Course Information

Title: Causal Inference
Number: BIOS 761 / EPI 760
Semester: Spring 2026 (01/13 - 04/27)
Credit hours: 4
Course schedule: Tuesday-Thursday 3:00 – 4:50 PM EST
Zoom room: https://zoom.us/j/91003528195

Instructors

Razieh Nabi, PhD
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Teaching Assistant: Zhaohua Zeng
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Course Description

This course is an elective for Biostatistics PhD students and second-year MSPH students, a required course for second-year Epidemiology PhD students, and is open to PhD students from other departments on a limited, case-by-case basis.
This course provides a comprehensive survey of modern topics in causal inference. It covers fundamental concepts, including counterfactual random variables, causal effect identifiability, graphical frameworks, G-computation, inverse probability of treatment weighting, efficient methods for doubly (or multiply) robust estimation, and causal mediation. The course emphasizes the integration of modern regression techniques (e.g., machine learning) in causal effect estimation and includes an applied introduction to these methods.
Methods from the course will be implemented in the R programming language and using relevant R packages. Intermediate R programming skills are expected (familiarity with manipulating data, writing functions in R, reading R documentation, the glm function are particularly important).

Students who are not confident in these skills are encouraged to complete related online courses (e.g., Coursera or DataCamp) to brush up on skills ahead of enrollment in the course.
Knowledge of basic probability and statistical theory is required including the following topics: random variables, distributions of random variables, independence, expectations, conditional distributions, expectations, conditional expectations. Knowledge of statistics is also required including: sampling distributions, consistency, the central limit theorem, regression (linear and logistic), basic principles of maximum likelihood estimation.

Prerequisites

Knowledge of basic probability and statistical theory is required – BIOS 513 (or an equivalent course) is strongly recommended. Proficiency in R, at the level taught in BIOS 545, is required.

Learning Objectives

Upon conclusion of the course, students should be able to:

- Use common frameworks to translate a research question into a causal effect parameter.
- Use graphical frameworks to assess identifiability of causal effects.
- Implement simple approaches to estimation and inference on various causal effects.
- Understand the motivation for and implementation of efficient, doubly robust approaches to estimation of various causal effect using existing software packages.
- Understand the motivation for incorporating modern regression (e.g., machine learning) into causal effect estimation and the difficulties in so doing.
- Describe issues that arise due to non-compliance. Implement estimators of quantities that are appropriate for answering causal questions in this context.
- Describe fundamental principles of causal mediation. Implement estimators of various mediation parameters.
- Understand time-varying confounding and why simple regression approaches fail to adequately answer causal questions in these contexts.
- Implement estimators of causal parameters describing the effects of longitudinal interventions.
- Interpret and write about results of analyses and describe limitations of various approaches.

Evaluation

Student grades will be based on:

- **Four to six homework assignments: 40%**
  The homework assignments will be a mixture of theoretical problems that complement lecture material (e.g., using a graph to determine whether a causal effect is identifiable), computational problems (e.g., implementing a particular estimator using a software package), and interpretation (e.g., writing a mock Methods section description of a method for an applied journal).

  The assignments should be submitted on Canvas (specific instructions will be provided during the first lecture).

- **Class participation: 20%**
  Class participation will be conducted via Zoom participation reports, active engagement in discussions and random in-class quizzes.

- **Midterm (February 24): 20%**
  The midterm exam will be a mix of proofs and code implementation.
- **Final (April 23): 20%**
  The final exam will be a mix of proofs and code implementation.

Grade scale

A	$93-100\%$	B+	$87-89.9\%$	B-	$80-82.9\%$	F	$<65\%$
A-	$90-92.9\%$	B	$83-86.9\%$	C	$65-79.9\%$		

Course Calendar ($\sim$ 14 weeks)

- **Chapter 1**: Introduction (2 weeks)
  - Causal and statistical questions: lay of the land
  - Causal inference and confounding bias
  - Average causal effect
- **Chapter 2**: Causal graphical models (1 week)
  - Different causal frameworks
  - Causal Directed Acyclic Graphs (DAGs)
  - Single-World Intervention Graphs (SWIGs)
- **Chapter 3**: Identification of causal effects (1.5 – 2 weeks)
- **Chapter 4**: Estimation of causal effects (1.5 – 2 weeks)
  - G-computation, IPW, doubly robust estimators

  Midterm Exam (February 24)
- **Chapter 5**: Unmeasured confounding (1 week)
  - Instrumental variables
  - Front-door model and its extensions
  - Sensitivity analysis
- **Chapter 6**: Longitudinal studies (1 – 1.5 weeks)
- **Chapter 7**: Mediation analysis (2 – 2.5 weeks)
  - Single mediator: definitions, identification, estimation
  - Multiple mediators: path-specific effects (PSEs)
- **Chapter 8**: Miscellaneous topics (2 weeks)
  - Algorithmic decision making
  - Missing data

  Final Exam (April 23)

Course Materials

There is no required textbook for this course. The following materials are useful for diving deeper into the content as you please.

- *Causal Inference: What If* by Miguel A. Hernan and James M. Robins. [Link]
- *Semiparametric Theory and Missing Data* by Anastasios A. Tsiatis.
- *Causality: Models, Reasoning, and Inference* by Judea Pearl. [Link]
- *Targeted Learning: Causal Inference for Observational and Experimental Data* by van der Laan and Rose.

- *Graphical Models* by Steffen L. Lauritzen (1996)
- *Statistical Methods for Dynamic Treatment Regimes (reinforcement learning, causal inference, and personalized medicine)* by Bibhas Chakraborty and E.M. Moodie.
- Selected papers, tutorials, websites to be shared as the semester progresses.

Course Policies

- Students are expected to attend lectures and participate in discussions during class.
- **Punctuality is important for class attendance.**
- Late homework submissions (without prior approval of instructor) will be penalized (# of late days $\times$ 20% of the grade will be deducted).

As the instructor of this course, I endeavor to provide an inclusive learning environment. If you experience barriers to learning in this course, do not hesitate to discuss them with me and the Office for Equity and Inclusion, 404-727-9877.

Further, you are bound by Emory University's Student Honor and Conduct Code. It is required that all material submitted by a student fulfilling his or her academic course of study must be the original work of the student. Violations of academic honor include any action by a student indicating dishonesty or a lack of integrity in academic ethics. Academic dishonesty refers to cheating, plagiarizing, assisting other students without authorization, lying, tampering, or stealing in performing any academic work, and will not be tolerated under any circumstances.

LGS Policies

Accessibility and Accommodations

Accessibility Services works with students who have disabilities to provide reasonable accommodations. In order to receive consideration for reasonable accommodations, you must contact the Office of Accessibility Services (OAS). It is the responsibility of the student to register with OAS. Please note that accommodations are not retroactive and that disability accommodations are not provided until an accommodation letter has been processed.
Students who registered with OAS and have a letter outlining their academic accommodations are strongly encouraged to coordinate a meeting time with me to discuss a protocol to implement the accommodations as needed throughout the semester. This meeting should occur as early in the semester as possible.
Contact Accessibility Services for more information at (404) 727-9877 or accessibility@emory.edu. Additional information is available at the OAS website.

Academic Integrity

You are excepted to uphold and cooperate in maintaining academic integrity as a member of the Laney Graduate School. By taking this course, you affirm your commitment to the Laney Graduate School Honor Code, which you can find in the Laney Graduate School Handbook. You should ensure that you are familiar with the rights and responsibilities of members of our academic community and with policies that apply to students as members of our academic community. Any individual, when they suspect that an offense of academic misconduct has occurred, shall report this suspected breach to the appropriate Director of Graduate Studies, Program Director, or Dean of the Laney Graduate School. If an allegation is reported to a Director of Graduate Studies or a Program Director, they are in turn required to report the allegation to the Dean of Laney Graduate School.

Stress Management and Mental Health

As a student, you may find that personal and academic stressors in your life, including those related to remote study, COVID-19, economic instability, and/or racial injustice, are creating barriers to learning this semester. If you are struggling with concentration, motivation, or emotional concerns that feel overwhelming and are impacting your daily functioning, please know that there are university resources available to support you. For more information on these resources see:

- Counseling & Psychological Services
- Office of Spiritual & Religious Life
- Student Case Management and Interventions Services
- Student Health Services Psychiatry
- Emory Anytime Student Health Services
- Emory Student Telehealth - 24/7 Medical & Mental Health Support