

Stat 992: Research in Causal Inference
Spring 2025 Syllabus
University of Wisconsin-Madison

Instructor: Hyunseung Kang

Email: hyunseung@stat.wisc.edu

Office: 1245B Medical Sciences Center (MSC)

Office Hours: Walk-ins when I'm available & by appointment.

Teaching Assistant: None.

Lecture: In-person, Tues. 1:00pm-2:15pm (Jan. 21 - Mar. 9), 6102 Social Sciences

Discussions: None.

Course Website: https://pages.cs.wisc.edu/~hyunseung/stat992_sp25/

Course Overview and Learning Outcomes

The course is a special topics course in statistics at the graduate level. The purpose of the course is to prepare graduate students to start research in causal inference.

At the end of the course, students will:

1. Understand key concepts in causal inference (counterfactuals/potential outcomes, confounding, missing data)
2. Learn how to identify causal estimands
3. Learn how to estimate/infer causal estimands

Prerequisites:

The official requisite for the course is to be in graduate/professional standing. The *effective* requisites are:

1. Working understanding of graduate-level probability theory, mathematical statistics, and linear models (i.e. at the level of Stat 609/610 and Stat 849/850). Specifically, you need to know (a) conditional expectations and independence, (b) convergence of random variables, (c) properties of maximum likelihood estimators, (d) statistical properties of generalized linear models, (e) Wald tests and likelihood ratio tests, and (f) nonparametric two-sample tests (e.g. permutation tests)
2. Be able to design simulations that numerically validate properties of estimators (e.g. bias, variance, convergence) and statistical tests (e.g. Type I error rate, power, coverage of confidence intervals)
3. Working understanding of the software R (e.g. write/debug/test R code or install/run/work with R packages)

Textbook:

There is no required textbook for the course. However, I recommend the following textbooks for references.

- a. Hernán and Robins (2020) “Causal Inference: What If” <https://miguelhernan.org/whatifbook>. This book remains the most comprehensive and friendly overview on several topics in causal inference. I particularly like its coverage of both potential outcomes and graph-based causal inference.
- b. Rosenbaum (2010 or 2020) “Design of Observational Studies” <https://link.springer.com/book/10.1007/978-1-4419-1213-8>. This book is a friendly overview on observational studies, sensitivity analysis, and unmeasured confounding. A lot of my intuition on causal inference under unmeasured confounding is based on this book and a “technical” version of this book by Rosenbaum (2002) “Observational Studies” <https://link.springer.com/book/10.1007/978-1-4757-3692-2>.

Both books are available online through the links above. For the Springer books, you need to log into your wise account.

Software:

The course uses the R software (link here: <https://www.r-project.org/>).

Homework, Exams, Quizzes, and Grading Policy:

There are no exam and quizzes for grading.

There is one graded assignment, which is to summarize one of the following papers below. These papers are based on topics that I am currently interested in.

1. Rosenbaum (1984) “The Consequences of Adjustment for a Concomitant Variable That Has Been Affected by the Treatment.” *JRSS:A*.
2. Kallus, Mao (2024) “On the role of surrogates in the efficient estimation of treatment effects with limited outcome data.” *arXiv*.
3. Du, Zeng, Kennedy, Wasserman, Roeder (2024) “Causal Inference for Genomic Data with Multiple Heterogeneous Outcomes.” *arXiv*.
4. Zhao, Small, Bhattacharya (2019) “Sensitivity analysis for inverse probability weighting estimators via the percentile bootstrap.” *JRSS:B*.
5. Rosenbaum (1987) “The Role of a Second Control Group in an Observational Study.” *Stat. Sci*.
6. Stoetzer, Zhou, Steenbergen (2024) “Causal inference with latent outcomes.” *American Journal of Political Science*.
7. Dahabreh, Robertson, Steingrimsson, Stuart, Hernán (2020) “Extending inferences from a randomized trial to a new target population.” *Stat. Med*.
8. Li, Luedtke (2023) “Efficient estimation under data fusion.” *Biometrika*.
9. Li, Wager (2022) “Random graph asymptotics for treatment effect estimation under network interference.” *AoS*.
10. Son, Reich, Schliep, Yang, Gill. “Spatial causal inference in the presence of preferential sampling to study the impacts of marine protected areas.” *arXiv*.

The general requirement for the summary is that you can lead a 30-minute reading session based on the summary. It should be written in a way that I can understand the key points from the paper from the summary.

The summary can be in any format (e.g., pdf, word, Powerpoint) and can be of any length. The summary is due on **Friday, March 7 at 5:00pm Madison local time**. Please submit your

summary via e-mail with the subject titled “*Stat 992 - Spring 2025: FirstName_LastName Assignment.*”

In general, I expect everyone to get an A in the course. Also, given that it’s a graduate-level topics course, my hope is that students primarily focus on engaging with the topics/papers rather than on their grades.

Course Calendar:

Each lecture will focus on a particular topic in causal inference. The lecture schedule is tentative and subject to change.

Week	Topic
Week 1, Jan. 21	<ul style="list-style-type: none"> • Course logistics • Key concepts in causal inference (counterfactuals/potential outcomes)
Week 2, Jan. 28	<ul style="list-style-type: none"> • Identification under a randomized experiment • Identification under strong ignorability (i.e. no unmeasured confounding) <ul style="list-style-type: none"> a. Identification of the average treatment effect on the treated b. Identification of static, single-time optimal treatment regime/policy
Week 3, Feb. 4	<ul style="list-style-type: none"> • Identification under unmeasured confounding: instrumental variables <ul style="list-style-type: none"> a. Identification under monotonicity and the local average treatment effect (i.e., complier effect) b. Identification under no additive interaction
Week 4, Feb. 11	<ul style="list-style-type: none"> • Identification under unmeasured confounding: <ul style="list-style-type: none"> a. Regression discontinuity designs b. Differences-in-differences
Week 5, Feb. 18	<ul style="list-style-type: none"> • Estimation (M/Z estimation, influence functions, double robustness, matching-based estimators, etc.)
Week 6, Feb. 25	<ul style="list-style-type: none"> • Sensitivity analysis
Week 7, Mar. 4	<ul style="list-style-type: none"> • Research topics in causal inference

Additional Course Details

Course Credit, Designation and Related Information

- a. Course Credit: 1
- b. Course Designations: Grad 50% - Counts toward 50% graduate coursework requirement. Unlimited number of completions.
- c. Credit Hours and Expectations: Students may take this course for 1 credit. The credit standard for this course is met by an expectation of a total of 45 hours of student engagement with the courses learning activities, which include regularly scheduled instructor, student meeting times during lecture, reading, writing, problem sets, studio time, labs, field trips, and other student work as described in the syllabus.

Academic Calendar and Religious Observances:

View the full [academic calendar](#) in addition to information about religious and election day observances. Students are responsible for notifying instructors within the first two weeks of classes about any need for flexibility due to [religious observances](#).

Establishment of the academic calendar for the University of Wisconsin–Madison falls within the authority of the faculty as set forth in [Faculty Policies and Procedures](#). Construction of the academic calendar is subject to various rules and laws prescribed by the Board of Regents, the Faculty Senate, State of Wisconsin and the federal government. Find [additional dates and deadlines for students](#) on the Office of the Registrar website.

Academic Integrity Statement and Data Ethics

By virtue of enrollment, each student agrees to uphold the high academic standards of the University of Wisconsin–Madison; academic misconduct is behavior that negatively impacts the integrity of the institution. Cheating, fabrication, plagiarism, unauthorized collaboration and helping others commit these previously listed acts are examples of misconduct which may result in disciplinary action. Examples of [disciplinary sanctions](#) include, but are not limited to, failure on the assignment/course, written reprimand, disciplinary probation, suspension or expulsion.

The members of the faculty of the Department of Statistics at UW-Madison uphold the highest ethical standards of teaching, data, and research. They expect their students to uphold the same standards of ethical conduct. Standards of ethical conduct in data analysis and data privacy are detailed on the ASA website (<https://www.amstat.org/your-career/ethical-guidelines-for-statistical-practice>), and include:

- Use methodology and data that are relevant and appropriate; without favoritism or prejudice; and in a manner intended to produce valid, interpretable, and reproducible results.
- Be candid about any known or suspected limitations, defects, or biases in the data that may affect the integrity or reliability of the analysis. Obviously, never modify or falsify data.
- Protect the privacy and confidentiality of research subjects and data concerning them, whether obtained from the subjects directly, other persons, or existing records.

By registering for this course, you are implicitly agreeing to conduct yourself with the utmost integrity throughout the semester.

Accommodations for Students with Disabilities

The University of Wisconsin–Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12) and UW–Madison policy ([UW-855](#)) require the university to provide reasonable accommodations to students with disabilities to access and participate in its academic programs and educational services. Faculty and students share responsibility in the accommodation process. Students are expected to inform faculty of their need for instructional accommodations during the beginning of the semester, or as soon as possible after being approved for accommodations. Faculty will work either directly with the student or in coordination with the [McBurney Disability Resource Center](#) to provide reasonable instructional and course-related

accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA.

Complaints

If you have a complaint about a TA or course instructor, you should feel free to discuss the matter directly with the TA or instructor. If the complaint is about the TA and you do not feel comfortable discussing it with him or her, you should discuss it with the course instructor. Complaints about mistakes in grading should be resolved with the instructor in the great majority of cases. If the complaint is about the instructor (other than ordinary grading questions) and you do not feel comfortable discussing it with him or her, contact the Director for Undergraduate Studies, Professor Jessi Cisewski-Kehe (jjkehe@wisc.edu) / Director of Graduate Studies, Professor Cecile Ane (cecile.ane@wisc.edu).

If your complaint concerns sexual harassment, please see campus resources listed at <https://compliance.wisc.edu/titleix/>. In particular, there are a number of options to speak to someone confidentially.

If you have concerns about climate or bias in this class, or if you wish to report an incident of bias or hate that has occurred in class, you may contact the Chair of the Statistics Department Climate & Diversity Committee, Professor Karl Rohe (karl.rohe@wisc.edu). You may also use the University's bias incident reporting system, which you can reach at <https://osas.wisc.edu/report-an-issue/bias-or-hate-reporting/>.

Course Evaluations

Students at the University of Wisconsin–Madison have the opportunity to evaluate their learning experiences and the courses they are enrolled in through course evaluations. Many instructors use a [digital course evaluation tool](#) to collect feedback from students. Students typically receive notifications two weeks prior to the end of the semester requesting that they complete course evaluations. Student participation is an integral component of course development, and confidential feedback is important. UW–Madison strongly encourages student participation in course evaluations.

Diversity & Inclusion

[Diversity](#) is a source of strength, creativity, and innovation for the University of Wisconsin–Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. UW–Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background – people who as students, faculty, and staff serve Wisconsin and the world.

Mental Health and Well-Being

Students often experience stressors that can impact both their academic experience and personal well-being. These may include mental health concerns, substance misuse, sexual or relationship violence, family circumstances, campus climate, financial matters, among others.

UW–Madison students are encouraged to learn about and utilize the university’s mental health services and/or other resources as needed. Student can visit uhs.wisc.edu or call University Health Services at (608) 265-5600 to learn more.

Netiquette on Piazza and Online Communication

See <https://kb.wisc.edu/50548> for a general netiquette. Specifically:

- Any comment or answers must be on topic, concise, polite, and respectful of others.
- Assume the best intentions of others in the class and be forgiving when you think that the tone of someone’s post is offensive. It is easy to misread the tone of someone’s written communication. If in doubt, ask an open, honest question about what the person meant so that you can clarify before making assumptions that damage your perception of your colleague.
- Students must not post answers to homework problems.
- Almost all questions should be sent via Piazza. For personal or sensitive issues, use private messages to instructor/TA in Piazza, or email.
- Students should not expect an immediate answer to a question posted late at night before an assignment due date.

Overlapping Course Time Statement

The Department of Statistics strongly discourages students from enrolling in any courses whose regular class meeting dates & times overlap with each other. This policy is in alignment with the College of Letters and Sciences Course Attendance Policy. It is also consistent with the Class Attendance Policy for Students at UW-Madison (<https://kb.wisc.edu/lis/24628>), whose first sentence reads, "It is expected that every student will be present at all classes." Statistics instructors may opt not to make any alternative arrangements in the event any conflict arises due to a student taking a course with class meetings that overlap with a Statistics course, including a conflict between two Statistics courses. Note that final exams occasionally are scheduled simultaneously for courses which meet at different times; in this situation, please contact your instructor well before the exam date about potential accommodations.

Privacy of Student Records & The Use of Audio Recorded Lectures

Lecture materials and recordings for this course are protected intellectual property at UW–Madison. Students enrolled in this course may use the materials and recordings for their personal use related to participation in the course. Students may also take notes solely for their personal use. If a lecture is not already recorded, students are not authorized to record lectures without permission unless they are considered by the university to be a qualified student with a disability who has an approved accommodation that includes recording. [Regent Policy Document 4-1] Students may not copy or have lecture materials and recordings outside of class, including posting on internet sites or selling to commercial entities, with the exception of sharing copies of personal notes as a notetaker through the McBurney Disability Resource Center. Students are otherwise prohibited from providing or selling their personal notes to anyone else or being paid for taking notes by any person or commercial firm without the instructor’s express written permission. Unauthorized use of these copyrighted lecture materials and recordings constitutes copyright infringement and may be addressed under the university’s policies, UWS Chapters 14 and 17, governing student academic and non-academic misconduct. View [more information about FERPA](#).

Students' Rules, Rights & Responsibilities

View more information about [student rules, rights and responsibilities](#) such as student privacy rights, sharing of academic record information, academic integrity and grievances.

Teaching & Learning Data Transparency

The privacy and security of faculty, staff and students' personal information is a top priority for UW–Madison. The university carefully reviews and vets all campus-supported digital tools used for teaching and learning, including those that support [data empowered educational practices](#) and proctoring. View more information about [teaching and learning data transparency](#) at UW–Madison.