

BRAIN INJURY IN EARLY CHILDHOOD: Clinical Assessment and Outcomes




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Objectives

1. Compare and contrast the clinical presentations of varied etiologies of brain injury in early childhood.
2. Review the known injury predictors that contribute to functional outcomes.
3. Describe how the developmental trajectory of skills is impacted by brain injury sustained in early childhood.



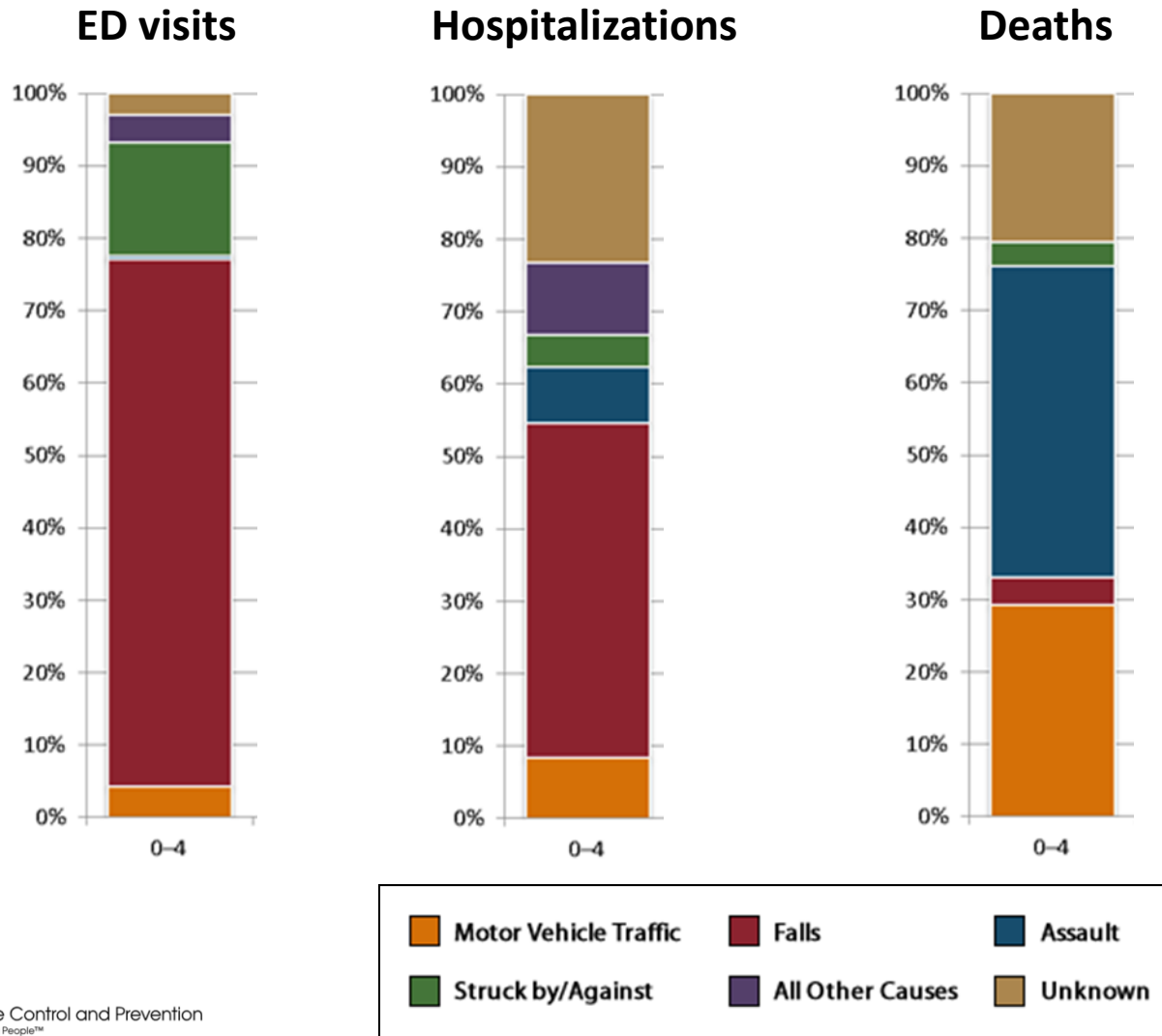


Pediatric Traumatic Brain Injuries

- Leading cause of death and disability in children and adolescents (0-19 years)
 - bimodal peaks: 0-4 years and 15-19 years
- >700,000 children affected annually
 - ~90% TBI events in preschool children classified as mild
 - 62,000 children hospitalized annually with moderate to severe TBIs
 - Estimated 145,000 children living with long-lasting, disabling effects following TBI
- Classifying TBIs



Percent Distributions of TBI-related _____ by Age Group and Injury Mechanism — United States, 2006–2010



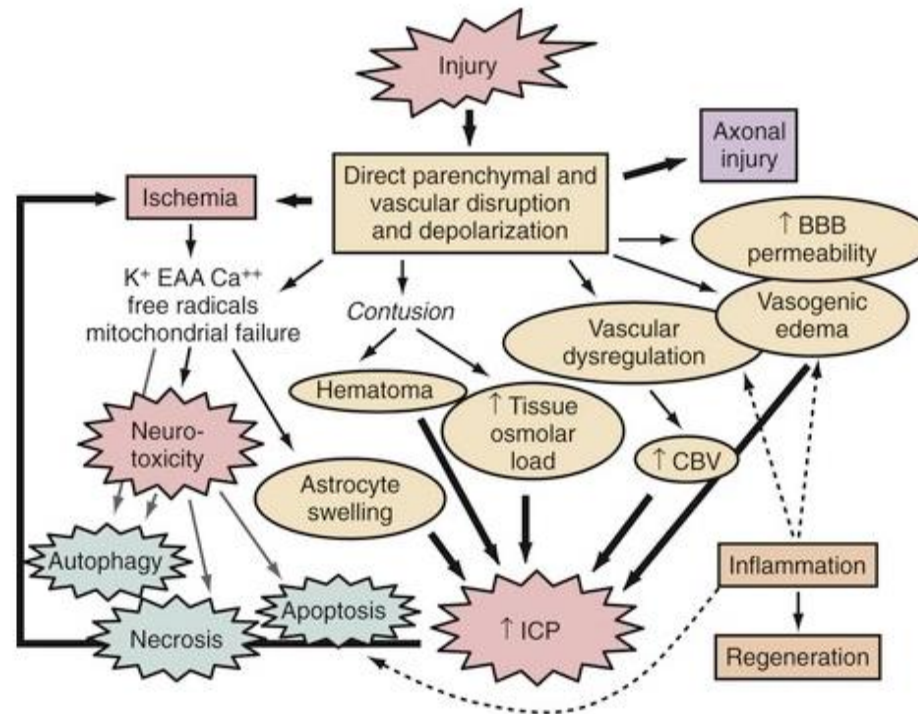


Colorado Data

- CDPHE 2007-2009
 - 307 TBI-related deaths
 - 2,392 children and youth discharged from hospital annually w/ dx of TBI
 - 2x more common in males (ages 0-20)
 - Leading causes of NON-FATAL TBI's:
 - Motor vehicle events
 - Falls
 - *Abuse*



Brain Injury



Symptom progression depends on degree of primary and secondary injury

Figure 29-1 Categories of biochemical, cellular, and molecular mechanisms proposed to be involved in the evolution of secondary damage after ischemic or traumatic brain injury. Three major categories for these secondary mechanisms include (1) ischemia, excitotoxicity, energy failure, and cell death cascades; (2) cerebral swelling; and (3) axonal injury. A fourth category, inflammation and regeneration, influences each of these cascades.

... a complicated process



Primary Injury

- tissue injury as direct consequence of forces directed on the tissue
- Extra-axial:
 - Epidural hemorrhage
 - Subdural hemorrhage
 - Subarachnoid hemorrhage
- Intra-cerebral:
 - Contusion (+/- hemorrhage)
 - Intraventricular hemorrhage
 - Hypoxic-ischemic injury
 - Diffuse axonal injury
- **Widespread injury -> immediate loss of consciousness**



Secondary Injury

- tissue becomes damaged as consequence of primary injury
- Mechanisms:
 - Excitotoxicity
 - Ischemia
 - Inflammation
 - Oxidative stress/free radical damage
 - Apoptosis/cell death





Mechanism: The History

- Does the history explain/correlate with the injury?
 - Severity of injury
 - Location of injury
 - Age of injury
 - Pattern of injury
 - Developmental stage of the child





Abusive Head Trauma (AHT)

- incidence: 16.1-33.8 cases/100,000 infants per year
- leading cause of death resulting from abuse in children < 2 years of age
 - Most are < 1 year (peak 6-8 months)
 - Estimated 80% of deaths from abuse in this age group are the result of head injuries
- up to 70% have been previously injured
- varying neurologic outcomes:
 - 1/3 die
 - 1/3 immediate neurological impairments
 - 1/3 appear “fine” at discharge



POLICY STATEMENT

Abusive Head Trauma in Infants and Children

Organizational Principles to Guide and
Define the Child Health Care System and/or
Improve the Health of All Children

Cindy W. Christian, MD, Robert Block, MD, and the Committee on Child Abuse and Neglect

ABSTRACT

Shaken baby syndrome is a term often used by physicians and the public to describe abusive head trauma inflicted on infants and young children. Although the term is well known and has been used for a number of decades, advances in the understanding of the mechanisms and clinical spectrum of injury associated with abusive head trauma compel us to modify our terminology to keep pace with our understanding of pathologic mechanisms. Although shaking an infant has the potential to cause neurologic injury, blunt impact or a combination of shaking and blunt impact cause injury as well. Spinal cord injury and secondary hypoxic ischemic injury can contribute to poor outcomes of victims. The use of broad medical terminology that is inclusive of all mechanisms of injury, including shaking, is required. The American Academy of Pediatrics recommends that pediatricians develop skills in the recognition of signs and symptoms of abusive head injury, including those caused by both shaking and blunt impact, consult with ~~pediatric subspecialists~~ when necessary, and embrace a less mechanistic term, abusive head trauma when describing an inflicted injury to the head and its contents.



Accidental Trauma (AT) vs. Non-Accidental Trauma (NAT)

- Most common findings in serious infant head injuries:
 - Skull fracture
 - Intracranial bleeding
 - Traumatic axonal injury





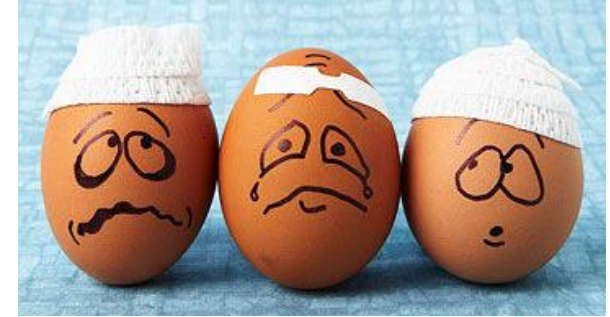
AT vs. NAT

	AT	NAT
Age at injury	Typically older	Younger
Brain injury		SDH, SAH, and RH more common
History of injury	Clear trauma hx – MVC or high fall	Often NO hx provided
Morbidity/Mortality		Higher mortality rates + Worse long-term neurological outcome
Other findings		Associated injuries + Seizures



Associated injuries with AHT

- Retinal hemorrhages
- Metaphyseal fractures
- Rib fractures
- Bruising/cutaneous injuries



... However, there are often NO external signs of trauma





Clinical Presentations



- Sudden onset
- Specific/obvious signs and sxs
- Delayed presentation
- Non-specific/subtle signs and sxs



Clinical Presentations

- Where do these children present?
- How do they present?
 - Sleepy
 - Vomiting
 - Irritable/fussy
 - Difficulty feeding
 - Seizures
 - “not acting right”
 - Breathing abnormality
 - Altered level of consciousness
 - Visual impairments
 - Death





Challenges

- Frequently nonspecific symptoms
- Often delayed presentation
- Absent, inaccurate, or minimized history
- Diagnosis may be missed

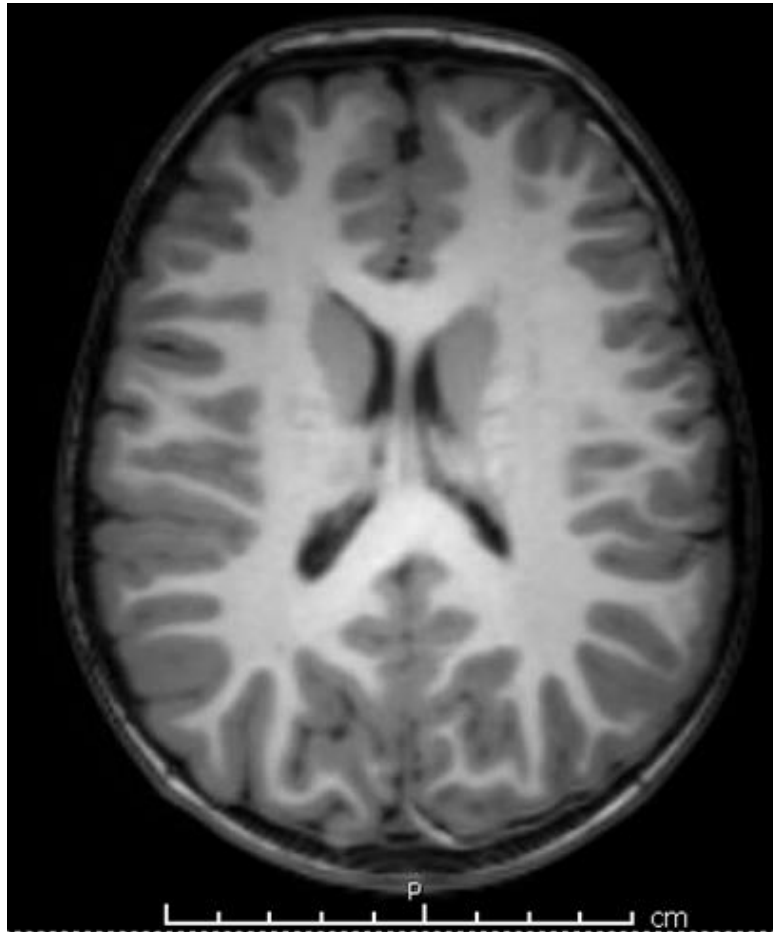


Predictors of Outcome

- Age at time of injury
- Inflicted injuries usually predict a worse outcome than accidental injuries
 - Unclear mechanism/history
 - Delay in seeking care
 - Possible prior injury
 - Psychosocial factors
- Focal vs. diffuse injury



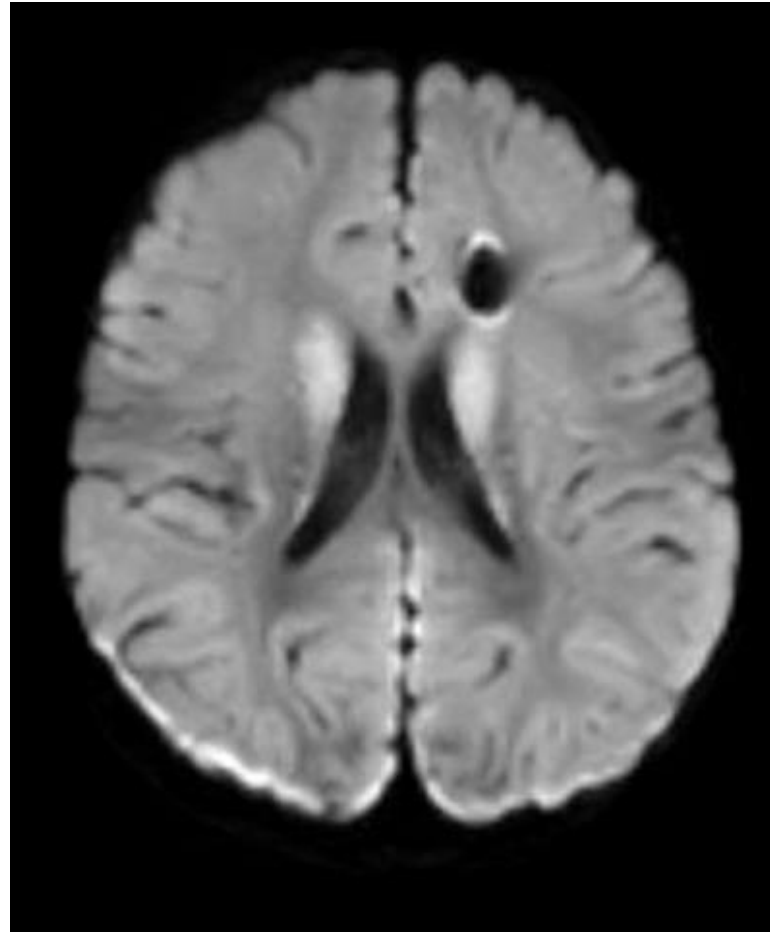
Radiographic Findings



Focal Injury



Radiographic Findings (continued) ...



Diffuse Injury





Outcomes

- Impacts:
 - Medical health of the child
 - Development of the child
- Plasticity and early brain development
 - Contradictory theories
- Long-term sequelae ...



OUTLINE

- A FRAMEWORK FOR UNDERSTANDING RISK FACTORS IN EARLY TBI
- DEVELOPMENTAL OUTCOMES
- MITIGATING RISK



A FRAMEWORK FOR UNDERSTANDING RISK FACTORS IN EARLY TBI

CONSIDER:

- AGE AT THE TIME OF INJURY
- DEVELOPMENTAL TRAJECTORY OF SPECIFIC SKILL AT THE TIME OF INJURY



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AGE AT TIME OF INJURY

BECAUSE BRAIN INJURY IMPACTS THE ACQUISITION OF NEW SKILLS, THE EARLIER THAT A DIFFUSE BRAIN INJURY IS SUSTAINED, THE GREATER THE IMPACT ON LATER DEVELOPMENT.



DOUBLE HAZARD MODEL

Children who sustain **early** and **severe** injuries have the worst outcomes.

Anderson et al., 2008



OUTCOMES

“Developmental frameworks of this nature imply that outcomes after brain injury ought to be sensitive to the repertoire of skills that the child has acquired, is currently acquiring and has yet to acquire at the time of injury, as well as the effect that particular brain injuries have on those developed and developing skills.”

Ewing-Cobbs & Barnes, 2002



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DEVELOPMENTAL OUTCOMES

CONSIDER:

- DEVELOPING VERSUS ESTABLISHED SKILLS
- SKILLS THAT HAVE YET TO DEVELOP OR ARE IN THE MOST RAPID STAGE OF DEVELOPMENT AT THE TIME OF INJURY MAY BE MOST VULNERABLE
- SKILLS THAT ARE WELL-CONSOLIDATED AT THE TIME OF INJURY MAY BE LESS VULNERABLE TO DISRUPTION FROM BRAIN INJURY

Ewing-Cobbs & Barnes, 2002;
Ewing-Cobbs, Fletcher & Landry,
1985; Rutter, 1982



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TRAJECTORY OF SKILL DEVELOPMENT



- EMERGING-not yet functional
- DEVELOPING-partially acquired, but incompletely functional
- ESTABLISHED-fully acquired



Dennis, 1998

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RECOVERY OR ACQUISTION?

FOR YOUNG CHILDREN, FOCUS MAY BE ON ACQUISTION OF A PARTICULAR SKILL AND NOT NECESSARILY ON RECOVERY OF FUNCTION.

SO, ASK HOW A SKILL DEVELOPS RATHER THAN HOW A SKILL RECOVERS.



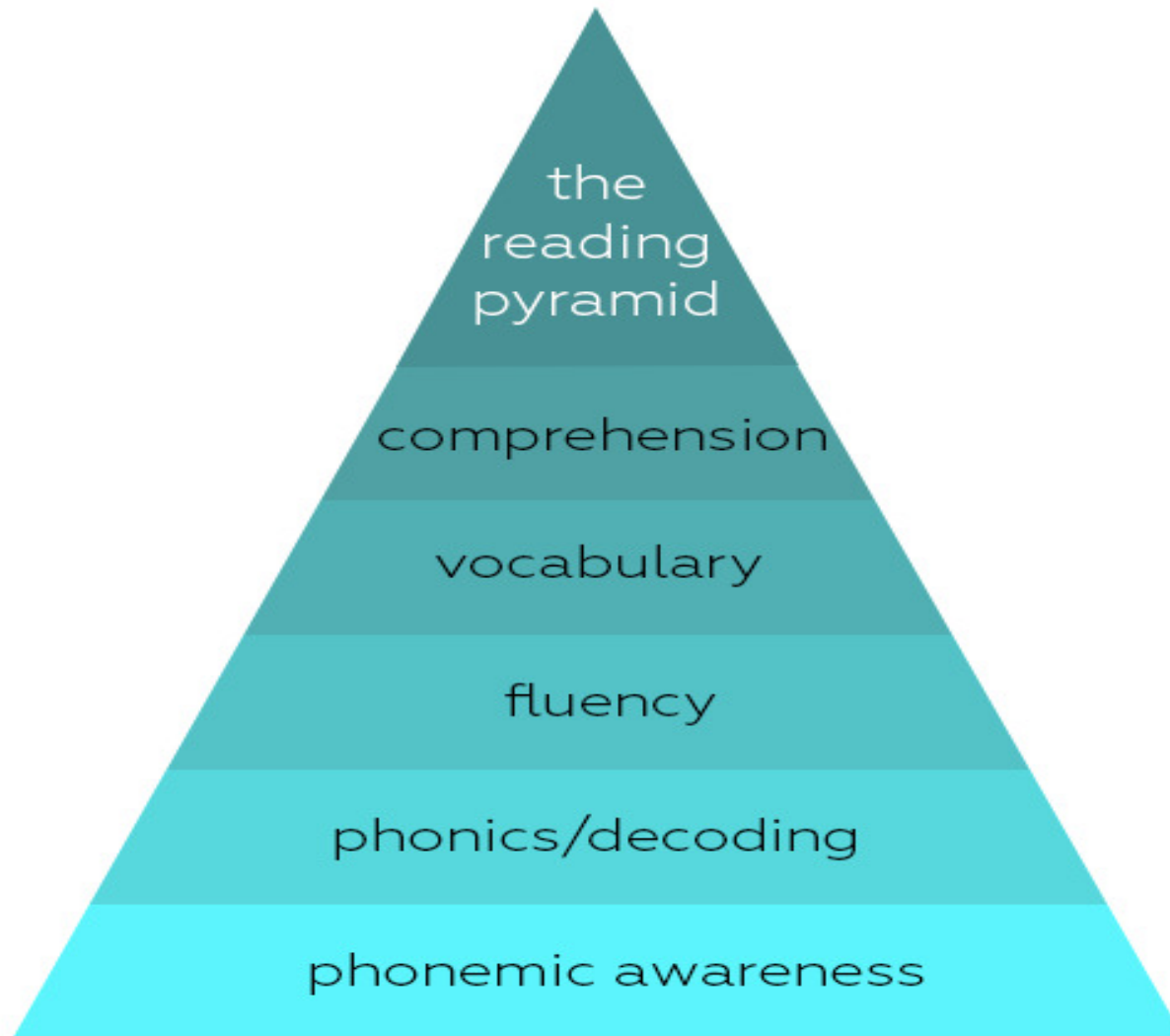


EVALUATION OF SKILLS

- TYPICAL AGE OF SKILL ACQUISITION
- ORDER OF ACQUISITION RELATIVE TO OTHER SKILLS
- RATE OF SKILL ACQUISITION
- STRATEGY FOR IMPLEMENTING A SKILL
- DEGREE OF MASTERY OR FINAL LEVEL OF COMPETENCE
- MAINTENANCE OF SPECIFIC SKILLS AT VARIOUS STAGES



DEVELOPMENT OF READING





READING OUTCOMES

PRESCHOOL: vocabulary, phonological awareness, phonological memory, rapid naming

EARLY SCHOOL: decoding

LATER SCHOOL: reading fluency and other language skills (vocabulary and inferential processing)



READING OUTCOMES

Barnes et al. (1999) looked at decoding skills and grouped children into three categories:

- before formal reading instruction (age 6)
- rapid phase of learning to read (early primary)
- after decoding skills were established (later school-age)



READING OUTCOMES

- **EMERGING:** before formal reading instruction
- **DEVELOPING:** rapid phase of learning to read
- **ESTABLISHED:** after decoding skills were established





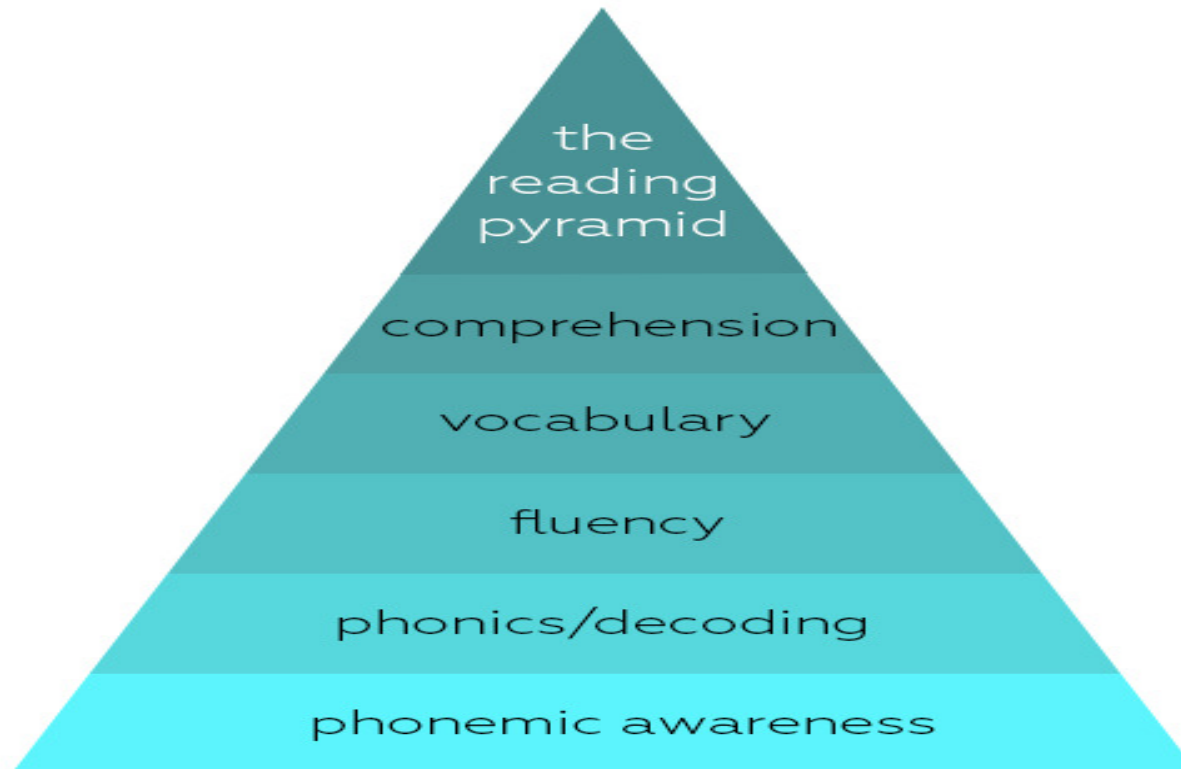
READING OUTCOMES

- Poorest outcomes for decoding were for children in the emerging group.
- Next poorest outcome was for children in the developing group.
- Children in the established group did not show word decoding problems. Reading comprehension problems were seen in this group as they were likely “emerging” and “developing” in this domain.
- Reading speed was impacted in all children even when word decoding skills were comparable to controls.



READING INTERVENTION

- SHOULD MONITOR PHONOLOGICAL AWARENESS, DECODING AND OTHER FOUNDATIONAL READING SKILLS
- LATER, MONITOR READING COMPREHENSION, VOCABULARY, AND FLUENCY





DEVELOPMENTAL OUTCOMES

IN GENERAL, YOUNG CHILDREN SHOW LOWER INITIAL COGNITIVE SCORES WITH LESS RECOVERY OVER TIME THAN OLDER CHILDREN AND ADULTS.

COGNITIVE SCORES CAN DECLINE OVER TIME WHEN A CHILD FAILS TO MEET NEW LEARNING/DEVELOPMENTAL EXPECTATIONS.





DEVELOPMENTAL OUTCOMES

SOME SKILLS SHOW A STABLE DEFICIT OVER TIME.

SOME SKILLS SHOW A TRANSIENT LAG AND THEN PARTIAL CATCH-UP.

EARLY TBI CAN DAMAGE AREAS THAT ARE REQUIRED FOR ACQUISITION OF MORE COMPLEX SKILLS AND SO SOME SKILLS CAN FALL FURTHER BEHIND AS CHILDREN GET OLDER.





OUTCOMES IN EARLY TBI

- OVERALL REDUCTIONS IN IQ SCORES IN CHILDREN.
- NO SIGNIFICANT INCREASE OR DECREASE IN IQ SCORES OVER TIME (PERSISTENT DEFICIT).
- LOWER ACADEMIC SCORES ACROSS DOMAINS, INCLUDING BASIC SKILLS OF WORD DECODING, SPELLING, AND MATH CALCULATION.
- MUCH HIGHER RATES OF GRADE RETENTION OR SPECIAL EDUCATION SUPPORT (48% IN EWING-COBBS ET AL. 2006).
- HIGHER RATES OF ADHD, ANXIETY AND DEPRESSION.
- THE NUMBER OF INTRACRANIAL AND EXTRAAXIAL LESIONS WAS SIGNIFICANTLY RELATED TO COGNITIVE AND ACADEMIC OUTCOMES.





INITIAL OUTCOME SCORES: 12 MONTH FOLLOW-UP

MEAN=100; STANDARD DEVIATION=15

Bayley Subtest	N	Mean	SD	Range of Scores
Cognitive	20	89	16.7	60-110
Adaptive	18	79.2	19.8	43-111
Social-Emotional	20	88	15.5	70-110
Gross Motor	22	87	16.7	55-120
Fine Motor	23	93.7	17.9	60-120
Expressive Language	20	92.5	18.1	60-115
Receptive Language	20	87.5	16.3	55-110

*1 child not testable due to level of impairment





AND THE GOOD NEWS.....

THERE ARE FACTORS THAT HELP IMPROVE
OUTCOMES:

“Everyday functioning” was moderated by
responsive, nonpunitive parenting that was
neither overly strict or permissive

Families with good coping abilities and resources,
including educational resources, learning support
and stimulation.

Wade, Zhang, Yeates, Stancin, and Taylor, 2016



MITIGATING RISK

Support from friends or a spouse

Good parental communication

Good pre-injury parental psychiatric functioning





SOCIAL-EMOTIONAL CAREGIVER REPORT

6 MONTH FOLLOW-UP:

MEAN=100; STANDARD DEVIATION=15

	KINSHIP	NON-KINSHIP
N	23	10
MEAN	104.8	80
SD	21.8	14.3





MITIGATING RISK

EARLY INTERVENTION FOR DEVELOPMENTAL PROBLEMS

- Access to early intervention services
- Children in more urban communities with more access to services often have better outcomes





CHCO Non-Accidental Brain Injury Care Clinic

- Providers were seeing school-age children in other clinics with cognitive and behavioral challenges related to early TBI from child abuse
- Lost to community and school-based follow-up services
- Combine awareness, education, research with clinical care
- Provide all children identified with non-accidental brain injury at CHCO access to expert medical, cognitive, and psychosocial follow-up services to attenuate the developmental fallout of their early TBI
- Follow all children with a MDT of Rehab Medicine, Neuropsychology, Child Protection Team (CPT), social work, therapies and other needed specialties
- Design a clinical care pathway and study the outcomes
- Provide family centered care in accordance with our hospital core values





NABICC: Non-Accidental Brain Injury Care Clinic

- Multidisciplinary specialty clinic
 - Case management
 - Rehab medicine
 - Neuropsychology
 - Child protection team
 - Social work
 - PT/OT
 - Speech and language pathology
 - Neurosurgery
 - Neurology
 - Ophthalmology
 - Nutrition





NABICC Stats:

- 30-40 patients referred/year
- Average age: 8 mos (range 2-36 mos)
- Demographics:
 - 50% Caucasian
 - 25% Hispanic
 - 20% African American
 - 5% other race/ethnicity
- 75-80% were admitted to PICU
- Typically seen 1, 3, 6, 12, 18, 24 mos post-injury
- 75-80% retention at 18 mos post-injury





FUTURE DIRECTIONS

Working on a proposal to study outcomes in children from NABICC with children with similar injuries who did not receive this intensive follow-up care.

Working on a proposal to develop a Parent-Child Interaction Therapy intervention specifically for non-accidental brain injury patients.

General TBI multi-disciplinary team in process.



questions

