Statistical Literacy: Confounding

MILO SCHIELD,
Augsburg College
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Vice President, National Numeracy Network
US Rep., International Statistical Literacy Project

January 13, 2011
University of Texas San Antonio (UTSA)
Slides at www.StatLit.org/pdf/2011-Schield-UTSA-Confounding-Slides.pdf

Statistical Literacy

Statistical literacy is **the ability to read and interpret summary statistics in everyday life**.

Statistical Literacy studies

(1) the relation between statistical associations and causation, and

(2) the full-range of influences on a statistic or on a statistical association. [Take CARE]

Take CARE: Context

The influence of factors **taken into account by**

- data broken out by subgroups in tables and graphs
- averages, ratios and comparisons of averages and ratios
- epidemiological models (cf., deaths attributed to obesity)
- regression models and
- the study design (cf., longitudinal vs. cross-sectional; experiment vs. observational study).

The influence of related factors (confounders)
not taken into account in the study and
not blocked by the study design.

Controlling for a confounder can DECREASE an association

MN has 3.8 times as much prison expense as ME

State	Total	# Inmates	Per Inmate
MN	$184M	4,865	$37,825
ME	$48M	1,424	$33,711

MN has 3.4 times as many inmates as ME

MN has 25% more prison expense *per inmate* than ME

Controlling for a confounder can NULLIFY an association

MD has 3 times as much prison expense as KS

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CA has almost twice as many inmates as NY

CA has 25% less prison expense *per inmate* than NY

2011 7

Controlling for a confounder can INCREASE an association

MN has 27% more prison expense than IA

State	Total	# Inmates	Per Inmate
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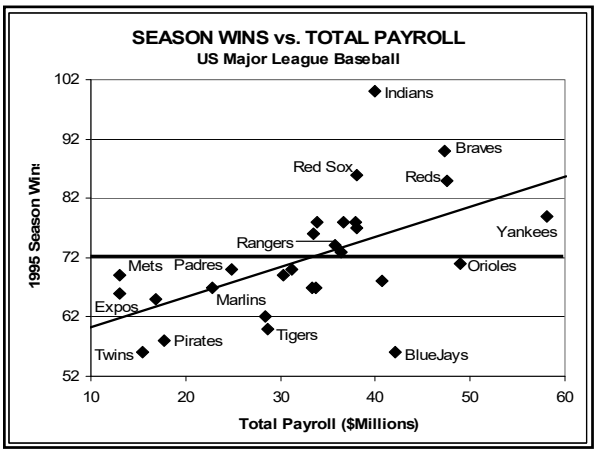
IA	$144M	5,929	$24,286

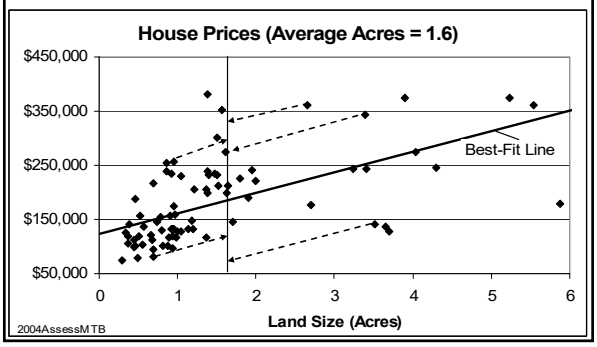
MN has 18% fewer inmates than IA

MN has 56% more prison expense *per inmate* than IA



2011 9

Adjusting for Land Size: Standardize on Average Lot



2011 10

SAT VERBAL SCORES: FLAT

GROUP	1981	2002	CHANGE
White	519 (85%)	527 (65%)	8
Black	412 (9%)	431 (11%)	19
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ALL Test takers	**504** (100%)	**504** (100%)	**ZERO**

2011 11

Multivariate Analysis can be Complex

To simplify, consider cases with
- a binary outcome,
- a binary predictor and
- a binary confounder.

What are the necessary conditions for nullification or a reversal?

See Schield (1999) and Schield and Burnham (2003)

2011 12

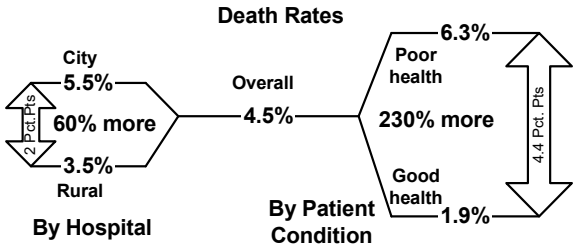
City Hospital: Hospital of Death??

Hospital	Total	Died	Death Rate
City	1,000	55	5.50%
Rural	1,000	35	3.50%
Both	2,000	90	4.50%

Condition	Total	Died	Death Rate
Good	800	15	1.90%
Poor	1,200	75	6.30%

2011 13

Can this confounder nullify or reverse this association?



2011 14

Confounder Reverses; City Hospital is Better

Condition	Hospital	Total	Died	Death Rate
Good	City	100	1	1.00%
	Rural	700	14	2.00%
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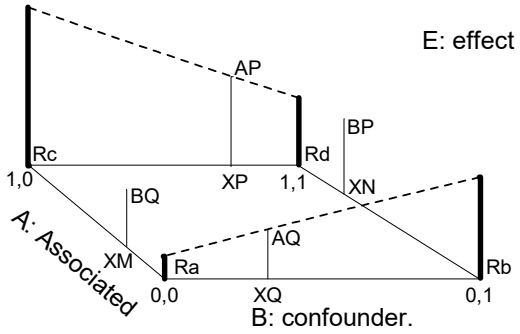
	Rural	300	21	7.00%
	Total	1,200	75	6.30%

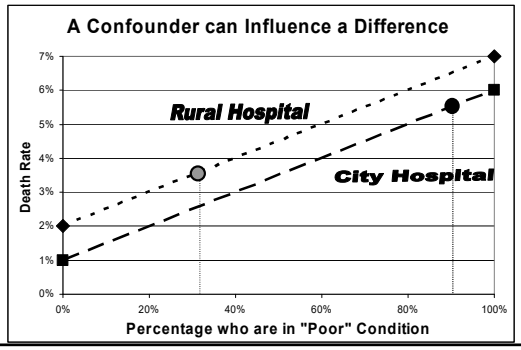
2011 15

Two-Group Rates with a Binary Confounder



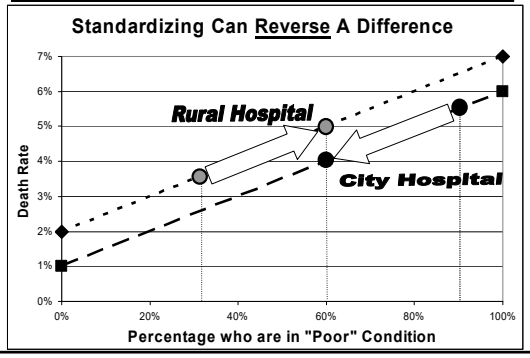
2011 16

Compare Hospital Death Rates Confounder: Patient Condition

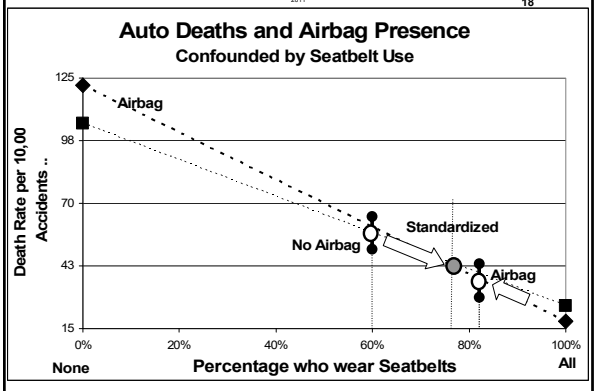


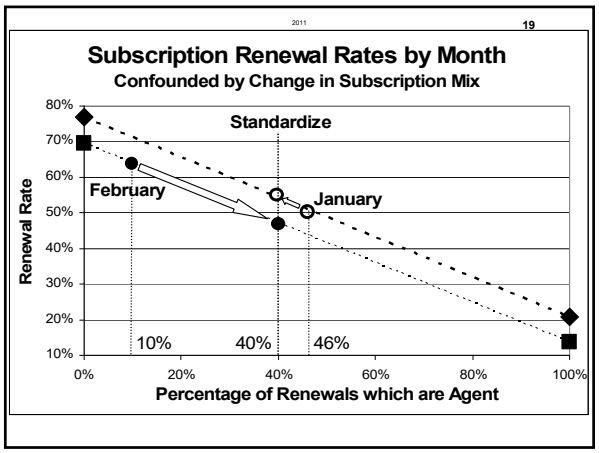
2011 17

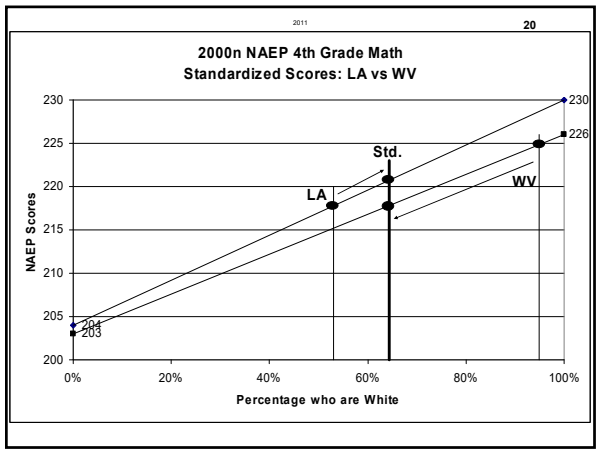
Standardize on combined confounder percentage

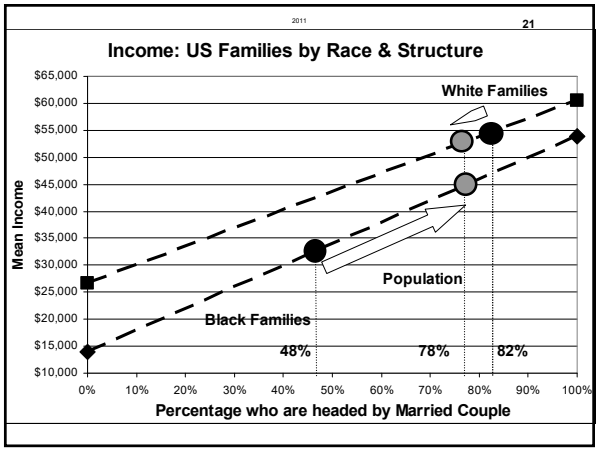


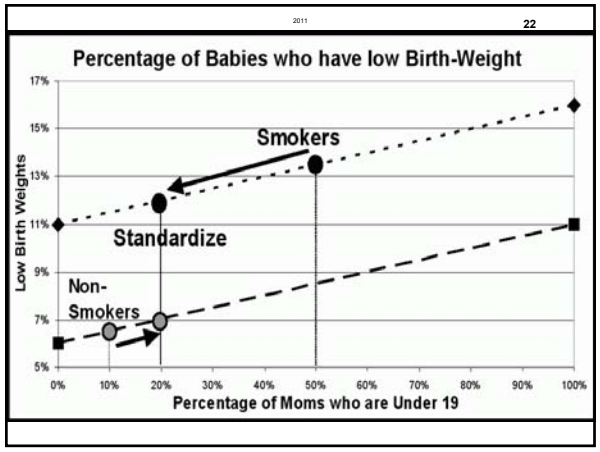
2011 18

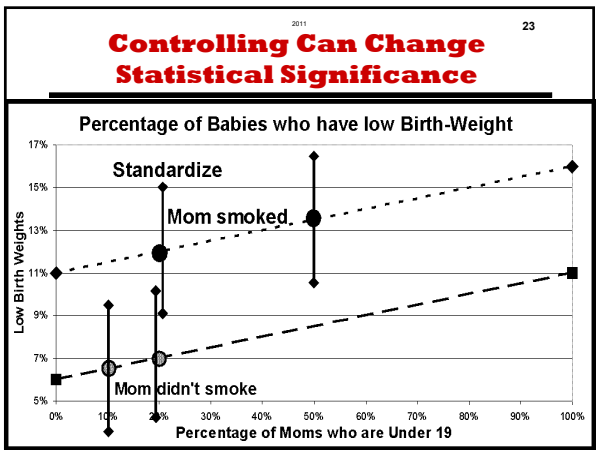


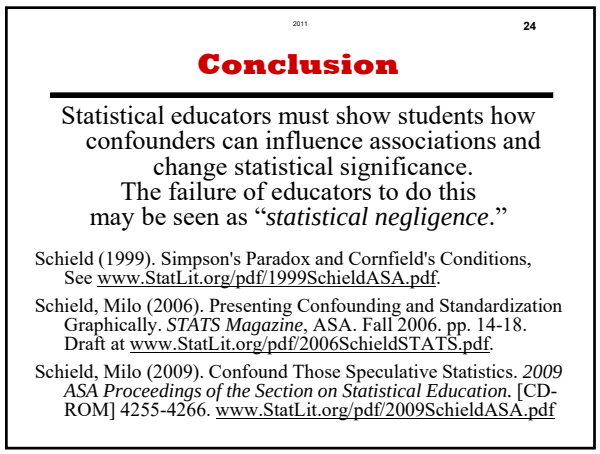

2011
19
Subscription Renewal Rates by Month
Confounded by Change in Subscription Mix
Standardize
February
January
Renewal Rate
80%
70%
60%
50%
40%
30%
20%
10%
10%
40%
46%
0%
20%
40%
60%
80%
100%
Percentage of Renewals which are Agent


2011
20
2000n NAEP 4th Grade Math
Standardized Scores: LA vs WV
NAEP Scores
230
225
220
215
210
205
200
230
226
Std.
LA
WV
204
203
0%
20%
40%
60%
80%
100%
Percentage who are White


2011
21
Income: US Families by Race & Structure
White Families
Mean Income
$65,000
$60,000
$55,000
$50,000
$45,000
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
Population
Black Families
48%
78%
82%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage who are headed by Married Couple


2011
22
Percentage of Babies who have low Birth-Weight
Smokers
Low Birth Weights
17%
15%
13%
11%
9%
7%
5%
Standardize
Non-
Smokers
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Moms who are Under 19


2011
23
Controlling Can Change
Statistical Significance
Percentage of Babies who have low Birth-Weight
Standardize
Mom smoked
Low Birth Weights
17%
15%
13%
11%
9%
7%
5%
Mom didn't smoke
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Moms who are Under 19


2011
24
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The failure of educators to do this may be seen as "*statistical negligence*."
Schield (1999). Simpson's Paradox and Cornfield's Conditions, See www.StatLit.org/pdf/1999SchieldASA.pdf.
Schield, Milo (2006). Presenting Confounding and Standardization Graphically. *STATS Magazine*, ASA. Fall 2006. pp. 14-18. Draft at www.StatLit.org/pdf/2006SchieldSTATS.pdf.
Schield, Milo (2009). Confound Those Speculative Statistics. *2009 ASA Proceedings of the Section on Statistical Education*. [CD-ROM] 4255-4266. www.StatLit.org/pdf/2009SchieldASA.pdf

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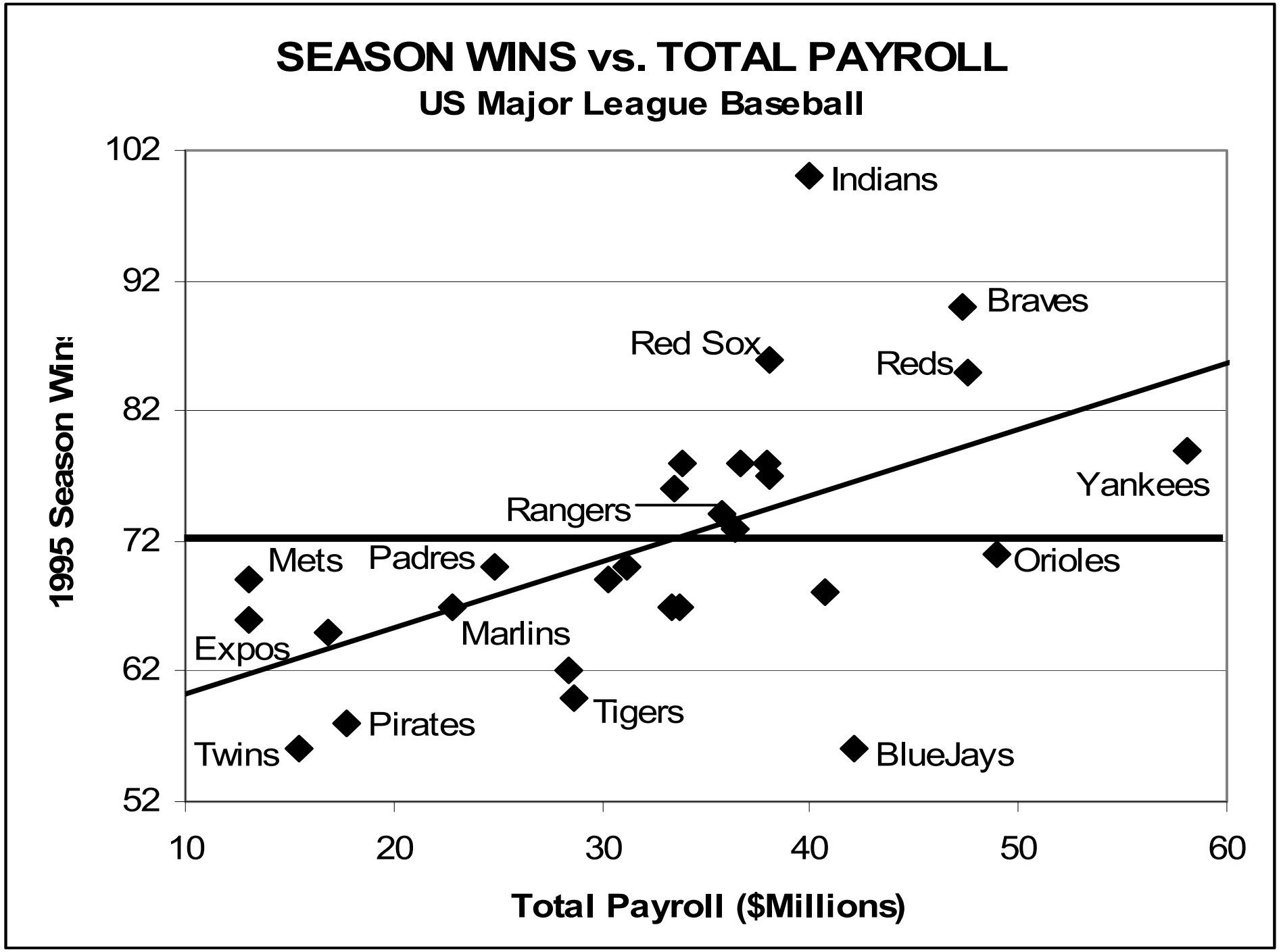
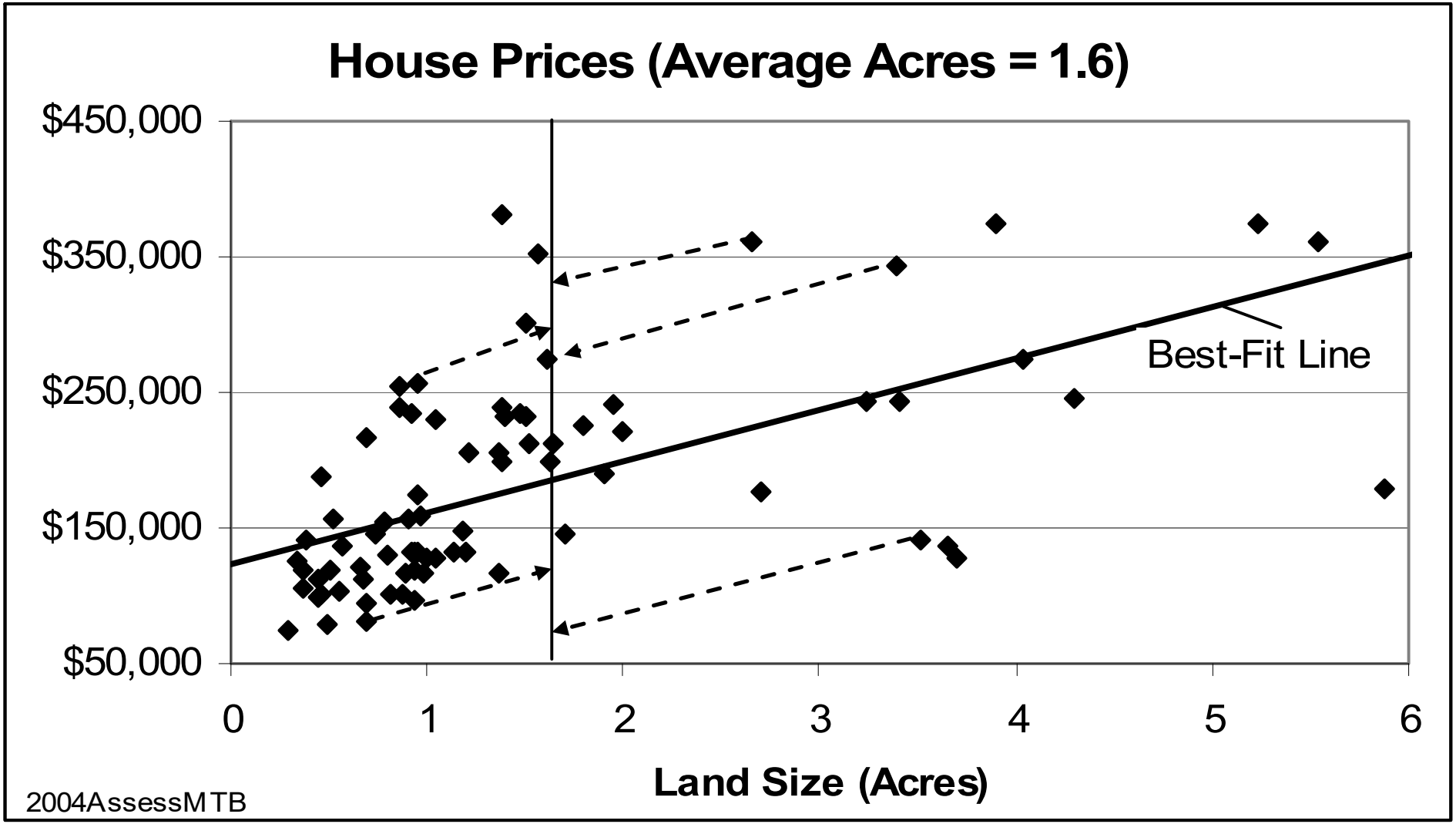

SEASON WINS vs. TOTAL PAYROLL
US Major League Baseball
1995 Season Wins
102
92
82
72
62
52
10
20
30
40
50
60
Total Payroll ($Millions)
Indians
Braves
Red Sox
Reds
Yankees
Rangers
Mets
Padres
Orioles
Expos
Marlins
Tigers
Pirates
Twins
BlueJays

Adjusting for Land Size: Standardize on Average Lot



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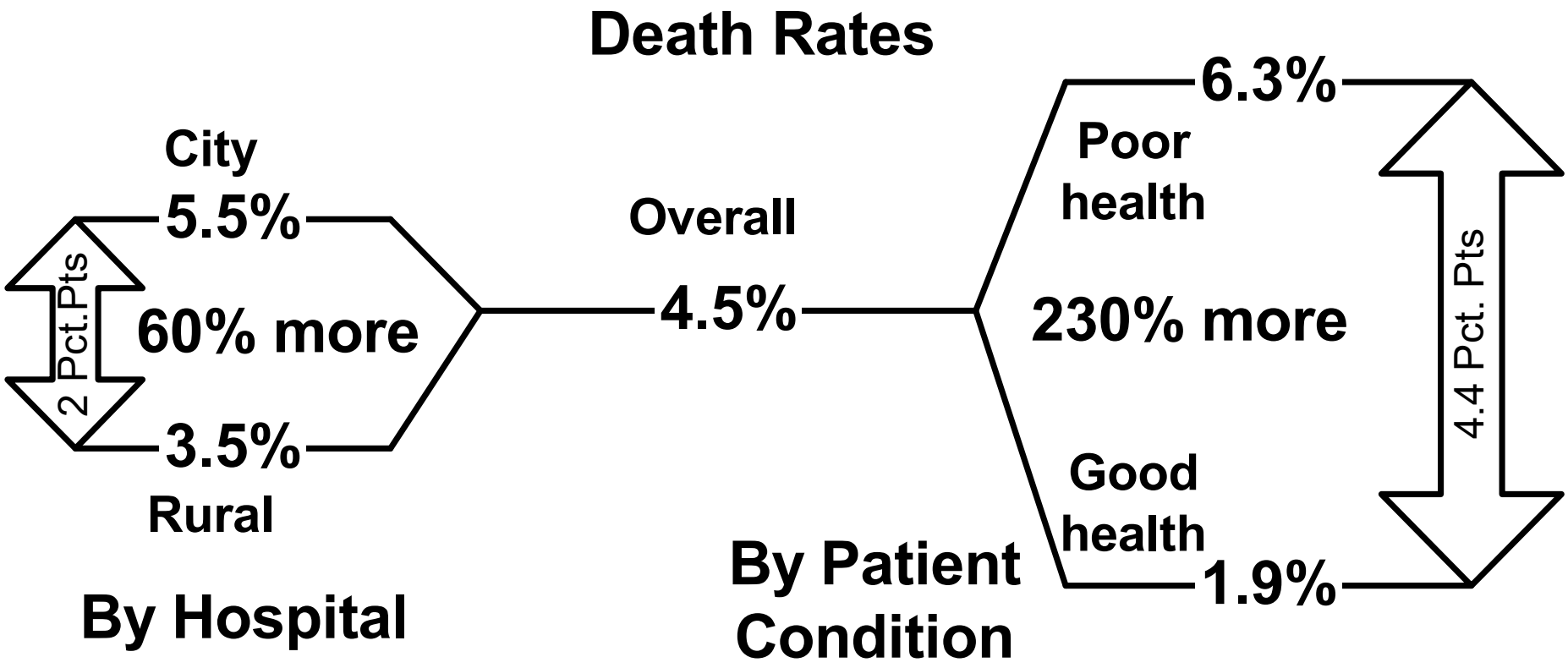

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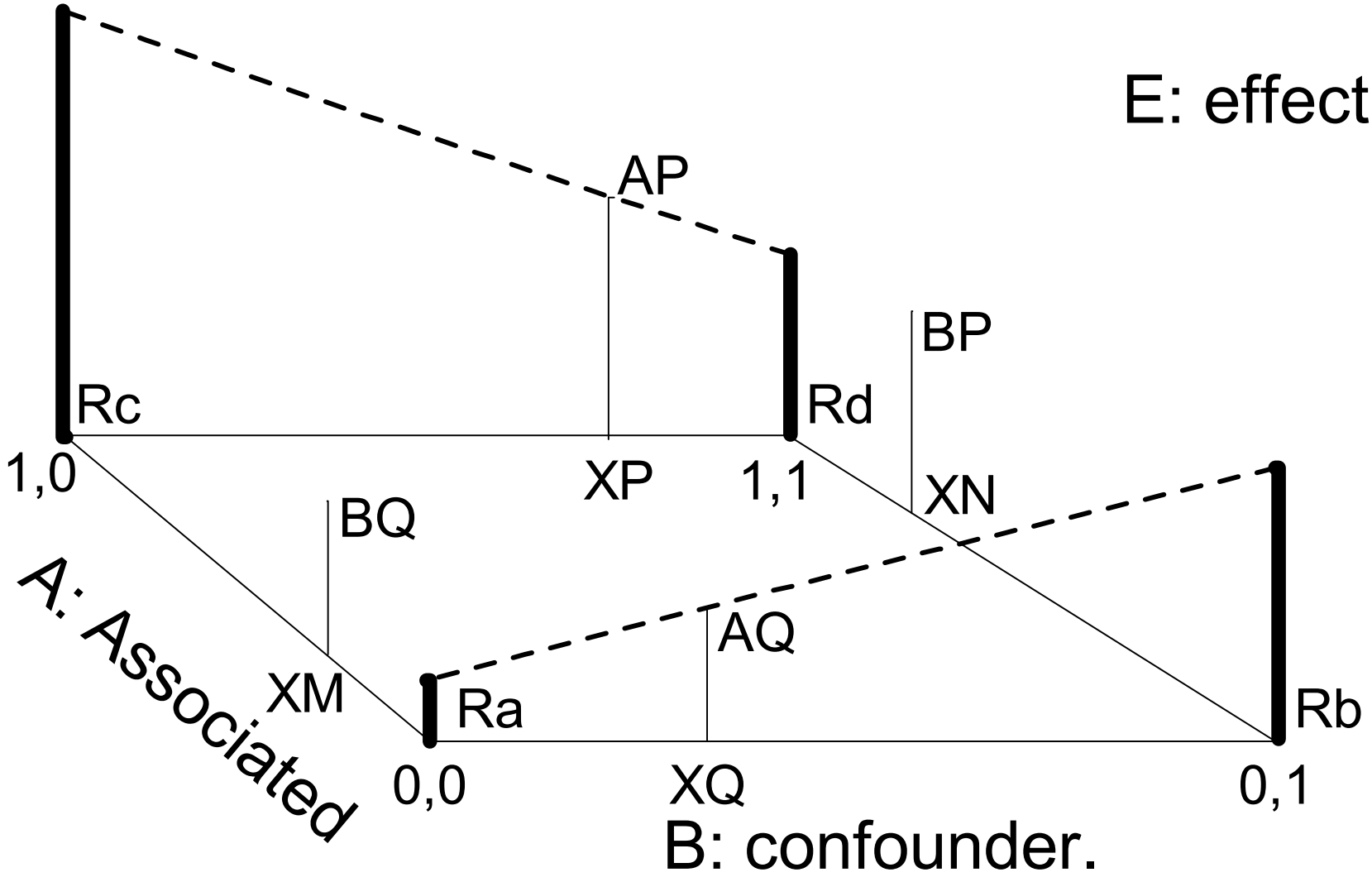
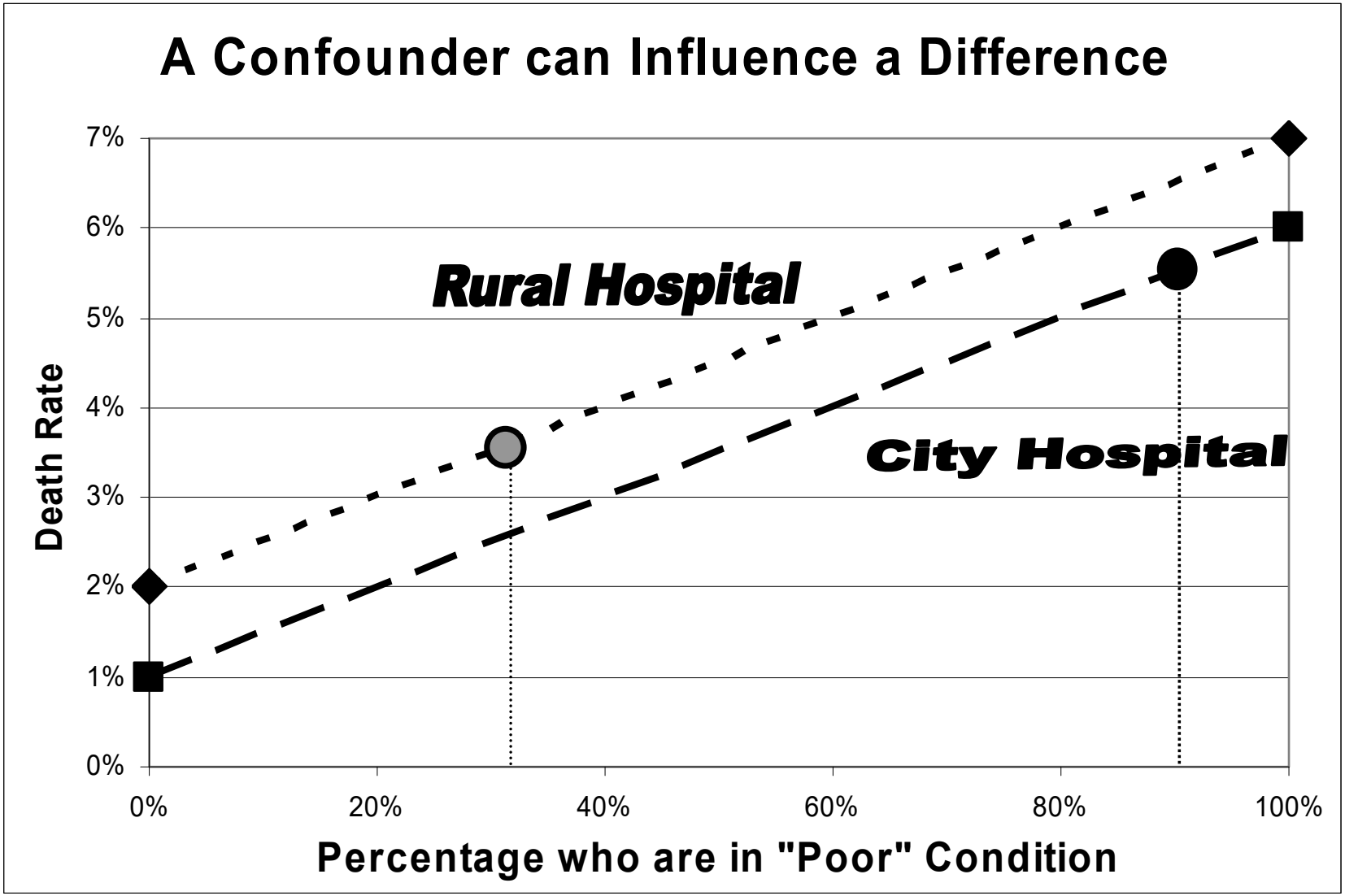
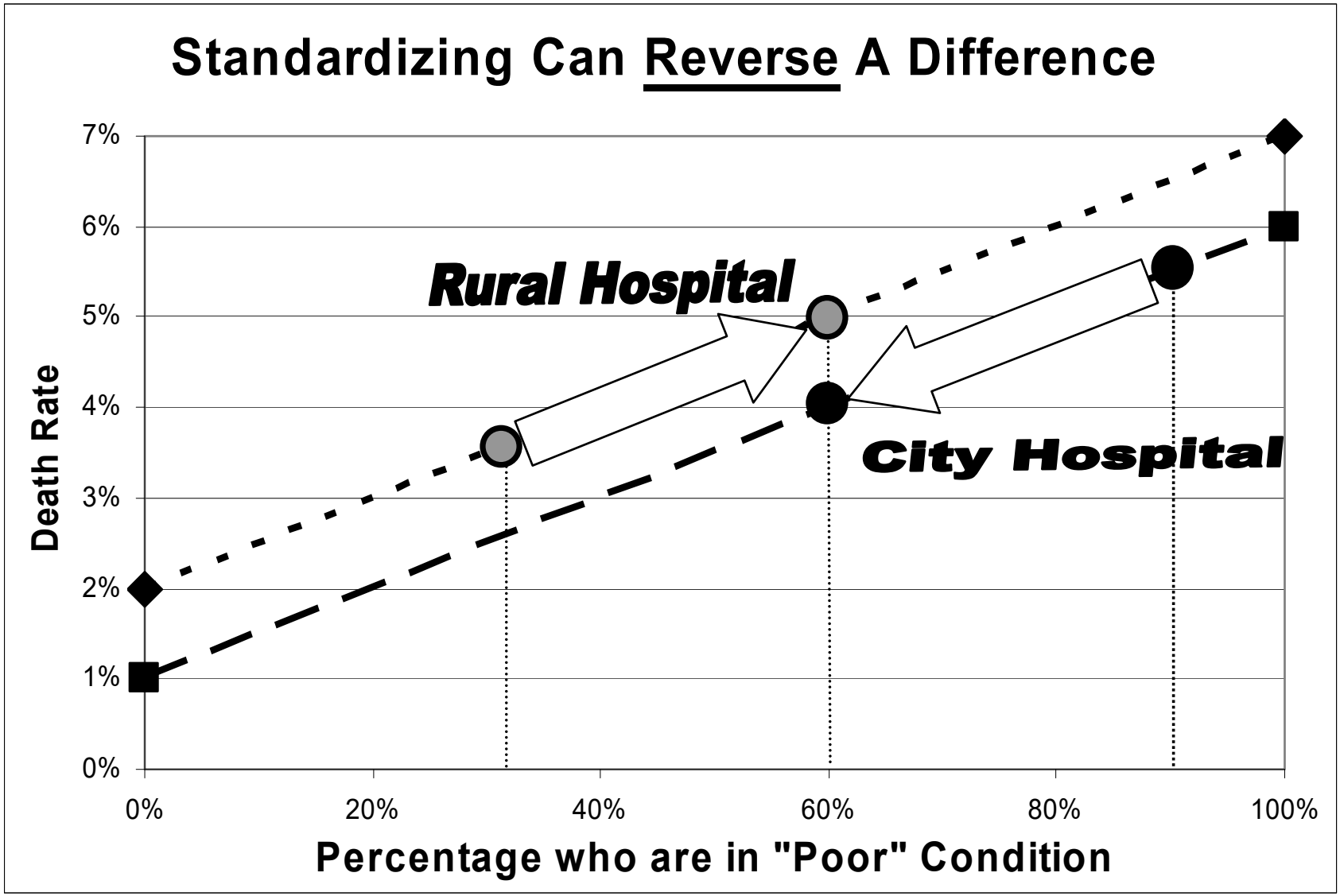
Two-Group Rates with a Binary Confounder



Compare Hospital Death Rates
Confounder: Patient Condition

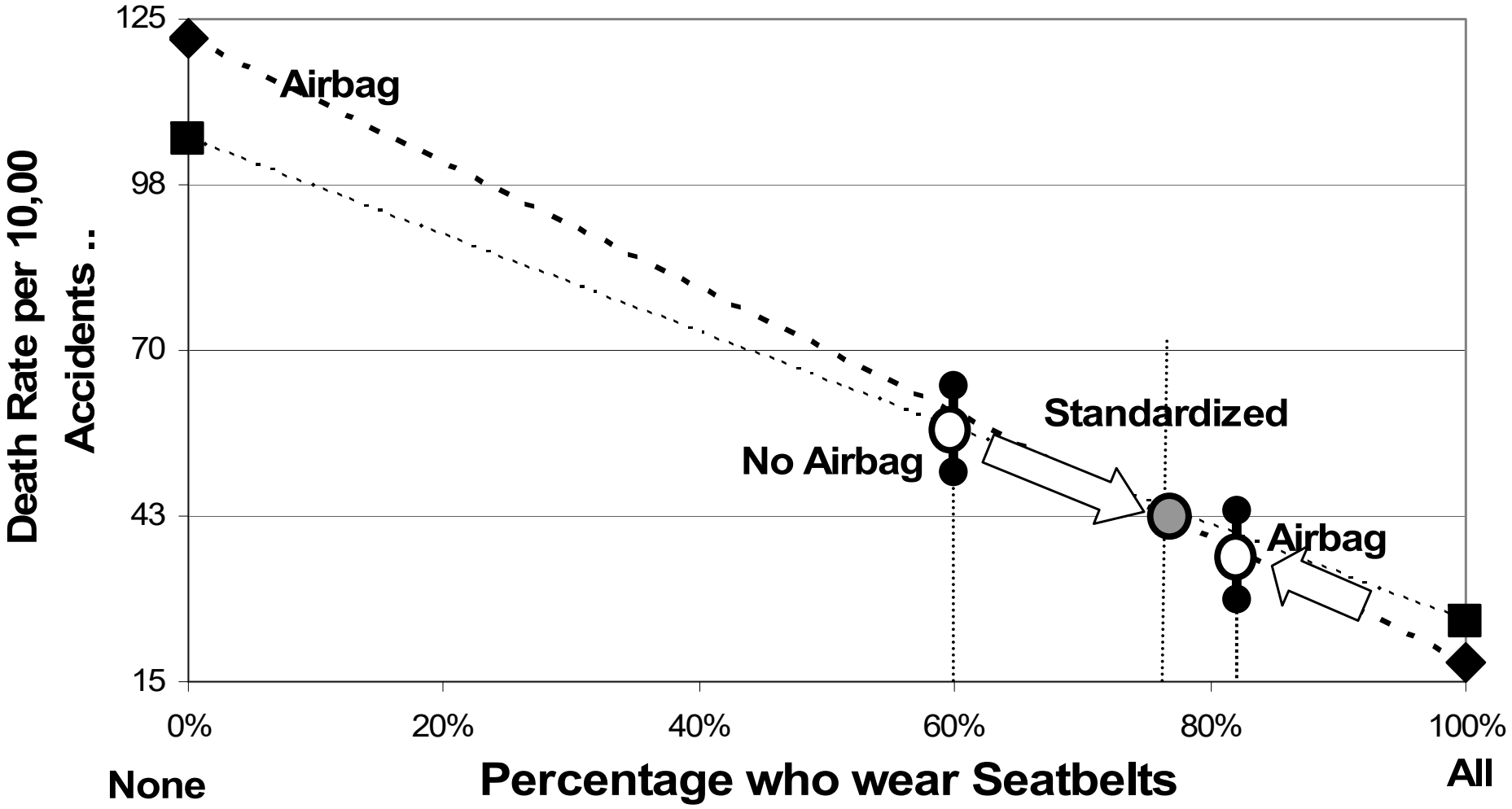


Standardize on combined confounder percentage



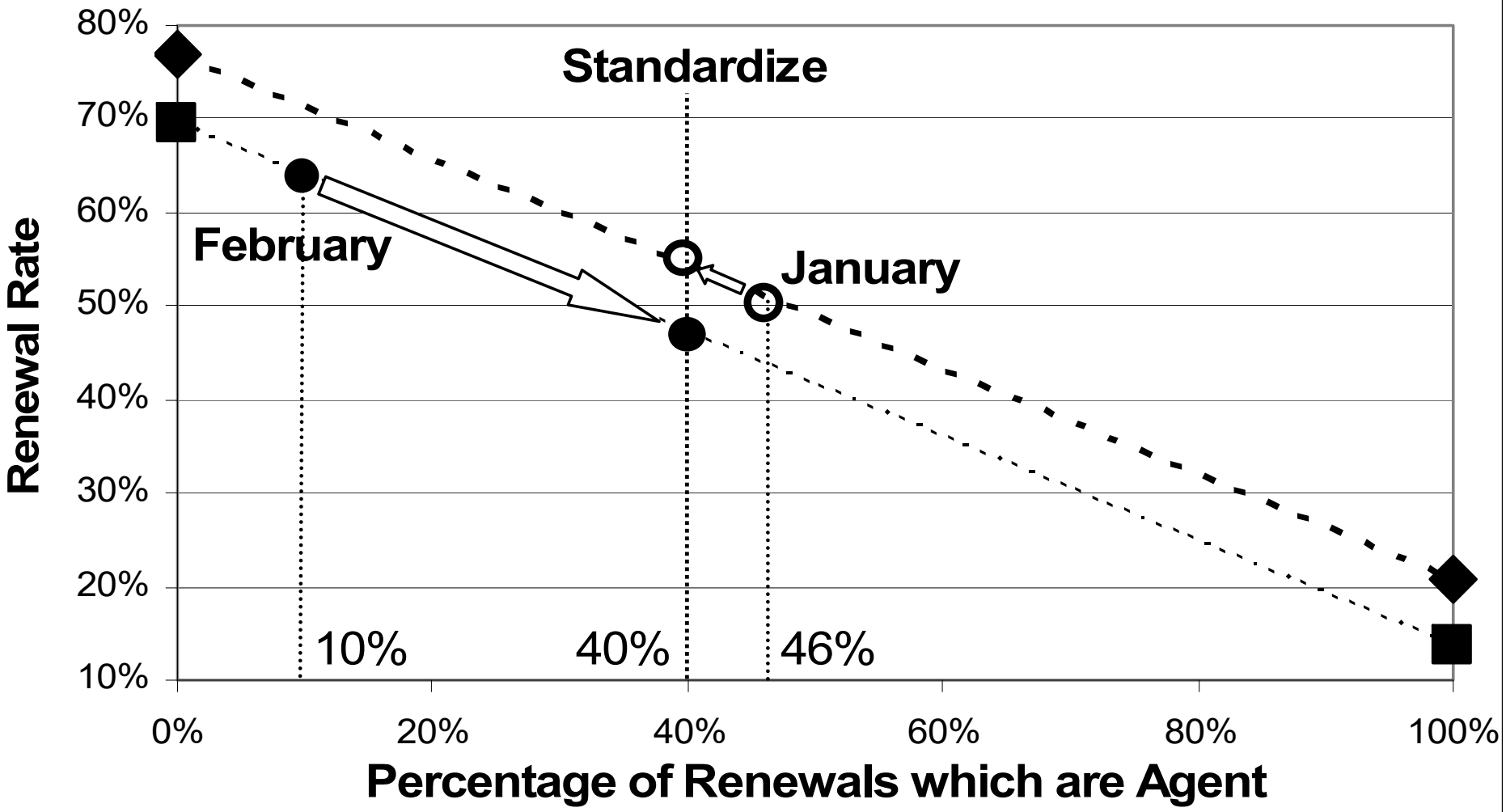
Auto Deaths and Airbag Presence

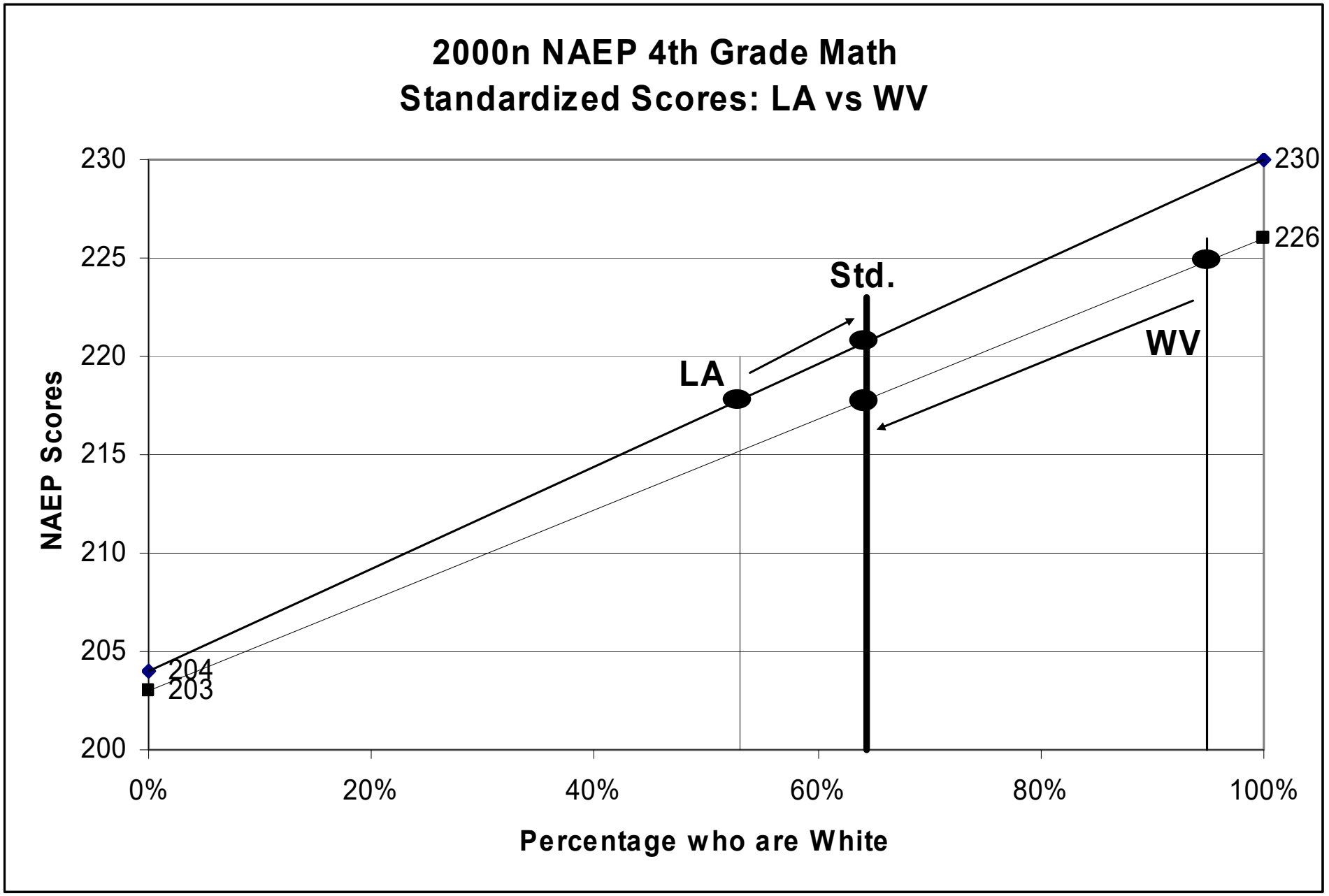
Confounded by Seatbelt Use



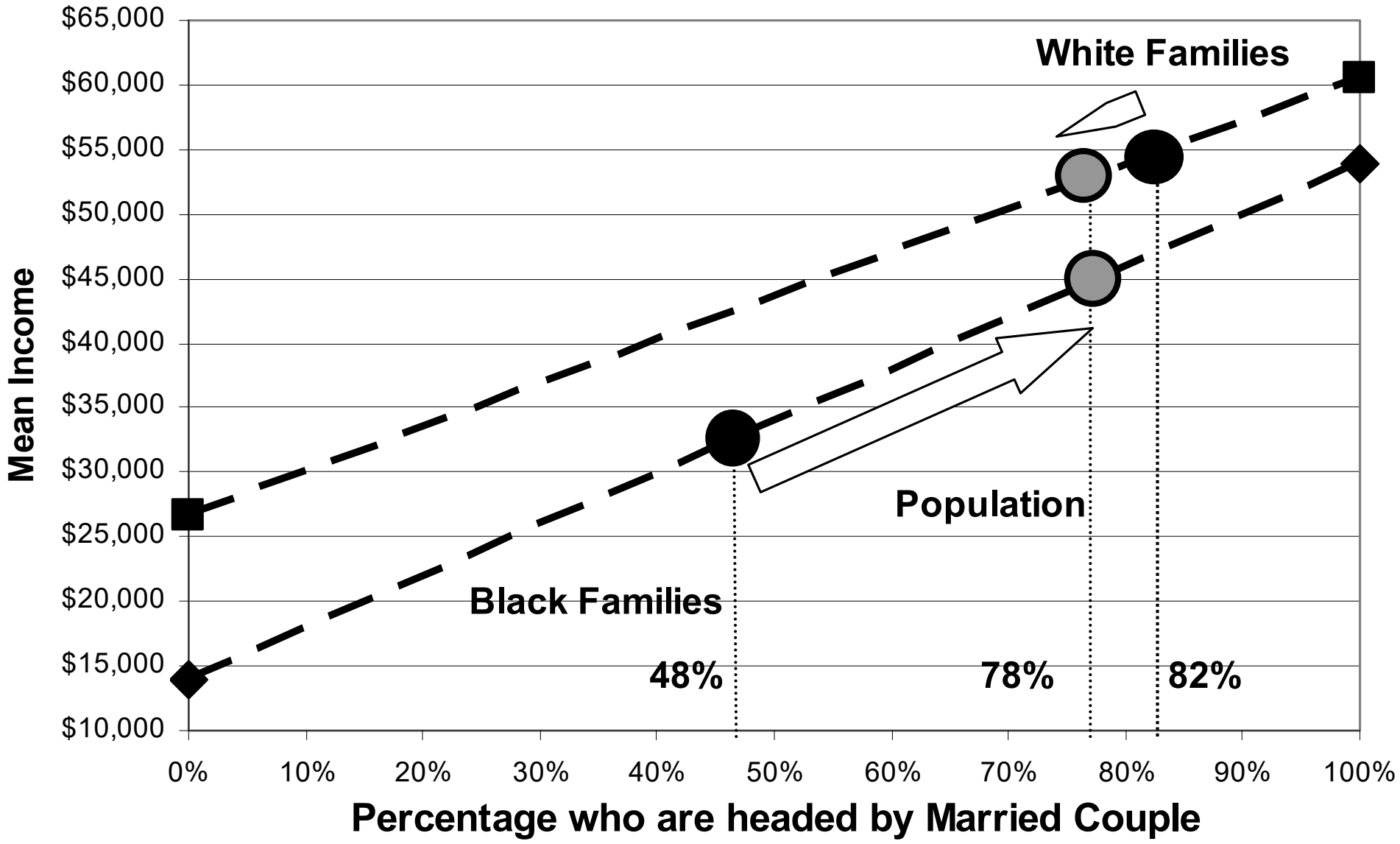
Subscription Renewal Rates by Month

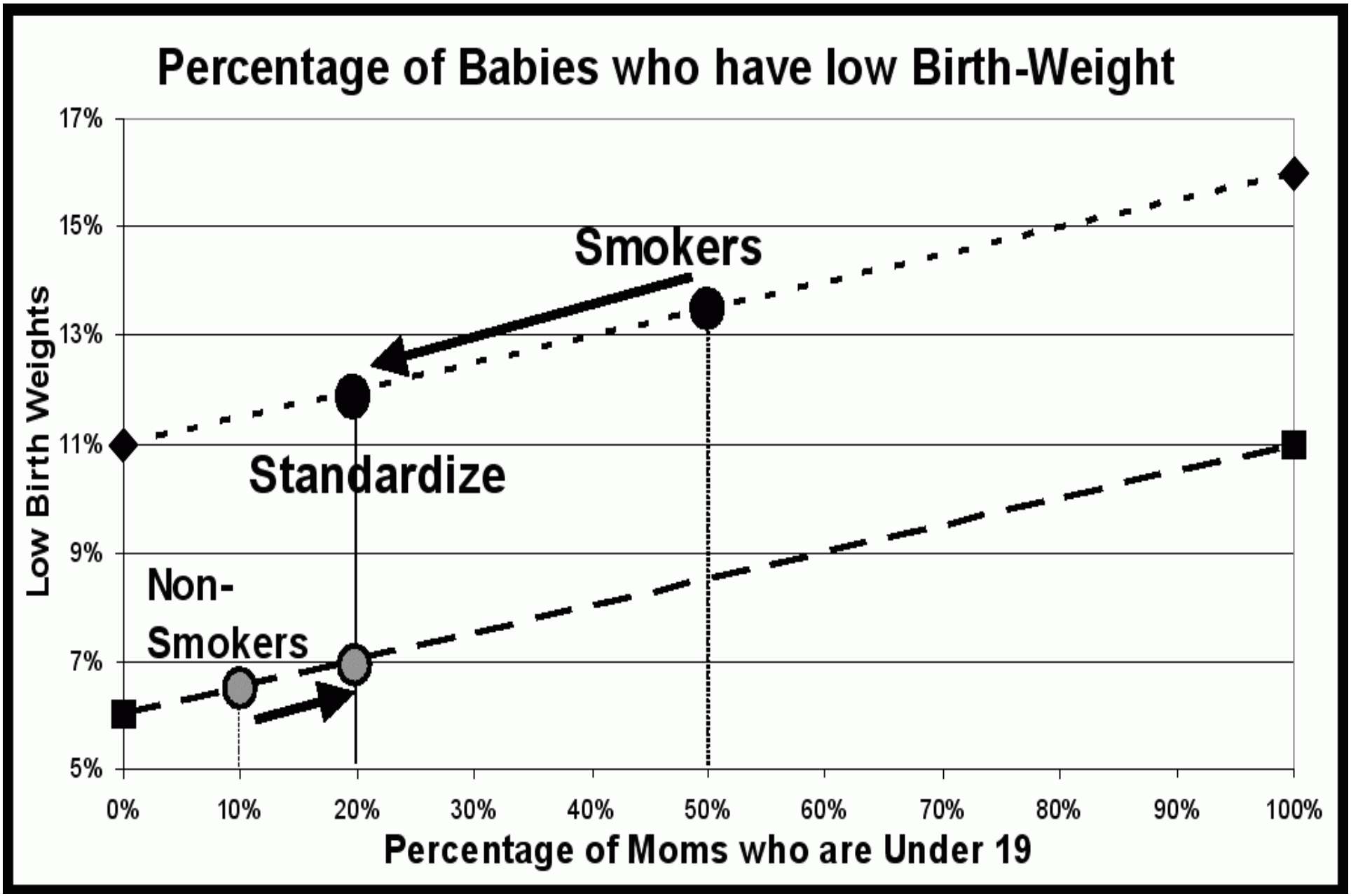
Confounded by Change in Subscription Mix



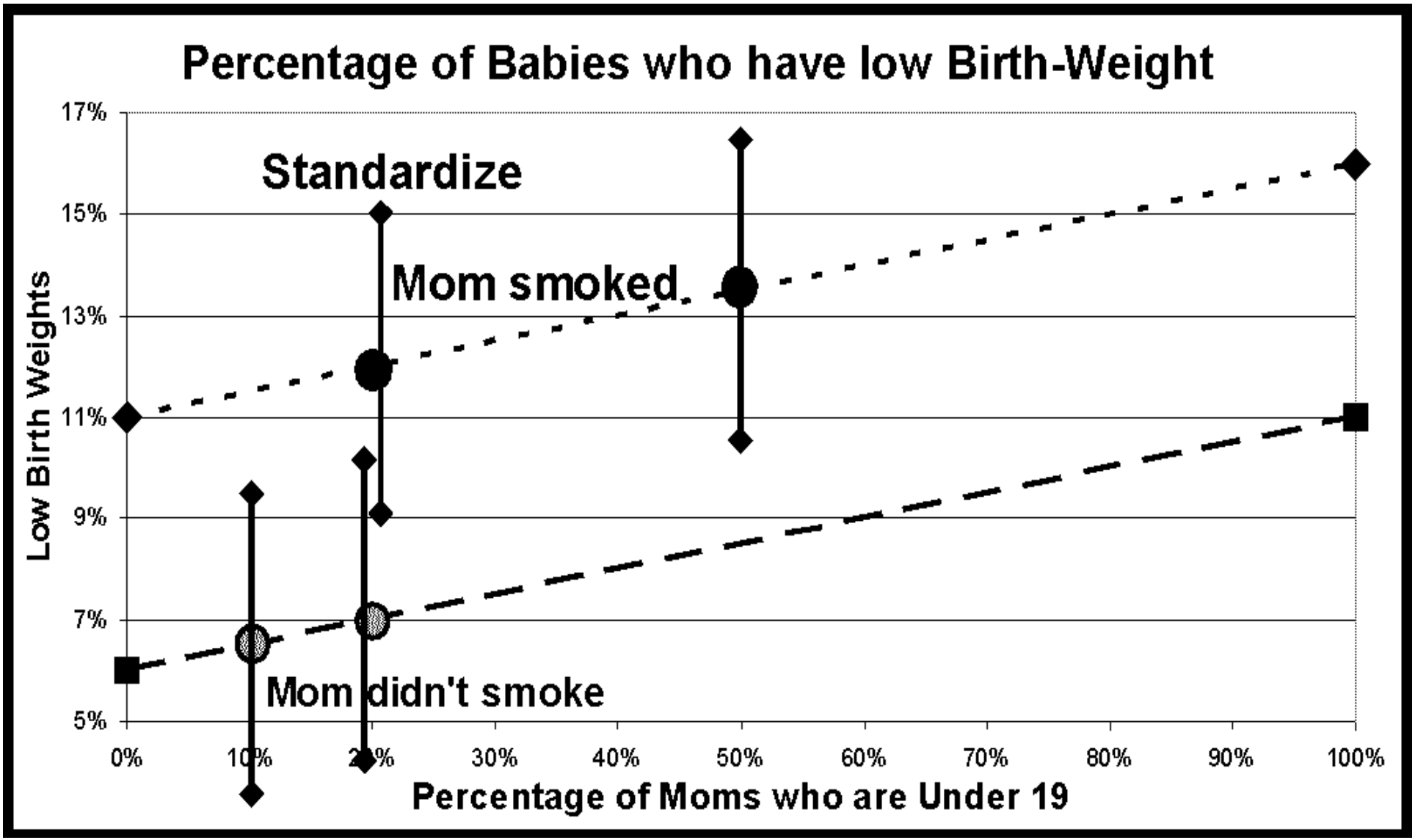

2000n NAEP 4th Grade Math
Standardized Scores: LA vs WV
NAEP Scores
230
225
220
215
210
205
200
0%
20%
40%
60%
80%
100%
Percentage who are White
LA
Std.
WV
204
203
230
226

Income: US Families by Race & Structure




Percentage of Babies who have low Birth-Weight
17%
15%
13%
11%
9%
7%
5%
Low Birth Weights
Smokers
Standardize
Non-
Smokers
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Moms who are Under 19

Controlling Can Change Statistical Significance



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