basque center for applied mathematics

Courses 2022-23

MATHEMATICAL MODELS IN EPIDEMIOLOGY (MME)

MTB Group

March 17th – May 5th, 2023
Friday (6 sessions)
April 7 and April 14, 2023 – Easter Break
11:45-17:15 (a total of 24 hours)

Epidemiological models are important tools to understand the dynamics of infectious diseases, contributing to public health authorities' capacity to implement the available intervention measures to control disease transmission. As the COVID-19 pandemic progressed, research on mathematical modeling became imperative and very influential, to understand the epidemiological dynamics of disease spreading and control under different scenarios. This course provides an introduction to mathematical epidemiology, from mathematical concepts and applications up to discussion of real world case studies, including the COVID-19 pandemic.

PROGRAMME

1. Mathematical concepts and applications

Intro deterministic and stochastic epidemiological models
Stability analysis, complex eigenvalues, bifurcation diagrams, state space plots
Basic concepts on epidemiology: reproduction number, growth rates, relative risk and vaccine efficacy
Data on epidemiology
Model validation with empirical data
Model projections
Infectious disease epidemiology
Multi-strain models
Chaotic dynamics
Lyapunov exponents, predictability
Model validation and data analysis
Control measures (vaccination and other)
Epidemic processes in complex networks

2. Case studies
    a. Epidemiological concepts
    b. Dengue fever: multi-strain, within-host, vaccine

c. COVID-19 pandemic: data analysis, epidemiological measures, projections, prediction
d. Other public health threads

<table>
<tr><td colspan="2">March 17</td><td colspan="2">March 24</td><td colspan="2">March 31</td></tr>
<tr><td>Introduction to MME</td><td rowspan="2">The SIR epidemic model</td><td>The SHAR epidemic model</td><td>Case study: Modeling COVID-19</td><td rowspan="2">Stochastic systems</td><td>Dengue, HIV, etc</td></tr>
<tr><td>The SIS epidemic Model</td><td>Concepts in Epidemiology: R0 and growth rates</td><td>SIR with seasonality and introduction to stochastic processes</td><td>Mathematical models applied to infectious disease dynamics: case studies</td></tr>
<tr><td colspan="2">April 21</td><td colspan="2">April 28</td><td colspan="2">May 5</td></tr>
<tr><td rowspan="2">Network theory</td><td>Bifurcation analysis</td><td>Parameter estimation</td><td>Optimal control (vectorborne diseases)</td><td rowspan="2">Multi-strain dengue models</td><td rowspan="2">COVID-19 models</td></tr>
<tr><td>Modeling chagas disease</td><td>Model selection</td><td>Optimal control (HIV)</td></tr>
</table>

PREREQUISITES:
Basic knowledge of ordinary differential equations, linear algebra, and probabilities/statistics

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[1] Maíra Aguiar, Nico Stollenwerk and Bob W. Kooi (April 20th 2012). Modeling Infectious Diseases Dynamics: Dengue Fever, a Case Study, Epidemiology Insights, Maria de Lourdes Ribeiro de Souza da Cunha, IntechOpen, DOI: 10.5772/31920. Available from: https://www.intechopen.com/chapters/35765
[2] Stollenwerk, N., Jansen, V.: Population Biology and Criticality: From Critical Birth–Death Processes to Self-Organized Criticality in Mutation Pathogen Systems. World Scientific, London (2011)
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[4] Aguiar, M., Ballesteros, S., Kooi, B.W., Stollenwerk, N. The role of seasonality and import in a minimalistic multi-strain dengue model capturing differences between primary and secondary infections: complex dynamics and its implications for data analysis. Journal of Theoretical Biology, 289, 181-196 (2011).
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[11] Aguiar, M., Millán Ortuondo, E., Bidaurrazaga Van-Dierdonck, J., Mar, J., Stollenwek, N.: Modelling COVID 19 in the Basque Country from introduction to control measure response. Sci. Rep. 10, 17306 (2020)
[12] Aguiar, M., Bidaurrazaga Van-Dierdonck, J., Stollenwerk, N.: Reproduction ratio and growth rates: measures for an unfolding pandemic. PLoS ONE 15, e0236620 (2020)
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[14] Pastor Satorras, R., Castellano, C., Van Mieghem, P., Vespignani, A. Epidemic processes in complex networks. Reviews of Modern Physics 87, 925 (2015).
[15] Maíra Aguiar, Joseba Bidaurrazaga Van-Dierdonck, Javier Mar, Nico Stollenwerk (2021). The role of mild and asymptomatic infections on COVID-19 vaccines performance: a modeling study. Journal of Advanced Research (In Press). https://doi.org/10.1016/j.jare.2021.10.012
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***Registration is free, but inscription is required before March 10th, 2023:** So as to inscribe go to https://forms.gle/cpA3B7zcGnFBB7FX6 and fill the registration form.