ALL-DAY CONFERENCE

# CHILD ABUSE EVIDENCE:

## Perspectives from Law, Medicine, Psychology + Statistics

**Friday, November 6 from 8:30 a.m. to 4:30 p.m.**

**University of Michigan Law School Honigman Auditorium, 100 Hutchins Hall**

# A Probabilistic Analysis of Short Fall Arguments in Legal Cases of Abusive Head Trauma

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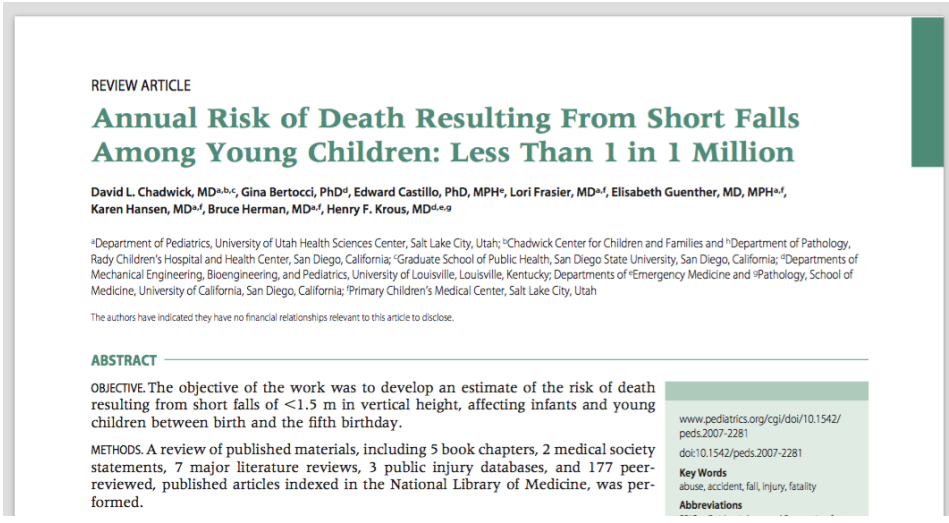
November 6, 2015


When a defendant claims an accidental short fall caused the damage, Chadwick's 2008 paper is often cited.



REVIEW ARTICLE

# Annual Risk of Death Resulting From Short Falls Among Young Children: Less Than 1 in 1 Million

**David L. Chadwick, MD[a,b,c], Gina Bertocci, PhD[d], Edward Castillo, PhD, MPH[e], Lori Frasier, MD[a,f], Elisabeth Guenther, MD, MPH[a,f], Karen Hansen, MD[a,f], Bruce Herman, MD[a,f], Henry F. Krous, MD[d,e,g]**

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The authors have indicated they have no financial relationships relevant to this article to disclose.

## ABSTRACT

OBJECTIVE. The objective of the work was to develop an estimate of the risk of death resulting from short falls of <1.5 m in vertical height, affecting infants and young children between birth and the fifth birthday.

METHODS. A review of published materials, including 5 book chapters, 2 medical society statements, 7 major literature reviews, 3 public injury databases, and 177 peer-reviewed, published articles indexed in the National Library of Medicine, was performed.

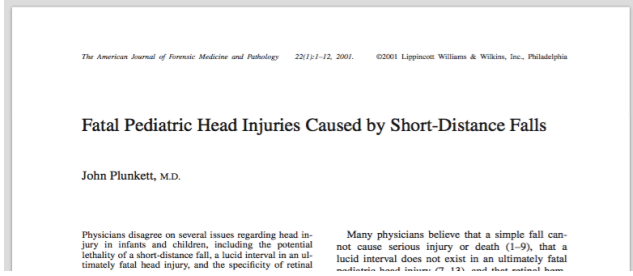
www.pediatrics.org/cgi/doi/10.1542/peds.2007-2281

doi:10.1542/peds.2007-2281

**Key Words**
abuse, accident, fall, injury, fatality

**Abbreviations**

Plunkett 2001 and Moran 2012 also study short fall deaths, but they do not provide other values for the risk of death due to short falls in children.



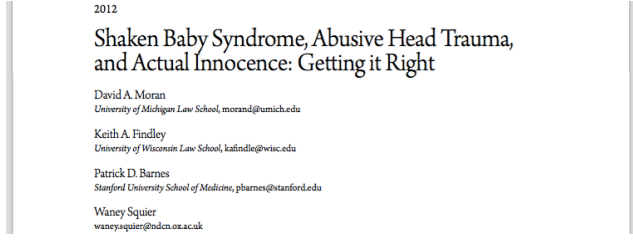
*The American Journal of Forensic Medicine and Pathology* 22(1):1–12, 2001. 

## Fatal Pediatric Head Injuries Caused by Short-Distance Falls

John Plunkett, M.D.

Physicians disagree on several issues regarding head injury in infants and children, including the potential lethality of a short-distance fall, a lucid interval in an ultimately fatal head injury, and the specificity of retinal

Many physicians believe that a simple fall cannot cause serious injury or death (1–9), that a lucid interval does not exist in an ultimately fatal



2012

## Shaken Baby Syndrome, Abusive Head Trauma, and Actual Innocence: Getting it Right

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# Chadwick et al. report the estimate of short fall deaths in California (1999–2003) by using the EPIC database.

**Explicit claim**: Chadwick's argument using EPIC data from 1999–2003:

$$\frac{\text{Number of infants who have died from a short fall in CA}}{\text{Number of all infants in CA}}$$

$$= P(\text{ Death and short fall } | \text{ Individuals is an infant in CA})$$

$$= 0.48 \text{ in a million}$$

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**Implicit claim**: The following is implicitly argued in court:

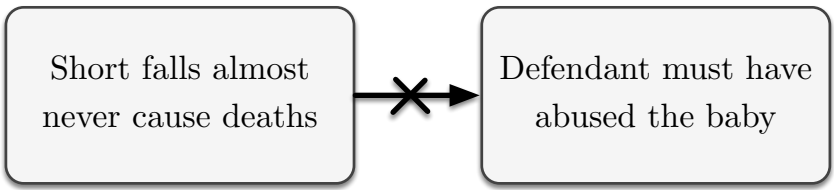
$$0.48 \text{ in a million} = P(\text{ Short fall } | \text{ E }),$$

where E = Evidence (infant with head trauma and death).

# Although Chadwick's quantity correctly reports the risk of short fall deaths, it is improperly used in court.

Assuming $P($ Short fall $\mid$ E $) = 0.48$ in a million

implies $P($ Shaken $\mid$ E $) = 1 - 0.48$ in a million $= 99.9999\%$.

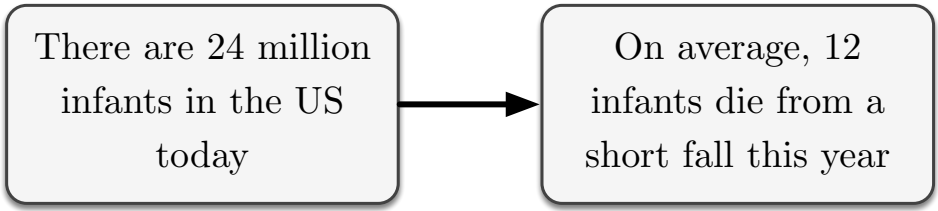



$\Rightarrow$ Chadwick's quantity was calculated correctly. But **this argument** is flawed.

Criticisms of the implicit argument made in court by using Chadwick's quantity.

# Criticism: Rare events are not impossible.

- Death due to short fall (EPIC 1999–2003): 0.48 in a million.




$\Rightarrow$ This argument has been mentioned by the Moran, Findley, Barnes, Squier 2012 paper and various expert witnesses in court.

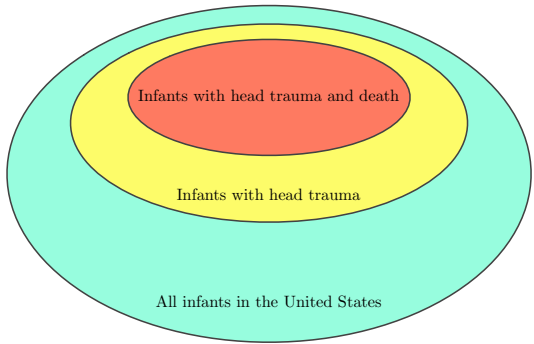
Some other reported values are also very small:

- Death due to struck by lightning (KID 2012): 0.63 in a million.
- Having Abusive Head Trauma (KID 2012): 85 in a million.

# Criticism: One must restrict the population *in light of the evidence* to a subset of individuals.

⇒ Chadwick's quantity is calculated for the entire population of infants.
⇒ Bue we have additional information, not just that this is an infant:

$$P(\text{ Shaken} \mid \text{Infant with head trauma and death }).$$




⇒ This argument has also been mentioned by various expert witnesses in court.

# Criticism: One must compare competing hypotheses in light of the evidence.

- Chadwick et al.'s quantity is in isolation.
- They calculate the probability that one event happens, but not the probabilities that any other possible cause happened for comparison.
- How likely are the other possible causes?

$\Rightarrow$ Comparing 1/1 million to 1/400 million. 1/million seems large!

Could estimate:
"Were the injuries caused by a short fall?"

$$\frac{P(\text{ Short fall} \mid \text{E})}{P(\text{ No short fall} \mid \text{E})}.$$

Eventually want to estimate:
"Were the injuries caused by shaking/child abuse?"

$$\frac{P(\text{ Shaken} \mid \text{E})}{P(\text{ Not shaken} \mid \text{E})}.$$

where E = Evidence, head trauma and death, or just head trauma.

We can expand the ratio to include the probability that given the evidence the child had a short fall or other causes.

- Recall E = the Evidence. We want

$$\frac{P(\text{ Shaken} \mid \text{E})}{P(\text{ Not shaken} \mid \text{E})}.$$

- In the denominator, there are several explanations (e.g. short fall, rickets, vitamin D deficiency, etc.) given the evidence E:

$$\frac{P(\text{ Shaken} \mid \text{E})}{P(\text{ Not shaken} \mid \text{E})} = \frac{P(\text{ Shaken} \mid \text{E})}{P(\text{ Short fall} \mid \text{E}) + P(\text{ Other causes} \mid \text{E})}.$$

Obtaining a value for

$$\frac{P(\text{ Shaken} \mid \text{E})}{P(\text{ Not shaken} \mid \text{E})}.$$

## For the purposes of this talk, one can define the evidence as the "triad" of symptoms.

• Let the evidence (E) be head trauma defined by the classical constellation of injuries in Abusive Head Trauma (the triad):

- Retinal hemorrhage
- Cerebral edema
- Subdural hemorrhage

$\Rightarrow$ It is possible to add more! This is just a starting point.

# The statistician can only estimate the part of the value that relies on data.

$$\frac{P(\text{ Shaken} \mid \text{E})}{P(\text{ Not shaken} \mid \text{E})} = \underbrace{\frac{P(\text{ E} \mid \text{Shaken})}{P(\text{ E} \mid \text{Not shaken})}}_{\text{From data}} \underbrace{\frac{P(\text{ Shaken})}{P(\text{ Not shaken})}}_{\text{From case}}.$$

$\Rightarrow$ From data: The statistician can only estimate the first term.

$\Rightarrow$ From case: e.g. amount of time spent with the child, child has injuries from prior abuse.

# The information required to calculate the values for the odds.

Need to fill in this table:

| | Triad | No triad |
|---|---|---|
| Shaken | | |
| Not shaken | | |
| Short fall | | |
| No short fall | | |
| Other causes | | |
| No other causes | | |

Need:

- Probability sample
- Large sample

# The information required to calculate the values for the odds.

Need to fill in this table:

| | Triad | No triad | Triad and death* | No triad and death* |
|---|---|---|---|---|
| Shaken | | | | |
| Not shaken | | | | |
| Short fall | | | | |
| No short fall | | | | |
| Other causes | | | | |
| No other causes | | | | |

* These are for the cases in which the child passed away.

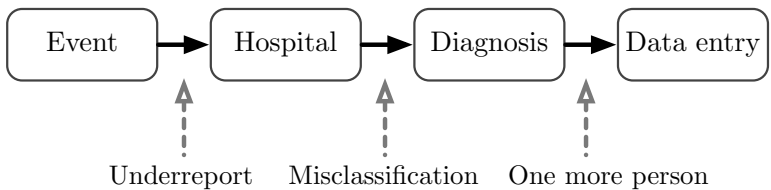
# Some major databases are insufficient.

**EPIC** — Epidemiology and Prevention for Injury Control

- Small sample (for rare events)
- Not representative of the US population.

**KID** — Kids' Inpatient Database:

- Only contains information from hospital records.
- Biased by several factors.




$\Rightarrow$ Cannot calculate the value because the data themselves are the problem.

# Summary: How to answer the question, "Could this child's injuries have been caused by a short fall?"

- The Chadwick quantity should not be used in court because of four criticisms:
  1. Rare events are not impossible.
  2. One must restrict the population in light of the evidence.
  3. One must compare competing hypotheses in light of the evidence.
- A better method would be to calculate the ratio: $\frac{P(\text{ Evidence } | \text{ Short fall })}{P(\text{ Evidence } | \text{ No short fall })}$, which can be combined with evidence from the case.
- But the data available today are not of high enough quality to allow for this calculation to be made properly.
- A correct statistical argument about the population cannot be made to answer the question above.

$\Rightarrow$ If you use a statistical argument in court, make sure you have high quality data and appropriate analysis.

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