SCHOOL OF PUBLIC HEALTH
UNIVERSITY OF MINNESOTA

PUBH 7401, SECTION 001

Fundamentals of Biostatistical Inference
Fall 2019

COURSE & CONTACT INFORMATION

Credits: 4
Meeting Day(s): Tuesday and Thursday
Meeting Time: 12:20-2:15 p.m.
Meeting Place: Moos 2-580

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COURSE DESCRIPTION

PubH 7401: Fundamentals of Biostatistical Inference is part of a two-course sequence in advanced biostatistical theory and methods. It presents a rigorous approach to probability and statistical inference with applications to research in public health and other health science fields. These courses are aimed at doctoral students in public health and health science fields other than Biostatistics.

Fundamentals of Biostatistical Inference covers the topics of

- probability,
- random variables: distribution functions, expectation, variance
- statistical estimation,
- sampling distributions and the Central Limit Theorem,
- hypothesis testing, and
- confidence intervals.

This course uses the statistical software R, a freely available statistical software package, to illustrate a variety of theoretical concepts.

COURSE PREREQUISITES

The course requires students to have a background in scalar calculus (e.g., Calculus I and II). We understand that it may have been a long time since you've last had calculus, so here are a few resources to refresh your calculus knowledge:

- Khan Academy: AP Calculus AB
- Garrett P., "Calculus Refresher." From Math Insight. http://mathinsight.org/calculus_refresher
- Fischer, I., "Basic Calculus Refresher." http://www.stat.wisc.edu/~ifischer/calculus.pdf

COURSE GOALS & OBJECTIVES

Upon completion of this course, students should understand and be able to apply the concepts of probability, distributions, the central limit theorem, likelihood theory, statistical estimation, hypothesis testing, and confidence interval construction to statistical applications

in their field of interest. In particular, this course should prepare students to implement and understand advanced statistical methods in their dissertations.

METHODS OF INSTRUCTION AND WORK EXPECTATIONS

Instruction
This course is not taught in the traditional lecture style. There will be frequent opportunities for you to work out examples and investigate concepts during class. Therefore, you should come prepared to actively participate in class. Additionally, because of the frequent use of R in class, you should try to bring a laptop to class, if possible. You can access the course content and assignments via the course's Canvas site.

Class Time and Preparation for Class
You are expected to attend class, participate in class discussions, and complete the assigned homework and exams. You should read through any assigned reading prior to coming to class. I do not expect you to be experts on the assigned reading before class, but you should have at least skimmed the material before class. From an educational research perspective, the benefits to reading the book before class is creating context to help you better make sense of the new material during class.

Homework
There will be approximately 10 homework assignments. These assignments are intended to keep you actively engaged with the material. You can expect the homework to consist of exercises from the textbook and additional problems that may involve simulation and exploration through the use of statistical software.

In general, homework will be assigned each week and students will have **one week** to complete the assignment. Try to work through the assignments throughout the week (rather than waiting until near the due date) in order to receive feedback from the instructors and the TA. You can expect homework to be returned within a week of the due date. Each homework assignment contributes equally in the final grade.

Working together on homework assignments is permitted, even encouraged. Students that work together will turn in their assignments as a group. However, if you work as a group, be sure you understand all of the material on the homework as you will be assessed individually on the exams.

Course Workload Expectations
PUBH 7401 is a 4-credit course. The University expects that for each credit, you will spend approximately three hours per week attending class or comparable online activity, reading, studying, completing assignments, etc. over the course of a 15-week term. Thus, this course requires approximately 180 hours of effort spread over the course of the term in order to earn an average grade. For PUBH 7401, this translates to approximately 60 hours of class contact hours, and 120 hours of out-of-class work.

Learning Community
School of Public Health courses ask students to discuss frameworks, theory, policy, and more, often in the context of past and current events and policy debates. Many of our courses also ask students to work in teams or discussion groups. We do not come to our courses with identical backgrounds and experiences and building on what we already know about collaborating, listening, and engaging is critical to successful professional, academic, and scientific engagement with topics.

In this course, students are expected to engage with each other in respectful and thoughtful ways.

In group work, this can mean:

- Setting expectations with your groups about communication and response time during the first week of the semester (or as soon as groups are assigned) and contacting the TA or instructor if scheduling problems cannot be overcome.
- Setting clear deadlines and holding yourself and each other accountable.
- Determining the roles group members need to fulfill to successfully complete the project on time.
- Developing a rapport prior to beginning the project (what prior experience are you bringing to the project, what are your strengths as they apply to the project, what do you like to work on?)

In group discussion, this can mean:

- Respecting the identities and experiences of your classmates.
- Avoid broad statements and generalizations. Group discussions are another form of academic communication and responses to instructor questions in a group discussion are evaluated. Apply the same rigor to crafting discussion posts as you would for a paper.
- Consider your tone and language, especially when communicating in text format, as the lack of other cues can lead to misinterpretation.

Like other work in the course, all student to student communication is covered by the Student Conduct Code (https://z.umn.edu/studentconduct).

COURSE TEXT & READINGS

There is an **optional** textbook for the course:

Devore and Beck's Modern Mathematical Statistics with Applications (Springer, 2nd ed., 2012).

The hard copy of the book is available through the University of Minnesota bookstore. However, a free PDF is available via the University of Minnesota Library website.

Other useful textbooks about advanced statistical theory and methods include

- Diez, Barr, and Çetinkaya-Rundel's OpenIntro Statistics (https://www.openintro.org/stat/textbook.php?stat_book=os) ← Free to download. A gentle introduction.
- Jeff Gill's Essential Mathematics for Political and Social Science Research (Cambridge University Press, 2006) ← Good review of mathematical concepts.
- Wackerly, Mendenhall, and Scheaffer's Mathematical Statistics with Applications (Cengage Learning, 7th ed., 2008) ←Equivalent difficulty.
- DeGroot and Schervish's Probability and Statistics (Pearson, 4th ed., 2012) ← Equivalent difficulty.
- Casella and Berger's Statistical Inference (Cengage Learning, 2nd ed., 2002) ← More advanced approach. This is the text used in first-year mathematical statistics courses at most graduate programs in statistics and biostatistics.

COURSE OUTLINE/WEEKLY SCHEDULE

Week	Topic	Readings	Activities/Assignments (see Canvas site for due dates)
Week 1	*Introduction to PUBH 7401* • Introduction to course • Review of common statistical procedures • Introduction to R computing environment	• Review of Introductory Statistics Material	
Week 2	*Introduction to Probability* • Conditional, marginal, and joint probability • Bayes' Theorem • Independence	• Chapters 2.1-2.5	• **Homework 1**
Week 3	*Conditional Probability Examples* • Lifetables and Kaplan-Meier • k-Nearest Neighbor	• Lecture slides	• **Homework 2**
Week 4	*Random Variables, Discrete Distributions, Expectation and Variance* • Random variables • Probability mass functions • Expectation and variance • Discrete distributions (Binomial, Poisson, Hypergeometric)	• Chapters 3.1-3.3 • Chapters 3.5-3.7	• **Homework 3**
Week 5	*Continuous Random Variables* • Continuous random variables • pdf and cdf • Expectation and variance • Continuous distributions (Normal, Exponential, Gamma, Beta)	• Chapters 4.1-4.2 • Chapters 4.3-4.5	• **Homework 4**
Week 6	*Multivariate Distributions* • Joint and marginal pmf and pdf • Covariance & correlation • Conditional distributions • Conditional expectation and variance • Introduction to random effects models and hierarchical modeling	• Chapters 5.1-5.2 • Chapters 5.3; 6.3	• **Take-Home Exam 1**

Week 7	*Statistics and Their Sampling Distributions* • Sampling distributions • Introduction to Bootstrap • Central Limit Theorem	• Chapters 6.1-6.2	• **Homework 5**
Week 8	*Point Estimators* • Point estimators • Criteria for evaluating point estimators	• Chapters 7.1-7.2	• **Homework 6**
Week 9	*Maximum Likelihood Estimators* • Likelihood construction • Fisher Information • Asymptotic relative efficiency • Bootstrap standard errors • MLE and (generalized) linear model • Delta theorem	• Chapter 7.2 • Chapter 7.4 • Chapters 12.1-12.2	• **Homework 7**
Week 10	*Method of Moments and Estimating Equations* • Method of moments estimators • Least squares estimator • Generalized estimating equations	• Lecture slides	• **Homework 8**
Week 11	*Confidence Intervals and Hypothesis Testing* • Coverage and average length • CI for maximum likelihood estimators • Bootstrap confidence intervals	• Chapter 6.4 & • Chapters 8.1-8.3 • Chapters 9.1-9.2 • Chapter 9.4	• **Take-Home Exam**
Week 12	*Hypothesis Testing* • Type I and II Errors & Size and Power • Power and size • Rejection region and p-values Permutation tests • Wald, score, and likelihood ratio tests	•	• **Homework 9**
Week 13	*THANKSGIVING* • Tuesday, Nov. 26: REVIEW • Thursday, Nov. 28: NO CLASS		

Week 14	*Introduction to Bayesian Inference* • Prior, likelihood, and posterior • Incorporating prior information • Inference and hypothesis testing • Credible intervals • Conjugate priors	• Lecture slides	• **Homework 10**
Week 15	• Tuesday, Dec. 10: TAKE-HOME FINAL EXAM	•	• **Take-Home Final Exam**

SPH AND UNIVERSITY POLICIES & RESOURCES

The School of Public Health maintains up-to-date information about resources available to students, as well as formal course policies, on our website at www.sph.umn.edu/student-policies/. Students are expected to read and understand all policy information available at this link and are encouraged to make use of the resources available.

The University of Minnesota has official policies, including but not limited to the following:

- Grade definitions
- Scholastic dishonesty
- Makeup work for legitimate absences
- Student conduct code
- Sexual harassment, sexual assault, stalking and relationship violence
- Equity, diversity, equal employment opportunity, and affirmative action
- Disability services
- Academic freedom and responsibility

Resources available for students include:

- Confidential mental health services
- Disability accommodations
- Housing and financial instability resources
- Technology help
- Academic support

EVALUATION & GRADING

A student's final grade will be calculated by weighting assessments (homework, Midterm Exams 1 & 2, and Final Exam) as follows:

- Homework (25%)
- Exams (75%)
    - Take-Home Exam 1 (20%)
    - Take-Home Exam 2 (25%)
    - Take-Home Final Exam (30%)

Grading Scale
The University uses plus and minus grading on a 4.000 cumulative grade point scale in accordance with the following, and you can expect the grade lines to be drawn as follows:

% In Class	Grade	GPA
93 - 100%	A	4.000
90 - 92%	A-	3.667
87 - 89%	B+	3.333
83 - 86%	B	3.000
80 - 82%	B-	2.667
77 - 79%	C+	2.333
73 - 76%	C	2.000
70 - 72%	C-	1.667
67 - 69%	D+	1.333
63 - 66%	D	1.000
< 62%	F	

- A = achievement that is outstanding relative to the level necessary to meet course requirements.
- B = achievement that is significantly above the level necessary to meet course requirements.
- C = achievement that meets the course requirements in every respect.
- D = achievement that is worthy of credit even though it fails to meet fully the course requirements.
- F = failure because work was either (1) completed but at a level of achievement that is not worthy of credit or (2) was not completed and there was no agreement between the instructor and the student that the student would be awarded an I (Incomplete).
- S = achievement that is satisfactory, which is equivalent to a C- or better
- N = achievement that is not satisfactory and signifies that the work was either 1) completed but at a level that is not worthy of credit, or 2) not completed and there was no agreement between the instructor and student that the student would receive an I (Incomplete).

The instructor reserves the right to adjust the scale downward (so that it requires a lower percentage to achieve a certain letter grade) but never higher.

Evaluation/Grading Policy	Evaluation/Grading Policy Description
Scholastic Dishonesty, Plagiarism, Cheating, etc.	You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis (As defined in the Student Conduct Code). For additional information, please see https://z.umn.edu/dishonesty The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty: https://z.umn.edu/integrity. NOTE: I expect that students will complete all exams **INDEPENDENTLY,** without assistance from any other people. If I have any reason to suspect that a student gave assistance on an exam to another student or received assistance on an exam from another student or a person outside the class, I will file a claim with the Office of Student Conduct and Academic Integrity. If you have additional questions, please clarify with your instructor. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class-e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam. Indiana University offers a clear description of plagiarism and an online quiz to check your understanding (http://z.umn.edu/iuplagiarism).
Late Assignments	Late assignments are not accepted unless approved in advance by the instructors or for a documented reason (such as illness).
Attendance Requirements	While attendance of classes is not an explicit factor in your final grade, regular class attendance will help you stay up on the material. I will do my best to communicate information both in-class and via the course Canvas site, but cannot guarantee that everything said in class will be distributed via other channels.
Extra Credit	It is my view that the benefits of extra-credit opportunities tend to accrue to students who are most comfortable operating within the academic system, i.e., they are less likely to benefit students from groups that are underrepresented in academia. Hence, as a rule, extra credit opportunities will not be available during this class. However, as noted above, depending on the final grade distribution I may adjust grade letter cutoffs in the above table. Any adjustments of this type will always be in favor of the student, i.e., it will result in the same or higher letter grade than the one dictated by the above table.