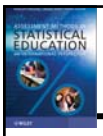
February 2012 1

Statistical Literacy for All

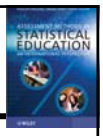
MILO SCHIELD,
Augsburg College
Director, W. M. Keck Statistical Literacy Project
US Rep, International Statistical Literacy Project
Member, International Statistical Institute
President: Twin Cities Chapter, ASA
Webmaster: www.StatLit.org

February 24, 2012
Slides at www.StatLit.org/pdf/2012Schield-Lehman6up.pdf

February 2012



Statistical Literacy



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

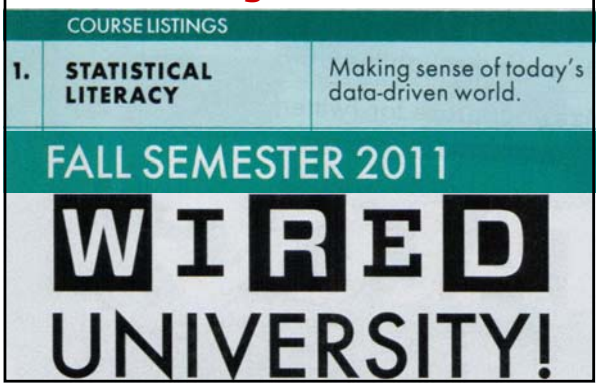
Statistical literacy is needed by 'data consumers.'

About 40% of all US college students graduating in 2003 had non-quantitative majors.

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

February 2012 3

Wired Magazine: Oct 2010



February 2012 4

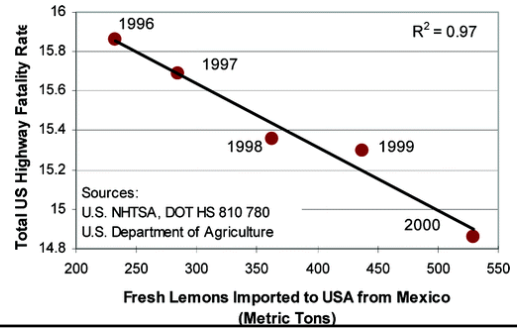
Statistical Literacy: Take CARE

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

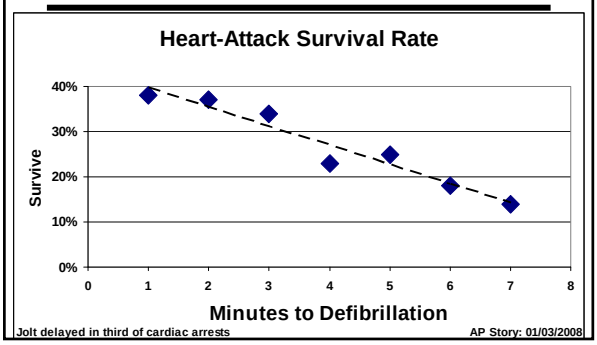
February 2012

1a. Association is probably not Causation



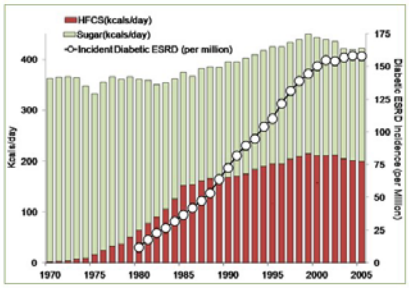
February 2012

1b. Association is Probably Causation



February 2012

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)

February 2012

Statistical Literacy Describing & Comparing

"Literacy" is a big idea in statistical literacy

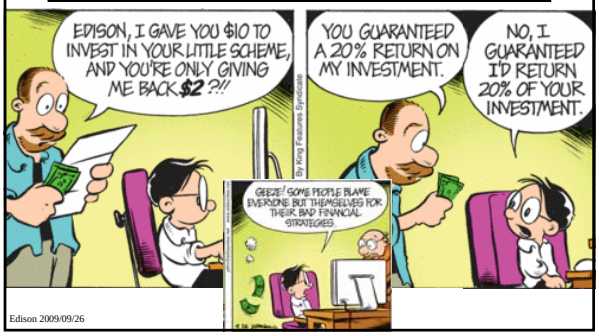
Must be able to describe and compare percentages and rates presented in tables and graphs.

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

February 2012 9

Small Change in Syntax; Big Change in Semantics



Edison 2009/09/26

February 2012

Statistical Literacy #1: 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

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

Intro statistics textbooks do NOT mention this!

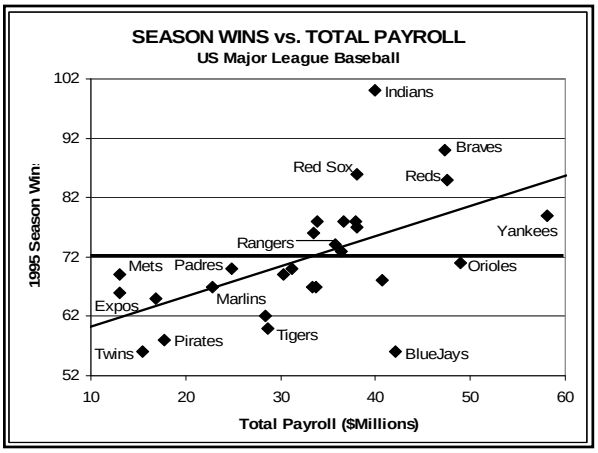
February 2012 11

Size of a statistic depends on what is "taken into account"

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



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

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

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

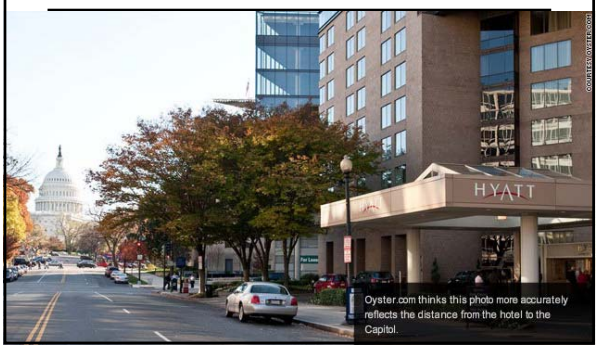
	Seatbelt		
Airbag	No	Yes	Total
Yes	122	18	34
No	105	25	58
Total	111	21	45

After controlling for the use of a seat belt (compare in a column), airbags make almost no difference in survival compared to seat belts (compare in a row)

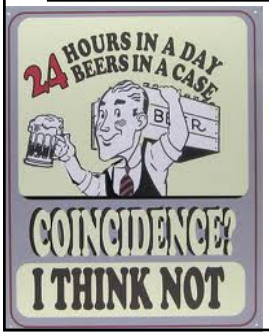
Assembly: Making small things big

7 nanograms per gram = 7 parts in a billion

Hyatt: Close to the US Capital

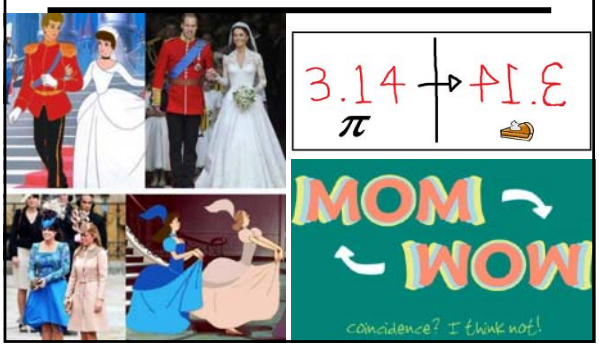


Randomness: Coincidence



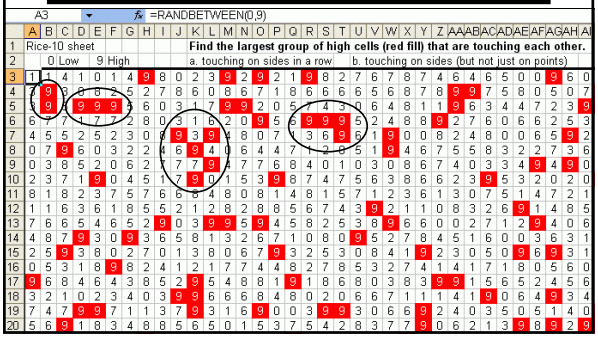
February 2012 19

Randomness: Coincidence?



February 2012 20

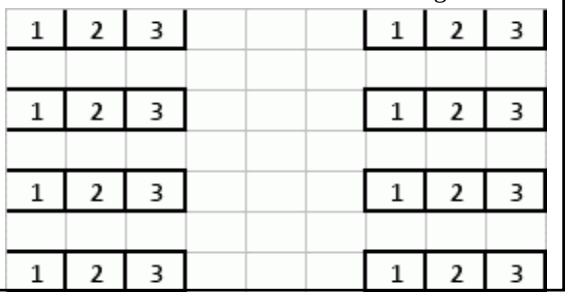
Seeing Coincidence



February 2012 21

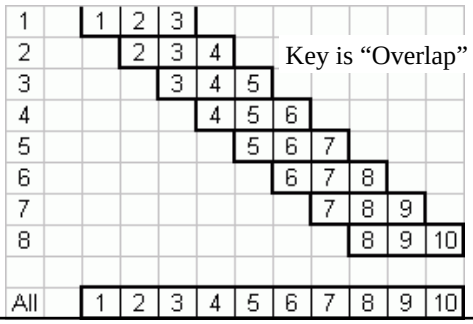
Flip 8 sets of 3 coins each [24 flips]; A run of three heads is "expected"

Chance of 3 heads: one chance in eight.



February 2012 22

Run of at least three heads: "Expected" in 10 flips of fair coin



February 2012 23

Error/Bias

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

How much of this difference is 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.

February 2012 24

Error/Bias

A recent survey shows that most Republicans surveyed prefer Obama as President.

Question: Who would you prefer as President?

- Barack Obama
- The captain of the Italian linear that crashed
- Charlie Sheehan
- Lady Gaga

February 2012

Conclusion #1
Most students are statistically illiterate

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.

February 2012

Conclusion #2

Graduates in non-quantitative majors are most likely to be the journalists, policy makers and politicians who influence decisions on funding for science, engineering and math.

The less value they see in STEM, the harder it is to get their support.

February 2012 27

Recommendation
Find Way to Support

Mathematics departments should find ways to support courses and programs involving quantitative or statistical literacy as a form of math-statistics appreciation.

Increased appreciation should be first; understanding principles taught in upper-level math-stat courses should be second.

February 2012

Importance of
Statistical Literacy

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

February 2012 30

References

Schield (1999). Simpson's Paradox and Cornfield's Conditions. www.StatLit.org/pdf/1999SchieldASA.pdf

Schield, Milo (2006). Presenting Confounding and Standardization Graphically. *STATS Magazine*, See www.StatLit.org/pdf/2006SchieldSTATS.pdf.

Schield, Milo (2012). Coincidences. MAA Boston. See
www.StatLit.org/pdf/2012Schield-MAA.pdf
www.StatLit.org/Excel/2012Schield-Runs.xls
www.StatLit.org/Excel/2012Schield-Rice.xls
www.StatLit.org/Excel/2012Schield-Bday.xls