Introduction to Causal Inference

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Outline

This course provides an introduction to the principles and methods of causal inference in medicine. In the first part, we establish a conceptual framework for understanding causality, highlighting key epistemological distinctions between association, intervention, and counterfactuals. We explore why experiments are foundational to generating causal knowledge and examine the assumptions required for different levels of the causal hierarchy. Two central approaches to causal inference - potential outcomes and directed acyclic graphs (DAGs) - are introduced and discussed.

The second part focuses on the practical application of causal inference in observational research. Students will learn about study design using the causal roadmap and the target trial framework, with an emphasis on minimizing bias and confounding. DAGs and related concepts - such as the disjunctive cause criterion - will be used to inform covariate selection and to identify and avoid common biases, including selection, time-related, and measurement biases. We will explore how graphical tools can guide the appropriate timing of measurements for confounders, treatments, and outcomes, and discuss the importance of aligning time zero across treatment groups to avoid immortal time bias.

In the computer-based practical sessions, students will apply these concepts using multivariable regression and inverse probability of treatment weighting. We will also introduce alternative strategies for causal inference that do not rely on measured confounders, but instead exploit exogenous variation - such as instrumental variables - that increase the likelihood of treatment, offering a means of causal identification without assuming conditional exchangeability.