

PHC/GMS 7858: Causal Artificial Intelligence for Health Research

Department of Health Outcomes and Biomedical Informatics and
Department of Epidemiology
College of Medicine and College of Public Health and Health Professionals
University of Florida

CREDIT HOURS: 3

SEMESTER: Fall 2024

DELIVERY FORMAT: On-Campus, in-person

Day/TIME: Mondays, 9:35 AM to 12:35 PM

LOCATION: Malachowsky Hall Room 7126 Conference Room

COMMUNICATION: Canvas course email

INSTRUCTORS

Instructor Name: Jie Xu, PhD (JX)

Room Number: Malachowsky Hall, Room 7020

Phone Number: 352-294-5932

Email Address: xujie@ufl.edu

Office Hours: Wed 3-5pm

Instructor Name: Panagiotis (Takis) Benos, PhD (TB)

Room Number: 2004 Mowry Rd, Room 4210

Phone Number: 352-273-5048

Email Address: pbenos@ufl.edu

Office Hours: Fri 10-11am

Teaching Assistant(s): TBD

Course listserv: tbd@lists.ufl.edu

You will be added to the listserv automatically through ONE.UF.

Preferred Course Communications: Students may email the instructor with questions but are encouraged to consider whether their questions are of general interest to the entire class.

Dedicated class time will be devoted to discussing and answering general questions about either course content or course mechanics that are relevant to all students.

Prerequisites:

- The students are required to have a demonstrated understanding of basic concepts of probability and statistics or data science unless they obtain prior exemption from the instructors. Examples of courses that can fulfill this requirement are listed below:
 - PHC 6053: Regression Methods for the Health and Life Sciences

- PHC 7065: Advanced Skills in Epidemiological Data Management
- GMS 6803 Data Science for Clinical Research
- GMS 6822 Measuring and Analyzing Health Outcomes
- GMS 6856 Introduction to Biomedical Natural Language Processing
- GMS 6805 Information Modeling in Biomedicine
- GMS 6804 Translational Bioinformatics
- Student are required to have passed one of the above courses. Instructor approval is required to enroll for those students who have not passed any of the listed courses or similar courses.
- The course requires the completion of a computational project. Thus, students need to have skills in at least one programming language commonly used in data analysis (R, Python, Java, etc) to ensure they can successfully complete their project.

PURPOSE AND OUTCOME

Course Overview

This course will cover theoretical and practical topics related to advanced methods in causal Artificial Intelligence (AI), embedding machine learning with causal inference methods on real-world data, and methodologies for automated causal learning. Health research approaches such as target trials and transportability, AI fairness, and tackling health disparities and inequity will be discussed. The students will learn the theory behind causal inference methods applied under different constraints, and they will be able to use them addressing real-world problems to identify factors directly affecting outcomes, and build predictive models and risk scores.

Relation to Program Outcomes

- Apply epidemiological methods to address critical and/or emerging public health and clinical research issues through the use of:
 - (i) Appropriate epidemiological research designs;
 - (ii) Advanced statistical analysis methods for health studies; (iii) Data structures and measurement methods for health research.
- Apply ethical thinking to a questionable ethics case from the current news.

Course Objectives and/or Goals

Upon completion of this course, students will be able to:

- Identify causal inference methods that can be tailored to AI for biomedical and health research
- Analyze data quality, data bias, and bias structures in real-world, data-intensive clinical biomedical research in the context of causal AI
- Apply causal AI data analysis techniques and tools apt for large collections of observational data (e.g., electronic health records)
- Critically evaluate cutting edge causal AI methods from the most recent literature

Instructional Methods

Teaching methods include lecture, discussion, and hands-on data analysis exercises.

DESCRIPTION OF COURSE CONTENT

Overview: Big data, high-performance computing, and artificial intelligence (AI)/(deep) machine learning are increasingly becoming key to precision health—both precision medicine (i.e., "the right treatments at the right time, every time to the right person") and precision public health (i.e., "the right intervention at the right time, every time to the right population")—from identifying disease risks and taking preventive measures, to making diagnoses and personalizing treatment for individuals and populations. Precision health, however, is not only about predicting risks and outcomes, but also about weighing interventions. Interventional clinical predictive models require the correct specification of cause and effect, and the calculation of so-called counterfactuals. In biomedical research, observational studies are commonly affected by confounding and selection bias. Data-driven prediction models are often mistakenly used to draw causal effects, but neither their parameters nor their predictions necessarily have a causal interpretation. When pursuing intervention modelling, the bio-health informatics community needs to employ causal approaches and learn causal structures.

Topical Outline/Course Schedule

The course schedule is subject to change according to students' background and interests based on the survey conducted at the beginning of the class.

Week	Date(s)	Topic	Readings	Instructor
1	Aug 26	Introductions, course mechanics/overview, and formal definitions for AI and causality/inference methods	Peters (ch. 1-3)	TB
2	Sep 2	UF Holiday: Labor Day		
3	Sep 9	Randomized experiments vs. observational studies, intervention vs. conditional probabilities	Peters (ch. 1-3)	TB
4	Sep 16	Graphical representation of causal structures and pathways: Bayesian networks and directed acyclic graphs (DAGs)	Peters (ch.1-3)	TB
5	Sep 23	Types of bias: confounding, collider bias, M-bias	Peters (ch.1-3)	TB
6	Sep 30	Total vs. direct causal effects, effect modification (mediators and moderators), interactions	Peters (ch.1-3)	TB

7	Oct 7	Introduction to d-calculus and adjustment criteria, DAG structure learning, e.g. PC algorithm	Peters (ch.4,6,7)	TB
8	Oct 14	Midterms – Project Proposal Due Presentation Day	N/A	TB&JX
9	Oct 21	Counterfactual prediction: individual treatment effects (ITE) vs. average treatment effects (ATE)	Tutorial	JX
10	Oct 28	Propensity scores and inverse probability weighting	Bica	JX
11	Nov 4	Trial emulation with real-world data	Hernán	JX
12	Nov 11	UF Holiday: Veterans Day		
13	Nov 18	Counterfactuals prediction with machine learning, e.g. deep counterfactual networks, virtual twin forests	Peters (ch.5, 8)	JX
14	Nov 25	Transportability/prediction invariance	Bareinboim	JX
15	Dec 2	Algorithmic fairness, health disparities, and inequity	Barocas	JX
16	Dec 9	Final- Project Report Due Presentation Day	N/A	TB&JX

Course Materials References and Technology

1. Peters J, Janzing D, Scholkopf B. Elements of Causal Inference: Foundations and learning algorithms. Adaptive Computation and Machine Learning. Francis Bach, Editor. The MIT Press Cambridge, Massachusetts. London, England.
<https://library.oapen.org/bitstream/handle/20.500.12657/26040/11283.pdf>
2. Tutorial on treatment effect estimation: <https://www.vanderschaar-lab.com/individualized-treatment-effect-inference/> (Tutorial)
3. Bica I, Alaa AM, Lambert C, Van Der Schaar M. From real-world patient data to individualized treatment effects using machine learning: current and future methods to address underlying challenges. Clinical Pharmacology & Therapeutics. 2021 Jan;109(1):87-100.
4. Hernán MA, Robins JM. Using big data to emulate a target trial when a randomized trial is not available. American journal of epidemiology. 2016 Apr 15;183(8):758-64.
<https://academic.oup.com/aje/article/183/8/758/1739860>
5. Bareinboim E, Pearl J. Causal inference and the data-fusion problem. Proceedings of the National Academy of Sciences. 2016 Jul 5;113(27):7345-52.
<https://www.pnas.org/content/113/27/7345>
6. Barocas S, Hardt M, Narayanan A. Fairness and machine learning Limitations and Opportunities. Available at <https://fairmlbook.org/>.

Other articles relevant to the course may be made available.

Required Technology

During the course, R and Python (both free software) code scripts will be used as examples, and all scripts will be made available for replication after class. Students need access to computing equipment but are not necessarily required to bring laptops in class.

For technical support for this class, please contact the UF Help Desk at:

- helpdesk@ufl.edu
- (352) 392-HELP - select option 2
- <https://helpdesk.ufl.edu/>

Additional Academic Resources

- [Career Connections Center](#): Reitz Union Suite 1300, 352-392-1601. Career assistance and counseling services.
- [Library Support](#): Various ways to receive assistance with respect to using the libraries or finding resources.
- [Teaching Center](#): Broward Hall, 352-392-2010 or to make an appointment 352- 392-6420. General study skills and tutoring.
- [Writing Studio](#): 2215 Turlington Hall, 352-846-1138. Help brainstorming, formatting, and writing papers.
- Student Complaints On-Campus: [Visit the Student Honor Code and Student Conduct Code webpage for more information.](#)
- On-Line Students Complaints: [View the Distance Learning Student Complaint Process.](#)

ACADEMIC REQUIREMENTS AND GRADING

Assignments

All assignments are to be submitted through the Canvas course site. The course products include attendance (5%), homework assignments (30%), a midterm presentation (10%), midterm project proposal (15%), final presentation (15%), and a final technical report/term paper (25%) on topics relevant to the course.

1. Attendance (5%):

Attendance will be evaluated based on students' participation, including their engagement in discussions and questions they ask during classes and student presentations.

2. Homework Assignments (30%):

Assignments include reading assigned papers that align with the weekly topics discussed in class. Each student will select one paper related to a specific week's theme and present and lead an in-class discussion (20%) on it during the week when the paper's topic matches the class topic. Additionally, question-based homework and coding assignments (10%) will occasionally be integrated into the curriculum. The student-led in-class discussion will be graded on several criteria:

- Preparation: Demonstrate a solid understanding of the topic with well-researched materials.
- Clarity: Present ideas in a clear and organized manner.
- Interaction: Facilitate meaningful discussion and respond effectively to questions.
- Time Management: Keep the presentation within 30-40 minutes, covering key topics and allowing time for discussion.
- Visual Aids/Materials: Use effective visual aids to enhance understanding.

3. Midterm:

Students will be asked to conduct a case study using the methods and tools learned from this course or a review of literature relevant to specific area of the course and write a technical report (i.e., term paper). You are encouraged to come up with an idea related to the course. You will conduct extensive background research (e.g., literature review), and you are expected to write a project proposal and give a presentation during the midterm. Please follow the requirements below for the project proposal and presentation.

a. **Project Proposal Requirements (15% of Total Grade):**

- Cover Page: Include title and list of team members.
- Abstract: Up to 1 page. Explain the motivation for the work to be accomplished.
- Project description: Up to five (5) pages, and please include the following:
 - Specific Aims/Objectives
 - Background and Significance
 - Approach/Research Design (preliminary data and analysis if applicable)
 - Timeline
- Literature cited (no page limit); please follow the JAMIA style.

Formatting: Single-column, double spaced; Arial font, font size 11 point; tables and figure labels can be in 10 point; 1 inch margins.

b. **Midterm (Proposal) Presentation (10% of Total Grade):**

- Up to ten (10) slides and no more than 15 minutes of presentation with 5 minutes Q&A.
- Please send the slides to the instructor at least three (3) days in advance.

Grading Criteria:

- **Project Proposal:** Preparation, clarity, background, approach, timeline, references, and formatting.
- **Presentation:** Content & organization, fluency & clarity, team member participation, use of visual aids, time management, and engagement & interaction.

4. Final:

Each project team is required to deliver a final presentation, submit a final project report, and provide associated code and datasets (or references to used datasets).

a. **Final Report Requirements (25% of Total Grade):**

The project report can be up to ten (10) pages (excluding references), with the following structure:

- Title (14-point typeface) and names of each team member
- Abstract: no more than 1 page summarizing the project.
- Introduction: background and objective(s) of the study.
- Methods: design, setting, and approaches.
- Results: key findings
- Discussion: key conclusions with direct reference to the implications of the methods and/or results.
- Author Contribution: Detailed explanation of contributions.
- References: please follow the JAMIA style.

Formatting: Single-column, double spaced; Arial font, font size 11 point; tables and figure labels can be in 10 point; 1 inch margins.

b. Final Presentation (15% of Total Grade)

- Up to fifteen (15) slides and no more than 25 minutes of presentation with 5 minutes Q&A.
- Please send the slides to the instructor at least three (3) days in advance.

Grading Criteria:

- **Final Report:** Abstract, introduction, methods, discussion, author contribution, timeline, references, and formatting.
- **Presentation:** Content & organization, fluency & clarity, team member participation, use of visual aids, time management, and engagement & interaction.

Grading

Requirement	Due Date	% of Final Grade
Attendance	Weekly	5%
Homework assignments	Weekly	30%
Student-led discussion (20%)		
Homework 1 (5%)	Week 10	
Homework 2 (5%)	Week 13	
Midterm	Week 9	25%
Presentation (10%)		
Proposal (15%)		
Final	Week 16	40%
Presentation (15%)		
Technical Report (25%)		

Grading Scale

Percentage Earned	Letter Grade
95-100	A
90-94	A-
87-89	B+
83-86	B
80-82	B-
77-79	C+
73-76	C
70-72	C-
67-69	D+
63-66	D
60-62	D-
Below 60	E

Please be aware that a C- is not an acceptable grade for graduate students. The GPA for graduate students must be 3.0 based on 5000 level courses and above to graduate. A grade of C counts toward a graduate degree only if based on credits in courses numbered 5000 or higher that have been earned with a B+ or higher.

Letter Grade	Grade Points
A	4.0
A-	3.67
B+	3.33
B	3.0
B-	2.67
C+	2.33
C	2.0
C-	1.67
D+	1.33
D	1.0
D-	0.67
E	0.0
WF	0.0
I	0.0
NG	0.0
S-U	0.0

More information on UF grading policy may be found at:

<https://gradcatalog.ufl.edu/graduate/regulations/#Grades>

Policy Related to Make up Work

Students are allowed to make up work only as the result of illness or other unanticipated circumstances. In the event of such emergency, documentation will be required in conformance with University policy. Work missed for any other reason will earn a grade of zero. *Please refer to UF's absence policy to ensure you meet UF policy on make-up work:*

<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/#absencestext> and <https://catalog.ufl.edu/UGRD/academic-regulations/examination-policies-reading-days/#excusedabsencestext>

Please note: Any requests for make-ups due to technical issues MUST be accompanied by the ticket number received from LSS when the problem was reported to them. The ticket number will document the time and date of the problem. You MUST e-mail me within 24 hours of the technical difficulty if you wish to request a make-up.

Policy Related to Required Class Attendance

Class attendance is mandatory. Excused absences follow the criteria of the UF Graduate Catalogue (e.g., illness, serious family emergency, military obligations, religious holidays), and should be communicated to the instructor prior to the missed class day when possible. UF rules require attendance during the first two course sessions. Missing more than three scheduled sessions will result in a failure. Regardless of attendance, students are responsible for all material presented in class and meeting the scheduled due dates for class assignments. Finally, students should read the assigned readings prior to the class meetings and be prepared to discuss the material for each session.

Excused absences must be consistent with university policies in the Graduate Catalog (<https://gradcatalog.ufl.edu/graduate/regulations/#Attendance%20Policies>). Additional information can be found here:

<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>

STUDENT EXPECTATIONS, ROLES, AND OPPORTUNITIES FOR INPUT

Expectations Regarding Course Behavior

We expect polite, inclusive, and active participation to the classes respecting civil rules and UF academic regulations (see next sections).

Cell phones should be silenced during class, and their usage should be minimal unless related to class activity (e.g. typing notes).

Communication Guidelines

All members of the class are expected to follow rules of common courtesy in all email messages, threaded discussions, and chats. The first instance of clearly rude and/or inappropriate behavior

will result in a warning. The second instance will result in a deduction of five percentage points from your overall grade. The third instance will result in a drop of a letter grade (A to B, A- to B-, and so on). Further information of online behavior can be found here <https://teach.ufl.edu/wp-content/uploads/2020/04/NetiquetteGuideforOnlineCourses.docx>

Academic Integrity

Students are expected to act in accordance with the University of Florida policy on academic integrity. As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge:

“We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity.”

You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is either required or implied:

“On my honor, I have neither given nor received unauthorized aid in doing this assignment.”

It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated. Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For additional information regarding Academic Integrity, please see Student Conduct and Honor Code or the Graduate Student Handbook for additional details:

<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>
<https://graduateschool.ufl.edu/work/handbook/>

Please remember cheating, lying, misrepresentation, or plagiarism in any form is unacceptable and inexcusable behavior.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” [The Honor Code](#) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see the [Notification to Students of FERPA Rights](#).

Recording Within the Course

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third-party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

Link to full policy: <https://phhp.ufl.edu/policy-classroom-guests-of-students/>

Online Faculty Course Evaluation Process

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

SUPPORT SERVICES

Accommodations for Students with Disabilities

If you require classroom accommodation because of a disability, it is strongly recommended you register with the Dean of Students Office <http://www.dso.ufl.edu> within the first week of class or as soon as you believe you might be eligible for accommodations. The Dean of Students Office will provide documentation of accommodations to you, which you must then give to me as the instructor of the course to receive accommodations. Please do this as soon as possible after you receive the letter. Students with disabilities should follow this procedure as early as possible in the semester. The College is committed to providing reasonable accommodations to assist students in their coursework.

Counseling and Student Health

Students sometimes experience stress from academic expectations and/or personal and interpersonal issues that may interfere with their academic performance. If you find yourself facing issues that have the potential to or are already negatively affecting your coursework, you are encouraged to talk with an instructor and/or seek help through University resources available to you.

- The **Counseling and Wellness Center** 352-392-1575 offers a variety of support services such as psychological assessment and intervention and assistance for math and test anxiety. Visit their web site for more information: <http://www.counseling.ufl.edu>. On line and in person assistance is available.
- **U Matter We Care** website: <http://www.umatter.ufl.edu/>. If you are feeling overwhelmed or stressed, you can reach out for help through the U Matter We Care website, which is staffed by Dean of Students and Counseling Center personnel.
- The **Student Health Care Center** at Shands is a satellite clinic of the main Student Health Care Center located on Fletcher Drive on campus. Student Health at Shands offers a variety of clinical services. The clinic is located on the second floor of the Dental Tower in the Health Science Center. For more information, contact the clinic at 392-0627 or check out the web site at: <https://shcc.ufl.edu/>
- Crisis intervention is always available 24/7 from:
 - **Alachua County Crisis Center:** (352) 264-6789, <http://www.alachuacounty.us/DEPTS/CSS/CRISISCENTER/Pages/CrisisCenter.aspx>
 - **University Police Department:** <https://police.ufl.edu> or call 352-392-1111 (or 9-1-1 for emergencies)

- **UF Health Shands Emergency Room/Trauma Center:** For immediate medical care, call 352-733-0111 or go to the emergency room at 1515 SW Archer Road, Gainesville, FL 32608; <https://ufhealth.org/emergency-room-trauma-center>

Do not wait until you reach a crisis to come in and talk with us. We have helped many students through stressful situations impacting their academic performance. You are not alone so do not be afraid to ask for assistance.

Inclusive Learning Environment

Public health and health professions are based on the belief in human dignity and on respect for the individual. As we share our personal beliefs inside or outside of the classroom, it is always with the understanding that we value and respect diversity of background, experience, and opinion, where every individual feels valued. We believe in, and promote, openness and tolerance of differences in ethnicity and culture, and we respect differing personal, spiritual, religious and political values. We further believe that celebrating such diversity enriches the quality of the educational experiences we provide our students and enhances our own personal and professional relationships. We embrace The University of Florida's Non-Discrimination Policy, which reads, "The University shall actively promote equal opportunity policies and practices conforming to laws against discrimination. The University is committed to non-discrimination with respect to race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information and veteran status as protected under the Vietnam Era Veterans' Readjustment Assistance Act."

Campus Resources:

Health and Wellness

U Matter, We Care:

If you or a friend is in distress, please contact umatter@ufl.edu or 352 392-1575 so that a team member can reach out to the student.

Counseling and Wellness Center: counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or police.ufl.edu.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling.

[Library Support](#), Various ways to receive assistance with respect to using the libraries or finding resources.

[Teaching Center](#), Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.

[Writing Studio](#), 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.

[Student Complaints Campus](#)

[On-Line Students Complaints](#)