Clinical Practice Guideline Recommendations in Pediatric Mild Traumatic Brain Injury: A Systematic Review

Lynne Moore, PhD*; Anis Ben Abdeljelil, BPharm, MSc; Pier-Alexandre Tardif, MSc; Roger Zemek, MD, FRCPC; Nick Reed, OT, PhD; Keith Owen Yeates, RPsych, PhD; Carolyn A. Emery, OT, PhD; Isabelle J. Gagnon, PT, PhD; Natalie Yanchar, MD, MSc; Mélanie Bérubé, PRN, PhD; Jennifer Dawson, PhD; Simon Berthelot, MD, MSc; Antonia Stang, MD, MSc; Suzanne Beno, DABP, MD; Emilie Beaulieu, MD, MPH; Alexis F. Turgeon, MD, MSc; Melanie Labrosse, MD, PhD; François Lauzier, MD, MSc; Ian Pike, PhD; Alison Macpherson, PhD; Gabrielle C. Freire, MD, MSc

*Corresponding Author. E-mail: Lynne.moore@fmed.ulaval.ca.

Study objective: Our primary objectives were to identify clinical practice guideline recommendations for children with acute mild traumatic brain injury (mTBI) presenting to an emergency department (ED), appraise their overall quality, and synthesize the quality of evidence and the strength of included recommendations.

Methods: We searched MEDLINE, EMBASE, Cochrane Central, Web of Science, and medical association websites from January 2012 to May 2023 for clinical practice guidelines with at least 1 recommendation targeting pediatric mTBI populations presenting to the ED within 48 hours of injury for any diagnostic or therapeutic intervention in the acute phase of care (ED and inhospital). Pairs of reviewers independently assessed overall clinical practice guideline quality using the Appraisal of Guidelines Research and Evaluation (AGREE) II tool. The quality of evidence on recommendations was synthesized using a matrix based on the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Evidence-to-Decision framework.

Results: We included 11 clinical practice guidelines, of which 6 (55%) were rated high quality. These included 101 recommendations, of which 34 (34%) were based on moderate- to high-quality evidence, covering initial assessment, initial diagnostic imaging, monitoring/observation, therapeutic interventions, discharge advice, follow-up, and patient and family support. We did not identify any evidence-based recommendations in high-quality clinical practice guidelines for repeat imaging, neurosurgical consultation, or hospital admission. Lack of strategies and tools to aid implementation and editorial independence were the most common methodological weaknesses.

Conclusions: We identified 34 recommendations based on moderate- to high-quality evidence that may be considered for implementation in clinical settings. Our review highlights important areas for future research. This review also underlines the importance of providing strategies to facilitate the implementation of clinical practice guideline recommendations for pediatric mTBI. [Ann Emerg Med. 2024;83:327-339.]

Please see page 328 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Every year in the United States, approximately 475,000 children 0 to 14 years of age sustain a traumatic brain injury (TBI), and the rate of TBI worldwide is estimated to be 134 per 100,000 children.[1-3] In the United States, children <5 years of age and adolescents (15 to 19 years) are among the most likely to have a TBI-related emergency department (ED) visit, with approximately 640,000 visits, 18,000 hospital stays and 1,500 deaths yearly for those aged 0 to 14 years.[4] Mild traumatic brain injury (mTBI) is defined as a Glasgow Coma Scale score ≥13 at 30 minutes postinjury,[5] with 1 or more of the following symptoms: <30 min loss of consciousness, <24 hours post-traumatic amnesia, impaired mental state at time of injury, and/or transient neurologic deficit. mTBI likely accounts for 70% to 90% of TBI-related pediatric ED visits.[6] In the United States, total population-level costs of pediatric mTBI in the 3 months postinjury were estimated at $695 million for 2010.[7]

Editor's Capsule Summary

What is already known on this topic

Many clinical practice guidelines for the emergency care of children with head injuries exist with varying evidentiary support.

What question this study addressed

What is the strength of evidence for the published pediatric head injury guidelines?

What this study adds to our knowledge

Of the 11 clinical guidelines identified and rated by experts, 6 guidelines were high quality and included 34 specific recommendations based on moderate- or high-quality evidence.

How this is relevant to clinical practice

Implementation of pediatric head trauma guidelines should focus on recommendations supported by the best evidence.

Multiple clinical practice guidelines containing recommendations on the diagnosis and management of pediatric mTBI have been developed by organizations, such as the Centers for Disease Control and Prevention (CDC) in the United States and PedsConcussion (PedsC) in Canada.[8,9] However, evidence suggests that adherence to clinical guideline recommendations for managing pediatric mTBI is only around 50%.[10,11] Lack of adherence may be due to incomplete knowledge of updated clinical practice guideline recommendations, heterogeneity in recommendations across the multiple clinical practice guidelines, and/or concerns about quality of evidence or strength of recommendations.[12,13] In addition, the volume and quality of evidence that informs clinical practice guidelines related to mTBI is increasing at a rapid rate, and this has resulted in regular updates to clinical practice guideline recommendations, which may contribute to implementation challenges.[14] A synthesis of recommendations from 4 expert consensus statements/clinical practice guidelines for mTBI targeting clinicians not specialized in the management of TBI (eg, primary care providers) was published in 2020.[15] However, a systematic review of clinical practice guideline recommendations for pediatric mTBI in acute care settings (ie, ED or inpatient) is lacking.

Importance

A synthesis of clinical practice guideline recommendations for acute pediatric mTBI care would help clinicians working in EDs and inpatient settings identify and integrate relevant practice recommendations. It would also provide them with objective and comparable information on the quality of evidence and strength of recommendations supporting them. It may also highlight opportunities for improvement in current clinical practice guidelines and areas of management where high-quality evidence is lacking.

Goals of This Study

Our primary objectives were to i) identify clinical practice guideline recommendations for children and youth with acute mTBI presenting to an ED, ii) appraise the quality of eligible clinical practice guidelines, and iii) synthesize the quality of evidence and the strength of associated recommendations. Our secondary objective was to identify gaps in current clinical practice guideline recommendations.

MATERIALS AND METHODS

This work is part of a series of systematic reviews of clinical practice guideline recommendations for pediatric trauma care, for which the protocol with detailed methods was published previously and registered on the International Prospective Register of Systematic Reviews (PROSPERO #CRD42021226934).[16] Our review is based on methodological guidelines for systematic reviews of clinical practice guidelines and Cochrane methodology for conducting systematic reviews and is reported according to the Preferred Reporting Items for Systematic review and Meta-Analysis protocols (PRISMA) statement (see Table E1 for PRISMA Checklist, available at http://www.annemergmed.com).[17-19] The review was designed and conducted with our interdisciplinary project advisory committee comprising 12 pediatric injury care clinicians (2 orthopedic surgeons, 3 emergency physicians, 2 trauma surgeons, 1 critical care physician, 2 nurse practitioners, and a physiotherapist), many of whom are members of research consortiums on pediatric injury and mTBI care (Pediatric Emergency Research Network [PERN], Pediatric Emergency Research Canada (PERC), Translating Emergency Knowledge for Kids [TREKK], and Canadian Traumatic Brain Injury Research Consortium [CTRC], and the Canadian Concussion Network (CCN)).

Eligibility

We included clinical practice guidelines with at least 1 recommendation for any diagnostic or therapeutic intervention in the acute phase of care (ED and inhospital) targeting pediatric (<19 years of age) mTBI populations presenting to the ED within 48 hours of injury developed

in high-income countries in the last 10 years. Clinical practice guidelines were defined as "statements that include recommendations intended to optimize patient care that are informed by a review of evidence and an assessment of benefits and harms of alternative care options."[20] High-income countries were based on World Bank definitions.[21] Publications only reporting data on the implementation of or adherence to clinical practice guidelines were not eligible but were used to identify any additional clinical practice guidelines. No restriction based on publication language was applied. We focused on recommendations from the acute phase of care as these represent most mTBI presentations to the ED, and recommendations on persisting symptoms have been covered in other reviews.[15,22] We focused on recommendations targeting ED presentations given that the most severe cases present to the ED. Recommendations for community-based primary care providers have been covered in another review.[15] Additionally, we did not consider recommendations pertaining to child abuse as a recent systematic review has synthesized clinical practice guidelines on that topic.[23]

Search Strategy

We searched Medical Literature Analysis and Retrieval System Online (MEDLINE), Excerpta Medica dataBASE (EMBASE), Cochrane CENTRAL, and Web of Science from January 1st, 2012 to June 30th, 2023. In addition, we searched the websites of medical associations publishing recommendations on pediatric injury care using a list established in consultation with our advisory committee (Table E2, available at http://www.annemergmed.com). Our search strategy was developed with an information specialist (PAT) using the 2015 Peer Review of Electronic Search Strategies (PRESS) statement (Table E3, available at http://www.annemergmed.com).[24] Keywords covering combinations of search terms under the themes pediatrics, injury, and clinical practice guidelines as well as MeSH (MEDLINE) or EMTREE (EMBASE) terms were used when appropriate. Key words related to brain injury and concussion were included.

Study Selection

We managed citations using EndNote (version X9.3.3, New York City: Thomson Reuters, 2018). First, pairs of reviewers (LM, PAT, ABA) independently screened titles and abstracts for eligibility. We then assessed full texts to determine eligibility for final inclusion and recorded reasons for exclusion. Selection was piloted on 3 samples of 1500 citations, when acceptable agreement was reached (kappa>0.8).[25] If duplicate clinical practice guidelines were identified, we only included the most recent version. For each clinical practice guideline, 2 reviewers independently located supporting documents (eg, updates, methodological details, systematic review results).

Quality

Pairs of reviewers (LM, PAT, ABA) with content expertise independently assessed the quality of included clinical practice guidelines using the 6 domains of the Appraisal of Guidelines Research and Evaluation (AGREE) II tool: scope and purpose (overall aim of the guideline, specific health questions, and target population), stakeholder involvement (developed by the appropriate stakeholders; represents the views of its intended users), rigor of development (process used to gather and synthesize the evidence, methods to formulate and update the recommendations), clarity and presentation (language, structure, and format), applicability (barriers and facilitators to implementation, strategies to improve uptake, and resource implications), and editorial independence (competing interests are recorded and addressed).[26] Each domain contains between 2 and 8 items that are scored on a Likert scale between 1 (strongly disagree) and 7 (strongly agree). In line with recommendations,[17] we piloted AGREE II on 4 representative samples of 5 clinical practice guidelines until acceptable agreement, based on the team's experience, was attained. Clinical practice guidelines were considered *high quality* if they scored $\geq$60% in at least 3 AGREE II domains, including rigor of development. If 3 domains scored $\geq$60% but rigor of development scored <60%, the clinical practice guidelines was considered of *moderate quality*. Clinical practice guidelines scoring <60% in 2 or more domains and scoring <50% in rigor of development were considered *low quality*.[17]

Data Extraction

We piloted our electronic data abstraction form and an instruction manual on 3 representative samples of 5 clinical practice guidelines until acceptable agreement, based on the team's experience, was attained. Then, pairs of reviewers (LM, PAT, ABA) with methodological and content expertise independently extracted the following data from clinical practice guidelines: first author's last name, title, country, organization, target users, patient population and focus, and recommendations. The same pairs of reviewers then independently assessed the eligibility of recommendations and extracted data on the quality of evidence and the strength of recommendation for each, according to grading criteria used in each clinical practice guideline.

Meta-Synthesis of Recommendations

We synthesized evidence on eligible recommendations from high-quality clinical practice guidelines using a matrix based on certain elements of the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Evidence-to-Decision framework.[27] The framework was developed a priori in consultation with our advisory committee. When the same or very similar recommendations were published by more than one clinical practice guideline, we grouped them. The matrix included the following elements for each recommendation: the clinical practice guideline(s) from which the recommendation was extracted, the quality of evidence, and the strength of recommendations. Grading criteria varied across clinical practice guidelines. We thus mapped quality of evidence and strength of recommendation ratings to GRADE categories (Table E4, validated by members of our advisory committee; available at http://www.annemergmed.com). The advisory committee also identified the following 10 key areas of management to categorize recommendations: 1) initial assessment, 2) initial diagnostic imaging, 3) repeat imaging, 4) monitoring/observation, 5) neurosurgical consultation, 6) hospital admission, 7) therapeutic interventions, 8) discharge advice, 9) follow-up, and 10) patient and family support. While imaging, neurosurgical consultation, and therapeutic interventions may be less applicable in mTBI populations, recommendations on their appropriateness are important, particularly in the context of health care resource constraints. Discrepancies in all phases of the review were resolved by discussion with a senior member of the research team, when necessary.

Protocol Deviations

We planned to use the AGREE Recommendations EXcellence (AGREE-REX) instrument to assess the clinical applicability and implementability of clinical practice guidelines.[17,26] When applying AGREE-REX to included clinical practice guidelines, we found the instrument to be more appropriate when the goal was to adapt clinical practice guidelines to a specific context rather than to evaluate their quality. On consultation with our advisory committee, we thus considered AGREE II to be sufficient to cover the quality of included clinical practice guidelines.

RESULTS

Clinical Practice Guidelines

The search strategy yielded 55,804 citations, 38,198 of which were screened following removal of duplicates (Figure E1, available at http://www.annemergmed.com). Eleven clinical practice guidelines[8,28-36] were included among the 501 full-texts and 95 medical association websites assessed. Three clinical practice guidelines were from the United States, 1 was from Australia, 2 from Canada, and the remaining were from Europe (Italy, Scandinavia, the Netherlands, and the United Kingdom; Table 1). Guidelines were published between 2012 and 2023 with half of them published within the 5 last years. The most common target users were emergency physicians. In total, 6 were specific to a pediatric population, and 5 targeted both adults and children. The foci of interest included initial assessment, initial and repeat diagnostic imaging, monitoring/observation, neurosurgical consultation, hospital admission, discharge advice and follow-up.

Quality of Selected Clinical Practice Guidelines

Six clinical practice guidelines (50%) were rated high quality using the AGREE II tool, 2 were rated moderate quality, and 3 low quality (Table 2). Low-quality clinical practice guidelines scored highly for scope and purpose and clarity of presentation but had limitations in all other domains. All clinical practice guidelines rated low or moderate quality had issues with rigor of development notably because they did not conduct a systematic review of the evidence, evaluate the strengths and limitations of the body of evidence, or establish a clear link between the body of evidence and the recommendations. Among clinical practice guidelines rated high quality, applicability was the most common limitation. More specifically, clinical practice guidelines did not describe barriers and facilitators to implementation, provide implementation tools, or consider resource implications. Editorial independence was also a limitation for 2 high-quality clinical practice guidelines, whereby competing interests of development group members were declared but not addressed.

Synthesis of Recommendations From High-Quality Clinical Practice Guidelines (AGREE II)

We identified a total of 101 recommendations pertaining to the acute care of children with mTBI from high-quality clinical practice guidelines (Table 3, Figure, and Table E5; available at http://www.annemergmed.com). In total, 11 (11%) were based on high-quality evidence and 23 (23%) on moderate-quality evidence, including initial assessment, initial diagnostic imaging, monitoring/observation, therapeutic interventions, discharge advice, follow-up, and patient and family support. Six of these (18%) targeted decreased use of low-value practices (ie, the use of biomarkers, head CT, skull radiographs, magnetic resonance imaging), and the remaining 28 targeted

Table 1. Characteristics of included clinical practice guidelines.

Title, year	Country	Organization (Acronym)	Target users	Patient Population (injury; age group (range); setting)	Focus*
Head Injury: Assessment and Early Management, 2023[36]	UK	National Institute of Health and Care Excellence (NICE)	Clinicians, people with head injury, their families and caregivers, commissioners, and providers	Head injury Adults and children (<16 yo) All settings	Initial assessment, initial diagnostic imaging, observation, repeat imaging, neurosurgical consult, hospital admission, discharge advice, and follow-up
Living Guideline for Pediatric Concussion Care, 2023[9]	Canada	PedsConcussion (PedsC)	Family or emergency physicians, health care professionals in remote regions, and rehabilitation professionals	Children and adolescents (5-18 yo) with concussion	Initial assessment, initial diagnostic imaging, monitoring/observation, therapeutic interventions, discharge advice, and follow-up
Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children, 2021[29]	Australia	Paediatric Research in Emergency Departments International Collaborative (PREDICT)	Physicians	mTBI (GCS 14-15) Children (< 18 yo) Acute care	Initial assessment, initial diagnostic imaging, repeat imaging, discharge advice, and follow-up
Emergency Medicine, 2021[34]	Canada	Choosing Wisely Canada (CWC)	Emergency physicians	mTBI (GCS 13-15) Children (NR) Emergency department	Initial diagnostic imaging
ACR Appropriateness Criteria® Head Trauma-Child, 2020[32]	USA	American College of Radiology (ACR)	Radiologists, radiation oncologists, and referring physicians	Acute blunt head trauma Children (NR) Emergency department	Initial diagnostic imaging
Italian Guidelines on the Assessment and Management of Pediatric Head Injury in the Emergency Department, 2018[30]	Italy	Italian Society of Pediatric Emergency Medicine (ISPEM)	Emergency physicians	Blunt head trauma Children (< 16 yo) Emergency department	Initial assessment, initial diagnostic imaging, observation, repeat imaging, neurosurgical consult, and hospital admission

Table 1. Continued.

Title, year	Country	Organization (Acronym)	Target users	Patient Population (injury; age group (range); setting)	Focus*
Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children, 2018[4]	USA	Centers for Disease Control and Prevention (CDC)	Emergency physicians, clinicians in primary care, outpatient specialty, inpatient, and emergency care settings	mTBI (GCS 13-15) Children (< 19 ISPEMyo) Primary care, outpatient, inpatient, and emergency care	Initial assessment, initial diagnostic imaging, discharge advice, and follow-up
Scandinavian Guidelines for Initial Management of Minor and Moderate Head Trauma in Children, 2016[28]	Scandinavia	Scandinavian Neurotrauma Committee (SNC)	Emergency physicians, general practitioners	Minor and moderate head trauma (GCS 9-15) Children (< 18 yo) Emergency department	Initial diagnostic imaging, observation, discharge advice, and follow-up
Traumatic Brain Injury, 2015[35]	USA	American College of Surgeons – Trauma Quality Improvement Program (ACS-TQIP)	Clinicians	TBI (GCS 3-15) Adults and children (NR) Acute care	Initial assessment
[Revised Practice Guideline 'Management of Patients with Mild Traumatic Head/Brain Injury'], 2012[31]	Netherlands	Dutch Institute for Healthcare Improvement (CBO)	Emergency and primary care physicians	mTBI Adults and children (NR)	Initial diagnostic imaging, admission, and referral
Mild Traumatic Brain Injury, 2012[33]	Multiple European countries	European Federation of Neurological Societies (EFNS)	NR	mTBI (GCS 13-15) Adults and children (NR)	Initial diagnostic imaging, observation, hospital admission, and follow-up

ACR, American College of Radiology; *ACS-TQIP*, American College of Surgeons — Trauma Quality Improvement Program; *CBO*, Dutch Institute for Health Care Improvement [Centraal Begeleidings Orgaan voor de Intercollegiale Toetsing]; *CDC*, Centers for Disease Control and Prevention; *CWC*, Choosing Wisely Canada; *ED*, emergency department; *EFNS*, European Federation of Neurological Societies; *GCS*, Glasgow Coma Scale; *ISPEM*, Italian Society of Pediatric Emergency Medicine; *(m)TBI*, (mild) traumatic brain injury; *NICE*, National Institute of Health and Care Excellence; *NR*, not reported; *PREDICT*, Pediatric Research in Emergency Departments International Collaborative; *SNC*, Scandinavian Neurotrauma Committee; *UK*, United Kingdom; *USA*, United States of America; *yo*, years old.
*Areas of focus with recommendations pertaining to pediatric mTBI.

Table 2. Clinical practice guideline quality according to AGREE II domains and total scores (%).

Guideline	Scope and Purpose*	Stakeholder Involvement†	Rigor of Development‡	Clarity of Presentation§	Applicability‖	Editorial Independence¶	Global Score#	Overall Quality**
Head Injury: Assessment and Early Management, NICE, 2023[36]	100	78	94	94	71	67	86	High
Living Guideline for Pediatric Concussion Care, PedsC, 2021[9]	100	67	92	94	29	75	78	High
Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children, PREDICT, 2021[29]	100	72	58	86	23	100	67	Moderate
Emergency Medicine, CWC, 2021[34]	67	56	19	67	21	50	39	Low
Appropriateness Criteria® Head Trauma-Child, ACR, 2020[32]	72	75	98	100	42	50	78	High
Italian Guidelines on the Assessment and Management of Pediatric Head Injury in the Emergency Department, ISPEM, 2018[30]	78	72	59	78	38	79	64	Moderate
Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children, CDC, 2018[4]	94	67	78	83	67	100	80	High
Scandinavian Guidelines for Initial Management of Minor and Moderate Head Trauma in Children, SNC, 2016[28]	97	61	77	86	38	17	67	High
Traumatic Brain Injury, ACS-TQIP, 2015[35]	72	28	4	44	0	0	21	Low

Table 2. Continued.

Guideline	Scope and Purpose*	Stakeholder Involvement†	Rigor of Development‡	Clarity of Presentation§	Applicability‖	Editorial Independence¶	Global Score#	Overall Quality**
Revised Practice Guideline 'Management of Patients with Mild Traumatic Head/ Brain Injury', CBO, 2012[31]	92	42	64	94	35	63	64	High
Mild Traumatic Brain Injury, EFNS, 2012[33]	72	17	35	83	6	29	39	Low

Red indicates low; orange indicates moderate; and green indicates high.
ACR, American College of Radiology; *ACS-TQIP*, American College of Surgeons — Trauma Quality Improvement Program; *AGREE*, Appraisal of Guidelines for Research & Evaluation; *CBO*, Dutch Institute for Health Care Improvement [Centraal Begeleidings Orgaan voor de Intercollegiale Toetsing]; *CDC*, Centers for Disease Control and Prevention; *CWC*, Choosing Wisely Canada; *EFNS*, European Federation of Neurological Societies; *ISPEM*, Italian Society of Pediatric Emergency Medicine; *NICE*, National Institute of Health and Care Excellence; *PedsC*, PedsConcussion; *PREDICT*, Pediatric Research in Emergency Departments International Collaborative.
*Objectives, health questions, and population to whom the clinical practice guideline applies are specifically described.
†Development group includes all relevant professionals, views of target population (patients, public etc.) sought, and clearly defined target users.
‡Systematic methods to search for evidence; criteria for selecting evidence, strengths and limitations of body of evidence, methods for formulating recommendations clearly described; health benefits, side effects, and risks considered explicit link between evidence and recommendations; externally reviewed by experts; and process for updating the clinical practice guideline provided.
§Recommendations specific and unambiguous, different management options clearly presented, and easily identifiable key recommendations.
‖Barriers and facilitators to application described, advice and/or tools for implementation, potential resource implications considered, and monitoring/auditing criteria presented.
¶Views of the funding body have not influenced the content, and competing interests are reported and addressed.
#Calculated as ((Sum of all scores – Global minimum [1*23*2]) / (Global maximum [7*23*2] – Global minimum [1*23*2]))*100.
***High:* ≥60% in at least 3 domains, including rigor of development. *Moderate:* 3 domains ≥60% but <60% for domain 3. Low: <60% in 2 or more domains and < 50% in domain 3.

increased use high-value practices. In total, 8 recommendations were mentioned in more than one clinical practice guideline, and 3 were mentioned in more than 2. Among recommendations based on high- or moderate-quality evidence, 34 were published by the CDC, 4 were from the American College of Radiology, 5 were from PedsC, 3 were from the Dutch Institute for Health Care Improvement, one was from the Scandinavian Neurotrauma Committee and one was from the National Institute of Health and Care Excellence. In total, 40 (40%) of the recommendations extracted from high-quality clinical practice guidelines were based on low-quality evidence, and 29 (29%) were not evidence-based, ie, were solely based on consensus. Low evidence or consensus-based recommendations were mostly suggested by PedsC (33), the Dutch Institute for Health Care Improvement (26), the National Institute of Health and Care Excellence (12), and the Scandinavian Neurotrauma Committee (2) (Table E5, available at http://www.annemergmed.com).

Gaps in Clinical Practice Guideline Recommendations

High-quality clinical practice guidelines covered all key areas of management (Figure). However, only 4 of the 10 key areas of management had recommendations based on high-quality evidence: initial assessment, initial diagnostic imaging, discharge advice, and follow-up. No recommendations based on either high or moderate-quality evidence were identified for repeat imaging, neurosurgical consultation, or hospital admission.

LIMITATIONS

This systematic review was conducted according to robust methodological standards and the latest guidelines on systematic reviews of clinical practice guidelines. Nevertheless, our review has some limitations. First, for feasibility reasons, our search strategy targeted clinical practice guidelines in pediatric mTBI populations, perhaps leading us to miss recommendations on pediatric mTBI published in clinical practice guidelines on all age groups or multidiagnostic populations (eg, ED presentations). However, considering that we reviewed multiple medical association web sites and references of included clinical practice guidelines and consulted with experts on our advisory committee, many of whom are members of pediatric emergency care and TBI research consortiums in the United States and Canada, we believe we captured the most relevant recommendations. Furthermore, as we restricted our review to ED presentations and acute care, we did not include several widely recognized clinical practice guidelines, such as the Consensus Statement on

Table 3. Recommendations based on high-quality evidence (mapped to GRADE)* from high-quality clinical practice guidelines (AGREE II)†.

Recommendations According to Key Areas of Management	Clinical Practice Guideline	Strength of Recommendation*
Initial Assessment		
HCPs should not use biomarkers outside of the research setting for the diagnosis of children with mTBI	CDC	Weak
Assess existing and new mental health symptoms and disorders	PedsC	NR
Note common modifiers that may delay recovery and use a clinical risk score to predict risk of prolonged symptoms	PedsC	NR
Initial Diagnostic Imaging		
ED HCPs should observe and consider head CT in children seen with severe headache, especially when associated with other risk factors and worsening headache after mTBI in accordance with validated clinical decisionmaking rules	CDC	Moderate
Children undergoing observation for headache with acutely worsening symptoms should undergo emergent neuroimaging	CDC	Moderate
Consider CT of the brain or cervical spine only in patients with acute head trauma in whom an intracranial or cervical spine injury is suspected; do not conduct routine neuroimaging for the purpose of diagnosing concussion	PedsC	NR
Skull radiographs should not be used in the diagnosis of pediatric mTBI or screening for intracranial injury	CDC ACR§ CBO§	Moderate
Discharge Advice		
ED HCPs may use validated prediction rules for persistent symptoms to provide prognostic counseling to children with mTBI	CDC	Weak
HCPs should inform the family on the following: 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, and clear clinician follow-up instructions	CDC	Strong
Recommend a period of relative rest‡ for 24 to 48 hours immediately following acute mTBI	PedsC	NR
Follow-Up		
Refer select patients‖ following acute injury to a medically supervised interdisciplinary team with the ability to individually assess aerobic exercise tolerance and to prescribe aerobic exercise treatment	PedsC	NR

ACR, American College of Radiology; *AGREE*, Appraisal of Guidelines for Research & Evaluation; *CDC*, Centers for Disease Control and Prevention; *mTBI*, mild traumatic brain injury; *CBO*, Dutch Institute for Health Care Improvement [Centraal Begeleidings Orgaan voor de Intercollegiale Toetsing]; *CT*, computed tomography; *ED*, emergency department; *GRADE*, Grading of Recommendations, Assessment, Development, and Evaluations; *HCP*, health care provider; *PedsC*, PedsConcussion.
*Mapped to GRADE criteria (see Table E3, available at http://www.annemergmed.com).
†Recommendations from clinical practice guidelines rated high quality on AGREE II.
‡Activities of daily living, including walking and other symptom-limited physical and cognitive activities, are permitted as tolerated.
§Low according to ACR and CBO.
‖For instance, highly active or competitive athletes, those who are not tolerating a graduated return to physical activity, or those who are slow to recover.

Concussion in Sport.[37] Second, while the definitions used to classify clinical practice guidelines as low, moderate or high quality using AGREE II are recommended and broadly used,[17] they have not been formally validated. Recommendations from clinical practice guidelines rated moderate or low quality were extracted and can be made available on request. Third, to facilitate the comparison of recommendations across clinical practice guidelines, we mapped criteria on quality of evidence and strength of recommendations to GRADE categories. Despite validating mapping criteria with members of our advisory committee, heterogeneity across clinical practice guidelines likely persists given the subjective nature of grading of evidence and establishing the strength of recommendations. Finally, our review focused on clinical practice guidelines from high-income countries. Our search strategy was not limited by the country income category, but we did not identify any clinical practice guidelines from low- or middle-income countries. This should be the focus of future work.

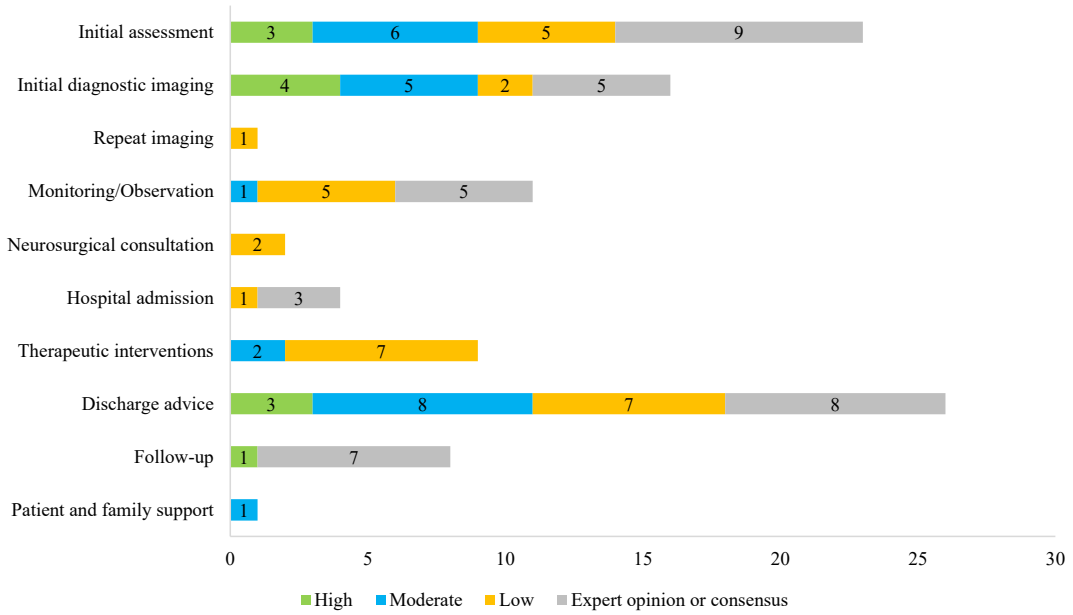

Figure. Number of recommendations from high-quality clinical practice guidelines (AGREE-II rating) according to key areas of management and quality of evidence.

DISCUSSION

In our systematic review of clinical practice guideline recommendations for pediatric acute mTBI, we identified 11 clinical practice guidelines, half of which were rated high quality, including clinical practice guidelines published by the National Institute of Health and Care Excellence from the UK, the CDC and American College of Radiology from the US, PedsC from Canada, the Scandinavian Neurotrauma Committee from Scandinavia, and the Dutch Institute for Health Care Improvement from the Netherlands. Applicability and editorial independence were identified as limitations even in some high-quality clinical practice guidelines. We extracted 101 recommendations from these clinical practice guidelines, of which 11% were based on high-quality evidence, 23% on moderate-quality evidence, 40% on low-quality evidence, and 29% on expert opinion/consensus only. We identified gaps in evidence-based recommendations for repeat imaging, neurosurgical consultation, and hospital admission.

Compared to other reviews on clinical practice guideline recommendations in pediatric injury care, a high proportion of identified clinical practice guidelines were rated moderate or high quality in this review (72% compared to 60% for moderate-severe TBI, 38% for solid organ injury, and 58% for major trauma) suggesting that mTBI care is supported by good quality clinical practice guidelines.[38-40] Specifically, although the involvement of all stakeholders, including allied health care professionals and patient and family representatives, was identified as a weakness in these other reviews, it was rated highly for all moderate- to high-quality clinical practice guidelines in this review on mTBI.[38-40] However, the lack of support for the implementation of clinical practice guidelines was identified as the most important limitation in all prior reviews of clinical practice guidelines on pediatric injury care as well as in this review.[38-41] Clinical practice guidelines published by the National Institute of Health and Care Excellence and CDC obtained high scores for this domain because they discussed barriers and facilitators to implementation, provided implementation tools (eg, clinical decision-making tools, patient-clinician shared decision-making tools, educative materials for patients), discussed resource implications (ie, included evidence from economic evaluations), and provided auditing criteria to assess adherence to recommendations. Implementation strategies have been shown to be effective in increasing adherence to clinical practice guideline recommendations.[42,43] Editorial independence has also been identified as a weakness of clinical practice guidelines.[44,45] Conflicts of interest may be due to financial relationships that have been associated with favorable recommendations of drugs and devices in clinical practice guidelines.[46] This may be less relevant in mTBI care than other areas of trauma care, which are more focused on therapeutic interventions. However, conflicts due to reimbursement incentives, intellectual biases, or research interests and career advancement, which have also been documented to influence clinical practice guideline

recommendations, do apply in key areas of management of mTBI.[47] The United States National Academy of Medicine and the *Lancet* have published comprehensive recommendations on how to address conflicts of interest in clinical practice guideline development.[47,48] Again, the National Institute of Health and Care Excellence and CDC scored highly on this domain as did the Pediatric Research in Emergency Departments International Collaborative and the Italian Society of Pediatric Emergency Medicine.

The proportion of recommendations based on moderate to high-quality evidence (34%) was also higher in this review than in other areas of pediatric injury care (8% for moderate-to-severe TBI, 17% for major trauma, and 20% for solid organ injury).[38-40] It also included recommendations based on moderate- to high-quality evidence on discharge advice, follow-up, and patient and family support, all identified as gaps in other areas of pediatric injury care.[38-40] This may reflect the large volumes of children presenting to the ED with mTBI, facilitating robust research including randomized controlled trials in this population. However, we did identify gaps in current recommendations. We did not identify any recommendations based on moderate- to high-level evidence on repeat imaging, neurosurgical consultation, or hospital admission. Low-quality evidence in adults suggests that repeat imaging for mTBI without neurologic deterioration is unnecessary.[49-54] However, high-quality prospective or randomized trials on this topic are lacking, and there is no evidence for children.[53,55,56] Additionally, neurosurgical consultation and hospital admission in patients with mild or mild complicated TBI (ie, mild TBI with nonoperative lesions on imaging) have been identified as a low-value practices in adults and have been reported to be frequent in children.[3,49,50] Potentially unnecessary consultations and admissions may be due to fear of missing clinically important TBI, lack of expertise in reading brain imaging, or support from a peer for medico-legal reasons.[50] They may also be motivated by concerns regarding the intentional nature of the trauma, especially in infants and young children.[23] Nevertheless, robust evidence on this topic in children is lacking. Given the burden on the health care system and on patients and families given unnecessary consultations and hospital admissions that often imply interhospital transfer, these practices should be the topic of further research.[57,58]

In summary, our review fills an important gap on recommendations for children and youth presenting to an ED with acute mTBI that can be used by clinicians practicing in emergency care settings. We identified 33 recommendations based on moderate- to high-quality evidence regarding initial assessment, initial diagnostic imaging, monitoring/observation, therapeutic interventions, discharge advice, follow-up, and patient and family support that may be considered for implementation in clinical settings. We highlighted important areas for future research, including repeat imaging, neurosurgical consultation, and hospital admission, which could lead to a more appropriate use of scarce resources in this patient population. Finally, our review underlines the importance of providing strategies to facilitate implementation, including clinician and patient/family education, clinical decision aids, shared decision-making tools, and auditing criteria.

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Author affiliations: From the Population Health and Optimal Health Practices Research Unit (Moore, Abdeljelil, Tardif, Bérubé, Berthelot, Turgeon, Lauzier), Centre de Recherche du CHU de Québec, Université Laval (Hôpital de l'Enfant-Jésus), Québec City, Québec, Canada; Department of Social and Preventative Medicine (Moore, Abdeljelil), Université Laval, Québec, Québec, Canada; Department of Pediatrics (Zemek), Children's Hospital of Eastern Ontario, Ottawa, Ontario, Canada; Department of Occupational Science and Occupational Therapy (Reed) and Rehabilitation Sciences Institute (Reed), University of Toronto, Toronto, Ontario, Canada; Department of Psychology (Yeates), Alberta Children's Hospital Research Institute, and Hotchkiss Brain Institute, University of Calgary, Calgary, Alberta, Canada; Sport Injury Prevention Research Centre (Emery), Faculty of Kinesiology, University of Calgary, Calgary, Alberts, Canada; Division of Pediatric Emergency Medicine (Gagnon), McGill University Health Centre, Montréal Children's Hospital, Montréal, Québec, Canada; Department of Surgery (Yanchar), University of Calgary, Calgary, Alberta, Canada; Faculty of Nursing (Bérubé), Université Laval, Québec City, Québec, Canada; Children's Hospital of Eastern Ontario Research Institute (Dawson), Ottawa, Ontario, Canada; Pediatrics, Emergency Medicine, and Community Health Sciences (Stang), Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada; Division of Emergency Medicine (Beno), Hospital for Sick Children, University of Toronto, Toronto, Ontario, Canada; Département de Pédiatrie (Beaulieu), Centre Hospitalier Universitaire de Québec-Université Laval, Québec City, Québec, Canada; Department of Anesthesiology and Critical Care Medicine (Turgeon, Lauzier), Université Laval, Québec City, Québec, Canada; Department of Pediatrics (Labrosse), CHU Sainte-Justine, Université de Montréal, Montréal, Québec, Canada; Department of Pediatrics (Pike), University of British Columbia, Vancouver, British Columbia, Canada; School of Kinesiology and Health Science (Macpherson), York University, Toronto, Ontario, Canada; Division of Emergency Medicine (Freire), Department of Pediatrics, University of Toronto, Toronto, Ontario, Canada; Child Health Evaluative Sciences Program (Freire), Peter Gilgan Institute for Research and Learning, The Hospital for Sick Children, Toronto, Ontario, Canada.

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