SPPH 518: An Introduction to Communicable Disease Mathematical Modeling

Faculty:

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Class times: Wednesdays 1:00-4:00 PM, Room B108 in the LPC Building located at: 2206 East Mall

Course Overview:

This course provides an overview of how the application of mathematical models aids in understanding communicable disease spread and control. This is an introductory level, graduate course for health professionals intended to provide students with knowledge of the basic concepts and methods in communicable disease mathematical modeling, also known as "mathematical epidemiology". The emphasis will be on developing a conceptual understanding of the *basic* methods required to build mathematical models and their applications. The conceptual aspect of each method will be accompanied by small, practical computer projects designed to demonstrate the application of each model and to facilitate discussions. These projects may be completed either individually or within small groups.

SPPH 518 is a three-credit course focused on understanding the key epidemiological parameters addressed in mathematical epidemiology as well as analysis and interpretation of information pertaining to infectious disease spread.

There are no prerequisites for SPPH 518. Familiarity with calculus and/or computer programming would be an asset. Students in other related disciplines may take the course with approval of Dr. Pourbohloul.

Learning Objectives:

SPPH 518 provides the basis for understanding the structure of mathematical models used in communicable disease epidemiology and an introduction to the concepts and methods for formulating and evaluating relevant public health programs.

Upon completion of this course the students will be able to:

- Review the key concepts in infectious disease epidemiology
- Understand the basic methods required to build a deterministic (compartmental) model and interpret the outcomes of simple deterministic models

- Use basic mathematical models to describe disease spread within a population
- Choose the appropriate model to study the transmission dynamics of a specific disease
- Estimate the basic reproduction number from simple models
- Understand the basic methods required to build a stochastic computer simulation model and interpret the outcomes
- Understand the basic methods required to build a contact network model and interpret the outcomes
- Make an informed decision on the validity of model design
- Interpret modeling papers and critically appraise published literature
- Understand the practical applications of modeling in public health policy design

Course Outline:

1) Simple ODE (compartmental) models, the basic reproduction number, and herd immunity;
2) More refined compartmental models;
3) Age-structured models for childhood infections: Design and evaluation of vaccination programs;
4) Transmission dynamics and health economics;
5) Modeling transmission dynamics of sexually-transmitted infections – Case study: Modeling HIV transmission;
6) Sexually-transmitted infections – Case study: Modeling HPV immunization program;
7) Modeling transmission dynamics of blood-borne infections and vector-borne infections;
8) Stochastic dynamics;
9) Spatial dynamics;
10) Limitations of deterministic approaches, heterogeneity in contact networks;
11) Introduction to graph theory;
12) Introduction to contact network epidemiology;
13) Analysis of respiratory contact networks and their application in understanding disease spread – Case study: SARS and influenza dynamics;
14) Special Topic (TBA)

Evaluation:

Class participation: 20%

Students are expected to actively participate in class discussions.

Topical literature review and oral presentation: 40%

Oral presentations will take the last half hour of each session and commence after the first month.

Modeling Project: 40%

Part 1 (interim report): 15%
Part 2 (final report): 25%

Students will be assigned into study groups at the beginning of the term to work on a specific real-life problem. Throughout the term, students will engage in problem-solving activities and the members of each group will be asked to write a report (1 per group) outlining their proposed response to the problem and submit it for evaluation. Each group should submit an ***interim report*** *to ensure that the group's research direction is on the right track (15%). In each report, the group should describe in detail the steps taken in order to fulfill the project's objectives. The* ***final report*** *should be 12 pages double-spaced (excluding graphs/charts) and will be due one week after the last day of class; the final report is worth 25% .*

Suggested Readings:

Keeling M J, Rohani P; Modeling Infectious Diseases in Humans and Animals; Princeton University Press (2008).

Anderson R M, May R M; Infectious Diseases of Humans: Dynamics and Control; Oxford University Press (1992).

Hethcote H W; The Mathematics of Infectious Diseases, *SIAM Review* 42, 599-653 (2000).

Newman M E J; The Structure and Function of Complex Networks; *SIAM Review* 45, 167-256 (2003).

Newman M E J; The spread of epidemic disease on networks; *Phys. Rev. E* 66, 016128 (2002).

Diekmann O, Heesterbeek J A P; Mathematical Epidemiology of Infectious Diseases: Model Building, Analysis and Interpretation; Wiley (2000).

Meyers L A, Pourbohloul B, Newman M E J, Skowronski D M, Brunham R C*;* Network theory and SARS: predicting outbreak diversity; *Journal of Theoretical Biology* 232, 71–81 (2005)*.*

Smith? R; Modeling Disease Ecology with Mathematics; American Institute of Mathematical Sciences (2008).