Babl Franz (Orcid ID: 0000-0002-1107-2187)
OAKLEY ED (Orcid ID: 0000-0002-3712-6200)
Lithgow Anna (Orcid ID: 0000-0003-2675-6749)
Wilson Catherine (Orcid ID: 0000-0001-5893-4226)

Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children

Authors

Franz E Babl[1,2,3], Emma Tavender[2,3], Dustin W Ballard[4], Meredith L Borland[5,6], Ed Oakley[1,2,3], Elizabeth Cotterell[7], Lambros Halkidis[8], Stacy Goergen[9,10], Gavin A Davis[2,11], David Perry[12], Vicki Anderson[2,3,13], Karen M Barlow[14,15], Peter Barnett[1,2,3], Scott Bennetts[16], Roisin Bhamjee[17], Joanne Cole[18], John Craven[19,20,21], Libby Haskell[22], Ben Lawton[14,23,24,25], Anna Lithgow[26], Glenda Mullen[27], Sharon O'Brien[5], Michelle Paproth, Catherine L Wilson[2], Jenny Ring[28,] Agnes Wilson[28], Grace SY Leo[24,27,29], Stuart R Dalziel[22,30] on behalf of Paediatric Research in Emergency Departments International Collaborative (PREDICT).

Franz E Babl, MD, paediatric emergency physician
Emma Tavender, PhD, implementation scientist
Dustin W Ballard, MD emergency physician
Meredith L Borland, MBBS, paediatric emergency physician
Ed Oakley, MBBS, paediatric emergency physician
Elizabeth Cotterell, MBBS, general paediatrician
Lambros Halkidis, MBBS, emergency physician
Stacy K Goergen, MBBS, radiologist
Gavin A Davis, MBBS, neurosurgeon
David Perry, MBBS, radiologist
Vicki Anderson, PhD neuropsychologist
Karen M Barlow, PhD, MBChB paediatric neurologist
Peter Barnett, MBBS, paediatric sports doctor, paediatric emergency physician
Scott Bennetts, MPH, ambulance guideline director
Roisin Bhamjee, MBBCh, general practitioner, lecturer in primary care
Joanne Cole, MBChB, emergency physician
John A Craven, BMBS, paediatric emergency physician
Libby Haskell, MN, nurse practitioner
Ben Lawton, MBBS, paediatric emergency physician
Anna Lithgow, MBBS, paediatrician
Glenda Mullen, nurse practitioner paediatric emergency
Sharon O'Brien, RN, research coordinator
Michelle Paproth, consumer representative
Catherine L Wilson, MPH, research network coordinator
Jenny Ring, PhD guideline methodologist
Agnes Wilson, PhD, guideline methodologist
Grace Leo, BMed MD, paediatric registrar
Stuart R Dalziel, PhD, paediatric emergency physician;

Affiliations

1. Emergency Department, Royal Children's Hospital, Melbourne, Australia
2. Clinical Sciences, Murdoch Children's Research Institute, Melbourne, Australia
3. Department of Paediatrics and Centre for Integrated Critical Care, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Melbourne, Australia
4. Kaiser Permanente, Oakland, California, United States

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/1742-6723.13722

5. Emergency Department, Perth Children's Hospital, Perth, Western Australia.
6. School of Medicine, Divisions of Emergency Medicine and Paediatrics, University of Western Australia, Perth, Australia
7. School of Rural Medicine, University of New England, Armidale, NSW, Australia
8. Emergency Department, Cairns Hospital, Queensland, Australia
9. Monash Imaging, Monash Health, Clayton, Victoria, Australia
10. Monash University, Clayton, Victoria, Australia
11. Cabrini Hospital, Malvern, Victoria, Australia
12. Auckland City Hospital, Auckland, New Zealand.
13. Psychology Service, Royal Children's Hospital, Melbourne, Australia
14. Centre for Children's Health Research, University of Queensland, Australia
15. Neurosciences Unit, Queensland Children's Hospital, Queensland, Australia
16. Ambulance Victoria, Melbourne, Australia
17. Department of General Practice, University of Melbourne, Melbourne, Australia
18. Tauranga Hospital, Tauranga, New Zealand
19. Emergency Department, Women and Children's Hospital, Adelaide, Australia
20. MedSTAR, SA Ambulance, Adelaide, Australia
21. Emergency Department, Flinders Medical Centre, Adelaide, Australia
22. Emergency Department, Starship Children's Health, Auckland, New Zealand
23. Emergency Department, Queensland Children's Hospital, Queensland, Australia
24. Don't Forget the Bubbles
25. Emergency Department, Logan Hospital, Queensland, Australia
26. Emergency Department, The Royal Darwin Hospital, Darwin, Australia
27. Emergency Department, Sydney Children's Hospital, Sydney, NSW, Australia
28. Health Research Consulting, Sydney, Australia
29. School of Women and Children's Health, University of New South Wales, NSW, Australia
30. Departments of Surgery and Paediatrics: Child and Youth Health, University of Auckland, Auckland, New Zealand

Keywords: traumatic brain injury, head injury, child, guideline

Short Running Title: Head Injury Guideline

Corresponding author:

Prof Franz E Babl
Emergency Research
Murdoch Children's Research Institute
Flemington Rd
Parkville
Victoria 3052
Australia
Phone 61 3 9345 6153
Fax 61 3 9345 600
Email franz.babl@rch.org.au

Acknowledgement

The Paediatric Research in Emergency Departments International Collaborative (PREDICT) would like to acknowledge the input and feedback provided in the consultation phase by stakeholders to ensure relevance of the final guideline to the Australian and New Zealand emergency and acute care setting. Formal feedback was received from: Australasian College for Emergency Medicine; New Zealand Emergency Medicine Network; The Royal Australasian College of Physicians; Paediatric Society of New Zealand; Australasian College of Paramedicine; Council of Ambulance Authorities Inc.; Royal Australian and New Zealand College of Radiologists; Australian Society of Medical Imaging and Radiation Therapy; New Zealand Institute of Medical Radiation Technology; Neurosurgical Society of Australasia; Royal Australasian College of Surgeons; Sports Medicine Australia; Australian Haemophilia Centre Directors' Organisation; Royal Flying Doctor Service; College of Emergency Nurses New Zealand; Australian College of Nurse Practitioners; College of Emergency Nurses Australasia; Australian College of Nursing; Metro & Regional Paediatrics Network, Agency for Clinical Innovation New South Wales; Advanced Paediatric Life Support Australia; Advanced Paediatric Life Support New Zealand; The Royal Australian College of General Practitioners; Australian College of Rural and Remote Medicine; Victorian Department of Education.

We acknowledge the generous, thoughtful contributions of the members of the Guideline Working Group: Franz E Babl, Stuart R Dalziel, Vicki Anderson, Dustin W Ballard, Karen Barlow, Peter Barnett, Scott Bennetts, Roisin Bhamjee, Meredith L Borland, Joanne Cole, Elizabeth Cotterell, John Craven, Gavin A Davis, Stacy Goergen, Lambros Halkidis, Libby Haskell, Ben Lawton, Anna Lithgow, Glenda Mullen, Ed Oakley, Sharon O'Brien, Michelle Paproth, David Perry, Catherine Wilson and Emma Tavender.
We are grateful for external input from Professor Nathan Kuppermann, University of California Davis, USA, Associate Professor Peter Dayan, Columbia University, New York, USA, Professor Erik Hess, The University of Alabama Birmingham, USA, Professor Silvia Bressan, University of Padua, Italy, Professor Paul Monagle, Department of Clinical Haematology and Laboratory Services, The Royal Children's Hospital, Melbourne, and Associate Professor Johan Undén, Lund University, Lund, Sweden.
We would like to thank the many additional clinicians, researchers and administrators who have reviewed this guideline during the consultation and endorsement process.
The Guideline development process was organised from inception to publication by Dr Emma Tavender, an implementation scientist with PREDICT.

We thank Dr Jenny Ring and Dr Agnes Wilson, Hereco, for their expertise and input in finalising the Technical Report and the Guideline Recommendations.
We thank Dr Grace Leo from Don't Forget the Bubbles for her work on the graphic design of the Guideline Algorithm.
We thank Mr Quincy McCrary and Ms Sara Pimental, Kaiser Permanente Librarian Services, USA and Ms Poh Chua, Royal Children's Hospital, Melbourne Australia for their literature searching expertise.
We thank Ms Marian Chandler, administrative assistant, PREDICT and Murdoch Children's Research Institute, for her support.

Funding

The PREDICT Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children was developed with funding support from the National Health and Medical Research Council (NHMRC) Centre of Research Excellence grants for Paediatric Emergency Medicine (GNT1058560/GNT1171228), Canberra, Australia, administered by the Murdoch Children's Research Institute, and from the Royal Children's Hospital Foundation, Melbourne, Australia. The project was also supported by the Victorian Government's Operational Infrastructure program.
FEB's time was part funded by an NHMRC Practitioner Fellowship, Canberra, Australia and a grant from the Royal Children's Hospital Foundation, Melbourne, Australia.
SRD's time was part funded by the Health Research Council of New Zealand (HRC13/556) and Cure Kids New Zealand.

Conflict of interest

A detailed list of expertise, affiliations and conflict of interest declarations for each author who was a member of the Guideline Working Group for the Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children is provided in the web appendix. Jenny Ring, Agnes Wilson and Grace SY Leo were not members of the Guideline Working Group. Jenny Ring and Agnes Wilson work for Health Research Consulting, Sydney, Australia. Grace SY Leo has no conflicts of interest.

Author contribution

Franz Babl, Emma Tavender and Stuart Dalziel drafted the manuscript. All authors contributed to the content of the work, critically reviewed the drafts and approved of the final version submitted.

ABSTRACT 247/250

Objective

Children frequently present with head injuries to acute care settings. Although international paediatric clinical practice guidelines for head injuries exist, they do not address all considerations related to triage, imaging, observation versus admission, transfer, discharge and follow-up of mild to moderate head injuries relevant to the Australian and New Zealand context. The Paediatric Research in Emergency Departments International Collaborative (PREDICT) set out to develop an evidence-based, locally applicable, practical clinical guideline for the care of children with mild to moderate head injuries presenting to acute care settings.

Methods

A multidisciplinary Guideline Working Group (GWG) developed 33 questions in three key areas – triage, imaging and discharge of children with mild to moderate head injuries presenting to acute care settings. We identified existing high-quality guidelines and from these guidelines recommendations were mapped to clinical questions. Updated literature searches were undertaken, and key new evidence identified. Recommendations were developed through either adoption, adaptation or development of *de novo* recommendations. The guideline was publicly consulted and revised following stakeholder feedback.

Results

The GWG developed 71 recommendations (evidence-informed=35, consensus-based=17, practice points=19), relevant to the Australian and New Zealand setting. The guideline is presented as three documents; (1) a detailed Full Guideline summarising the evidence underlying each recommendation, (2) a Summary of Guideline Recommendations, and (3) a clinical Algorithm: Imaging and Observation Decision-making for Children with Head Injuries.

Conclusions

The PREDICT Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children provides high-level evidence and practical guidance for front line clinicians.

INTRODUCTION

Head injury is one of the most common reasons for children to present to emergency departments (EDs) (1-5). Despite this, clinically important intracranial injuries are uncommon. In Australia and New Zealand approximately 2 in 100 who present with head injuries of all severities have abnormal cranial computed tomography (CT) scans and 1 in 200 children require neurosurgery (5).

Identifying intracranial injuries in children with seemingly mild injuries can be difficult and over the last 15 years has been a focus of ED research worldwide (2-5). High-quality clinical decision rules (CDR), also sometimes termed clinical prediction rules, have been developed using large prospective multicentre datasets, to identify head injured children who are at increased risk of clinically important intracranial injuries (2-4). In the Australian and New Zealand setting, the Pediatric Emergency Care Applied Research Network (PECARN) CDR (3) has been identified as having the highest sensitivity (5), but implementation of this rule into Australian and New Zealand clinical practice will need to be embedded into a local framework: 1) PECARN was developed in a different health care setting in North America with high CT utilization for paediatric head injuries. By contrast, in Australia and New Zealand only 10% of head injured children undergo CT scanning (5-7) with sensitivity of PEACRN being preserved (5). 2) its use has the potential to increase CT scanning rates. The primary focus of the PECARN CDR was to determine who should not undergo a CT scan, with a potential increase in CT scanning if all those not classified as low risk were to undergo a CT scan.

Contemporaneously there has been a research focus on early identification and management of post-concussive symptoms in children(8). While structural intracranial injury following head injury in children is uncommon, persistent post-concussive symptoms affect more than a third of all head injured children. At the same time, recent evidence (9-11) has called into question and potentially reversed previous worldwide consensus recommending a period of strict rest prior to return to exercise and education.

Thus, there is a critical need for local guidance for the use of CT scanning for identification of clinically important intracranial lesions as well as the early management and caregiver advice regarding post-concussive symptoms. Guidance should be developed when important ‘new knowledge’ needs to be integrated into practice, as in the above examples, but also when ‘variation in care’ occurs (12). Within Australian and New Zealand tertiary paediatric, metropolitan and regional/rural EDs there is

considerable variation in CT scanning rates and length of ED stay for children with head injuries of all severities (6,7).

Existing international clinical practice guidelines (10,11,13-18) do not adequately address the local Australian and New Zealand clinical practice context. This is most notable in regard to triage, referral, imaging, and discharge planning for paediatric head injury patients. Existing guidelines also do not consistently address the most recent evidence. The Paediatric Research in Emergency Departments International Collaborative (PREDICT) network, who have previously created the first Australian and New Zealand guideline for bronchiolitis(19), set out to address this gap with a local guideline for the care of children with mild to moderate head injuries. The development of collaborative guidelines across hospitals is broadly supported in PREDICT(20).

Our goal was to develop an evidence-based, locally applicable, and practical clinical guideline for clinicians in Australia and New Zealand caring for children presenting to acute care settings with mild to moderate head injury. Specific objectives were to:

- improve outcomes for children who present with mild to moderate head injury
- identify all paediatric patients who have a clinically important intracranial injury in need of intervention, such as neurosurgery and/or intensive care (critical patient-important outcome)
- promote consistency of management (i.e. standardisation of observation criteria and duration of ED stay), and in doing so reduce unnecessary interventions, including inappropriate use of head CT scans in children at very low risk of intracranial injury
- improve guidance for discharge and follow-up.

METHODS

The target population for the PREDICT Head Injury Guideline was children aged less than 18 years of age presenting with head injuries to EDs and acute assessment areas of rural, regional, metropolitan and tertiary hospitals in Australia and New Zealand within 72 hours of injury. The scope was to address aspects of diagnosis and management: assessment, imaging versus observation, discharge disposition and advice (including for concussion) for those discharged home. The target audience was clinicians

involved in the assessment and management of children with head injuries in hospitals in Australia and New Zealand.

We excluded the neurosurgical management of children identified with structural intracranial injuries; the management within the intensive care unit of children identified with an intracranial injury; the management of children with severe head injury; the management of concussion in the community and rehabilitation for traumatic brain injury.

Definitions

There is some debate regarding definitions of head injury, of degrees of severity of traumatic brain injury and of concussion, and how they relate to each other. There is variation in the use and definitions of these terms between organisations. Based on common ED practice in Australia and New Zealand the PREDICT Guideline uses the term head injury as an overarching term for injuries of any severity to the head and brain due to direct or indirect force. The focus of the Guideline is mild to moderate head injury. While there is inconsistency, most definitions of mild to moderate head injury are based on the initial assessment of a Glasgow Coma Scale score (GCS) (21-23). Within Australia and New Zealand 98.3% of children who present to EDs with a head injury have a GCS of 14 or 15 on initial clinician assessment (5). It is for these children that the guideline is predominantly written. The discharge advice also remains relevant to children who initially present with a GCS ≤ 13, but have early recovery to baseline neurological function within the ED (24).

Guideline Process

A separate paper has been published detailing the methods and guideline development process (25). A summary of the methods is detailed here.

A seven person PREDICT Guideline Steering Committee was formed and this group recruited and convened a 25 member multidisciplinary Guideline Working Group (GWG) from across Australia and New Zealand including emergency physicians, paediatricians, neurosurgeons, paediatric neurologists, sports medicine doctors, radiologists, nurse/nurse practitioners, neuropsychologists, general practitioners, paramedics, implementation scientists and consumers. The GWG developed 33 clinical questions in three key areas – triage, imaging and discharge/concussion. This process was informed by clinician interviews with 24 ED clinicians at 19 hospitals in Australia and New Zealand caring for children with head injuries.

We used a guideline development process, informed by the steps in the Grading of Recommendations Assessment, Development and Evaluation (GRADE) ADOLOPMENT (26) and ADAPTE guideline development frameworks (2).

An extensive search was conducted in October 2018 (re-run in February 2019) to identify national and international guidelines relevant to the acute management of mild to moderate head injury in children. Selection of existing evidence-based guidelines for possible inclusion was undertaken based on: i) the quality of the guideline methodology (assessed using Appraisal of Guidelines for Research and Evaluation (AGREE) II (28), ii) appropriateness of questions in the source guidelines to the scope of the proposed guideline, iii) currency of the literature, and iv) relevance of the context of the existing guideline to Australian and New Zealand practice.

Recommendations from the selected source guidelines were mapped to the 33 guideline questions. An updated literature search was undertaken for the time period 1 Jan 2015 – 28 May 2019 to identify new studies, published after the literature review date in the source guidelines. The GWG then decided to either adopt or adapt recommendations from existing guidelines, or to develop new recommendations. The wording of the recommendations reflected the strength of the supporting evidence with recommendations classed as 'evidence-informed recommendations (EIR)', 'consensus-based recommendations (CBR)' or 'practice points (PP)' (see Table 1 for classification details). The guideline development process was conducted between February 2019 and September 2020. The guideline was finalised following stakeholder feedback. The guideline has been developed in accordance with the principles set out in the 2016 National Health and Medical Research Council's (NHMRC) Standards for Guidelines (29).

RESULTS

We identified four high-quality guidelines from which to draw evidence or recommendations:

- the Consensus Statement on Concussion in Sport - the 5th International Conference on Concussion in Sport held in Berlin October 2016 (10,11),
- the Italian Guidelines on the Assessment and Management of Pediatric Head Injury in the Emergency Department (15),

- the Centers for Disease Control and Prevention Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children (17),
- and the National Institute for Health and Care Excellence Guidance on Head Injury: Assessment and Early Management (CG 176) (14).

We identified 440 new studies in the literature review.

Seventy-one recommendations were developed; 35 EIRs (9 adopted, 14 adapted and 12 new), 17 CBRs (7 adapted and 10 new) and 19 PPs (1 adapted and 18 new) (See **Table** 2 for recommendations). The final guideline is presented as three documents; a detailed Full Guideline summarising all the evidence underlying each recommendation (identified from existing international guidelines and the new evidence search) and explaining the rationale used to develop the recommendations (www.PREDICT.org.au); the Summary of Guideline Recommendations (**Table 2**); and a clinical Guideline Algorithm: Imaging and Observation Decision-Making for Children with Head Injuries (**Figure 1**) incorporating the core recommendations for use by clinicians assessing a head injured child in an acute care setting.

Triage

Six triage-related recommendations were developed: 1 adapted and 5 new; 1 EIR, 3 CBRs, and 2 PPs (**Table 2**). Evidence was sought on triage prior to ED arrival to address the impact of geography on possible transfers over long distances and the location of specialty services, especially neurosurgery, at mainly tertiary paediatric hospitals. In particular, evidence was sought on methods of identification of children with head injuries who require transfer for head CT scans or possible neurosurgery. No applicable evidence was found. The decision on who needs, and who does not need, hospital assessment was inferred from CDRs describing who should have a CT scan for identification of intracranial injuries.

Imaging

Thirty-five imaging-related recommendations were developed: 3 adopted, 10 adapted and 22 new; 18 EIRs, 5 CBRs, and 12 PPs (**Table 2**). A large body of evidence, including Australian and New Zealand evidence, (5-7, 24, 30-35) was available for the key initial decision process in the acute care setting, i.e. the question of "Which children should undergo head CT?" Among Australian and New Zealand head injured children, the PECARN CDR was the most accurate in identifying children with clinically important

traumatic brain injury, traumatic brain injury on CT and requirement for neurosurgical management (5). Therefore, the risk factors identified in the PECARN CDR, together with post-traumatic seizures (36) and abnormal neurological examination (**Table 2 Box A**), were used to risk stratify mild and moderate head injured children within the PREDICT Guideline Recommendations and the Guideline Algorithm.
The PECARN CDR determines who should not undergo a CT scan; if misinterpreted as indicating that all those not classified as low risk should undergo a CT scan it could result in high CT scanning rates (5). The head CT rate at 10 sites in Australia and New Zealand (5) was lower than in North American sites that participated in the PECARN CDR (3). The Australian sites, however, had a higher rate of structured observation in the ED or in hospital, particularly for patients with PECARN CDR risk factors (31). There is good quality evidence to support structured observation (31,37,38). Further, actual practice in Australia and New Zealand, which favoured observation in preference to CT scan in selected patients, showed similar sensitivity to that of the PECARN CDR (35). However, evidence for the structure and duration of observation is limited resulting in CBRs, rather than EIRs, regarding observation in the guideline.

The PECARN CDR was developed in a cohort of children presenting within 24 hours of head injury (3). Australian and New Zealand observational data suggest that those who present between 24 and 72 hours have an increased rate of traumatic brain injury on CT but similar rates of clinically important traumatic brain injury and need for neurosurgery when compared with children presenting within 24 hours (34). These data have resulted in a CBR that children presenting between 24 and 72 hours after a head injury should be risk stratified in the same way as children presenting within 24 hours.
Quality of evidence to develop imaging guidance for children with underlying ventricular shunts, bleeding disorders, neurodevelopmental disorders, associated conditions such as intoxication, or associated concerns such as abusive head trauma was limited by small sample sizes (30, 32, 33, 39, 40) resulting in a greater number of CBRs and PPs (**Table 2**).

Discharge

Thirty discharge-related recommendations were developed, 6 adopted, 11 adapted and 13 new; 16 EIRs, 9 CBRs, and 5 PPs (**Table 2**). EIRs were adopted or adapted to identify children suitable for discharge home from the ED, and subsequent advice with respect to when to return to ED.

Evidence from a large prospective observational study in Canada suggests that identification of children presenting acutely in the ED with head injury who are at risk of subsequent persistent post-concussive

symptoms is modest at best (8). Given the high frequency of subsequent post-concussive symptoms, and the considerable morbidity caused by these, an EIR is made that children should attend a primary healthcare practitioner 1-2 weeks post injury for assessment of post-concussive symptoms.

Analysis from the same cohort suggests that children who follow strict rest protocols in the first seven days (no, or very little, activity while they have symptoms) are at greater risk of persistent post-concussive symptoms at 4 weeks (9). This and other evidence has resulted in EIRs that children have a brief period (up to a maximum of 24-48 hours), of physical and cognitive rest post injury. Following this, physical and cognitive activity can be commenced at a level that does not exacerbate post-concussive symptoms.

Similarly, return to school EIRs allow for return to class at a level that does not exacerbate post-concussive symptoms, with EIRs highlighting the need for schools to have a formal concussion policy and utilise academic accommodations to support recovery .

Guideline recommendations on discharge management with respect to return to sport were adapted from recommendations from the Consensus Statement on Concussion in Sports (10,11). The resulting CBRs were adapted to be consistent with the available resources for all children within Australian and New Zealand medical systems, and not focused specifically on young athletes within elite sport systems.

DISCUSSION (Word count 611)

The PREDICT Head Injury Guideline provides high-level evidence and practical guidance for clinicians providing acute care for children with mild to moderate head injuries. This will help address variation in practice in the management of paediatric head injury across Australia and New Zealand (6,7). Similar to our previous guideline (19) it is hoped that this guideline will be used to inform hospital and other institutional guidelines on the management of mild and moderate head injury in Australia and New Zealand, and be incorporated into local practice. Clinicians across institutions support the development of national acute care guidelines to reduce duplication of effort (20).

Our aim was to produce a guideline that is robust, evidence-based, highly applicable to our local context and additionally, presented in a format that is readily accessible, pragmatic and ‘user-friendly’ for front-

line clinicians across Australia and New Zealand. The existing international head injury guidelines did not meet this aim. Therefore, we chose to use an innovative and practical approach of assessing existing guidelines and then adopting, adapting or creating new recommendations based on this assessment and a systematic review of the literature (27). We believe this process has achieved our aim. However, as we identified and assessed four source guidelines, rather than a single guideline, (10,11, 14, 15,17) it is worth considering whether a *de novo* development of the guideline would have been less lengthy and resource intensive.

The strength of the guideline development process was that it was undertaken by a multidisciplinary team with front-line clinicians from a range of centres, including tertiary children's hospitals and rural hospitals, and staff who are involved in the management of children presenting to hospital with mild and moderate head injury from many related specialties and fields, including ambulance service, general practice, intensive care, retrieval services, neurosurgery and radiology. Members were representative of 6 Australian states or territories and New Zealand. In addition, we had valuable input from a consumer representative. By drawing on existing international guidelines, a process based on elements of ADAPTE, we could utilise their literature reviews and incorporate the experience and wisdom of their consensus recommendations. We sought and received feedback from the major relevant Australian and New Zealand professional colleges and organisations increasing the relevance of the final guideline as a clinical tool. Recently, the Ontario Neurotrauma Foundation published the Living Guideline for Diagnosing and Managing Pediatric Concussion (released in September 2019) (43). While not incorporated into our guideline process, the guideline recommendations from the Ontario Neurotrauma Foundation are largely consistent with our recommendations.

The guideline does have a number of limitations. Our focus was on hospital-based clinicians who have access to CT imaging and the capacity to provide structured observation. While not designed for care at the sports field, in general practice, or for pre-hospital management, the guideline will remain relevant to those clinicians, who refer into hospitals with CT scanning facilities. Furthermore, the scope of this guideline did not cover the full range of pediatric head injury, as we excluded care for patients with: penetrating trauma, severe head injuries, abnormal head CT scans, neurosurgical management, care in intensive care units, and ongoing rehabilitation.

In order to enhance the usability of the final guideline, we are in the process of developing additional implementation materials e.g. discharge communication materials for clinicians, children, their families and schools, which will be made available on the PREDICT website (www.PREDICT.org.au).

Conclusions

The PREDICT Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children and the accompanying Guideline Algorithm: Imaging and Observation Decision-Making for Children with Head Injuries for bedside use provides high-level evidence and practical guidance for clinicians providing acute care for children in the Australian and New Zealand setting and may be relevant more widely.

References

1. James SL, Theadom A, Ellenbogen RG, et al. Global, regional, and national burden of traumatic brain injury and spinal cord injury, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet Neurology. 2019;18(1):56-87.
2. 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): 341-8.
3. 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): 1160-70.
4. Dunning J, Daly JP, Lomas JP, et al. 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): 885-91.
5. Babl FE, Borland ML, Phillips N, Kochar A, Dalton S, McCaskill M, Cheek JA, Gilhotra Y, Furyk J, Neutze J, Lyttle MD, Bressan S, Donath S, Molesworth C, Jachno K, Ward B, Williams A, Baylis A, Crowe L, Oakley E, Dalziel SR; Paediatric Research in Emergency Departments International Collaborative (PREDICT). Accuracy of PECARN, CATCH, and CHALICE head injury decision rules in children: a prospective cohort study. Lancet. 2017 Jun 17;389(10087):2393-2402.
6. Wilson CL, Tavender EJ, Phillips NT, Hearps SJ, Foster K, O'Brien SL, et al. Variation in CT use for paediatric head injuries across different types of emergency departments in Australia and New Zealand. Emerg Med J. 2020;37(11):686-9.
7. Phillips N, Dalziel S, Borland M, Dalton S, Lyttle MD, Bressan S, Oakley E, Hearps S, Kochar A, Furyk J, Cheek JA, Gilhotra Y, Neutze J, Babl FE, on behalf of the Paediatric Research in Emergency Department International Collaborative (PREDICT) group. Imaging and admission practices in paediatric head injury across emergency departments in Australia and New Zealand: A PREDICT study. Emerg Med Australas. 2020 Apr;32(2):240-249. doi: 10.1111/1742-6723.13396. Epub 2019 Nov 26.
8. Zemek R, Barrowman N, Freedman SB, Gravel J, Gagnon I, McGahern C, Aglipay M, Sangha G, Boutis K, Beer D, Craig W, Burns E, Farion KJ, Mikrogianakis A, Barlow K, Dubrovsky AS, Meeuwisse W, Gioia G, Meehan WP 3rd, Beauchamp MH, Kamil Y, Grool AM, Hoshizaki B, Anderson P, Brooks BL, Yeates KO, Vassilyadi M, Klassen T, Keightley M, Richer L, DeMatteo C, Osmond MH; Pediatric Emergency Research Canada (PERC) Concussion Team. Clinical Risk Score

for Persistent Postconcussion Symptoms Among Children With Acute Concussion in the ED. JAMA. 2016 Mar 8;315(10):1014-25.
9. Grool AM, Aglipay M, Momoli F, Meehan WP 3rd, Freedman SB, Yeates KO, Gravel J, Gagnon I, Boutis K, Meeuwisse W, Barrowman N, Ledoux AA, Osmond MH, Zemek R; Pediatric Emergency Research Canada (PERC) Concussion Team. Association Between Early Participation in Physical Activity Following Acute Concussion and Persistent Postconcussive Symptoms in Children and Adolescents. JAMA. 2016 Dec 20;316(23):2504-2514.
10. McCrory P, Meeuwisse W, Dvorak J, Aubry M, Bailes J, Broglio S, et al. Consensus statement on concussion in sport-the 5(th) international conference on concussion in sport held in Berlin, October 2016. Br J Sports Med. 2017;51(11):838-47.
11. Davis GA, Anderson V, Babl FE, Gioia GA, Giza CC, Meehan W, et al. What is the difference in concussion management in children as compared with adults? A systematic review. Br J Sports Med. 2017;51(12):949-57.
12. IOM (Institute of Medicine). 2011. Clinical Practice Guidelines We Can Trust. Washington, DC: The National Academies Press. Available from https://www.awmf.org/fileadmin/user_upload/Leitlinien/International/IOM_CPG_lang_2011.pdf
13. Astrand R, Rosenlund C, Unden J, Scandinavian Neurotrauma C. Scandinavian guidelines for initial management of minor and moderate head trauma in children. BMC Med. 2016;14:33.
14. National Institute for Health and Care Excellence. Head injury: assessment and early management (NICE guideline CG176)2014 [updated 2019 Sept] [cited 2020 Nov 20]. Available from: www.guidance.nice.org.uk/CG176.
15. Da Dalt L, Parri N, Amigoni A, Nocerino A, Selmin F, Manara R, et al. Italian guidelines on the assessment and management of pediatric head injury in the emergency department. Ital J Pediatr. 2018;44(1):7.
16. Ontario Neurotrauma Foundation. Guidelines for diagnosing and managing pediatric concussion. Toronto: Ontario Neurotrauma Foundation; 2014.
17. Lumba-Brown A, Yeates KO, Sarmiento K, Breiding MJ, Haegerich TM, Gioia GA, et al. Centers for Disease Control and Prevention Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children. JAMA Pediatr. 2018;172(11):e182853.
18. Ryan ME, Palasis S, Saigal G, Singer AD, Karmazyn B, Dempsey ME, et al. ACR Appropriateness Criteria head trauma--child. J Am Coll Radiol. 2014;11(10):939-47.
19. O'Brien S, Borland ML, Cotterell E, Armstrong D, Babl FE, Bauert P, Brabyn C, Garside L, Haskell L, Levitt D, McKay N, Neutze J, Schibler A, Sinn K, Spencer J, Stevens H, Thomas D, Zhang M, Oakley E, Dalziel SR, PREDICT Network, Australasia. Australasian bronchiolitis guideline. J Paediatr Child Health. 2019 Jan;55(1):42-53. doi: 10.1111/jpc.14104. Epub 2018 Jul 15.
20. Dalton S, Babl FE. Paediatric emergency guidelines: Could one size fit all? Emerg. Med. Australas. 2009; 21: 67–70.
21. Crowe LM, Hearps S, Anderson V, Borland ML, Phillips N, Kochar A, Dalton S, Cheek JA, Gilhotra Y, Furyk J, Neutze J, Lyttle MD, Bressan S, Donath S, Molesworth C, Oakley E, Dalziel SR, Babl FE. Investigating the Variability in Mild Traumatic Brain Injury Definitions: A Prospective Cohort Study. Arch Phys Med Rehabil. 2018; 99(7): 1360-1369.
22. Advanced Paediatric Life Support A Practical Approach to Emergencies, Chapter 4 The child with a decreased conscious level. Samuels M., Wieteska, S. (Eds). John Wiley and Sons Sixth Edition 2017.(2)
23. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet. 1974 Jul 13;2(7872):81-4.

24. Kochar A, Borland M, Phillips N, Dalton S, Cheek J, Furyk J, Neutze J, Lyttle MD, Hearps S, Dalziel S, Bressan S, Oakley, Babl FE. Association of clinically important traumatic brain injury and Glasgow Coma Scale scores in children with head injury. Emerg Med J. 2020 Mar;37(3):127-134. doi: 10.1136/emermed-2018-208154. Epub 2020 Feb 12.
25. Tavender EJ, Ballard DW, Wilson A, Borland ML, Oakley E, Cotterell E, et al. Developing the Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children: An Adoption/Adaption Approach. Emerg Med Australas. 2020 (in press).
26. Schunemann HJ, Wiercioch W, Brozek J, Etxeandia-Ikobaltzeta I, Mustafa RA, Manja V, et al. GRADE Evidence to Decision (EtD) frameworks for adoption, adaptation, and de novo development of trustworthy recommendations: GRADE-ADOLOPMENT. J Clin Epidemiol. 2017;81:101-10.
27. Fervers B, Burgers JS, Haugh MC, Latreille J, Mlika-Cabanne N, Paquet L, et al. Adaptation of clinical guidelines: literature review and proposition for a framework and procedure. Int J Qual Health Care. 2006;18(3):167-76.
28. Brouwers MC, Kho ME, Browman GP, Burgers JS, Cluzeau F, Feder G, et al. AGREE II: advancing guideline development, reporting and evaluation in health care. CMAJ. 2010;182(18):E839-42.
29. National Health and Medical Research Council. Guidelines for Guidelines, Adopt, adapt or start from scratch2018 [cited 2020 Nov 20]. Available from: https://www.nhmrc.gov.au/guidelinesforguidelines/plan/adopt-adapt-or-start-scratch.
30. Bressan S, Monagle P, Dalziel SR, Borland ML, Phillips N, Kochar A, Lyttle MD, Cheek JA, Neutze J, Oakley E, Dalton S, Gilhotra Y, Hearps S, Furyk J, Babl FE; Paediatric Research in Emergency Departments International Collaborative (PREDICT). Risk of traumatic intracranial haemorrhage in children with bleeding disorders. J Paed Child Health. 2020 Aug 18. doi: 10.1111/jpc.15073. PMID: 32810331 [Epub ahead of print].
31. Singh S, Hearps S, Borland M, Dalziel S, Neutze J, Donath S, Cheek JA, Kochar A, Gilhotra Y, Phillips N, Williams A, Lyttle MD, Bressan S, Oakley E, Holmes JF, Kuppermann N, Babl FE. (PREDICT). The Effect of Patient Observation on Cranial Computed Tomography Rates in Children with Minor Head Trauma. AEMJ. 2020 Feb 16. Doi: 10.1111/acem.13942 [Epub ahead of print].
32. Pfeiffer H, Cowley L, Kemp A, Dalziel S, Smith A, Cheek JA, Borland ML, O'Brien S, Bonisch M, Neutze J, Oakley E, Crowe L, Hearps S, Lyttle M, Bressan S, Babl FE. Validation of the PredAHT-2 prediction tool for abusive head trauma. Emerg Med J. 2020 Mar;37(3):119-126. doi: 10.1136/emermed-2019-208893. Epub 2020 Jan 13.
33. Babl FE, Lyttle MD, Phillips N, Kochar A, Dalton S, Cheek JA, Furyk J, Neutze J, Bressan S, Williams A, Hearps SJC; MBiostat, Oakley E, Davis GA, Dalziel SR, Borland ML. Mild traumatic brain injury in children with ventricular shunts: a PREDICT study. J Neurosurg Pediatr. 2020 Nov 20:1-7
34. Borland ML, Dalziel SR, Phillips N, Lyttle MD, Bressan S, Oakley E, Hearps SJC, Kochar A, Furyk J, Cheek JA, Neutze J, Gilhotra Y, Dalton S, Babl FE; Paediatric Research in Emergency Department International Collaborative (PREDICT) Group. Delayed Presentations to Emergency Departments of Children With Head Injury: A PREDICT Study. Ann Emerg Med. 2019 Jul;74(1):1-10.
35. Babl FE, Oakley E, Dalziel SR, Borland ML, Phillips N, Kochar A, Dalton S, Cheek JA, Gilhotra Y, Furyk J, Neutze J, Donath S, Hearps S, Molesworth C, Crowe L, Bressan S, Lyttle MD. Accuracy of Clinician Practice Compared With Three Head Injury Decision Rules in Children: A Prospective Cohort Study. Ann Emerg Med. 2018 Jun;71(6):703-710.
36. Badawy MK, Dayan PS, Tunik MG, Nadel FM, Lillis KA, Miskin M, Borgialli DA, Bachman MC, Atabaki SM, Hoyle JD Jr, Holmes JF, Kuppermann N; Pediatric Emergency Care Applied Research Network (PECARN).Prevalence of Brain Injuries and Recurrence of Seizures in Children With Posttraumatic Seizures. Acad Emerg Med. 2017 May;24(5):595-605.

37. 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 Dec;62(6):597-603.
38. Holmes JF, Borgialli DA, Nadel FM, Quayle KS, Schambam N, Cooper A, Schunk JE, Miskin ML, Atabaki SM, Hoyle JD, Dayan PS, Kuppermann N; TBI Study Group for the Pediatric Emergency Care Applied Research Network. Do children with blunt head trauma and normal cranial computed tomography scan results require hospitalization for neurologic observation? Ann Emerg Med. 2011 Oct;58(4):315-22.
39. Lee LK, Dayan PS, Gerardi MJ, Borgialli DA, Badawy MK, Callahan JM, Lillis KA, Stanley RM, Gorelick MH, Dong L, Zuspan SJ, Holmes JF, Kuppermann N; Traumatic Brain Injury Study Group for the Pediatric Emergency Care Applied Research Network (PECARN). tracranial hemorrhage after blunt head trauma in children with bleeding disorders. J Pediatr. 2011 Jun;158(6):1003-1008
40. Giordano P, Lassandro G, Notarangelo LD, Bressan S, Ramenghi U, Saracco P, et al. Head injury in children with coagulation disorders a position paper by the Italian Society of Pediatric Emergency Medicine (SIMEUP) and the Italian Association of Pediatric Hematology and Oncology – Coagulation Disorders Working Group (AIEOP). Italian Journal of Pediatrics. In press
41. O'Neill JA, Cox MK, Clay OJ, Johnston JM, Novack TA, Schwebel DC, et al. A Review of the Literature on Pediatric Concussions and Return-to-Learn (RTL): Implications for RTL Policy, Research, and Practice. Rehabil Psychol. 2017;62(3):300–23
42. DeMatteo C, Bednar ED, Randall S, Falla K. Effectiveness of Return to Activity and Return to School Protocols for Children Postconcussion: A Systematic Review. BMJ Open Sport Exerc Med. 2020;6(1).
43. Reed N, Zemek R, Dawson J, Ledoux A, et al. Living Guideline for Diagnosing and Managing Pediatric Concussion2019. Available from: https://braininjuryguidelines.org/pediatricconcussion/.

Appendix

Membership, Expertise, Affiliation and Conflict of Interest Declaration of the PREDICT Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children Working Group

Name	Expertise	Affiliation	Conflict of Interest Declaration
Prof Franz Babl (co- hair)	Emergency Physician	Department of Paediatrics, University of Melbourne Consultant, Emergency Department, Royal Children's Hospital Melbourne, Victoria Head, Emergency Research, Murdoch Children's Research Institute (MCRI)	• **Board memberships**: PREDICT has governance of project. PREDICT research may be included in guidelines. • **Memberships:** Royal Australasian College of Physicians, potential end-user of guideline. • **Employment**: Royal Children's Hospital, University of Melbourne – both potential end-users of guidelines. MCRI – research undertaken by me while employed by all three may be included.
Prof Stuart Dalziel (co-chair)	Emergency Physician	Paediatric Emergency Medicine Specialist Director of Emergency Medicine Research Children's Emergency Department Starship Children's Hospital, Auckland, New Zealand Cure Kids Chair of Child Health Research Dept of Paediatrics: Child and Youth Health, University of Auckland	• **Board memberships**: PREDICT has governance of project. PREDICT research may be included in guidelines. • **Memberships:** Royal Australasian College of Physicians, New Zealand Emergency Medicine Network – potential end-user of guideline. • **Employment**: Starship Children's Hospital and the University of Auckland – both potential end-users of guidelines. Research undertaken by me while employed by both may be included. • **Expert testimony:** *Ad hoc* for the New Zealand Coronial Service.
Prof Ed Oakley	Emergency Physician	Chief of Critical Care/ Emergency Physician Royal Children's Hospital Melbourne, Victoria	**Memberships:** • Member of Australasian College of Emergency Medicine Council of Advocacy, Practice and Partnership, Quality and Safety Committee, Research Committee, Clinical Trial Network. • Co-opted member of Executive Committee of PREDICT.
Prof Meredith Borland	Emergency Physician	Consultant, Emergency Department Director of Emergency Medicine Research Perth Children's Hospital, Western Australia School of Medicine, University of Western Australia	• **Board memberships**: PREDICT has governance of the project. PREDICT research may be included in guidelines. • **Memberships:** Australasian College for Emergency Medicine – potential end-user of Guideline. • **Employment**: Perth Children's Hospital – potential end-users of guidelines. Research undertaken by me while employed may be included.
A/Prof Peter Barnett	Sports Physician Emergency Physician	Emergency Consultant Emergency Department, RCH, Melbourne, Victoria	NIL

Name	Expertise	Affiliation	Conflict of Interest Declaration
Dr Ben Lawton	Emergency Physician (mixed Metro)	Emergency Department, Logan Hospital, Queensland	**Board memberships**: PLX
Dr Jo Cole	Emergency Physician (mixed regional)	Emergency Department, Tauranga Hospital, New Zealand	NIL
Glenda Mullen	Nurse Practitioner	Emergency Department, Sydney Children's Hospital, New South Wales	**Memberships:** College of Emergency Nursing Australasia (CENA). Members are likely to be end-users of the Guideline.
Dr Lambros Halkidis	Emergency Physician (mixed regional)	Staff Specialist Emergency Medicine, Emergency Department, Cairns Hospital, Queensland	NIL
A/Prof Elizabeth Cotterell	Paediatrician (Rural)	Director of Paediatrics, Armidale Rural Referral Hospital, New South Wales	• **Affiliations:** School of Rural Medicine, University of New England, Armidale. • **Memberships:** Royal Australasian College of Physicians. Potential end-user of Guideline. • **Employment**: Hunter New England Health. – potential end-user of Guideline.
Prof Gavin Davis	Neurosurgeon /Concussion	Cabrini Hospital, Victoria	**Memberships:** • Board member of the CISG and 9Lives. • Honorary member of AFL Concussion Working Group. • **Other:** Has received travel assistance for meetings from FIFA, NRL, NFL, but has never received any payment from any of these organisations.
Sharon O'Brien	Nurse	Paediatric Nurse and Research Coordinator Emergency Department Perth Children's Hospital, Western Australia	• **Board memberships:** PREDICT has governance of project. PREDICT research may be included in guidelines. • **Employment:** Perth Children's Hospital – potential end-user of guidelines. Research undertaken by me while employed may be included.
Libby Haskell	Nurse Practitioner	Emergency Department Starship Children's Hospital, Auckland, New Zealand	• **Memberships:** PREDICT (executive member 2020), College of Emergency Nurses NZ – potential end-users of Guideline. • **Employment**: Starship Children's Hospital – potential end-user of Guideline.
Prof Stacy Goergen	Radiologist	Director of Research, Monash Imaging, Victoria Clinical Adjunct Professor, Monash University, Melbourne, Victoria	• **Memberships:** Current Chair, Safety Quality and Standards Committee, Royal Australian and New Zealand College of Radiologists (RANZCR) and member of the RANZCR. • **Employment:** Monash Health.
Dr David Perry	Paediatric and Obstetric Radiologist	Radiology, Auckland City Hospital, New Zealand	• **Memberships:** Royal Australasian College of Physicians, New Zealand Emergency Medicine Network – potential end-user of Guideline. • **Employment:** Radiologist at Starship Children's Hospital, potential end-user of Guideline. • **Expert testimony:** Expert witness in abusive head injury cases.
Dr John Craven	Paediatrician/Emergency Physician/ Retrieval	Paediatric Emergency Consultant, Women's and Children's Hospital Adelaide, South Australia Head of Unit and Paediatric Retrieval Consultant SAAS MedSTAR Kids	**Employment:** SAAS MedSTAR, Flinders Medical Centre, Women's & Children's Hospital, Flinders University.
Scott Bennetts	Pre-Hospital – ambulance service	Manager of Clinical Effectiveness, Ambulance Victoria	NIL

Name	Expertise	Affiliation	Conflict of Interest Declaration
Prof Vicki Anderson	Neuro-cognitive Specialist	Head of Psychology, Royal Children's Hospital, Melbourne, Victoria Theme Director, Clinical Sciences Research, MCRI	• **Expert testimony:** Medico legal assessment. • **Payment for lectures/educational tools:** Delivery of keynotes/workshops. • **Royalties:** For published texts.
Dr Anna Lithgow	Paediatrician (Indigenous Health)	Royal Darwin Hospital, Northern Territory	NIL
A/Prof Karen Barlow	Concussion and Rehabilitation	Consultant Paediatric Neurologist, Queensland Children's Hospital, Queensland Child Health Research Centre	• **Memberships**: Royal Australasian College of Physicians - potential end-user of Guideline. • **Consultancy***:* Clinical Pathway for concussion care in Alberta. Paid to University of Calgary. • **Employment:** Chair of Acquired Brain Injury Rehabilitation Research, University of Qld. • **Expert testimony:** Occasional medicolegal work in TBI. • **Honorarium for manuscript prep:** Concussion management – AAN Continuum paper. • **Other grants:** Clinical care pathway for children with concussion. Financial Markets Foundation for Children Grant, Australia. **Board membership:** Highmark interactive, concussion assessment e-health tool.
Dr Roisin Bhamjee	General Practitioner Registrar in training	Clinical Lecturer, Department of General Practice University of Melbourne, Victoria	NIL
Dr Dustin Ballard	Emergency Physician (USA)	Kaiser Permanente, Northern California, USA Visiting scholar, University of Auckland School of Medicine, New Zealand	**Employment:** Work on the Guideline supported by a US/NZ Fulbright Scholarship.
Dr Emma Tavender	Knowledge Translation Co-ordinator	MCRI, Melbourne, Victoria	**Membership:** Co-opted member of PREDICT Executive, Associate Editor of Cochrane EPOC Group. **Employment:** MCRI and work on the Guideline supported by an NHMRC Centre of Research Excellence.
Cate Wilson	PREDICT Research Co-ordinator	MCRI, Melbourne, Victoria	NIL
Michelle Paproth	Consumer	Consumer Representative	NIL

Table 1: Types of Recommendations

Type of recommendation	Description
Evidence-informed recommendation (EIR)	Recommendation formulated with evidence from source guideline and/or PREDICT literature search
Consensus-based recommendation (CBR)	Recommendation formulated by consensus, where evidence was sought but none was identified, or where the identified evidence was limited by indirectness
Practice point (PP)	A recommendation that was outside the scope of the evidence search and is based on consensus

Each recommendation is classed as new (i.e. created by the Guideline Working Group), adopted (i.e. taken from existing guidelines) or adapted (i.e. adapted from existing guidelines).

Table 2: Recommendations

Triage

1	CBR	Children with head injury should be assessed in a hospital setting if the mechanism of injury was severe[1] or if they develop the following signs or symptoms within 72 hours of injury: • seizure or convulsion • double vision, ataxia, clumsiness or gait abnormality • loss of consciousness • deteriorating level of consciousness • weakness and tingling in arms or legs • presumed skull fracture (palpable fracture, 'raccoon eyes' or Battle's signs) • vomiting[2] • severe headache • not acting normally, including abnormal drowsiness, increasing agitation, restlessness or combativeness (in children aged less than 2 years, not acting normally as deemed by a parent) • occipital or parietal or temporal scalp haematoma (in children aged less than 2 years only).[3]	New
2	CBR	Children with trivial head injury[4] do not need to attend hospital for assessment; they can be safely managed at home.[3]	New

[1] Severe mechanism of injury: motor vehicle accident with patient ejection, death of another passenger or rollover; pedestrian or bicyclist without helmet struck by motorised vehicle; falls of 1 m or more for children aged less than 2 years, and more than 1.5 m for children aged 2 years or older; or head struck by a high-impact object.

[2] A case of a single isolated vomit can be assessed in general practice.

[3] In children aged less than 2 years the signs of intracranial injury may not be apparent in the first hour.

[4] Trivial head injury includes ground-level falls, and walking or running into stationary objects, with no loss of consciousness, a GCS score of 15 and no signs or symptoms of head trauma other than abrasions.

3	EIR	Consultation with a neurosurgical service may not be routinely required for infants and children with an isolated, non-displaced, linear skull fracture on a head CT scan without intracranial injury and a GCS score of 15.[5]	New
A	PP	Children aged less than 2 years with a suspected or identified isolated, non-displaced, linear skull fracture should have a medical follow-up within 1–2 months to assess for a growing skull fracture.[6]	New
B	PP	In all children presenting with mild to moderate head injury, the possibility of abusive head trauma should be considered.	New
4	CBR	Consultation with a neurosurgical service should occur in all cases of intracranial injury or skull fracture shown on a head CT scan, other than in infants and children with an isolated, non-displaced, linear skull fracture on a head CT scan without intracranial injury and a GCS score of 15.[5]	Adapted

[5] Measured using an age-appropriate GCS.

[6] A growing skull fracture is a rare complication of linear skull fractures. It can occur in children aged less than 2 years with a skull bone fracture, and it represents the diastatic enlargement of the fracture due to a dural tear, with herniating brain tissue or a cystic cerebrospinal fluid-filled mass underneath. In the setting of a known skull fracture, a growing fracture is indicated by any of the following: persistent boggy swelling along a fracture line; palpable diastasis; an enlarging, asymmetrical head circumference; or delayed onset neurological symptoms. This can be assessed by a neurosurgeon, paediatrician or GP who is able to assess for a growing skull fracture.

Decision rules for CT scan

5	EIR	In children with mild to moderate head injury and a GCS score of 14–15[5] who have one or more risk factors for a clinically-important traumatic brain injury[7] (see below or Box A for risk factors, and *Algorithm: Imaging & Observation Decision-making for Children with Head Injuries*), clinicians should take into account the number, severity and persistence of signs and symptoms, and family factors (e.g. distance from hospital and social context) when choosing between structured observation and a head CT scan.[8] ***Risk factors for clinically-important traumatic brain injury:[7]*** – GCS score of 14[5] or other signs of altered mental status[9] – Severe mechanism of injury[1] – Post-traumatic seizure(s) – Abnormal neurological examination Specific risk factors for children aged less than 2 years: – Palpable skull fracture[10] – Occipital or parietal or temporal scalp haematoma[11] – History of LOC 5 seconds or more – Not acting normally per parent Specific risk factors for children aged 2 years and older: – Signs of base of skull fracture[12] – History of LOC – History of vomiting[13] – Severe headache.	New
6	EIR	For children presenting to an acute care setting within 24 hours of a head injury and a GCS score of 15,[5] a head CT scan should not be performed without any risk factors for clinically-important traumatic brain injury[7] (see PREDICT Recommendation 5 or Box A for risk factors, and *Algorithm:Imaging & Observation Decision-making for Children with Head Injuries*).	New
7	EIR	Children presenting to an acute care setting within 72 hours of a head injury and a GCS score of 13 or less[5] should undergo an immediate head CT scan.[8]	New
8	CBR	Children with delayed initial presentation (24–72 hours after head injury) and a GCS score of 15[5] should be risk stratified in the same way as children presenting within 24 hours.	New
C	PP	For children with mild to moderate head injury, consider shared decision-making[14] with parents, caregivers and adolescents (e.g. a head CT scan[8] or structured observation).	New

[7] Clinically-important traumatic brain injury is defined as death from traumatic brain injury, neurosurgical intervention for traumatic brain injury, intubation for more than 24 hours for traumatic brain injury, or hospital admission of 2 nights or more associated with traumatic brain injury on CT.

[8] Sedation is usually not required in children for non-contrast CT scans as they generally only take seconds to complete. If sedation is required for uncooperative children requiring imaging local safe sedation practice should be followed.

[9] Agitation, drowsiness, repetitive questioning, slow response to verbal communication.

[10] Palpable skull fracture: on palpation or possible on the basis of swelling or distortion of the scalp.

[11] Non-frontal scalp haematoma: occipital, parietal or temporal.

[12] Signs of base of skull fracture: haemotympanum, 'raccoon eyes', cerebrospinal fluid (CSF) otorrhoea or CSF rhinorrhoea, Battle's signs.

[13] Isolated vomiting, without any other risk factors, is an uncommon presentation of clinically-important traumatic brain injury. Vomiting, regardless of the number or persistence of vomiting, in association with other risk factors increases concern for clinically-important traumatic brain injury.

[14] Validated tools should be adapted for shared decision-making with parents, caregivers and adolescents.

D	PP	All cases of head injured infants aged 6 months and younger should be discussed with a senior clinician. These infants should be considered at higher risk of intracranial injury, with a lower threshold for observation or imaging.[8]	New

Ventricular shunts

9	EIR	In children with a ventricular shunt (e.g. ventriculoperitoneal shunt) presenting to an acute care setting following mild to moderate head injury, who have no risk factors for clinically-important traumatic brain injury[7] (see PREDICT Recommendation 5 or Box A for risk factors), consider structured observation over an immediate head CT scan.	Adapted
E	PP	In children with a ventricular shunt and mild to moderate head injury, consider obtaining a shunt series, based on consultation with a neurosurgical service, if there are local signs of shunt disconnection, shunt fracture (e.g. palpable disruption or swelling), or signs of shunt malfunction.	New

Anticoagulant or antiplatelet therapy, and known bleeding disorders

10	EIR	In children with congenital or acquired bleeding disorders, following a head injury that results in presentation to an acute care setting, where there are no risk factors for clinically-important traumatic brain injury[6] (see PREDICT Recommendation 5 or Box A for risk factors), consider structured observation over an immediate head CT scan. If there is a risk factor for intracranial injury, a head CT should be performed. If there is a deterioration in neurological status, a head CT should be performed urgently.	Adapted
F	PP	In children with coagulation factor deficiency (e.g. haemophilia), following a head injury that results in presentation to an acute care setting, the performance of a head CT scan or the decision to undertake structured observation must not delay the urgent administration of replacement factor.	New
G	PP	In all children with a bleeding disorder or on anticoagulant or antiplatelet therapy, following a head injury that results in presentation to an acute care setting, clinicians should urgently seek advice from the haematology team treating the child in relation to risk of bleeding and management of the coagulopathy.	New
11	CBR	In children with immune thrombocytopaenias, following a head injury which results in presentation to an acute care setting, where there are no risk factors for clinically-important traumatic brain injury[7] (see PREDICT Recommendation 5 or Box A for risk factors), consider structured observation over an immediate head CT scan. If there is a risk factor for intracranial injury, a head CT should be performed. If there is a deterioration in neurological status, a head CT should be performed urgently. Clinicians should check a platelet count in all children with immune thrombocytopaenias, and blood group in all symptomatic patients, if not already available.	Adapted
H	PP	In children with immune thrombocytopaenia with mild to moderate head injury and platelet counts of less than 20×10^9/L, consider empirical treatment after discussion with the haematology team treating the child.	New

12	EIR	In children with mild to moderate head injury on warfarin therapy, other anticoagulants (e.g. direct oral anticoagulants) or antiplatelet therapy, consider a head CT scan regardless of the presence or absence of risk factors for clinically-important traumatic brain injury[7] (see PREDICT Recommendation 5 or Box A for risk factors). Seek senior clinician review to inform timing of the head CT scan. Discuss the patient with the team managing the anticoagulation regarding early consideration of reversal agents. Check the appropriate anticoagulant measure (if available); for example, international normalised ratio (INR), activated partial thromboplastin time (APTT) or anti-Xa assay.	Adapted
I	PP	In adolescents with mild to moderate head injury and taking anticoagulants, including warfarin, consider managing according to adult literature and guidelines.	New

Neurodevelopmental disorders

13	CBR	It is unclear whether children with neurodevelopmental disorders presenting to an acute care setting following mild to moderate head injury have a different background risk for intracranial injury. Consider structured observation or a head CT scan for these children because they may be difficult to assess. For these children, shared decision-making with parents, caregivers and the clinical team that knows the child is particularly important.	New

Intoxication

14	CBR	In children who are drug or alcohol intoxicated presenting to an acute care setting following mild to moderate head injury, treat as if the neurological findings are due to the head injury. The decision to undertake structured observation or a head CT scan should be informed by the risk factors for clinically-important traumatic brain injury[7] (see PREDICT Recommendation 5 or Box A for risk factors) rather than the child being intoxicated.	New

Discharge without CT scan

15	EIR	In children presenting to an acute care setting following mild to moderate head injury, the risk of clinically-important traumatic brain injury[7] requiring hospital care is low enough to warrant discharge home without a head CT scan if the patient has no risk factors for a clinically important traumatic brain injury[7] (see PREDICT Recommendation 5 or Box A for risk factors), has a normal neurological examination and has no other factors warranting hospital admission (e.g. other injuries, clinician concerns [e.g. persistent vomiting], drug or alcohol intoxication, social factors or underlying medical conditions such as bleeding disorders).	New
J	PP	In children undertaking structured observation following mild to moderate head injury, consider observation up to 4 hours from the time of injury, with discharge if the patient returns to normal for at least 1 hour. Consider an observation frequency of every half hour for the first 2 hours, then 1-hourly until 4 hours post injury. After 4 hours, continue observation at least 2-hourly for as long as the child remains in hospital.	Adapted
K	PP	The duration of structured observation may be modified based on patient and family variables, including time elapsed since injury or signs and symptoms, and reliability and ability of the child or parent to follow advice on when to return to hospital.	New

Normal initial CT scan

16	EIR	After a normal initial head CT scan in children presenting to an acute care setting following mild to moderate head injury, the clinician may conclude that the risk of clinically-important traumatic brain injury[7] requiring hospital care is low enough to warrant discharge home, provided that the child has a GCS score of 15,[5] normal neurological examination and no other factors warranting hospital admission (e.g. other injuries, clinician concerns [e.g. persistent vomiting], drug or alcohol intoxication, social factors or underlying medical conditions such as bleeding disorders).	Adapted
L	PP	The duration of structured observation for children with mild to moderate head injury who have a normal initial head CT scan but do not meet discharge criteria should be based on individual patient circumstances. Consider an observation frequency of every half hour for the first 2 hours, then 1-hourly until 4 hours post injury. After 4 hours, continue at least 2-hourly for as long as the child remains in hospital.	New

Repeat imaging

17	EIR	After a normal initial head CT scan in children presenting to an acute care setting following mild to moderate head injury, neurological deterioration should prompt urgent reappraisal by the treating clinician, with consideration of an immediate repeat head CT scan and consultation with a neurosurgical service. Children who are being observed after a normal initial head CT scan[15] who have not achieved a GCS score of 15[5] after up to 6 hours observation from the time of injury should have a senior clinician review for consideration of a further head CT scan or MRI scan and/or consultation with a neurosurgical service. The differential diagnosis of neurological deterioration or lack of improvement should take account of other injuries, drug or alcohol intoxication and non-traumatic aetiologies.	Adapted

Abusive head trauma

18	EIR	In children presenting to an acute care setting following mild to moderate head injury where abusive head trauma is suspected, a head CT scan should be used as the initial diagnostic tool to evaluate possible intracranial injury and other injuries (e.g. skull fractures) relevant to the evaluation of abusive head trauma. The extent of the assessment should be coordinated with the involvement of an expert in the evaluation of non-accidental injury.	Adapted
M	PP	Detection of skull fractures, even in the absence of other intracranial injury, is important in cases of suspected abusive head trauma.	New

X-ray

19	EIR	In children presenting to an acute care setting following mild to moderate head injury, clinicians should not use plain X-rays of the skull prior to, or in lieu of, a head CT scan to diagnose skull fracture or to determine the risk of intracranial injury.	Adapted

[15] The initial head CT scan should be interpreted by a radiologist to ensure no injuries were missed.

Ultrasound

20	EIR	In children presenting to an acute care setting following mild to moderate head injury, clinicians should not use ultrasound of the skull prior to, or in lieu of, a head CT scan to diagnose or determine the risk of intracranial injury.	Adapted
21	EIR	In infants presenting to an acute care setting following mild to moderate head injury, clinicians should not use transfontanelle ultrasound prior to, or in lieu of, a head CT scan to diagnose intracranial injury.	Adopted

MRI versus CT scan

22	EIR	In children presenting to an acute care setting following mild to moderate head injury, for safety, logistical and resource reasons, MRI should not be routinely used for primary investigation of clinically-important traumatic brain injury.[16]	Adopted
N	PP	In certain settings with the capacity to perform MRI rapidly and safely in children, MRI may be equivalent to a head CT scan in terms of utility.	New

Biomarker testing

23	EIR	In infants and children with mild to moderate head injury, presenting to an acute care setting, healthcare professionals should not use biomarkers to diagnose or determine the risk of intracranial injury outside of a research setting.	Adopted

CT scan protocols

24	EIR	In children with head injury, radiation dose should be optimised for head CT scans, with the primary aim being to produce diagnostic quality images that can be interpreted by the radiologist and are sufficient to demonstrate a small volume of intracranial haemorrhage (e.g. thin-film subdural haematoma).	New
25	EIR	Age-based CT scanning protocols that are optimised and as low as reasonably achievable (ALARA) for a paediatric population should be used.	New
26	EIR	Soft tissue and bone algorithm standard thickness and fine-slice images and multiplanar 2D and bony 3D reconstructions should be acquired, archived and available to the radiologist for review at the time of initial interpretation.	New
27	CBR	Cervical spine imaging should not be routine in all children with mild to moderate head injury who require imaging.	New

Follow-up and discharge advice

28	EIR	Children presenting within 72 hours of a mild to moderate head injury can be safely discharged into the community if they meet all the following criteria: • deemed at low risk of a clinically-important traumatic brain injury as determined either by a negative head CT scan, or structured observation, or the absence of risk factors for a clinically-important traumatic brain injury[7] (see PREDICT Recommendation 5 or Box A for risk factors) • neurologically normal • a GCS score of 15[5] • no other factors that warrant admission or a longer period of structured observation (e.g. other injuries or suspected abusive head trauma, clinician concerns [e.g. persistent vomiting], drug or alcohol intoxication).	Adapted

[16] If an MRI is planned, the concurrent imaging of the spine should be considered and may warrant discussion with other specialist teams.

29	CBR	Children presenting within 72 hours of a mild to moderate head injury, and deemed appropriate for discharge with respect to low risk of a clinically-important traumatic brain injury[7] should be discharged home according to local clinical practice regarding their ability to return to hospital (in terms of distance, time, social factors and transport).	Adapted
30	CBR	Children discharged from hospital after presenting within 72 hours of a mild to moderate head injury should have a suitable person at home to supervise them for the first 24 hours post injury.	Adapted
31	EIR	All parents and caregivers of children discharged from hospital after presenting within 72 hours of a mild to moderate head injury should be given clear, age-appropriate, written and verbal advice on when to return to the emergency department; this includes worsening symptoms (e.g. headache, confusion, irritability, or persistent or prolonged vomiting), a decreased level of consciousness or seizures.	Adopted
32	EIR	All parents and caregivers of children discharged from hospital after presenting within 72 hours of mild to moderate head injury should be given contact information for the emergency department, telephone advice line or other local providers of advice.	Adopted
33	EIR	All parents and caregivers of children discharged from hospital after presenting within 72 hours of mild to moderate head injury should be given clear, age-appropriate written and verbal advice on the possibility of persistent or delayed post-concussive symptoms, and the natural history (including the recovery process) of post-concussive symptoms in children.	Adopted
34	EIR	All parents and caregivers of children discharged from hospital after presenting within 72 hours of mild to moderate head injury should be given clear, age-appropriate written and verbal advice on exercise, return to sport, return to school, alcohol and drug use, and driving.	Adopted
35	EIR	Children presenting within 72 hours of a mild to moderate head injury deemed at low risk of a clinically-important traumatic brain injury,[7] as determined by any of the following – a negative head CT scan, structured observation or the absence of risk factors for clinically-important traumatic brain injury (see PREDICT Recommendation 5 or Box A for risk factors) – do not require specific follow-up for an acute intracranial lesion (e.g. bleeding).	New
36	EIR	All parents and caregivers of children discharged from hospital after presenting within 72 hours of mild to moderate head injury should be advised that their child should attend primary care 1–2 weeks post injury for assessment of post-concussive symptoms and to monitor clinical status.	New
37	EIR	In children at high risk of persistent post-concussive symptoms (more than 4 weeks) (see Practice point O), clinicians should consider provision of referral to specialist services for post-concussive symptom management.	Adapted

O	PP	For children presenting within 72 hours of mild to moderate head injury, emergency department clinicians should consider factors known to be associated with an increased risk of developing post-concussive symptoms. Examples include, but are not restricted to, a high degree of symptoms at presentation, girls aged over 13 years, previous concussion with symptoms lasting more than a week, or past history of learning difficulties or attention deficit hyperactivity disorder (ADHD). There are validated prediction rules (e.g. Predicting Persistent Post-concussive Problems in Pediatrics (5P) clinical risk score) or risk tables to provide prognostic counselling and follow-up advice to children and their caregivers on their potential risk of developing post-concussive symptoms (see Tables 6.3.3 and 6.3.4 in full Guideline for further details).	New
38	EIR	In children whose post-concussive symptoms do not resolve within 4 weeks, clinicians should provide or refer the child to specialist services for persistent post-concussive symptom management.	Adapted

Return to sport

39	CBR	Children with mild to moderate head injury should not return to contact sport until they have successfully returned to school. Early introduction (after 24 hours) of gradually increasing, low to moderate physical activity is appropriate, provided it is at a level that does not result in exacerbation of post-concussive symptoms.	Adapted
40	CBR	Children with post-concussive symptoms should avoid activities with a risk of contact, fall or collisions that may increase the risk of sustaining another concussion during the recovery period.	Adapted
41	CBR	Children with post-concussive symptoms who play sport should commence a modified non-contact exercise program and must subsequently be asymptomatic before full contact training or game day play can resume.	Adapted
P	PP	A modified non-contact exercise program can be supervised by a parent (for younger children) or sports or health personnel (for children with ongoing significant symptoms or older children wanting to resume contact sport).	New

Physical rest

42	EIR	Children with mild to moderate head injury should have a brief period of physical rest post injury (not more than 24–48 hours post injury).	Adapted
43	EIR	Following a mild to moderate head injury, children should be introduced to early (between 24 and 48 hours post injury), gradually increasing, low to moderate physical activity, provided that it is at a level that does not result in significant exacerbation of post-concussive symptoms. Physical activities that pose no or low risk of sustaining another concussion can be resumed whenever symptoms improve sufficiently to permit activity, or even if mild residual post-concussive symptoms are present.	Adapted

Cognitive rest

44	EIR	Children with mild to moderate head injury should have a brief period of cognitive rest[17] post injury (not more than 24–48 hours post injury).	New

[17] Low-level cognitive activity, in appropriate short periods, that does not exacerbate symptoms.

45	EIR	Following a mild to moderate head injury, children should be introduced to early (between 24 and 48 hours post injury), gradually increasing, low to moderate cognitive activity, at a level that does not result in significant exacerbation of post-concussive symptoms.	New

Return to school

46	EIR	Children with post-concussive symptoms should gradually return to school at a level that does not result in significant exacerbation of post-concussive symptoms. This may include temporary academic accommodations and temporary absences from school.	Adapted
47	EIR	All schools should have a concussion policy that includes guidance on sport-related concussion prevention and management for teachers and staff, and should offer appropriate short-term academic accommodations and support to students recovering from concussion.	Adopted
48	EIR	Clinicians should assess risk factors and modifiers that may prolong recovery and may require more, prolonged or formal academic accommodations. In particular, adolescents recovering from concussion may require more academic support during the recovery period.	Adopted
Q	PP	Protocols for return to school should be personalised and based on severity of symptoms, with the goal being to increase student participation without exacerbating symptoms. Academic accommodations and modifications after concussion may include a transition plan and accommodations designed to reduce demands, monitor recovery and provide emotional support (see Box B).	New

Screen time

49	CBR	Following a mild to moderate head injury, children's use of screens should be consistent with the recommendation for gradually increasing, low to moderate cognitive activity; that is, activity at a level that does not result in significant exacerbation of post-concussive symptoms.	New
R	PP	Parents and caregivers should be aware of general recommendations for screen use in children aged 2–5 years; that is, limiting screen use to 1 hour per day, no screens 1 hour before bed, and devices to be removed from bedrooms before bedtime.	New
S	PP	Parents and caregivers should be aware of general recommendations for screen use in children aged over 5 years; that is, promote that children get adequate sleep (8–12 hours, depending on age), recommend that children not sleep with devices in their bedrooms (including TVs, computers and smartphones) and avoid exposure to devices or screens for 1 hour before bedtime.	New

Return to driving/operating machinery

50	CBR	Adolescents (and children as appropriate) who have had a mild to moderate head injury causing loss of consciousness must not drive a car, motorbike or bicycle, or operate machinery for at least 24 hours.	New
51	CBR	Adolescents (and children as appropriate) who have had a mild to moderate head injury should not drive a car or motorbike, or operate machinery until completely recovered or, if persistent post-concussive symptoms are present, until they have been assessed by a medical professional.	New

Repeat concussion

52	CBR	Children diagnosed with a repeat concussion soon after the index injury (within 12 weeks) or after multiple repeat episodes are at increased risk of persistent post-concussive symptoms. Parents and caregivers of children with repeat concussion should be referred for appropriate medical review (e.g. to a paediatrician).	New

Box A	**Head injury risk factors for clinically-important traumatic brain injury[1]**
GCS score of 14[2] or other signs of altered mental status[3]	
Severe mechanism of injury[4]	
Post-traumatic seizures	
Abnormal neurological examination	
Age less than 2 years	**Age 2 years or older**
Palpable skull fracture[5]	Signs of base of skull fracture[6]
Occipital or parietal or temporal scalp haematoma[7]	History of LOC
History of LOC ≥5 seconds	History of vomiting[8]
Not acting normally per parent	Severe headache
Adapted from the PECARN rule (3)	

1 Clinically-important traumatic brain injury is defined as death from traumatic brain injury, neurosurgical intervention for traumatic brain injury, intubation for more than 24 hours for traumatic brain injury, or hospital admission of 2 nights or more associated with traumatic brain injury on CT.

2 Measured using an age-appropriate GCS.

3 Other signs of altered mental status: agitation, drowsiness, repetitive questioning, slow response to verbal communication.

4 Severe mechanism of injury: motor vehicle accident with patient ejection, death of another passenger or rollover; pedestrian or bicyclist without helmet struck by motorised vehicle; falls of 1 m or more for children aged less than 2 years and more than 1.5 m for children aged 2 years or older; or head struck by a high-impact object.

5 Palpable skull fracture: on palpation or possible on the basis of swelling or distortion of the scalp.

6 Signs of base of skull fracture: haemotympanum, 'raccoon' eyes, cerebrospinal fluid (CSF) otorrhoea or CSF rhinorrhoea, Battle's signs.

7 Non-frontal scalfp haematoma: occipital, parietal or temporal.

8 Isolated vomiting, without any other risk factors, is an uncommon presentation of clinically important traumatic brain injury. Vomiting, regardless of the number of vomits or persistence of vomiting, in association with other risk factors increases concern for clinically-important traumatic brain injury.

Box B	**Examples of academic accommodations and modifications that may be used following concussion to facilitate increasing school participation without exacerbating symptoms**
Transition plan • Notify school of concussion before or upon returning to school. • Develop a plan for gradual return to school day and activities. • Provide a medical certificate to account for any missed assignments or exams, or design a plan of assistance to support completion of these.	
Accommodations designed to reduce demands, monitor recovery and provide emotional support • Provide an appropriate environment with low stimulus for break times and potential rest times. • Consider exemption from exams. • Reduce both the number and size of classroom and homework assignments. • Allow participation in classes or activities requiring physical activity that does not exacerbate symptoms. • Reschedule, coordinate or pace exams; hold exams when the student is asymptomatic or experiencing low level symptoms that are not exacerbated by the task. • Negotiate the timing of large assignments, to reduce co-occurring deadlines. • Assign a counsellor to meet with the student to evaluate the student's emotional status, assist with problem-solving and ensure that homework needs are being addressed.	
Additional commonly used academic accommodations • Use preferential seating that is designed to reduce exposure to distracting lights and/or noises, allow for teacher monitoring and facilitate focused attention. • Allow for test-taking in a distraction-free environment. • Allow extended time for in-class and out-of-class exams and assignments. • Use a notetaker, whose notes can be photocopied or shared electronically and provided to the student.	
Adapted from O'Neil et al. (2017) (41) (Table 3) and DeMatteo et al. (2020) (43)	

CBR: consensus-based recommendation; CT: computed tomography; EIR: evidence-informed recommendation; GCS: Glasgow Coma Score; GP: general practitioner; LOC: loss of consciousness; MRI: magnetic resonance imaging; PP: practice point

Algorithm: Imaging & Observation Decision-Making for Children with Head Injuries

Further details and footnotes are important to interpretation of the algorithm, please see page 2.

Clinician assessment of child
presenting within 72 hours of head injury[1,2]

Does the child have these special conditions?
- Possible abusive head trauma
- Drug or alcohol intoxicated
- < 6 months old
- Neurodevelopmental disorders
- Ventricular shunt
- Bleeding disorders

Please see page 2

GCS ≤ 13[3]

GCS 14-15[3]

Assess for risk factors for intracranial injury[4] & initial observation

All children:
- GCS 14 or other signs of altered mental status[5]
- Abnormal neurological examination
- Severe mechanism of injury[6]
- Post-traumatic seizure(s)

Age < 2yrs:
- Palpable skull fracture[7]
- Non-frontal scalp haematoma[8]
- History of LOC[9] ≥ 5 seconds
- Acting abnormally per parent

Age ≥ 2yrs:
- Signs of base of skull fracture[10]
- History of LOC[9]
- History of vomiting[11]
- Severe headache

If signs or symptoms deteriorate during observation stop and request senior clinician review.

Any risk factors:
Recommended period of observation is up to 4 hours post injury including 1 hour of return to normal.[12,13]

No risk factors:
No need for observation

High risk
= imaging

Palpable skull fracture[7] **OR**
Signs of base of skull fracture[10] **OR**
Worsening signs and symptoms **OR**
Persistent GCS 14 **OR**
Persistent signs of altered mental status.[5]

Intermediate risk
= consider imaging

≥ 2 Risk factors **OR**
Post-traumatic seizure(s) **OR**
Persistent severe headache or persistent vomiting > 4 hours post injury.

Low risk

Not intermediate or high risk AND Improving signs and symptoms:
GCS 15, acting normally, no current signs of altered mental status, vomiting has stopped, severe headache resolved.

Very low risk

No risk factors

Alert senior clinician

Senior clinician review to consider need for observation vs head CT vs discharge.

Head CT[14]

Is the CT normal **OR**
Showing an isolated non-displaced skull fracture **AND**
GCS 15?

YES

NO

Senior clinician concerns?

YES

NO

Further observation with serial reassessment[12]

Is there neurological deterioration **OR**
Patient has GCS 14 after 6 hours total observation?

YES

NO

Senior clinician review

If signs or symptoms stable:
consider (re)imaging or admission.
If signs or symptoms worsening:
(re)image and consult neurosurgery.

Consult neurosurgery and admit

Discharge with advice if no other factors requiring admission[13,15]

Further details to aid algorithm interpretation

[1] Always consider possible cervical spine injuries in children presenting with head injuries.

[2] Children with delayed initial presentation (24-72 hrs post head injury) and GCS 15 should be risk stratified the same way as children presenting within 24 hours. They do not need to be assessed with a further 4 hrs of observation.

[3] Remember to use an age-appropriate Glasgow Coma Scale (GCS).

[4] Risk factors adapted from Kuppermann N et al. *Lancet* 2009;374(9696):1160-70.

[5] Other signs of altered mental status: agitation, drowsiness, repetitive questioning, slow response to verbal communication.

[6] Severe mechanism of injury: motor vehicle accident with patient ejection or rollover, death of another passenger, pedestrian or cyclist without helmet struck by motor vehicle, falls of ≥ 1m (< 2 yrs), fall > 1.5m (≥ 2yrs), head struck by high impact object.

[7] Palpable skull fracture: on palpation or possible on the basis of swelling or distortion of the scalp.

[8] Non-frontal scalp haematoma: occipital, parietal, or temporal.

[9] Loss of consciousness.

[10] Signs of base of skull fracture: haemotympanum, 'raccoon' eyes, cerebrospinal fluid (CSF) otorrhoea or CSF rhinorrhoea, Battle's signs.

[11] Isolated vomiting, without any other risk factors, is an uncommon presentation of clinically important traumatic brain injury (ciTBI). Vomiting, regardless of the number or persistence of vomiting, in association with other risk factors, increases concern for ciTBI.

[12] Frequency of observation to be ½ hourly for the first 2 hours, then 1-hourly until 4 hours post injury. After 4 hours, continue 2-hourly as long as the patient is in hospital. Observation duration may be modified based on patient and family variables. These include time elapsed since injury/symptoms and ability of child/parent to follow advice on when to return to hospital.

[13] Shared decision-making between families and clinicians should be considered.

[14] Do not use plain X-rays, or ultrasound of the skull, prior to or in lieu of CT scan, to diagnose or risk stratify a head injury for possible intracranial injuries.

[15] Other factors warranting hospital admission may include other injuries or clinician concerns e.g. persistent vomiting, drug or alcohol intoxication, social factors, underlying medical conditions.

Special Conditions

Possible abusive head trauma

Follow local screening tools for abusive head trauma (AHT). CT should be used as initial diagnostic tool to evaluate possible intracranial injury and other injuries relevant for the evaluation of AHT e.g. skull fractures. The extent of the assessment of a child with possible AHT should be co-ordinated with the involvement of an expert in the evaluation of non-accidental injury.

Drug or alcohol intoxicated

Treat as if the neurological findings are due to the head injury. Decision to CT scan or observe should be informed by risk factors for intracranial injury rather than the child being intoxicated.

< 6 months of age

Consider at higher risk of intracranial injury with a lower threshold for observation or imaging. Discuss with a senior clinician.

Neurodevelopmental disorders

It is unclear whether these children have a different background risk for intracranial injury. As these children may be difficult to assess, consider structured observation or head CT scan and include the paediatric team that knows the child (parents, caregivers, and clinicians) in shared decision-making.

Ventricular shunt (e.g. ventriculo-peritoneal shunt)

Consider structured observation over immediate CT scan if there are no risk factors of intracranial injury. If there are local signs of shunt disconnection/shunt fracture (such as palpable disruption or swelling) or signs of shunt malfunction, consider obtaining a shunt series based on consultation with a neurosurgical service.

Bleeding disorders or anti-coagulant or anti-platelet therapy

Urgently seek advice from the treating haematology team around risk of bleeding and management of coagulopathy. Consider structured observation over immediate CT scan if there are no risk factors for intracranial injury. If there is a risk factor for intracranial injury a head CT should be performed. If there is a deterioration in neurological status, perform urgent head CT scan.

Coagulation factor deficiency

CT scan or decision to observe must not delay the urgent administration of replacement factor.

Immune thrombocytopaenias (ITP)

Check a platelet count in all patients and blood group in all symptomatic patients if not already available. For ITP with platelet counts < 20 x 10^9 /L, consider empirical treatment after discussion with the treating haematology team.

On warfarin therapy or other newer anticoagulants (e.g. direct oral-anticoagulant) or anti-platelet therapy

Consider CT regardless of the presence or absence of risk factors for intracranial injury. Seek senior clinician review to inform timing of the CT and discuss the patient with the team managing the anticoagulation regarding early consideration of reversal agents. For children on anticoagulation therapy, if available, check the appropriate anticoagulant measure (e.g. International normalised ratio).

Citation: Babl FE, Tavender E, Dalziel S. On behalf of the Guideline Working Group for the Paediatric Research in Emergency Departments International Collaborative (PREDICT). Australian and New Zealand Guideline for Mild to Moderate Head injuries in Children – Algorithm (2021). PREDICT, Melbourne, Australia.