EVIDENTIAL STATISTICS

Reforming the Introductory Course in Applied Statistics for Non-Majors

Milo Schield
Augsburg College
schield@augsburg.edu

JSM-98
Section on Statistical Education
August 12, 1998
Dallas, Texas
Applied introductory statistics

Many say that introductory statistics has problems and must be reformed.

Dr. 'Bob' Hogg

"I am tired of hearing about problems in introductory statistics.

I know there are problems with introductory statistics;

But I defy anyone to identify what is wrong and what we must do to fix it."

JSM-95 Orlando FL.
"The problem is that introductory statistics is designed like a human anatomy course -- not like a human physiology course.

So much time is spent trying to get these students to understand where the basic organs are in the Statistical body, that they never get a chance to understand how the organs function together to maintain homeostasis."

From "Testing basic statistical concepts." Posted to sci.stat.edu news-group on 2 June, 1997 by Robert Schilling, MPH at Loma Linda, CA. Email to rschill718@aol.com.
**Evidential statistics**

uses traditional **statistics** as evidence in arguments with **non-statistical conclusions**.

**Evidential statistics** is macro-statistics: a mixture of traditional statistics philosophy of science, and critical thinking.

---

### Sciences of Method

<table>
<thead>
<tr>
<th>Content</th>
<th><strong>METHOD OF REASONING</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>DEDUCTIVE</strong></td>
</tr>
<tr>
<td>WORDS</td>
<td>Logic</td>
</tr>
<tr>
<td>NUMBERS</td>
<td>Mathematics Probability</td>
</tr>
</tbody>
</table>
An example of evidential statistics:

Two hunters were being chased by a hungry bear

The first hunter shouted to the second, "It's hopeless!"
This bear runs twice as fast as we can.

The second hunter shouted back: "So what? I don't have to outrun the bear. I just have to outrun YOU...!"

Thanks to David Friedman's Intermediate Microeconomics Text for this example.
Statistics is like a baseball game.

Describing and modeling gets one to 1\textsuperscript{st}

Classical Inference gets one to 2\textsuperscript{nd}.

Bayesian Inference gets one to 3\textsuperscript{rd}.

Evidential statistics reviews all these runs and tries to get one back home.
The run to 1\textsuperscript{st} base

Evidential statistics is concerned with BIAS

"...the most serious threat to the progress of science... comes from bias, not random variation."

John Bailar, Chair, Board of Trustees NISS

What you take into account (control for) can change the magnitude and direction of an association between two variables. [Simpson's paradox]
The run from 2\textsuperscript{nd} to 3\textsuperscript{rd}

The more unlikely a relationship
\textit{if} due to chance,
then
the more unlikely the relationship
\textit{is} due to chance and
the more likely the relationship
is due to some determinate cause.

The smaller the p-value
in a classical test of hypothesis,
the more one is justified
in rejecting the truth of the null.
The run to home plate

Sometimes students cannot distinguish association from causation.

A is positively associated with B
A is riskier than B
A is determined by B
A is explained by B
A is linked to (related to) B
A is a factor in relation to B
A is attributable to B
A can be attributed to B
The run to home plate

Students can't distinguish association from causation.

Suppose A and B are positively associated:

1. Subjects who have more A are likely to have more B

2. As A increases, B [tends to] increase

3. As A is increased within a subject, we expect that B will increase within that same subject.
The run to home plate

The quality of a statistic depends on the kind of study: experimental versus observational.

In presenting regression and ANOVA, we don't dwell on the source of the data (experimental or observational) since the kind of study doesn't affect the statistics

But the kind of study affects the value of the statistics as evidence.
The run to home plate

Good experiments limit arguments.

"Can magnets block pain?"
A recent double-blind experiment of 50 subjects says "Yes"
75% in treatment group got relief;
19% in control group got relief.

While we may have questions, we do have reason to believe this study could be replicated and something like the observed outcome should result.
The run to home plate

Experiments and observational studies vary in the strength they give to support a conclusion.

<table>
<thead>
<tr>
<th>Support</th>
<th>Observational</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>Impossible</td>
<td>Double blind: controlled or repeatable</td>
</tr>
<tr>
<td>Moderate</td>
<td>Longitudinal</td>
<td>No-blind and, missing data. Uncontrolled or unrepeatable</td>
</tr>
<tr>
<td>Weak</td>
<td>Cross-sectional</td>
<td></td>
</tr>
</tbody>
</table>
"Statistics: a Guide to Public Policy"
1998 JSM Theme

"Public policy is a series of uncontrolled, [unrepeatable] experiments."
David Pavelchek. JSM-95. Session 172. Orlando, FL

To guide public policy, we must teach Evidential Statistics

Evidential statistics is a key in reforming statistical education!
Seven Reasons Against Teaching Evidential Statistics

1. Dilutes our discipline
   - Mathematics is deductive.
2. Division of labor
   - Causality is discipline specific
3. Arrogance to try to teach all things
   - Mathematics and probability
   - Statistical inference and modeling
   - Critical thinking & Phil. of Science
4. Too much stuff for one semester
5. Lack of texts
6. **Inability to teach**
7. **Inability to test**
Florence Nightingale
the passionate statistician, used statistics as evidence to support her claim that improved medical care would save lives.

Statistic #1
Crimea, 1859: For every soldier killed in battle, seven died after the battle.

Statistic #2
The death rate for young soldiers in peacetime was twice that of the general population.
(Brown, 1988 People Who Have Helped the World, p. 44)

Florence Nightingale introduced many techniques designed to take into account (control for) confounding factors. She noted that mortality statistics should be age-specific and that crude death rates can be misleading.

Statistics began as the queen of the social sciences.

David Moore is right on! Introductory statistics should be taught as a liberal art.

It is time to assert our identity!

We should teach Evidential Statistics: statistics as evidence
Jessica Utts, Univ. Calif, Davis
Seeing Through Statistics

Gary Smith, Pomona College, Calif
Statistical Reasoning

Gudmund Iverson, Swathmore
Statistics: A Conceptual Approach

Donald Macnaughton, Toronto
www.matstat.com/teach

Milo Schield, Augsburg College
www.augsburg.edu/ppages/schield
Thanks to

Alexander Krugushev, Duxbury
Editor for Jessica Utts

William Barton, McGraw-Hill
Editor for Gary Smith

Jerry Lyons, Springer-Verlag
Editor for Gudmund Iverson

Jerry Moreno,
JSM-98 Stat. Ed. Program Chair