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Confounding: A Big Idea

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Director, W. M. Keck Statistical Literacy Project

VP. National Numeracy Network

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Core Concepts in Intro Stats

McKenzie (2004): Survey of Educators

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Ambiguity of "Importance"

	Classifying Important Ideas		
	Logically	Socially	Cognitively
Topic	{Common}		
Claim		**Good/Bad***	**Fallacy**
	* Contribution or catastrophe		

Topic (randomness) or a claim: ME ~ 1/sqrt(n)

This paper focuses on claims or relationships having substantial social or cognitive consequences.

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1A: Fallacies

1. Confusion of the inverse: P(A|B) = P(B|A)
2. Conjunction fallacy: P(A&B) > P(A)
3. P(A&B |C) > P(A |B&C): Three-factor fallacy
4. **Individual fallacy**
5. **Ecological fallacy**
6. **Simpson's Paradox**

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Contributions of Statistics to Human Knowledge

Statistics are numbers in a context
Association is not causation

RANDOMNESS and CAUSATION
- Chance, independence and sampling distributions
- Margin of error, hyp tests & statistical significance
- *Random assignment and causation (Fisher: RCT)*

CONFOUNDING and CAUSATION
- Comparisons, ratios, models and study designs
- Epidemiological causation (Bradford-Hill)
- *Confounder conditions for nullification (Cornfield)*

V0.7 Conditional probability, medical tests and Bayesian reasoning
Coincidence, Simpson's Paradox and regression to the mean

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#2A: Butterfly Fallacy

One should never trust a statistical association generated by an observational study.

An unknown or unmeasured confounder – regardless of size (a small as a butterfly) – can nullify or reverse an observed association.

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Smoking Causes Cancer: Fisher's Argument

Observational data: Smokers are **10 times** as likely to develop lung cancer as are non-smokers.

Some statisticians wanted to support the claim that smoking "caused" lung cancer.

Sir Ronald Fisher (1958) noted that "association was not causation" and that there was a difference (**factor of two**) in smoking preference between fraternal and identical twins.

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Smoking Causes Cancer: Cornfield's Reply

Cornfield et al (1959) argued that to nullify or reverse the observed association, the relative risk of a confounder must exceed the relative risk of that association.

Fisher never replied.

"Cornfield's minimum effect size is as important to observational studies as is the use of randomized assignment to experimental studies." Schield (1999)

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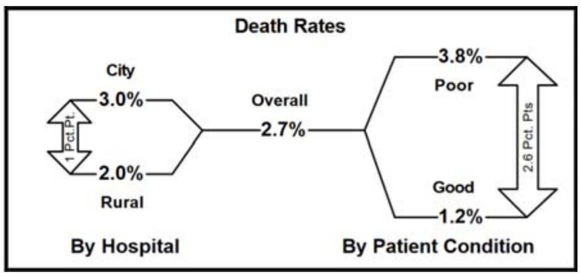
Cornfield Condition for Nullification or Reversal



Schield (1999) based on realistic data

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Confounder Distribution: Simple One-Parameter Model

How to deal with unknown or unmeasured confounders?

Assume: RR of confounders is distributed exponentially with a minimum RR of one and a mean RR of two.

RR	CDF		RR-1	CDF
1	0.00		0	0.00
2	0.63		1	0.63
3	0.86		2	0.86
4	0.95		3	0.95
5	0.98		4	0.98

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Effect Sizes: Relative Risk 95% Confounder Resistant: Exp20

Obese vs. non-Obese

RR of Health Outcome	Women	Men
Type 2 Diabetes	12.7	5.2
Hyptertension	4.2	2.6
Heart attack	3.2	1.5
Colon Cancer	2.7	3.0
Angina	1.8	1.8
Gall-bladder	1.8	1.8
Ovarian Cancer	1.7	
Osteoarthritis	1.4	1.9
Stroke	1.3	1.3
Average	3.4	2.4

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Conclusion

Students should be exposed to the major contributions of statistics to human knowledge.

Including multivariate thinking in the intro course means discussing confounding.

Introducing confounding means dealing with
- the Butterfly fallacy,
- the Cornfield conditions and
- ranking the resilience of an association to unknown or unmeasured confounders.

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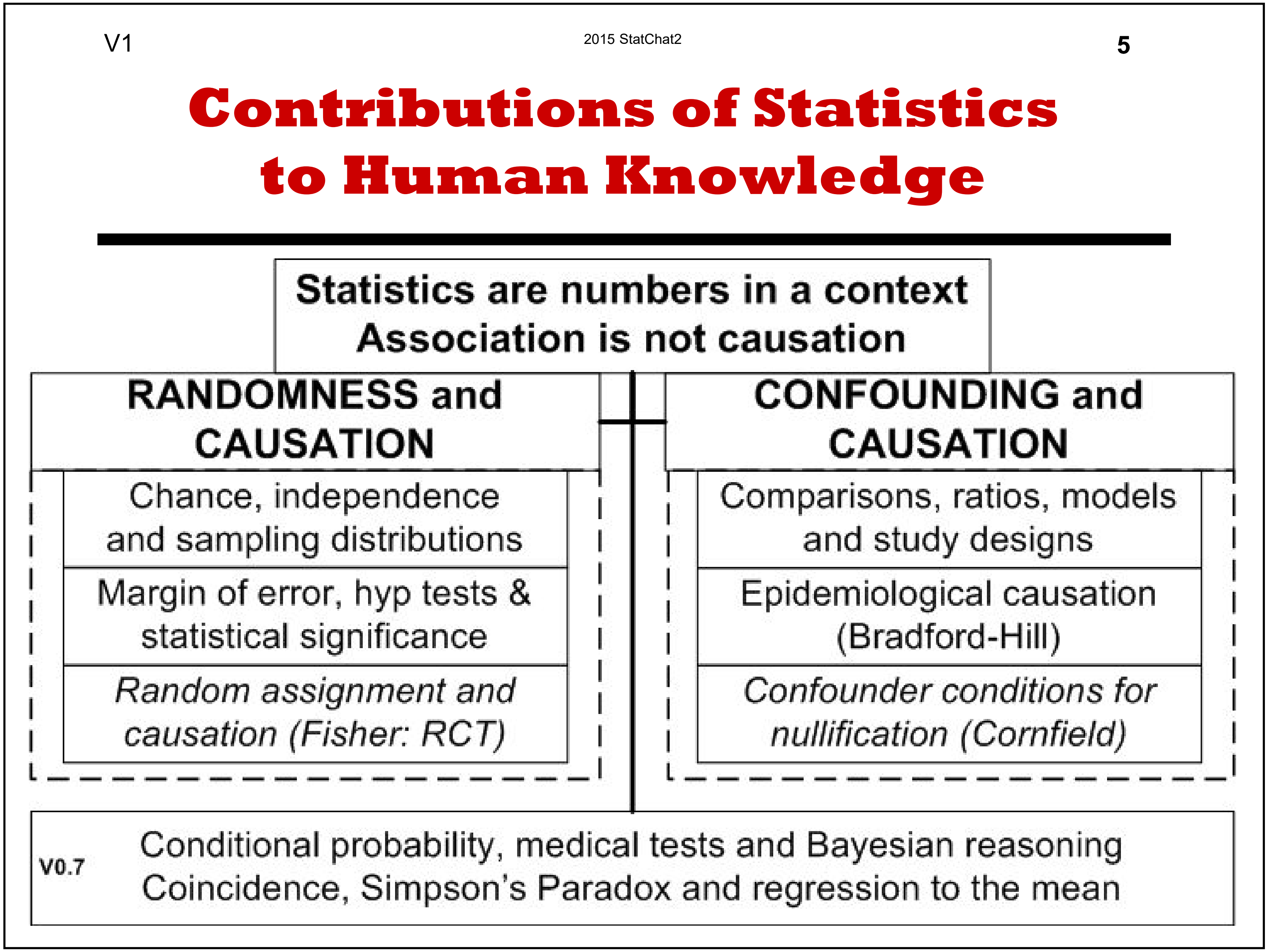
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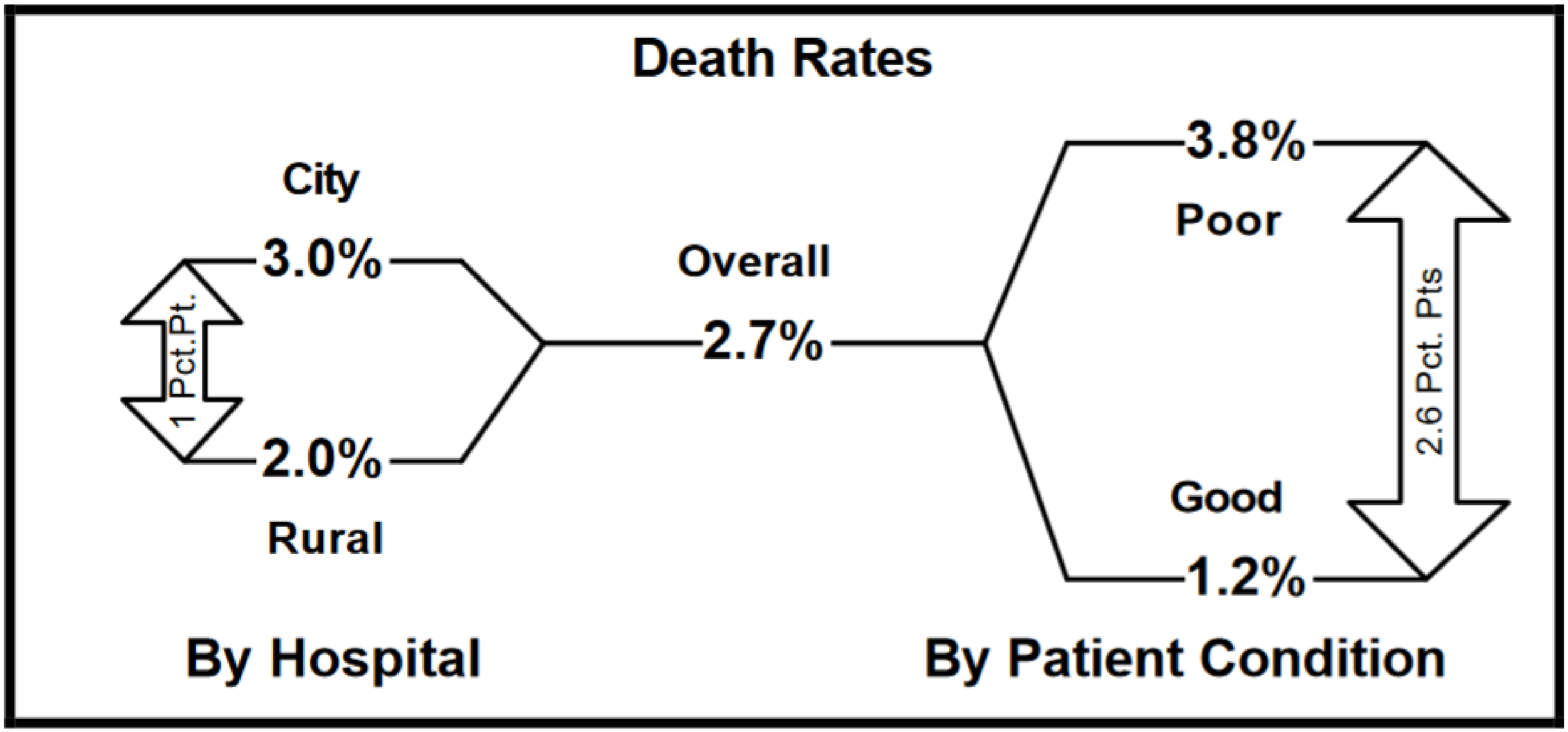

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