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ORIGINAL RESEARCH

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

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Abstract

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

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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 created through either adoption, adaptation or development of *de novo* recommendations. The guideline was revised after a period of public consultation.

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: (i) a detailed Full Guideline summarising the evidence underlying each recommendation; (ii) a Guideline Summary; and (iii) 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.

Key words: *child, guideline, head injury, traumatic brain injury.*

Key findings

- Although international paediatric clinical practice guidelines for head injuries exist, they do not address many of the considerations relevant to the Australian and New Zealand context.
- Led by PREDICT, a multidisciplinary guideline working group has developed a binational head injury guideline for children addressing triage, imaging, observation and discharge considerations.
- The Guideline provides evidence-based, locally applicable, practical clinical guidance for the care of children with mild to moderate head injuries presenting to acute care settings in Australia and New Zealand.

Introduction

Head injury is one of the most common reasons for children to present to 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: (i) PECARN was developed in a different health care setting in North America with high CT utilisation 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 PECARN being preserved.[5] (ii) 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 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), which has 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.
- 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 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 h 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 (GCS) score.[21–23] Within Australia and New Zealand 98.3% of children who present to EDs with a head injury have a GCS score 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 score ≤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, retrieval clinicians, radiologists, nurse/nurse practitioners, neuropsychologists, general practitioners, ambulance staff, 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 GRADE (Grading of Recommendations Assessment, Development and Evaluation) 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

TABLE 1. *Types of recommendations*

Type of recommendation	Description
Evidence-informed recommendation	Recommendation formulated with evidence from source guideline and/or PREDICT literature search
Consensus-based recommendation	Recommendation formulated by consensus, where evidence was sought but none was identified, or where the identified evidence was limited by indirectness
Practice point	A recommendation that was outside the scope of the evidence search and was 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† or if they develop the following signs or symptoms within 72 h 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‡ • 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)§	New
2	CBR	Children with trivial head injury¶ do not need to attend hospital for assessment; they can be safely managed at home§	New
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††	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‡‡	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††	Adapted
Decision rules for CT scan			
5	EIR	In children with mild to moderate head injury and a GCS score of 14–15†† who have one or more risk factors for a clinically important traumatic brain injury§§ (see below or Box 1 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¶¶ *Risk factors for clinically important traumatic brain injury*§§: • GCS score of 14†† or other signs of altered mental status[a] • Severe mechanism of injury† • Post-traumatic seizure(s) • Abnormal neurological examination Specific risk factors for children aged less than 2 years: • Palpable skull fracture[b] • Occipital or parietal or temporal scalp haematoma[c] • History of LOC 5 s or more • Not acting normally per parent Specific risk factors for children aged 2 years and older: • Signs of base of skull fracture[d] • History of LOC	New

(*Continues*)

TABLE 2. *Continued*

		• History of vomiting[e] • Severe headache	
6	EIR	For children presenting to an acute care setting within 24 h of a head injury and a GCS score of 15††, a head CT scan should not be performed without any risk factors for clinically important traumatic brain injury§§ (see PREDICT Recommendation 5 or Box 1 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 h of a head injury and a GCS score of 13 or less†† should undergo an immediate head CT scan¶¶	New
8	CBR	Children with delayed initial presentation (24–72 h after head injury) and a GCS score of 15†† should be risk stratified in the same way as children presenting within 24 h	New
C	PP	For children with mild to moderate head injury, consider shared decision-making[f] with parents, caregivers and adolescents (e.g. a head CT scan¶¶ or structured observation)	New
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¶¶	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§§ (see PREDICT Recommendation 5 or Box 1 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§§ (see PREDICT Recommendation 5 or Box 1 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§§ (see PREDICT Recommendation 5 or Box 1 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	Adapted

TABLE 2. *Continued*

		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	
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§§ (see PREDICT Recommendation 5 or Box 1 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§§ (see PREDICT Recommendation 5 or Box 1 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§§ 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§§ (see PREDICT Recommendation 5 or Box 1 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, underlying medical conditions such as bleeding disorders or possible abusive head trauma)	New
J	PP	In children undertaking structured observation following mild to moderate head injury, consider observation up to 4 h from the time of injury, with discharge if the patient returns to normal for at least 1 h. Consider an observation frequency of every half hour for the first 2 h, then 1-hourly until 4 h post injury. After 4 h, 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

(*Continues*)

TABLE 2. *Continued*

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§§ requiring hospital care is low enough to warrant discharge home, provided that the child has a GCS score of 15,†† 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, underlying medical conditions such as bleeding disorders or possible abusive head trauma)	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 h, then 1-hourly until 4 h post injury. After 4 h, 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[g] who have not achieved a GCS score of 15†† after up to 6 h 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
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

TABLE 2. *Continued*

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[h]	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 h 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 (see PREDICT Recommendation 5 or Box 1 for risk factors) • Neurologically normal • A GCS score of 15†† • 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
29	CBR	Children presenting within 72 h of a mild to moderate head injury, and deemed appropriate for discharge with respect to low risk of a clinically important traumatic brain injury§§ 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 h of a mild to moderate head injury should have a suitable person at home to supervise them for the first 24 h post injury	Adapted
31	EIR	All parents and caregivers of children discharged from hospital after presenting within 72 h 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

(*Continues*)

TABLE 2. *Continued*

32	EIR	All parents and caregivers of children discharged from hospital after presenting within 72 h 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 h 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 h 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 h of a mild to moderate head injury deemed at low risk of a clinically important traumatic brain injury§§, 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 1 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 h 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 h 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 Paediatrics [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 h) 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

TABLE 2. *Continued*

41	CBR	Children with post-concussive symptoms who play sport should commence a modified non-contact exercise programme and must subsequently be asymptomatic before full contact training or game day play can resume	Adapted
P	PP	A modified non-contact exercise programme 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 h post injury)	Adapted
43	EIR	Following a mild to moderate head injury, children should be introduced to early (between 24 and 48 h 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[i] post injury (not more than 24–48 h post injury)	New
45	EIR	Following a mild to moderate head injury, children should be introduced to early (between 24 and 48 h 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 2)	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 h per day, no screens 1 h before bed, and devices to be removed from bedrooms before bedtime	New

(*Continues*)

TABLE 2. *Continued*

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 h, 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 h 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 h	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

†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. ‡A case of a single isolated vomit can be assessed in general practice. §In children aged less than 2 years the signs of intracranial injury may not be apparent in the first hour. ¶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. ††Measured using an age-appropriate GCS. ‡‡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. §§Clinically important traumatic brain injury is defined as death from traumatic brain injury, neurosurgical intervention for traumatic brain injury, intubation for more than 24 h for traumatic brain injury, or hospital admission of 2 nights or more associated with traumatic brain injury on CT. ¶¶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. [a]Agitation, drowsiness, repetitive questioning, slow response to verbal communication. [b]Palpable skull fracture: on palpation or possible on the basis of swelling or distortion of the scalp. [c]Non-frontal scalp haematoma: occipital, parietal or temporal. [d]Signs of base of skull fracture: haemotympanum, 'raccoon eyes', cerebrospinal fluid (CSF) otorrhoea or CSF rhinorrhoea, Battle's signs. [e]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. [f]Validated tools should be adapted for shared decision-making with parents, caregivers and adolescents. [g]The initial head CT scan should be interpreted by a radiologist to ensure no injuries were missed. [h]If an MRI is planned, the concurrent imaging of the spine should be considered and may warrant discussion with other specialist teams. [i]Low-level cognitive activity, in appropriate short periods, that does not exacerbate symptoms. CBR, consensus-based recommendation; CT, computed tomography; EIR, evidence-informed recommendation; GCS, Glasgow Coma Scale; GP, general practitioner; LOC, loss of consciousness; MRI, magnetic resonance imaging; PP, practice point.

of the guideline methodology (assessed using Appraisal of Guidelines for Research and Evaluation [AGREE] II);[27] (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

BOX 1. *Head injury risk factors for clinically important traumatic brain injury† (adapted from the PECARN rule, Kuppermann* et al.[3]*)*

GCS score of 14‡ or other signs of altered mental status§

Severe mechanism of injury¶

Post-traumatic seizures

Abnormal neurological examination

Age less than 2 years	**Age 2 years or older**
Palpable skull fracture††	Signs of base of skull fracture‡‡
Occipital or parietal or temporal scalp haematoma§§	History of LOC
History of LOC ≥5 s	History of vomiting¶¶
Not acting normally per parent	Severe headache

†Clinically important traumatic brain injury is defined as death from traumatic brain injury, neurosurgical intervention for traumatic brain injury, intubation for more than 24 h for traumatic brain injury, or hospital admission of 2 nights or more associated with traumatic brain injury on CT. ‡Measured using an age-appropriate GCS. §Other signs of altered mental status: agitation, drowsiness, repetitive questioning, slow response to verbal communication. ¶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. ††Palpable skull fracture: on palpation or possible on the basis of swelling or distortion of the scalp. ‡‡Signs of base of skull fracture: haemotympanum, 'raccoon' eyes, cerebrospinal fluid (CSF) otorrhoea or CSF rhinorrhoea, Battle's signs. §§Non-frontal scalp haematoma: occipital, parietal or temporal. ¶¶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. GCS, Glasgow Coma Scale; LOC, loss of consciousness.

the 33 guideline questions. An updated literature search was undertaken for the time period 1 January 2015 to 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 recommendations *de novo*. 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.[28]

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 Paediatric 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]
- 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 (nine adopted, 14 adapted and 12 new), 17 CBRs (seven adapted and 10 new) and 19 PPs (one 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 Guideline Summary (Table 2); and a clinical Guideline Algorithm: Imaging and Observation Decision-Making for Children with Head Injuries (Fig. 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: one adapted and five new; one EIR, three CBRs and two 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

BOX 2. *Examples of academic accommodations and modifications that may be used following concussion to facilitate increasing school participation without exacerbating symptoms (adapted from O'Neil* et al.[29] *[table 3] and DeMatteo* et al.[30]*)*

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 examinations, 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 examinations
- 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 examinations; hold examinations 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 examinations and assignments
- Use a notetaker, whose notes can be photocopied or shared electronically and provided to the student

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 the identification of intracranial injuries.

Imaging

Thirty-five imaging-related recommendations were developed: three adopted, 10 adapted and 22 new; 18 EIRs, five CBRs and 12 PPs (Table 2). A large body of evidence, including Australian and New Zealand studies,[5–7,24,31–36] was available for the key initial decision process in the acute care setting, that is, 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[37] and abnormal neurological examination (Table 2; Box 1), 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 increased 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.[32] There is evidence to support structured observation.[32,38,39] 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.[36] 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 h of head injury.[3] Australian and New Zealand observational data suggest that those who present between 24 and 72 h 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 h.[35] These data have resulted in a CBR that children presenting between 24 and 72 h after a head injury should be risk stratified in the same way as children presenting within 24 h.

The quality of the evidence to develop imaging guidance for

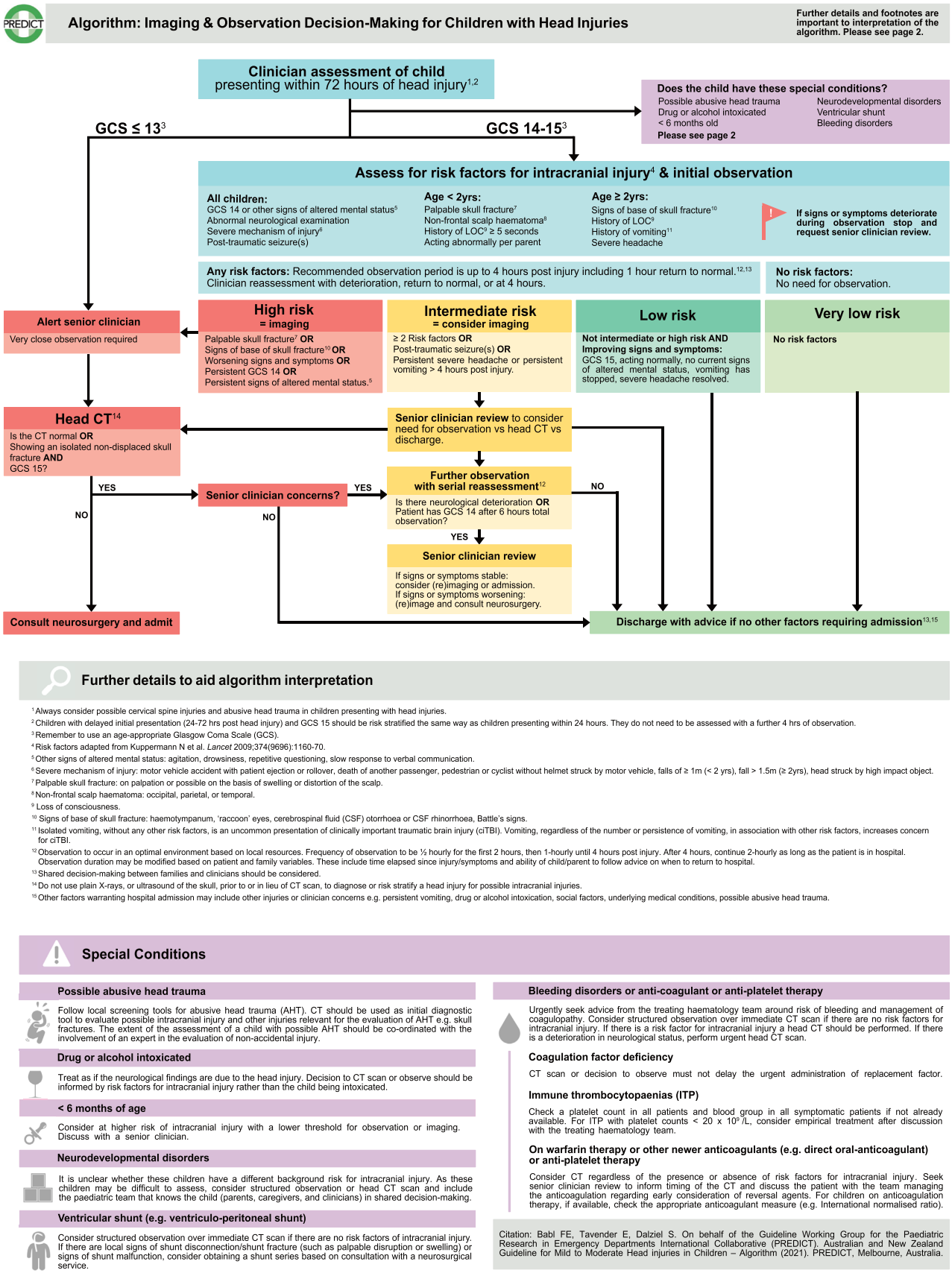

Figure 1. *Algorithm: imaging and observation decision-making for children with head injuries.*

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[31,33,34,40,41] resulting in a greater number of CBRs and PPs (Table 2).

Discharge

Thirty discharge-related recommendations were developed, six adopted, 11 adapted and 13 new; 16 EIRs, nine CBRs and five PPs (Table 2). EIRs were adopted or adapted to identify children suitable for discharge home from the ED, and subsequent advice on 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 was 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 7 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 (not more than 24–48 h), 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 the Consensus Statement on Concussion in Sports.[10,11] The resulting CBRs were adapted to be consistent with the resources generally available for children within the Australian and New Zealand medical systems, and not focused specifically on young athletes within elite sport systems.

Discussion

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 to 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 and applicable to our local context. 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.[42] 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 were involved in the management of children presenting to hospital with mild to moderate head injury from many related specialties and fields, including ambulance services, general practice, retrieval services, neurosurgery and radiology. Members were representative of six 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 paediatric 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 offering 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.

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Author contributions

FEB, ET and SRD drafted the manuscript. All authors contributed to the content of the work, critically reviewed the drafts and approved of the final version submitted.

Competing interests

A detailed list of expertise, affiliations and conflict of interest declarations for each author who was a member of the GWG for the Australian and New Zealand Guideline for Mild to Moderate Head Injuries in Children is provided in Appendix S1. JR, AW and GSYL were not members of the GWG. JR and AW work for Health Research Consulting, Sydney, Australia. GSYL has no conflicts of interest.

Data availability statement

No additional data available.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix S1. 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.