Causal research in modern methodological framework

Faculty of Medicine Postgraduate Education Unit (PGE) and Finnish Doctoral Program in Oral Sciences FINDOS-Turku organize four-day course Spring term, 2025. All doctoral candidates at the Faculty of Medicine are welcome to attend the course. The number of participants is limited to 40 people.

Course leader: Associate Professor Ulvi Gürsoy, Institute of Dentistry

Teachers: Emeritus professor Esa Läärä, University of Oulu (esa.laara@oulu.fi), University teacher Auli Suominen, University of Turku

Credits: 2 ECTS

Introduction: Causal knowledge and the ability to infer causation from observed data play important roles in health sciences. Randomized controlled trial, when feasible, is an ideal design for assessing the effects of medical and surgical treatments or public health interventions. However, many research questions, such as those addressing causes of diseases, have to rely on observational studies. These are affected by systematic errors or biases that threaten the validity of causal inference. Traditional statistical methods focusing on associations and predictions is inadequate in causal analysis, for which a more precise language and a more structured approach is needed.

This intensive course provides a modern framework for the analysis and inference on causal effects of interest from observational data. The effects are defined in terms of carefully specified causal estimands, which are relevant contrasts of pertinent counterfactual quantities. The strategy of analysis utilizes causal diagrams, i.e. directed acyclic graphs (DAG), whose basic concepts and principles are covered. An overview is provided on the main observational study designs: the variants of cohort and case-control studies. The major biases due to confounding, selection, measurement errors and overadjustment, are characterized with causal diagrams. Primary attention is devoted to adequate control of confounding with the help of causal diagrams and modern statistical approaches like g-computation and inverse probability weighting. Deficiencies of conventional null-hypothesis significance testing is also reviewed.

Lectures are complemented by practical sessions, in which the principles and methods learned in lectures are applied in critical analysis and interpretation of selected real studies. For these sessions, students are asked to read in advance a few articles. Some examples on using R environment will accompany some of the teaching sessions, but deep familiarity with R is not assumed.

Learning outcomes: After successful completion of the course, the student is able to define the basic concepts and rules of causal diagrams, how to specify precisely causal effect of a single time-fixed exposure and identify it using causal diagrams in the presence confounding. The student can also characterize the major types of bias with the help of these diagrams, the main features of the common observational study designs used in causal research and the key principles of statistical analysis and inference on causal estimands.

Prerequisites: Basic course in statistical methods. Some knowledge on linear, logistic and Cox regression is useful

Recommended reading before the course:
Digitale JC et al. Tutorial on directed acyclic graphs. *J Clin Epidemiol* 2022;142:264-267. https://doi.org/10.1016/j.jclinepi.2021.08.001
Igelström P et al. Causal inference and effect estimation using observational data. *JECH* 2022;76:960-966. https://doi.org/10.1136/jech-2022-219267
van Amsterdam WAC et al. Causal inference in oncology: Why, what, how, and when. *Clin Oncol* 2024 (in press). https://doi.org/10.1016/j.clon.2024.07.002

Requirements: Active participation in lectures, and practical sessions. Each day the participants are given selected articles for reading and doing homework exercises.

Evaluation: Pass/Fail

Registration in Peppi by **19.2.2025**.

Programme

27.2.2025
Place: MED C202

9.00-10.30 **Lecture I:** Causal research questions, potential outcomes or counterfactuals. Parameters for causal effects. Basic elements of causal diagrams

10.30-10.40 **Break**

10.40-12.00 **Practical session I:** Reformulating causal questions and effect parameters from published articles

12.00-13.00 **Lunch (not free)**

13.00-15.00 **Lecture II:** Identifying causal effects, confounding and its control in a causal diagram

28.2.2025
Place: MED C202

9.00-10.30 **Lecture III:** Selection bias and information bias in causal diagrams

10.30-10.40 **Break**

10.40-12.00 **Practical session II:** Constructing and analyzing causal diagrams in concrete research questions

12.00-13.00 **Lunch (not free)**

13.00-15.00 **Lecture IV:** Types and dimensions of experimental and observational designs

13.3.2025
Place: Dent 4

9.00-10.30 **Lecture V:** Randomized trials, cohort studies and target trial emulation (TTE)

10.30-10.40 **Break**

10.40-12.00 **Practical session III:** Critical analysis of published cohort and TTE studies

12.00-13.00 **Lunch (not free)**

13.00-15.00 **Lecture VI:** Different variants of case-control studies

14.3.2025
Place: Dent 4

9.00-10.30 **Lecture VII:** Estimability of causal parameters in different variants of case-control studies

10.30-10.40 **Break**

10.40-12.00 **Practical session IV:** Critical analysis of published case-control studies

12.00-13.00 **Lunch (not free)**

13.00-15.00 **Lecture VIII:** Principles of statistical estimation and inference of causal parameters from empirical data.