North Carolina State University
College of Veterinary Medicine,
Comparative Biomedical Sciences

Course syllabus: CBS 810-005 Special topics: Modeling in infectious disease dynamics

Instructors

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Lecture Locations and Times

Location: 458 Research Building Monday and Wednesday 2:00-3:15pm

Course Description

Mathematical models are an important tool for studying the emergence, transmission, and control of infectious diseases. The objective of this graduate course is to introduce mathematical modeling as a research tool to study infectious diseases. This is a highly interdisciplinary graduate course. In previous years, students with very different backgrounds and prior knowledge of mathematics and biology have taken the course.

Major Course Learning Objectives

The learning objectives of the course are to (1) explain the role of mathematical modeling in infectious disease epidemiology, (2) explain key concepts of infectious disease transmission and control, (3) analyze epidemiological data to extract information on disease transmission and control efficacy, (4) construct and analyze mathematical models for epidemiological processes, and (5) develop skills in critically evaluating modeling papers.

Recommended texts

While there is no single book that fits the entire course. We will use material from the below listed books. Depending on your background, you may find one book more useful than another. In addition, some papers will be required reading. All required reading material, lecture notes and/or PowerPoint files will be posted in moodle.

- Keeling, M. J. and P. Rohani. 2008. Modeling infectious diseases in humans and animals. Princeton University Press, Princeton, NJ.
- Anderson, R. M. and R. M. May. 1992. Infectious diseases of humans: dynamics and control. Oxford University Press, Oxford.
- Hudson, P. J., B. T. Grenfell, A. Rizzoli, H. Heesterbeek, and A. Dobson. 2002. The Ecology of Wildlife Diseases. Oxford University Press, New York, NY.

- Diekmann, O., J. A. P. Heesterbeek, and T. Britton. 2013. Mathematical tools for understanding infectious disease dynamics. Princeton University Press. (More suitable for math students)
- Vynnycky, E. and R. G. White. 2010. An introduction to infectious disease modeling. Oxford University Press, Oxford, UK. (More suitable for biology students)

Course Structure

The course will consist on a mix of lectures, computer labs (we will be using R, http://www.r-project.org/), and group discussion of published papers.

Grading

This course is a S/U graded doctoral course. A satisfactory grade will be based on participation and completion of the assignments. Assignments will consist on short written assignments, online quizzes and computer based homework. Students should attend classes, but attendance is not mandatory.

Students with disabilities policy

"Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG 02.20.01)."

N.C. State University Polices, Regulations, and Rules (PRR):

"Students are responsible for reviewing the PRRs which pertain to their course rights and responsibilities. These include: http://policies.ncsu.edu/policy/pol-04-25-05 (Equal Opportunity and Non-Discrimination Policy Statement), http://oied.ncsu.edu/oied/policies.php (Office for Institutional Equity and Diversity), http://policies.ncsu.edu/policy/pol-11-35-01 (Code of Student Conduct), and http://policies.ncsu.edu/regulation/reg-02-50-03 (Grades and Grade Point Average)."

Course topics

1. Infectious disease epidemiology. Concepts: Infectious disease trends, infection and disease timelines, epidemiological patterns.

2. Introduction to epidemiological modeling. Role of mathematics in epidemiology. Types of models.

3. Deterministic models. Nonlinear dynamics and threshold behavior. Basic reproduction number. Herd immunity and vaccination thresholds.

4. Introduction to R. Simulation and fitting of deterministic SIR models.

5. Estimation of the basic reproduction number from field data.

6. Heterogeneity in transmission. Multi-host, multi-pathogen models. Emerging and zoonotic diseases.

7. Indirectly transmitted disease. Models for vector-borne diseases.

8. Next generation matrix: basic reproduction number revisited.

9. Stochastic models. Demographic and environmental stochasticity. Simulation of stochastic models.

10. Spatial and network models. Agent-based models.

11. Models and control strategies. Vaccination strategies

Tentative schedule

Date	Topic	Content
19-Aug	Introduction	Basic concepts of epidemiology and infectious disease
24-Aug	Introduction Cont'd	Basic concepts of epidemiology and infectious disease
26-Aug	Mathematical Modeling	Introduction of epidemiology modeling
31-Aug	Mathematical Modeling Cont'd	Overview of types of models
2-Sep	Deterministic Model	Introduction to compartment models
7-Sep	Labor day	No class
14-Sep	Deterministic Model Cont'd	Demographics, etc.
16-Sep	Determnistic Model Lab	Introduction to R
21-Sep	Deterministic Model Lab Cont'd	Simulation and Fitting of SIR models
24-Sep	Introduction to R0	Basic concept of R0
28-Sep	R0 Endemic	R0 for endemic diseases and seroepidemiology
30-Sep	Inference from Data Lab	Estimating R0 and parameters from field data
5-Oct	Zoonotic Diseases	Introduction to zoonotic diseases and multi-host model
7-Oct	Vector Borne Diseases	Introduction to vector-borne diseases
12-Oct	Multi-strain Pathogens	Introduction to multi-strain and cross-immunity
14-Oct	Next Generation Matrix	NGM- R0 revisited
19-Oct	Stochastic Models	Demographic stochasticity
21-Oct	Stochastic Models Cont'd	Building stochastic model and Gillespie's algorithm
26-Oct	Stochastic Model Lab	Simulating stochastic model with Gillespie's algorithm
28-Oct	Spatial Models	Metapopulation models and other spatial models
2-Nov	Agent-based Models	Introduction to ABM
4-Nov	Network Models	Introduction to networks for epidemiology
9-Nov	Multihost and metapopulation Lab	Simulating metapopulation models
11-Nov	Vaccination	Introduction to vaccination
16-Nov	Control Strategies	Introduction to other control strategies
18-Nov	Control Strategy Lab	Simulating effects of various control strategies

23-Nov	Group discussion	
25-Nov	Groups discussion	
30-Nov	Group discussion	
2-Dec	Group discussion	