# Statistical Questions About Shaken Baby Syndrome/ Abusive Head Trauma

Maria Cuellar
University of Pennsylvania
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# Outline

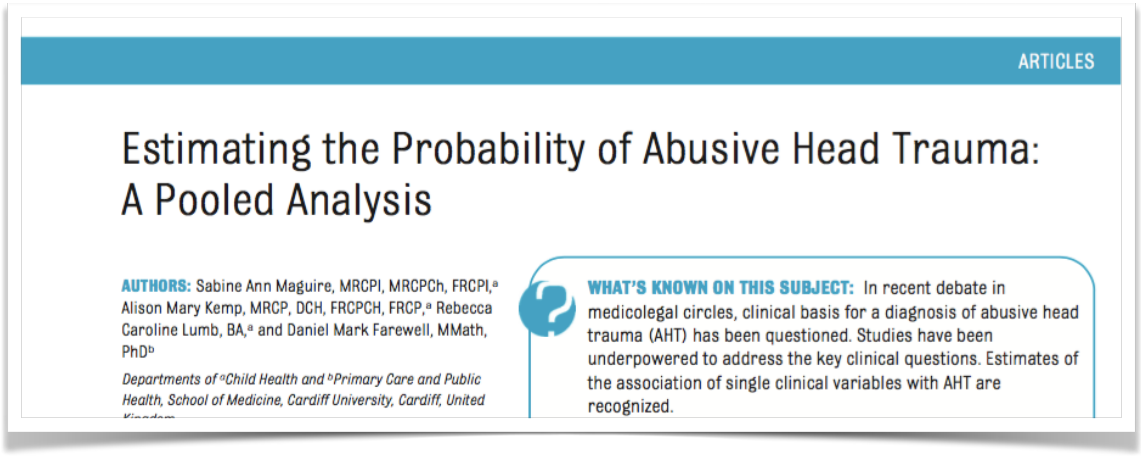
1. Statistical model
2. Prevalence estimates
3. Conclusion

# Statistical model

# Maguire's Model to Predict Abuse

Maguire and co-authors propose a model (logistic regression) to make diagnosis of SBS more objective.

Authors' suggestion: New child needs diagnosis? Doctor can use the model!



ARTICLES

Estimating the Probability of Abusive Head Trauma: A Pooled Analysis

**AUTHORS:** Sabine Ann Maguire, MRCPI, MRCPCh, FRCPI,[a] Alison Mary Kemp, MRCP, DCH, FRCPCH, FRCP,[a] Rebecca Caroline Lumb, BA,[a] and Daniel Mark Farewell, MMath, PhD[b]

*Departments of [a]Child Health and [b]Primary Care and Public Health, School of Medicine, Cardiff University, Cardiff, United*

**WHAT'S KNOWN ON THIS SUBJECT:** In recent debate in medicolegal circles, clinical basis for a diagnosis of abusive head trauma (AHT) has been questioned. Studies have been underpowered to address the key clinical questions. Estimates of the association of single clinical variables with AHT are recognized.

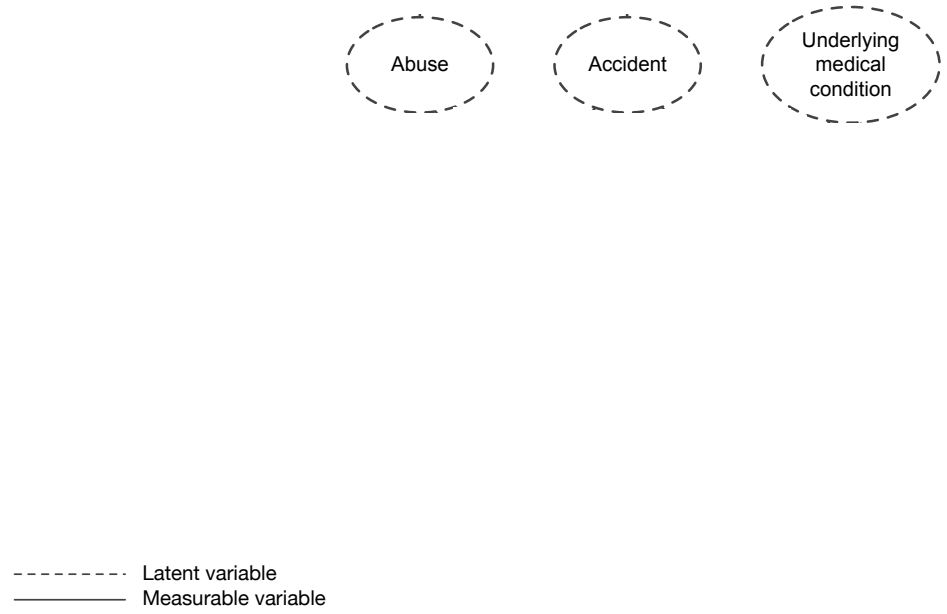
Maguire, Sabine Ann, et al. Pediatrics 128.3 (2011): e550-e564.

# Data Used by Maguire's Model

- Obtained (proprietary) data from 6 physicians
- Children under age 3 with intracranial injury
- Sample size is 1,053 (348 were marked as abused)
- Large portion of missing data in clinical features
- Criteria: "Abuse confirmed in court or admitted by perpetrator or confirmed by multidisciplinary assessment or independently witnessed."

| Abuse | Retinal hemorrhage | Rib fracure | Long bone fracture | … |
|---|---|---|---|---|
| Yes | Yes | No | No | |
| No | . | Yes | . | |
| Yes | Yes | . | . | |

# Hypothesized Data-Generation Process for Maguire Data



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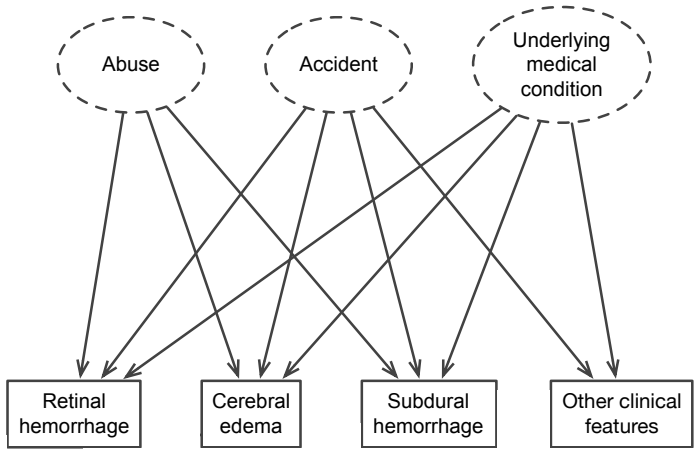


Latent variable
Measurable variable

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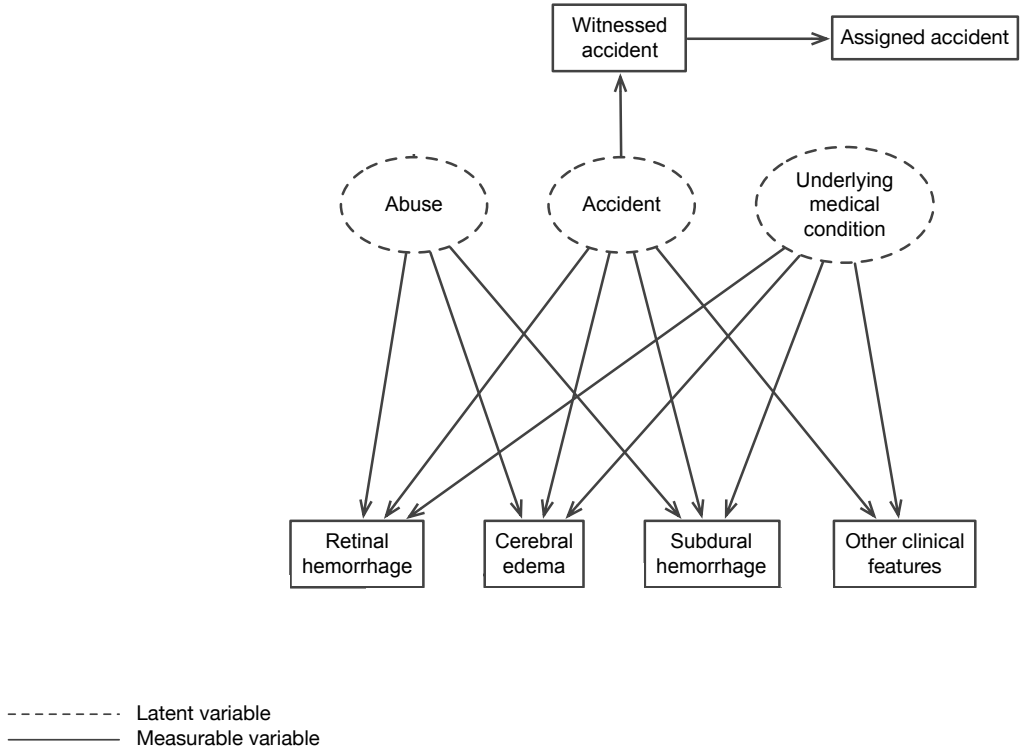

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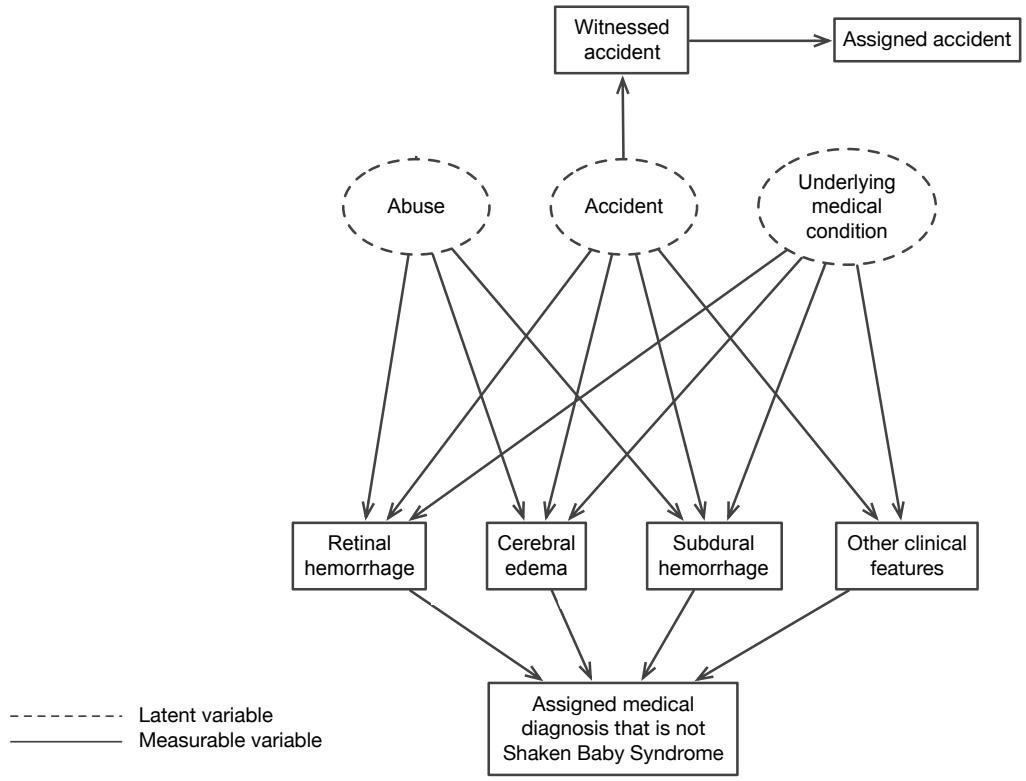

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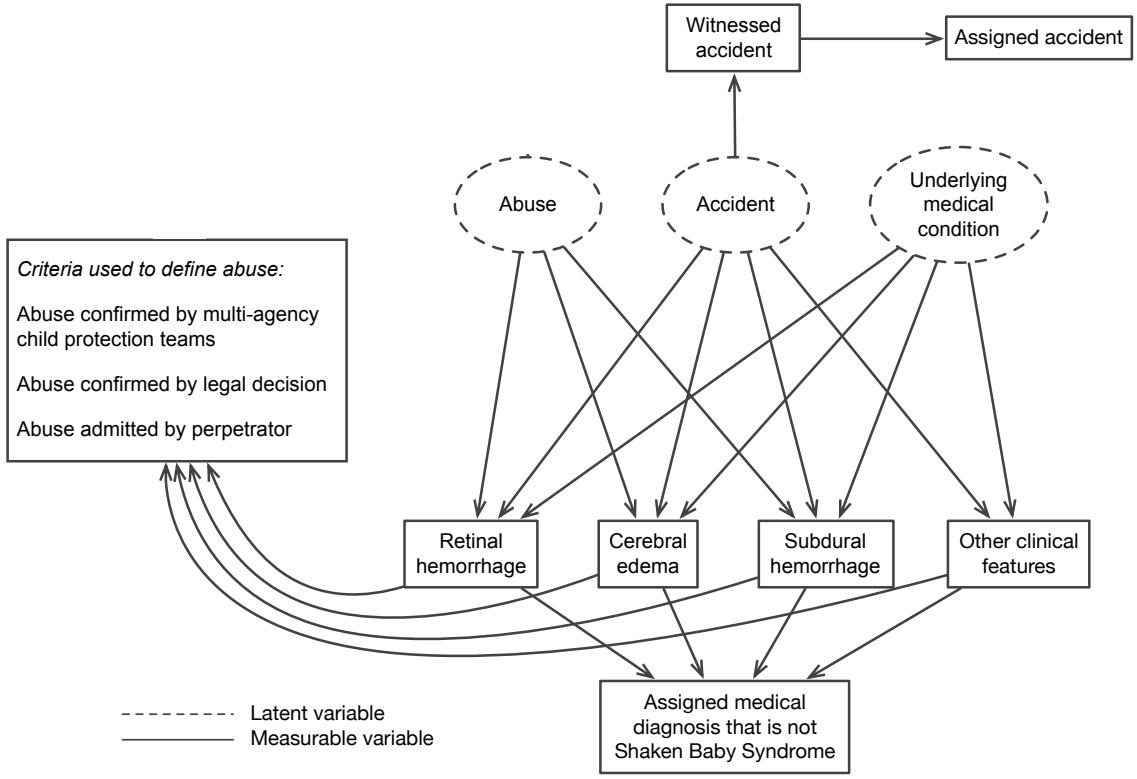

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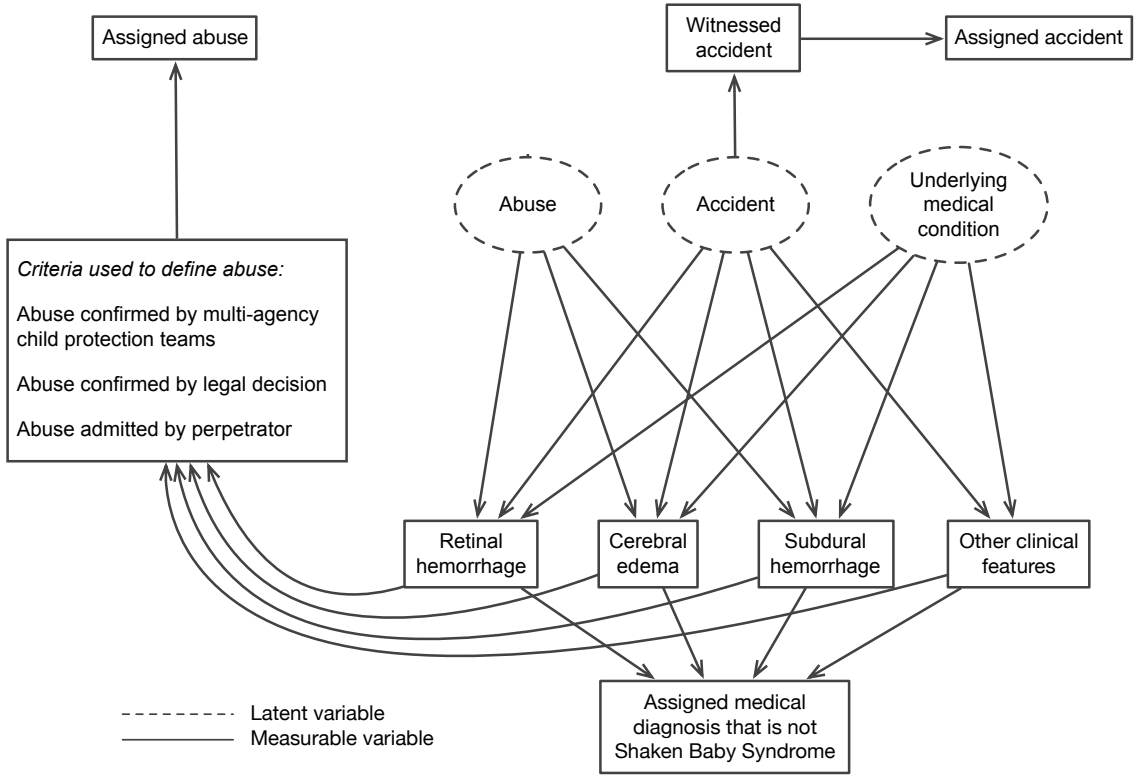

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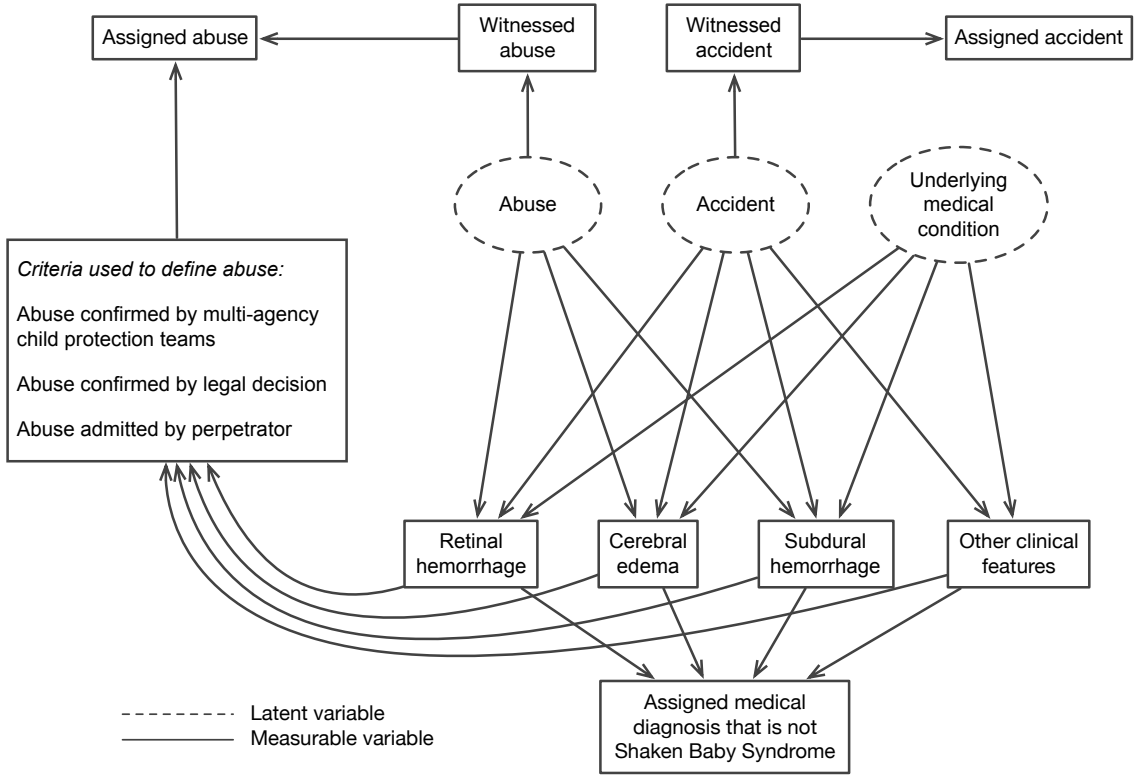

# Prevalence estimates

# Physicians gathered to determine diagnostic codes

**Table 1** CDC's recommended operational case definition based on ICD-9-CM† diagnoses and external cause-of-injury codes for defining non-fatal abusive head trauma in children aged <5 years

| | Clinical diagnosis code | External cause-of-injury or abuse code |
|---|---|---|
| Definite or presumptive abusive head trauma | 781.0—781.4, 781.8, 800, 801, 803, 804.1—804.4, 804.6—804.9, 850, 851, 852.0—852.5, 853.0, 853.1, 854.0, 854.1, 925.1, 950.0—950.3, 959.01, 995.55‡ | E960.0, E967, E968.1, E968.2, E968.8, E968.9, 995.50*, 995.54, 995.59* |
| Probable abusive head trauma | All of those above (except 995.55) | E987, E988.8, E988.9 |
| Non-abusive head trauma | 781.0—781.4, 781.8, 800, 801, 803, 804, 850, 851, 852, 853, 854.0, 854.1, 925.1, 950.0—950.3, 959.01 | Excluding all those above |

*Excludes cases in the presence of a fall or unintentional injury code: E800—E807, E810—E838, E840—E848, E880—E888 and E890—E928.
†International Classification of Diseases, Ninth Revision, Clinical Modification.
‡Does not require an external cause or abusive code.

# Attempt to estimate prevalence of AHT

Three papers:

1. Parks, S., Sugerman, D., Xu, L., & Coronado, V. (2012). Characteristics of non-fatal abusive head trauma among children in the USA, 2003–2008: application of the CDC operational case definition to national hospital inpatient data. Injury Prevention, 18(6), 392-398.
2. Parks, S. E., Kegler, S. R., Annest, J. L., & Mercy, J. A. (2012). Characteristics of fatal abusive head trauma among children in the USA: 2003–2007: an application of the CDC operational case definition to national vital statistics data. Injury prevention, 18(3), 193-199.
3. Parks, S. E., Annest, J. L., Hill, H. A., & Karch, D. L. (2012). Pediatric abusive head trauma: recommended definitions for public health surveillance and research. CDC report.

- The goal was to standardize the definition of AHT by asking a group of experts:
  - "The code-based case definitions for non-fatal AHT in children <5 years of age which were developed by a Centers for Disease Control and Prevention-convened expert panel has been successfully operationalised and applied to US death data.
  - < The proposed definition for non-fatal AHT can be a useful tool for standardising future public health surveillance activities related to head trauma in young children."
- But do all experts in the field agree about these codes?

# Prevalence by age and calendar year

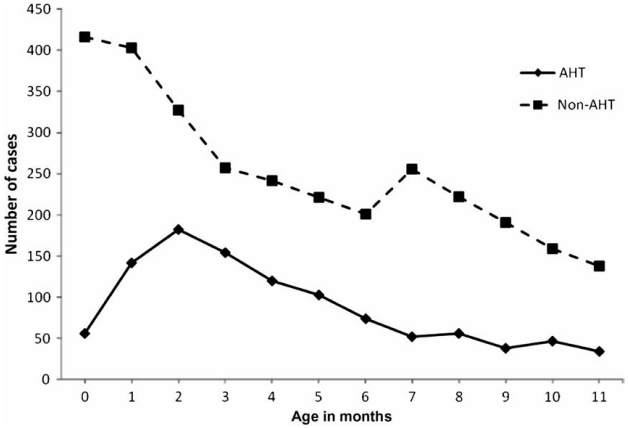


**Figure 1** Estimated annual number of cases of non-fatal abusive head trauma (AHT) and non-AHT hospitalisations by month of age, USA, 2003—8.

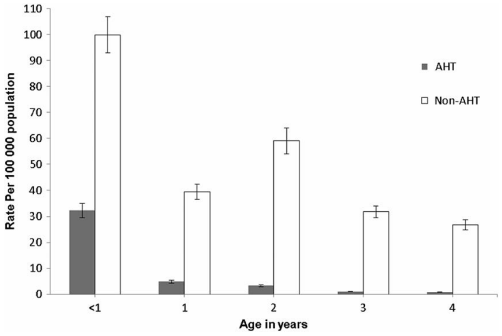


**Figure 2** Estimated annual rates of non-fatal abusive head trauma (AHT) and non-AHT hospitalisations by age based on the CDC expert panel's operational AHT definition, USA, 2003—8. Error bars represent ±SD for each rate.

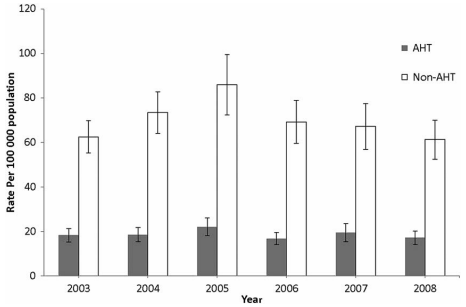


**Figure 3** Estimated rates of non-fatal abusive head trauma (AHT) and non-AHT hospitalisations by year for children aged <2 years, USA, 2003—8. Error bars represent ±SD for each rate.

# Conclusion

- **Circularity —** Both studies suffer from circularity, and try to get around it by appealing to “ground truth”. In 1, the “ground truth” is the model, and in 2, is it he group of physicians. Neither succeeds.
    - **Study 1 —** Given these cases, how common are the diagnostic features in cases of AHT? Also, for a new case with certain features, what is the probability that it is AHT?
    - **Study 2 —** Given these diagnostic codes from a group of physicians, how many cases are there?
- **Recommendation —** We need to study the diagnoses excluding the subjective determinations. How?

# Phone Call, December 2016

- Wisconsin Office of the State Public Defender, defending a 32-year-old mother.

- Expert witness is **certain** a child was abused, backs it up with Maguire statistical article.

From the prosecutor statement:

"The Maguire article establishes a **predicted probability level** for an abusive head trauma diagnosis at **100%, with a confidence interval of between 95% and 100%**…additional factors only further increase the probability of abuse in this case."

Questions?

# Breakdown by sex, race, season of admission

**Table 3** Estimated annual numbers and rates of non-fatal abusive head trauma (AHT) and non-AHT hospitalisations by selected demographic and admission characteristics for children aged <2 years, USA, 2003–8

| | Definite/presumptive AHT | | | Probable AHT | | | Total AHT | | | Non-AHT | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Rate | 95% CI | No. | Rate | 95% CI | No. | Rate | 95% CI | No. | Rate | 95% CI | OR (95% CI) | p Value |
| Total | 1409 | 17.0 | 14.2 to 19.8 | 143 | 1.7 | 1.2 to 2.2 | 1552 | 18.7 | 15.6 to 21.8 | 5801 | 69.8 | 60.8 to 78.8 | | |
| Sex | | | | | | | | | | | | | | |
| Female | 569 | 14.0 | 11.4 to 16.6 | 51 | 1.3 | 0.9 to 1.7 | 620 | 15.3 | 12.5 to 18.1 | 2434 | 59.9 | 52.0 to 67.8 | 1.0 (reference) | |
| Male | 839 | 19.7 | 16.4 to 23.0 | 92 | 2.2 | 1.5 to 2.9 | 931 | 21.9 | 18.3 to 25.5 | 3343 | 78.6 | 68.3 to 88.9 | 1.092 (0.981 to 1.216) | 0.1084 |
| Unknown | 1 | | | 0 | | | 1 | | | 25 | | | | |
| Race* † | | | | | | | | | | | | | | |
| White | 478 | | | 45 | | | 523 | | | 2182 | | | | |
| Black | 199 | | | 28 | | | 227 | | | 672 | | | | |
| Native American | 5 | | | 1 | | | 6 | | | 32 | | | | |
| Asian/PI | 14 | | | 1 | | | 15 | | | 145 | | | | |
| Hispanic | 194 | | | 32 | | | 225 | | | 999 | | | | |
| Other/unknown | 518 | | | 37 | | | 555 | | | 1772 | | | | |
| Month of admission | | | | | | | | | | | | | | |
| Winter (December–February) | 327 | 3.9 | 3.2 to 4.6 | 30 | 0.4 | 0.3 to 0.5 | 357 | 4.3 | 3.6 to 5.0 | 1115 | 13.4 | 11.5 to 15.3 | 1.0 (reference) | |
| Spring (March–May) | 349 | 4.2 | 3.3 to 5.1 | 31 | 0.4 | 0.3 to 0.5 | 380 | 4.6 | 3.7 to 5.5 | 1327 | 16.0 | 13.7 to 18.3 | 0.896 (0.771 to 1.040) | 0.1486 |
| Summer (June–August) | 328 | 3.9 | 3.1 to 4.7 | 36 | 0.4 | 0.2 to 0.6 | 364 | 4.4 | 3.5 to 5.3 | 1475 | 17.7 | 15.0 to 20.4 | 0.771 (0.660 to 0.900) | 0.0011 |
| Fall (September–November) | 314 | 3.8 | 3.1 to 4.5 | 33 | 0.4 | 0.2 to 0.6 | 347 | 4.2 | 3.4 to 5.0 | 1320 | 15.9 | 13.6 to 18.2 | 0.821 (0.718 to 0.940) | 0.0047 |
| Unknown | 92 | 1.1 | 0.5 to 1.7 | 13 | 0.2 | 0.1 to 0.3 | 104 | 1.3 | 0.6 to 2.0 | 565 | 6.8 | 3.3 to 10.3 | | |

*White, white; non-Hispanic, black; Black, non-Hispanic; AI/AN, American Indian/Alaska Native; A/PI, Asian/Pacific Islander.
†Due to the large percentage of missing data the rates for race/ethnicity could not be calculated.