I. Course Description

The course provides an overview of inferential methods needed for biostatistical research. The course emphasizes topics without overt reliance on measure-theoretic concepts. Classic likelihood inference, asymptotic distribution theory, and robust inferential methods (M-estimation) will be emphasized.

II. Course Prerequisites

Stat 8101-8102 or equivalent; students should be comfortable with the multivariate normal distribution and have some introduction to convergence concepts.

III. Course Goals and Objectives

Upon completion of this course:

- Students will understand how to construct likelihoods for a variety of scenarios, become knowledgeable with computational methods to maximize the likelihood, and understand large-sample results for likelihood-based methods
- Students will understand likelihood-based tests and confidence regions.
- Students will learn and be able to use several techniques to prove large sample convergence for a variety of estimators
- Students will understand how likelihood methods can be made more robust through the use of estimating functions and how to conduct large-sample robust inference
IV. Methods of Instruction and Work Expectations

Students are expected to attend class, participate in class discussions and complete the assigned
homeworks and exams. Students should have read through the assigned reading at least once prior to
coming to class. We certainly do not expect students to be experts on the assigned reading before class.
Working together on homework assignments is permitted but each student is expected to
independently write-up homework assignments using their own computing and in their own words.
Students are highly encouraged to work through the assignments throughout the week (rather than waiting
until near the due date) in order to receive feedback from the instructor and the TA.

V. Course Text and Readings

Required Text:

Other textbooks on advanced inference that may be useful. Note that many of the following texts may rely
overly on measure theory which is beyond the scope of this course. Nonetheless, these remain important
texts for reference.

VI. Course Outline/Weekly Schedule

Week 1 (Week of January 19)
Lecture 1 – Wednesday, January 21
Topics: Review Syllabus | Introduction | Distribution functions
Readings: Boos and Stefanski Chapter 1
Homework 1 assigned

Week 2 (Week of January 26)
Lecture 2 – Monday, January 26
Topics: Modes of convergence: convergence in probability (weak law of large numbers), almost sure
convergence (strong law of large numbers), convergence in distribution (central limit theorem, extremal
limiting distribution)
Readings: Boos and Stefanski Chapter 5.1-5.2

Lecture 3 – January 28
Topics: Relationships between modes of convergence | Extensions to vector-valued random variables
Readings: Boos and Stefanski Chapter 5.3-5.4
Homework 1 due
Homework 2 assigned

Week 3 (Week of February 2)
Lecture 4 – February 2
Topics: Laws of Large Numbers | Central Limit Theorem | Order notation
Readings: Boos and Stefanski Chapter 5.5.3
Lecture 5 – February 4  
Topics: Proof tools: Markov’s Inequality, Slutsky’s Theorem, Mann-Wald theorem, Cramér-Wold device, Multivariate Slutsky’s Theorem  
Readings: Boos and Stefanski Chapter 5.5  
Homework 2 due  
Homework 3 assigned

Week 4 (Week of February 9)  
Lecture 6 – February 9  
Topics: The Multivariate Delta Method and the CLT  
Readings: Boos and Stefanski Chapter 5.5.5

Lecture 7 – February 11  
Topics: Review of likelihood and the likelihood principle | Constructing likelihoods  
Readings: Boos and Stefanski Chapter 2.1-2.2  
Homework 3 due  
Homework 4 assigned

Week 5 (Week of February 16)  
Lecture 8 – February 16  
Topics: Likelihoods for regression models | Marginal and conditional likelihoods  
Readings: Boos and Stefanski Chapter 2.3-2.4

Lecture 9 – February 18  
Topics: Likelihood equations and the MLE  
Readings: Boos and Stefanski Chapter 2.5  
Homework 4 due  
Homework 5 assigned

Week 6 (Week of February 23)  
Lecture 10 – February 23  
Topics: Likelihood equations and the MLE, cont’d.  
Readings: Boos and Stefanski Chapter 2.5

Lecture 11 – February 25  
Topics: Methods for maximizing likelihoods (profile likelihoods, Newton methods, EM algorithm)  
Readings: Boos and Stefanski Chapter 2.6  
Homework 5 due  
Homework 6 assigned

Week 7 (Week of March 2)  
Lecture 12 – March 2  
Topics: Wald, likelihood ratio, and score tests for one and multi-dimensional parameters  
Readings: Boos and Stefanski Chapter 3.1-3.2

Lecture 13 – March 4  
Topics: Wald, likelihood ratio, and score tests, cont’d. | Confidence regions  
Readings: Boos and Stefanski Chapter 3.3  
NO NEW HOMEWORK  
Homework 6 due

Week 8 (Week of March 9)  
Lecture 14 – March 9  
Topics: Midterm review  
Readings: No new readings

Lecture 15 – March 11  
MIDTERM 1
Homework 7 assigned

Week 9 (Week of March 16) – SPRING BREAK

Week 10 (Week of March 23)
Lecture 16 – March 23
Topics: Rigorous proof of consistency asymptotic normality for MLE
Readings: Boos and Stefanski Chapter 6.1-6.3

Lecture 17 – March 25
Topics: Asymptotic null distribution of likelihood-based tests | Local Asymptotic Power | Nonstandard MLE (especially null hypothesis on boundary of parameter space)
Readings: Boos and Stefanski Chapter 6.5
Homework 7 due
Homework 8 assigned

Week 11 (Week of March 30)
Lecture 18 – March 30
Topics: Approximation by averages | Introduction to M-estimation | Delta method via M-Estimation
Readings: Boos and Stefanski Chapter 5.5.7, 7.1-7.2

Lecture 19 – April 1
Topics: Influence curve | Connection of M-estimation to influence curve | Non-smooth estimating functions
Readings: Boos and Stefanski Chapter 5.5.8, 7.3-7.4
Homework 8 due
Homework 9 assigned

Week 12 (Week of April 6)
Lecture 20 – April 6
Topics: Estimating functions for regression problems
Readings: Boos and Stefanski Chapter 7.5

Lecture 21 – April 8
Topics: Generalized Wald, score, and likelihood ratio test | Quadratic inference functions and score tests
Readings: Boos and Stefanski Chapter 8.3
Homework 9 due
Homework 10 assigned

Week 13 (Week of April 13)
Lecture 22 – April 13
Topics: Statistical inference for Monte Carlo simulation studies
Readings: Boos and Stefanski Chapter 9

Lecture 23 – April 15
Topics: Presentation of Monte Carlo simulation results | Designs for Monte Carlo simulations
Homework 10 due
Homework 11 assigned

Week 14 (Week of April 20)
Lecture 24 – April 20
Topics: Introduction to the Jackknife | Connection to influence curve
Readings: Boos and Stefanski Chapter 10.1-10.2

Lecture 25 – April 22
Topics: Examples of Jackknife | Delete-d and grouped Jackknife | Jackknife for regression setting
VII. Evaluation and Grading

There will be 13 homework assignments assigned weekly on Wednesday except prior to the midterm and final. Students will have one week to complete each assignment, so the assignment will be due the following Wednesday. The lowest two assignments will be dropped. There will be an in-class midterm exam on the last class before spring break. A final exam will be given and will be cumulative but will be weighted more heavily towards material since the midterm exam.

A student’s final grade will be calculated by weighting the three components of the course (homework, midterms and final exam) as follows:
- Homework – 35%
- Midterm Exam – 30%
- Final exam – 35%

A letter grade will be determined from the percentage of points each student receives as follows:
- A 93 - 100%
- A- 90 – 92%
- B+ 87 – 89%
- B 83 – 86%
- B- 80 – 82%
- C+ 77 – 79%
- C 73 – 76%
- C- 70 – 72%
- D+ 67 – 69%
- D 63 – 66%
- F 0 – 62%

A 4.000 - Represents achievement that is outstanding relative to the level necessary to meet course requirements
A- 3.667
B+ 3.333
B 3.000 - Represents achievement that is significantly above the level necessary to meet course requirements
B- 2.667
C+ 2.333
C 2.000 - Represents achievement that meets the course requirements in every respect
C- 1.667
D+ 1.333
D 1.000 - Represents achievement that is worthy of credit even though it fails to meet fully the course requirements

For those enrolled S/N, a letter grade of C or better must be achieved to receive an S. The University Senate has established a uniform grading policy for all letter grades: http://www.policy.umn.edu/Policies/Education/Education/GRADINGTRANSCRIPTS.html.

If you would like to switch grading options (e.g., A/F to S/N), it must be done within the first two weeks of the semester.

Course Evaluation
The SPH will collect student course evaluations electronically using a software system called CoursEval: www.sph.umn.edu/courseval. The system will send email notifications to students when they can access and complete their course evaluations. Students who complete their course evaluations promptly will be able to access their final grades just as soon as the faculty member renders the grade in SPHGrades: www.sph.umn.edu/grades. All students will have access to their final grades through OneStop two weeks after the last day of the semester regardless of whether they completed their course evaluation or not. Student feedback on course content and faculty teaching skills are an important means for improving our work. Please take the time to complete a course evaluation for each of the courses for which you are registered.

Incomplete Contracts
A grade of incomplete “I” shall be assigned at the discretion of the instructor when, due to extraordinary circumstances (e.g., documented illness or hospitalization, death in family, etc.), the student was prevented from completing the work of the course on time. The assignment of an “I” requires that a contract be initiated and completed by the student before the last official day of class, and signed by both the student and instructor. If an incomplete is deemed appropriate by the instructor, the student in consultation with the instructor, will specify the time and manner in which the student will complete course requirements. Extension for completion of the work will not exceed one year (or earlier if designated by the student’s college). For more information and to initiate an incomplete contract, students should go to SPHGrades at: www.sph.umn.edu/grades.

University of Minnesota Uniform Grading and Transcript Policy - A link to the policy can be found at onestop.umn.edu.

VIII. Other Course Information and Policies

Grade Option Change (if applicable)
For full-semester courses, students may change their grade option, if applicable, through the second week of the semester. Grade option change deadlines for other terms (i.e. summer and half-semester courses) can be found at onestop.umn.edu.

Course Withdrawal
Students should refer to the Refund and Drop/Add Deadlines for the particular term at onestop.umn.edu for information and deadlines for withdrawing from a course. As a courtesy, students should notify their instructor and, if applicable, advisor of their intent to withdraw.
Students wishing to withdraw from a course after the noted final deadline for a particular term must contact the School of Public Health Office of Admissions and Student Resources at sph-ssc@umn.edu for further information.

**Student Conduct Code**
The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University. Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.

As a student at the University you are expected to adhere to Board of Regents Policy: **Student Conduct Code**. To review the Student Conduct Code, please see:

Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor's ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities."

**Use of Personal Electronic Devices in the Classroom**
Using personal electronic devices in the classroom setting can hinder instruction and learning, not only for the student using the device but also for other students in the class. To this end, the University establishes the right of each faculty member to determine if and how personal electronic devices are allowed to be used in the classroom. For complete information, please reference:

**Scholastic Dishonesty**
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. (Student Conduct Code: http://regents.umn.edu/sites/default/files/policies/Student_Conduct_Code.pdf) If it is determined that a student has cheated, he or she may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see:
http://policy.umn.edu/Policies/Education/Education/INSTRUCTORRESP.html.

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty: http://www1.umn.edu/oscai/integrity/student/index.html. If you have additional questions, please clarify with your instructor for the course. 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.

**Makeup Work for Legitimate Absences**
Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include verified illness, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. For complete information, please see:
http://policy.umn.edu/Policies/Education/Education/MAKEUPWORK.html.

**Appropriate Student Use of Class Notes and Course Materials**
Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in
effective learning. Such actions violate shared norms and standards of the academic community. For additional information, please see: http://policy.umn.edu/Policies/Education/Education/STUDENTRESP.html.

Sexual Harassment
"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult Board of Regents Policy: http://regents.umn.edu/sites/default/files/policies/SexHarassment.pdf.

Equity, Diversity, Equal Opportunity, and Affirmative Action
The University will provide equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy: http://regents.umn.edu/sites/default/files/policies/Equity_Diversity_EO_AA.pdf.

Disability Accommodations
The University of Minnesota is committed to providing equitable access to learning opportunities for all students. Disability Services (DS) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

If you have, or think you may have, a disability (e.g., mental health, attentional, learning, chronic health, sensory, or physical), please contact DS at 612-626-1333 to arrange a confidential discussion regarding equitable access and reasonable accommodations.

If you are registered with DS and have a current letter requesting reasonable accommodations, please contact your instructor as early in the semester as possible to discuss how the accommodations will be applied in the course.

For more information, please see the DS website, https://diversity.umn.edu/disability/.

Mental Health and Stress Management
As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: http://www.mentalhealth.umn.edu.

The Office of Student Affairs at the University of Minnesota
The Office for Student Affairs provides services, programs, and facilities that advance student success, inspire students to make life-long positive contributions to society, promote an inclusive environment, and enrich the University of Minnesota community.

Units within the Office for Student Affairs include, the Aurora Center for Advocacy & Education, Boynton Health Service, Central Career Initiatives (CCE, CDes, CFANS), Leadership Education and Development –Undergraduate Programs (LEAD-UP), the Office for Fraternity and Sorority Life, the Office for Student Conduct and Academic Integrity, the Office for Student Engagement, the Parent Program, Recreational Sports, Student and Community Relations, the Student Conflict Resolution Center, the Student Parent HELP Center, Student Unions & Activities, University Counseling & Consulting Services, and University Student Legal Service.

For more information, please see the Office of Student Affairs at http://www.osa.umn.edu/index.html.

Academic Freedom and Responsibility: for courses that do not involve students in research
Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom. Along with this
freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.*

Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help. Contact the instructor, the Department Chair, your adviser, the associate dean of the college, or the Vice Provost for Faculty and Academic Affairs in the Office of the Provost.

OR:

**Academic Freedom and Responsibility, for courses that involve students in research**

Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom and conduct relevant research. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.*

When conducting research, pertinent institutional approvals must be obtained and the research must be consistent with University policies.

Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help. Contact the instructor, the Department Chair, your adviser, the associate dean of the college, or the Vice Provost for Faculty and Academic Affairs in the Office of the Provost.

* Language adapted from the American Association of University Professors "Joint Statement on Rights and Freedoms of Students".

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