INSTRUCTOR: Annelies Van Rie, MD, PhD
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Office Hours by Appointment

TIME: Mondays 1-3:50
LOCATION: HSL room 307

OBJECTIVE

Dynamic mathematical transmission models have become an essential tool in the study of infectious diseases and the estimation of effects of the introduction of new public health interventions. This course aims to introduce the key concepts and methods of mathematical modeling of infectious diseases and will help students discover how mathematical models help us understand the spread of infectious pathogens in dynamic populations. In addition to developing a firm understanding of the basics of mathematical modeling theory, students will explore existing mathematical models in practical computer lab sessions. Students will learn to determine the key parameters involved in the spread of pathogens, and the impact changes in these parameters have over time. In class, we will discuss the public health and social consequences that each model and its results carry, and discuss how they can be used to inform policy decisions. Through discussions of published papers, students will learn how to critically evaluate a mathematical modeling paper and how to communicate modeling results to readers of scientific journals as well as policy makers.

At the successful completion of the course, the student will:

- Have a solid understanding of the terminology, concepts and methods of mathematical modeling of infectious diseases.
- Understand when a dynamic mathematical approach is appropriate
- Be knowledgeable of the main areas in infectious diseases where mathematical modeling has contributed to our understanding
- Have better analytic skills to study the epidemiology of infectious disease at a population level.
- Be able to understand and critically read a mathematical modeling paper

COURSE FORMAT:

The first 8 lectures cover the most important theoretical and methods aspects. In general, the first 1.5 hour will be lecture format, followed by computer practicum. Next, an exam will evaluate the comprehension of the methodological topics covered during the first 6 lectures. The subsequent 2 sessions of the course consist of a 2 hour in-depth structured discussion of recent mathematical modeling publications followed by a one hour in-class group work on the final modeling project during which each group will have the opportunity to receive input and guidance. The last class is a 3-hour in-class preparation of the final group work, allowing for my input and guidance.

TEXTBOOK:
Vynnycky E and White R. An introduction to Infectious Disease Modelling. Oxford University Press

READINGS: Assigned articles published in professional journals will be available through PubMed.

ASSIGNMENTS:
For the following 2 assignments, you will be asked to form groups of 3 students.

Group assignment 1: journal article review.

The 4 papers selected for this year are:

1. **Mayer BT, Eisenberg JNS, Henry CJ, Gomes GM, Ionides EL, Koopman JS**. Successes and shortcomings of polio eradication: a transmission modeling analysis. Am J Epidemiol 2013; 177(11):1236-1245
2. **Chao DL, Halstead SB, Halloran EM, Longini IR.** Controlling dengue with vaccines in Thailand. PLOS Neglected Tropical Diseases 2012; 6(10):e1876
3. **Xiridou M, van Houdt R, Hahne S, Coutinho R, van Steenbergen J, Kretzschmar M**. Hepatitis B vaccination of men who have sex with men in the Netherlands: should we vaccinate more men, younger men or high risk men? Sex Transm Infect 2013; 89:666-671
4. **Dimitrov D, Boily MC, Beigi R, Brown ER**. Population-level benefits from providing effective HIV prevention means to pregnant women in high prevalence settings. PLoS ONE 2013; 8(9):e73770

The **purpose** of this assignment is to develop the skills to critically evaluate epidemiological literature in the field of mathematical modeling and present the information in a clear and concise manner.

The **assignment**:

- All students will read all 4 papers.
- Each student will select one of the 4 papers as their main review paper. Make sure to also read the **online supplementary documents** for the paper you select as your main paper. Send selection of your main paper by email to vanrie@email.unc.edu **by 5pm Feb 9**. Choices for papers and roles available will be posted on Sakai and updated as student choices are received.
    - **One student will take the role of author** and will present the paper
    - **Two students will be reviewers** and prepare a written review and submit this the latest at noon on the Friday before the article is scheduled to be discussed in class.
    - **One student will be the "author replying to reviewer's comments"** and prepare a reply to the reviewer 's comments.
    - All students will present during class using a PowerPoint presentation (about 10 min each).
    - The review should focus on the research question, model type and structure, assumptions and parameters, assessment of model predictions with data, sensitivity and uncertainty analysis, model validation, presentation of the results by the authors, public health relevance, and accessibility of the paper from the perspective of a policy maker. Try to focus on the methods and limit the amount of time you spend on the actual results of the study.
- For the 3 secondary articles (= papers you did not choose as your main paper), submit three questions to me by email for the general discussion following the PowerPoint presentation. Send questions by email to vanrie@email.unc.edu by **5 PM on Sunday evening prior to the date the paper will be discussed**.

Group Assignment 2: conceptualize a mathematical modeling study

The **purpose** of this assignment is to develop a research question for which a dynamic mathematical modeling approach is appropriate.

The **assignment**: as a group you will:

- Based on interest and experience, students can send ideas for research questions by email between Jan 14 and March 6. Project topics will be posted on Sakai as soon as I approve them. By 5 PM on March 8, you will need to send by email to the topic you want to join for assignment 2.
- Each group will then work on the selected research question. You will have time in class to work on this assignment during which I will work with each group individually to give guidance. Below are the tasks and dates you are expected to work in class on these tasks. Depending on progress made in class, you may need to supplement this time outside of the classroom.
    - March 17: Refine the research question and outline the significance and public health relevance of the question
    - March 24: Conceptualize the modeling approach to answer this question and construct the model structure for the selected approach
    - March 31: Write the equations that determine the flow corresponding to the model structure, create list of key assumptions
    - April 7: Identify the key parameters and perform a limited literature review to define the parameter values, develop a strategy for parameter and model validation
    - April 14: finalize all sections and prepare presentation
    - NOTE: you are not expected to "run" the model. As such, presentation of results is not expected for this assignment.
- Each group will give a formal power point presentation of their modeling study on April 21

GRADES:
Modeling theory (exam): 50%
Group Assignment 1: 25%
- 10% presentation (author, reviewer, reply to reviewer comments)
- 3 times 5% for your contribution (questions) to the discussion of the other 3 papers

Group Assignment 2: 25%
- 15%: your group project
- 5%: presentation of section of the group project
- 5%: contribution (questions) to the discussion of the other group projects

IMPORTANT DATES:

Exam: March 3

Assignment 1:
- Email choice of main paper and role (author, reviewer, reply to comments): 5 PM Feb 9
- Email 3 questions for secondary papers:
    - 5 PM March 31 for Mayer and Xiridou paper
    - 5 PM April 7 for Chao and Dimitrov paper

Assignment 2:
- Submit potential topics for potential modeling studies by email between Jan 14 and March 6
- Email your final choice of topic by 5 PM on March 8 (just before spring break!)

Course Schedule

Date	Lecture	Computer lab / practicum	Readings
13-Jan	Introduction and basic concepts - Role of models in public health - Infection and transmission - Mathematical modeling methods	NA	Textbook page 1-19
20-Jan	Martin Luther King Day		
27-Jan	Short term disease dynamics: Part I - The classic epidemic model - Difference equations	Epidemic measles model	Textbook page 19-40
3-Feb	Short term disease dynamics: Part II - The classic epidemic model - Complications to classic models - Growth rate and R0 with random mixing	Endemic measles model	Textbook page 41-82
10-Feb	Long term dynamics and use of sero-prevalence data - Properties of classic models - Sustained oscillations - Sero-prevalence data and average age of infection	Analysis of sero-prevalence data	Textbook page 82-101
17-Feb	Modeling vaccine preventable diseases - Herd immunity - Beneficial and perverse effects of vaccination	Measles vaccination model	Textbook page 105-148
24-Feb	Integrating contact patterns in models - Theoretical and empiric contact pattern structures - Age specific transmission - Calculating R0 when mixing is not random	WAIFW matrices	Textbook page 177-222
3-March	Exam		
10-March	Spring break		
17-March	Modeling sexually transmitted diseases - Modeling STIs - Sexual missing patterns - Modeling HIV	In-class time for assignment 2: - Refine the research question - Outline the significance and public health relevance of the question	Textbook page 223-268

Date	Lecture	Computer lab / practicum	Readings
24-March	Stochastic and network models - Types of stochastic models - Types of network models	In-class time for assignment 2: - Conceptualize the modeling approach - Construct the model structure for the selected approach	Textbook page 149-176 and page 268-276
31-March	**Student presentations** Assignment 1 Paper discussion Session I *INSTRUCTIONS* *- The "author" starts, followed by the "reviewer" and then the "reply to reviewer comments". Each student should present for 10-12 min.* *- The presentation will be followed by class discussion guided by the questions that were submitted.*	In-class time for assignment 2: - Write the equations that determine the flow corresponding to the model structure - Create list of key assumptions	1. **Mayer BT et al**. Successes and shortcomings of polio eradication: a transmission modeling analysis. Am J Epidemiol 2013; 177(11):1236-1245 2. **Chao DL et al.** Controlling dengue with vaccines in Thailand. PLOS Neglected Tropical Diseases 2012; 6(10):e1876
7-April	**Student presentations** Assignment 1 Paper discussion Session II *STUDENT PRESENTATIONS* *- The "author" starts, followed by the "reviewer" and then the "reply to reviewer comments". Each student should present for 10-12 min.* *- The presentation will be followed by class discussion guided by the questions that were submitted.*	In-class time for assignment 2: - Identify the key parameters and perform a limited literature review to define the parameter values - Develop a strategy for parameter and model validation	1. **Xiridou M et al**. Hepatitis B vaccination of men who have sex with men in the Netherlands: should we vaccinate more men, younger men or high-risk men? Sex Transm Infect 2013; 89:666-71 2. **Dimitrov D et al.** Population-level benefits from providing effective HIV prevention means to pregnant women in high prevalence settings. PLoS ONE 2013; 8(9):e73770
14-April	NA	In-class time for assignment 2: - Finalize all sections - Prepare presentation	NA
21-April	**Student presentations** Assignment 2 Mathematical modeling project *INSTRUCTIONS* *- Each student will have 10 minutes to present a section of the group project.* *- The presentation will be followed by a discussion where all other students are invited to ask questions.*	NA	NA