Preface

Mathematical modelers are joining with biological, epidemiological, behavioral, and social science studies to produce better projections and better understanding of the transmission dynamics of infectious diseases. They are working with public health workers to create new tools for devising effective strategies to minimize the emergence, impact, and spread of epidemics. For these tools to be useful and used, the decision-makers must fully understand the assumptions, such as any behavior changes of the population during an epidemic, used in defining the model and how sensitive the model predictions, such as the number of people infected, depend upon these assumptions. That is, a clear description of the model formulation and sensitivity analysis of the predictions are both necessary to quantify the uncertainty in the model forecasts.

This collection of articles by epidemic modeling experts describe how these models are created to capture the most important aspects of an emerging epidemic. It provides examples of how these models can help public health workers better understand the spread of infections and reduce the uncertainty of the estimates of disease prevalence. That is, the analysis and model simulations can quantify the relative importance of the complex mechanisms driving the spread of an infection and anticipate the future course of an epidemic. In addition to models focusing on forecasting and controlling infections, the volume contains a discussion on the modern statistical modeling methods to design, conduct, and analyze clinical trials measuring the effectiveness of potential vaccines.

The focus of the volume is on models based on the underlying transmission mechanisms of an infectious agent, rather than statistical forecasting of past trends to predict future incidence. These mechanistic models can help anticipate the emergence and evaluate the potential effectiveness of different approaches for bringing an epidemic under control. Recently, the models have been used to help understand and predict the spread of emerging and re-emerging infectious diseases including Zika, Middle East Respiratory Syndrome, chikungunya, and Ebola. They have been helpful to better understand the impact of increased resistance of well-established diseases such as gonorrhea, tuberculosis, and bronchitis to the antibiotics that once held them in check. The models are being developed to help guide public health workers in controlling infections that have proven difficult to immunize against and to treat once they occur, including influenza, HIV/AIDS, and the common cold. The transmission models are being coupled with cost–benefit analysis to facilitate estimating the relative impact of possible interventions and forecast the requirements that an epidemic will place on the health care system.

In the first chapter, Richard Rothenberg discusses the role of epidemic models to confront public health emergencies including the HIV/AIDS epidemic in the US and the recent 2014 Ebola epidemic in West Africa. This is followed by chapters on how modeling the transmission and control of the Ebola virus disease can capture the behavior changes in the population, the effect of movement restrictions on Ebola control, the impact of early diagnosis and isolation, the performance of ring vaccination strategies, and the use of optimal control theory to guide the number of sickbeds during epidemics.

The volume contains articles on how structured models can be used to address public health policy questions relevant for infectious diseases ranging from waterborne diseases, such as cholera to sexually transmitted infections, such as chlamydia. The articles include an analysis of the role of mass immunization campaigns in controlling measles in Sao Paulo, Brazil in the 1990s in the presence of behavior-dependent vaccination. Other contributions include an evaluation of the impact of including or excluding disease-induced mortality rates on disease dynamics using detailed agent-based model simulations of pandemic influenza and a quantitative framework for modeling household transmission using compartmental models of infectious disease.

We hope the contributions in this volume will incite further research in the field of mathematical epidemiology.

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