 2	Modest 5	Minimal 3	Yes
Feasible	Rarely 0	Occasionally 0	Usually 9	Always 1	Yes
Cost relative to net benefit	Very Large 0	Large 2	Moderate 5	Small 3	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

15f. For students who demonstrate prolonged symptoms and academic difficulties despite an active treatment approach, healthcare providers *should* refer the child for a formal evaluation by a specialist in pediatric mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 1	Benefit >> Harm 4	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 8	Critically Important 9	Yes
Variation in preferences	Large 2	Moderate 3	Modest 9	Minimal 4	No
Feasible	Rarely 0	Occasionally 7	Usually 11	Always 0	Yes
Cost relative to net benefit	Very Large 0	Large 1	Moderate 17	Small 0	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

16a. Healthcare providers in the ED *should* clinically observe and consider obtaining a head CT in children presenting with severe and worsening headache following mTBI to evaluate for ICI requiring further management in accordance with validated clinical decision making rules. **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 5	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 5	Critically Important 11	Yes
Variation in preferences	Large 0	Moderate 0	Modest 5	Minimal 11	Yes
Feasible	Rarely 0	Occasionally 0	Usually 6	Always 10	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 12	Small 4	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

16b. Children undergoing observation periods for headache with acutely worsening symptoms *should* undergo emergent neuroimaging. **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 9	Benefit >>> Harm 10	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 3	Critically Important 15	Yes
Variation in preferences	Large 0	Moderate 1	Modest 3	Minimal 15	Yes
Feasible	Rarely 0	Occasionally 1	Usually 11	Always 7	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 16	Small 3	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

16c. Healthcare providers and caregivers *should* offer non-opioid analgesia (i.e., ibuprofen or acetaminophen) to children with painful headache following acute mTBI, but also provide counseling to the family regarding the risks of analgesic overuse, including rebound headache. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 2	Benefit >> Harm 5	Benefit >>> Harm 9	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 13	Critically Important 2	Yes
Variation in preferences	Large 0	Moderate 0	Modest 6	Minimal 10	Yes
Feasible	Rarely 0	Occasionally 0	Usually 8	Always 8	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 8	Small 8	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

16d. Healthcare providers *should not* administer 3% hypertonic saline to children with mTBI for treatment of acute headache outside of a research setting at this time. **(Moderate Confidence in Inference, Level R)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 2	Benefit >> Harm 8	Benefit >>> Harm 6	Yes
Importance of outcomes	Not Important or 1	Mildly 5	Very 9	Critically Important 2	Yes
Variation in preferences	Large 0	Moderate 2	Modest 1	Minimal 14	Yes
Feasible	Rarely 0	Occasionally 1	Usually 4	Always 12	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 6	Small 11	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

Note: Strength of recommendation ultimately rated as Level R because the statement recommends against performing the tests outside of a research setting.

16e. Chronic headache following mTBI is likely to be multifactorial, and, therefore, healthcare providers *should* refer children with chronic headache after mTBI for multidisciplinary evaluation and treatment, with consideration of analgesic overuse as a contributory factor. **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 6	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 16	Critically Important 1	Yes
Variation in preferences	Large 0	Moderate 2	Modest 10	Minimal 5	Yes
Feasible	Rarely 0	Occasionally 7	Usually 8	Always 2	Yes
Cost relative to net benefit	Very Large 0	Large 2	Moderate 14	Small 1	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

17. Healthcare providers *may* refer children with subjective or objective evidence of persistent vestibulo-ocular motor dysfunction following mTBI to a program of vestibular rehabilitation. **(Moderate Confidence in Inference, Level C)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 1	Benefit > Harm 0	Benefit >> Harm 10	Benefit >>> Harm 6	Yes
Importance of outcomes	Not Important or 2	Mildly 2	Very 12	Critically Important 1	Yes
Variation in preferences	Large 1	Moderate 4	Modest 7	Minimal 5	No
Feasible	Rarely 1	Occasionally 12	Usually 4	Always 0	Yes
Cost relative to net benefit	Very Large 0	Large 4	Moderate 13	Small 0	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

18a. Healthcare providers *should* provide guidance on proper sleep hygiene methods to facilitate recovery from pediatric mTBI. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 1	Benefit >>> Harm 16	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 14	Critically Important 3	Yes
Variation in preferences	Large 0	Moderate 0	Modest 7	Minimal 10	Yes
Feasible	Rarely 0	Occasionally 0	Usually 6	Always 11	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 2	Small 15	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

18b. If sleep problems emerge or continue despite appropriate sleep hygiene measures, healthcare providers *may* refer children with mTBI to a sleep disorder specialist for further assessment. **(Moderate Confidence in Inference, Level C)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 1	Benefit >> Harm 8	Benefit >>> Harm 8	Yes
Importance of outcomes	Not Important or 0	Mildly 2	Very 14	Critically Important 1	Yes
Variation in preferences	Large 1	Moderate 4	Modest 7	Minimal 5	No
Feasible	Rarely 0	Occasionally 10	Usually 7	Always 0	Yes
Cost relative to net benefit	Very Large 0	Large 2	Moderate 15	Small 0	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

19a. Healthcare providers *should* attempt to determine the etiology of cognitive dysfunction, within the context of other mTBI symptoms. **(Moderate Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 1	Benefit >> Harm 4	Benefit >>> Harm 11	Yes
Importance of outcomes	Not Important or 0	Mildly 1	Very 10	Critically Important 5	Yes
Variation in preferences	Large 1	Moderate 2	Modest 5	Minimal 8	Yes
Feasible	Rarely 1	Occasionally 3	Usually 9	Always 3	No
Cost relative to net benefit	Very Large 0	Large 3	Moderate 8	Small 5	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

19b. Healthcare providers *should* recommend treatment for cognitive dysfunction that reflects its presumed etiology. **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 0	Benefit >> Harm 4	Benefit >>> Harm 13	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 13	Critically Important 4	Yes
Variation in preferences	Large 0	Moderate 3	Modest 11	Minimal 3	Yes
Feasible	Rarely 0	Occasionally 4	Usually 12	Always 1	Yes
Cost relative to net benefit	Very Large 0	Large 0	Moderate 14	Small 3	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

19c. Healthcare providers *may* refer children with persisting complaints related to cognitive function for a formal neuropsychological evaluation to assist in determining etiology and recommending targeted treatment. **(High Confidence in Inference, Level B)**

Domain	Rating				Consensus
Rationale is logical	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Evidence statements accurate	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Axioms true	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Related evidence strong & applicable	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Internal inferences logically follow	< 50%	50% to < 80%	80% to < 100%	100%	Yes
Confidence in Inference	Very low	Low	Moderate	High	
Benefit relative to Harm	Harm ≥ Benefit 0	Benefit > Harm 1	Benefit >> Harm 6	Benefit >>> Harm 10	Yes
Importance of outcomes	Not Important or 0	Mildly 0	Very 11	Critically Important 6	Yes
Variation in preferences	Large 0	Moderate 4	Modest 10	Minimal 3	Yes
Feasible	Rarely 0	Occasionally 7	Usually 10	Always 0	Yes
Cost relative to net benefit	Very Large 0	Large 1	Moderate 16	Small 0	Yes
Strength of recommendation	**R/U**	**C**	**B**	**A**	

Recommendations did not attain consensus at the “Should” level and so the recommendation developers exercised the option of changing to the “May” wording at which point consensus was reached.