DEPARTMENT: EH and GH
COURSE NUMBER: EH547/GH506
SECTION NUMBER: Spring 2015
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CREDIT HOURS: 2
COURSE TITLE: Introduction to Microbial Risk Assessment

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BRIEF COURSE DESCRIPTION
Introductory course risk-assessment methods for infectious diseases, with emphasis on description of microbial infectivity, quantification of microbial concentrations in the environment, description of risk, and exposure in outbreaks. Upon completion of this short introductory course, students can be expected to understand the general approach of microbial risk assessment and acquire skills to work with specialists (microbiologists, epidemiologists, biostatisticians) in a multidisciplinary team to tackle microbial risk assessment problems.

LIST SCHOOL LEVEL, DEPARTMENT, AND/ OR PROGRAM COMPETENCIES
RSRH Core competencies
- Use analytic reasoning and quantitative methods to address questions in public health and population-based research
- Describe environmental conditions, including biological, physical and chemical factors, that affect the health of individuals, communities and populations

MPH in Global Environmental Health
- Assess the sources and movement of contaminants through the environment
- Characterize the magnitude, frequency, and duration of environmental exposures

MPH in Global Health (Infectious Disease concentration)
- Conduct research, including formulation of specific research aim, conducting a literature review and formulating a hypothesis and selecting appropriate methodologies related to the emphasis.
- Communicate the key methods, findings and public health implications of the thesis on a poster and verbally to an audience of public health professionals
- Explain the science of infectious disease research including types of organisms, mechanisms of pathogenesis, host response and susceptibility
**LIST LEARNING OBJECTIVES ASSOCIATED WITH THE COMPETENCIES**

Upon completion of this short introductory course students will be expected to understand the general approach of microbial risk assessment and to have acquired skills to work with specialists (microbiologists, epidemiologists, biostatisticians) in a multidisciplinary team to tackle microbial risk assessment problems.

Specifically, students will be able to identify and explain major environmental risks to human health, ranging from the small scale (individual) to the global scale, and assess the magnitude of these hazards and quantify the effects of prevention and control measures.

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**EVALUATION**

The course consists of a series of lectures including plenary discussion, followed by homework exercises for all the relevant topics treated in the course. Question sheets and worked answers will be provided. Exercises cover the main topics with approximately the following emphasis: 30% dose response assessment; 25% microbial detection and reduction; 20% assessment of waterborne microbial risk; and 25% assessment of airborne microbial risk and events in infectious disease transmission.

Afternoon sessions include selected case studies with examples from QRA practice. Cases are assigned to (groups of) students who will have the opportunity to present their findings on the last (Friday) afternoon.

Grading is based on performance with exercises (30%) and case study presentations (70%).

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**ACADEMIC HONOR CODE**

The RSPH requires that all material submitted by a student in fulfilling his or her academic course of study must be the original work of the student.
Synopsis: Introduction to microbial risk assessment

Course objectives

Objective of the course is to introduce the main topics in risk modeling for infectious diseases. In a (brief) introduction into risk (what is it, how can it be quantified) the concepts of microbial infectivity and pathogenicity will be defined and methods for their measurement will be demonstrated. Various aspects of exposure to microbial pathogens will be treated from performance of detection methods to statistical models for quantifying reduction in treatment. Assembling a risk chain from a series of models, characterized by probability distributions, will be demonstrated for a practical example, a case study in waterborne risk. In addition to this general introduction a few special topics will be discussed, including risk from airborne pathogens, and the importance of events in transmission of infectious disease, in particular for outbreaks. Theoretical and practical exercises are available; time will be allotted for discussing the exercises and their solutions.

Upon completion of this short introductory course candidates may be expected to understand the general approach of microbial risk assessment and to have acquired skills to work with specialists (microbiologists, epidemiologists, bio-statisticians) integrating information in a multidisciplinary team.

Brief description of lectures

Introduction (Monday)

Introduction to risk, quantification of risk, conceptual framework, tiered approach
1. Probability and risk, severity of outcomes, loss as a mathematical concept, risk metrics
2. Elements of microbial risk assessment (quantitative microbiology): detection methods, dose response models, translation to population level, applications of microbial risk assessment
3. Statistical issues in mathematical modeling: model choice and identifying mechanisms
4. Stochastic effects in deterministic models (Bedaux and Kooijman, 1994)

Dose response assessment (Monday)

1. Introduction on microbial infectivity
2. Introduction on concepts of microbial dose response models (Haas,1983; Teunis and Havelaar, 2000)
3. Use of outbreak data: opportunities and problems
4. Hierarchical (mixed) models in microbial dose response assessment
5. Infectivity of VTEC: heterogeneity in exposure, predicted distribution of single hit probability (Teunis et al., 2008b)
6. Infectivity of the parasite Trichinella: sexual reproduction and infectivity
7. Application of the results in microbial risk assessment

Statistical methods: quantitative microbiology (Tuesday)

1. a likelihood approach to microbial counts: sampling distributions, probability and likelihood,
2. parameter estimation, accounting for repeated observations, censoring, heterogeneity
3. basics of hypothesis testing, building statistical models
**Statistical methods: estimating a small probability (Tuesday)**

1. estimating extremely small probabilities of adverse effects
2. Poisson approximation, likelihood function
3. Confidence intervals, likelihood ratio tests
4. Heterogeneity, trends

**Microbial detection and fractions of microbial data (Wednesday)**

1. Detection of microbes in environmental samples
2. Introduction: environmental transmission of microbes
3. Issues in microbial detection: overdispersion, imperfect detection, aggregation, skewed distributions
4. Examples: time series of pathogen concentrations, use of Bayesian adaptive filters, characterization of drinking water treatment processes, importance of events in occurrence
5. Analysis of inactivation data: detection of microorganisms and ratio calculations (Teunis et al., 1999)
6. Introduction: a small (hypothetical) experiment to quantify a ratio
7. Models for microbial count data: overdispersion, Poisson-Gamma mixtures, ratio distribution (Teunis et al., 2003, 2009)
8. Statistical models for quantitative PCR data

**Waterborne risk (Thursday)**

1. Quantitative risk assessment of waterborne norovirus
2. Norovirus exposure assessment: source waters, treatment, unheated tap water consumption
3. Norovirus hazard characterization: infectivity and pathogenicity (Teunis et al., 2008a)
4. Norovirus risk characterization: infection and illness risks, numbers of cases
5. Special topic: time series (Teunis et al., 2003)

**Airborne risk (Thursday)**

1. Influenza virus infectivity and pathogenicity: quantitative risk assessment
2. Characterization of influenza virus infectivity and pathogenicity: basic model, hierarchical (mixed) model framework, human challenge studies, aerosol and droplet inoculation (Teunis et al., 2010)
3. Spreading virus through aerosols: aerosol production, droplet size distribution, sedimentation and droplet sizes (Nicas et al., 2005)

**Events in infectious disease transmission: outbreaks (Friday)**

1. Importance of events in (environmental) transmission of infectious disease
2. Introduction: infectious disease transmission and pathogen
3. Outbreaks: transmission matrix, transmission of norovirus, transmission of SARS (Wallinga and Teunis, 2004; Heijne et al., 2009)
4. Environmental transmission: skewed risk, peak concentrations in surface waters, events in
reduction in treatment (Teunis et al., 2003)

5. Intervention and prevention: outbreaks, variability of risk, multiple barrier concept (Teunis et al., 2003)

**Events in infectious disease transmission: drinking water distribution (Friday)**

1. Virus intrusion into drinking water distribution networks
2. Sewage sources for contamination of soil around distribution networks
3. Meta-analysis of virus in sewage
4. Transport of virus in the drinking water distribution network
5. Infection risk for virus in distribution systems
6. Spatial and temporal aspects of virus risk
7. Sensitivity analysis

**References**


Course Evaluation
Exercises will be provided for each of the relevant topics treated in the course. Answers with worked examples will be provided.

Basic knowledge required
- Infectious disease epidemiology: incidence, attack rate, transmission
- Microbiology: detection (recovery), enumeration, microbial suspensions
- (Mathematical) Statistics: probability distributions, likelihood, Monte Carlo simulation, variability and uncertainty