Biostat 881: Advanced Topics in Causal Inference, Winter 2022

Monday/Wednesday 1-2:30pm

Instructor: Jean Morrison
Office: M4148 SPH II / Zoom see Canvas for meeting room
Office hours: TBD(in person).
    Please "stop by" and tell me about yourself.
    Outside of listed office hours, individual appointments are welcome. Please email me to
        find a day/time.
E-mail: jvmorr@umich.edu (Please include BIOSTAT881 in the subject line of all emails)

Course Description:

This course provides a survey of topics in modern causal inference. We will learn theory and methodology aimed at drawing causal conclusions from observational and experimental data.

Topics covered in this course will fall into four sections: Part I (Foundational Ideas) includes introduction to potential outcomes, use of directed acyclic graphs (DAGs) to depict causal relationships, and concepts such as confounding, colliding, and mediation. Part II (Modeling) focuses on modeling and estimation strategies, putting the concepts learned in Part I into action. In Part III we cover time-varying treatments. In Part IV, we will cover a selection of special topics including instrumental variable analysis and use of machine learning in causal inference. Topics covered in Part IV will be partly chosen according to student and instructor interest. This section of the class will rely primarily on reading and group discussion of papers.

To cement the ideas learned through lectures, students will conduct a self-designed project throughout the semester.

Topics covered:
Part I
- Definition of potential outcomes and causal effects.
- Modeling using directed acyclic graphs (DAGs) including concepts of Markov properties, d-separation, confounding and the backdoor criterion, effect modification, and mediation.
- Single world intervention graphs (SWIGs)
- Using DAGs to formulate causal contrasts corresponding to a scientific question.

Part II

- Using parametric modeling to estimate causal effects.
- Propensity scores and propensity score based estimation methods.
- Matching
- Causal survival analysis

Part III

- Causal estimation with time-varying treatments

Part IV, Topics may include

- Instrumental variable analysis and Mendelian randomization
- Machine learning for causal inference
- High-dimensional mediation analysis
- Variable selection in causal inference

Course Materials:

Required Textbook:

- [Miguel A. Hernán, James M. Robins (2019) Causal Inference: What If](#)

All required and suggested readings besides HR will be provided as PDFs.

Journal Articles:

Reading journal articles will be an important part of this class. A list of required and suggested readings for each lecture can be found on the schedule page.

Additional Textbooks:

These are resources which you may find useful but which are not required

- Judea Pearl (2000). Causality: Models, Reasoning, and Inference. Cambridge University Press.
- Morgan S and Winship C. (2014) Counterfactuals and Causal Inference: Methods and Principles for Social Research. Cambridge University Press.

- Imbens G and Rubin R. (2015) Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction. Cambridge University Press.
- Mark van der Laan and Sherri Rose. (2011) Targeted Learning: Causal Inference for Observational and Experimental Data.
- Spirtes P, Glymour C, Scheines R (1993). Causation, Prediction, and Search. Lecture Notes in Statistics 81. New York: Springer-Verlag.
- van der Laan MJ, Robins JM (2003). Unified Methods for Censored Longitudinal Data and Causality. New York: Springer Verlag.
- Chakraborty B and Moodie E. (2015) Statistical Methods for Dynamic Treatment Regimes: Reinforcement Learning, Causal Inference, and Personalized Medicine. Springer New York.

Pre-requisites:
Biostat 601, 602, 650, 651, and 653. Biostat 801, 802 (concurrent ok) or Stat 610, 611.

Course Objectives:

At the end of the course the students will be able to:

1. Translate a scientific question into a causal contrast to be estimated.
2. Derive graphical models for investigating the conditions under which the causal contrasts of interest are identified from data collected under specific study designs.
3. Formulate adequate structural models for making inference about the causal contrasts of interest.
4. Implement simulations appropriate for investigating the properties of causal estimators.
5. Read and understand modern literature in causal inference (*)

Grading and Student Work
Assignments:

Homework: Homework will provide students with an opportunity to test and apply what they have learned. Homework will consist of theoretical questions and problems as well as some simulations to be conducted in R or statistical software of your choosing. For these explorations, I'd like you to hand in annotated code in addition to its output (RMarkdown highly encouraged). There will be approximately 3 assignments over the first 8 weeks of the semester.

Project: Throughout the semester, students will design, propose, and carry out a project applying some of the concepts and methods learned in the class. See the project page fore more details. The project will involve several graded activities including a proposal page, a written progress report, a peer review activity, a final report, and a final presentation.

In-Class Activities: To help with review, we will do short in-class activities in many classes. In-class activities will be graded on a completed/not-completed scale. Completing the in-class activity requires being present for class on the day of the activity. However, to allow flexibility for travel, illness, and other constraints, students only need to complete 80% of in-class activities to receive full credit.

Grading:

30% Homework

50% Project:

- Proposal (1 page): 3%
- Progress report: 7%
- Participation in progress report peer review: 7%
- Final report: 30%
- Final report presentation: 3%

20% In-class Activities

Deadlines and Late Work

The deadlines given in the course schedule are designed to keep you on track. If you can't complete an assignment by the deadline, let me know at least 24 hours in advance (except in extenuating

circumstances) and we will arrange an extension that allows you to complete it. There are three deadlines that are inflexible. These are:

- The project progress report. Project progress reports will be read by your peers, so it is important to submit this on time.
- Group discussion of progress reports will occur one week after progress reports are submitted. You need to read each of your group member's reports and complete the peer review guide (not handed in) before this date.
- Final presentations are on April 17th and April 25th. Since this is the end of the semester, there is no way to do late/make up presentations.

What you can expect from me
> Commitment to your learning and your success
I believe all students are unique and will thrive in a learning environment that is challenging yet supportive of critical thinking and active learning. My goal as an instructor is to encourage mastery, competency and transformational learning relevant to success in the field of public health. Please talk to me if there is anything you want to discuss or about which you are unclear. I want to be supportive of your learning and growth.

> Inclusive & supportive learning community
I believe that learning happens best when we all learn together as a community. This means creating a space characterized by generous listening, adventurous civility, humility, patience, and hospitality. I will strive to create a safe classroom environment that promotes scholarly dialogue and informed debates that are respectful of diverse perspectives. Classroom discussions, activities, and assignments dealing with sensitive issues involving social determinants of health will demonstrate these values and beliefs.

> Openness to feedback
I appreciate straightforward feedback from you regarding how well the class is meeting your needs. Let me know if material is not clear or when its relevance to the student learning outcomes for the course is not apparent. Please also let me know if there's an aspect of the class you find particularly interesting, helpful, or enjoyable!

> Responsiveness
I will monitor email daily and respond to all messages within ~24 hours Monday-Friday (~48 hours over weekends or holiday periods).

> Clear guidelines and prompt feedback on assignments
I'll provide clear instructions for all assignments. If you have questions, please ask in class, via email, on the course discussion board, or at office hours. I'll provide feedback on your submissions and update grades promptly in Canvas.

> Privacy and Respect
If you need disability accommodations, I will only share enough information to make arrangements, and only with the appropriate people. Details of your diagnosis are your business and will be treated with respect. This is also true of any other personal information you share with me. Please note that if you

tell me about an instance of sexual misconduct, I may be required to make a **report to the** [Equity, Civil Rights and Title IX Office](#). Other [confidential resources](#) are available.

What I expect from you
> Attend class
You are strongly encouraged to attend all classes. If you must miss a class due to illness, a family emergency, a religious holiday, or some other valid reason, please let me know prior to the class in question.

> Participate
I encourage you to come to class and office hours and actively participate and to ask questions in person and via any Zoom session. I'll expect all of us to be respectful of each other's contributions, whether we agree with them or not.

> Be proactive
If you find that you have any trouble keeping up with assignments or other aspects of the course, make sure you let me know as early as possible. Make sure that you are proactive in informing me when difficulties arise during the course so that I can help you find a solution.

> Complete assignments
All assignments for this course will be submitted electronically through Canvas unless otherwise instructed. I encourage you to make your best effort to submit all assignments on time, but I understand that sometimes circumstances arise that are beyond our control. If you need an extension, please contact me. Assignments submitted late without prior approval will not be eligible for full credit.

> Commit to integrity
As a student in this course and at this university you are expected to maintain a high degree of professionalism, commitment to active learning and participation in this class, and also integrity in your behavior in and out of the classroom. Preparation of papers assigned on an individual basis must represent your own individual effort. When used, resource materials should be cited in conventional reference format.

To promote academic integrity and improve student outcomes this course will use a plagiarism detection service. Cheating and other forms of academic misconduct will not be tolerated and will be dealt with firmly. Student academic misconduct refers to behavior that includes plagiarism, cheating on exams or assignments, fabrication of data, falsification of records or official documents, intentional misuse of equipment or materials (including library materials), or aiding and abetting the perpetration of such acts.

Please visit https://sph.umich.edu/admissions/policies-procedures/mph-mhsa.html for the full Policy on Student Academic Conduct Standards and Procedures.

>Take advantage of academic resources
- The **SPH Writing Lab** serves students (undergraduate majors, master's and Ph.D.s) in SPH, as well as faculty and staff, offering help on all professional writing tasks, including class papers, dissertations, personal statements, and grant applications, to name a few. You can make a virtual appointment on the Writing Lab's [Google calendar](#).

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- Access **U-M Library resources** no matter where you're working, and consult the [research guide](#) for resources, strategies, and information on conducting research in Public Health. Email SPHLibraryHelp@umich.edu to have our librarians help you locate library resources, connect with a specialist, or find support at any stage of your project.

> Seek help if you need it

We believe it is important to support the physical and emotional well-being of our students. If you are experiencing physical or mental health issues, we encourage you to use available resources such as those listed below. if you have questions or need help finding the right resources for you, please contact our department Wellness and Inclusion Advocate, Andrea Hill (andhill@umich.edu)

- **Basic Needs**: U-M Student Life compiles resources to support your basic needs, including food, kitchen and cooking supplies, personal household items, housing, emergency funding and medical insurance.

- **Campus Mind Works:** Lists resources by identity group, including graduate students, students of color, international students, students in recovery, LGBTQ students and first generation students.

- **Counseling and Psychological Services**: CAPS provides free, confidential, short-term counseling, support groups, mental wellness classes, and online mental health resources, including screening and helpful apps. After-hours [urgent care](#) and multi-lingual therapists are available. SPH has an "embedded" CAPS counselor on site named [Meghan Narula](#). You can contact her directly at mbnarula@umich.edu.

- **SPH Emergency Fund Request**: Request support if you encounter an emergency situation or another unusual, unforeseen expense while enrolled in your degree program.

- **Sexual and Gender-Based Misconduct Reporting and Resources**: The university provides confidential and non-confidential resources in response to sexual misconduct. [Sexual Assault Prevention and Awareness Center](#) (SAPAC), [CAPS](#), [UHS Sexual Assault Services](#) and the [Office of the Ombuds](#) are all confidential resources. You may also make a crime report to the [Division of Public Safety & Security](#) and/or an informational report to the [Office for Institutional Equity](#) (OIE.) OIE is responsible to investigate and report on issues of discrimination, which includes sexual and gender-based misconduct under Title IX. If you disclose misconduct to a university employee (including the Wellness and Inclusion Advocate) who is *not* designated as a confidential resource, they will be required to file an informational report with OIE that includes your name and information you shared. This will not obligate you to take any action, and names are not included in public reports, but OIE would contact you to offer resources. In situations where appropriate, OIE may refer students to the university's [Mediation Services](#).

- **University Health Service**: UHS provides physical and [Mental Health Services](#) including medication. They also offer wellness coaching and support for students in recovery through [Wolverine Wellness](#).

- **Well-being for U-M Students**: Embrace the concept of well-being as a multidimensional lifelong journey. Search university-wide resources (note the "virtual" location filter) and take breaks with stress-relieving videos.

> Inform me of any accommodations needed

If you need special accommodations due to a disability, illness, or injury, please inform me as soon as possible. In particular, if you are registered with the university's Services for Students with Disabilities and would like to activate any accommodations, please provide me with your VISA letter as early as possible. Please note that some accommodations take longer to implement than others (e.g. scheduling live captioning during Zoom sessions).

Some religious holidays may occur on regularly scheduled class days. Because available class sessions are limited in number, we will have to hold class on all such days. If you must miss a meeting due to a religious holiday, please get permission from me prior to the class in question. Please visit https://www.provost.umich.edu/calendar for the complete University policy.

> Support Diversity, Equity, and Inclusion

The University of Michigan School of Public Health seeks to create and disseminate knowledge, with the aim of preventing disease and promoting the health of populations worldwide. We recognize the histories of social discrimination globally and seek to promote and extend opportunities for members of all groups that historically have been marginalized. We commit to developing the institutional mechanisms and norms necessary to promote the values of diversity, equity, and inclusion, both inside and outside our classrooms. To this end, SPH upholds the expectations that all courses will (1) be **inclusive**, (2) promote **brave discussions**, (3) follow **multicultural ground rules**, and (4) abide **by U-M policies and procedures**.

- **Inclusive courses** are those in which teachers and learners co-create and co-sustain environments that support and encourage all members to participate equitably.

- **Brave** discussions promote diversity and social justice learning by acknowledging the dynamics of oppression and privilege both inside and outside the classroom.

- **Multicultural ground rules** acknowledge diverse experiences in the classroom and offer strategies for holding one another appropriately accountable.

- **U-M policies and procedures** can be found at https://diversity.umich.edu with additional resources and instructions for reporting discrimination at https://sph.umich.edu/diversity-equity-inclusion/resources.html.