

**American University of Beirut  
Faculty of Health Sciences**

**EPHD 404  
Introduction to Causal Inference Methods  
[2 credits]**

**Course Syllabus  
Spring Semester, Academic Year 2020-2021**

**Class Time and Venue:**

*April 6- 14, 2021*

Lectures: Tuesday April 6- Wednesday April 14 2021 3-6pm; with two full days Thursday 8 and Tuesday 13 (9am -12pm and 3-6pm)

Classroom: Online and Multipurpose Room, Van Dyck 2<sup>nd</sup> Floor

**Course Instructors and Contact Details:**

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**Course Description**

This course provides an overview and understanding of key concepts and theoretical frameworks of causal inference without and with models. The course will cover causation in health research, Directed Acyclic Graphs (DAGs), and epidemiologic methods for causal inference such as inverse probability weighting and marginal structural models. Other topics such as mediation and instrumental variables will also be covered. The course will involve lectures and practical applications through journal club, lab sessions with data, homework, and class projects.

**Course Format**

This course stretching over 7 days includes both lecture sessions and practice sessions of different formats. Full and active participation and preparation is expected from all participants. Each day will be focused on specific theoretical concepts and topics within the emerging field of causal inference and epidemiologic methods. There will be lectures to cover each topic followed by journal club and data club. The journal club sessions will elaborate on specific topics and will include discussion of assigned readings, such as chapters from the assigned textbook, articles, and examples. The data sessions will be based on hands-on applications on the material covered using exercises and datasets provided by the instructors.

**Course Learning Objectives:**

**By the end of the course, students will be able to:**

- LO1: Appraise key concepts and theoretical frameworks of causal inference without and with models.
- LO2: Critically assess structural conceptualization of epidemiological concepts and biases.
- LO3: Apply different tools for achieving causal inference using non-randomized designs, accounting for important biases, as well as understanding assumptions and challenges.
- LO4: Apply causal inference frameworks and methods to study design and analysis of epidemiological data.
- LO5: Use advanced statistical methods to analyze data generated from different epidemiological study designs.

**Program Competencies mapped to EPHD 404:**

- PC2: Produce rigorous syntheses of published literature using systematic methodologies, and evaluate the quality of synthesized evidence.
- PC9: Use advanced statistical methods to analyze data generated from different epidemiological study designs
- PC11: Interpret and evaluate original or published results

**Mapping of Course Learning Objectives to CEPH Competencies**

	LO1	LO2	LO3	LO4	LO5	Assignment where Competency primarily assessed
Program Competency PC2: Produce rigorous syntheses of published literature using systematic methodologies, and evaluate the quality of synthesized evidence	X	X	X			Journal club preparation (20%)
Program Competency PC9: Use advanced statistical methods to analyze data generated from different epidemiological study designs			X	X	X	In class exercises (20%), Take-home exam I (20%), Take-home exam II (40%).
Program Competency PC11: Interpret and evaluate original or published results		X	X		X	Journal club preparation (20%), Take-home exam II (40%).

### **Assigned Text Book and Readings**

Required text: Miguel A. Hernan, James M. Robins: <https://www.hsph.harvard.edu/miguel-hernan/causal-inference-book/>

Optional text: Jay S. Kaufman, J. Michael Oakes: Methods in Social Epidemiology. Second Edition.

Required readings: See the course schedule. Readings will be posted on Moodle and course dropbox.

Other materials required for each student: For lab sessions, students need to bring their laptop to class with R installed on it. Data to be used in lab sessions will be uploaded on Moodle.

### **Course requirements and Student evaluation:**

#### **Pre-requisites:**

Prerequisites for the course include EPHD 320 or SHARP 300/320 or any equivalent intermediate level course in Epidemiology and basic Biostatistics.

#### **Attendance:**

Attendance will be taken at all lectures and practical sessions. Students are required to read the assigned readings *prior* to the class sessions, participate in class discussions and assignments.

#### **Total Credits:**

The course is 2 credits (1.3 credit lecture, 0.7 credit lab/projects).

#### **Student Evaluation:**

*Journal club preparation, class attendance, & participation* (20% of final grade):

The course is not entirely in lecture format. Participation and involvement in in-class activities (all in-class exercises and discussions) is required (10%). Students will have to demonstrate having prepared for discussions of the assigned readings, which will be assessed by their active participation and synthesis of readings and discussion materials during journal club sessions (10%). Students need to advise the course instructor in writing, if they intend to miss any class time.

*In-class exercises* (20% of final grade): There will be in class exercises including presentation of research question of interest, DAG exercises, and data programming using a real life dataset.

*Take home Exam I* (20% of final grade): Students will have a take home exam due on **Monday April 12 at 12pm**. The exam will test students on material discussed in class, specifically potential outcomes and DAGs.

*Take home Exam II* (40% of final grade): Students will have a take home exam due on **Friday, April 16 at 12PM**. Using a real-life dataset, the exam will test students on material discussed in class, specifically IPW and MSM.

Table-1 Summary of students' assessments mapped to course learning objectives

	Learning Objectives				
	LO1	LO2	LO3	LO4	LO5
Journal club preparation and in-class participation relevant to specific topics [20%]	X	X			
In-class exercises [20%]			X	X	X
Take-home exam 1 [20%: use DAGs for design and analysis]	X	X		X	
Take-home exam 2 [40%: data analysis]			X	X	X

Table -2 Description of Assessment methods, Due Dates and Corresponding Learning Objectives

Assessment method	Due dates/Deadlines	LOs covered	Grade percentage
<b>Journal club preparation, class attendance &amp; participation</b>	<b>Tuesday April 6 - Wednesday April 14</b>	LO 1-2	20%
<b>In-class exercises</b>	<b>Tuesday April 6 - Wednesday April 14</b>	LO 3-5	20%
<b>Take-home Exam I</b>	<b>Monday, April 12</b>	LO 1,2,4	20%
<b>Take-home Exam II</b>	<b>Friday, April 16</b>	LO 3-5	40%
<p><u>Note on exams:</u> Exams 1 and 2 will be take-home exams on two main components of the course. <b>Exam 1</b> will focus on reading and using DAGs to understand research questions, biases, and accordingly, plan appropriate analyses that account for biases. It will be based on a series of exercises and short answer questions to demonstrate knowledge of potential outcomes and DAGs and their use in analytical models and identifying biases. Exam 1 will allow students to think about methodological strategies and challenges in causal inference.</p> <p><b>Exam 2</b> will focus on applied data analysis on the methods introduced in the second half of the course. Students will be given two days to hand-in their take home projects, which will involve using weighing and marginal structural models to observational epidemiological data with the aim of answering research questions of interest. Exam 2 will allow student to apply knowledge and methods covered, conduct analysis, and interpret findings within a causal inference framework. Students are required to take exams on the assigned time. Make up exams will be given <u>only</u> in case of emergencies or major illness (certified medical report is required).</p>			
<b>In-class exercises</b>	Tuesday April 6 - Wednesday April 14	LO 3-5	20%
<b>Journal club preparation, class attendance &amp; participation</b>	Tuesday April 6 - Wednesday April 14	LO 1-2	20%

Note on in-class exercises, journal clubs, and participatory attendance: **In-class exercises:** we will invite students to think of a particular research question of interest to them in terms of causal inference framework and analysis (brief oral presentations). Students will be asked prior to the launch of the course to prepare their short talk/presentation about their research question at the start of the course (Day 1) and to revisit it at the end of the course (Day 7).

Two in-class exercises supervised by the course instructors will take place on Day 3: the first involves a set of practice exercises to become familiar in identifying open, blocked, and backdoor paths and minimal sufficient adjustment sets; the second involves using DAGs to identify confounding and selection bias for specific research questions and study designs.

An in-class exercise supervised by the course instructors will take place on Day 5 using a real life dataset and during which students will learn how to construct weights and run an MSM. This in-class project will allow students to organize datasets and analyses and apply causal inference methods. Students are expected to show initiative and demonstrate an understanding of the methods covered.

There will also be several short in class exercises using DAGs and tailored to specific topics covered in class (Day 2- 7).

**Journal club preparation, participation & attendance:** The course requires students to be prepared to synthesize and discuss assigned readings and examples paired with the topics covered throughout the course. In the journal club sessions, students will address all learning objectives. Students are expected to discuss the assigned readings and the value/limitations of the various causal inference concepts covered (including concepts of counterfactuals and causation, causal inference in observational studies, examples of confounding, mediation, and biases in causal inference framework). Students can find the topics to be discussed on Moodle. Journal club sessions will take place on Day 1, Day 2, Day 3, and Day 6.

Students are required to attend all classes and sessions of the course. In case of absence, students are responsible for the material missed and for any announcements made. Students who miss more than one-fifth of class sessions are subject to withdrawing from the course with a W-grad (check AUB catalogue). As detailed above, class participation however extends beyond just attendance. The course includes several participation-oriented activities and students are expected to actively participate in class discussions during all class sessions particularly journal clubs and in-class demonstrations and data clubs. All students are asked to come prepared, having read and reflected on the reading materials and examples to be covered for the journal clubs, and to actively participate in the in-class DAGs and analysis exercises. Journal club and overall attendance and participation are factored into the final grade (20%).

## **Policies and other General Notes:**

### **Cheating and Plagiarism**

Education is demanding and time management is essential. Do not hesitate to use the resources around you but do not cut corners. Cheating and plagiarism will not be tolerated. Please review the Student Code of Conduct in your handbook and familiarize yourself with definitions and penalties. If you are in doubt about what constitutes plagiarism, ask your instructor because it is your responsibility to know. The American University of Beirut has a strict anti-cheating and anti-plagiarism policy. Students will be penalized for cheating and plagiarism, as they are not tolerated. Penalties include failing marks on the assignment in question, suspension or expulsion from University and a permanent mention of the disciplinary action in the student's records.

### **Students with Disabilities**

AUB strives to make learning experiences accessible for all. If you anticipate or experience academic barriers due to a disability (including learning difficulties, mental health, chronic or temporary medical conditions), please inform me immediately so that we can privately discuss options. In order to ensure that you receive the support you need and to facilitate a smooth accommodation process, you are encouraged to register with the Accessible Education Office (AEO): [accessibility@aub.edu.lb](mailto:accessibility@aub.edu.lb); +961-1-350000, x3246; West Hall, 314'.

### **Use of Mobile**

The use of mobile phones for any reason is not allowed during class time. Please make sure to place them out of sight. Laptops are allowed for note taking or search purposes only.

### **Non-Discrimination – Title IX – AUB**

AUB is committed to facilitating a campus free of all forms of discrimination including sex/gender-based harassment prohibited by Title IX. The University's non-discrimination policy applies to, and protects, all students, faculty, and staff. If you think you have experienced discrimination or harassment, including sexual misconduct, we encourage you to tell someone promptly. If you speak to a faculty or staff member about an issue such as harassment, sexual violence, or discrimination, the information will be kept as private as possible, however, faculty and designated staff are required to bring it to the attention of the University's Title IX Coordinator. Faculty can refer you to fully confidential resources, and you can find information and contacts at [www.aub.edu.lb/titleix](http://www.aub.edu.lb/titleix). **To report an incident**, contact the University's Title IX Coordinator Mitra Tauk at 01-350000 ext. 2514, or [titleix@aub.edu.lb](mailto:titleix@aub.edu.lb). An anonymous report may be submitted online via EthicsPoint at [www.aub.ethicspoint.com](http://www.aub.ethicspoint.com).

**EPHD 404 Detailed Course Outline, April 6-14, 2021**

Schedule of Lectures, Practical Sessions, Readings and Assessments

TIME	Tuesday April 6	Wednesday April 7	Thursday April 8	Friday April 9	Monday April 12	Tuesday April 13	Wednesday April 14
9:00AM – 10:00AM			<b>Lecture:</b> Introduction to DAGs			<b>Lecture:</b> Applications using causal framework: Introduction to Mediation analysis	
10:00AM – 11:00AM							
11:00AM – 12:00PM			<i>In-class activity</i>			<i>In-class activity</i>	
3:00PM – 4:00AM	Introductions and course overview	<b>Lecture:</b> Introduction to causal effects and randomized experiments (cntd’)  <i>In-class activity</i>	<b>Lecture:</b> Confounding and selection bias using DAGs	<b>Lecture:</b> Propensity scores  <b>Lecture:</b> Inverse probability weights (IPW)	<b>Discuss Limitations of conventional methods</b>  <b>Lecture:</b> Introduction to MSM  <i>In-class activity</i>	<b>Lecture:</b> Applications using causal framework: Instrumental variables  <i>In-class activity</i>	<b>Open Forum</b>
4:00PM – 5:00PM	<i>In-class activity</i>						
5:00PM – 6:00PM	<b>Lecture:</b> Introduction to causal effects and randomized experiments	<b>Lecture:</b> Observational studies within a causal framework	<i>In-class activity</i>				-

**Class Sessions Topics & Required Readings**

Class Session	Topics, Required Readings, and Assignments Due
Tuesday April 6; Wednesday April 7 2021	
<p><b>Lecture:</b> Introduction to causal effects.  <b>Lecture:</b> Introduction to causal effect and randomized experiments.  <b>Lecture:</b> Observational studies within causal framework.</p> <p><i>Session Objectives</i></p> <ol style="list-style-type: none"> <li>1. Understanding the definition and measures of causal effects.</li> <li>2. Discuss causation vs. association.</li> <li>3. Learn about counterfactuals and potential outcomes.</li> <li>4. Understand randomization and conditional randomization.</li> <li>5. Discuss the theory behind standardization and Inverse Probability Weighting.</li> <li>6. Rethink observational studies within randomized experiment paradigm.</li> <li>7. Learn about the exchangeability, consistency, and positivity assumptions.</li> <li>8. Discuss well-defined interventions as a pre-requisite.</li> </ol> <p><i>Activity</i></p> <ol style="list-style-type: none"> <li>1. Draw a conceptual framework for a research question of your interest (to be revisited at the end of the course).</li> <li>2. Demonstration through videos and pop-culture examples of counterfactuals and causation.</li> <li>3. Journal Club: Hernan M. Does Water Kill? A call for less casual causal inferences. <i>Annals of Epidemiology</i>, 2016; 26(10): 674-680.</li> </ol> <p><i>Readings</i></p> <ol style="list-style-type: none"> <li>1. Hernan &amp; Robins. Part I, Chapters 1, 2 and 3.</li> <li>2. Glymour M and Spiegelman D. Evaluating Public Health Interventions: Causal Inference in Public Health Research – Do Sex, Race, and Biological Factors Cause Health Outcomes? <i>International Journal of Epidemiology</i>, 2017; 107: 81-85.</li> <li>3. Hernan M. Does Water Kill? A call for less casual causal inferences. <i>Annals of Epidemiology</i>, 2016; 26(10): 674-680</li> <li>4. Robins JM, Weissman MB. Commentary: Counterfactual Causation and Streetlamps: What is to be done? <i>International Journal of Epidemiology</i>, 2016, 1830-1835.</li> <li>5. Rubin DB. The design versus the analysis of observational studies for causal effects: parallels with the design of randomized trials. <i>Stat Med</i>. 2007; 26(1):20-36. (Optional: Section 4)</li> <li>6. Hernan M and Taubman SL. Does obesity shorten life? The importance of well-defined interventions to answer causal questions. <i>International journal of obesity</i>, 2008, 32: S8-S14</li> </ol>	

7. Rehkopf D, Glymour MM, Osypuk T. The consistency assumption for causal inference in social epidemiology: When a rose is not a rose. *Current Epidemiology Reports*, 2016; 3(1): 63 – 71.

**Thursday April 8, 2021**

**Lecture:** Introduction to DAGs.

**Lecture:** Confounding and selection bias using DAGs.

Session Objectives

1. Learn about the concept, terminology, and structure of Directed Acyclic Graphs.
2. Learn about the structure of confounding using DAGs.
3. Learn about the structure of selection bias using DAGs.

Activity

1. General DAG practice (paths and structural relations between variables).
2. DAGs practice on confounding and selection bias (in-class exercises and short questions on design and analytical strategies using DAGs).
3. Discuss examples of DAGs applied in published work

Readings

1. Hernan & Robins. Part I, Chapters 6, 7, and 8.
2. Glymour M. Using Causal Diagrams to understand common problems in social epidemiology. Chapter 16.
3. Hernán MA, Hernández-Díaz S, Robins JM. A structural approach to selection bias. *Epidemiology*. 2004 Sep;15(5):615-25. doi: 10.1097/01.ede.0000135174.63482.43. PMID: 15308962.
4. Tennant PWG, Murray EJ, Arnold KF, et al.,. Use of directed acyclic graphs (DAGs) to identify confounders in applied health research: review and recommendations. *Int J Epidemiol*. 2020 Dec 17:dyaa213. doi: 10.1093/ije/dyaa213. Epub ahead of print. PMID: 33330936.

**Friday April 9, 2021**

**Lecture:** Propensity scores.

**Lecture:** Inverse probability weighting.

Session Objectives

1. Learn about exchangeability and how to adjust for confounding.
2. Learn how to adjust for selection bias.

3. Understand the reasoning behind propensity scores.
4. Calculate a propensity score: matching, adjusting.
5. Learn how to calculate inverse probability treatment weights and stabilized weights.
6. Diagnostics of IPTWs

Readings

1. Hernan & Robins. Part II, Chapter 12.
2. Glymour M. Using Causal Diagrams to understand common problems in social epidemiology. Chapter 16.
3. Rosenbaum PR, Rubin DB. The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika*. 1983;70(1):41-55.
4. Kurth T, Walker AM, Glynn RJ, et al. Results of multivariable logistic regression, propensity matching, propensity adjustment, and propensity-based weighting under conditions of nonuniform effect. *Am J Epidemiol*. 2006; 163(3):262-270.

**Take home Exam 1. Due Monday April 12 at 12pm.**

**Monday April 12, 2021**

**Lecture:** Introduction to marginal structural models.

Session Objectives

1. Understand the theory and assumptions of marginal structural models.
2. Understand the framework of mediation.
3. Learn how to perform a mediation analysis within a causal inference framework.

Activity

1. *Lab session: using a dataset, learn how to create IPWs, illustrate the weights graphically, check for assumption violations, and run a MSM.*

Readings

1. Hernan & Robins. Part II, Chapter 12.
2. Robins JM, Hernan MA, Brumback B. Marginal structural models and causal inference in epidemiology. *Epidemiology*. 2000; 11(5):550-560.
3. Cook NR, Cole SR, Hennekens CH. Use of a marginal structural model to determine the effect of aspirin on cardiovascular mortality in the Physicians' Health Study. *Am J Epidemiol*. 2002; 155(11):1045-1053.

**Tuesday, April 13, 2021**

**Lecture:** Applications using causal framework: Introduction to Mediation analysis.

**Lecture:** Applications using causal framework: Instrumental variables.

Session Objectives

1. Understand the framework of mediation.
2. Learn how to perform a mediation analysis within a causal inference framework.
3. Understand IV methodology and the 2 stage least square analysis.

Activity

1. *Two Journal club sessions and examples in published literature on mediation and IV applications.*

Readings

1. Hernan & Robins. Part I, Chapter 4 and Part II, Chapter 16.
2. Valeri L and VanderWeele TJ. Mediation analysis allowing for exposure-mediator interactions and causal interpretations: theoretical assumptions and implementation with SAS and SPSS macros.
3. VanderWeele TJ and Vansteelandt S. Conceptual issues concerning mediation, interventions and composition.

**Take home Exam 2. Due Friday, April 16 at 12PM.**

**Wednesday, April 14, 2021**

**Open forum**

Activity

1. Q and A
2. Revisiting your research question from day 1 and draw and discuss a conceptual framework.