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## Statistical Literacy and Liberal Education

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*Free Minds '09*  
 Las Vegas, NV 7 July 2009  
[www.StatLit.org/pdf/2009Schield2FreeMinds6up.pdf](http://www.StatLit.org/pdf/2009Schield2FreeMinds6up.pdf)

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## Statistical Literacy

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Statistical Literacy (ability, discipline, course):

- ability to evaluate the role of numbers.
- studies numbers encountered in everyday life.
- a quantitative literacy course for students in non-quantitative majors.

“Widespread statistical illiteracy ... is cause for immediate concern.” Charles Murray (2008), *Real Education*

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## Association is a Sign of Causation

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Associations are evidence. Typically, associations are evidence of a causal connection:

- Foods, herbs, potions: healthy vs. poison
- Treatments: effective vs. ineffective
- Principles: Life-enhancing vs. Not

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Internal causation may be forward or reverse:  
 Example: As number of golf courses increased, so did the number of divorces.

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## Distinguishing Claims: Association vs. Causation

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Students have trouble distinguishing these.

Examples:

1. Families that pray together stay together.
2. Most heroin users first used marijuana.
3. College grads earn higher salaries.
4. Thunder follows lightning.
5. The more fire engines, the bigger the fire.

Some of these may involve causation.  
 None of these statements assert causation.

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## Distinguishing Claims: Association vs. Causation

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Titles in news stories:

1. Unfair boss could shorten your life
2. Smoking ups impotence risk in younger men.
3. Broccoli reduces breast cancer risk.
4. Parental tobacco leads to brain tumors.
5. Teen with peanut allergy dies after kiss.

Some of these relationships may involve causation.  
 None of these statements assert causation.

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## Care Take CARE: Associations are Contextual

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**The Point**  
 An argument is like a house.  
 The more disputable the point,  
 the stronger the evidence  
 (the walls and floors) must be.  
**Statistics As Evidence**

"All statistics are socially constructed  
 So, "Take CARE"!!  
 Statistics may be influenced by:

C	A	R	E
Context	Assembly	Randomness	Error

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**Influence of Context  
Overview:**

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Context includes what factors are *taken into account* by:

- **ratios**, comparisons, comparisons of ratios
- Study design:
  - experimental vs. observational
  - longitudinal vs. cross-sectional
  - random assignment and random selection

What factors are not *taken into account*:

- **confounding/confounders**

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**Confusion of the  
Converse and Inverse**

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**Confusion of the converse:**

- Some humans are men; some men are human. **True**
- No men are birds; no birds are men. **True**
- All men are human vs. all humans are men. **False**

**Confusion of the inverse:** Do these say the same thing?

1. a. Most accidents occur within 25 miles of home.  
b. Per mile driven, you are more likely to have an accident within 25 miles of home than further away.
2. a. 99% of those people who have AIDS *test positive*.  
b. 99% of those people who test positive *have AIDS*.

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**Confusion of the Inverse  
Medical Tests**

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AIDS Medical test: 99% “accuracy”:  
99% with AIDS test positive. 99% without – negative  
Suppose 1% of your population has AIDS.

TEST RESULT	AIDS? No	AIDS? Yes	ALL
NEGATIVE	98,010	10	98,020
POSITIVE	990	990	1,980
ALL	99,000	1,000	100,000

50% of those testing positive *have AIDS*: 990/1,980.  
50% predictive power is true whenever the prevalence (1%) equals the confirmation error rate: (100% - 99%).

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**Influence of Assembly:  
Definition**

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Claim: the US leads the world in health-care spending, but trails dozens of countries in basic health outcomes  
Infant Morality: Mortality rate per 1,000 *live births* is higher in the US than in Canada, Germany and Japan.  
In Canada, Germany and Austria, a premature baby weighing less than 500 grams is not considered a living child. In other countries babies that survive less than 24 hours are also excluded and are classified as “stillborn.”  
A child born in Hong Kong or Japan that lives less than a day is reported as a “miscarriage” and not counted.  
**Publication:**IBD; **Date:**Jul 1, 2009; **Section:**Issues & Insights; **Page Number:**A10

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**Influence of Assembly:  
Definition of Overweight**

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In 1998, the National Institutes of Health (NIH) **lowered the overweight BMI score for men and women to match international standards.**

Before: a 5'3" woman 151# with a large frame was not considered overweight (BMI of 27). Under the revised BMI, she is solidly in the overweight column.

This added 30 million Americans who were previously in the "healthy weight" category to the "overweight" category.

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**Influence of Assembly:  
Definition & Presentation**

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Assembly #1: Choice of definitions, groups or measures:  
80% of middle-school kids are *involved in bullying*.

Assembly #2: Choice in presentation:  
Compared to Hawaii, the 1996 **auto death rate** in Arkansas was 104 percent *higher* (per vehicle), 78 percent *higher* (per registered driver) and yet 77 percent *lower* (per mile of road).  
Men are more likely than women to have very high IQ;  
Men are more likely than women to have very low IQ.


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**Influence of Assembly:  
Presentation**

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Child Abuse Statistics

Each year, more than 7,000 children in Minnesota are confirmed to be victims of physical or sexual abuse, emotional maltreatment, or neglect.



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**Influence of Randomness  
Averages in Small Groups**

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**Does Duct Tape Cure Warts?**

"After 6 weeks, the warts of 8 children (16 percent) in the duct tape group and the warts of 3 children (6 percent) in the placebo group had disappeared," the researchers wrote in the Archives of Pediatrics and Adolescent Medicine.

Duct-tape almost 3 times (16/6) as successful as placebo. This difference was not statistically significant.

[http://news.yahoo.com/s/nm/20061106/hl\\_nm/warts\\_dc](http://news.yahoo.com/s/nm/20061106/hl_nm/warts_dc)

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**Influence of Randomness  
Extremes in Large Groups**

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Angelo Gallina won the California \$17 million Super-Lotto Plus jackpot and the \$126,000 Fantasy 5 top prize on the same day.

Looking forward, Angelo's chances were about zero. Must we reject coincidence and look for a related factor?

Not necessarily. With so many people playing so many lotteries over enough time, it is almost a certainty that someone will win two lotteries in one day.

This reflects the Law of Very Large Numbers: "the unlikely is almost certain given enough tries."

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**Association can be  
Influenced by Error (bias)**


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Temp biased up:  
Why?

Thermometer near

- concrete
- other cars
- building

Bartow, FL



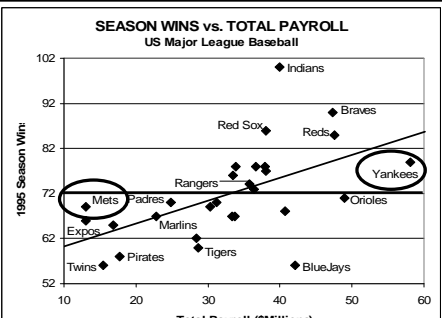
[http://www.norcalblogs.com/watts/weather\\_stations/](http://www.norcalblogs.com/watts/weather_stations/)

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**Reversal:  
Influence of Confounding**

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SEASON WINS vs. TOTAL PAYROLL  
US Major League Baseball



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**Spurious Association  
Influence of Confounding**

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NAEP Math Scores 2000, grade 8

Average		Internet Access at Home?				
Score	State	YES		NO	ALL	
274	Maryland	281	70%	258	30%	100%
271	Arizona	281	55%	258	45%	100%

NAEP: National Assessment of Educational Progress

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### Speculative Statistics

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Most statistics are counted or measured:

- All: deaths, births, marriages, divorces
- Sampled: unemployed, opinion, temperatures

Some statistics are modeled: **Speculative statistics**

- predictions: weather forecasts, global warming
- associations: Deaths **attributed to** primary or second-hand smoke, obesity, radon, etc.

Attributable to ~ Attributed to ~ Due to ~ Caused by

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### Percentage of Deaths Attributed to City Hospital

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Consider these death rates:

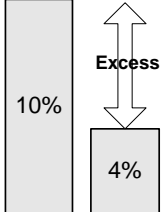
- 10% for a city research hospital.
- 4% for a rural non-research hospital.

Based on this, one can say

- “60% of the deaths at city hospital are *attributed to* that hospital.”

The math is simple:

- $\text{Excess} / \text{Higher} = (10\% - 4\%) / 10\% = 60\%$



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### Number of Deaths Attributed to City Hospital

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Suppose these are patients at two hospitals:

- 100,000 at the city research hospital
- 10,000 at the rural non-research hospital

Deaths by hospital:

- 10,000 deaths at City: 10% death rate
- 400 deaths at Rural: 4% death rate

Conclusion: 6,000 of the deaths at City hospital (60% of 10k) are *attributable to* that hospital.

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### Decisions Based on Statistical Deaths

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With this data, what should we do?

- Fire the managers at this “hospital of death”?
- Retrain the staff
- Recommend that patients avoid this hospital?
- Stop funding (close) under-performing hospitals?

## Take CARE!

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### CDC: Estimate of Deaths Due to Overweight

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**2004: 400,000** “Obesity might soon pass smoking as the country’s leading cause of preventable death.”

One of the four scholars was CDC boss Julie Gerberding, who had earlier compared the **obesity epidemic** in America with the plagues of the Middle Ages.

Announcing the new findings, she said, “Our worst fears were confirmed.”

**2005: 26,000.** The new finding transformed obesity from fearsome killer to pitiable also-ran, ranking in 7th place.

[http://www.forbes.com/free\\_forbes/2005/0620/140.html](http://www.forbes.com/free_forbes/2005/0620/140.html)

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### Weight-Death Association: Plausible Confounders

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What confounders might be positively associated with the outcome (death) and the predictor (overweight)?

Taking into account such confounders will decrease the observed association between overweight and death.

Candidates:

- Health, fitness, attitude
- Sex, race, heredity
- Occupation (risk taking), education
- Age [Did the CDC fail to control for age???

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## Statistical Literacy and Induction

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Statistical associations are a type of generalization.

Many students have no experience in forming generalizations. Many have no experience in thinking about what factors were not taken into account. They aren't accustomed to "hypothetical thinking."

Taking a statistical literacy course helps them understand some pitfalls in forming generalizations.

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## Statistical Literacy and the Social Sciences

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Confounding (Simpson's paradox) is the Achilles heel of the social sciences.

All too many social science majors leave their research methods course thinking that a statistically significant association is immune to the influence of confounding.

Statistical Literacy reveals the falsity in this claim. Statistical Literacy may undercut the power of the social sciences and elevate the stature of the humanities

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## Statistical Literacy and Liberal Education

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Many – if not most – arguments in public policy and in ethics today use statistics as evidence.

*"Numeracy is the new literacy of our age. An innumerate citizen today is as vulnerable as the illiterate peasant of Gutenberg's time"* Lynn Steen

Statistical literacy should be a part of the general education – the liberal education – of all college grads. Ideally some parts of it would be taught in high school.

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## Statistical Literacy: Course Background

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Course developed with a \$500,000 grant from the W. M. Keck Foundation – a private organization.


Goal: to develop statistical literacy as *"an interdisciplinary curriculum in the liberal arts."*

Taught as a catalog-approved course in General Studies (GST 200) at Augsburg College since 1999.

Designed for the 40% of college students in non-quantitative majors: majors with no math requirement.

See: [www.statlit.org/Schild.htm](http://www.statlit.org/Schild.htm) and [www.statlit.org/pdf/2008StatLit2A.pdf](http://www.statlit.org/pdf/2008StatLit2A.pdf)

www.statlit.org 30



Google: [www.StatLit.org](http://www.StatLit.org) is the #1 site for *Statistical Literacy*

**SITE VISITS: by Year**

Calendar Year	Visits
2005	37,781
2006	58,308
2007	85,169
2008	102,860

**STAT LIT SITE DOWNLOADS: by Year**

Calendar Year	Downloads
2005	22,731
2006	41,860
2007	66,428
2008	106,035

Milo Schield is the webmaster.

## **Statistical Literacy Course On-line Training**

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Volunteers to test an on-line teacher training program.

Testing the math/stats part of the course first.

- Having taken a statistics course preferred.
- Having taught preferred.

Activity:

- Study Schield's Statistical Literacy 2009 textbook.
- Complete on-line exercises; discuss experiences.
- Summarize strengths and weaknesses of training.

Time involved: 5-10 hours per week for 6 weeks.

For details, contact [milo@pro-ns.net](mailto:milo@pro-ns.net)