# Delayed Presentations to Emergency Departments of Children With Head Injury: A PREDICT Study

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**Study objective:** Existing clinical decision rules guide management for head-injured children presenting 24 hours or sooner after injury, even though some may present greater than 24 hours afterward. We seek to determine the prevalence of traumatic brain injuries for patients presenting to emergency departments greater than 24 hours after injury and identify symptoms and signs to guide management.

**Methods:** This was a planned secondary analysis of the Australasian Paediatric Head Injury Rule Study, concentrating on first presentations greater than 24 hours after injury, with Glasgow Coma Scale scores 14 and 15. We sought associations with predictors of traumatic brain injury on computed tomography (CT) and clinically important traumatic brain injury.

**Results:** Of 19,765 eligible children, 981 (5.0%) presented greater than 24 hours after injury, and 465 injuries (48.5%) resulted from falls less than 1 m and 37 (3.8%) involved traffic incidents. Features associated significantly with presenting greater than 24 hours after injury in comparison with presenting within 24 hours were nonfrontal scalp hematoma (20.8% versus 18.1%), headache (31.6% versus 19.9%), vomiting (30.0% versus 16.3%), and assault with nonaccidental injury concerns (1.4% versus 0.4%). Traumatic brain injury on CT occurred in 37 patients (3.8%), including suspicion of depressed skull fracture (8 [0.8%]) and intracranial hemorrhage (31 [3.8%]). Clinically important traumatic brain injury occurred in 8 patients (0.8%), with 2 (0.2%) requiring neurosurgery, with no deaths. Suspicion of depressed skull fracture was associated with traumatic brain injury on CT consistently, with the only other significant factor being nonfrontal scalp hematoma (odds ratio 19.0; 95% confidence interval 8.2 to 43.9). Clinically important traumatic brain injury was also associated with nonfrontal scalp hematoma (odds ratio 11.7; 95% confidence interval 2.4 to 58.6) and suspicion of depressed fracture (odds ratio 19.7; 95% confidence interval 2.1 to 182.1).

**Conclusion:** Delayed presentation after head injury, although infrequent, is significantly associated with traumatic brain injury. Evaluation of delayed presentations must consider identified factors associated with this increased risk. [Ann Emerg Med. 2019;74:1-10.]

Please see page 2 for the Editor's Capsule Summary of this article.



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## INTRODUCTION

Mild blunt head injuries in children are a common reason for presentation to emergency departments (EDs) worldwide.[1] The majority of children present to the hospital within 24 hours after injury, but there is a subset of children who present greater than 24 hours after injury with persistent or worsening head injury symptoms, with symptoms of other injuries, or because caregivers discover a scalp hematoma made more prominent with edema and liquefaction.[2,3]

The prevalence of traumatic brain injury in children who sustain head injury[4-7] has been described in studies to derive clinical decision rules to guide the use of cranial computed tomographic (CT) scanning. Both the Pediatric Emergency Care Applied Research Network (PECARN)[4] and the Canadian Assessment of Tomography for Childhood Head Injury (CATCH)[5] clinical decision rules specifically exclude children with head injury who present greater than 24 hours after injury. The Children's Head Injury Algorithm for the Prediction of Important Clinical Events (CHALICE)[6] clinical decision rule has no exclusions except failure to consent, but no data on the significance of delayed presentations have been published, to our knowledge.

The most concerning complication of minor head injuries is the delayed or missed diagnosis of complicated

**Editor's Capsule Summary**

*What is already known on this topic*

Clinical decision rules for pediatric head trauma were designed to evaluate children who present in the first 24 hours after trauma.

*What question this study addressed*

What is the prevalence of traumatic brain injury on computed tomography scan and clinically important traumatic brain injury in children presenting greater than 24 hours after a minor head injury?

*What this study adds to our knowledge*

This prospective cohort study reported that some children initially presenting greater than 24 hours after head trauma (N=981) had traumatic brain injury (3.8%) or clinically important traumatic brain injury (0.8%), with 6 of the 8 patients with clinically important traumatic brain injury having an accompanying skull fracture and all having concerning physical findings such as nonfrontal boggy hematoma.

*How this is relevant to clinical practice*

Physicians should consider the relatively high probability of traumatic brain injury when managing children with delayed presentation for head trauma.

skull fractures or intracranial injury, especially those that require intervention. Delayed hemorrhage may result from slow venous bleeding, blood dyscrasias, and coagulation disorders.[1] In adults, the available low-quality studies suggest delayed presentations have lower rates of intracranial injury[8-12] and yet account for 15% of cranial CTs undertaken. In addition, there is little evidence on how existing clinical decision rules can be applied to this cohort of patients.[9] For children younger than 2 years, retrospective studies have suggested that intracranial hemorrhage in delayed presentations occurs at a rate similar to that of individuals presenting within 24 hours after the head injury,[3] although additional evaluation for nonaccidental injury may still be required.[2] A retrospective review of children presenting greater than 6 hours after injury suggested that intracranial hemorrhage was rare in this cohort.[1]

We aimed to determine the prevalence of traumatic brain injury on CT scan and clinically important traumatic brain injury in children presenting greater than 24 hours after a minor head injury. We also sought to determine which variables from previously published high-quality clinical decision rules[4-6] may increase the risk of these outcomes to assist clinicians to better identify patients likely to require cranial CT scan or observation in the hospital.

## MATERIALS AND METHODS

### Study Design

This was a planned secondary analysis of the Australasian Paediatric Head Injury Rule Study cohort,[7] in which all published rule-specific predictor and outcome variables for PECARN,[4] the CATCH,[5] and the CHALICE[6] clinical decision rules were collected, with the primary outcome in the parent study of determining diagnostic accuracy (sensitivity, specificity, negative predictive value, and positive predictive value) for each of the clinical decision rules.

Treating clinicians enrolled patients presenting with a history of head injury and recorded prospective data on the ED presentation. There was no attempt to influence the clinician's management, including undertaking a CT scan for the evaluation of the patients. Patients were enrolled by the treating ED clinician, who then used a paper-based case report form to collect predictive clinical data before any neuroimaging. The site research assistant recorded ED and hospital management data after the visit and conducted a telephone follow-up for patients who had not undergone neuroimaging.[13]

The institutional ethics committees at each participating site approved the study. Informed verbal consent was obtained from parents or guardians, apart from instances of significant life-threatening or fatal injuries, for which participating ethics committees granted a waiver of consent. The trial protocol[13] was developed by the study investigators and was registered with the Australian New Zealand Clinical Trials Registry.

### Setting

Ten pediatric EDs in Australia and New Zealand, associated with the Paediatric Research in Emergency Department International Collaborative research network,[14] recruited patients into the study.

### Selection of Participants

Children younger than 18 years with head injury of any severity who presented to the participating EDs between April 2011 and November 2014 were included.

### Data Collection and Processing

In this planned subanalysis, we compared the cohort of children who presented greater than 24 hours after head injury with those who presented within 24 hours. We excluded from the analysis children with Glasgow Coma Scale (GCS) score less than 14 because decisionmaking in regard to CT scanning and management is not controversial. Re-presentations for the same injury were also excluded to determine factors in a de novo presentation rather than deterioration after an earlier assessment.

We used the definition of traumatic brain injury on CT of intracranial hemorrhage or contusion, cerebral edema, traumatic infarction, diffuse axonal injury, shearing injury, sigmoid sinus thrombosis, signs of brain herniation, midline shift, diastasis of the skull, pneumocephalus, and depressed skull fracture. Clinically important traumatic brain injury was defined as death, intubation greater than 24 hours, neurosurgery (intracranial pressure monitoring, craniotomy, hematoma evacuation, elevation of depressed skull fracture, dura repair, tissue debridement, and lobectomy), or traumatic brain injury–related hospital admission of 2 or more nights in accordance with the PECARN study.[15] We determined to describe the children presenting greater than 24 hours after injury because clinicians report uncertainty in management decisions with these delayed presentations.

### Outcome Measures

We report demographics, including age, sex, vomiting, any loss of consciousness, headache, any amnesia, seizure, nonaccidental injury concern, altered mental state such as drowsiness or abnormal GCS score, examination features suggestive of depressed skull fracture, abnormal neurologic examination result, and the presence of a nonfrontal scalp hematoma. Nonaccidental injury concern was determined by the treating clinician at the ED assessment, who recorded this concern on the paper-based case report form.

### Primary Data Analysis

We tested associations between the delay in presentation and injury mechanisms: falls (<1, 1 to 1.5, 1.5 to 3, and >3 m), road traffic incident (as a pedestrian, cyclist, or occupant of a vehicle), and high-speed injury from a projectile or object, all of which have previously been demonstrated to be predictors of increased risk of traumatic brain injury.[4] Low-impact mechanisms were defined as those not meeting the PECARN clinical decision rules' definition of severe mechanisms: motor vehicle crash with patient ejection, death of another passenger, or rollover; pedestrian or cyclist without helmet who is struck by a vehicle; and falls greater than 1 m (for patients <2 years) or greater than 1.5 m (for patients >2 years) or being struck by a high-impact object.

Case report form data were subsequently entered into EpiData (version 2010; EpiData Association, Odense, Denmark[16]) and later Research Electronic Data Capture (version 8.9.1; Vanderbilt University, Nashville, TN), hosted at Murdoch Children's Research Institute,[17] and were analyzed with Stata (version 13; StataCorp, College Station, TX). Descriptive statistics were calculated for key variables, with 95% confidence intervals (CIs) where relevant. Comparisons of demographic and injury characteristics between patients presenting within and greater than 24 hours after injury were carried out, and percentage differences (with 95% CIs) are presented. Associations between clinical predictors and outcomes between patients presenting to the ED within and greater than 24 hours after a head injury were analyzed by odds ratios (ORs) and 95% CIs. Multiple logistic regression analyses were undertaken, but because many predictors and outcomes had rare frequency, assumptions of cell sizes were violated. Exact methods for multiple logistic regressions were also explored but did not add information beyond bivariate analyses. Variables included in the bivariate analyses were determined through analysis of patients, with significant differences in those presenting greater than 24 hours after injury in regard to vomiting, headache, known or suspected loss of consciousness at injury, any amnesia, suspicion of depressed skull fracture, and nonfrontal scalp hematoma.

## RESULTS

The original study[7] included 20,137 head injury presentations. The present study excluded 352 cases with GCS score less than 14 and a further 20 with unknown time to presentation (Figure). Of the 19,765 novel presentations of children enrolled in the Australasian Paediatric Head Injury Rule Study cohort who met our inclusion criteria, 981 children (5.0%) presented greater than 24 hours after injury, with 386 (39.4%) being female patients and 277 (28.3%) being younger than 2 years (Table 1). Four hundred sixty-five patients (48.5%; 95% CI 45.3% to 51.7%) presented because of falls less than 1 m compared with 9,333 (50.8%; 95% CI 50.1% to 51.5%) who presented within 24 hours after a fall of less than 1 m. A road traffic incident was the reason for presentation for 37 patients (3.8%; 95% CI 2.6% to 5.0%) compared with 1,038 (5.5%; 95% CI 5.2% to 5.9%) presenting within 24 hours. Head CTs were undertaken for 213 children (21.7%; 95% CI 19.1% to 24.3%) presenting greater than 24 hours after injury and 1,606 (8.6%; 95% CI 8.2% to 9.0%) of those presenting within 24 hours.

Children presenting greater than 24 hours after injury were significantly more likely than those presenting within

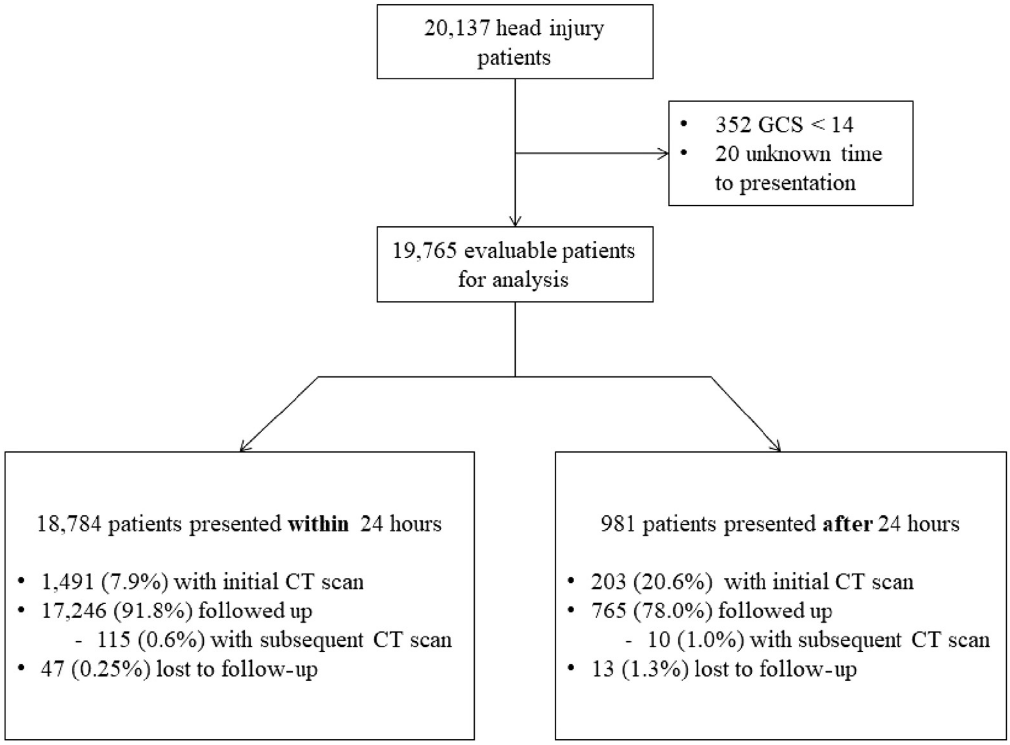


**Figure.** Participant flow.

24 hours to display the following features at any time between the injury and presentation (respectively): nonfrontal scalp hematoma (20.8% versus 18.1%), headache (31.6% versus 19.9%), any vomiting (30.0% versus 16.3%), and assault with nonaccidental injury concerns (1.4% versus 0.4%) (Table 1). Loss of consciousness (13.5% versus 14.3%) and amnesia (6.3% versus 8.2%) were significantly more likely to occur in patients presenting within 24 hours after injury (Table 1).

Thirty-seven of 981 children had a traumatic brain injury on CT as defined by PECARN (3.8%; 95% CI 2.6% to 5.0%), with an OR of 3.1 (95% CI 2.2 to 4.4), compared with those presenting within 24 hours after injury (Table 2). The commonest injuries were depressed skull fracture (8 [0.8%; 95% CI 0.4% to 1.67%]) and intracranial hemorrhage or contusions (31 [3.2%; 95% CI 2.2% to 4.5%]) (Table 3). Clinically important traumatic brain injury occurred in 8 children (0.8%, 95% CI 0.4% to 1.6%; OR 1.0, 95% CI 0.5 to 2.0), with 2 (0.2%; 95% CI 0.0% to 0.5%) requiring neurosurgical interventions. The clinical synopses of these 8 children with clinically important traumatic brain injury are presented in Table 4 and highlight variables present in published clinical decision rules at the delayed presentation. There were no deaths or intubations greater than 24 hours because of head injury in the delayed presentation cohort.

Bivariate analysis demonstrated significant variables associated with traumatic brain injury on CT in delayed presentations, with 30 children with nonfrontal scalp hematoma having positive results for traumatic brain injury on CT (OR 19.0; 95% CI 8.2 to 43.9) (Table 5). All 8 cases with suspicion of depressed skull fracture had positive results for traumatic brain injury on CT and were not included in the bivariate analysis. No cases of children with amnesia had positive results for traumatic brain injury on CT. Suspicion of depressed fracture (OR 19.7; 95% CI 2.1 to 182.1) and nonfrontal scalp hematoma (OR 11.7; 95% CI 2.4 to 58.6) were also significantly associated with clinically important traumatic brain injury (Table 5). In children with loss of consciousness or amnesia, there were no instances of clinically important traumatic brain injury.

## LIMITATIONS

In the original study, CT scans were obtained for a minority of patients; it would have been unethical to obtain them for patients the clinicians did not think required them. However, the benefit of this observational study, with extensive follow-up, allowed unexpected consequences of the head injury to be detected after patient discharge from the hospital, without CT scanning. In the parent study, 5,203 of 29,433 patients (17.6%) were missed for

**Table 1.** Characteristics of patients by time of presentation after injury.

| Factor | After 24 Hours (n=981) No. | After 24 Hours (n=981) % | Within 24 Hours (n=18,784) No. | Within 24 Hours (n=18,784) % | Difference % | Difference 95% CI | |
|---|---|---|---|---|---|---|---|
| **All ages, y** | | | | | | | |
| <1 | 132 | 13.5 | 2,166 | 11.5 | 1.9 | −0.3 | to 4.1 |
| 1–2 | 145 | 14.8 | 2,852 | 15.2 | −0.4 | −2.7 | to 1.9 |
| >2 | 704 | 71.8 | 13,766 | 73.3 | −1.5 | −4.4 | to 1.4 |
| **Sex** | | | | | | | |
| Female, No. (%) | 386 | 39.4 | 6,790 | 36.2 | 3.2 | 0.1 | to 6.3 |
| **Mechanism** | | | | | | | |
| **All falls** | 667 | 69.6 | 13,247 | 72.1 | −2.6 | −5.6 | to 0.4 |
| <1 m | 465 | 48.5 | 9,333 | 50.8 | −2.3 | −5.6 | to 0.9 |
| 1–2 m | 137 | 14.3 | 2,501 | 13.6 | 0.7 | −1.6 | to 2.9 |
| 2–3 m | 42 | 4.4 | 1,036 | 5.6 | −1.3 | −2.6 | to 0.1 |
| >3 m | 7 | 0.7 | 137 | 0.8 | 0 | −0.6 | to 0.5 |
| Unknown height | 16 | 1.7 | 240 | 1.3 | 0.4 | −0.5 | to 1.2 |
| Fall downstairs | 9 | 1.0 | 245 | 1.4 | −0.4 | −1.0 | to 0.2 |
| **Traffic incident** | 37 | 3.8 | 1,038 | 5.5 | −1.8 | −3.0 | to −0.5 |
| Pedestrian struck by moving vehicle | 2 | 0.2 | 198 | 1.1 | −0.9 | −1.2 | to −0.5 |
| Bike rider struck by automobile | 0 | 0 | 22 | 0.1 | −0.1 | −0.2 | to −0.1 |
| Fall from bicycle (no helmet) | 15 | 1.5 | 352 | 1.9 | −0.4 | −1.2 | to 0.4 |
| Motor vehicle related | 23 | 2.4 | 719 | 3.9 | −1.5 | −2.5 | to −0.5 |
| **Miscellaneous** | | | | | | | |
| Object struck head, accidental | 71 | 7.4 | 1,215 | 6.6 | 0.8 | −0.9 | to 2.5 |
| Assault (NAI concern) | 14 | 1.4 | 81 | 0.4 | 1.0 | 0.3 | to 1.7 |
| Any vomiting | 290 | 30.0 | 3,034 | 16.3 | 13.7 | 10.8 | to 16.6 |
| Headache | 310 | 31.6 | 3,735 | 19.9 | 11.7 | 8.8 | to 14.7 |
| **Any LOC at injury, min** | 107 | 11.4 | 2,419 | 13.5 | −2.1 | −4.2 | to 0.0 |
| ≤5 | 107 | 100.0 | 2,351 | 97.2 | 2.8 | 2.2 | to 3.5 |
| >5 | 0 | 0 | 68 | 2.8 | −2.8 | −3.5 | to −2.2 |
| **Any amnesia, min** | 62 | 6.3 | 1,544 | 8.2 | −1.9 | −3.5 | to −0.3 |
| ≤5 | 43 | 69.4 | 872 | 56.5 | 12.9 | 1.1 | to 24.6 |
| >5 | 19 | 30.7 | 672 | 43.5 | −12.9 | −24.6 | to −1.1 |
| **Altered consciousness** | 23 | 2.3 | 512 | 2.7 | −0.4 | −1.4 | to 0.6 |
| Abnormal drowsiness | 21 | 2.2 | 465 | 2.5 | −0.4 | −1.3 | to 0.6 |
| GCS score 14 if <1 y | 2 | 0.2 | 52 | 0.3 | −0.1 | −0.4 | to 0.2 |
| Seizure | 17 | 1.7 | 274 | 1.5 | 0.3 | −0.6 | to 1.1 |
| Suspicion of depressed skull fracture | 8 | 0.8 | 62 | 0.3 | 0.5 | −0.1 | to 1.1 |
| Nonfrontal scalp hematoma | 204 | 20.8 | 3,402 | 18.1 | 2.7 | 0.1 | to 5.3 |

*NAI*, Nonaccidental injury; *LOC*, loss of consciousness.

inclusion. There is a potential that delayed presentations were among those missed, resulting in selection bias; however, the size of the screened cohort and the inclusion of all Australasian tertiary pediatric centers as study sites make it unlikely that serious adverse events in patients with delayed presentations were missed. Patients who presented with a head injury greater than 24 hours after injury who had isolated symptoms (such as vomiting or headache) may have been missed because the treating clinician determined an alternate diagnosis; however, at every site the research assistants reviewed these cases with the site investigator to determine whether those patients constituted a missed recruitment. The decision to undertake CT scanning was a clinician one, with no information recorded to indicate

**Table 2.** Prevalence of traumatic brain injury on CT and clinically important traumatic brain injury in patients with late versus early presentation.

| | After 24 Hours (n=981) | | | Within 24 Hours (n=18,784) | | | Difference | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | 95% CI | No. | % | 95% CI | % | 95% CI |
| TBI on CT | 37 | 3.8 | 2.6 to 5.0 | 233 | 1.2 | 1.1 to 1.4 | 2.53 | 1.33 to 3.73 |
| ciTBI | 8 | 0.8 | 0.3 to 1.4 | 151 | 0.8 | 0.7 to 0.9 | 0.01 | –0.57 to 2.07 |
| Neurosurgical intervention | 2 | 0.2 | 0.0 to 0.5 | 25 | 0.1 | 0.1 to 0.2 | 0.07 | –0.22 to 0.36 |

*TBI*, Traumatic brain injury; *ciTBI*, clinically important TBI.
TBI on CT includes patients with or without ciTBI.

why there was a higher CT rate for the delayed presentation; however, there is little guidance for clinicians because current clinical decision rules do not address management in delayed presentations. The CT rate implies either that early presentations may be associated with minor mechanisms with minimal symptoms and signs or that clinicians have greater suspicion of clinically important traumatic brain injury for delayed presentations because of persistence of symptoms. We could not assess clustering of recruitment by ED clinicians at individual sites because the names of individual clinicians were not collected.

**Table 3.** Details of traumatic brain injuries in children with delayed presentation to the hospital and GCS score greater than or equal to 14 (n=986).

| Type of TBI | No. | % | 95% CI |
|---|---|---|---|
| **Clinically important TBI*** | 8 | 0.8 | 0.4–1.6 |
| Hospitalization ≥2 nights in association with TBI on CT | 8 | 0.8 | 0.4–1.6 |
| Neurosurgery | 2 | 0.2 | 0.1–0.8 |
| Intubation for TBI ≥24 h | 0 | | |
| Death because of TBI | 0 | | |
| **TBI on CT*** | 37 | 3.8 | 2.7–5.2 |
| **Intracranial hemorrhage/contusion** | 31 | 3.2 | 2.2–4.5 |
| Extra-axial (subdural/extradural) | 28 | 2.9 | 2.0–4.1 |
| Parenchyma | 2 | 0.2 | 0.1–0.8 |
| Subarachnoid | 0 | | |
| Cerebral edema | 2 | 0.2 | 0.1–0.8 |
| Traumatic infarction | 0 | | |
| Diffuse axonal injury | 0 | | |
| Shearing injury | 0 | | |
| Sigmoid sinus thrombosis | 0 | | |
| Midline shift or brain herniation | 2 | 0.2 | 0.1–0.8 |
| Diastasis of skull | 1 | 0.1 | 0.0–0.7 |
| Pneumocephalus | 1 | 0.1 | 0.0–0.7 |
| Depressed skull fracture | 8 | 0.8 | 0.4–1.6 |

*Patients could meet more than one criterion for clinically important TBI or have more than one TBI on CT.

We report both traumatic brain injury on CT and clinically important traumatic brain injury in accordance with the PECARN clinical decision rule outcomes, which are well disseminated and renowned methods determining the requirement for imaging head-injured children. It is recognized that certain outcomes (such as an intracranial hemorrhage) for traumatic brain injury on CT, although not necessarily requiring interventions as required for the definition of clinically important traumatic brain injury, may still have significant implications for a child, particularly in relation to advice on resuming sports activities.

We focused on the first presentation to the study EDs for the head injury and have not reported data on children re-presenting to the ED after previous medical assessment because this implies an evolution of the head injury. We concentrated on assessing factors in children whose caregivers did not seek medical attention about the injury until greater than 24 hours afterward. As a consequence, we cannot determine whether at the injury there were predictor variables for neuroimaging or admission present. Some children may have presented to other health care settings or nonstudy EDs before assessment at a study ED; these patients were included in this study if they had not had CT scans elsewhere before arrival.

Finally, the patients reflect an Australian and New Zealand cohort with a bias toward tertiary children's hospitals, where the neuroimaging rate is lower than that reported in US studies.[18]

Although it is possible that the data collection of clinical decision rule predictor variables influenced the CT ordering practice of the ED clinicians involved in the study, data on a large number of predictor variables were collected, and for each data point a range of response options was elicited, which would likely have limited influence on decisionmaking of clinicians. In addition, according to a clinician survey before the study no specific head injury rules had been incorporated into clinical practice or practice guidelines in Australia and New Zealand.[19]

**Table 4.** Case synopsis of patients presenting after 24 hours with clinically important traumatic brain injury.

| Age | Sex | GCS Score on Presentation | Mechanism | Time of Presentation After Injury | Symptoms/Signs on Presentation | Injury Recorded on CT | Hospital Admission | Neurosurgery | Intubated >24 Hours | Death Because of Head Injury |
|---|---|---|---|---|---|---|---|---|---|---|
| 6–12 mo | Male | 15 | Low-level fall ≤1 m | >2 days | Ongoing vomiting >3 times*; irritable*, <5-cm parietal scalp hematoma; possible skull fracture on palpation* | Extra-axial hemorrhage, nondepressed skull fracture | >2 days | Craniotomy with hematoma evacuation | No | No |
| 3 y | Female | 15 | Low-level fall ≤1 m | >2 days | Single vomiting episode*; presented with >5-cm boggy temporal scalp hematoma* | Epidural hematoma; nondepressed skull fracture | 2 days | No | No | No |
| 6 y | Female | 15 | Low-level fall ≤1 m | 2 days | Presented with <5-cm boggy swelling parietal scalp hematoma* | Extradural hemorrhage; nondepressed skull fracture | >2 days | No | No | No |
| 6–12 mo | Male | 15 | Low-level fall ≤1 m | 1 day | Vomited twice*; presented with >5-cm boggy parietal scalp hematoma* | Extra-axial hemorrhage; nondepressed skull fracture | 2 days | No | No | No |
| 13 y | Male | 15 | Struck by high-speed object | >2 days | Presented with moderate headache* and irritability*, <5-cm occipital scalp hematoma* | Extra-axial hemorrhage | >2 days | No | No | No |
| 14 y | Male | 15 | Blunt injury with bat during sports | 1 day | Presented with mild headache,* <5-cm frontal scalp hematoma, ptosis and periorbital swelling | Extra-axial hemorrhage; nondepressed skull fracture; orbital fracture | >2 days | Craniotomy with hematoma evacuation | No | No |
| 6–12 mo | Female | 15 | Fall out of bed >2 days before | >2 days | Swelling for 2 days; presented with 5-cm boggy temporal scalp hematoma* | Depressed skull fracture and small extra-axial hemorrhage | >2 days | No | No | No |
| 15 y | Male | 14 | Low-level fall ≤1 m | 1 day | Altered mental status*, moderate headache* | Subdural hemorrhage with midline shift | 2 days | No | No | No |

*Symptoms or signs positive for clinical decision rule predictor variables.

**Table 5.** Variables associated with increased risk for clinically important traumatic brain injury and traumatic brain injury on CT in patients presenting greater than 24 hours with GCS score greater than or equal to 14 (bivariate analyses).

| | No TBI on CT | | | TBI on CT | | | | |
|---|---|---|---|---|---|---|---|---|
| **Variables** | **n/N** | **%** | **95% CI** | **n/N** | **%** | **95% CI** | **OR** | **95% CI** |
| Any vomiting | 24/691 | 3.5 | 2.2–5.1 | 13/290 | 4.5 | 2.4–7.5 | 1.3 | 0.7–2.6 |
| Headache* | 30/671 | 4.5 | 3.0–6.3 | 7/310 | 2.3 | 0.9–4.6 | 0.5 | 0.2–1.1 |
| Known/suspected LOC at injury | 36/874 | 4.1 | 2.9–5.7 | 1/107 | 0.9 | 0.0–5.1 | 0.2 | 0.0–1.6 |
| Any amnesia* | 37/919 | 4.0 | 2.9–5.5 | 0/62 | 0.0 | 0.0–5.8 | 0.2† | 0.0–3.1 |
| Nonfrontal scalp hematoma | 7/777 | 0.9 | 0.4–1.8 | 30/204 | 14.7 | 10.1–20.3 | 19.0 | 8.2–43.9 |
| | **No ciTBI** | | | **ciTBI** | | | | |
| Any vomiting | 4/691 | 0.6 | 0.2–1.5 | 4/290 | 1.4 | 0.4–3.5 | 2.4 | 0.6–9.7 |
| Headache* | 5/671 | 0.7 | 0.2–1.7 | 3/310 | 1.0 | 0.2–2.8 | 1.3 | 0.3–5.5 |
| Known/suspected LOC at injury | 8/874 | 0.9 | 0.4–1.8 | 0/107 | 0.0 | 0.0–3.4 | 0.5† | 0.0–8.3 |
| Any amnesia* | 8/919 | 0.9 | 0.4–1.7 | 0/62 | 0.0 | 0.0–5.8 | 0.9† | 0.0–15.0 |
| Suspicion of depressed fracture | 7/973 | 0.7 | 0.3–1.5 | 1/8 | 12.5 | 0.3–52.7 | 19.7 | 2.1–182.1 |
| Nonfrontal scalp hematoma | 2/777 | 0.3 | 0.0–0.9 | 6/204 | 2.9 | 0.1–6.3 | 11.7 | 2.4–58.6 |

*"Unknown"/"preverbal" recoded to "no."
†Haldane-Anscombe correction (zero cell count).

## DISCUSSION

In this large prospective observational study, we demonstrated that 5% of children with minor head injuries present to the ED greater than 24 hours after the injury and have a significantly higher rate of CT scanning than children presenting within 24 hours. Most of these head injuries occurred after low-impact falls (such as falls <1 m), and the majority of patients who sustained a clinically important traumatic brain injury in this delayed presentation cohort were in this category. This indicates a need for vigilance in assessing and managing these patients in the ED, as evidenced by the higher CT rate. Symptoms or signs more frequently present in delayed rather than early presentations were nonfrontal scalp hematoma, headache, any vomiting, and assault with nonaccidental injury concerns. These features have face validity and are easily assessed, prompting clinicians to raise their concern for traumatic brain injury, which will assist them in determining the need for further investigation or observation. The features significantly associated with traumatic brain injury on CT and clinically important traumatic brain injury (suspicion of depressed skull fracture and nonfrontal scalp hematoma) have been identified for the first time, to our knowledge, and these results will guide clinicians to evaluate these suspicions promptly with a CT scan.

We could not determine why the patients delayed presentation to the ED, and we were specifically not evaluating those re-presenting to the ED because of evolution of symptoms of head injury. Symptoms that may prompt a child to be brought to the ED greater than 24 hours after injury appear to be similar to those listed in head injury advice sheets provided to families presenting within 24 hours with a child with a head injury.[20] These include features such as persistent headache and vomiting. In this study, the ORs for the presence of vomiting and headache in patients with delayed presentations did not reach statistical significance, which reinforces that the clinician attempting to differentiate the likely risk of a significant head injury in a child with a reported minor head injury who has vomiting (that may or may not be associated with an intercurrent gastroenteritis) should evaluate these patients carefully for the significant factors of altered consciousness, suspicion of depressed fracture, or presence of nonfrontal scalp hematoma. We did not limit recruitment to a specified period from the injury and did not assess persistent headache in the setting of postconcussion syndrome; however, headache was not significantly associated with traumatic brain injury on CT or clinically important traumatic brain injury.

In adult populations, delayed presentations in head injury have been studied only retrospectively.[9-11,21] Although results from these cohort studies reveal comorbidities and risks in the adult population, the presence of significant injury is at best equal to or even slightly less than when presentation is not delayed. Unfortunately, in these studies the definition of delayed presentation is heterogeneous, ranging from 4 hours to greater than 24 hours, and further hampers comparison with our prospective cohort of children.

Although clinicians reported their concern for nonaccidental injury, we did not further evaluate whether the clinician's nonaccidental injury concerns were confirmed. One of the traditional historical associations with nonaccidental injury relates to delay in presentation, and this may contribute to the higher CT rate in our delayed cohort. This study expands on recent publications by Sellin et al[2] and Gelernter et al[3] on delayed presentation in children younger than 2 years, which concentrated on the detection of nonaccidental injury. Sellin et al[2] demonstrated that isolated scalp swelling with nonfocal examination findings had excellent prognosis and may not require radiology or neurosurgical interventions (while emphasizing the need for full evaluation of nonaccidental injury). Gelernter et al[3] also demonstrated similar rates of abnormal CT findings between presentations within and greater than 24 hours after injury, but their study specifically included only children who had already received CTs, thus rendering these retrospective data less generalizable.

In this study, we have described the variables associated with increased risk of significant injury when a child presents greater than 24 hours after a head injury. The current published clinical decision rules[4-6] were not designed to provide guidance on their application for children who present greater than 24 hours after injury. To our knowledge, there have been no other studies that have reported a prospective collection of outcomes in this cohort. Presenting greater than 24 hours after injury with a GCS score greater than or equal to 14 significantly increases the risk of a traumatic brain injury on CT (OR 3.1), which may require neurosurgical management, prolonged hospitalization, or intubation greater than 24 hours. The presence of certain variables (including suspicion of depressed fracture and nonfrontal scalp hematoma) has been demonstrated to increase the risk of traumatic brain injury on CT and clinically important traumatic brain injury in delayed presentations, and clinicians should base their management decisions about CT scan use on these increased risks.

One of the strengths of this study is that, to our knowledge, this is the first large prospective cohort study of children to determine the rate and pattern of delayed presentations in head injury. The PECARN and CATCH rules do not address this, and the CHALICE study outcomes for the delayed presentation cohort were not reported. The 8 children who developed clinically important traumatic brain injury in our cohort had clinical decision rule predictor variables at their delayed presentation. As such, we were able to report predictor variables that should be strongly considered in delayed presentations and should influence the need for imaging or prolonged observation.

Delayed presentation greater than 24 hours after head injury in children, although infrequent, may be significantly associated with traumatic brain injury. Factors associated with traumatic brain injury include suspicion for depressed skull fracture and nonfrontal scalp hematoma. Treating clinicians should evaluate and manage delayed presentations outside of the current head injury clinical decision rule parameters because these rules have not been validated for this subset of patients.

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