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Preface

Special issue: modeling, analysis, and control of epidemics in networks

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The role of network-oriented approaches in understanding and controlling the spread of disease in human social networks is widely accepted. Although there is a rich literature on the modeling, analysis, and control of epidemic spread processes in complex networks, the recent COVID-19 pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has highlighted the need for increased research efforts to adequately prepare us for the future spread of unknown diseases. For example, due to the lack of reliable networked models, government interventions for the current pandemic are often designed without a detailed understanding of how effective the interventions will be. To bridge this gap between theory and practice, further interdisciplinary research efforts are needed to deepen our theoretical understanding of modeling, analysis, and control of networked epidemic processes.

This special issue contributes to the field by collecting new results in the modeling, analysis, and control of epidemics in networks. In the context of modeling, the paper by Yin et al. proposes a proactive-reactive susceptible-discussing-immune (PR-SFI) model to describe the patterns of co-propagation in social networks. The model parameters are fitted with real data of COVID-19 related topics in Chinese Sina-Microblog, and calibrated and validated using the prediction accuracy of accumulated forwarding users. Sensitivity analysis and numerical experiments provide insights into optimal strategies for public health emergency information dissemination. The work of Zúñiga Macías et al. focuses on proposing a methodology to divide a territory into time-varying epidemic regions according to geographical proximity and infection level. A novel Lagrangian-SEIR-based model is proposed to describe the dynamics within and between these regions. The infections from July 31, 2020 to March 31, 2021 are analyzed, with monthly adjustments, and the estimates obtained at the level of epidemic regions show satisfactory results. In the paper by Zhai and Xu, the classical infectious disease warehouse model was extended by three transmission pathways based on the characteristics of meme transmission. Individual heterogeneity factors such as individual interest, risk perception, and trust perception were used to construct a meme transmission model called Individual Heterogeneity SEIR (IHSEIR). The equilibrium of the model and the basic reproduction number were obtained using mean field theory.

In the direction of analysis, Zheng et al. investigated the main effect of directed network and delay on the dynamic behavior of the epidemic. The algebraic expressions of Turing instability and Hopf bifurcation are used to illustrate the dynamic mechanism of the periodic outbreak. The discrepancy ratio between the imported and exported is proposed to explain the importance of the quarantine policy and the spread mechanism. The work of Li et al. introduces a high-dimensional SIR model to analyze the competition among different strains in patchy environments. They found global stability conditions of the disease-free equilibrium and persistence conditions of the model, as well as competitive exclusion conditions. This work provides insight into the properties of the multi-strain patchy model and can be applied to other related high-dimensional systems. Dhar et al. studied the recent trends of COVID-19 infection spread to explore the advantages of leaky vaccination dynamics in the SEVR (Susceptible Effected Vaccinated Recovered) compartmental model. They used Caputo-Fabrizio (CF) and Atangana-Baleanu derivative in the Caputo sense (ABC) non-singular kernel fractional derivative operators with memory effect within the model to show possible long-term approaches of infection along with limited defensive vaccine efficacy. They also investigated the effect of mortality rate on the state variables. Xing and Li's paper is devoted to a non-autonomous SVIR epidemic model with relapse. The permanence of the system is proved, and the result on the existence and uniqueness of globally attractive almost periodic solution of this system is obtained by constructing a suitable Lyapunov function. Examples and numerical simulations are given to demonstrate the feasibility of the main results.

Finally, in the direction of controlling epidemics, Liao et al.'s paper has formulated a mathematical model for the transmission dynamics of citrus Huanglongbing. Optimal control theory is applied to investigate the optimal strategy for controlling the spread of the disease using three time-dependent control variables obtained from sensitivity analysis. The results show that stability changes occur through Hopf bifurcation in the delayed system. Bae and Lee study the control methods of epidemic models on dynamic networks with temporary link deactivation. They suggest that a control scheme that has been shown to be ineffective in controlling dynamic network models may provide effective responses for networks with certain types of link dynamics. They observe that faster and more effective eradication could be achieved by frequently updating control schemes. Seck et al. formulate an epidemiological model to study the spread of Ebola virus disease in a considered area. They determine an optimal control strategy that aims to reduce the number of infected individuals according to some operational constraints. Xie et al. proposed a SEIR model to study the impact of limited medical resources and population heterogeneity on disease transmission. They found that a backward bifurcation occurs under certain conditions, but if the direction is positive, there may be multiple equilibrium points near $R_0 = 1$. The influence of population heterogeneity on virus transmission is analyzed, and optimal control theory is used to further study the time-varying control of the disease.

As the above list shows, there is a wide variety of results being developed for the modeling, analysis, and control of networked epidemics. Our goal in this issue is to promote an exchange of ideas between these different research directions, which we hope will enrich them all.

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