Evidence of Child Abuse: Inferring the Causes of Effects

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Child Abuse Evidence: New Perspectives from Law, Medicine, Psychology, and Statistics

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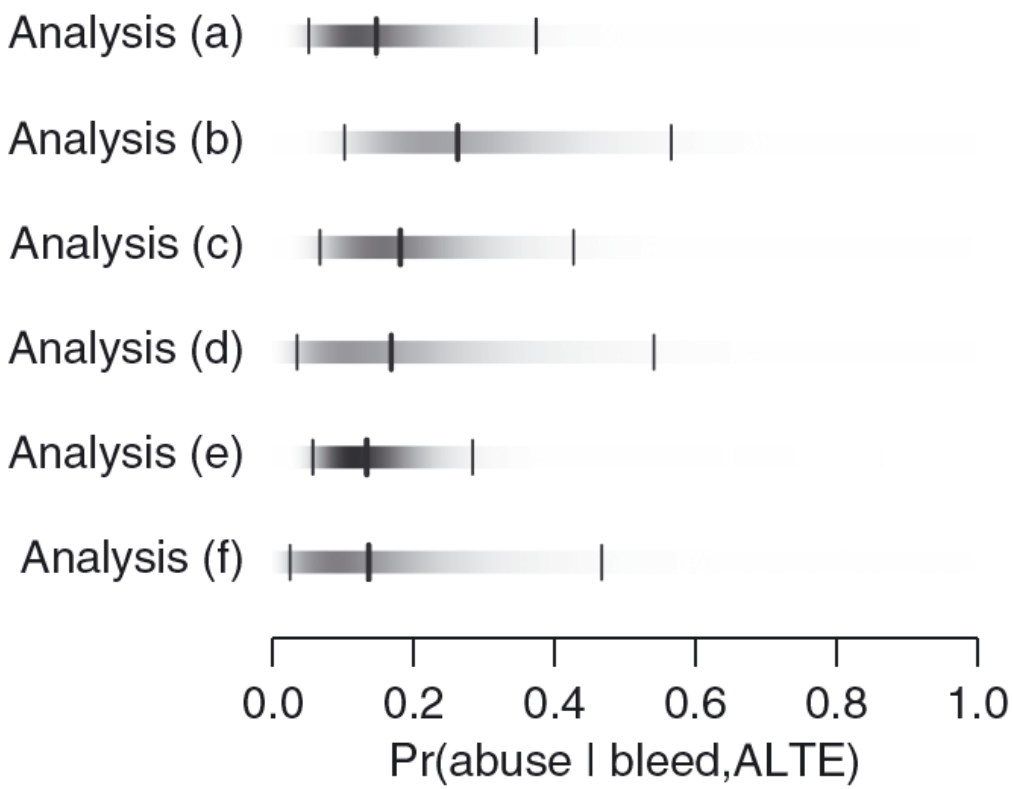
Statistical Study Predicting Abuse

- **N. Best, D. Ashby, F. Dunstan, D. Foreman and N. McIntosh ((2013)**



Density strip plots of the posterior credence distribution of Pr(abuse | bleed, ALTE)

Abusive Head Trauma (Shaken Baby Syndrome)

- **"SBS is injury to skull or intracranial contents of infant or young child due to inflicted blunt impact and/or violent shaking."**
- **The Triad: constellation of 3 medical findings, subdural hematoma, retinal bleeding, and brain swelling.**
- **Violent shaking → Triad (and death)**
- **We observe triad (and death). Was the cause violent shaking?**

Questions

- **What are the data?**
  - **Provenance of the data.**
  - **Biases in evaluation.**
  - **Biases in interpretation.**
  - **Blinding in assessment?**
- **What is the science?**
- **What statistical question do we want to answer?**
  - **Predictions? Conditional on what quantities?**
  - **Causation?**

Causes of Effects

- **Effects of Causes (EoC):** ***Does violent shaking of infants cause the specific triad symptoms in infants?***
- **Causes of Effects (CoE):** ***Was violent shaking the cause of triad symptoms observed in infant?*** **[Can we eliminate alternative possible causes.]**
- **Is a question about CoE essentially the same as one about EoC? If not how do they differ?**

2012 KIDS Data (from Cuellar)

- **Traditionally we would address this question with high quality experimental data, and odds ratio or risk ratio.**
- **What is available?**
- **Problem: Misclassification and misdiagnosis**

	Triad		
Diagnosis	Yes	No	Totals
Shaking	160??	113???	273??
Short Fall	78???	3646??	3724??
Totals			

Understanding Causes of Effects in Simpler Setting

- **Effects of Causes (EoC):** ***I have a headache. Will taking aspirin help?***
- **Causes of Effects (CoE):** ***Was it the aspirin I took 30 minutes ago that caused my headache to disappear?***
- **Is a question about CoE essentially the same as one about EoC?**
- **If not how do they differ?**

Assessing Causes of Effects

- ***Was it the aspirin I took 30 minutes ago that caused my headache to disappear?***
- **Recovery rates (in randomized trial):**
  - **No aspirin: 12%**
  - **Aspirin: 30%**
- **Odds Ratio:**

$$\alpha = (30 \times 88)/(12 \times 70) = 3.14$$

- **[This what statisticians traditionally would have liked to do in SBS setting, but we could not because of thee poor data available.]**

Probability of Causation

- **Potential responses:**

  R_1 **to aspirin;** R_0 **to no aspirin**

- ***Probability of Causation*:**

  PC $= \Pr(R_0=0 \mid R_1=1)$

- **Requires JOINT DISTRIBUTION of** (R_0, R_1)
  - **Cannot estimate!**
    - ***Only know marginal probabilities***
- **What can we say?**

Probability of Causation

	R_0		
R_1	0	1	Total
0	$88 - x$	$x - 18$	70
1	x	$30 - x$	30
Total	88	12	100

- PC = $\Pr(R_0=0 \mid R_1=1) = x/30$
- Know $18 \leq x \leq 30$
- So PC $\geq 60\%$

Probability of Causation

- **In general, this argument shows**

$$PC \geq 1 - 1/RR$$

where RR = $\Pr(R_1 = 1)/\Pr(R_1 = 0)$

is the (experimental) *risk ratio*.

- **In particular,**

RR > 2 and PC > ½

–"proof on the balance of probabilities"

–But converse is false!

Probability of Causation for SBS

- **Causes: violent shaking =1, no violent shaking =0**
- **Potential responses: triad=1, no triad=0**

  R_1 to shaking; R_0 to no shaking
- ***Probability of Causation*:**

  PC = Pr(R_0=0 | R_1=1)
- **Requires JOINT DISTRIBUTION of (R_0, R_1)**
  - **Cannot estimate!**
    - **No experimentsl data**
    - ***We can only ESTIMATE marginal probabilities, for R_0 and R_1.***
    - **Bounds on PC.**
    - **Bayesian analysis for observational data.**

Case Study in Dawid, Musio, and Fienberg (2015)

- Data from Best et al. (2013) involving diagnosis of abuse in an infant child, presenting with an acute life-threatening event ("ALTE").
- Attribution: If the child suffers ALTE, what is the probability this was caused by abuse?
- Full Bayesian Analysis with observational data.
- Individual-focused uncertainty interval for PC* is (0, 0.043)
- Upper bound does not meet the balance of probabilities criterion for civil litigation.

Moral for Child Abuse Evidence

- **Most statisticians and epidemiologists seek out quality data to address tradition scientific question of effects of causes.**
  - **Gold Standard of randomized experiments unavailable.**
  - **We only have deeply flawed observational data.**
- **But real question is one of causes of effects.**
  - **New statistical approaches are required, with much greater uncertainty.**
- **This is an overlay to the issues addressed by other speakers today.**

References

- **N. Best, D. Ashby, F. Dunstan, D. Foreman, and N. McIntosh (2013) A Bayesian Approach to Complex Clinical Diagnoses: A Case-Study in Child Abuse (with Discussion). *Journal of the Royal Statistical Society: Series A*, 176: 53–96.**
- **A. P. Dawid, D. L. Faigman and S. E. Fienberg (2014) Fitting Science Into Legal Contexts: Assessing Effects of Causes or Causes of Effects? *Sociological Methods & Research*, 43: 359-390.**
- **A. P. Dawid, M. Musio, and S. E. Fienberg (2015) From Statistical Evidence to Evidence of Causation. *Bayesian Analysis*, forthcoming.**