Syllabus Module 229–Major A ISB: "Modeling of infectious diseases"

Module : 229	**Modeling of infectious diseases**
UE coordinator	Elisabeta Vergu, PhD Senior researcher INRA, UR341 Mathématiques et Informatique Appliquées, Jouy-en-Josas Elisabeta.vergu@jouy.inra.fr
Dates	November 28th to December 2nd 2016
Credits/ECTS	3 ECTS
Duration	5 days of 6 hours = 30 hours
UE description	Mathematical models are conceptual tools that describe the functioning of systems of objects. In epidemiology, they contribute to the understanding of fundamental epidemiological processes or are used to predict disease spread at various spatial-temporal scales and its prevention and control. Alone or combined with economic cost-effectiveness studies, mathematical models and associated statistical techniques have become invaluable decision-making tools in public health in general and in planning mitigation strategies against any epidemic of a communicable disease in particular.
Prerequisit	Advanced core in Biostatistics
Course learning objectives	At the end of the module, the students should be able to: • Critically read and analyse research articles featuring modeling-based epidemiological studies; • Provide the general ideas for constructing and analysing simple models of epidemic spread and control; • Interpret models outputs as information that help guide public health decision making.
UE Structure (details of sessions title/speaker/date/duration)	The course will present the simplest models and methods used in infectious diseases modelling either conceptually or practically (through computer-based exercises and critical reading of scientific research articles) and will illustrate this methodology with several developed examples from public health field. Its content may be split into 5 sessions: ▪ Brief overview of the basic concepts and ideas of modelling: (i) presentation of main classes of epidemic models (population vs individual based, deterministic vs stochastic, spatial models), (ii) construction of SIR-like models and calculation of basic reproductive numbers (R0); Day 1: 6 hours : Elisabeta Vergu ▪ Mathematical modeling for the preparedness against unnaturally-born outbreaks: use of modeling, inclusion of parameters representing preventive and control measures, interventions evaluation. Example of the small-pox; Day 2: 6 hours : Elisabeta Vergu ▪ Overview of the parameters of epidemic models and their relevance for public health & Introduction to methods and issues surrounding their estimation; Day 3: 6 hours : Simon Cauchemez; • Analysis of temporal patterns of the spread of an epidemic with dynamic models. Case study on the analysis of drug sales to model an epidemic of scabies. Network modeling, from theory to practice. Lab work on the GleamViz

	epidemic simulator to capture the spatial (i.e. worldwide) spreading of an epidemic; Day 4: 6 hours :Pascal Grépey • Introduction to the use of modeling tools for assessing the economic value of vaccinations programs & Illustration through several applications related to vaccines developed at Sanofi Pasteur ; Day 5: 6 hours : Laurent Coudeville
Course requirement	
Grading and assessment	Submission of an individual report and class participation Individual report: 30% Grade Final written exam: 70% Grade
Location	George Sand EHESP Paris Campus
Readings	See references given per session

Session 1	**Module 229 Major A ISB: "Modeling of infectious diseases"**
Session Title	**What can we learn and can't learn from mathematical models?**
Speakers	Elisabeta Vergu, PhD Senior researcher INRA, UR341 Mathématiques et Informatique Appliquées, Jouy-en-Josas Elisabeta.vergu@jouy.inra.fr
Session Outline	General introduction to mathematical modeling: concepts and main classes of epidemic models (population vs individual based, deterministic vs stochastic, spatial models) Formulate SIR-like models and calculate corresponding basic reproductive numbers (R0)
Learning Objectives	- Understand the role of mathematical modeling for the study of infectious diseases - Describe different types of epidemic models and chose the most appropriate for the question under study - Translate assumptions into equations - Implement basic models into a computer language - Interpret model outputs - Calculate the basic reproduction number (R0) - Uses of R0 - Evaluate control measures using R0 and its variants
Duration	6 hours
Dates	Monday November 28th , 2016
Training methods	Lecture Exercises (paper and computer-based) Article reading and interpretation
Reading	
Validation	Evaluation of the exercises/article reading and final examination at the end of the Module

Session 2	**Module 229 Major A ISB: "Modeling of infectious diseases"**
Session Title	**What can we learn and can't learn from mathematical models?**
Speakers	Elisabeta Vergu, PhD Senior researcher INRA, UR341 Mathématiques et Informatique Appliquées, Jouy-en-Josas Elisabeta.vergu@jouy.inra.fr
Session Outline	Mathematical modelling for the preparedness against unnaturally-born outbreaks: use of modeling, inclusion of parameters representing preventive and control measures, interventions evaluation Example of the small-pox
Learning Objectives	- Understand the role of mathematical modeling for the preparedness against unnaturally-born outbreaks

	- Describe the main disease characteristic to be included in the model - Describe host population characteristic to be considered - Describe type of modeling approaches available - Inclusion of preventive and control measures in epidemic spread models - Assess the uncertainty - Interpret model outputs
Duration	6 hours
Dates	Tuesday November 29th , 2016, 9h-17h
Training methods	Lecture, Article reading and interpretation
Reading	
Validation	Evaluation of the exercises/article reading and final examination at the end of the Module

Session 3	**Module 229 Major A ISB: "Modeling of infectious diseases"**
Session Title	**Introduction to the methods and issues surrounding parameter estimation in epidemic models: general concepts and main objectives**
Speakers	Simon Cauchemez, PhD Head of Mathematical Modelling of Infectious Diseases Unit Institut Pasteur simon.cauchemez@pasteur.fr
Session Outline	Overview of the parameters of epidemic models and their relevance for public health & Introduction to methods and issues surrounding their estimation
Learning Objectives	- Describe the different transmission parameters of epidemic models - Understand relevance of each parameter for public health - Describe data available for estimation - Describe different sources of bias in estimation - Describe different methods for estimation of parameters - Apply methods to estimate the reproduction number from early exponential growth
Duration	6 hours
Dates	Wednesday November 30th , 2016 9h-17h
Training methods	Lecture, Practical
Reading	
Validation	Evaluation of the exercises and final examination at the end of the Module

Session 4	**Module 229 Major A ISB: "Modeling of infectious diseases"**
Session Title	**Analysis of temporal and spatial patterns of the spread of an epidemic**
Speaker	Pascal Crépey, PhD EHESP, Paris pascal.crepey@ehesp.fr
Session outline	Analysis of temporal patterns of the spread of an epidemic with dynamic models. Case study on the analysis of drug sales to model an epidemic of scabies. Network modeling, from theory to practice. Lab work on the GleamViz epidemic simulator to capture the spatial (i.e. worldwide) spreading of an epidemic.
Learning Objectives	- Develop ad-hoc compartmental models (like the susceptible-infectious-recovered (SIR) model) to match epidemiologic surveillance data. - Understand how to use other sources of data than surveillance data in epidemic modeling. - Explain the concept and use of meta-population and network models. - Measure the impact of control strategies for the transmission of infectious diseases by modeling the transmission parameters targeted by these strategies. - Identify the limitations of the presented models, and conditions that may limit their use.
Reading	To be communicated later.
Duration	6 hours
Dates	Thursday December 1st , 2016 14h-17h
Training methods	Lecture Lab exercice on computers
Validation	Evaluation of the exercises and final examination at the end of the module

Session 5	**Module 229 Major A ISB: "Modeling of infectious diseases"**
Session Title	**Modeling tools for assessing the economic value of vaccination programs**
Speaker	Laurent Coudeville, PhD, Modeling director, Sanofi Pasteur, Lyon, France Laurent.coudeville@sanofipasteur.com
Session outline	1. Introduction to the use of modeling tools for assessing the economic value of vaccinations programs 2. Illustration through several applications related to vaccines developed at Sanofi Pasteur

Learning Objectives	- Introduction to the methods of economic evaluation and their utilization in the field of vaccination - Introduction to the modeling tools used for vaccines - Transmission models for assessing the expected impact of vaccination programs - Correlate of protection model for the evaluation of vaccine efficacy and duration of protection from immunogenicity data - Economic models based on the results of transmission models and correlate of protection models - Presentation of examples of correlate of protection models - Prediction of vaccine efficacy of influenza vaccines administered by the intradermal and intramuscular routes - Duration of protection induced by a live-attenuated Japanese encephalitis vaccine - Presentation of examples of transmission models - Potential impact of dengue vaccination in Vietnam - Economic value of adult pertussis vaccination in the US - Evaluation of the understanding of the basic concepts through exercises
Reading	Shepard et al [2011]. Economic Impact of Dengue Illness in the Americas. Am J Trop Med Hyg; 84:200-207. Coudeville et al. [2010] A new approach to estimate vaccine efficacy based on immunogenicity data applied to influenza vaccines administered by the intradermal or intramuscular routes. Hum Vaccin. 2010; 6: 841–848. Coudeville et al. [2009]. Adult Vaccination Strategies for the Control of Pertussis in the United States: An Economic Evaluation Including the Dynamic Population Effects. PLoS One. 2009; 4: e6284. Coudeville et al. [2008] Adult pertussis vaccination strategies and their impact on pertussis in the United States: evaluation of routine and targeted (cocoon) strategies. Epidemiol Infect 136:604-620 Bailleux et al. [2008] Predicted long-term persistence of pertussis antibodies in adolescents after an adolescent and adult formulation combined tetanus, diphtheria, and 5-component acellular pertussis vaccine, based on mathematical modeling and 5-year observed data. Vaccine; 31:3903-3908.
Duration	6 hours
Dates	Friday December 2nd , 2016 9h-17h
Training methods	Lecture Exercises in groups of 2-3 students
Validation	Evaluation of the exercises and final examination at the end of the Module