

Indications for computed tomography of the head in children following head trauma: shortcomings in the NICE, CATCH, SIGN, PECARN, and CHALICE guidelines

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Abstract

Introduction: Several guidelines exist for head computed tomography (CT) in children after trauma (NICE, CATCH, SIGN, PECARN, CHALICE), but they differ significantly, potentially leading to inconsistent diagnostic practices.

Methods: We analyzed and compared CT indication criteria across the five guidelines, focusing on differences, omissions, and unclear definitions. No human/animal subjects; IRB approval not required.

Results: Only few indications were common to all five guidelines. For example, “warfarin use” is included only in NICE (and excluded in PECARN); “irritability” appears only in CATCH, while “severe mechanism of injury” is emphasized by PECARN, NICE, and CHALICE, but poorly defined. Several symptoms (e.g., “worsening headache”) lack clear definitions. None of the guidelines explicitly address multisystem trauma.

Conclusions: Current pediatric head CT guidelines are inconsistent and have important limitations. Harmonization and clarification of vague terms are recommended to improve decision-making and patient safety.

Introduction

Head trauma in children – defined as any injury to the scalp, skull, or brain, excluding superficial facial injuries – is a common presentation in emergency departments. Pediatric head injuries are generally classified by Glasgow Coma Scale (GCS) score as mild (GCS 13–15), moderate (GCS 9–12), or severe (GCS ≤ 8) [1]. Each year in the United States, traumatic brain injuries in children result in over 500,000 emergency department visits and about 60,000 hospitalizations [2], making head trauma one of the most frequent reasons for pediatric acute care. While management of moderate and severe head injuries is usually straightforward (due to obvious indications for intervention and imaging), deciding when to perform a head computed tomography (CT) scan in cases of mild head injury can be challenging. CT imaging entails radiation exposure, so indiscriminate use is undesirable – yet missing a significant intracranial injury is dangerous. To assist clinicians, several clinical decision rules and guidelines have been developed internationally. In particular, five prominent guidelines address pediatric head trauma CT indications: the Scottish Intercollegiate Guidelines Network (SIGN) guideline [3], the UK National Institute for Health and Care Excellence (NICE) head injury guideline [4], the Canadian Assessment of Tomography for Childhood Head injury

rule (CATCH) [5], the Pediatric Emergency Care Applied Research Network rule (PECARN) [6] from the USA, and the Children’s Head injury Algorithm for the Prediction of Important Clinical Events (CHALICE) [7] rule from the UK. These guidelines aim to standardize evaluation by outlining clinical criteria for which a head CT is recommended (or, for some rules like PECARN, criteria below which CT can be safely avoided). Table 1 provides a comparative summary of CT indications according to each guideline.

Despite their common goal, these guidelines often disagree on which clinical factors warrant imaging. A given child might be recommended for immediate CT under one rule but not under another, purely based on which guideline is applied. Such variability may lead to inconsistent care, especially in settings where multiple guidelines inform practice (e.g. a regional trauma system drawing on both local and international recommendations).

This article reviews the content of the five major pediatric head trauma CT guidelines, with a focus on identifying discrepancies in included indications, any ambiguous or non-evidence-based criteria, and any important clinical factors that are omitted. By highlighting these shortcomings, we aim to inform future guideline updates and assist clinicians in understanding the limitations of current decision rules.

Table 1. Comparison of pediatric head CT indications across five clinical decision rules/guidelines. A plus sign (“+”) indicates the criterion is explicitly listed as an indication for CT; “–” indicates it is not listed; “n/a” denotes “not applicable” (typically because a guideline excludes that scenario, e.g. PECARN excludes anticoagulated patients); “+/obs.” indicates the factor is acknowledged but may lead to observation rather than automatic CT under that rule.

Indication for head CT	NICE	CATCH	SIGN	PECARN < 2 y	PECARN ≥ 2 y	CHALICE
Suspected non-accidental injury (abuse)	+	–	–	n/a	n/a	–
Convulsion (post-traumatic, no epilepsy)	–	–	–	–	–	–
GCS < 14 on initial assessment	+	–	–	n/a	n/a	–
GCS < 15 in infant (any time)	+	–	–	–	–	–
GCS < 15 2 h after injury	+	–	–	–	–	–
GCS ≤ 13 on admission (hospital)	+	–	–	n/a	n/a	–
Signs of skull fracture	–	–	–	–	–	–
Tense or bulging fontanelle (infant)	+	–	–	–	–	–
Signs of basal skull fracture ¹	+	–	+	–	–	+
Suspected open or depressed skull fracture	+	–	+	+	+	+
Scalp hematoma or bruise (large, infant)	–	–	–	–	–	+
Neurological symptoms	–	–	–	–	–	–
Focal neurological deficit	+	+	+	–	–	+
Loss of consciousness ≥ 5 min (witnessed)	+	–	–	+/obs.	+/obs.	+
“Pathological” drowsiness (abnormal)	+	–	–	+	+	+
≥ 3 episodes of vomiting	+	+	+	–	–	+
Post-traumatic seizure	Handled variably; see text					
Mechanism of injury	–	–	–	–	–	–
Dangerous mechanism (e.g. high-speed crash)	+	–	–	+/obs.	+/obs.	+
Fall from height > 3 m	+	–	–	+	+	+
Fall from height > 3× patient’s height	–	–	–	–	–	+
High-speed projectile or object strike	–	–	–	–	–	+
Bleeding risk ²	–	–	–	–	–	–
Anticoagulation (warfarin therapy)	+	–	–	n/a	n/a	–
Known bleeding/clotting disorder	–	–	–	–	–	–
	(not mentioned)			(exclusion)	(exclusion)	
Other considerations	–	–	–	–	–	–
Worsening headache (progressive/severe)	+	–	+	–	–	+
Irritability or agitation on exam	–	+	–	–	–	–
“Intoxication” (suspected intoxication)	+	–	–	–	–	–
Age < 1 year (as isolated risk factor)	+	–	+	–	–	–

¹Signs of basal skull fracture include periorbital ecchymoses (raccoon eyes), retroauricular ecchymosis (Battle’s sign), hemotympanum, or cerebrospinal fluid otorrhea/rhinorrhea. Not validated in coagulopathies; consider lower threshold for CT. ²Common pediatric coagulopathies (e.g. hemophilia) are not specifically addressed by any of the five guidelines, despite their relevance. n/a – not applicable. +/obs. – prefer observation over immediate CT.

Methods

We conducted a comparative analysis of the indications for head CT in children as recommended by the five guideline/decision-rule documents: SIGN (Scottish guideline, 2009), NICE (UK, updated 2023), CATCH (Canada, 2010), PECARN (USA, derivation 2009 with subsequent validations), and CHALICE (UK, derivation 2006). The source documents for each guideline were obtained from published literature or official websites. We extracted all explicit criteria or risk factors that each guideline identifies as warranting acute head CT after head injury, focusing on the pediatric context (SIGN and NICE guidelines also cover adults, but we included only pediatric-specific recommendations from them). We tabulated these indications side-by-side to visualize which guidelines overlap or differ (Table 1). If a guideline stratified recommendations by age (as PECARN does for age < 2 years vs. ≥ 2 years), each stratum's criteria were recorded separately.

During data extraction, we noted instances where a guideline's terminology was vague or undefined (e.g. "severe headache" or "drowsiness") and instances where certain clinical scenarios were handled differently or not mentioned at all. No statistical comparisons were performed as our analysis is qualitative. Instead, we focused on descriptive identification of differences. To supplement the guideline review, we searched the literature for studies addressing the validity of specific controversial criteria (e.g., isolated skull fracture outcomes, significance of vomiting, etc.) to provide context in the discussion. Given that this study did not involve human subjects or patient data, any institutional review board approval was not required.

Results

Our analysis revealed substantial heterogeneity among the five guidelines regarding pediatric head CT indications after trauma. Table 1 outlines the presence ("+"), absence ("−"), or guideline-specific qualification of various potential indications across the five protocols. Notably, there was no single clinical criterion that appeared in all five guidelines. Even seemingly fundamental factors – such as a depressed skull fracture or signs of basilar skull fracture – are not uniformly present (one guideline omits basilar skull signs, and one omits explicit mention of open/depressed fractures; see Table 1). Each guideline had at least one unique criterion not found in the others.

As seen in Table 1, some criteria are present only in one guideline (for example, suspected non-accidental trauma is an immediate CT indication in NICE, but none of the other guidelines mention it). Similarly, anticoagulation (warfarin) use is only considered by NICE – PECARN, in fact, explicitly excluded patients on anticoagulants from its study derivation cohort, and the other rules do not address it. In contrast,

PECARN uniquely stratifies recommendations by age (with slightly different criteria for children < 2 years versus ≥ 2 years), whereas the other guidelines use a single set of criteria across all pediatric ages (with a few specific provisos, e.g. NICE and CHALICE add special considerations for infants).

We found notable inconsistencies and ambiguities in how symptoms are defined. For instance, "worsening headache" is listed as an indication in the CATCH and PECARN rules, yet neither provides a operational definition – there is no guidance on what duration or intensity of headache qualifies as "worsening" enough to merit a CT. This ambiguity poses a challenge as interpretation is left to the clinician's judgment. A similar issue arises with "pathological drowsiness" (or abnormal sleepiness). NICE, PECARN, and CHALICE all include persistent drowsiness as a warning sign, but none clearly delineate how to distinguish pathological drowsiness from normal post-traumatic fatigue or the expected somnolence in an upset toddler past their bedtime. Such vagueness can lead to variable application: one physician might err on the side of scanning any child who seems more sleepy than baseline, while another might observe the child longer to differentiate fatigue from true neurological depression.

Likewise, some criteria appear somewhat subjective or not evidence-backed. The CATCH rule's inclusion of "irritability on examination" (in a child with a minor head injury) exemplifies this – a frightened toddler in the emergency department may be crying or irritable due to stranger anxiety or pain from other injuries, not necessarily due to an occult brain injury. Yet under CATCH, marked irritability is a high-risk factor triggering CT. Similarly, PECARN's algorithm uses "severe mechanism of injury" (such as a high-impact collision or fall from substantial height) as a criterion, recommending CT or observation based on the mechanism even if the child shows no neurological symptoms. While the mechanism is intuitively important, its predictive value for intracranial injury is relatively low in the absence of other findings [1]. Thus, these mechanism-based recommendations can lead to scanning a large number of children "to maximize safety" – for example, PECARN would advise considering CT for a child who fell > 3 feet (< 2 years old) or > 5 feet (≥ 2 years old) even if they are completely asymptomatic, though PECARN data also suggest that isolated severe mechanisms carry low risk of traumatic brain injury [8]. Another area of discrepancy is the handling of skull fractures. All five guidelines agree that a child with a known or strongly suspected skull fracture should undergo CT – this is one of the few universal points. However, emerging evidence indicates that an isolated linear skull fracture without any neurological signs has a very low likelihood of requiring neurosurgical intervention or of harboring a significant intracranial hemorrhage [9].

In other words, a well-appearing child with a skull fracture on skull X-ray (and no other symptoms) may often be managed safely with observation alone [9]. Despite this, current guidelines treat any skull fracture as an automatic indication for CT, which may need re-evaluation in future iterations. The insistence on CT for every skull fracture likely stems from legacy practice and an abundance of caution, but it exemplifies how guidelines sometimes do not incorporate the most recent outcome data.

Several common post-concussive symptoms – especially vomiting and brief loss of consciousness – are handled somewhat differently across rules, but are generally considered CT indicators in most guidelines (NICE, SIGN, CHALICE, and PECARN all list vomiting and loss of consciousness (LOC) of some duration as criteria; CATCH requires ≥ 2 episodes of vomiting and LOC is not a stand-alone criterion in CATCH). We note that vomiting, particularly in isolation, has poor specificity for significant brain injury in children; many children vomit once or twice after a minor fall due to pain or crying. Yet most guidelines err on the side of caution by listing “ ≥ 3 vomits” (or in CHALICE, ≥ 2) as a threshold for imaging. The same is true for brief loss of consciousness (LOC) – while frightening to witness, a single brief LOC in an older child, if followed by normal behavior, has limited predictive value for intracranial hemorrhage. Still, except for CATCH and SIGN, the other guidelines include LOC (with varying time cut-offs) as an independent CT indication. This conservative stance ensures high sensitivity, at the expense of specificity [1]. One controversial criterion found in NICE (and only there) is anticoagulation (warfarin) use in a pediatric head trauma patient. The NICE guideline, which covers all ages, added warfarin therapy as a CT indication by extrapolation from adult data – acknowledging at the same time that this scenario is exceedingly rare in pediatrics. In practice, it is uncommon to encounter a child on warfarin (chronic anticoagulation in pediatrics is more often achieved with other agents or in conditions like hemophilia which are managed differently). Indeed, PECARN specifically excluded patients with bleeding disorders or anticoagulant use from their study, due to insufficient numbers to analyze. Our view is that guidelines should perhaps generalize this to any bleeding dyscrasia (e.g., severe hemophilia, platelet disorder) as a relative indication for CT, but none of the current rules explicitly mention such conditions. This represents a gap – children with known bleeding tendencies might be at higher risk of intracranial bleed even from minor trauma, yet no guideline provides advice for this scenario.

Omission of multisystem trauma: An especially significant oversight we identified is that none of the five guidelines explicitly addresses children with multisystem (polytrauma) injuries. Multisystem trauma refers to a patient who has sustained severe

injuries to at least two distinct body regions, often accompanied by physiologic compromise such as shock (hypotension) upon presentation. Pediatric trauma is the leading cause of death in children over 1 year of age worldwide [10] and a large proportion of these fatalities involve multiple injuries. In severely injured children, traumatic brain injury is a major contributor to mortality and long-term morbidity [11]. Published trauma series show that mortality in pediatric polytrauma patients can range from single-digit percentages in moderate injury cases to over 20–30% in cases involving severe head trauma [12]. One study of blunt trauma in young children noted that about 29% of those with multisystem injuries had an associated closed head injury. Such combined injuries often have synergistically worse outcomes – for example, a child with both a head injury and abdominal hemorrhage is at much higher risk of deterioration than a child with either injury in isolation.

Despite these considerations, current pediatric head injury CT rules were largely derived in cohorts that excluded multi-trauma patients (e.g., PECARN explicitly excluded patients with acute multi-system injuries requiring immediate intervention). The result is that the guidelines give no guidance on head CT in a child who, e.g., was in a high-speed car crash with both a head impact and abdominal trauma. In practice, most clinicians would have a lower threshold for scanning the head in such cases, given that an unreliable exam (due to shock or distracting injuries) might mask neurological signs. However, it is striking that none of the guidelines list “multiple trauma” or “polytrauma” as a consideration. We consider this a major shortcoming – future revisions should include a statement that in the setting of multisystem or serious extra-cranial injuries, clinicians should maintain a high index of suspicion and a lower threshold for head CT, even if the isolated head injury decision rule criteria are not strictly met. Multisystem trauma in children is a complex scenario that often falls to trauma protocols rather than isolated head injury algorithms, but since head CT is part of many trauma evaluations, integrating the guidance would be beneficial. By not mentioning it at all, the guidelines leave a gap between specialized trauma team practice and algorithmic decision rules for minor head injury.

Discussion

The observed variability among the NICE, CATCH, SIGN, PECARN, and CHALICE guidelines underscores that pediatric head trauma management is not guided by a single unified evidence base, but rather by multiple studies and consensus opinions that sometimes conflict. Each guideline-making body had to balance sensitivity (avoiding missed injuries) with specificity (avoiding unnecessary radiation). North American rules like PECARN leaned towards

very high sensitivity – resulting in criteria like any signs of altered mental status or certain mechanisms triggering CT – whereas UK-based rules like CHALICE were slightly more specific, at the cost of potentially missing a small fraction of injuries [1]. Our review highlights that, in striving to maximize sensitivity, some guidelines included ill-defined or overly broad criteria (e.g., “vomiting” without context, or “severe mechanism” without nuance), which can reduce their usability. A busy clinician might find these criteria difficult to interpret or apply, leading either to overuse of CT or to disregard of the guideline altogether. Importantly, none of the guidelines is a replacement for clinical judgment – and indeed, studies have shown that experienced physicians’ judgment can perform on par with the decision rules [1].

However, standardized guidelines remain valuable for less experienced providers and to ensure a baseline of care, especially in widespread emergency settings. Therefore, it is worthwhile to refine these tools. Based on our analysis, we suggest several areas for improvement in future guideline revisions or new decision tools:

- **Clarify Symptom Criteria:** Terms like “worsening headache” or “abnormal drowsiness” should be accompanied by objective parameters or examples. For instance, guidelines could specify that “worsening headache” means a headache that is progressively increasing in intensity and not relieved by appropriate analgesia, or define “abnormal drowsiness” as the child not awakening to voice or having difficulty staying awake during assessment, etc. Providing such definitions (possibly in an appendix to the guideline) would reduce ambiguity.
- **Incorporate Clinical Context:** Some factors might need conditional recommendations rather than absolute. For example, vomiting in isolation could prompt a period of observation rather than immediate CT in an otherwise normal exam, a nuance that PECARN already suggests (“observation vs. CT” for isolated vomiting or isolated severe mechanism). Emphasizing these conditional pathways can help avoid reflexive scanning for one isolated symptom.
- **Update Evidence on Fractures:** Given data that neurologically intact children with isolated linear skull fractures rarely need neurosurgery [9], guidelines might modify the recommendation to: perform CT if a skull fracture is suspected and there are neurological symptoms, or at least acknowledge that isolated skull fractures in well children could be evaluated with observation and perhaps subsequent neuroimaging (e.g., delayed CT or MRI) rather than emergent CT in every case. Any such change would need careful vetting, but it is an area where practice is evolving.
- **Address Special Populations:** As noted, inclusion of guidance for children with bleeding disorders (e.g.,

hemophilia on factor replacement) and children with multisystem trauma would be useful. Even if the guidance is simply a statement like “These rules have not been validated in patients with known coagulopathy or multisystem trauma; clinicians should have a low threshold for imaging in such cases”, it would alert users to be cautious.

- **Consistency and Simplification:** Ultimately, the existence of five different sets of criteria is itself problematic. Efforts toward unifying guidelines or at least reconciling their differences could improve care. For instance, an international panel could potentially develop a single algorithm, drawing on the strongest aspects of each rule and new evidence. In the meantime, educational efforts should make clinicians aware of the differences – our Table 1 can serve as a reference for those familiar with one guideline (e.g., PECARN) to understand how another (e.g., NICE) might differ.

Conclusions

The current guidelines for head CT in pediatric trauma – NICE, CATCH, SIGN, PECARN, and CHALICE – each provide value in decision-support, but none is without limitations. There is considerable inconsistency among them, reflecting different trade-offs between sensitivity and specificity. Many criteria in these protocols are based on expert consensus and can be subjective or undefined (leading to possible overuse of CT), and some important clinical scenarios (like polytrauma or coagulopathies in children) are not addressed at all. Rigid adherence to any single rule should not eclipse clinical judgment; every child’s presentation is unique. We recommend that future revisions strive for more precision in definitions, incorporation of the latest evidence (for example, regarding isolated skull fractures and isolated brief seizures), and inclusion of broader context (such as multisystem injury considerations). By harmonizing guidelines and correcting the identified shortcomings – for example, providing clear criteria for ambiguous symptoms and acknowledging high-risk situations currently omitted – we can improve the decision-making process for pediatric head trauma. The goal is to minimize unnecessary radiation exposure for children while safely identifying those with serious intracranial injuries. Achieving this balance requires continuous refinement of our clinical decision rules in light of both clinical experience and emerging data.

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Conflict of interest

The authors declare no conflict of interest.

References

1. Easter JS, Bakes K, Dhaliwal J, Miller M, Caruso E, Haukoos JS. Comparison of PECARN, CATCH, and CHALICE rules for children with minor head injury: a prospective cohort study. *Ann Emerg Med.* 2014; 64(2): 145-152.
2. Haydel MJ, Weisbrod LJ, Saeed W. Pediatric Head Trauma. StatPearls [Internet]. Jan 2025 [cited 2025 Jun 27]. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK441859/>
3. Scottish Intercollegiate Guidelines Network (SIGN). Early Management of Patients with a Head Injury – Quick Reference Guide. Edinburgh: SIGN 2009. Available from: <https://www.sign.ac.uk/assets/sign110.pdf>
4. National Institute for Health and Care Excellence (NICE). Head Injury: Assessment and Early Management. NICE Guideline NG232; May 2023. Available from: <https://www.nice.org.uk/guidance/ng232>.
5. Osmond MH, Klassen TP, Wells GA, Correll R, Jarvis A, Jobert G, Bailey B, Chauvin-Kimoff L, Pusic M, McConnell D, Nijssen-Jordan C, Silver N, Taylor B, Stiell IG; Pediatric Emergency Research Canada (PERC) Head Injury Study Group. CATCH: a clinical decision rule for the use of computed tomography in children with minor head injury. *CMAJ.* 2010; 182(4): 341-348.
6. Gambacorta A, Moro M, Curatola A, Brancato F, Covino M, Chiaretti A, Gatto A. PECARN rule in the diagnostic process of pediatric patients with minor head trauma in the emergency department. *Eur J Pediatr.* 2022; 181(5): 2147-2154.
7. Dunning J, Daly JP, Lomas JP, Lecky F, Batchelor J, Mackway-Jones K; Children's head injury algorithm for the prediction of important clinical events study group. Derivation of the CHALICE decision rule for head injury in children. *Arch Dis Child.* 2006; 91(11): 885-891.
8. Ak R, Celik NB, Erdogan HD, Karaküçük AY, Gökdoğan S, Korkmaz S, Seyhan AU. Evaluation of three clinical decision rules in pediatric patients with minor head injury: PECARN, CHALICE and CHATCH. *Glob Emerg Crit Care* 2023; 2(2): 33-40.
9. Arneitz C, Sinzig M, Fasching G. Diagnostic and clinical management of skull fractures in children. *J Clin Imaging Sci.* 2016; 6: 47.
10. Ramaiah R. Pediatric trauma – broader perspectives. *Austin J Anesth Analg.* 2014; 2(2): 1012.
11. Haydel MJ, Weisbrod LJ, Wajeedha W. Pediatric Head Trauma. StatPearls Publishing; 2025 Jan-.
12. Peclet MH, Newman KD, Eichelberger MR. Thoracic trauma in children: an indicator of increased mortality. *J Paediatr Surg.* 1990; 25(9): 961-966.

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