

**Stat 992: Topics in Causal Inference**  
Spring 2024 Syllabus  
University of Wisconsin-Madison

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**Instructor:** Hyunseung Kang  
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**Office:** 1245B Medical Sciences Center (MSC)  
**Office Hours:** By appointment.

**Teaching Assistant:** None.

**Lecture:** Wed. 2:00pm-3:30pm (Apr. 1-May3), 1175 Grainger Hall  
**Instructional Modality:** In-person.  
**Discussion Section:** None.

**Course Website:** Canvas <https://canvas.wisc.edu/courses/392705> (for submitting assignment), and my homepage (for lecture notes)

**Course Description and Overview:**

The course is a special topics course in statistics at the graduate level. The purpose of the course is to prepare students to start research in causal inference. Each week, we'll focus on some key topics in causal inference and for more details on these topics, see the course calendar below.

**Course Learning Outcomes:**

At the end of the course, students will:

1. Understand key concepts in causal inference (confounding, counterfactuals, missing data)
2. Learn how to identify causal estimands
3. Learn how to estimate/infer causal estimands
4. Learn how to conduct numerical evaluations for causal estimands

**Requisites:**

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) generalized linear models and their statistical properties, (e) Wald tests and likelihood ratio tests, and (f) parametric and nonparametric two-sample tests (e.g. two-sample t-test, Wilcoxon signed rank test)
2. Be able to design simulations in order to empirically 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 some R code or install/run/debug existing R packages)

### Discussion or Laboratory Sessions

There are no discussion or laboratory sessions.

### Required Textbook:

There is no required textbook for the course.

### Required Software:

The course uses the R software.

### Homework, Exams, Quizzes, and Grading Policy:

There are no exam and quizzes for grading.

There is only one graded assignment for the course; see this [page](#) for details. You must submit the assignment by **Friday, May 3rd, 2024 (5:00pm Central)** to the course Canvas website.

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 Schedule:

There are five lectures for the course. Each lecture will focus on a particular topic in causal inference. We'll take a five-minute break during the middle of the lecture. The lecture schedule is tentative and subject to change.

Week (Wednesdays)	Topic
Week 1, Apr. 3	<ul style="list-style-type: none"><li>• Course logistics</li><li>• Key concepts in causal inference (confounding, counterfactuals, missing data)</li><li>• Identification of the average treatment effect under a randomized experiment</li></ul>
Week 2, Apr. 10	<ul style="list-style-type: none"><li>• Identification of causal estimands under strong ignorability (i.e. no unmeasured confounding)<ol style="list-style-type: none"><li>a. Identification of the average treatment effect on the treated</li><li>b. Identification of static, single-time optimal treatment regime/policy</li><li>c. <u>If time permits</u>: survival outcomes</li></ol></li><li>• Identification of causal estimands under unmeasured confounding<ol style="list-style-type: none"><li>a. Instrumental variables</li><li>b. Regression discontinuity designs</li><li>c. Differences-in-differences</li><li>d. <u>If time permits</u>: synthetic controls, staggered designs, longitudinal studies</li></ol></li></ul>
Week 3, Apr. 17	<ul style="list-style-type: none"><li>• Estimation of causal estimands<ol style="list-style-type: none"><li>a. Likelihood-based methods, M-estimators, influence functions</li><li>b. Double robustness, efficiency</li></ol></li></ul>

Week 4, Apr. 24	<ul style="list-style-type: none"> <li>• Estimation of causal estimands <ul style="list-style-type: none"> <li>a. Machine learning estimators via cross-fitting</li> <li>b. Matching-based estimators</li> <li>c. Estimators for policy learning (i.e. direct and indirect methods)</li> </ul> </li> </ul>
Week 5, May 1	<ul style="list-style-type: none"> <li>• Sensitivity analysis: <ul style="list-style-type: none"> <li>a. General bias formula</li> <li>b. Rosenbaum's framework</li> <li>c. <u>If time permits</u>: Omitted variable bias framework, Tan (2006), and Robins et al. (2000)</li> </ul> </li> <li>• A tour of recent topics in causal inference: <ul style="list-style-type: none"> <li>a. Causal inference under dependence</li> <li>b. Causal inference under unmeasured confounding</li> <li>c. Applications to statistical genetics, economics, political science, and measurement models in educational psychology</li> </ul> </li> </ul>

**Additional Course Details:**

- a. Course Credit: 1
- b. Course Designations: Grad 50% - Counts toward 50% graduate coursework requirement. Unlimited number of completions.

**Course Credits 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.

**Regular and Substantive Student-Instructor Interaction:**

All course material will be presented via regular, direct instruction where students can directly interact with the teaching staff. The course may require students to work in small groups to present papers. The small groups will be moderated by the teaching staff and the teaching staff will provide feedback on students' presentations. Students will also interact amongst during their presentations and the teaching staff will moderate these interactions. The teaching staff will communicate relevant academic-related information through lectures, office hours, Canvas, e-mail, and video and/or audio conferencing tools.

**Academic Calendar & Religious Observances:**

See [here](#).

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. For additional dates and deadlines for students, see the [Office of the Registrar's pages](#). Students are responsible for

notifying instructors within the first two weeks of classes about any need for flexibility due to [religious observances](#).

### **Academic Integrity 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/ASA/Your-Career/Ethical-Guidelines-for-Statistical-Practice.aspx>), 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 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. (See: [McBurney Disability Resource Center](#))

### **Course Evaluations:**

Students will be provided with an opportunity to evaluate their enrolled courses and their learning experience. Most instructors use AEFIS [a digital course evaluation survey tool](#). In most instances, students receive an official email two weeks prior to the end of the semester, notifying them that anonymous course evaluations are available. 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 UW-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. The University of Wisconsin-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 Statement:**

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.

Students are encouraged to learn about and utilize UW-Madison's mental health services and/or other resources as needed. Visit [uhs.wisc.edu](https://uhs.wisc.edu) or call University Health Services at (608) 265-5600 to learn more.

**Privacy of Student Records & The Use of Audio Recorded Lectures Statement:**

View [more information about FERPA](#).

Lecture materials and recordings for this course are protected intellectual property at UW-Madison. Students in courses may use the materials and recordings for their personal use related to participation in class. 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.

**Students' Rules, Rights, and Responsibilities:**

See [here](#).

**Teaching & Learning Data Transparency Statement:**

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 to support teaching and learning, to help support success through [learning analytics](#), and to

enable proctoring capabilities. View the university's full teaching and learning [data transparency statement](#).

### **Netiquette on Online Communication:**

See [here](#) 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.

### **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 Cecile Ane ([cecile.ane@wisc.edu](mailto:cecile.ane@wisc.edu)) / Director of Graduate Studies, Professor Bret Larget ([bret.larget@wisc.edu](mailto:bret.larget@wisc.edu)).

If your complaint concerns sexual harassment, please see campus resources listed at <https://compliance.wisc.edu/titleix/resources/>. 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 Jessi Cisewski-Kehe ([jkehe@wisc.edu](mailto:jkehe@wisc.edu)). You may also use the University's bias incident reporting system, which you can reach at <https://doso.students.wisc.edu/report-an-issue/bias-or-hate-reporting/>.