EPIB 676-001 Advanced topics in decision-analytic modeling for health

Course syllabus, Fall 2024, McGill University

Table of contents

Course description

Advanced methods used to model health policy decisions and conduct model-based health technology assessment, both theory and technical applications. Methods covered include: Markov and microsimulation models, Bayesian model calibration and evaluation, probabilistic sensitivity analysis, value of information analysis, and equity-informative health policy analysis. Application areas include: disease screening, prevention, and treatment, public health measures, and prioritization of clinical research.

Learning objectives

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

- Develop decision analytic models to inform health policy and clinical decisions
- Understand and critically appraise model-based decision analyses
- Create transparent reports of model-based decision analyses that conform to open science principles

Instructor

W. Alton Russell, PhD, Assistant Professor, McGill School of Population and Global Health. alton.russell@mcgill.ca | mchi.mcgill.ca/decision-modeling-lab | Office: 2001 McGill College #1113

Class meetings & office hours

Class meetings will be held 11:35am – 12:55am on Tuesdays and Thursdays at 2001 McGill College Ave in room #1203. Attendance is expected.

Office hours will be held 1:30pm - 2:30pm in Conference Room #1103 on Tuesdays and Thursdays on days in which class meets. Students can take advantage of office hours to discuss assignments, projects, and readings or ask general career/research questions. All students are encouraged to attend. Most discussions take place openly so that other students can listen in or join in. Students who would like a private discussion should let the instructor know.

Target audience

The course is geared towards PhD students and advanced Masters students interested in applying model-based analyses of health policies, decisions, or technologies in research. Modeling skills developed in the course will also be useful for students interested in industry or government roles related to economic evaluation, policy modeling, health technology assessment, or health economics and outcomes research.

Prerequisites

The ideal preparation of this course includes (1) at least an introductory programming course, (2) a course in probability, (3) a course in statistics. A course on cost-effectiveness such as PPHS 528 is not necessary but would provide helpful context (PPHS 528 can be taken concurrently). Prior experience programming in R is ideal, but students with solid experience in another programming fundamentals (e.g., nested loops, functions, data structures) should be able to learn the R syntax and environment as they go. Students who lack a prerequisite other than programming may need to spend extra time on some course components but should be able to succeed in the course. Students without programming, or with neither statistics nor probability training should not take the course. To help make an informed decision on how well-prepared you are for the course, you can attempt to complete assignment 0 early (available on Github).

Readings

Readings drawn from various sources are assigned before most class sessions as indicated in the schedule below. PDFs of the readings are available on MyCourses. Some readings are tutorials with accompanying code, which you are encouraged to download and run. To get full credit for class engagement, students should come to class prepared to discuss the readings.

If >20 pages are assigned for a given class, students may skim some of the material, particularly readings that are marked as 'secondary.' But students should be sufficiently familiar with each reading to quickly find relevant material as they work on assignments and projects.

Laptops and software

Students should bring a personal laptop to class; please let the instructor know right away if this is a challeng so we can find a solution. Before the first session, students should install and configure the necessary software (R, RStudio, git) using the 'Setting up your software enviroment' instructions from session 1.

Approach to learning

The course provides hands-on experience applying course concepts early and often. The course has two phases with some overlap:

- **The methods phase (15 sessions)** focuses on understanding methods and workflows and building programming skills. Readings are primarily pedagogical in nature, including tutorials with accompanied R code you can examine and run. Some class sessions will include running sample code on your own laptop. Six programming assignments will provide hands-on experience in coding a model-based decision analysis.

- **The application phase (11 sessions)** focuses on the use of decision analytic modeling to inform health policy and clinical practice. You'll be assigned a diverse set of applied modeling analyses as readings, and you'll hear from several decision-analytic modeling analysts in class sessions. Students will also analyze and present an existing open-source modeling study. For the course project, students will develop their own model-based decision analysis.

Assignments & evaluation

Class engagement (8%)

Students are expected to attend class on time and prepared to discuss assigned readings. Students should actively engage in discussions, ask questions, and follow along with programming examples on their own laptops.

R programming assignments (48%)

A series of time-intensive programming assignments will provide hands-on experience developing decision analytic modeling analyses. For each assignment, students will download a Zip file that contains a Quarto document from the class Github site. The Quarto document includes questions, instructions, and starter code. Students will complete the assignments by completing the code and answering questions. Once complete, students will render their Quarto document to an HTML file, which they upload to MyCourses for grading.

0. Simpler models (8%)
1. Decision trees, cost-effectiveness (8%)
2. Cohort models (8%)
3. Simulation (8%)
4. Uncertainty analysis (8%)
5. Calibration, validation, and value of information (8%)

Out of fairness to all classmates, late assignments will be penalized 20% per day except if an exception is made more than 2 days before the deadline or under exceptional circumstances. All assignments will be available at least 10 days before their deadline. Students should:

- Start early
- Read the whole assignment before you begin and feel free to go out of order
- Spend some time on it each day for 3 or more days (instead of completing it in one sitting)

- Work alone first, then discuss with classmates or the instructor (but you must write your own code and responses)
- Come to office hours to discuss

Presentation of open-source modeling analysis (8%)

Students will find a published applied decision-analytic modeling analysis that includes code. Students will attempt to understand the code run the model on their own machine and give a brief in-class presentation about their experience.

Course project (36%)

The default course project entails developing a decision-analytic model an use it to inform a decision from health policy or clinical practice. Students are encouraged to analyze a decision problem related to their own research and/or engage with domain experts outside the class when applicable. Other project topics, such as developing or assessing a novel method or using modeling methods for an application that is not a decision analysis, may be approved by the instructor on a case-by-case basic. Students are strongly encouraged to come to office hours to discuss their project with the instructor.

1. Proposal (2%)
2. Class presentation (8%)
3. Written report (with code) (26%)

Logistics

PDFs of all readings are available to enrolled students in MyCourses. Assignments are due at 11:59pm EST on the date indicated in the schedule below. Grades and feedback will also be provided within MyCourses. All other course materials are available on Github, including the assignments.

Academic integrity

McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the *Code of Student Conduct and Disciplinary Procedures* (see here for more details). Students found guilty of such academic offences will be given a failing grade to this course.

Language of submission

In accordance with McGill University's *Charter of Students' Rights*, students have the right to submit any written work that is to be graded in either English or French.

Course schedule

Date	Topics, Readings/tasks to be completed before class |
29 Aug Th	**1. Course introduction** • Why do decision analysis • Analytic perspective • Using R and RStudio • **Assignment 0 available (simpler models)** (1) Follow the 'Setting up your software enviroment' instructions to make sure you have an up-to-date local version of R and Rstudio desktop on your laptop. (2) Read through the Hello, Quarto tutorial for RStudio
3 Sep Tu	**2. Economic evaluation** • Decision analytic frameworks • Quantifying health and costs • Incremental analysis • **Assignment 1 available (decision trees, cost-effectiveness)** • **Assignment 0 due Wednesday** Ch. 1 'Introduction to health economic evaluation' from Bayesian Methods in Health Economics (2012) by Gianluca Baio
5 Sep Th	**3. Probability, decision trees** • Conditional probability • Distributions, expectation, variance • Decision trees Ch 9 sections 9.1-9.4 (pg 311 - 331) of 'Economic evaluation using decision-analytic modelling' from 'Methods for the Economic Evaluation of Health Care Programmes' (2014) by Drummond et. al.

Date	Topics, Readings/tasks to be completed before class
10 Sep Tu	**4. Cohort models I** • Discrete time state-transition models • Markov model solution • Time-varying transitions • **Assignment 2 available (cohort models)** Alarid Escudero et. al. 2022. An introductory tutorial on cohort state-transition models in R using a cost-effectiveness analysis example
12 Sep Th	**5. Cohort models II** • Capturing health-economic outcomes • Discrete time error corrections • Capturing epidemiological outcomes • Differential equation models • **Assignment 1 due Friday** Alarid Escudero et. al. 2022. A tutorial on time-dependent cohort state-transition models in R using a cost-effectiveness analysis example
17 Sep Tu	**6. Workflow and good coding practices** • Open science practices • An R project workflow • Version control • **Open-source model presentation assigned** Alarid-Escudero et. al. 2019. A Need for Change! A Coding Framework for Improving Transparency in Decision Modeling
19 Sep Th	**7. Simulation I** • Monte Carlo simulation • Simulating decision trees • Simulating state transition models • **Assignment 3 available (simulation)** Krijkamp et. al. 2018. Microsimulation modeling for health decision sciences Using R: A tutorial

Date	Topics, Readings/tasks to be completed before class |
24 Sep Tu	**8. Simulation II** • Efficient coding strategies • Efficiency improvement for simulations • **Assignment 2 due Wednesday** Karnon et. al. Modeling using discrete event simulation: A report of the ISPOR-SMDM Modeling Good Research Practices Task Force
26 Sep Th	**9. Simulation III** • Discrete even simulation • Agent based models • Network model models Chhatwal & He 2015. Economic evaluations with agent-based modelling: An introduction.
1 Oct Tu	**10. Designing & parameterizing an analysis** • Perspective, time horizons, comparators • Deciding on scope & structure • Literature-based inputs • Patient-level data inputs • **Project proposal assigned** **Primary**: *Roberts et. al. 2012. Conceptualizing a model: a report of the ISPOR-SMDM Modeling Good Research Practices Task Force* **Secondary**: Ch 8 (pg 209 - 236) 'Finding and summarizing the evidence' from *Decision Making in Health and Medicine (2014) by Hunink et. al.*
3 Oct Th	**11. Uncertainty analysis** • Probabilistic sensitivity analysis • Credible intervals • Univariate sensitivity analysis • Scenario analysis • **Assignment 3 due Friday** • **Assignment 4 available (Sensitivity analysis)** Briggs et. al. 2012. Model parameter estimation and uncertainty analysis: ISPOR-SMDM modeling good practices task force report

Date	Topics, Readings/tasks to be completed before class |
8 Oct Tu	**12. Statistical models, causal inference, and decision-analytic modeling** • Time-to-event models • Competing events • Temporal extrapolation **Primary:** Kühne et. al. (2022). Causal evidence in health decision making: methodological approaches of causal inference and health decision science **Supplemental:** Williams et. al. (2016). Cost-effectiveness analysis in R using a multi-state modeling survival analysis framework: A tutorial
10 Oct Th	**13. Calibration & validation** • Bayesian model calibration • Model validation **Primary:** Menzies et. al. 2017. Bayesian methods for calibrating health policy models: A tutorial. **Supplemental:** Eddy et. al. 2012. Model transparency and validation: ISPOR-SMDM modeling good practices task force report
15 Oct Tu	*Thanksgiving break/reading week, no class*
22 Oct Tu	**14. Guest lecture 1 [AABB]:** • Office hours on Zoom only Manuscript, Code
24 Oct Th	**15. Value of information analysis** • For research prioritization and as sensitivity analysis • VOI measures (EVPI, EVPPI, EVSI) • Challenges and limitation • **Assignment 5 available (calibration, validation, VoI)** Fenwick et. al. 2020. Value of information analysis for research decisions—an introduction: Report 1 of the ISPOR Value of Information Analysis Emerging Good Practices Task Force
29 Oct Tu	**16. Guest lecture 2 [SMDM]:** • Office hours on Zoom only

Date	Topics, Readings/tasks to be completed before class |
31 Oct Th	**17. Equity and distributional considerations** • Evaluation frameworks • Estimating heterogeneity • **Project proposal due Friday** *Avanceña and Prosser (2021). Innovations in cost-effectiveness analysis that advance equity can expand its use in health policy* **Supplemental:** *Love-Koh et. al. (2019). Aggregate distributional cost-effectiveness analysis of health technologies*
5 Nov Tu	**18. Student presentations of open-source modeling analyses**
7 Nov Th	**19. Guest lecture: Dynamic compartmental** modelling to inform influenza dynamics and vaccine policies in the United States by Kyue Lee, PhD (University of Washington School of Pharmacy) Manuscript, Code, Supplemental manuscript • **Assignment 4 due Friday**
12 Nov Tu	**20. Guest lecture 4**
14 Nov Th	**21. Guest lecture 5** • **Assignment 5 due Friday**
19 Nov Tu	**22 Guest lecture 6**
21 Nov Th	**23. Guest lecture:** "Estimating the total incidence of type 1 diabetes in children and adolescents aged 0–19 years from 1990 to 2050: a global simulation-based analysis" by Zachary J. Ward, MPH PhD (Harvard T.H. Chan School of Public Health) Manuscript, Code to be posted on MyCourses
26 Nov Tu	**24. Guest lecture 8**
28 Nov Th	**25. Guest lecture 9**
3 Dec Tu	**26. Final presentations and wrap-up lecture**

Date	Topics, Readings/tasks to be completed before class |
10 Dec Tu	Final project report + code due on MyCourses (no class)