

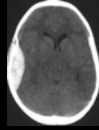
## Traumatic Brain Injury Prediction Rules in Children:

*Getting the Evidence Right,*

*Translating into Practice, and Shared Decision Making*



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Melbourne, Australia  
December 7<sup>th</sup>, 2016*

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## Disclosure

- ◆ No financial relationships or conflict of interests related to this talk

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## Objectives

- ◆ Review the PECARN Traumatic Brain Injury (TBI) Prediction Rules derivation / validation
- ◆ Describe how PECARN is translating the TBI Prediction Rules into practice
- ◆ Describe the principles of shared decision-making and patient-centered outcomes in research and its application to the PECARN TBI Prediction Rules

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## Case

- ◆ 8 month-old falls 2 feet from a carrier
- ◆ No LOC, one episode of emesis
- ◆ On exam, acting normally
- ◆ Small forehead hematoma, tender at site

*What are you going to do?*

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## Epidemiology of Pediatric Head Trauma

- ◆ Trauma the leading cause of death among children > 1 year
- ◆ Traumatic brain injury (TBI) the leading cause of death and disability due to trauma (> 70% of deaths)
- ◆ On an annual basis in the U.S., blunt head trauma in children results in:
  - 6,000 deaths
  - 60,000 hospitalizations
  - 620,000 ED visits (~50% evaluated with CT scans, use of CT increasing over the past decade, much variability in care)

*NHAMCS 2006; Blackwell 2007; Centers for Disease Control 2010, Mannix 2012, 2013*

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## Controversy over CT for Minor Blunt Head Trauma

### Arguments for liberal use of CT:

- ◆ Preventable morbidity/mortality due to unrecognized TBIs
- ◆ Preverbal children difficult to eval.
- ◆ When indicated, benefit of CT greatly outweighs risk, *however...*



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## Controversy over CT for Minor Blunt Head Trauma

### Arguments against liberal use of CT:

- ◆ Of the large number of children evaluated with CT after blunt head trauma, fewer than 10% have TBI
- ◆ Drawbacks of CT include transport outside the ED, pharmacological sedation, costs
- ◆ **Most important (theoretical) risk:** *lethal malignancy risk from a single CT may be as high as 1:2500*
- *Imaging in pediatric head trauma high priority for AAP, NAM, EMSC*

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## CT Radiation Risks

- ◆ **Estimates** (theoretical, not observed) of risks of lethal malignancies extrapolated from survivors of WWII atomic explosions:
  - 1 per 2500 head CT scans for 5 year-olds
  - 1 per 5000 for 10 year-olds
- ◆ CT radiation risks important from a public-health view
  - ~300,000 CTs for BHT, ~6 million pediatric CTs annually in U.S.

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## Reducing CT Radiation Exposure

- ◆ Age and size-based radiation-reduction efforts ongoing ("ALARA" principle)
- ◆ Creation/validation of large CT imaging rules
- ◆ Slowing of new indications of CT, improved awareness of guidelines, increased use of ultrasound ([Arasu 2015](#))
- ◆ Feedback to physicians on test ordering, shared decision-making ([Kanzaria 2015](#))

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## Pediatric Emergency Care Applied Research Network (PECARN)



Supported in full by Project #U03 MC00001-01 from the Maternal and Child Health Bureau, Health Resources and Services Administration, Department of Health and Human Services

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## Ongoing PECARN Research Development

- Patient safety and error reduction
- Quality of PEM care
- **Evaluation of head trauma**
- C-Spine immobilization
- Steroids in acute bronchiolitis
- The burden of mental illness and psychiatric emergencies in PED
- RCT of fluids for DKA
- Magnesium for sickle cell pain
- Therapeutic hypothermia in pediatric cardiopulmonary arrest
- Diagnostic categorization of illnesses and injuries in the PED
- Management of status epilepticus
- Evaluation of abdominal trauma
- Screening for alcohol abuse
- Probiotics for AGE
- **Knowledge translation of TBI rules**
- RNA transcription biosignatures to diagnose febrile infants



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## The PECARN Head Injury Study

**Goal:** to derive a clinical decision rule to accurately identify children at near zero risk of clinically important traumatic brain injury after blunt trauma with high accuracy and wide generalizability

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## The PECARN TBI Rules (derived and validated)

Children are at very low risk of clinically-important traumatic brain injury (TBI) if they meet all criteria in age-specific rule:

### Children < 2 years

1. Severe mechanism of injury
2. History of LOC  $\geq$  5 sec
3. GCS = 14 or other signs of altered mental status
4. Not acting normally per parent
5. Palpable skull fracture
6. Occipital/parietal/temporal scalp hematoma

### Children 2-18 years

1. Severe mechanism of injury
2. History of LOC
3. GCS = 14 or other signs of altered mental status
4. History of vomiting
5. Severe headache in the ED
6. Signs of basilar skull fracture

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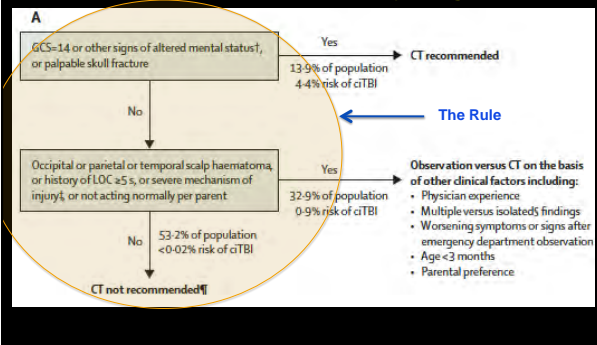
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## Recommendations for children younger than 2




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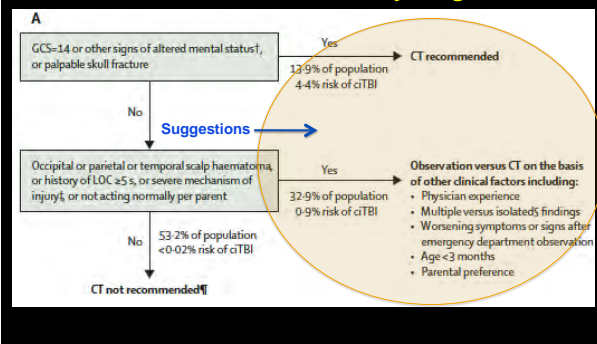
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## Recommendations for children younger than 2




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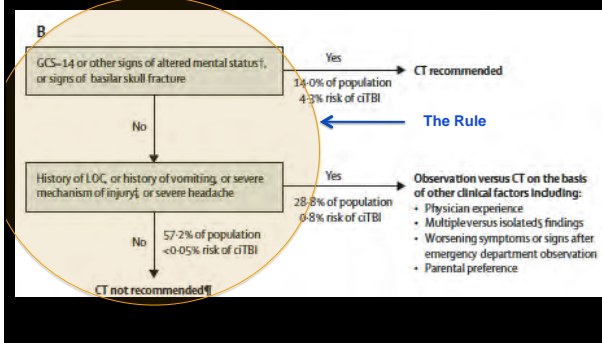
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## Recommendations for children 2 years and older




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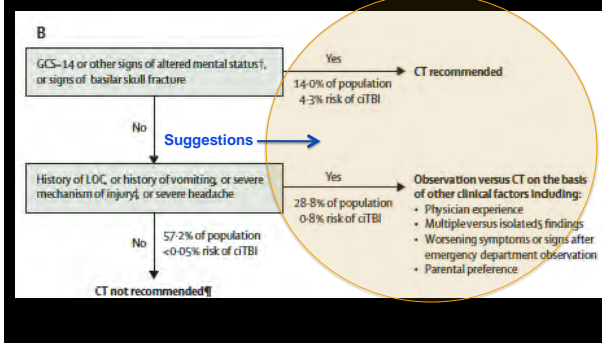
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## Recommendations for children 2 years and older




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## What to do with Negative CT Scans

PEDIATRICS/ORIGINAL RESEARCH

### Do Children With Blunt Head Trauma and Normal Cranial Computed Tomography Scan Results Require Hospitalization for Neurologic Observation?

James F. Holmes, MD, MPH, Dominic A. Borgiatti, DO, MPH, Frances M. Nadel, MD, MSCE, Kimberly S. Quaike, MD, Neil Schambam, MD, Ari Cooper, MD, Jeff E. Schunk, MD, Michelle L. Miskin, MS, Shireen M. Atabaki, MD, MPH, John D. Hoyte, MD, Peter S. Dayan, MD, MSc, Nathan Kuppermann, MD, MPH, and the TBI Study Group for the Pediatric Emergency Care Applied Research Network\*

From the Department of Emergency Medicine, University of California, Davis School of Medicine, Sacramento, CA (Holmes); the Department of Emergency Medicine, University of Michigan School of Medicine and Hurley Medical Center, Flint, MI (Borgiatti); the Department of Pediatrics, University of Pennsylvania School of Medicine, Philadelphia, PA (Nadel); the Department of Pediatrics, Washington University School of Medicine, St. Louis, MO (Quaike); the Departments of Emergency Medicine and Pediatrics, New York Beth Israel Medical Center, Newark, NJ (Schambam); the Department of Surgery, Columbia University Medical Center at Harlem Hospital, New York, NY (Cooper); the Department of Pediatrics, University of Utah, Salt Lake City, UT (Schunk); and PECARN Central Data Management and Coordinating Center, University of Utah, Salt Lake City, UT (Miskin); the Departments of Pediatrics and Emergency Medicine, The George Washington University School of Medicine, Washington, DC (Atabaki); the Department of Emergency Medicine, Michigan State University School of Medicine/Helen DeVos Children's Hospital, Grand Rapids, MI (Hoyte); the Department of Pediatrics, Columbia University College of Physicians and Surgeons, New York, NY (Dayan); and the Departments of Emergency Medicine and Pediatrics, University of California, Davis School of Medicine, Sacramento, CA (Kuppermann).

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## Observation Before CT Decisions

### The Effect of Observation on Cranial Computed Tomography Utilization for Children After Blunt Head Trauma

**ABSTRACT:** Lisa J. Nagwal, MD, MPH, MPH, JPHL, ScM, MD, MEd, Allison G. Campbell, MEd, PhD, Arthur Cooper, MD, MEd, Michelle Minkov, MD, Steven M. Kravitz, MD, MPH, James Nagwal, MD, FRCPC, David, MD, MSc, James J. Minnema, MD, MPH, Nathan Apperlyman, MD, MPH, and the Traumatic Brain Injury Group for the Pediatric Emergency Care Applied Research Network

**OBJECTIVE:** Emergency department observation of children with minor blunt head trauma for symptom progression before making a decision regarding computed tomography may decrease computed tomography use. The actual impact of this strategy on computed tomography use and clinical outcomes, however, is unknown.

**WHAT'S KNOWN ON THIS SUBJECT:** Emergency department observation of children with minor blunt head trauma for symptom progression before making a decision regarding computed tomography may decrease computed tomography use. The actual impact of this strategy on computed tomography use and clinical outcomes, however, is unknown.

**WHAT THIS STUDY ADDS:** Clinicians currently observe some children with head trauma before deciding whether to obtain a cranial computed tomography scan. Patients who were observed had a significantly lower rate of overall cranial computed tomography use after adjusting for markers of head injury severity.

**OBJECTIVE:** Children with minor blunt head trauma often are observed in the emergency department before a decision is made regarding computed tomography use. We studied the impact of this clinical strategy on computed tomography use and outcomes.

KEY WORDS

## Isolated Clinical Findings outcomes

<p><b>MINI REVIEW</b></p> <p><b>Prevalence of Clinically Important Traumatic Brain Injuries in Children With Minor Blunt Head Trauma and Isolated Severe Injury Mechanisms</b></p> <p>Lisa J. Nagwal, MD, MPH, MPH, JPHL, ScM, MD, MEd, Allison G. Campbell, MEd, PhD, Arthur Cooper, MD, MEd, Michelle Minkov, MD, Steven M. Kravitz, MD, MPH, James Nagwal, MD, FRCPC, David, MD, MSc, James J. Minnema, MD, MPH, Nathan Apperlyman, MD, MPH, and the Traumatic Brain Injury Group for the Pediatric Emergency Care Applied Research Network (PEDIARN)</p>	<p><b>PEDIATRIC MEDICAL RESEARCH</b></p> <p><b>Risk of Traumatic Brain Injuries in Children Younger than 24 Months With Isolated Scalp Hematomas</b></p> <p>Heidi S. Dizon, MD, MPH, Rachel F. Coombs, MD, MPH, Sara Kucharski, MD, MPH, Steven M. Kravitz, MD, MPH, Michelle Minkov, MD, David Warner, MD, Nathan Apperlyman, MD, MPH, and the Traumatic Brain Injury Group for the Pediatric Emergency Care Applied Research Network (PEDIARN)</p>
<p><b>PEDIATRIC MEDICAL RESEARCH</b></p> <p><b>Association of Traumatic Brain Injuries With Vomiting in Children With Blunt Head Trauma</b></p> <p>Heidi S. Dizon, MD, MPH, Rachel F. Coombs, MD, MPH, Sara Kucharski, MD, MPH, Steven M. Kravitz, MD, MPH, Michelle Minkov, MD, David Warner, MD, Nathan Apperlyman, MD, MPH, and the Traumatic Brain Injury Group for the Pediatric Emergency Care Applied Research Network (PEDIARN)</p>	<p><b>Original Investigation</b></p> <p><b>Isolated Loss of Consciousness in Children With Minor Blunt Head Trauma</b></p> <p>Lisa J. Nagwal, MD, MPH, MPH, JPHL, ScM, MD, MEd, Allison G. Campbell, MEd, PhD, Arthur Cooper, MD, MEd, Michelle Minkov, MD, Steven M. Kravitz, MD, MPH, James Nagwal, MD, FRCPC, David, MD, MSc, James J. Minnema, MD, MPH, Nathan Apperlyman, MD, MPH, and the Traumatic Brain Injury Group for the Pediatric Emergency Care Applied Research Network (PEDIARN)</p>
<p><b>Headache in Traumatic Brain Injuries From Blunt Head Trauma</b></p> <p>Heidi S. Dizon, MD, MPH, Rachel F. Coombs, MD, MPH, Sara Kucharski, MD, MPH, Steven M. Kravitz, MD, MPH, Michelle Minkov, MD, David Warner, MD, Nathan Apperlyman, MD, MPH, and the Traumatic Brain Injury Group for the Pediatric Emergency Care Applied Research Network (PEDIARN)</p>	<p><b>Original Investigation</b></p> <p><b>Association of a Guardian's Report of a Child Acting Abnormally With Traumatic Brain Injury After Minor Blunt Head Trauma</b></p> <p>David M. Bellone, MD, MEd, James J. Minnema, MD, MPH, James J. Nagwal, MD, MPH, David Warner, MD, MPH, Nathan Apperlyman, MD, MPH</p>

How to get clinicians to use the prediction rules?



## Knowledge Translation

“Knowledge translation (KT) is the effective and timely incorporation of evidence-based information into the practices of health professionals in such a way as to effect optimal health care outcomes and maximize the potential of the health system.”

(Modified from the Canadian Institutes for Health Research definition)

Need definitive, validated evidence that is ripe for translation  
 - Not all data should be translated

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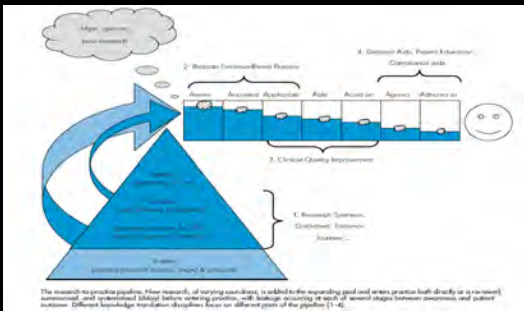
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## Knowledge Translation Pipeline



Glasziou and Haynes, 2005

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The image shows two flowcharts from the 'Choosing Wisely' initiative for Pediatric Head Trauma CT Decision Guides. The top flowchart is for 'Children 2 years and older' and the bottom for 'Children younger than 2 years'. Both guides start with a 'YES TO MRI' path if there are signs of basilar skull fracture, hemiparesis, or anisocoria. If 'NO', they lead to 'CT not indicated, Observe' with a 'Low Risk - <math>\le 0.25\%</math>' outcome. The 'NO' path also includes criteria like 'No LOC > 5 seconds', 'No severe mechanism of injury', and 'No anisocoria, hemiparesis, or anisocoria'. The 'YES TO MRI' path includes criteria like 'No LOC > 5 seconds', 'No severe mechanism of injury', and 'No anisocoria, hemiparesis, or anisocoria'. The 'YES TO MRI' path also includes criteria like 'No LOC > 5 seconds', 'No severe mechanism of injury', and 'No anisocoria, hemiparesis, or anisocoria'. The 'YES TO MRI' path also includes criteria like 'No LOC > 5 seconds', 'No severe mechanism of injury', and 'No anisocoria, hemiparesis, or anisocoria'.

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## Translating Research into Practice

### *What works*

*Clinical decision support more successful when:*

- ◆ Automatic provision of support in workflow
- ◆ Recommendations given rather than risks
- ◆ Support given at the time and location of decision-making
- ◆ Support is computer based

Kawamoto, BMJ, 2005

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## Challenges to Knowledge Translation using Computerized Algorithms

### *The human brain*

Shankar Vedantam (author of *"The Hidden Brain"* and NPR social science correspondent) and Berkeley Dietvorst (Wharton doctoral student)

- Even though algorithms typically outperform humans, we are distrustful of algorithms
- People fail to use algorithms even when they see it outperform humans
- Humans fear machines ("algorithmic aversion")

NPR Radio, February 3, 2015

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## Translating Research into Practice

### *What PECARN is doing...*

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**Implementation of the PECARN Traumatic  
Brain Injury Prediction  
Rules Using Electronic Health Record-Based  
Clinical Decision Support:  
*An Interrupted Time Series Trial***

Funded by the American Recovery and Reinvestment  
Act – Office of the Secretary: Grant #S02MC19289-01-00



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**Specific Aims**

1. To develop and pilot test a computer-based data collection and recommendation system to implement the PECARN TBI prediction rules.
2. To assess whether this system decreases the number of (unnecessary) head CTs in the ED in children at very low risk of important brain injuries.

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**Methods**

**Computer-Based Decision Support  
Development and Pilot**

- ◆ Perform focus groups
- ◆ Perform ED work flow assessments
- ◆ Develop EHR blunt head injury template
- ◆ Develop CDS
- ◆ Pilot testing

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# Blunt Head Trauma Assessment

**Blunt Head Trauma Assessment (skip any question if unable to determine answer)**

Blunt head trauma? Yes - less than 24 hours ago Yes - more than 24 hours ago

Loss of consciousness? Yes - less than 5 seconds Yes - 5 seconds up to one minute Yes - 1 minute or longer

Heading once injury? No Yes

Acting normally per caregiver? Yes No

Event mechanism of injury? No Mild Moderate

Current headache? No Mild Moderate

Other signs of altered mental status? No Yes

Temporal, parietal, or occipital scalp hematomas? No Yes

**Other signs of altered mental status?**

Row Information:  
Other signs of altered mental status defined as any of the following:

- Agitation
- Sonolence
- Repetitive questioning
- Slow response to verbal communication

Temporal, parietal, or

GCS

Eye Opening 4/3/2/1

Verbal Response 5/4/3/2/1

Motor Response 6/5/4/3/2/1

Total GCS

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# Case

- ◆ 8 month-old falls 2 feet from a carrier
- ◆ No LOC, one episode of emesis
- ◆ On exam, acting normally
- ◆ Small forehead hematoma, tender at site

What are you going to do?

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Traumatic Brain Injury Risk: Child less than 2 years

**RECOMMENDATION:** A head CT is not recommended for this patient based on the absence of any of the PECARN prediction rule variables.

**Risk Estimate:** The risk of clinically important traumatic brain injury for patients less than 2 years is < 1/5000

Importantly, the PECARN rules were based on attending initial evaluations (not based on subsequent evaluations over time).

The age-specific PECARN rule findings documented are:

Loss of consciousness?	No
Acting normally per caregiver?	Yes
Mechanism of injury?	Mild
Total Glasgow Coma Scale score:	15
Other signs of altered mental status?	No
Scalp hematomas?	None
Palpable skull fracture or swelling on the basis of swelling or distortion of the scalp?	No

If the above clinical findings are incorrect, please revise.

Note: The PECARN prediction rules do not apply to patients with bleeding diatheses, vascular (e.g., "SP") abnormalities, known brain tumors, or pre-existing neurological disorders complicating your clinical assessment.

Click here to view the PECARN prediction rule message (Lemuel)

\*Click to provide a revised risk assessment

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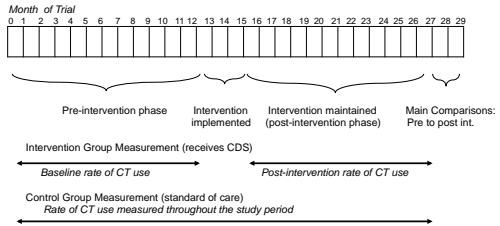
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**Methods – design**

**Interrupted Time Series Trial with  
Concurrent Controls**



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***What about sharing decision-making  
with patients/parents/guardians when the  
decision is not clear?***

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**The Head CT Choice Trial**

**Funded by a grant from the Patient Centered  
Outcomes Research Initiative (PCORI)**



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## Overview

- ◆ What is shared decision making?
- ◆ Why shared decision making?
- ◆ Why in pediatric minor head trauma?

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## What is Shared Decision Making?

- ◆ **Educating** patients (parents) such that they are **empowered** to apply their values and preferences to management decisions
- ◆ **Inviting** patients (parents) to participate in decision making *to the extent that they desire*
- ◆ Coming to a consensus on the best management approach, such that **risk-informed parental preferences** are taken into consideration

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## What Shared Decision Making is Not

- ◆ Handing over the decision to the patient (parent) regardless of your professional opinion
- ◆ Primarily an effort to manage legal risk: it's not about the clinician, it's about the patient

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## Why Do Shared Decision Making?

- ◆ Respect for autonomy
- ◆ Opportunity to rapidly develop rapport, educate and meaningfully connect

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Paternalistic



Shared Decision Making



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## Why Pediatric Head Trauma?

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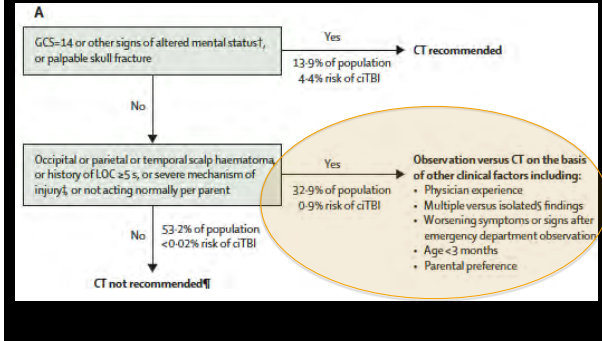
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## Recommendations for children younger than 2




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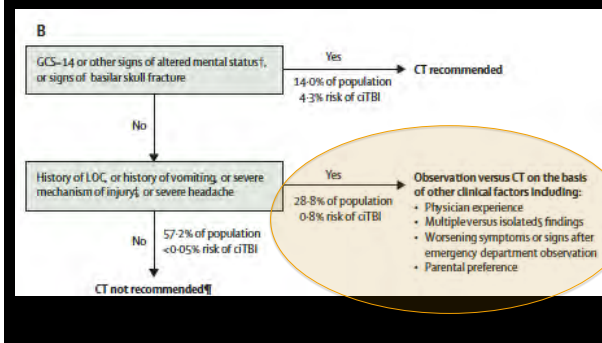
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## Recommendations for children 2 years and older




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Let's talk about concussion and your child's risk for more serious injury such as bleeding in or around the brain.

**Concussion**

Brain movement within the skull

- Symptoms may include headache, nausea, dizziness, or difficulty concentrating
- Symptoms should resolve in several days to a few months
- Recovery is almost always complete
- Cannot be seen on a CT scan

**Brain Injury**

Bleed

In 100 children with minor head injury similar to your child:  
1 will have brain injury and @ will die

- Occurs when the head injury is severe enough to cause bleeding in or around the brain
- May require medical intervention such as a stay in the hospital or surgical procedure

Reprinted with permission from the American Academy of Pediatrics

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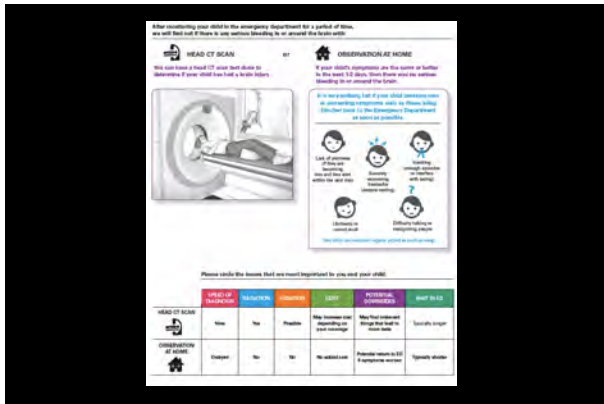
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## Head CT Choice Trial

- ◆ Hypothesis: Use of Head CT Choice will
  - Significantly increase parents' knowledge, engagement, and satisfaction
  - Safely decrease the rate of CT and 7-day healthcare utilization

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## Conclusion

- ◆ Limiting inappropriate imaging a priority in EM
- ◆ Requires generating/validating definitive evidence
- ◆ Requires dissemination and implementation at the point of patient care, with minimal interruption
- ◆ Shared decision-making appropriate when the decision is not clear

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