

# Centers for Disease Control and Prevention Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children

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**IMPORTANCE** Mild traumatic brain injury (mTBI), or concussion, in children is a rapidly growing public health concern because epidemiologic data indicate a marked increase in the number of emergency department visits for mTBI over the past decade. However, no evidence-based clinical guidelines have been developed to date for diagnosing and managing pediatric mTBI in the United States.

**OBJECTIVE** To provide a guideline based on a previous systematic review of the literature to obtain and assess evidence toward developing clinical recommendations for health care professionals related to the diagnosis, prognosis, and management/treatment of pediatric mTBI.

**EVIDENCE REVIEW** The Centers for Disease Control and Prevention (CDC) National Center for Injury Prevention and Control Board of Scientific Counselors, a federal advisory committee, established the Pediatric Mild Traumatic Brain Injury Guideline Workgroup. 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. This information includes selected studies published since the evidence review was conducted that were deemed by the workgroup to be relevant to the recommendations. The dates of the initial literature search were January 1, 1990, to November 30, 2012, and the dates of the updated literature search were December 1, 2012, to July 31, 2015.

**FINDINGS** The CDC guideline includes 19 sets of recommendations on the diagnosis, prognosis, and management/treatment of pediatric mTBI that were assigned a level of obligation (ie, must, should, or 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.

**CONCLUSIONS AND RELEVANCE** This guideline identifies the best practices for mTBI based on the current evidence; updates should be made as the body of evidence grows. In addition to the development of the guideline, CDC has created user-friendly guideline implementation materials that are concise and actionable. Evaluation of the guideline and implementation materials is crucial in understanding the influence of the recommendations.

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**M**ild traumatic brain injury (mTBI), or concussion, 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.<sup>1</sup> In a subset of pediatric patients, postconcussive symptoms persist beyond 2 weeks and can continue for longer than 3 months.<sup>2</sup> Pathophysiologic injury and symptoms (both acute and long-term) affect a child's ability to function physically, cognitively, and psychologically after mTBI.<sup>3-5</sup>

Consensus guidelines on the management of mTBI in adults have been developed.<sup>6,7</sup> In 2013, evidence-based guidelines related to the management of sports-related concussion in children and adults were published,<sup>8</sup> and the Ontario Neurotrauma Foundation<sup>9</sup> published an evidence-based guideline for diagnosing and managing pediatric concussion in 2014. To date, no broad, evidence-based clinical guidelines have been developed in the United States for the purposes of diagnosis, prognosis, and management/treatment of pediatric mTBI. Clinical guidance for health care professionals is critical to improving the health and safety of this vulnerable population.

This guideline provides evidence-based recommendations for health care professionals that were developed using a rigorous scientific process based on a comprehensive review of pediatric mTBI scientific evidence.<sup>10</sup> Recommendations aim to provide health care professionals in primary care, outpatient specialty, inpatient, and emergency care settings in the United States with evidence-based guidance on the diagnosis and management of mTBI in children 18 years and younger.

Although "concussion," "minor head injury," and mTBI are frequently used interchangeably, they have different connotations for families, researchers, and health care professionals, allowing for misinterpretation.<sup>11-15</sup> Therefore, the guideline recommends the clinical use of the single term *mild traumatic brain injury*. In 2004, the World Health Organization Collaborating Centre Task Force on Mild Traumatic Brain Injury,<sup>15</sup> alongside the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine<sup>13</sup> and the US Centers for Disease Control and Prevention (CDC) Mild Traumatic Brain Injury Working Group Report to Congress,<sup>14</sup> defined mTBI as "an acute brain injury resulting from mechanical energy to the head from external physical forces including: (1) 1 or more of the following: confusion or disorientation, loss of consciousness for 30 minutes or less, post-traumatic amnesia for less than 24 hours, and/or other transient neurological abnormalities such as focal signs, symptoms, or seizure; (2) Glasgow Coma Scale score of 13-15 after 30 minutes post-injury or later upon presentation for healthcare."<sup>15(p7)</sup> A wide clinical and functional definition of pediatric mTBI was used for this guideline to be cognizant of the heterogeneity of presentations and outcomes of children with mTBI and to prevent the exclusion of children representing the more severe end of the mTBI spectrum. Specifically, pediatric patients were included with Glasgow Coma Scale (GCS) scores of 13 to 15 with or without the complication of intracranial injury (ICI) on neuroimaging and regardless of potentially requiring a hospital admission and/or neurosurgical intervention.

## Methods

This guideline was based on a previous systematic review of the literature<sup>10</sup> to obtain and assess evidence toward developing clinical

## Key Points

**Question** Based on current evidence, what are best practices for diagnosis, prognosis, and management/treatment of pediatric mild traumatic brain injury (mTBI)?

**Findings** Based on a previous systematic review of the literature, this guideline includes 19 sets of recommendations on diagnosis, prognosis, and management/treatment of pediatric mTBI. Each recommendation was assigned a level of obligation (ie, must, should, or may) based on confidence in the evidence.

**Meaning** Clinical guidance for health care professionals is critical to improving health and safety of this vulnerable population; the recommendations represent current best practices and comprise the first evidence-based clinical guideline to date for diagnosing and managing pediatric mTBI in the United States.

cal recommendations for health care professionals related to the diagnosis, prognosis, and management/treatment of pediatric mTBI. The dates of the initial literature search were January 1, 1990, to November 30, 2012, and the dates of the updated literature search were December 1, 2012, to July 31, 2015. No institutional review board approval or participant informed consent was necessary.

## Federal Advisory Committee Process

The CDC National Center for Injury Prevention and Control Board of Scientific Counselors (BSC), a federal advisory committee, established the Pediatric Mild Traumatic Brain Injury Guideline Workgroup to conduct a systematic review of the literature and draft clinical recommendations for health care professionals on the diagnosis, prognosis, and management/treatment of mTBI among children 18 years and younger. Before 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. The CDC reviewed disclosed activities, and no conflicts of interest were identified. Furthermore, members of the BSC completed an Office of Government Ethics 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<sup>10</sup> and the Pediatric Mild Traumatic Brain Injury Guideline Workgroup Report ("Workgroup Report").<sup>16</sup>

## American Academy of Neurology Guideline

The Pediatric Mild Traumatic Brain Injury Guideline Workgroup conducted a systematic review of the literature and drafted clinical recommendations using the methods developed by the American Academy of Neurology.<sup>17</sup> 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<sup>10</sup> accompanying the guideline. Evidence was rated as part of the systematic review using a modified Grading of Recommendations Assessment Development and Evaluation method. The workgroup drafted recommendations based on the systematic review, as well as related evidence, scientific principles, and expert inference, and categorized recommendations into 3 topic areas of the diagnosis, prognosis, and management/treatment of pediatric mTBI.

Clinical recommendations were collated and distributed among 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).<sup>16</sup> Each workgroup member was requested to review and vote on all of the potential recommendations, and an 80% response was required for each recommendation before tabulation. After 4 rounds of voting, the workgroup achieved consensus on 46 clinical recommendations: 11 pertained to diagnosis, 12 were related to prognosis, and 23 focused on management/treatment. The **Box** describes how workgroup members assigned a level of confidence in the inference (ie, high, moderate, low, or very low) and a strength of recommendation (ie, level A, B, C, U, or R) for each recommendation. A more detailed description of the voting process, as well as summaries of the clinical evidence profile for each recommendation, are available in the eAppendix and the eTable in the **Supplement**. Using the Workgroup Report, CDC grouped the 46 recommendations into 19 sets of recommendations on the diagnosis, prognosis, and management/treatment of pediatric mTBI that were assigned a level of obligation (ie, must, should, or may) based on confidence in the evidence and on clinical focus (eg, "General Health Care Provider Counseling of Prognosis" and "Cognitive Impairment Management/Treatment") and constructed a draft Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children ("Guideline"). As coauthors of the guideline, workgroup members individually reviewed the full draft guideline before public comment and peer review.

### Public Comment and Peer Review

To obtain comments from the public on the full draft guideline, the CDC published a notice in the *Federal Register* (82 FR §45588) announcing the availability of the guideline for public comment during a 60-day period on Regulations.gov (docket number CDC-2017-0089) from September 29 through November 28, 2017. In addition, public comments were received on the Workgroup Report during a BSC meeting open to the public. Because the guideline provides scientific information that could have a clear and substantial influence 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 2 external, independent reviewers. The CDC carefully considered comments of the public and peer reviewers when developing and revising the guideline.

## Recommendations

The guideline includes 19 sets of recommendations on the diagnosis, prognosis, and management/treatment of mTBI in children. A list of all of the recommendations is provided in the eTable in the **Supplement**.

### Diagnostic Recommendations

This section contains recommendations regarding the diagnostic utility of head imaging, symptom scales, cognitive testing, and serum biomarkers.

## Box. Assigning Level of Confidence in the Inference and Strength of Recommendation

### Level of Confidence in the Inference

- As part of the systematic review, the American Academy of Neurology Classification of Evidence Scheme<sup>17</sup> was used to assign the risk of bias and assign a class for each study, including class I (eg, high-quality RCTs), class II (eg, RCTs with significant limitations), class III (eg, other controlled studies), and class IV (eg, no measures of the 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 was assigned on the basis of the following 5 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, or very low.

### Strength of Recommendation<sup>a</sup>

There is not a direct correspondence between the class of studies and confidence in the inference or strength of recommendation. While the class of studies is an important consideration, the methods that were used consider a number of additional factors in deriving these judgments. The determination by the workgroup of strength of recommendation was initially anchored to level of confidence in the inference but was modified on the basis of workgroup members' assessment of each recommendation, including the following: the importance of the outcome, benefit relative to harm, expected variation in patient preferences, financial burden relative to benefit expected, and the feasibility of the intervention (eg, the availability).

- 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).

Abbreviation: RCT, randomized clinical trial.

<sup>a</sup> More detailed information related to how workgroup members assigned level of confidence in the inference and strength of recommendation can be found in the eAppendix in the **Supplement**.

### Risk Factors for ICI and Computed Tomography

**Recommendation 1A:** Health care professionals should not routinely obtain head computed tomography (CT) for diagnostic purposes in children with mTBI (moderate confidence in the inference ["moderate"]; strength of recommendation level B ["level B"]).

**Recommendation 1B:** Health care professionals should use validated clinical decision rules to identify children with mTBI at low risk for ICI in whom head CT is not indicated, as well as children who may be at higher risk for clinically important ICI and thus may warrant head CT. Existing decision rules,<sup>33</sup> such as the Pediatric Emergency Care Applied Research Network (PECARN)

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 younger than 2 years
- Vomiting
- Loss of consciousness
- Severe mechanism of injury
- Severe or worsening headache
- Amnesia
- Nonfrontal scalp hematoma
- Glasgow Coma Scale score less than 15
- Clinical suspicion for skull fracture (moderate; level B).

**Recommendation 1C:** For children diagnosed as having mTBI, health care professionals 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 seen in the ED with mTBI will have ICI.<sup>18-32</sup> Identification of risk factors for ICI in children initially seen 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. Intracranial injury further influences the prognosis of patients with mTBI (see the Prognosis Recommendations section). Moderate evidence indicates that several risk factors identify patients with increased risk of ICI.<sup>20,22,33-35</sup> Generally, risk factors are not sufficiently predictive in isolation to guide clinical care (excluding GCS score and clinical suspicion for skull fracture).<sup>36-40</sup>

Instead, strong clinical evidence shows that the use of clinical decision rules that combine multiple risk factors are more effective in identifying children at low risk for ICI.<sup>20,22,33,35</sup> The risks of ICI provided in this document were not separated by isolated findings versus multiple findings. In addition, some of the reported risks of ICI could be higher in these recommendations because of the inclusion of studies of mTBI with GCS scores of 13 to 15. 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 in studies<sup>41-44</sup> with an increase in the lifetime cancer risk, although the cumulative absolute risk appears small. Furthermore, certain pediatric populations will require sedation to obtain adequate neuroimaging, increasing the overall risk related to imaging processes.<sup>45</sup> Families require clinical counseling regarding these risks to understand the best practices for the clinical care of their child. They should be aware that, after seemingly minor head injuries and mTBI, ICI resulting in clinically important outcomes, such as neurosurgical intervention, is rare.<sup>18-20,25-27,29,33,46-53</sup> 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

**Recommendation 2:** Health care professionals should not routinely use magnetic resonance imaging (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. An MRI is more sensitive in identifying structural abnormalities than CT,<sup>54,55</sup> and MRI

avoids the use of ionizing radiation associated with CT. Nevertheless, MRI more often requires sedation because of longer imaging acquisition times and is more expensive than CT; however, rapid-sequence MRI in nonsedated patients has recently been successfully used in children with suspected acute TBI.<sup>56</sup>

#### Single-Photon Emission CT

**Recommendation 3:** Health care professionals should not use single-photon emission CT (SPECT) in the acute evaluation 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. Furthermore, 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 radiopharmaceutical, and may be more expensive than head CT alone because it is often used in conjunction with CT.

#### Skull Radiograph

**Recommendation 4A:** Skull radiographs should not be used in the diagnosis of pediatric mTBI (high; level B).

**Recommendation 4B:** Skull radiographs should not be used in the screening for ICI (high; level B).

**Rationale:** The systematic review identified 2 class III studies<sup>19,57</sup> evaluating the use of skull radiographs in children after minor head injury. One study<sup>19</sup> identified a possible skull fracture in 7.1% (95% CI, 4.0%-10.3%) of these patients. A radiograph is not the optimal test to diagnose skull fracture with ICI after mTBI for several reasons: specifically, the literature reports that skull radiographs have 63% sensitivity for diagnosing a single skull fracture in children; a radiograph cannot detect ICIs, such as hemorrhage, shift from midline, or edema; and radiographs use radiation for imaging.<sup>57</sup> Clinical suspicion for skull fracture is a risk factor for ICI after mTBI in children.<sup>22,33-35</sup> Head CT better detects ICIs and better characterizes skull fractures, making it the more appropriate diagnostic imaging choice when such imaging is clinically indicated.

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

**Recommendation 5A:** Health care professionals should use an age-appropriate, validated symptom rating scale as a component of the diagnostic evaluation in children seen with acute mTBI (moderate; level B).

**Recommendation 5B:** Health care professionals 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).

**Recommendation 5C:** The Standardized Assessment of Concussion should not be exclusively used to diagnose mTBI in children aged 6 to 18 years (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 reinjury. The systematic review concluded that the Graded Symptom Checklist is useful in distinguishing children 6 years and older with mTBI from those without TBI within the first 2 days after injury.<sup>58</sup> The review

concluded that the Post Concussion Symptom Scale used in a computerized neurocognitive testing battery distinguishes high school athletes with mTBI from those without TBI within the first 4 days after injury.<sup>59,60</sup> 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 (eg, the Health and Behavior Inventory<sup>61</sup> and the Post-Concussion Symptom Inventory<sup>62</sup>). Symptom rating scales can be applied quickly and inexpensively.

Two class II studies<sup>59,60</sup> met inclusion criteria related to computerized cognitive testing and the diagnosis of mTBI in children. These studies specifically used a computerized neurocognitive testing battery and demonstrated that it probably distinguishes high school athletes with and without mTBI in the first 4 days after injury and may add sensitivity to the use of a symptom rating scale alone.<sup>59,60</sup> While these 2 studies only reviewed 1 specific computerized neurocognitive battery, related evidence suggests that other validated computerized cognitive tests are also able to discriminate between children with and without mTBI.<sup>63,64</sup>

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 because of lack of statistical significance from a single class III study.<sup>58</sup>

#### Serum Markers

**Recommendation 6:** Health care professionals should not use 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 2 class II studies,<sup>65,66</sup> SIOOB was shown to be associated with a low sensitivity but high specificity in patients with severe TBI, with no discrimination in mild to moderate TBI. In a class II study,<sup>65</sup> tau protein levels were significantly different across pediatric patients with mTBI with normal head CT, those with abnormal CT, and among non-TBI controls. A single class II study<sup>66</sup> explored the use of autoantibodies against glutamate receptors and oxide metabolites as a marker to discriminate between severe and mTBI in children. There was good discrimination between the 2 groups; however, further data are needed. A single class III study<sup>67</sup> examined multiplex bead array biomarkers in a small number of infants with TBI compared with controls and found significant differences in a number of biomarkers. Related studies<sup>68-71</sup> have demonstrated associations between neuronal ubiquitin C-terminal hydrolase-L1 and glial fibrillary acidic protein biomarker levels and ICI in adults, and a single class II study<sup>72</sup> of 23 children found insufficient evidence for the use of these biomarkers in distinguishing children with or without mTBI.

#### Prognostic Recommendations

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

#### General Health Care Professional Counseling of Prognosis

**Recommendation 7A:** Health care professionals should counsel patients and families that most (70%-80%) children with mTBI do not

show significant difficulties that last more than 1 to 3 months after injury (moderate; level B).

**Recommendation 7B:** Health care professionals 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,<sup>73-75</sup> and no single factor can predict symptom resolution or outcome.<sup>76</sup> Symptoms experienced by most children with mTBI resolve within 1 to 3 months after injury.<sup>73</sup> A single class III study<sup>77</sup> 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. Related studies<sup>78,79</sup> in children and adults with mTBI report direct patient benefits of counseling by health care professionals. 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.<sup>80-82</sup> Important aspects of health care professional counseling are outlined in recommendation 12.

#### Prognosis Related to the Premorbid Conditions

**Recommendation 8A:** Health care professionals should assess the premorbid history of children either before injury as a part of preparticipation athletic examinations or as soon as possible after injury in children with mTBI to assist in determining prognosis (moderate; level B).

**Recommendation 8B:** Health care professionals should counsel children and families completing preparticipation athletic examinations and children with mTBI, as well as their families, that recovery from mTBI might be delayed in those with the following:

- Premorbid histories of mTBI
- Lower cognitive ability (for children with an intracranial lesion)
- Neurological or psychiatric disorder
- Learning difficulties
- Increased preinjury symptoms (ie, 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.<sup>83-89</sup>

#### Assessment of Cumulative Risk Factors and Prognosis

**Recommendation 9A:** Health care professionals should screen for known risk factors for persistent symptoms in children with mTBI (moderate; level B).

**Recommendation 9B:** Health care professionals 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 (eg, demographic) and injury-related factors predict outcomes in pediatric mTBI. Specifically, symptoms may last longer among older children/adolescents,<sup>73,90,91</sup> children of Hispanic race/ethnicity (compared with white race/ethnicity),<sup>91</sup> children of lower socioeconomic status,<sup>89,91</sup> children with more severe presenta-

tions of mTBI<sup>75,92,93</sup> (including those associated with ICI),<sup>92,94</sup> and children reporting more acute postconcussion symptoms.<sup>74,84,95</sup> In addition, headaches persist longer in girls.<sup>90</sup> However, no single factor is strongly predictive of outcome. Only 1 prediction rule has been validated to date. It is based on a 2016 study<sup>96</sup> of 3063 children with mTBI seen in the ED and demonstrated that an empirically derived set of risk factors predicted the risk of persistent postconcussion symptoms at 28 days.

#### Assessment Tools and Prognosis

**Recommendation 10A:** Health care professionals should use a combination of tools to assess recovery in children with mTBI (moderate; level B).

**Recommendation 10B:** Health care professionals should use validated symptom scales to assess recovery in children with mTBI (moderate; level B).

**Recommendation 10C:** Health care professionals may use validated cognitive testing (including measures of reaction time) to assess recovery in children with mTBI (moderate; level C).

**Recommendation 10D:** Health care professionals 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.<sup>76</sup> However, multiple tools have shown utility in the assessment of individual patients and their recovery from mTBI.<sup>97-99</sup> 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.<sup>100</sup> Less evidence supports balance testing as a predictor for prognosis in children, but it has shown utility in older adolescent athletes.<sup>101</sup>

#### Interventions for mTBI With Poor Prognosis

**Recommendation 11A:** Health care professionals should closely monitor children with mTBI who are determined to be at high risk for persistent symptoms based on their premorbid history, demographics, and/or injury characteristics (high; level B).

**Recommendation 11B:** For children with mTBI whose symptoms do not resolve as expected with standard care (ie, within 4-6 weeks), health care professionals should provide or refer for appropriate assessments and/or interventions (moderate; level B).

Rationale: The symptoms experienced by most children with mTBI resolve within 1 to 3 months after injury,<sup>73</sup> but some children are at risk for persistent symptoms and delayed recovery (ie, 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. Health care professionals can more effectively counsel patients with mTBI when they have assessed prognostic risk factors.

#### Recommendations Related to Management/Treatment

This section contains recommendations 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 recommendations related to the management/treatment 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 health care professional 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 after 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.<sup>80-82</sup> Patient and family education and reassurance are key components of mTBI care initiatives and ED discharge instructions.<sup>77-79,102</sup> Standardized processes of evaluation and discharge instruction provide significant benefit with respect to pediatric patient mTBI outcomes.<sup>78</sup>

#### Cognitive/Physical Rest and Aerobic Treatment

**Recommendation 13A:** Health care professionals should counsel patients to observe more restrictive physical and cognitive activity during the first several days after mTBI in children (moderate; level B).

**Recommendation 13B:** Following these first several days, health care professionals should counsel patients and families to resume a gradual schedule of activity that does not exacerbate symptoms, with close monitoring of symptom expression (number and severity) (moderate; level B).

**Recommendation 13C:** After the successful resumption of a gradual schedule of activity (see recommendation 13B), health care professionals 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 and severity) (high; level B).

**Recommendation 13D:** Health care professionals 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.<sup>103,104</sup> However, scientific evidence supporting its timing, duration, and efficacy is limited.<sup>105</sup> Related evidence suggests that rest or reduction in cognitive/physical activity is beneficial immediately after mTBI and, for those who are slow to recover, may help accelerate recovery.<sup>106-108</sup> The postinjury period is a posited temporal window of vulnerability for reinjury<sup>109,110</sup> because the reinjury threshold is lower during recovery and the symptom burden may be greater.<sup>111-113</sup> On the other hand, studies<sup>114-117</sup> in children and adults with prolonged symptoms beyond 4 weeks demonstrate that physical exercise, performed below symptom exacerbation, reduced postconcussive symptoms in active rehabilitation models.

The optimal timing to initiate an aerobic program after pediatric mTBI has not been established, and only a limited number of

studies<sup>114-116</sup> have applied this treatment to patients with symptoms persisting past 4 weeks. Related evidence suggests that early rest (within the first 3 days of injury) may be beneficial<sup>103,118</sup> but that inactivity beyond this period for most children may worsen their self-reported symptoms.<sup>119</sup>

#### Psychosocial/Emotional Support

**Recommendation 14:** Health care professionals may assess the extent and types of social support (ie, emotional, informational, instrumental, and 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 proved useful in promoting the recovery of persons with TBI, particularly those with cognitive deficits.<sup>113,120</sup> Limited research with those who have experienced an mTBI demonstrates similar benefits.<sup>121,122</sup> Direct, ancillary, and extrapolated evidence is strongly suggestive of the utility of social support in the management of mTBI.

#### Return to School

**Recommendation 15A:** To assist children returning to school after 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).

**Recommendation 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).

**Recommendation 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 (eg, Individuals With Disabilities Education Act §504)<sup>123</sup> (high; level B).

**Recommendation 15D:** Postconcussion symptoms and academic progress in school should be monitored collaboratively by the student, family, health care professional(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).

**Recommendation 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).

**Recommendation 15F:** For students who demonstrate prolonged symptoms and academic difficulties despite an active treatment approach, health care professionals should refer the child for a formal evaluation by a specialist in pediatric mTBI (moderate; level B).

**Rationale:** Return to school after mTBI must be carefully planned given the injury symptoms (eg, headaches and fatigue interfering with learning, greater problems concentrating on schoolwork, and difficulty taking notes) that can affect learning and performance.<sup>124,125</sup> Limited evidence exists to guide the timing or progression of return to activity in relation to academic activities.<sup>119</sup> Consensus-based recommendations for returning to school after

mTBI attempt to minimize cognitive and physical overexertion, while encouraging a prompt return to school to avoid the deleterious effects of prolonged school absence.<sup>104</sup> 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.<sup>104,124,126-129</sup> 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.<sup>123,130</sup>

#### Posttraumatic Headache Management/Treatment

**Recommendation 16A:** Health care professionals in the ED should clinically observe and consider obtaining a head CT in children seen with severe headache, especially when associated with other risk factors and worsening headache after mTBI, to evaluate for ICI requiring further management in accord with validated clinical decision-making rules (high; level B).

**Recommendation 16B:** Children undergoing observation periods for headache with acutely worsening symptoms should undergo emergent neuroimaging (high; level B).

**Recommendation 16C:** Health care professionals and caregivers should offer nonopioid analgesia (ie, ibuprofen or acetaminophen) to children with painful headache after acute mTBI but also provide counseling to the family regarding the risks of analgesic overuse, including rebound headache (moderate; level B).

**Recommendation 16D:** Health care professionals 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).

**Recommendation 16E:** Chronic headache after mTBI is likely to be multifactorial; therefore, health care professionals 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 seen with a headache, including worsening or severe headache, after mTBI with GCS scores of 13 to 15 are probably at moderate risk for ICI, as reflected by a risk difference of 1.9% (95% CI, 0.1%-3.6%) from 3 class I studies<sup>20,22,33</sup> and 1 class II study.<sup>35</sup> This evidence supports the contention that the risk of not identifying more severe forms of TBI manifesting as a progressive, severe headache in a child with or without other risk factors outweighs the risk of ionizing radiation. Risk of isolated severe headache after mTBI for ICI was not supported in a large study<sup>40</sup> when GCS scores were 14 or above. Painful headache in children requires intervention. Nonopioid analgesics, such as ibuprofen and acetaminophen, are often effective in treating headaches in children, and opioids are not generally recommended as therapy for headaches.<sup>62,131,132</sup> Nonopioid analgesic overuse carries important risks of toxic effects and rebound headache.<sup>133</sup> There is insufficient evidence to currently recommend the administration of 3% hypertonic saline as a treatment for acute headache after mTBI in children. Among children in the ED, a single class I study<sup>134</sup> found that

3% hypertonic saline possibly decreases pain with headache immediately after administration but not at 3 days after intervention.

#### Vestibulo-Oculomotor Dysfunction Management/Treatment

**Recommendation 17:** Health care professionals may refer children with subjective or objective evidence of persistent vestibulo-oculomotor dysfunction after mTBI to a program of vestibular rehabilitation (moderate; level C).

**Rationale:** A single class II study<sup>135</sup> reported that vestibular and oculomotor dysfunction may contribute to the diagnosis of mTBI and longer symptom duration. Limited evidence suggests that early vestibulo-ocular and cervicovestibular physical therapy may be of benefit for patients seen with subjective reports (symptoms of dizziness) or objective physical examination findings.<sup>136-139</sup>

#### Sleep Management/Treatment

**Recommendation 18A:** Health care professionals should provide guidance on proper sleep hygiene methods to facilitate recovery from pediatric mTBI (moderate; level B).

**Recommendation 18B:** If sleep problems emerge or continue despite appropriate sleep hygiene measures, health care professionals 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<sup>140</sup> and, when not adequate, adversely affects medical conditions, including TBI.<sup>141-143</sup> 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 the management of disrupted sleep may be a critical target of treatment for the child with mTBI.<sup>144-146</sup>

#### Cognitive Impairment Management/Treatment

**Recommendation 19A:** Health care professionals should attempt to determine the etiology of cognitive dysfunction within the context of other mTBI symptoms (moderate; level B).

**Recommendation 19B:** Health care professionals should recommend treatment for cognitive dysfunction that reflects its presumed etiology (high; level B).

**Recommendation 19C:** Health care professionals may refer children with persisting problems related to cognitive function

for a formal neuropsychological evaluation to assist in determining the etiology and recommending targeted treatment (high; level C).

**Rationale:** Cognitive impairment occurs after mTBI and includes the areas of attention, memory and learning, response speed, and aspects of executive functions.<sup>59,60,147,148</sup> Cognitive impairment may be directly related to the pathology of the brain injury (ie, impaired neurotransmission) but may also reflect secondary effects of other symptoms (eg, ongoing headache pain, fatigue/low energy, and low frustration tolerance) that may produce a disruption in cognitive processing. Neuropsychological evaluations can assist in determining the etiology of cognitive impairment and directing treatment.<sup>148</sup>

## Conclusions

The science of managing mTBI in children is rapidly evolving and expanding. This guideline identifies the best practices based on the current evidence for health care professionals in primary care, outpatient specialty, inpatient, and emergency care settings; updates may be made as the body of evidence grows. Suggestions related to key future directions for research are described in the systematic review<sup>10</sup> that informed this guideline.

Equally as important as the development of this guideline is a multifaceted approach to its implementation.<sup>149,150</sup> The CDC created user-friendly implementation materials<sup>151</sup> that are concise and actionable.<sup>150</sup> These materials include a screening tool, online training, and fact sheets. Patient discharge instructions, inclusive of a return-to-activity protocol, and symptom-based recovery tips were also created.<sup>152</sup> The CDC will leverage its HEADS UP campaign (<http://www.cdc.gov/HEADSUP>) to support distribution of the guideline implementation materials through leading organizations and digital platforms (ie, web, mobile, and 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 the CDC's Injury Center<sup>153</sup>; evaluation is crucial for understanding the influence of the recommendations, both intended and unintended, and for revising future recommendations and implementation materials.

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