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

| N° : 229 | Modeling of infectious diseases |
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| **Coordinator** | Elisabeta Vergu, PhD<br>Senior researcher<br>INRAE, UR1404 MaIAGE, Jouy-en-Josas<br>elisabeta.vergu@inrae.fr |
| **Dates** | 2020 December 14-18 |
| **ECTS** | 3 ECTS |
| **Duration** | 5 days of 6 hours = 30 hours |
| **Location** | Room : 409, EHESP 20 Avenue George Sand 93210 LA PLAINE ST DENIS |
| **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. |
| **Prerequisite** | Advanced core in Biostatistics |
| **Course learning objectives** | At the end of the module, the students should be able to:<br>• Critically read and analyze research articles featuring modeling-based epidemiological studies;<br>• Provide the general ideas for constructing and analyzing simple models of epidemic spread and control;<br>• Interpret models outputs as information that help guide public health decision making. |
| **Structure**<br>(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:<br>▪ 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 with various structures. Day 1: 6 hours; Elisabeta Vergu<br>▪ The basic reproduction number: concepts, derivation of its expression, uses. Exercises. Day 2: 6 hours; Elisabeta Vergu<br>▪ 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 (to be confirmed)<br>• Overview of multiple examples to illustrate the relevancy of the network metaphor in the epidemiological modeling of infectious diseases. Network modeling and visualization, from theory to practice. Lab work on R/shiny and on the GleamViz epidemic simulator to capture the spatial (i.e. worldwide) spreading of an epidemic. Day 4: 6 hours; Pascal Crépey<br>▪ Mathematical modeling for the preparedness against unnaturally-born outbreaks: use of modeling, inclusion of parameters representing preventive and control measures, interventions evaluation. Day 5: 6 hours; Elisabeta Vergu |

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| **Resources** | See references given per session |
| **Course requirement** | None |
| **Grading and assessment** | Class participation and group work (exercises, paper reading and presentation made by groups): 30% of the final grade<br>Written exam: 70% of the final grade |
| **Course policy** | **Attendance & punctuality**<br>**Regular and punctual class attendance is a prerequisite for receiving credit in a course.** Students are expected to attend each class. Attendance will be taken at each class.<br>The obligations of attendance and punctuality cover every aspect of the course: - lectures, conferences, group projects, assessments, examinations, as described in EHESP Academic Regulations http://mph.ehesp.fr EHESP Academic Regulation Article. 3).<br>If students are not able to make it to class, they are required to send an email to the instructor and to the MPH program coordinating team explaining their absence prior to the scheduled class date. All supporting documents are provided to the end-of-year panel.<br><br>Students who miss class are responsible for content. Any student who misses a class has the responsibility for obtaining copies of notes, handouts and assignments. If additional assistance is still necessary, an appointment should be scheduled with the instructor. Class time is not to be used to go over material with students who have missed class.<br><br>**Lateness**: Students who are more than 10 minutes late may be denied access to a class. Repeated late arrivals may be counted as absences (See http://mph.ehesp.fr EHESP Academic Regulation Article. 3 Attendance & Punctuality)<br><br>**Maximum absences authorized & penalty otherwise**<br>Above 20% of absences will be designated a fail for a given class. The students will be entitled to be reassessed in any failed component(s). If they undertake a reassessment or they retake a module this means that they cannot normally obtain more than the minimum pass mark (i.e. 10 out of 20)<br><br>**Exceptional circumstances**<br>Absence from any examination or test, or late submission of assignments due to illness, psychological problems, or exceptional personal reasons must be justified; otherwise, students will be penalized, as above mentioned. Students must directly notify their professor or the MPH academic secretariat before the exam or before the assignment deadline. Before accepting the student's justification, the professor or the MPH academic secretariat has the right to request either a certificate from the attending physician or from a psychologist, or from any other relevant person (See http://mph.ehesp.fr EHESP Academic Regulation Article 4 Examinations).<br><br>**Courtesy**: <u>All cell phones/pages MUST be turned off during class time</u>.<br>Students are required to conduct themselves according to professional standards, eating during class time is not permitted during class time, such as course or group work. |
| **Valuing diversity** | Diversity enriches learning. It requires an atmosphere of inclusion and tolerance, which oftentimes challenges our own closely-held ideas, as well as our personal comfort zones. The results, however, create a sense of community and promote excellence in the learning environment. This class will follow principles of inclusion, respect, tolerance, and acceptance that support the values of diversity. Diversity includes consideration of: (1) life experiences, including type, variety, uniqueness, duration, personal values, political viewpoints, and intensity; and (2) factors related to "diversity of presence," including, among others, age, economic circumstances, ethnic identification, family educational attainment, disability, gender, geographic origin, maturity, race, religion, sexual orientation and social position. |

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| **Course evaluation** | EHESP requests that you complete a course evaluation at the end of the school year. Your responses will be anonymous, with feedback provided in the aggregate. Open-ended comments will be shared with instructors, but not identified with individual students. Your participation in course evaluation is an expectation, since providing constructive feedback is a professional obligation. Feedback is critical, moreover, to improving the quality of our courses, as well as for instructor assessment. |

| Session 1 | **Module 229 Major A ISB: "Modeling of infectious diseases"** |
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| Session Title | **Introduction to models of epidemic spread** |
| Speakers | Elisabeta Vergu, PhD<br>Senior researcher<br>INRAE, UR1404 MaIAGE, Jouy-en-Josas<br>elisabeta.vergu@inrae.fr |
| Session Outline | General introduction to mathematical modeling: concepts and main classes of epidemic models (population vs individual based, deterministic vs stochastic, spatial models)<br>Formulate SIR-like models with various structures. |
| Learning Objectives | - Understand the role of mathematical modeling for the study of infectious diseases<br>- Step-by-step model elaboration.<br>- Translate assumptions into equations<br>- Implement basic models into a computer language<br>- Interpret model outputs<br>- Describe different structures of epidemic models (with respect to heterogeneities in contacts, infectivity etc) and chose the most appropriate for the question under study |
| Duration | 6 hours |
| Dates | Monday December 14, 2020, 9:30-4:00 |
| Training methods | Lecture<br>Exercises (paper and computer-based)<br>Article reading and interpretation |
| Reading | |
| Validation | Evaluation of the exercises/article reading and final examination on 2021 January 28/29 |

| Session 2 | **Module 229 Major A ISB: "Modeling of infectious diseases"** |
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| Session Title | **The reproduction number (R0) and variants and their uses** |
| Speakers | Elisabeta Vergu, PhD<br>Senior researcher<br>INRAE, UR1404 MaIAGE, Jouy-en-Josas<br>elisabeta.vergu@inrae.fr |
| Session Outline | Definition of the concept of basic reproduction numbers (R0), derivation and uses |
| Learning Objectives | - Define one of the most important concepts in epidemiology of infectious diseases, the basic reproduction number (R0)<br>- Derive its expression using several methods on a simple SIR model<br>- Derive its expression specifically for different model structures. |

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| | - Various uses of R0<br>- Focus on the evaluation of control measures using R0 and its variants |
| Duration | 6 hours |
| Dates | Tuesday December 15 2020, 9:30 – 4:00pm |
| Training methods | Lecture<br>Exercises (paper and computer-based)<br>Article reading and interpretation |
| Reading | |
| Validation | Evaluation of the exercises/article reading and final examination on 2021 January 28/29 |

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| 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<br>Senior Researcher,<br>Head of Mathematical Modelling of Infectious Diseases Unit, Institut Pasteur, Paris<br>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<br>- Understand relevance of each parameter for public health<br>- Describe data available for estimation<br>- Describe different sources of bias in estimation<br>- Describe different methods for estimation of parameters<br>- Apply methods to estimate the reproduction number from early exponential growth |
| Duration | 6 hours |
| Dates | Wednesday December 16 2020, 9:30 to 4:00 pm |
| Training methods | Lecture,<br>Practical |
| Reading | |
| Validation | Evaluation of the exercises/article reading and final examination on 2021 January 28/29 |

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| 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<br>Professor<br>EHESP, Rennes<br>pascal.crepey@ehesp.fr |

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| Session outline | The review of multiple examples will illustrate the relevancy of the network metaphor in the epidemiological modeling of infectious diseases. Network modeling and visualization, from theory to practice. Lab work on R/shiny and on the GleamViz epidemic simulator to capture the spatial (i.e. worldwide) spreading of an epidemic. |
| Learning Objectives | - Use R and shiny to visualize and explore epidemiologically relevant networks.<br>- Master the concept and use of meta-population and network models.<br>- Develop ad-hoc compartmental models (like the susceptible-infectious-recovered (SIR) model) to match epidemiologic surveillance data (with Gleamviz).<br>- Measure the impact of control strategies for the transmission of infectious diseases by modeling the transmission parameters targeted by these strategies.<br>- Identify the limitations of the presented models, and conditions that may limit their use. |
| Reading | |
| Duration | 6 hours |
| Dates | Thursday December 17, 2020, 9:30 to 4:00pm |
| Training methods | Lecture<br>Lab exercise on computers |
| Validation | Evaluation of the exercises/article reading and final examination on 2021 January 28/29 |

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| Session 5 | **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<br>Senior researcher<br>INRAE, UR1404 MaIAGE, Jouy-en-Josas<br>elisabeta.vergu@inrae.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<br>Example of the small-pox |
| Learning Objectives | - Understand the role of mathematical modeling for the preparedness against unnaturally-born outbreaks<br>- Describe the main disease characteristic to be included in the model<br>- Describe host population characteristic to be considered<br>- Describe type of modeling approaches available<br>- Inclusion of preventive and control measures in epidemic spread models<br>- Assess the uncertainty<br>- Interpret model outputs |
| Duration | 6 hours |
| Dates | Friday December 18 2020, 9:30-4:00pm |
| Training methods | Lecture,<br>Article reading and interpretation |
| Reading | |

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| Validation | Evaluation of the exercises/article reading and final examination on 2021 January 28/29 |