**Web Appendices**

Probabilities and utilities used in the economic model

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Usual care** | | **PECARN** | **CATCH** | | **CHALICE** | **Distribution** | **Source** |
| **Probabilities: risk of brain injury** | | | | | | |  | APHIRST data, Table 2 |
| High risk, usual care | 0.0830 | | 0.2480 | 0.3020 | | 0.22000 |  |  |
| Low risk, usual care | 0.9170 | | 0.7520 | 0.6980 | | 0.78000 |  |
| **Probabilities: immediate outcomes** | | | | | | |  |  |
| High risk, ciTBI, neurosurgical | 0.0146 | | 0.0045 | 0.0040 | | 0.0053 | Dirichlet |  |
| High risk, ciTBI, non-neurosurgical | 0.0850 | | 0.0256 | 0.0256 | | 0.0302 |  |
| High risk, no TBI | 0.9004 | | 0.9699 | 0.9699 | | 0.9645 |  |
| Low risk, ciTBI, neurosurgical | 0.0001 | | 0.0002 | 0.0002 | | 0.0001 |  |
| Low risk, ciTBI, non-neurosurgical | 0.0001 | | 0.0011 | 0.0011 | | 0.0007 |  |
| Low risk, no TBI | 0.9998 | | 0.9987 | 0.9987 | | 0.9992 |  |
| **Long term outcomes** | | | | | **Probability** | | **Distribution** | **Source** |
| **ciTBI, neurosurgical** |  | | | | | |  | Review of clinical records for ciTBI at Royal Children’s Hospital Melbourne (n=39) |
| GOS-E pediatric 8 | 0.0000 | | | | | |  |
| GOS-E pediatric 7 | 0.2000 | | | | | |  |
| GOS-E pediatric 6 | 0.2000 | | | | | |  |
| GOS-E pediatric 5 | 0.1000 | | | | | |  |
| GOS-E pediatric 4 | 0.0588 | | | | | |  |
| GOS-E pediatric 3 | 0.1412 | | | | | |  |
| GOS-E pediatric 2 | 0.0403 | | | | | |  |
| GOS-E pediatric 1 | 0.2597 | | | | | |  |
| **ciTBI, non-neurosurgical** | | | | | | | Dirichlet |
| GOS-E pediatric 8 | 0.0345 | | | | | |  |
| GOS-E pediatric 7 | 0.0345 | | | | | |  |
| GOS-E pediatric 6 | 0.1609 | | | | | |  |
| GOS-E pediatric 5 | 0.0805 | | | | | |  |
| GOS-E pediatric 4 | 0.0913 | | | | | |  |
| GOS-E pediatric 3 | 0.2191 | | | | | |  |
| GOS-E pediatric 2 | 0.0509 | | | | | |  |
| GOS-E pediatric 1 | 0.3284 | | | | | |  |
| **No TBI** | | | | | | |  |
| GOS-E pediatric 1 | 1.0000 | | | | | |  |
| **Other probabilities** |  | **Probability (95%CI)** | | **Standard Error** | | | **Distribution** | **Source** |
| Probability of cancer |  | | 0.12 | (a) | | | Beta | Stein et al (2008)1 |
| **Utilities** | | | | | | |  |  |
| Utility of GOS-E pediatric state 1 |  | | 0 |  | | |  | Kosty et al (2012)2 |
| Utility of GOS-E pediatric state 2 |  | | 0.11 (0.132 to -0.15) | 0.020 | | | Beta |
| Utility of GOS-E pediatric state 3 |  | | 0.41 (0.492 to -0.55) | 0.022 | | | Beta |
| Utility of GOS-E pediatric state 4 |  | | 0.58 (0.696 to -0.78) | 0.019 | | | Beta |
| Utility of GOS-E pediatric state 5 |  | | 0.70 (0.84 to -0.95) | 0.016 | | | Beta |
| Utility of GOS-E pediatric state 6 |  | | 0.81 (0.972 to -1.0) | 0.014 | | | Beta |
| Utility of GOS-E pediatric state 7 |  | | 0.86 (0.946 to -0.99) | 0.013 | | | Beta |
| Utility of GOS-E pediatric state 8 |  | | 1 |  | | |  |
| Utility decrement for missed brain injury |  | | 0.1a |  | | |  | Assumption |
| Utility decrement from cancer per CT scan |  | | 0.0130 |  | | |  | Stein et al (2008)1 |

GOS-E: Glascow Outcome Score Extended, SD- standard deviation, ciTBI: clinically important traumatic brain injury, TBI: traumatic brain injury

a in the absence of reported data on measures of variance, the standard error is assumed to be half the mean

References

1. Stein SC, Hurst RW, Sonnad SS. Meta-analysis of cranial CT scans in children. A mathematical model to predict radiation-induced tumors. *Pediatr Neurosurg.* 2008;44(6):448-457.

2. Kosty J, Macyszyn L, Lai K, McCroskery J, Park HR, Stein SC. Relating quality of life to Glasgow outcome scale health states. *J Neurotrauma.* 2012;29(7):1322-1327.

Web Appendices

Detailed model outputs: probilities, cost and QALYs

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **CATCH** | Probability | Cost | QALYs |  | Probability | Cost | QALYs |
| CT scan | 0.302 | $ 16,006 | 16.89349 | No CT scan | 0.698 | $ 2,331 | 17.01260 |
| ciTBI, neurosurgical | 0.004 | $ 1,315,862 | 9.98744 | Missed ciTBI, neurosurgical | 0.0001 | $ 1,319,355 | 10.38355 |
| ciTBI, non-neurosurgical | 0.022 | $ 395,909 | 12.70450 | Missed ciTBI, non-neurosurgical | 0.0009 | $ 403,448 | 12.67909 |
| No TBI | 0.974 | $ 2,156 | 17.01548 | No TBI | 0.9990 | $ 1,866 | 17.01704 |
| **CHALICE** |  |  |  |  |  |  |  |
| CT scan | 0.220 | $ 21,003 | 16.84798 | No CT scan | 0.780 | $ 2,317 | 17.01320 |
| ciTBI, neurosurgical | 0.005 | $ 1,315,862 | 9.98744 | Missed ciTBI, neurosurgical | 0.0001 | $ 1,319,355 | 10.38355 |
| ciTBI, non-neurosurgical | 0.030 | $ 395,909 | 12.70450 | Missed ciTBI, non-neurosurgical | 0.0007 | $ 403,448 | 12.67909 |
| No TBI | 0.964 | $ 2,156 | 17.01548 | No TBI | 0.9992 | $ 1,866 | 17.01704 |
| **USUAL CARE** |  |  |  |  |  |  |  |
| CT scan | 0.083 | 55539 | 16.54281 | No CT scan | 0.917 | $ 1,913 | 17.01654 |
| ciTBI, neurosurgical | 0.015 | $ 1,315,862 | 9.98744 | Missed ciTBI, neurosurgical | 0.0000 | $ 1,319,355 | 10.38355 |
| ciTBI, non-neurosurgical | 0.085 | $ 395,909 | 12.70450 | Missed ciTBI, non-neurosurgical | 0.0120 | $ 403,448 | 12.67909 |
| No TBI | 0.090 | $ 2,156 | 17.01548 | No TBI | 0.99988 | $ 1,866 | 17.01704 |
| **PECARN** |  |  |  |  |  |  |  |
| CT scan | 0.176 | $ 24,671 | 16.81545 | No CT scan | 0.824 | $ 2,532 | 17.01131 |
| ciTBI, neurosurgical | 0.006 | $ 1,315,862 | 9.98744 | Missed ciTBI, neurosurgical | 0.0002 | $ 1,319,355 | 10.38355 |
| ciTBI, non-neurosurgical | 0.036 | $ 395,909 | 12.70450 | Missed ciTBI, non-neurosurgical | 0.0010 | $ 403,448 | 12.67909 |
| No TBI | 0.958 | $ 2,156 | 17.01548 | No TBI | 0.9988 | $ 1,866 | 17.01704 |

Web Appendices

Inclusion and exclusion criteria, predictor variables, and outcome measures of PECARN, CATCH, and CHALICE clinical decision rules

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | PECARN < 2 | PECARN **≥** 2 | CATCH | CHALICE |
| Inclusion criteria | Age <18 years; presenting within 24 h of head injury | Age <18 years; presenting within 24 h of head injury | Age <17 years All of the following: Blunt trauma to the head resulting in witnessed LOC, definite amnesia, witnessed disorientation, persistent vomiting (two or more distinct episodes of vomiting 15 min apart), persistent irritability in the ED (in children <2 years) Initial GCS score in ED ≥13, as determined by treating physician Injury within the past 24 h | Age <16 years; any history or signs of injury to the head |
| Exclusion criteria | Trivial mechanism of injury, defined by ground-level fall or walking or running into stationary objects and no signs or symptoms of head trauma other than scalp abrasions and lacerations Penetrating trauma  Known brain tumours Pre-existing neurological disorder complicating assessment Neuroimaging at an outside hospital before transfer Patient with ventricular shunt Patient with bleeding disorder GCS score <14 | Trivial mechanism of injury, defined by ground-level fall or walking or running into stationary objects and no signs or symptoms of head trauma other than scalp abrasions and lacerations Penetrating trauma  Known brain tumours Pre-existing neurological disorder complicating assessment Neuroimaging at an outside hospital before transfer Patient with ventricular shunt Patient with bleeding disorder GCS score <14 | Obvious penetrating skull injury Obviously depressed fracture Acute focal neurological deficit Chronic generalised developmental delay Head injury secondary to suspected child abuse  Returning for reassessment of previously treated head injury Patients who were pregnant | Refusal to consent |
| Predictor variables\* |  |  |  |  |
| Mechanism of injury | Severe mechanism of injury (MVC with patient ejection, death of another passenger, or rollover; pedestrian or bicyclist without helmet struck by motorised vehicle; falls >0·9 m; or head struck by high-impact object) | Severe mechanism of injury (MVC with patient ejection, death of another passenger, or rollover; pedestrian/bicyclist without helmet struck by motorised vehicle; falls >1·5 m; or head struck by high-impact object) | Dangerous mechanism of injury (eg, MVC; fall from elevation ≥3 ft (≥91 cm) or ≥5 stairs; or fall from bicycle with no helmet) | High-speed RTA as pedestrian, cyclist, or occupant (defined as accident with speed >40 miles per h or 64 km/h); fall >3 m in height; or high-speed injury from projectile or object |
| History | LOC for ≥5 s Not acting normally per parent report | Any or suspected LOC History of vomiting Severe headache | History of worsening headache† | Witnessed loss of consciousness for >5 min ≥3 discrete episodes of vomiting after head injury Amnesia (antegrade or retrograde; >5 min) Suspicion of non-accidental injury (any suspicion by the examining doctor) Seizure in patient with no history of epilepsy |
| Examination | GCS score <15 Other signs of altered mental status (agitation, somnolence, repetitive questioning, slow response to verbal communication) Palpable or unclear skull fracture Occipital, parietal, or temporal scalp haematoma | GCS score <15 Other signs of altered mental status (agitation, somnolence, repetitive questioning, slow response to verbal communication) Clinical signs of basilar skull fracture (eg, haemotympanum, “raccoon” eyes, otorrhoea or rhinorrhoea of CSF, Battle’s sign) | GCS score <15 at 2 h after injury† Irritability on examination† Any sign of basal skull fracture (eg, haemotympanum, “raccoon” eyes, otorrhoea or rhinorrhoea of CSF, Battle’s sign)  Suspected open or depressed skull fracture† Large, boggy scalp haematoma | GCS score <14, or <15 if aged <1 year Abnormal drowsiness (in excess of that expected by examining doctor) Positive focal neurology (motor, sensory, coordination, or reflex abnormality) Signs of basal skull fracture (haemotympanum, “raccoon” eyes, otorrhoea or rhinorrhoea of CSF, Battle’s sign, facial crepitus, or severe facial injury) Suspicion of penetrating or depressed skull injury, or tense fontanelle  Presence of bruise, swelling, or laceration >5 cm if aged <1 year |
| Primary outcome | Clinically important TBI, defined as death from TBI, neurosurgical intervention for TBI (intracranial pressure monitoring, elevation of depressed skull fracture, ventriculostomy, haematoma evacuation, lobectomy, tissue debridement, dura repair, or other), intubation of more than 24 h for TBI or hospital admission of  2 nights or more for TBI‡, associated with TBI on CT§ | Clinically important TBI, defined as death from TBI, neurosurgical intervention for TBI (intracranial pressure monitoring, elevation of depressed skull fracture, ventriculostomy, haematoma evacuation, lobectomy, tissue debridement, dura repair, or other), intubation of more than 24 h for TBI, or hospital admission of 2 nights or more for TBI‡, associated with TBI on CT§ | Need for neurological intervention, defined as either death within 7 days secondary to the head injury or need for any of the following procedures within 7 days: craniotomy, elevation of skull fracture, monitoring of intracranial pressure, or insertion of endotracheal tube for the management of head injury | Clinically significant intracranial injury, defined as death as a result of head injury, requirement for neurosurgical intervention, or marked abnormality on CT (defined as any new, acute, traumatic intracranial pathology as reported by consultant radiologist, including intracranial haematomas of any size, cerebral contusion, diffuse cerebral oedema, and depressed skull fracture) |
| Secondary outcome | None | None | Brain injury on CT, defined as any acute intracranial finding revealed on CT that was attributable to acute injury, including closed depressed skull fracture  (ie, depressed past the inner table) and pneumocephalus, but excluding non-depressed skull fractures and basilar skull fractures | Presence of skull fracture Admission to hospital |
| We have changed the order in which the variables are presented to facilitate comparison. PECARN=Pediatric Emergency Care Applied Research Network. CATCH=Canadian Assessment of Tomography for Childhood Head Injury. CHALICE=Children’s Head Injury Algorithm for the Prediction of Important Clinical Events. ED=emergency department. GCS=Glasgow Coma Scale. LOC=loss of consciousness. MVC=motor vehicle crash. RTA=road traffic accident. CSF=cerebrospinal fluid. TBI=traumatic brain injury. \*In each of the three clinical decision rules, the absence of all of the above predictor variables indicates that cranial CT scan is unnecessary. †High-risk predictors for CATCH (need for neurological intervention). ‡Hospital admission for TBI defined by admission for persistent neurological symptoms or signs such as persistent alteration in mental status, recurrent emesis due to head injury, persistent severe headache, or ongoing seizure management. §TBI on CT defined by any of the following descriptions: intracranial haemorrhage or contusion, cerebral oedema, traumatic infarction, diffuse axonal injury, shearing injury, sigmoid sinus thrombosis, midline shift of intracranial contents or signs of brain herniation, diastasis of the skull, pneumocephalus, or skull fracture depressed by at least the width of the table of the skull. | | | | |
| Reproduced from Babl FE, Borland ML, Phillips N, et al. Accuracy of PECARN, CATCH, and CHALICE head injury decision rules in children: a prospective cohort study. *Lancet.* 2017;389(10087):2393-2402. | | | | |