Teaching Biostatistical Literacy: A Flipped-Classroom Approach

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Outline

- Our literacy course
  - Background, audience, goal, topics
- Our teaching approach
  - Inverted or ‘flipped’ classroom
- Challenges and rewards of the flipped-classroom approach

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**

Student Audience

- 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

Primary Course Goal

- 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.
  - 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.

Course Topics by Unit (Week)

1. Introduction, study designs, sampling methods
2. Survival data, Kaplan-Meier curves
3. Sampling distributions, confidence interval for a proportion
4. Summarizing continuous variables (tables, plots)
5. Confidence interval for a mean
6. Hypothesis testing
7. Challenges (multiple testing, normality, outliers)
8. Statistical tests I: comparing proportions, risks, odds
9. Statistical tests II: comparing survival curves, means, paired means
10. Communicating risk, sensitivity, specificity, PPV
11. Correlation, simple linear regression
12. Multiple linear regression
13. Logistic and proportional hazards regression
14. ANOVA
15. Island Project Presentations

Teaching Approach

- Inverted (flipped) classroom
- Focus is on learning by doing
- Steps (same every week):
  - Pre-week: preparation and readiness quiz
  - Class time: learning activities and discussion
  - Lab time: Island project
  - End-of-week: review and final quiz

Example Unit Outline

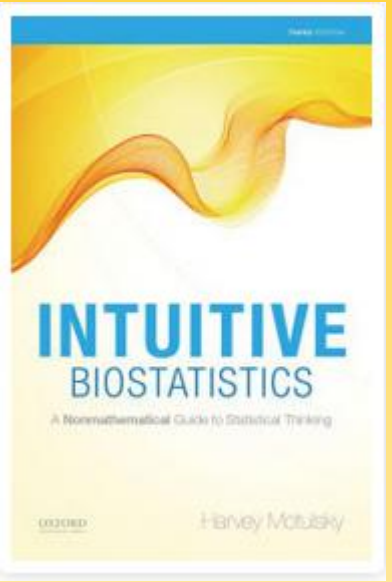
Learning Objectives: Example

Unit 12: Multiple Linear Regression (MLR)

- Be able to describe when multiple linear regression can be used, and what it is used for.
- Be able to write down the equation for a multiple linear regression model (including interaction terms) and describe what each parameter means.
- Know what kind of a plot is used to assess how well a multiple linear regression model fits the data, and be able to interpret both the plot and the model R^2 value.
- Be able to interpret the fitted model regression coefficients, and make a conclusion from their confidence intervals and *p*-values.
- Be able to explain what 'variable selection' is, how to recognize it in an article, and why it is a potential issue.
- Be able to recognize or give examples of study designs which result in correlated data and cannot be analyzed using MLR.

Literacy Course

Pre-week Preparation



- Review the learning objectives
- Listen to a few short recorded audio lectures (or read the scripts)
- Read several selections from the textbook
  - Harvey Motulsky, **Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking**, 3rd Ed. (Oxford, 2014)

Pre-Week Assessment: Readiness Quiz

- Formative assessment
  - Tests a basic level of understanding (e.g. terminology), so students are prepared for the in-class learning activities
- About 20 multiple-choice questions, takes ~20 min.
- Administered online
- Can take it twice, best score counts
  - Encouraged to take it with a study partner or group
- Weekly, so low stakes
- Example question:
  - True/False: If the hazard ratio for death is less than 1.0, it means that the group of interest has a lower hazard of death, or longer survival, compared to the reference group.

Literacy Course

In-Class Learning Activities

- Tuesdays: Concept Activity
  - Focus is on understanding a key concept for the unit, e.g. what is a sampling distribution
  - Some of these involve using software applets such as StatKey
- Thursdays: Literature Activity
  - Focus is on reading and understanding an article from the medical or public health literature

Proportion of Smokers
Concept Activity

The goal of this activity is to explore the concept of sampling variability and use it to explain what a confidence interval means.

The sample proportion that you obtained is automatically added as a dot to the dotplot, the large plot window entitled `Sampling Dotplot of Proportion`.

Let's **pretend** you were to take another random sample from the same population.

5. Would you expect your new sample proportion to equal the population proportion of US males who smoke? Why or why not?

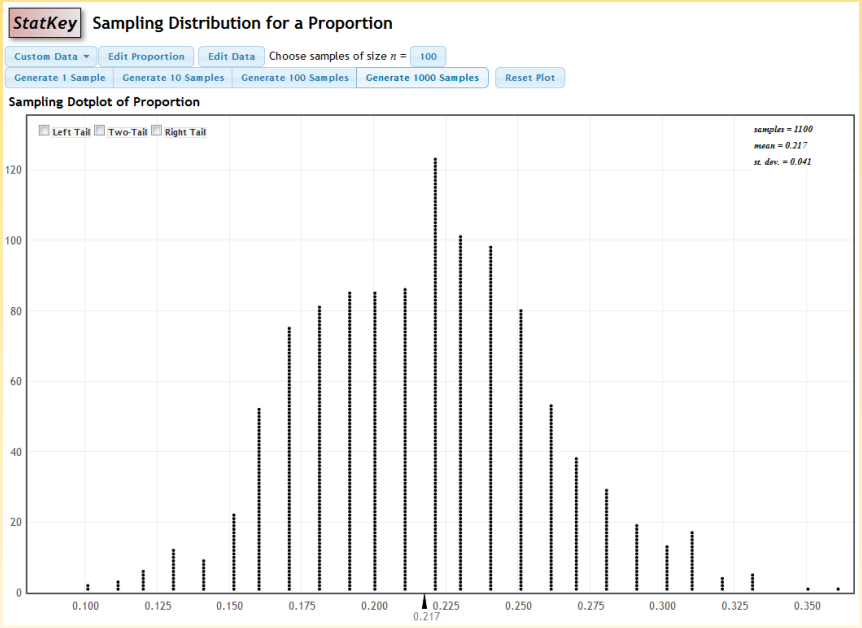
6. Would you expect your new sample proportion to equal your last sample proportion? Why or why not?

   - Click on the *Generate 1 Sample* button.

7. In your second random sample, what proportion of the 100 men are smokers?

8. Why is your second estimate different than your first estimate?

9. Why is your second estimate different than the population proportion of US men who smoke?



Hypoglycemia and Risk of Death
Literature Activity

The goal of this activity is to gain practical experience with interpreting the results of logistic regression and proportional hazards regression analyses.

RESULTS

Table 1: Risk Factors for Hypoglycemia

6. What statistical method was used for the analyses in this table? Write out the regression model equation the authors would have used. (You only have to include the first few predictors.)

7. Which factors are most strongly associated with risk of *moderate* hypoglycemia? Cite results from the table to support your answer.

8. For each factor cited in the previous question, use numbers from the table to explain how much and in which direction that factor affects the risk of moderate hypoglycemia.

9. Are the factors most strongly associated with moderate hypoglycemia the same as the factors most strongly associated with severe hypoglycemia? Cite results from the table to support your answer.

Table 1. Results of Multivariate Analysis for Factors at Baseline That Were Independent Risk Factors for Subsequent Moderate or Severe Hypoglycemia.*

Variable	Moderate Hypoglycemia		Severe Hypoglycemia	
	Odds Ratio (95% CI)	P Value	Odds Ratio (95% CI)	P Value
Age, per 1-yr increase	1.00 (1.00–1.01)	0.04	1.00 (0.99–1.01)	0.6
APACHE II score, per 1-point increase†	1.01 (1.00–1.02)	0.01	1.01 (0.99–1.03)	0.5
BMI, per 1-point increase‡	0.97 (0.96–0.98)	<0.001	0.96 (0.94–0.99)	0.003
Blood glucose, per increase of 1 mg/dl§	—		1.00 (0.99–1.00)	0.009
Sex				
Female	1.00		1.00	
Male	0.78 (0.67–0.90)	0.001	0.88 (0.66–1.17)	0.4
Postoperative status				
No	1.00		1.00	
Yes	0.82 (0.71–0.96)	0.01	0.78 (0.56–1.07)	0.1
Severe sepsis				
No	1.00		1.00	
Yes	1.28 (1.08–1.53)	0.006	0.92 (0.66–1.29)	0.6
Trauma				
No	1.00		1.00	
Yes	1.28 (1.03–1.59)	0.02	0.77 (0.46–1.28)	0.3
Diabetes¶				
No	1.00			
Yes	1.24 (1.01–1.52)	0.04		
Prior insulin treatment				
No	1.00		1.00	
Yes	1.61 (1.14–2.28)	0.007	1.46 (0.85–2.52)	0.2
Prior glucocorticoid treatment				
No	1.00		1.00	
Yes	1.09 (0.88–1.34)	0.4	1.51 (1.05–2.18)	0.03
Cardiovascular failure‖				
No	1.00		1.00	
Yes	1.24 (1.07–1.44)	0.005	1.41 (1.04–1.92)	0.03
Treatment group				
Conventional glucose control	1.00		1.00	
Intensive glucose control	24.19 (20.98–27.88)	<0.001	16.39 (9.32–28.81)	<0.001

Literacy Course

End-of-Week Assessment: EOW Quiz

- Summative assessment
  - Directly tied to the week's learning objectives
- About 6 short-essay questions, takes ~1 hr.
- Administered online
- Taken once, independently
- Weekly, so low stakes

EOW Quiz Example

TABLE 2—Association Between FEV_1 (% Predicted) and Body Composition, by Linear Regression With FEV_1 (% Predicted) as Outcome

	Regression coefficient			
Variable	Unadjusted (95% CI)	*P* value	Adjusted (95% CI)[1]	*P* value
BMI	11.7 (7.10,16.4)	0.0001	10.8 (5.9,15.6)	0.0001
Fat mass	13.2 (−1.61, 28)	0.08	12.4 (−1.90, 26.7)	0.09
Fat-free mass	4.9 (0.40, 9.42)	0.03	4.4 (−0.06, 8.80)	0.05

[1]Potential confounding variables adjusted for were presence or absence of liver dysfunction and of *P. aeruginosa* colonization.

1. [unadj] Write the appropriate **unadjusted** regression equation for the relationship between *FEV1* and *BMI* using the notation of b_0 for the intercept and b_1 for the slope. [Note: Do not include any interaction terms. Do not use any values from the table].

2. Using the table above, what is the estimated value for the slope (b_1) in the unadjusted model?

3. [adj] Taking into account Footnote 1 in the table, write the appropriate **adjusted** regression equation for the relationship between *FEV1* and *BMI* using the notation of b_0 for the intercept and b_1, b_2, and b_3 for the slopes. [Note: Do not include any interaction terms. Do not use any values from the table].

4. Using the table above, what is the estimated value for the slope (b_1) for *BMI* in the adjusted model?

5. [relationship BMI] Did adjustment for liver dysfunction and P. aeruginosa colonization change the relationship, **both** the point estimate and the statistical significance, between *FEV1* and *BMI*? Provide evidence from the table to support **both** of your answers. **(2 pts)**

Benefits For Students

- Biostatistics is **scary**; active learning allows students to do the hard parts in a supportive environment, with classmates, instructors nearby to help.
  - vs. traditional approach: students wrestle with the hard parts alone at home doing the homework.
- More challenging material can be used, since the instructors are on hand to help.
- It keeps students engaged.
- Learning is enhanced and reinforced by explaining to / arguing with classmates.
- Plus it is **way** more fun!

Student Responses about the Goal

- I feel much more confident now looking at scientific literature. The class was still challenging to me, but I feel more prepared to take on articles, graphs and figures and interpret them more correctly. Before this class, I had never considered whether a score was significant or not. It was up to my interpretation, ha!
- I understand how to read tables, what values mean, how to assess for bias or other tricks used by authors, etc. I feel that I can better understand research articles and draw my own conclusions, which I could not do before.
- I'm applying these principles in my field, in life, and as I think critically about what I'm hearing from friends or in the news. This class has increased my ability to ask the right questions of numbers.

Student Responses about the Method

- I felt I learned much more by listening to lectures at home and testing knowledge with the readiness quiz, then putting my knowledge into action by working with my peers in class to put together all the information we learned.
- I appreciated the opportunity to engage with the material in class. I learned so much because of the conversations with my classmates.
- I was pleasantly surprised to discover the group discussions helped solidify my understanding.
- The social engagement actually made me look forward to class and I helped me stay committed to attending class rather than missing it.
- Completing the concept and literature activities in class [was most helpful]. I would never have had the patience or spent the time to do it at home so I really appreciated the flipped classroom.

Benefits For Instructors

- You get to spend nearly all of your classroom time engaging directly with students who really want to understand this particular question right now
  - vs. lecturing at students who may not be paying a whole lot of attention.
- It is way more fun! When the activity is going well, there is a contented buzz of students talking and laughing.
  - When it is not, then you intervene and talk with the whole class to clarify the difficult concept.

Challenges / Barriers

- Unfamiliar to students - need to manage expectations
  - Student: “The flipped classroom style was LEAST helpful until I had tried it and understood it. The first three-four weeks of class were frustrating and exhausting. Suddenly, after I'd been through the unfamiliar process several times, I began to appreciate and feel more confident with it.”
- Unfamiliar to instructors – no longer the center of attention
  - You may feel at first that you are not “doing anything useful” as you wander around the classroom listening and observing.
- Classroom must allow students to work together in groups (e.g. movable tables and chairs)
- For classes larger than 25 students, more than one instructor needs to be present in the room
- Requires more upfront work than simply giving a lecture – more like developing an online class.

Flipped Classroom

Easing Into Active Learning

- Traditional / All lecture
- Leave blanks in the lecture slides (or provide a worksheet) for students to fill in as they listen
- Add periodic questions to the lecture; use audience-response systems to assess the class' understanding
  - Clickers, Twitter, colored cards, …
- Remove the examples from the lecture slides and turn them into activities for the students to do in class
- Give "mini-lectures" to *review* the textbook material
- Flipped / No lecture

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