

2012 Keene2 1

Critical Thinking About Statistics

MILO SCHIELD,
Augsburg College

Director W. M. Keck Statistical Literacy Project
Webmaster www. StatLit.org
VP National Numeracy Network
US Rep: International Statistical Literacy Project
May 15, 2012
www.StatLit.org/pdf/2012Schield2Keene6up.pdf


2012 Keene2

Statistical LITERACY

Focuses on Social Arguments

Florence Nightingale

“Seven times as many died after the battle as died in the battle.”

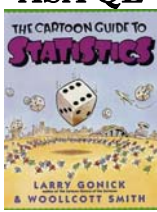


Nurses save lives;
We need more nurses!

Statistical LITERACY

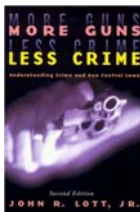
studies inductive arguments

ASA QL



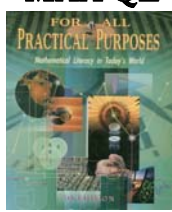
Deductive

Stat Lit



Inductive

MAA QL



Deductive

2012 Keene2 4

Induction Background

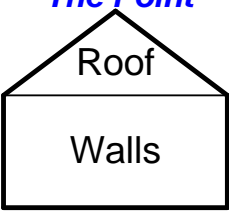
Induction is informal/practical: From Some to All, from Cause to Effect, From Past or Present to Future.

In deduction, the conclusion is implicit in the premises. In induction, generalizations *go beyond* what is observed

- Water runs downhill; living things are mortal
- Tides, seasons and eclipses are predictable
- All orbits are elliptical [Kepler's law]
- Things continue to exist, even when we can't see them
- Reason is man's primary means of survival.

1. Studies Arguments using Statistics as Evidence

The Point



Roof

Walls

Foundation

*Strength of Statistic
in supporting the Point
assuming statistic is true*

Truth of the statistic

2012 Keene2

Statistical LITERACY

Adds Perceived Value

Percentage of 48 Statistical Literacy students*
who strongly agree that this course

- helped my critical thinking skills..... **48%**
- is relevant to my major or work..... **42%**
- is relevant to my personal or civic life.. **33%**
- should be *required* for graduation..... **23%**

* Preliminary results: 48 students 2001T4 & 2002T1 all taught by Schield

2012 Keene2 7

**Weakness #1:
No Thesis; No Argument**

Students don't recognize the difference between:

1. a topic or subject [e.g., bears]
2. an issue or question: Should bears be protected?
3. a thesis or claim. *Bears should be protected.*

Papers without an issue are like travelogues:

- lots of facts
- no argument (no real substance)

2012 Keene2 8

**Weakness #2:
Irrelevance**

If data is relevant to the topic, students presume it is OK.

1) TOPIC

2) Issue or Question

3) Thesis or claim

Data must be relevant to the thesis or question.

2012 Keene2 9

**Weakness #3:
Comparison Problems**

No comparison:

- Many students are happy; Few students are unhappy.

Incomplete comparison:

- More doctors like Crest.

Vague comparisons:

- Most students are happy.
- Women are happier than men.

Source: www.statlit.org/pdf/2005SchieldCarleton.pdf

2012 Keene2 10

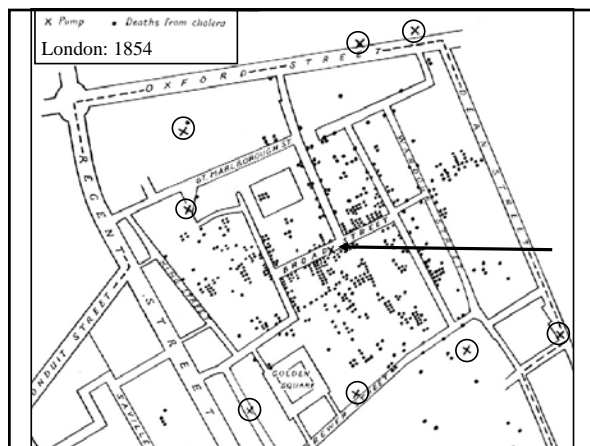
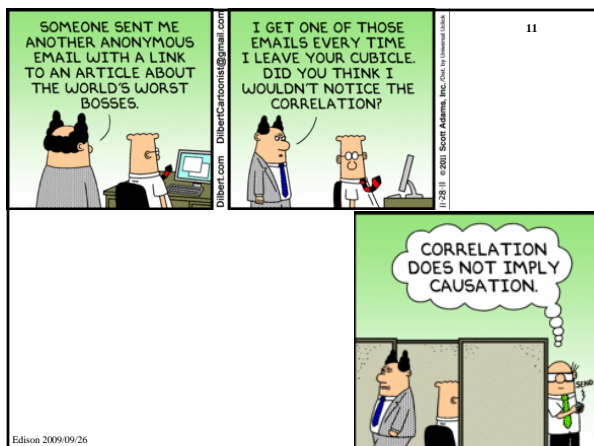
**Weakness #4:
No Hypothetical Thinking**

One-sided (*naive*) thinking

No alternate explanations (What else could have...?)

No estimates of implications (What if?)

Students have little experience in hypothetical thinking



2012 Keene2 13

Sir Bradford Hill's Criteria: From Association to Causation

1. **Strength:** the larger the *association*, the more likely that it is causal.
2. **Consistency:** Consistent findings strengthens the likelihood of an effect.
3. **Specificity:** The more specific an *association* is, the bigger the probability of a causal relationship.
4. **Temporality:** The effect has to occur after the cause.
5. **Biological gradient:** Greater exposure leads to greater (or lower) effect.
6. **Plausibility:** A plausible mechanism between cause and effect is helpful.
7. **Coherence:** Coherence between epidemiological and laboratory findings increases the likelihood of an effect.
8. **Experiment:** "Occasionally it is possible to appeal to experimental evidence."
9. **Analogy:** The effect of similar factors may be considered.

Source: The Environment and Disease: Association or Causation? (1965)

2012 Keene2 14

Famous Studies

Experiments:

1. Discovery of smallpox: Jenner used cowpox.
2. Test of penicillin

Observational studies

1. Does smoking cause cancer? (1950s) RR=10
2. Test of polio vaccine (1950s) Large-scale.
3. Most studies today (Small size; factor of 2)
Generally not upheld in experiments.

2012 Keene2

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.'

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

2012 Keene2 16

Small Change in Syntax; Big Change in Semantics

Edison 2009/09/26

2012 Keene2 17

Association versus Causation

#1: Distinguish association from causation

1. More educated people make more money.
2. As education increases, income increases
3. The more education you get, the more money you can expect to make.

#2: Understand language of association
Stroke risk up by 25% for every 10db.

#3: Association is not causation [Fallacy]

#4: Association is often evidence of causation

2012 Keene2 18

From Association To Causation

©2012 John L. Hart EUP 2-14
www.JohnHartStudios.com

Edison 2009/09/26

2012 Keene2 19

Distinguish Causation from Association

Causation (8%): *cause, effects, results, prevents*
Association (2%): *associate, relate, correlate,*
Between (67%):
Action verbs: ups, cuts, raises, boosts, increases
Other: due to, because of, attributed to

Inappropriate use of "causes":

- Obesity **causes** later onset of puberty in boys
- Junk food **causes** a third of heart attacks.
- Obesity growing to be top cancer **cause**.

2012 Keene2 20

"Between" Words in Headlines

- Study: *Estratest doubles breast cancer risk*
- *Gene increases depression risk: study.*

Here "before-after studies" are impossible.

- *Weddings boost mood: study.*
- *Expanding waist worsens kids' sleep apnea.*

Here "before-after studies" are possible.

Journalists should distinguish these situations.

2012 Keene2 21

Distinguish 'Due to' From 'Result of' or 'Caused by'

US Healthcare: Third Leading Cause of Death

225,000 Americans die each year die as a result of their medical treatments:

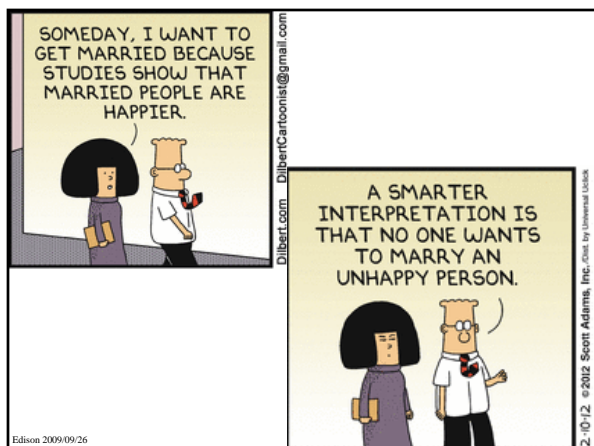
- 7,000 deaths/year due to hospital medication errors
- 12,000 deaths/year due to unnecessary surgery
- 20,000 deaths/year due to other errors in hospitals
- 80,000 deaths/year due to infections in hospitals
- 106,000 deaths/year due to negative effects of drugs

Reference: Starfield, B. (2000, July 26). Is US health really the best in the world? *Journal of the American Medical Association*, 284(4), 483-485.

2012 Keene2 22

Association vs. Causation 11 Headlines, Same Story

1. Study: 45,000 Uninsured *Die* a Year (CBS News)
2. 45,000 deaths *attributable to* uninsurance
3. 45,000 US deaths *associated with* lack of insurance
4. No health coverage *tied to* 45,000 deaths a year
5. Lack of insurance *linked to* 45,000 deaths
6. Study: 45,000 U.S. Deaths *From* Lack of Insurance
7. One death every 12 minutes *due to* no health insurance
8. 45,000 ... die *because of* lack of health insurance
9. Lack of Health Insurance *Kills* 45,000 a Year
10. Lack of Health Insurance *cause* 44,789 deaths
11. Lack of insurance *to blame for* almost 45,000 deaths



2012 Keene2 24

Conclusion

Most news stories include numbers to support their claims. We are subject to a torrent of statistics daily.

Adults need to be statistically literate so they can evaluate the strength of inductive arguments -- arguments that often use statistical associations as evidence for causal connections.

2012 Keene2

25

Induction in Philosophy

Louis Groarke: *An Aristotelian Account of Induction*.
Doug Harriman: *The Logical Leap: Induction in Physics*

Since Galileo, the physical sciences have successfully formed inductions that have prevailed in their context despite the acquisition of new knowledge.

Q. Why have the humanities made so little progress during that same period?

The Social Sciences: The attempt to merge science and the humanities using statistics.

2012 Keene2

26

1: Confusing Million and Billion

In a three year period there were 23 mix-ups of the words *million* and *billion* in the Los Angeles Times and 38 mix-ups in the New York Times.

Analysis: This is a big mix-up! Data is needed on how readers understand these big numbers.

In a convenience survey, 200 Augsburg College students were asked "**How big is a billion?**" They said:

1,000 million (59%), 100 million (18%), a million-million (10%), 10 million (7%) and "Don't know"

2012 Keene2

27

2: Confusion of the Inverse

AP: 9/30/09. **Too much candy could lead to prison**

LONDON, England — *Willy Wonka would be horrified. Children who eat too much candy may be more likely to be arrested for violent behavior as adults...*

*Of children who ate candies daily at age ten, **69% were arrested** for violent offenses by age 34.*

The real statistic:

69% of those arrested for violent offenses by age 34 ate candies daily at age ten.

2012 Keene2

28

3: Missing Context

*Soft Drinks Could Boost Pancreatic Cancer Risk. People who down two or more soft drinks a week may have **double the risk** of developing deadly pancreatic cancer, compared to non-soda drinkers.*

But the overall number of people developing the malignancy remains low..."

Estimated risk: 14 per 100,000. *Doubling this risk means ONE more person in a group of 7,200 soda drinkers may develop pancreatic cancer.*

2012 Keene2

29

4: Incomplete Comparisons

LA Times: Jan 31, 2010. Opinion: Doug Smith:
NY Times was more likely to overstate the case

- a. "than to understate the case"
- b. "than the LA Times was."

*More doctors like Crest ...
"than [they like] any other toothpaste"
"than nurses like Crest"*

2012 Keene2

30

5: Incomplete Comparisons with multiple groups

1. *Taller People Earn More Money. Reuters 8/25/2006.*
"Earn more" than what group: shorter people.
Single groups are no problem.

Multiple groups are a problem:

2. *Obese women less likely to be screened for cancer*
"Less likely" than obese men or non-obese women?
3. *Study: Young girls more likely to be fat. AP 2007*
"More likely" than older girls or young boys?

2012 Keene2 31

6: Confusing "Frequently" with "Likely"

1. 1995 Honda Civic: Most Frequently Stolen Car. State Farm Insurance. 7/9/2008.
2. New car study lists most likely to be stolen – '96 Honda Civic. Mountain Times 8/27/2009
3. Study: Cadillac Escalade most likely stolen. AP

How can two cars both be "most likely" to be stolen?
Confusion between "frequently" and "likely"
Frequently compares counts; *Likely* compares ratios.
#1 and #3 are correct; #2 is wrong

2012 Keene2 32

7: Slope-based Comparisons

As X increases, Y increases/decreases.
Each Daily Soda Increases Obesity Risk 60%.
For every can or glass of sugar-sweetened beverage a child drank [a day] ..., a child's ... chance of becoming obese increased 60%.

60% sounds big – but 60% of what?
If the chance of obesity is 5% for non-drinkers, then a 60% increase means an 8% chance.
60% gets more attention than 3 percentage points!

2012 Keene2 33

Statistical Inference

With random assignment, we can be very confident that *statistically-significant* differences in group outcomes are **caused by** differences in **treatment**.

Widely used in Psych and drug trials of drugs. Problems:

- 1) Can't always randomly assign people:
 - Impossible to assign sex, eye color, age.
 - Unethical to assign cruel/unusual treatments.
- 2) Can't publicly observe consciousness. People can lie.

Must use associations as evidence of causation.

2012 Keene2 34

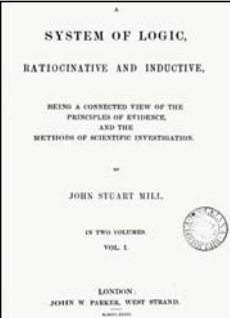
Mill's Methods of Induction

Identifying causes:

- Agreement (Necessary)
- Difference (Sufficient)
- Agreement & Difference
- Residues
- Concomitant variations

1843: First edition

SYSTEM OF LOGIC,
RATIOCINATIVE AND INDUCTIVE,
BEING A CONSISTENT VIEW OF THE
PRINCIPLES OF EVIDENCE,
AND THE
METHODS OF SCIENTIFIC INVESTIGATION.
—
JOHN STUART MILL.
IN TWO VOLUMES.
VOL. I.
LONDON:
JOHN W. PARKER, WEST STRAND.



2012 Keene2 35

Influences on Association: Take CARE

C: Context ["taken into account" (e.g., ratios)
Not taken into account: *confounded*
confound: confuse; *confounder*: found with

A: Assembly [Define, measure, or present]
Example: Bullying


R: Randomness
Unlikely almost certain with enough tries
Smaller samples have more uncertainty

Error/Bias
Subject, measurement or sample bias.

2012 Keene2 36

Association versus Causation

NON SEQUITUR
BY WILEY



2012 Keene2

Statistical Literacy: 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 insignificant* (and vice versa).
 Intro statistics textbooks do NOT mention this!

2012 Keene2 38

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%

