

# **Statistical Literacy: A Math-Stat Alternative**

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Slides at [www.StatLit.org/pdf/2012Schield-T3Conference6up.pdf](http://www.StatLit.org/pdf/2012Schield-T3Conference6up.pdf)

# High School Mathematics

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In 2004, 70% of high school graduates completed either Algebra 2, pre-calculus or calculus as their highest-level math course. (Dossey, 2008)

This 70% probably includes all the high-school seniors that go on to college.

In 2003, 40% of college seniors graduated in majors that did not require a mathematics course. Schield (2008)

# QL & School Mathematics: Percentages and Fractions

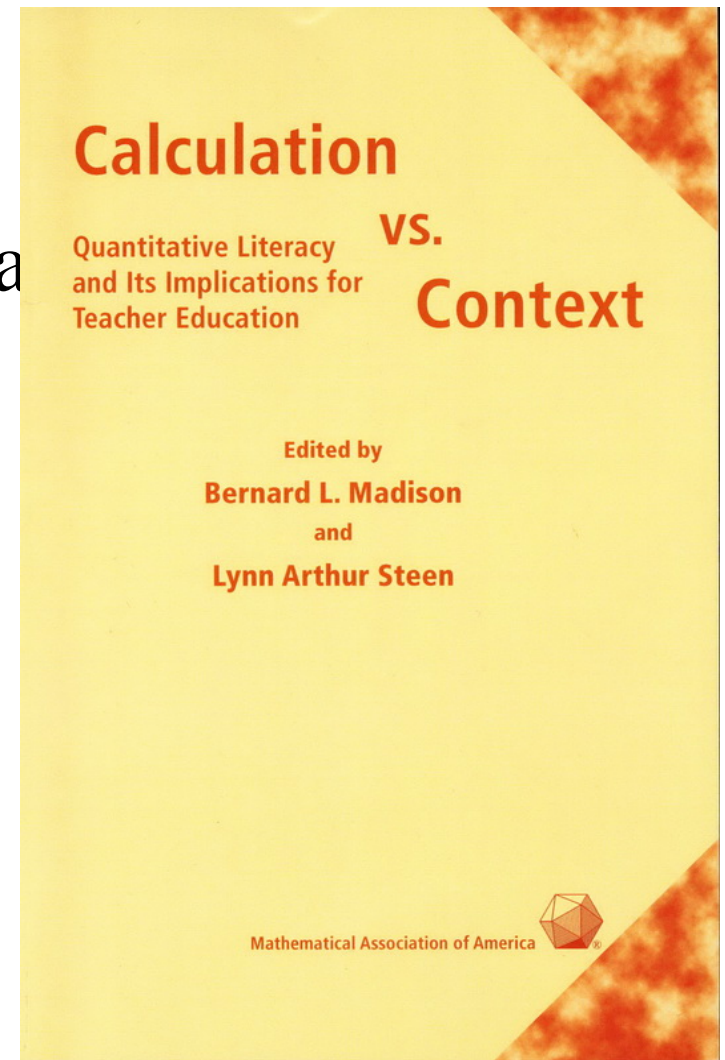
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Introduce rates and percentages as presented in tables and graphs in middle school as a pre-Algebra bridging course

Introduce Statistical Literacy as an alternative to Algebra 2 or AP Statistics.

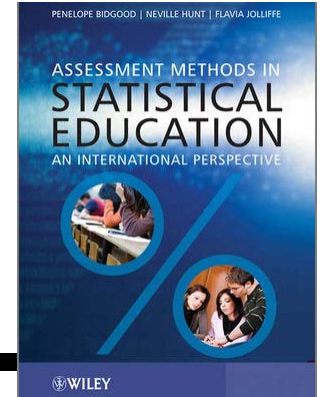
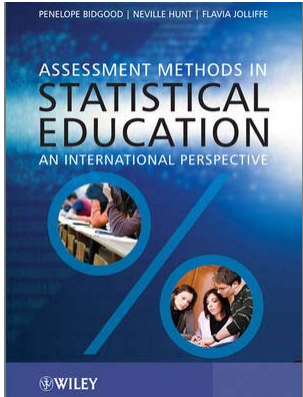
Schild (2008).

[www.StatLit.org/pdf/2008SchildMAA.pdf](http://www.StatLit.org/pdf/2008SchildMAA.pdf)



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# Statistical Literacy



**Statistical literacy** is the ability to **read and interpret** summary statistics in the everyday media: in graphs, tables, statements and essays.

Statistical literacy is needed by ‘data consumers.’

About 20% of all US four-year colleges offer a course titled “Statistical Literacy”.

Schild (2010) in *Assessment Methods in Statistical Education*

# Wired Magazine: Oct 2010

## COURSE LISTINGS

**1. STATISTICAL LITERACY**

Making sense of today's data-driven world.

## FALL SEMESTER 2011

# WIRED

# UNIVERSITY!



# Statistical Literacy: Take CARE

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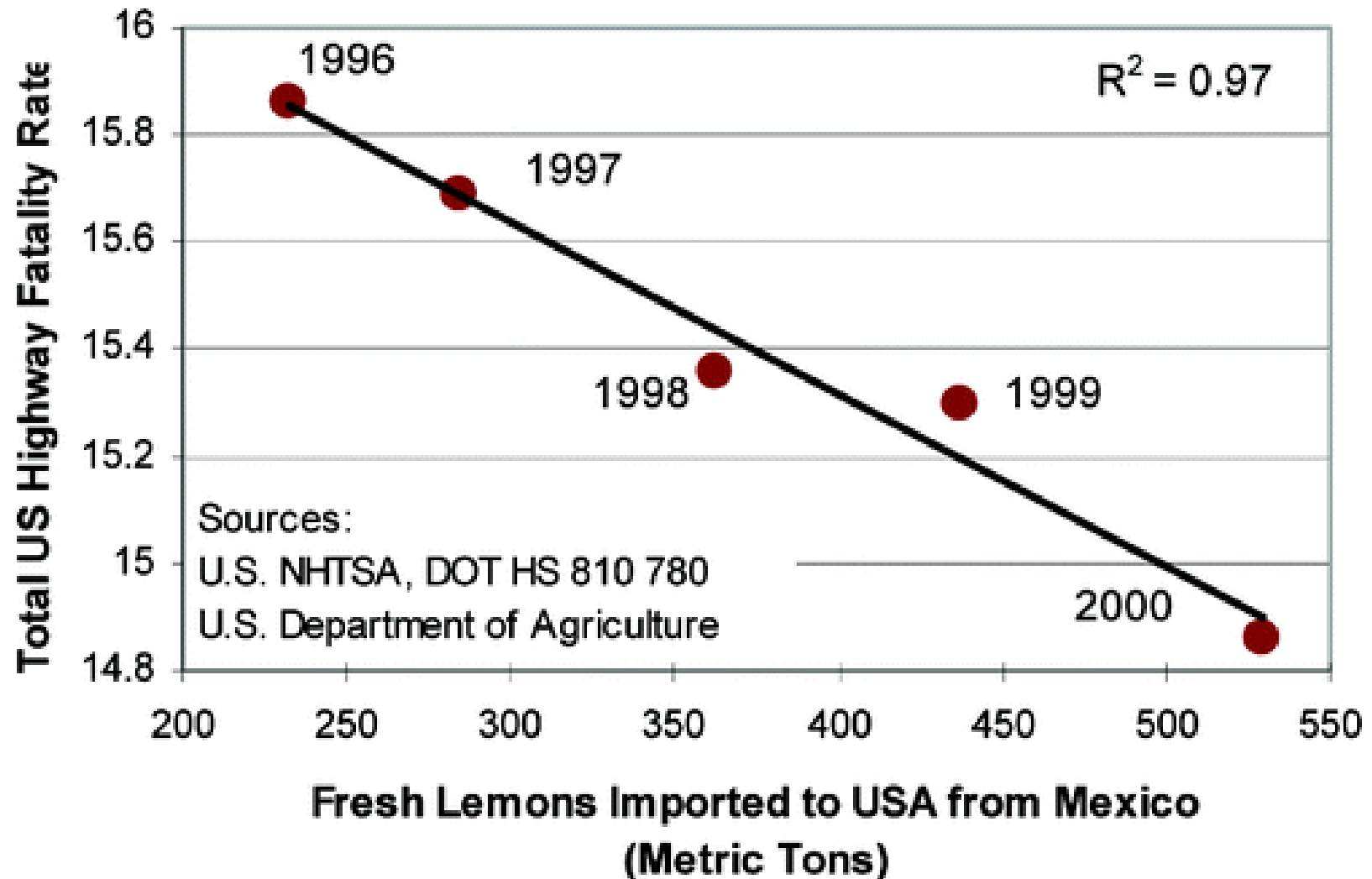
Associations may be useful in

- identifying causation
- making a prediction, a generalization or a specification.

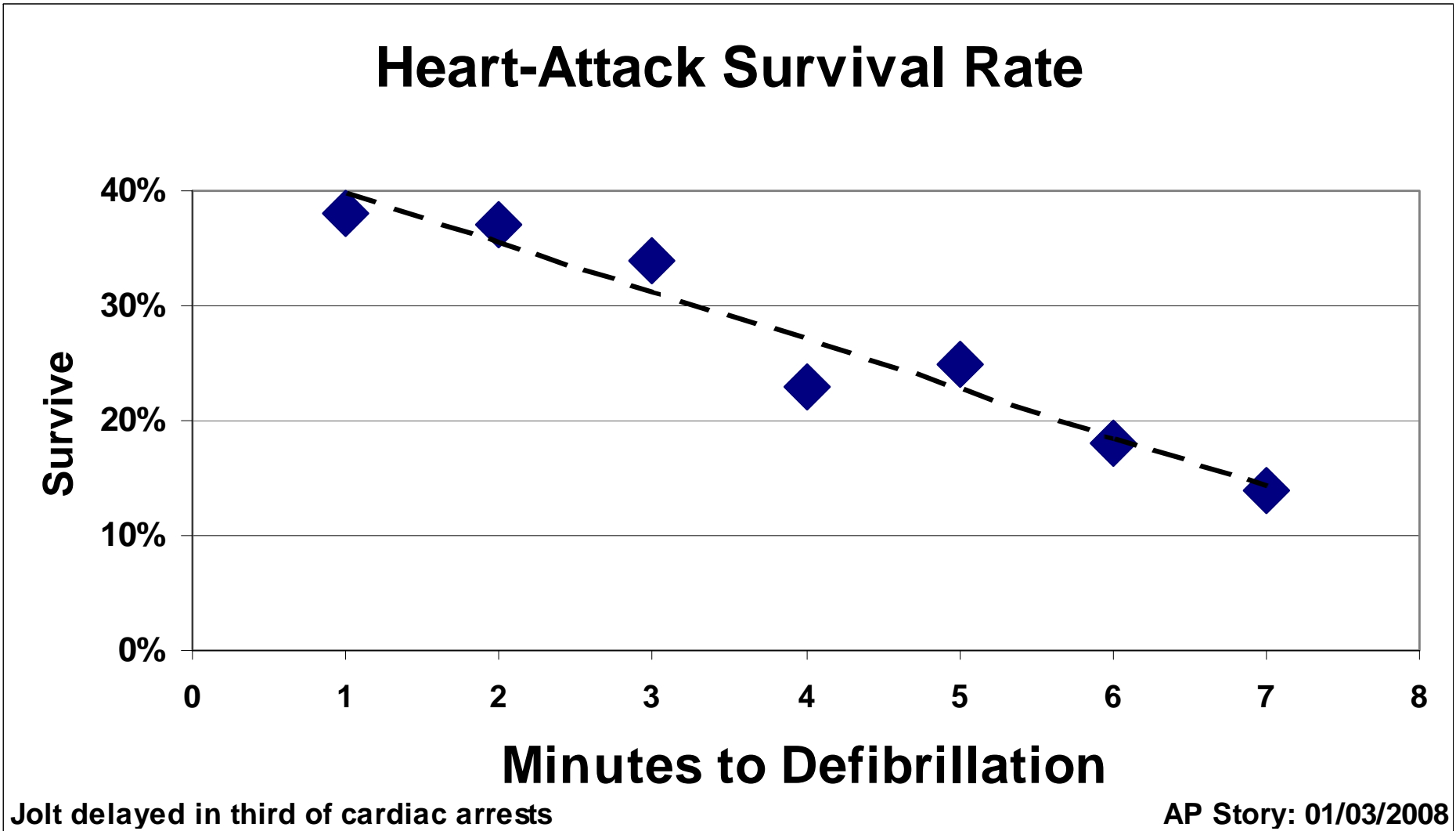
Statistical associations may be influenced by:

- Context: what is (and is not) taken into account
- Assembly: how things are defined or measured
- Randomness: coincidence or margin of error
- Error/bias: Subject, research or sampling bias

# 1a. Association is probably not Causation

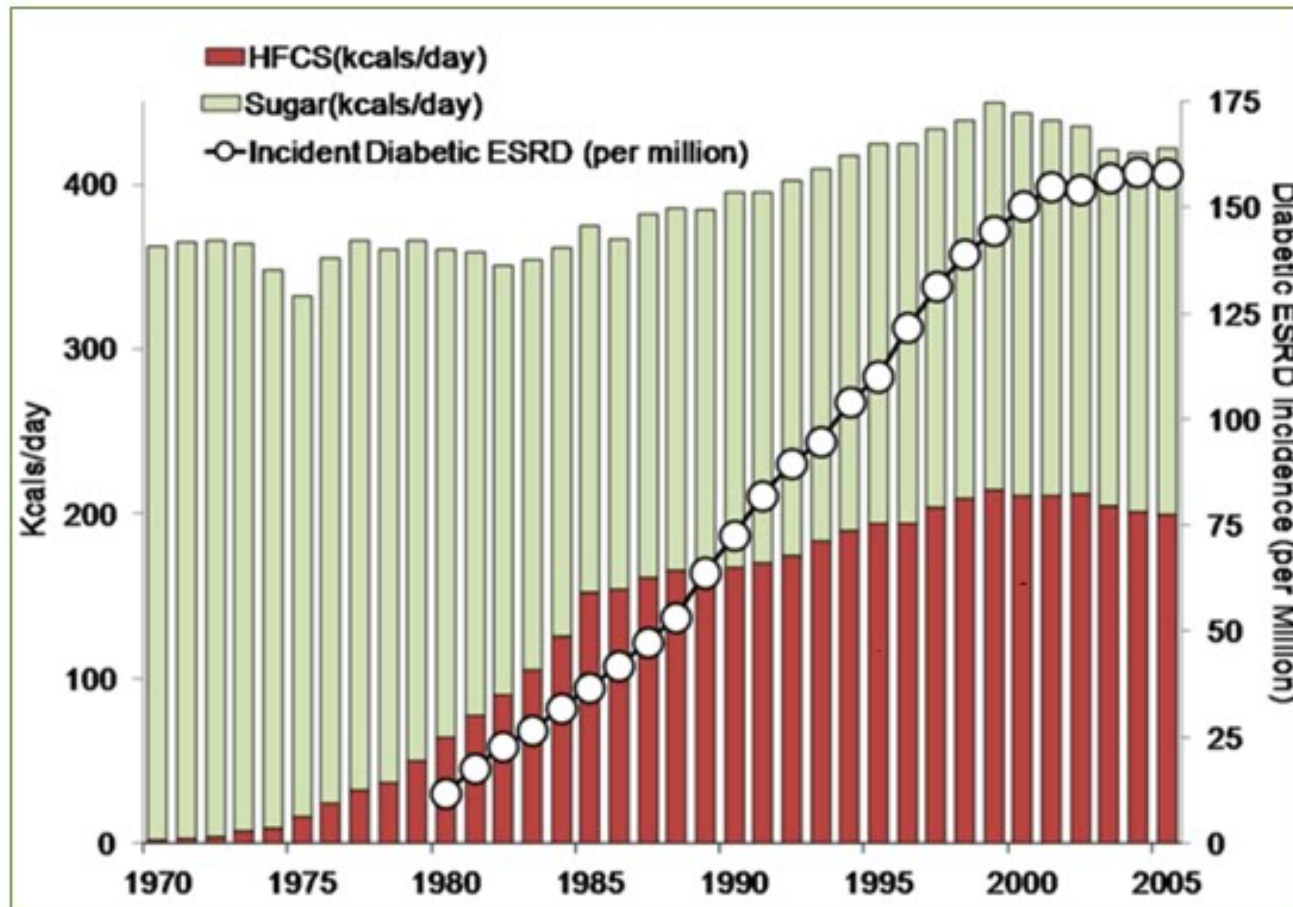


# 1b. Association is Probably Causation



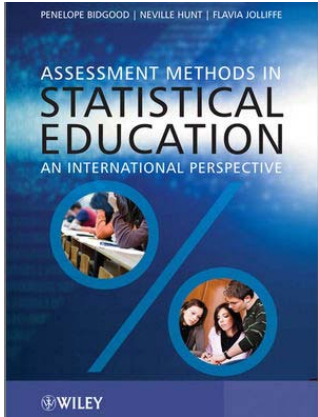


# 1c. Association is possibly a sign of Causation



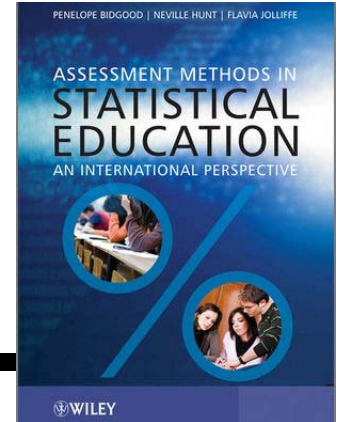
U.S. Trends in Total Sugar and High Fructose Corn Syrup (HFCS) availability, and Incident Diabetic End-Stage Renal Disease (ESRD)

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# Statistical Literacy

## Describing & Comparing

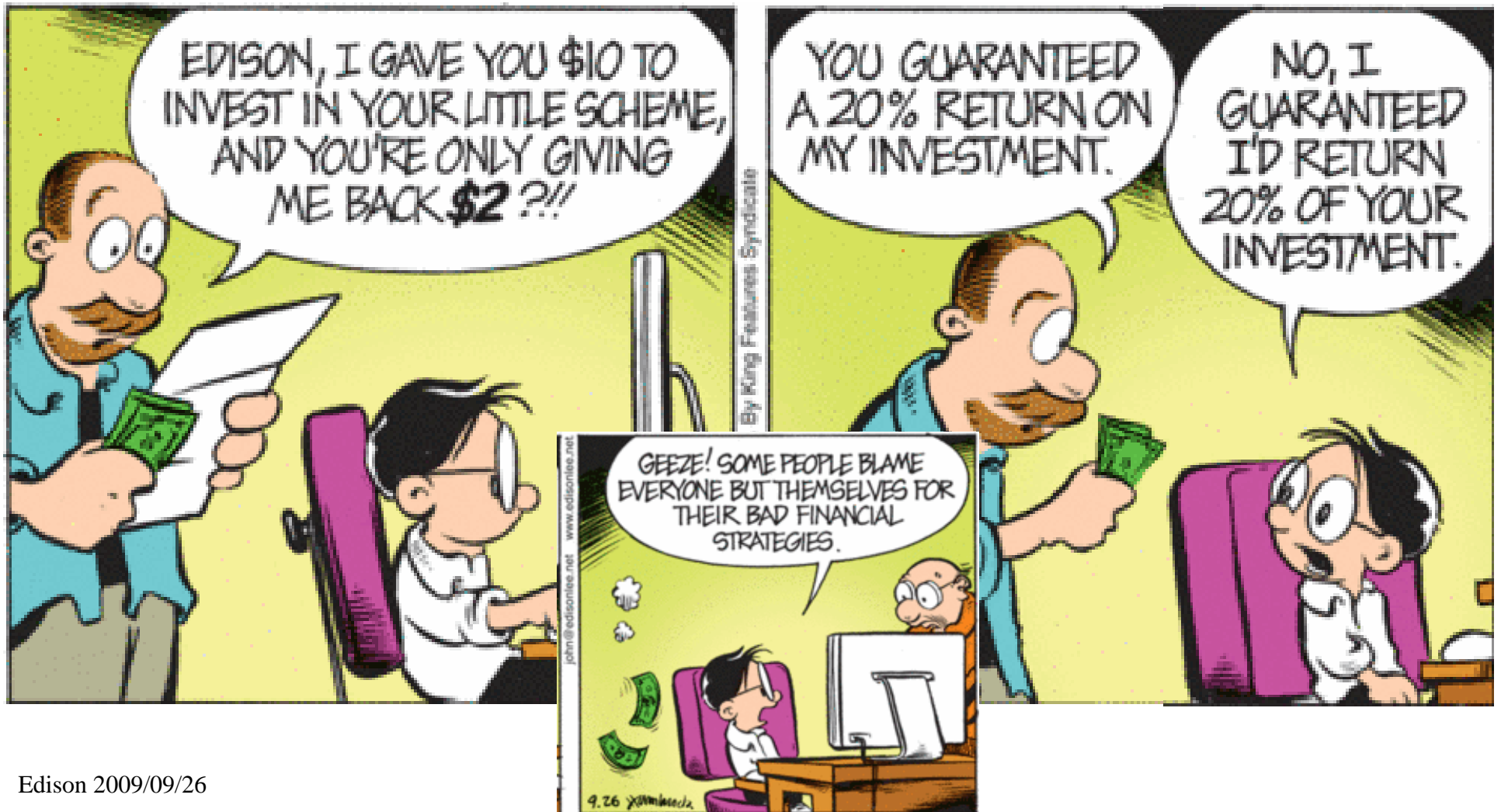


“Literacy” is a big idea in statistical literacy  
Must be able to describe and compare percentages  
and rates presented in tables and graphs.

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Is “*the percentage of men who smoke*” the same as  
“*the percentage of men among smokers*”? No  
If “*Smoking is more likely among women than  
men*” does this mean that “*Smokers are more  
likely to be women than men*”? No

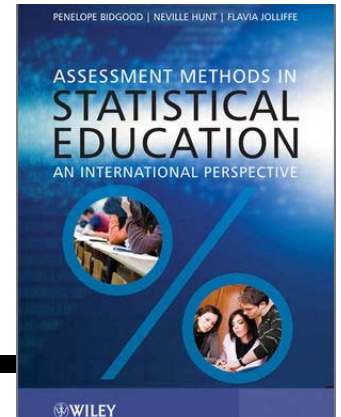
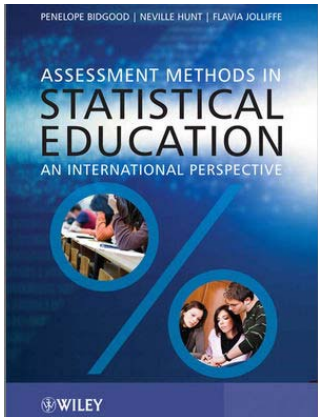
# Small Change in Syntax; Big Change in Semantics



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# StatLit: Take CARE

## Context & Confounding



“Confounding” is a big idea in Statistical Literacy.

Controlling for a confounder can influence:

- the size of rates, percentages and relative risks
- the percentage or # of cases attributed to X
- whether a difference is statistically Significant

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*Statistically-significant* differences can become *statistically insignificant* (and vice versa).

Intro statistics textbooks do NOT mention this!

# Reading Graphs

- a) 16% of employees who have taken office supplies for personal use earn less than \$25,000.
- b) 16% of employees who earn less than \$25,000 have taken office supplies for personal use.
- c) Graph is ambiguous.
- d) I can't tell.



## Size of a statistic depends on what is “taken into account”

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### State Prison Expense (1996)

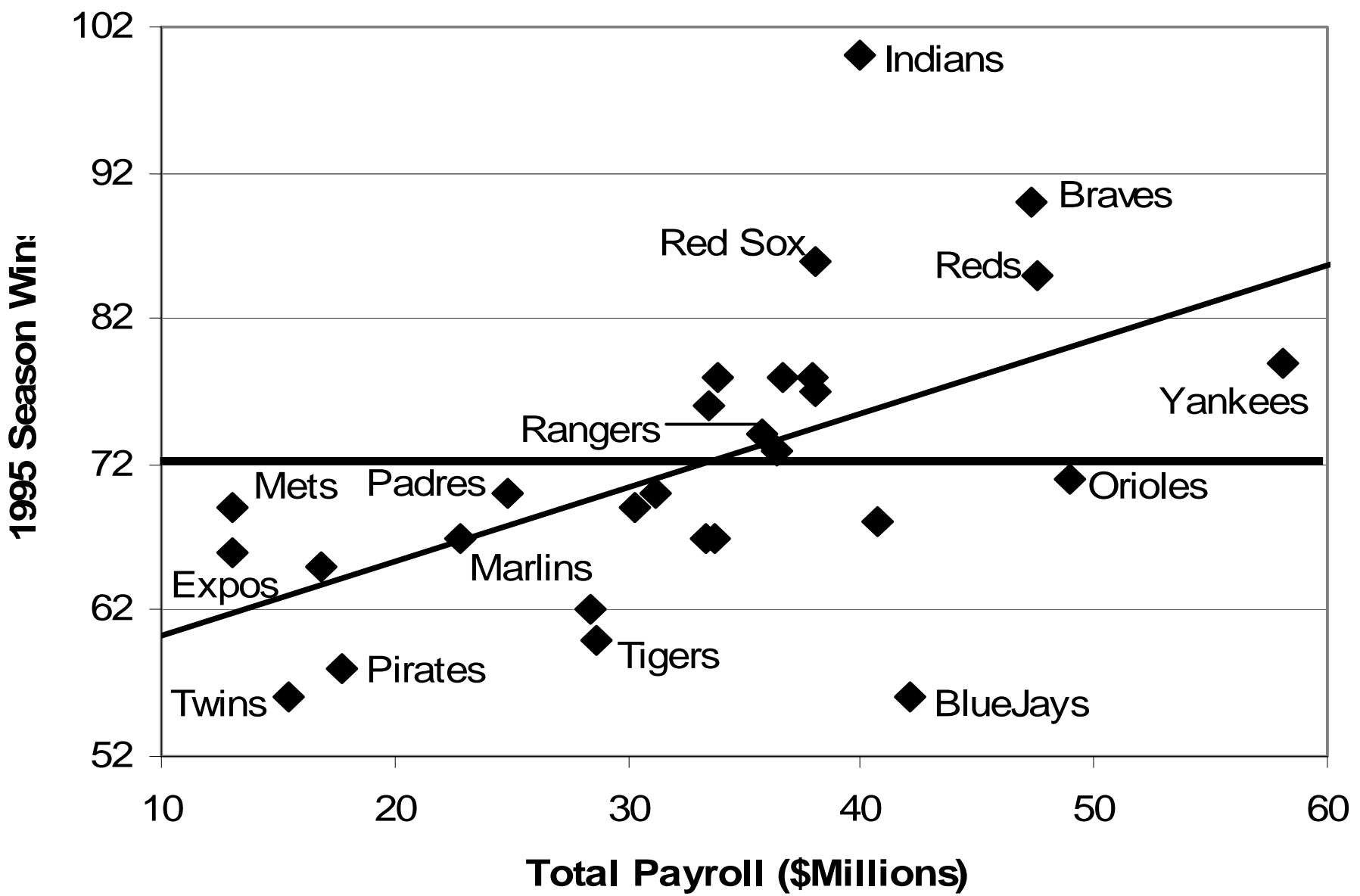
State	Total	Compare	Inmates	Per Inmate	Compare
MN	\$184M	27% more	4,865	\$37,825	56% more
IA	\$144M	12% less	5,929	\$24,286	36% less

State	Total	Compare	Inmates	per Inmate	Compare
CA	\$2.9B	50% more	136K	\$21,385	25% less
NY	\$1.9B	34% less	69K	\$28,426	33% more



# SEASON WINS vs. TOTAL PAYROLL

## US Major League Baseball





# US SAT-VERBAL SCORES

Average SAT-V	1981	2002	Change	1981	2002
All Test-Takers	504	504	0	100%	100%
White	519	527	8	85%	65%
Black	412	431	19	9%	11%
Asian	474	501	27	3%	10%
Mexican	438	446	8	2%	4%
Puerto Rican	437	455	18	1%	3%
American Indian	471	479	8	0%	1%

# Patient Death Rates

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City hospital has a higher death rate than Rural.

DEATH RATE		Patient Condition	
Hospital	Good	Poor	TOTAL
City	1.0%	6.0%	5.5%
Rural	2.0%	7.0%	3.5%
TOTAL	1.9%	6.3%	4.5%

After controlling for patient condition  
(compare within a given column),  
City hospital has a lower death rate than Rural.

## Death Rates per 10,000 Auto Accidents

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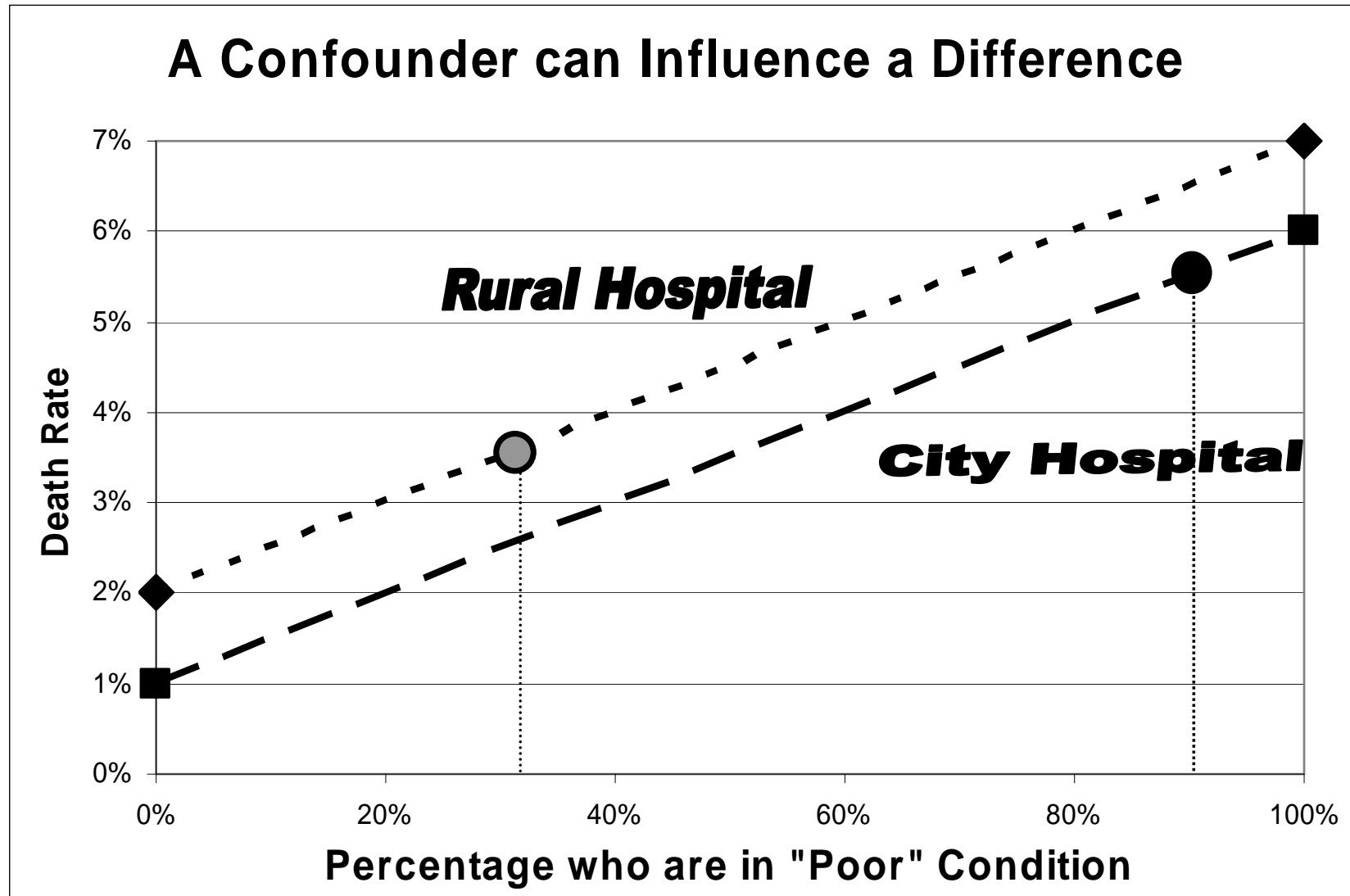
People in auto accidents are less likely to die if their car has an air bag.

	Seatbelt		
Airbag	No	Yes	Total
Yes	122	18	34
No	105	25	58
Total	111	21	45

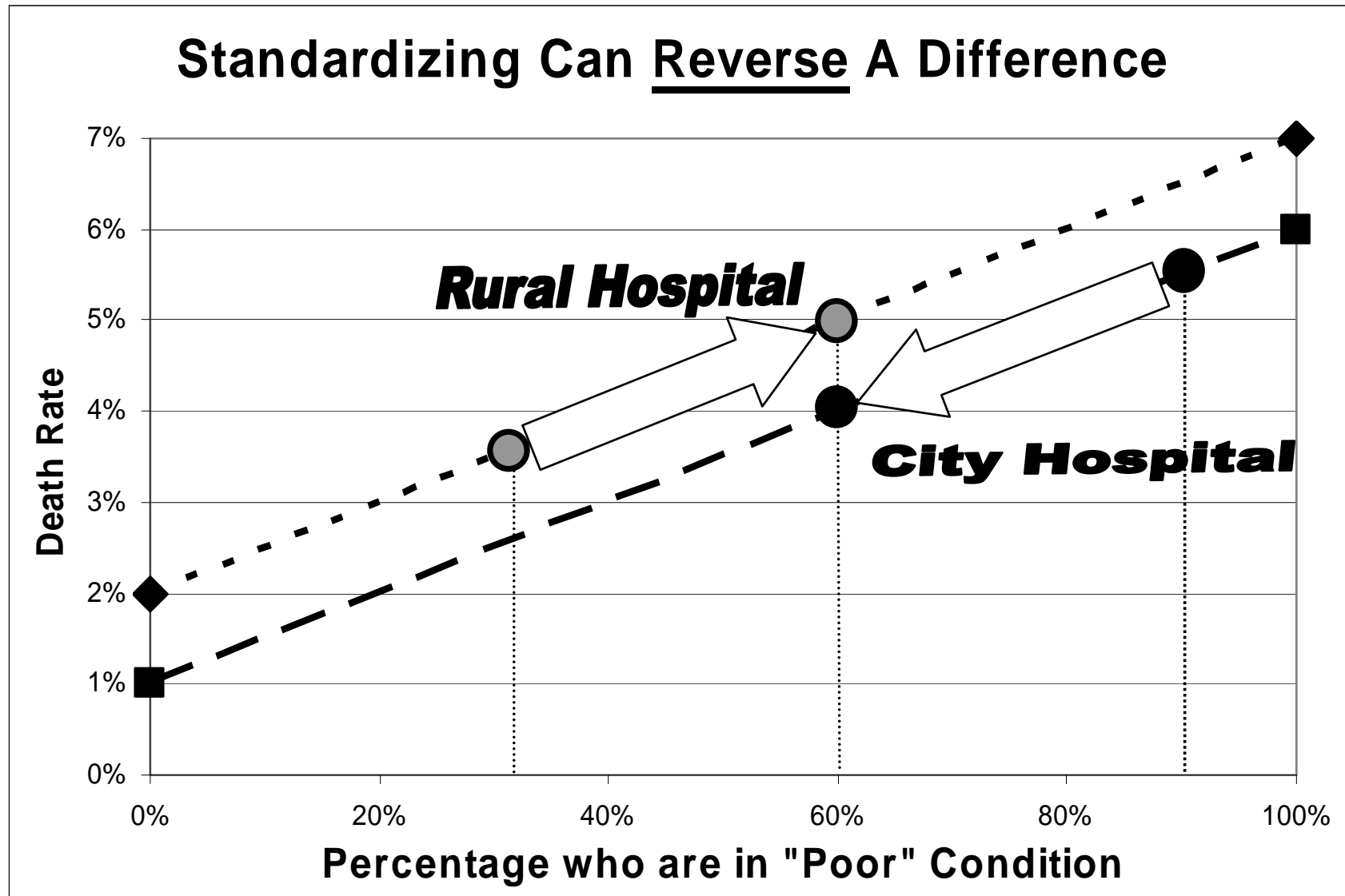
After controlling for the use of a seat belt (compare in a column), airbags make a “mixed” difference in survival compared to seat belts (compare in a row)

# Compare Hospital Death Rates

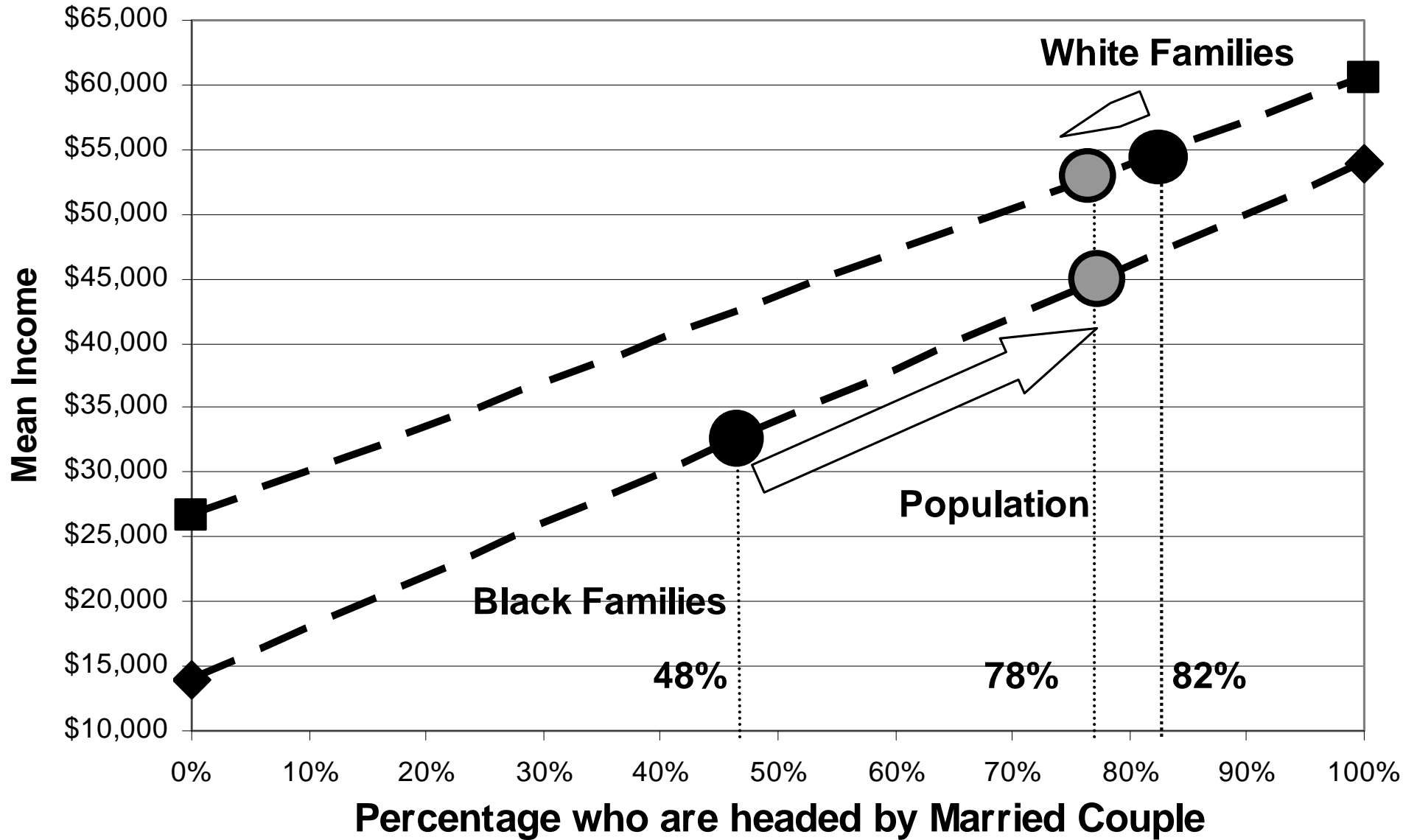
## Confounder: Patient Condition

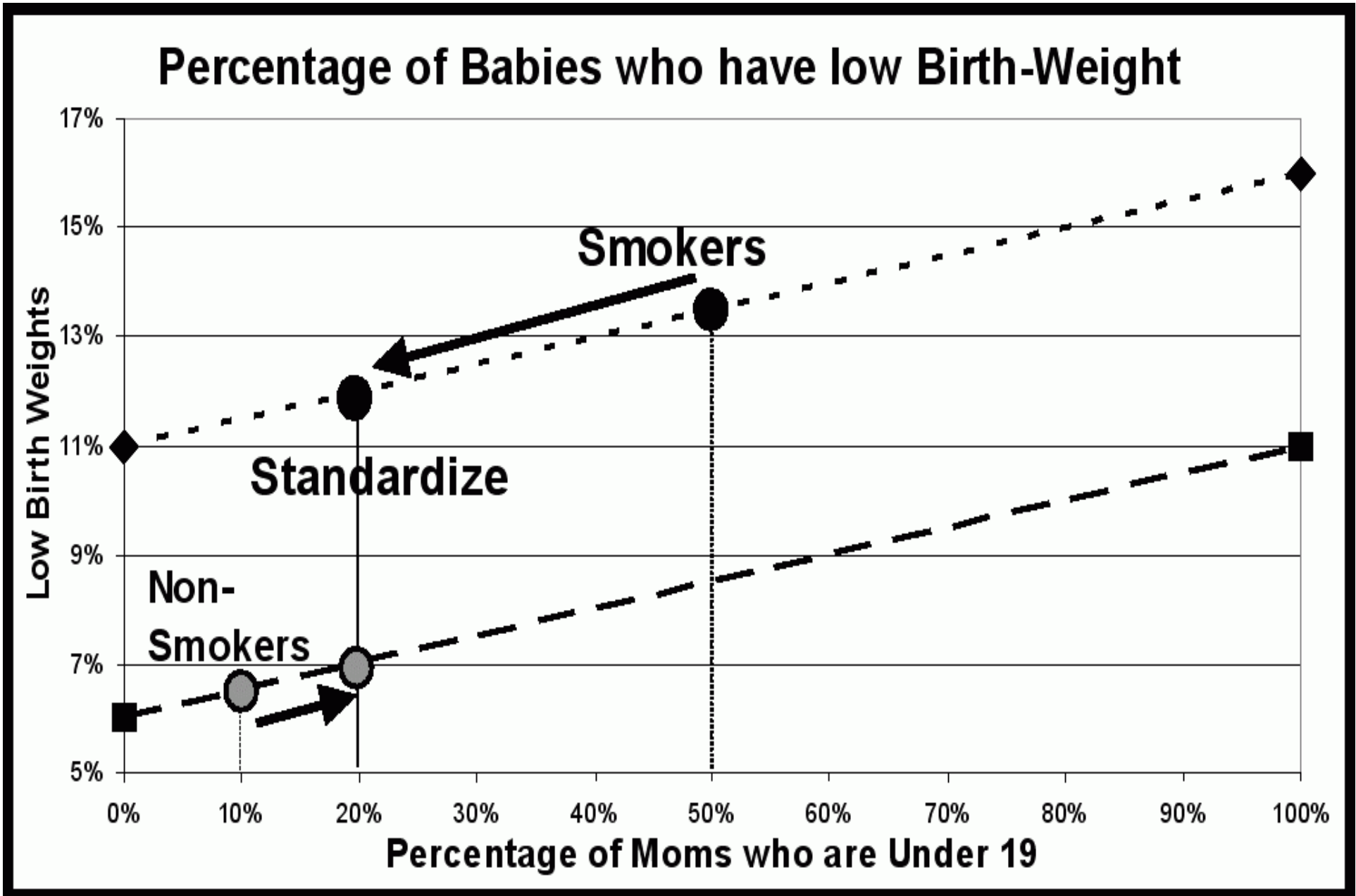


# Standardize on combined confounder percentage



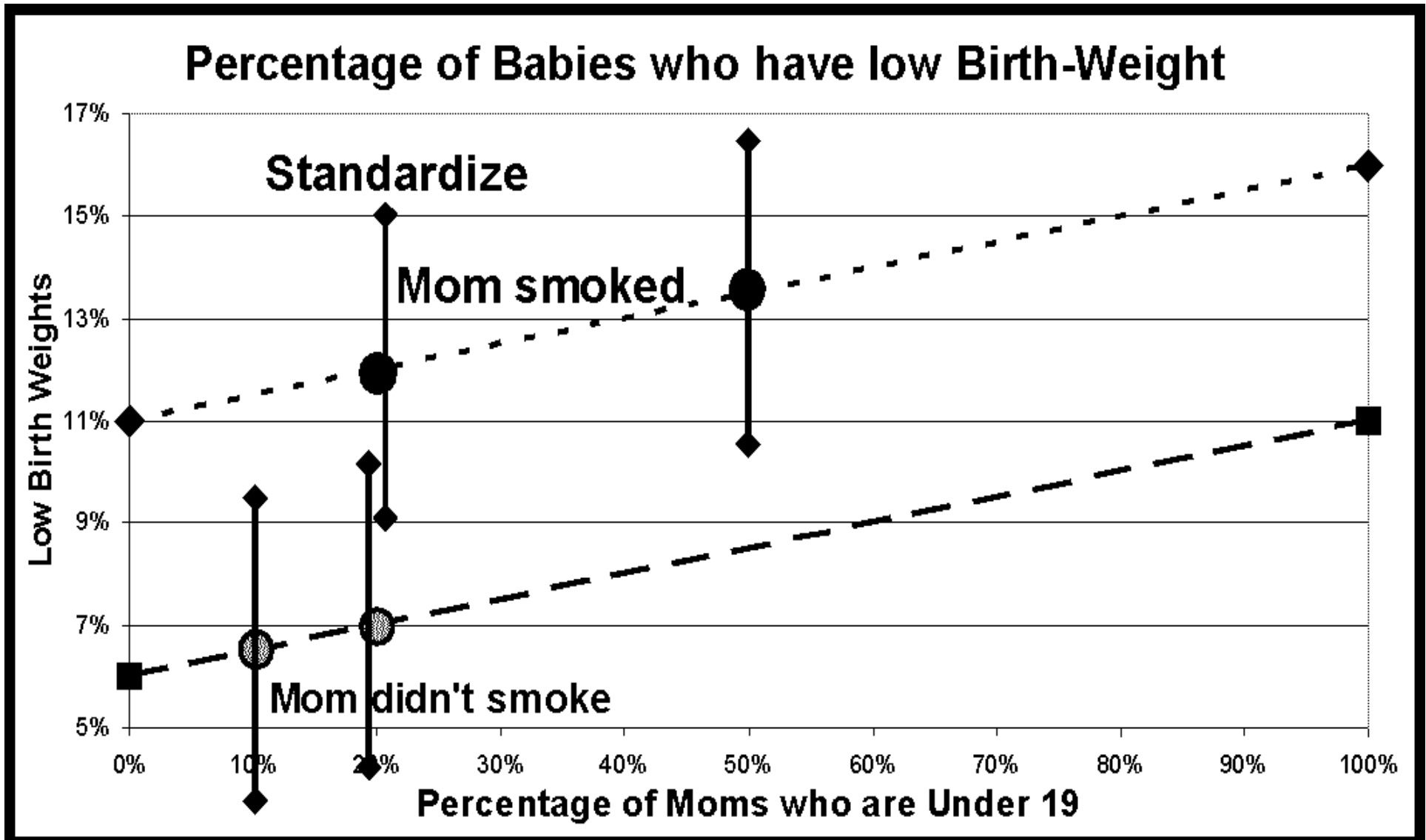
# Income: US Families by Race & Structure







# Controlling Can Change Statistical Significance



# Hyatt: Close to the US Capital



COURTESY OYSTER.COM

# StatLit: Take CARE

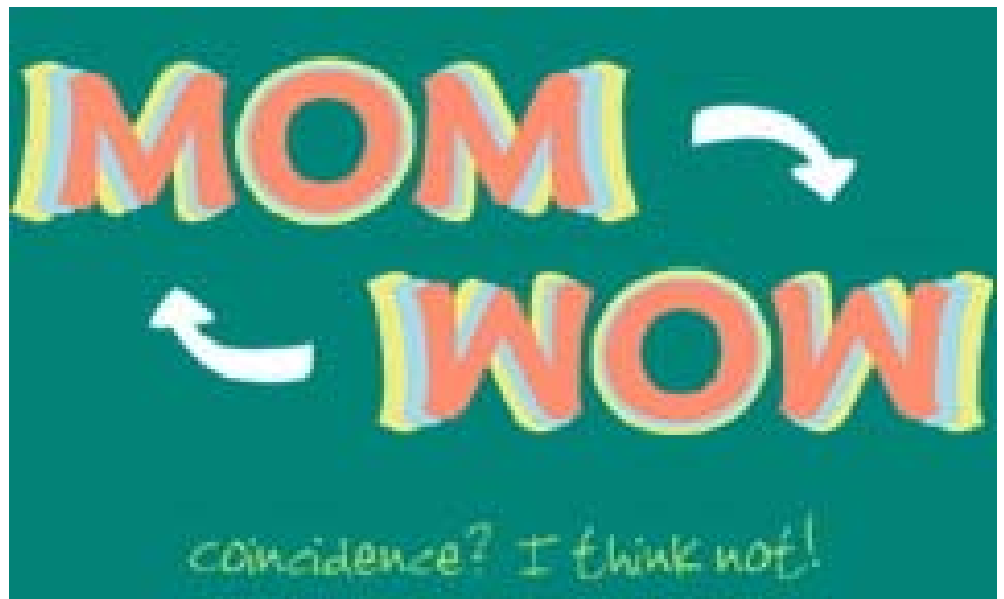
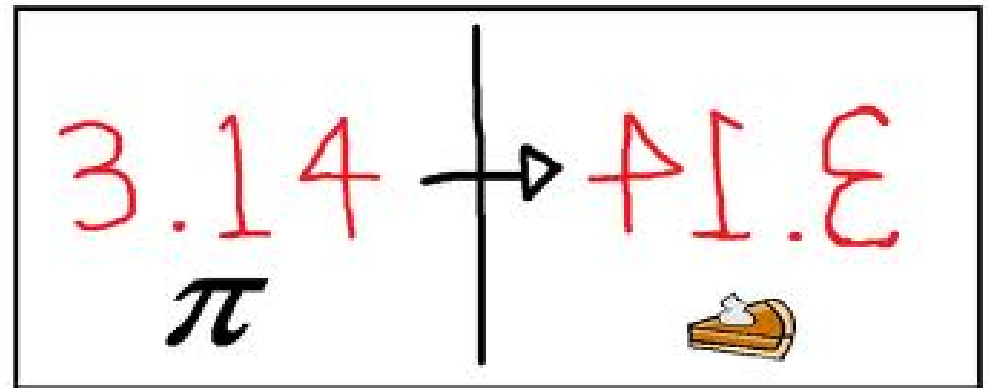
## Assembly

7 nanograms per gram = 7 parts in a billion





# Randomness: Coincidence?



# Seeing Coincidence

A3		=RANDBETWEEN(0,9)																																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	
1	Rice-10 sheet										<b>Find the largest group of high cells (red fill) that are touching each other.</b>																									
2	0 Low					9 High					a. touching on sides in a row										b. touching on sides (but not just on points)															
3	1	1	4	1	0	1	4	9	8	0	2	3	9	2	9	2	1	9	8	2	7	6	7	8	7	4	6	4	6	5	0	0	9	6	0	
4	7	9	8	8	8	2	5	2	7	8	6	0	8	6	7	1	8	6	6	6	6	5	6	8	7	8	9	9	7	5	8	0	5	0	7	
5	3	9	1	9	9	9	9	5	6	0	3	1	7	9	9	2	0	5	7	4	3	0	6	4	8	1	1	9	6	3	4	4	7	2	3	9
6	6	7	7	1	7	7	2	8	0	3	1	6	2	0	9	5	6	9	9	9	5	2	4	8	8	9	2	7	6	0	6	6	2	5	3	
7	4	5	5	2	5	2	3	0	8	9	3	9	4	8	0	7	1	3	6	9	6	1	9	0	0	8	2	4	8	0	0	6	5	9	2	
8	0	7	9	6	0	3	2	2	4	6	9	4	0	6	4	4	7	1	2	8	5	1	9	4	6	7	5	5	8	3	2	2	7	3	6	
9	0	3	8	5	2	0	6	2	7	7	7	9	4	7	7	6	8	4	0	1	0	3	0	8	6	7	4	0	3	3	4	9	4	9	0	
10	2	3	7	1	9	0	4	5	1	7	9	0	1	5	3	9	8	7	4	7	5	6	3	8	6	6	2	3	9	5	3	2	0	2	0	
11	8	1	8	2	3	7	5	7	6	6	8	4	8	0	8	1	4	8	1	5	7	1	2	3	6	1	3	0	7	5	1	4	7	2	1	
12	1	1	6	3	6	1	8	5	5	2	1	2	8	2	8	8	5	6	7	4	3	9	2	1	1	0	8	3	2	6	9	1	4	8	5	
13	7	6	6	5	4	6	5	2	9	0	3	9	9	5	9	4	5	8	2	5	3	8	9	6	6	0	0	2	7	1	2	9	4	0	6	
14	4	8	7	9	3	0	9	3	6	5	8	1	3	2	6	7	1	0	8	0	9	5	2	7	8	4	5	1	6	0	0	3	6	3	1	
15	2	5	9	3	8	0	2	7	0	1	3	8	0	6	7	9	3	2	5	3	0	8	4	1	9	2	3	0	5	0	9	6	9	3	1	
16	0	5	3	1	8	9	8	2	4	1	2	1	7	7	4	4	8	2	7	8	5	3	2	7	4	1	4	1	7	1	8	0	5	6	0	
17	9	6	8	4	6	4	3	8	5	2	9	5	4	8	8	1	9	1	8	6	8	0	3	8	3	9	9	1	5	6	5	2	4	5	6	
18	3	2	1	0	2	3	4	0	3	9	9	6	6	6	8	4	8	0	2	0	6	6	7	1	1	1	4	1	9	0	6	4	9	3	4	
19	7	4	7	9	9	7	1	1	3	7	9	3	1	6	9	0	0	3	9	9	3	0	6	6	9	2	4	0	3	5	0	5	1	4	0	
20	5	6	9	1	8	3	4	8	8	5	6	5	0	1	5	3	7	5	4	2	8	3	7	7	9	0	6	2	1	3	9	8	9	2	9	

**Flip 8 sets of 3 coins each [24 flips];  
A run of three heads is “expected”**

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Chance of 3 heads: one chance in eight.

1	2	3				1	2	3
1	2	3				1	2	3
1	2	3				1	2	3
1	2	3				1	2	3

# Run of at least three heads: “Expected” in 10 flips of fair coin

	A	B	C	D	E	F	G	H	I	J	K	L
1	<b>Run of 3 heads (1 chance in 8) is "expected" in 10 flips of a fair coin.</b>										Schild (2012) V1	
2	• Coin	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
3	<b>RUN</b>											
4	<b>3</b>	1	1	1	0	0	1	1	0	0	1	
5												
6	<b>3</b>	1	1	1								Set #1
7												
8	<b>2</b>		1	1	0							Set #2
9												
10	<b>1</b>			1	0	0						Set #3
11												
12	<b>1</b>				0	0	1					Set #4
13												
14	<b>2</b>					0	1	1				Set #5
15												
16	<b>2</b>						1	1	0			Set #6
17												
18	<b>1</b>							1	0	0		Set #7
19												
20	<b>1</b>								0	0	1	Set #8
21	<b>Distribution of longest run in a set of 3</b>											
22	Longest Run	0	1	2	3							
23	Actual #	0	4	3	1							
24	Pctg of 8	0.0%	50.0%	37.5%	12.5%							

Key is “Overlap”



## What is the chance of “that”?

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This question is ambiguous – underspecified!!!

Q1. What is chance of 3 heads in the next 3 flips?

A1. One chance in 8 (12.5%)

Q2. What is the chance of a run of at least 3 heads somewhere in a string of 10 flips?

A2. About 50%.

# StatLit: Take CARE

## Error/Bias

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Suppose that men make a third more income than women for the same job.

Is any of this difference due to bias?

- Lying or “reaching” by men. Rounding up. Including anticipated bonus/raise.
- Conservatism by women. Rounding down. Quoting regular pay or even take-home pay.

# **Conclusion #1**

## **Most students are statistically illiterate**

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They don't believe that taking into account a related factor can change an association.

They can't see why coincidences are common. They can't read tables or graphs. They can't describe and compare rates and percentages.

They can't think hypothetically about what might have influenced an association.

They don't see how definitions affect numbers.

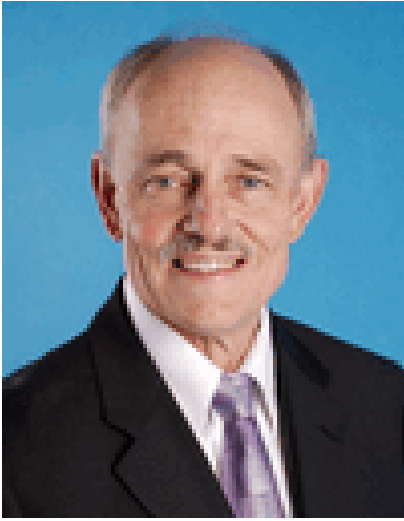
## **Offer Statistical Literacy**

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High-school math teachers should consider offering a course in statistical literacy for students interested in non-quantitative majors in college.

Focus on numbers in the news. Focus on context and confounding.

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## Importance of Statistical Literacy

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*I've been increasingly impressed by how important statistical literacy has become for all of us around the globe.*

*Statistical literacy has risen to the top of my advocacy list, right alongside numeracy, and perhaps even ahead of "algebra for all."*

**J. Michael Shaughnessy, NCTM President**

[www.StatLit.org/pdf/2010Shaughnessy-StatisticsForAll-NCTM.pdf](http://www.StatLit.org/pdf/2010Shaughnessy-StatisticsForAll-NCTM.pdf)

# Teacher Training

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To learn more about statistical literacy, go to [www.StatLit.org](http://www.StatLit.org): Google rated #1 for 7 years.

Take the online teacher-training program. This program combines Moodle exercises with a unique anonymous web forum. For details, see [www.StatLit.org/pdf/2011SchieldNNN.pdf](http://www.StatLit.org/pdf/2011SchieldNNN.pdf)

For more information on the 2012 online summer course, contact [Schield@Augsburg.edu](mailto:Schield@Augsburg.edu)

# References

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