In Defense of Art Appreciation: What Your Doctor Does NOT Need to Know About Biostatistics

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Gap in Introductory Biostatistics Education

- Standard approach
  - Focus on **data analysis**
  - Does not meet needs of many students
    - Clinicians, public health professionals vs. researchers, data analysts
- A different approach is needed for these students
  - Focus on **literacy**
    - Example: *Statistical Reasoning in Public Health* one-semester course at Johns Hopkins (McGready, 2013)
    - "Provides a broad overview of biostatistical methods and concepts used in the public health sciences, emphasizing interpretation and concepts rather than calculations or mathematical details."
- Case study: Minnesota's new one-semester course in biostatistical literacy
  - Why it is needed
  - What topics it should include and not include

Current Introductory Biostatistics Courses

- **PubH 6414-6415 (_online_ and in-person)**
  - 3 credits, college algebra prerequisite
  - R Commander and R software
- PubH 6450-6451 (in-person only)
  - 4 credits, college algebra prerequisite; more in-depth.
  - R or SAS software
- PubH 7401-7402 (in-person only)
  - 4 credits, calculus prerequisite; more in-depth, additional topics (multinomial models, repeated measures).
  - R, SAS or STATA software
- _First semester_: basic distributions, descriptive statistics and graphing, hypothesis testing and confidence intervals for means and proportions, linear regression, analysis of variance.
- _Second semester_: multiple regression, power and sample size, logistic regression, Kaplan-Meier curves and time-to-event models.

'Guide to Introductory Courses in Biostatistics' on division website to help students choose best course.

Student Backgrounds

PubH 6414 Online, Fall 2012

- MPH, MS, MHA, MHI programs
    - Public Health Practice (9) – mostly DVM, MD, PharmD
    - Environmental Health (6) – RNs, MDs, people from industry
    - Maternal and Child Health (4) – mostly MDs
    - Health Informatics (4)
    - Community Health Promotion (3) – one journalist
    - Public Health Administration and Policy (3) – one JD/MPH
    - Nutrition (2)
    - Health-care administration (1)
    - Clinical Research (1)
    - Kinesiology (1)
    - Core Concepts (9)
- Dentistry residency (16)
- Pharmacy residency (5)
- PhD or DNP Nursing (3)
- PhD Computational Biology (1)
- Non-degree (9) – MD, RN, dental hygiene

The Instructors

PubH 6414 – 6415 sequence

- Six instructors, mostly MS level
- Consultant / teachers: we consult with the same population that we teach.
- Non-traditional backgrounds: chemistry, art, math, civil engineering, nutrition, statistics

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Motivations for Change

- Most PubH 6414-15 students take only one semester of the two-semester sequence.
  - Insufficient preparation
- Some students take PubH 6414-15 solely because it is offered online.
- The two lower sequences had become increasingly similar.
- Our students have very *different* objectives:
  1. Understand the medical literature (literacy).
  2. Be able to analyze their own data.
- Our existing courses were not meeting the needs of those whose objective is literacy.

Process

- Highly nonlinear
  - Conversations with students
  - External guidance
  - Conversations with faculty

- Key question
  - What do <u>our</u> students need to know about statistics?

Image: ScottGulbransen.com 'co-creation process'
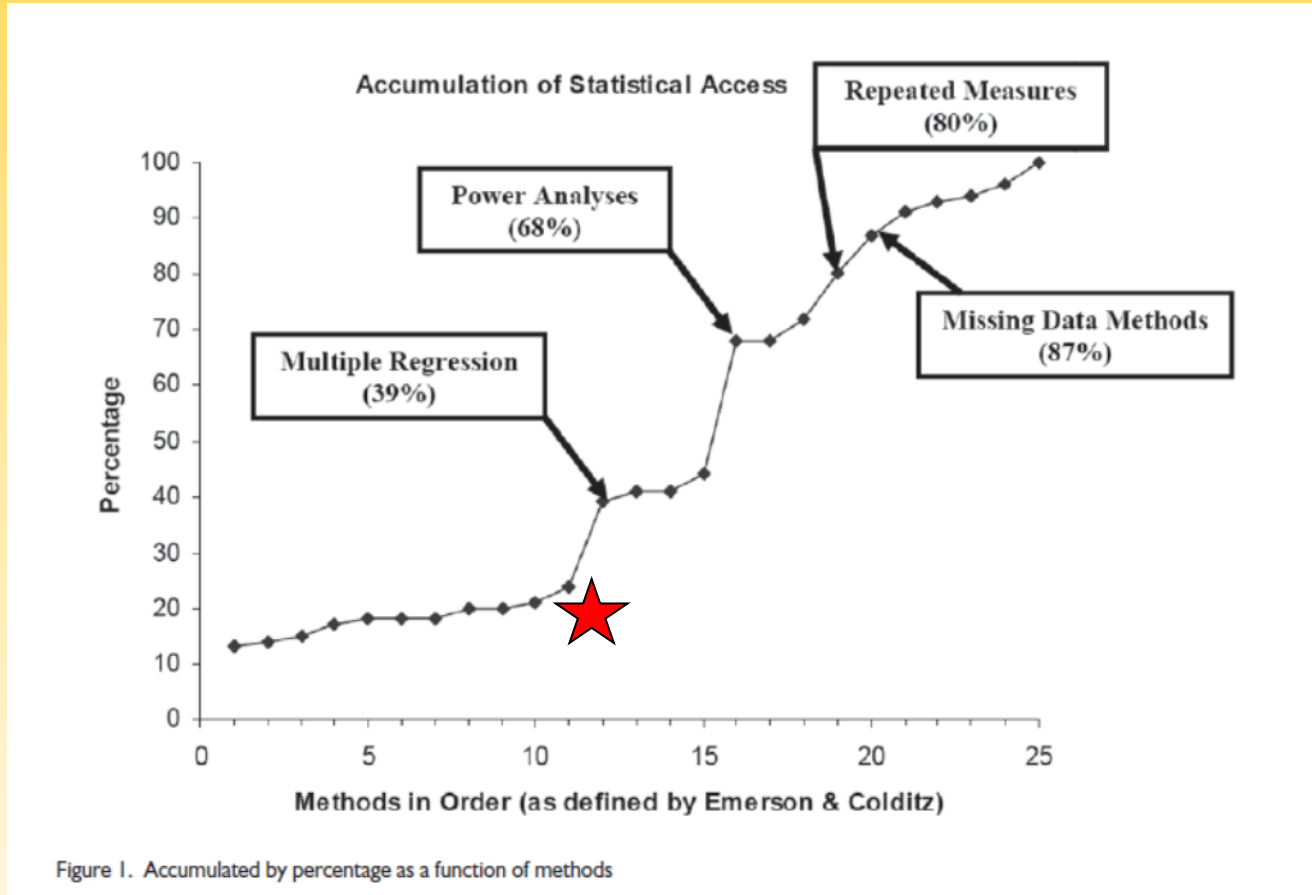
Conversations with Students

- Course 'suggestion box' (anonymous)
- Course evaluations (anonymous)
  - Positive: course is taught well
  - …but, for some, it is the wrong course
- 'Voting with their feet'
- Group discussions
  - "Which topics should be retained and which topics dropped from this course, in order to best prepare you for your future medical or public health work?"

"What we really need…"

- "Better address the needs of those students who practice (or plan to) as medical or public health professionals who will hire statisticians - not function in that role themselves"
- "More focus on interpretations and less on calculations"
  - "Learning how to interpret results, rather than performing the tests ourselves"
  - "Add more conceptual questions"
  - "Focus on application of concepts and less quantitative problem solving"
- Reduce or eliminate software
  - "It took a long time trying to understand the software which added little to understanding of the course material"
- More "reading and understanding statistical data presented in research"
  - More "reading and interpreting journal articles"
  - More "real-life analysis exercises through journal reviews"
  - "Focus on how to 'dissect a research paper' "

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Statistical Content of NEJM Articles

Accumulation of Statistical Access

Figure I. Accumulated by percentage as a function of methods

Switzer and Horton, 2007
(Emerson and Colditz, 1983)

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Statistical Content of *Pediatrics* Articles

TABLE 1	Use of Statistical Procedures in Selected Volumes of *Pediatrics*, 1952–2005				
	Vol 9, 1952[a]	Vol 29, 1962[a]	Vol 49, 1972[a]	Vol 69, 1982[a]	Vol 115, 2005
No. of articles	67	98	115	151	171
No statistics, %	66	59	45	30	1
Only descriptive statistics, %	21	20	27	23	10
No statistics or only descriptive statistics, Student's t test, χ^2, and/or Pearson's r, %	97	95	88	65	18
Inferential statistical procedures, %	13	20	28	48	89
Mean inferential procedures/article	1.7	1.5	2.0	2.5	3.9

[a] Source: Hayden GF. *Pediatrics*. 1983;72:84–87.

"Pediatric residents are expected to study research design and statistical methods to enable them to critically appraise the pediatric literature and apply the findings to patient care."

Hellems et al., 2007

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New MCAT^{2015} Exam

'Scientific Inquiry and Reasoning Skills' are tested along with subject matter knowledge in the first three sections, and a new fourth section focuses on 'Critical Analysis and Reasoning Skills'

Skill 1: Knowledge of Scientific Concepts and Principles

Skill 2: Scientific Reasoning and Evidence-based Problem Solving

Skill 3: Reasoning About the Design and Execution of Research

Skill 4: Data-based and Statistical Reasoning

Source: AAMC Preview Guide to MCAT^{2015} (November 2011)
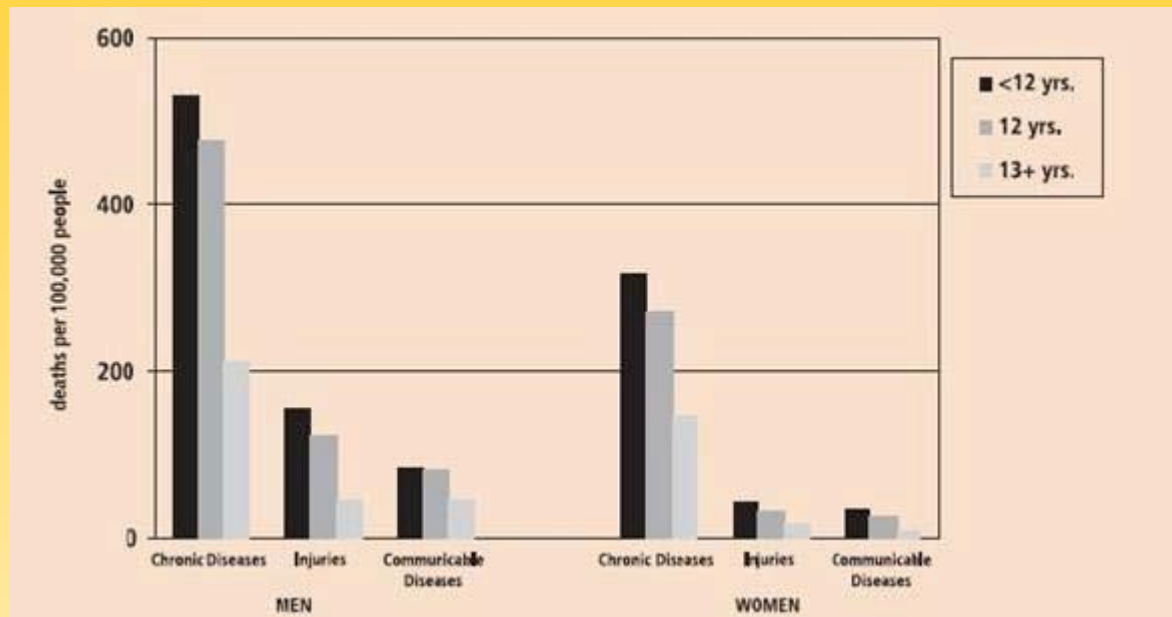
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Figure 1. Death Rates across Different Modes of Mortality as a Function of Years of Education and Gender

Which of the following conclusions is supported by the findings?

A. College education is associated with better health outcomes.

B. It is more important to educate women about communicable disease prevention than men.

C. Women are more likely than men to die from chronic disease regardless of their education level.

D. Lower levels of education leads to poorer health outcomes for men but not for women.

Board Exams

(one example)

Pediatric Emergency Medicine:

- XIII. Core Knowledge in Scholarly Activities (7% of exam)
  - A. Principles of Use of Biostatistics in Research
    - Understand the appropriate use of …
    - Identify when to apply …
    - Interpret the results of …
    - Identify the limitations of …
    - 'Calculate …' is used <u>only</u> for: RR, OR, sensitivity, specificity, PPV and NPV

Source: American Board of Pediatrics, Content Outline: Pediatric Emergency Medicine (rev. October 2009)

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Conversations with Faculty

- Client programs
  - Formal survey of our client programs
  - Informal feedback from client programs
    - See 'Voting with their feet'
- Biostatistics
  - Faculty meetings and informal conversations
  - Informal feedback from other consulting biostatisticians
- Both
  - Brainstorming meeting between biostatistics faculty and client program faculty
  - School-level committee meetings

Common Misconceptions

- Literacy is for students who aren't smart enough to do data analysis.
  - Interest in literacy is orthogonal to math ability.
  - Data analysis isn't too *difficult*, it is too *irrelevant*. Given limited time, it is a distraction from developing literacy.
- You can't really understand statistics until you have done the calculations.
  - It isn't necessary to know how something works in order to use it effectively (e.g. driving a car).
- We don't want to teach 'statistics appreciation'!
  - Art (or music or…) appreciation is a necessary complement to art.
    - Artists need customers, agents, dealers, etc.
  - Biostatistical literacy is a necessary complement to biostatistics.
    - People who analyze data need people who can read, understand and act on the analysis results.

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Limited Time Requires Choices

Client Program Survey:

- Option A: Our students should be able to read and understand the results of research studies published in their field. They should be able to work with a statistician to design a research study and to interpret its results.
  - One-semester course.

- Option B: Our students should be able to design a simple research study, analyze the study data using statistical software such as SAS or R, and interpret the results, all with minimal assistance from a statistician.
  - Two-semester course sequence.

Most programs wanted both… but given the limited space (time) in their programs, they had to prioritize.

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Planned Changes

- Refocus PubH 6414 on biostatistical literacy.
  - Include:
    - Multiple regression
    - Survival analysis
    - Only <u>one</u> semester!
  - Eliminate:
    - Use of statistical software (R, SAS, …)
    - Nearly all calculations
    - Basic descriptive statistics
      - Students are learning this in elementary school now!
- Direct students wishing to learn data analysis into the PubH 6450-51 sequence.
    - Offer it online to remove barrier.

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New Course Description

PubH 6414 Biostatistical Literacy has the primary goal of developing student ability to read and interpret statistical results in the primary literature of their specific scientific field of interest. This course will involve **minimal calculation** and offer **no formal training in any statistical programming software**. Biostatistical Literacy will cover the fundamental concepts of study design, descriptive statistics, hypothesis testing, confidence intervals, odds ratios, relative risks, adjusted models in multiple linear, logistic and Poisson regression, and survival analysis. The focus will be when to use a given method and how to interpret the results, not the actual computation or computer programming to obtain results from raw data.

Textbook: Harvey Motulsky, MD. *Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking*, 2nd Edition. Oxford University Press: 2010.

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Next Steps

- Course development began Jan. 2013
- Pilot offering: online, fifteen separate weeks from August 2013 – June 2014, N=12 dentistry residents
  - Three-stranded approach:
    - Learn concepts
      - Textbook readings and recorded mini-lectures (in advance)
      - Individual and collaborative group activities (during the week)
    - Read the literature
      - Dissect one article each week
    - Carry out a research study
      - The Island (Bulmer, 2011)
- Pilot material will be evaluated and improved using a modified Japanese lesson study approach (Roback, 2006)
- First official offering: online and in person, fall semester 2014

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