Networks and Heterogeneous Media
Vol. 17, No. 3, June 2022, pp. i–ii
doi:10.3934/nhm.2022020

ADVANCED MATHEMATICAL METHODOLOGIES TO CONTRAST COVID-19 PANDEMIC

Background. The COVID-19 pandemic impacted the whole world including scientific communities. Notably, mathematical models became standard tools to predict, manage and control the pandemic. However, the same models were also deeply criticized because of their limited capability in making precise predictions. There are various reasons behind this drawbacks, including: the novelty of a fast spreading pandemic in a connected world, the role played by the human factor, the abundance of data with low level of fidelity, and the appearance of virus variants with different clinical impacts.

The community of modelers discussed the various reasons for drawbacks but also concentrated the efforts to generate new approaches to tackle with the unprecedented situation of the COVID-19 pandemic, and also help with future pandemics. This special issue collects a number of interesting approaches, which provide an interesting and broad perspective on such activities.

Papers. The paper by Bellomo, Burini and Outada focused on a multiscale model showing waves of infection increases related to non-pharmaceutical interventions which vary in time. Also the authors include dynamic related to virus variants and indicate how the model can support decision making.

The paper by X. Li, Wang, H. Li and Bertozzi derive a martingale formulations for a stochastic SIR model, consisting of a classical deterministic SIR mode and a stochastic ones. The authors provide a theoretical explanation of finite size effects and illustrate their results with data from COVID-19 pandemic.

The paper by Cantin, Silva and Banos studies hybrid models obtained by coupling ODE models with agent-based ones. The authors provide sufficient conditions for pseudoperiodic solutions and provide an interpretation as pandemic waves, as observed during the COVID-19 pandemic. Moreover, it is shown how the microscopic scale dynamics (agent-based) influence the macroscopic ones (ODE).

The paper Kunwar, Markovichenko, Chyba, Mileyko, Koniges and Lee consider the problem of model choice depending on the phase of the pandemic, by considering two model types: equation-based models (such as standard compartmental epidemiological models) and agent-based models. The models are tested on data from the Hawaiian island of Oahu under different scenarios. They show that model choice should be guided by available computational and human resources.

The paper by Colombo, Marcellini and Rossi moves the needle in compartmental models, including sub-compartments capturing the role of immunization times and use of different vaccines. The model characteristics are described via special case studies, where the intra-compartment dynamics influence the whole evolution of the pandemics.

The paper by Bertaglia, Liu, Pareschi and Zhu introduces a bi–fidelity approach to quantify uncertainty in spatially dependent epidemic models. The authors' proposal consists in evaluating a high–fidelity model on a small number of samples, properly selected from a large number of evaluations of a low–fidelity model. This approach is then supported and exemplified through numerical experiments.

The paper by Gong and Piccoli tackle the modeling the effects of virus mutations on virus spreading and effects. Technically, they adopt the framework of measure differential inclusions, where (possibly generalized) Wasserstein distance is the key tool in all well posedness and stability estimates. The proposed model then consists of a measure differential equation coupled with a SIR type ordinary differential equation.

The paper by Luo et al. aims to design optimal strategies for a vaccination campaign during a COVID-19 pandemic situation in order to minimize the mortality among the population. Hence the authors consider an optimal control problem for an extended age structured SEIRV model and they apply this framework to real-data taken from the US Census for New Jersey and Florida.

The paper by Della Marca, Loy and Tosin focuses on the interplay between the dynamics of an epidemic and the evolution of individuals's viral load. Starting from a microscopic stochastic model for infection transmission based on the individual physiological course of the disease, the authors propose a macroscopic compartment model able to predict the evolution of the viral load momentum.

Guest Editors:
Monique Chyba
Department of Mathematics
University of Hawaii at Manoa, USA
mchyba@math.hawaii.edu,chyba@hawaii.edu

Rinaldo M. Colombo
Department of Information Engineering
University of Brescia, Italy
rinaldo.colombo@unibs.it

Mauro Garavello
Department of Mathematics and its Applications
University of Milano-Bicocca, Italy
mauro.garavello@unimib.it

Benedetto Piccoli
Department of Mathematical Sciences and
Center for Computational and Integrative Biology
Rutgers University, USA
piccoli@camden.rutgers.edu