UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

## Causal Inference

**2526-1-F8205B018**

---

### Learning objectives

1. **Knowledge and Understanding:**

The course aims to introduce principles of causal inference in observational studies to be able to define (1) the causal effect, (2) the difference between association and causation, (3) the concept of confounding and selection bias, (4) direct acyclic graphs, (5) estimation of causal effects, (6) statistical models for causal effects (7) mediation (8) target emulation trials

2. **Applying knowledge and understanding:**

Based on the concepts and methods presented in class, students will be able to draw cuasal graphs and assess how to run statistical models to estimate causal effects using both Stata (StataCorporation), widely used in the field of epidemiology and biostatistics and R.

3. **Making judgements:**

Having learnt methods and applications, students will show which methods and techniques are to be used given the study and the data at hand, by critically assessing the statistical and clinical implications of the models being used.

4. **Communication skills:**

The student will be able to explain how the methods can be applied and interpret the results in a clear and simple way.

5. **Learning skills:**

The students will learn how to analyse basic and more advanced statistical methods to fit causal models, by understanding the methodology and by using Stata.

## Contents

Causal inference from observational data is a key task of biostatistics and of allied sciences such as sociology, education, behavioral sciences, demography, economics, health services research, etc.

These disciplines share a methodological framework for causal inference that has beendeveloped over the last decades.

This course presents this unifying causal theory and shows how biostatistical concepts and methods can be understood within this general framework. The course emphasizes conceptualization but also introduces statistical models and methods for causal inference.

Specifically, the content is:
a) formally define causal concepts such as causal effect and confounding
b) identify the conditions required to estimate causal effects
c) use analytical methods that, under those conditions, provide estimates that can be endowed with a causal interpretation.

The (causal) methods can be used under less restrictive conditions than the traditional statistical methods. For example, instrumental variable methods allow one to estimate the causal effect of an exposure in the presence of unmeasured confounders of the exposure and outcome.

## Detailed program

**Section (I): Causal inference without models:**
1 A definition of causal effect
1.1 Individual causal effects
1.2 Average causal effects
1.3 Measures of causal effect
1.4 Random variability
1.5 Causation versus association

2 Randomized experiments
2.1 Randomization
2.2 Conditional randomization
2.3 Standardization
2.4 Inverse probability weighting
3 Observational studies
3.1 Identifiability conditions
3.2 Exchangeability
3.3 Positivity
3.4 Consistency: First, define the counterfactual outcome
3.5 Consistency: Second, link counterfactuals to the observed data
3.6 The target trial

Graphical representation of causal effects
6.1 Causal diagrams
6.2 Causal diagrams and marginal independence
6.3 Causal diagrams and conditional independence

## Prerequisites

The course is offered in english, fluency in the english language is an important condition for successfully attending the lectures (listening comprehension and reading ability) and reading the additional material.

## Teaching methods

Blended/elearning: frontal lectures, online lectures, class work, seminars, use of Stata and Dagitty. Online teaching will be used to allow students (not coming to class) to follow some of the lectures of the course. Lectures will be prepared and uploaded during the course. Moreover, homeworks will be discussed and possible solutions proposed once the homeworks are corrected.

## Assessment methods

1. Class Project (group): (80 %)
2. Final Written exam (20 %)

Both call project based on team work and the final exam will help to evaluate the student knowledge necessary to assess the goal of the study being proposed to be analyzed using dagitty and Stata

## Textbooks and Reading Materials

Hernán MA, Robins JM (2020). Causal Inference: What If. Boca Raton: Chapman &Hall/CRC. http://www.hsph.harvard.edu/faculty/miguel-hernan/causal-inference-book/

## Semester

II Semester, IV term

## Teaching language

English

## Sustainable Development Goals

QUALITY EDUCATION