PREFACE

Information systems are central to the development of effective comprehensive approaches aimed at the prevention, detection, mitigation, and management of human and animal infectious disease outbreaks. Infectious disease informatics (IDI) is a subfield of biomedical informatics concerned with the development of methodologies and technologies needed for collecting, sharing, reporting, analyzing, and visualizing infectious disease data and for providing data-driven decision-making support for infectious disease prevention, detection, mitigation, and management. The growth and vitality of IDI are central to our national security. Biosurveillance is an important partner of IDI applications and focuses primarily on the early detection of new outbreaks of infectious diseases and on the early identification of elevated or new diseases' risks.

IDI and biosurveillance research directly benefits public health and animal health agencies in their multiple activities in fighting and managing infectious diseases. IDI and biosurveillance research provides quantitative methods and computational tools that are instrumental in the decision-making process carried out by government agencies with responsibilities in infectious diseases within national and international contexts. IDI also has important applications in law enforcement and national security concerning, among other issues, the prevention of and timely response to the deliberate release of biological agents. As a result of the increasing threats to our national security, a large amount of animal and public health infectious disease data are being collected by various laboratories, health care providers, and government agencies at local, state, national, and international levels. In fact, many agencies charged with collecting these data have developed information access, analysis, and reporting systems of varying degrees of sophistication. Researchers from a wide range of backgrounds including but not limited to epidemiology, statistics, applied mathematics, computer science and machine learning/data mining, have contributed to the development of technologies that facilitate real-time data collection and access. They have also developed algorithms needed to analyze or mine the collected data.

This book on IDI and biosurveillance compiles a high-quality collection of academic work in various sub-areas of IDI and biosurveillance to provide an integrated and timely view of the current state-of-the-art. It also identifies technical and policy challenges and opportunities with the goal of promoting cross-disciplinary research that takes advantage of novel methodology and lessons learned from innovative applications. This book fills a systemic gap in the literature by emphasizing informatics-driven perspectives (e.g.,

information system design, data standards, computational aspects of biosurveillance algorithms, and system evaluation) rather than just statistical modeling and analytical work. Finally, this book attempts to reach policy makers and practitioners through the clear and effective communication of recent research findings in the context of case studies in IDI and biosurveillance, providing "hands-on" in-depth opportunities to practitioners to increase their understanding of value, applicability, and limitations of technical solutions.

SCOPE AND ORGANIZATION

This volume collects the state-of-the-art research and modern perspectives of distinguished individuals and research groups on cutting-edge IDI technical and policy research and its application in biosurveillance. The contributed chapters are grouped into three units.

Unit I provides an overview of recent biosurveillance research while highlighting the relevant legal and policy structures in the context of ongoing IDI and biosurveillance activities. It also identifies IDI data sources and addresses information collection, sharing, and dissemination issues, as well as ethical considerations.

Unit II consists of chapters that survey various types of surveillance methods used to analyze IDI data in the context of public health and bioterrorism. Specific computational techniques covered include: text mining, time series analysis, multiple data streams methods, ensembles of surveillance methods, spatial analysis and visualization, social network analysis, and agent-based simulation.

Unit III examines IT and decision support for public health event-response and bio-defense. Included are discussions of practical lessons learned in developing public health and biosurveillance systems, technology adoption, and syndromic surveillance for large events.

These three units include the following chapters:

Unit I: Informatics Infrastructure and Surveillance Data Sources

- Real-time Public Health Biosurveillance: The chapter surveys recent public health biosurveillance efforts, highlights related legal and policy considerations, and shares insights on various constraints biosurveillance system designers need to consider.
- Designing Ethical Practice in Biosurveillance: The chapter draws upon experience and lessons learned through Project Argus and presents ethical and legal dimensions of biosurveillance systems design and operations.

- Using Emergency Department Data for Biosurveillance: The chapter presents benefits and challenges of using Emergency Department data for IDI and biosurveillance. Detailed examples from a well-known biosurveillance system, NC DETECT, are presented.
- Clinical Laboratory Data for Biosurveillance: The chapter provides an overview of the types of data used for IDI and biosurveillance, and discusses in detail clinical laboratory data as a data source for biosurveillance and related data sharing and analysis issues.
- Biosurveillance based on Test Orders from Veterinary Diagnostic Labs: The chapter discusses the use of tests orders made to veterinary diagnostic laboratories as a biosurveillance data source. It also shares insights concerning outbreak detection and biosurveillance involving zoonotic pathogens.

Unit II: Surveillance Analytics

- Markov Switching Models for Outbreak Detection: The chapter presents an outbreak detection model using syndrome count-based time series. This model is rooted in Markov Switching models and possesses many desirable computational properties.
- Detection of Events in Multiple Streams of Surveillance Data: The chapter reviews analytic approaches that can be used to simultaneously monitor multiple data streams. Both multivariate methods and more recent methods that do not assume joint models of multiple data streams are presented.
- Algorithm Combination for Improved Performance in Biosurveillance: The chapter introduces a new outbreak detection scheme that is based on ensembles of existing algorithms. The IDI application of this scheme is demonstrated through monitoring daily counts of pre-diagnostic data.
- Modeling in Space and Time: The chapter presents an open-source IDI and biosurveillance software system, the Spatial-temporal Epidemiological Modeler (STEM), as a collaborative platform to define and visualize simulations of infectious disease spreading.
- Surveillance of Infectious Diseases Using Spatial and Temporal Clustering Methods: This chapter surveys common temporal, spatial, and spatio-temporal clustering methods and discusses how such methods can be used for outbreak detection, disease mapping, predictive modeling.
- Age-adjustment in National Biosurveillance Systems: The chapter presents population surveillance as a subarea of biosurveillance, with a particular emphasis on age and age-adjustment. Both data sources available for population surveillance and related analytical tools are discussed.

- Modeling in Immunization and Biosurveillance Research: The chapter presents mathematical modeling techniques suitable for applications concerning vaccine-preventable diseases. Issues concerning vaccination modeling and the interface between biosurveillance and public health response to vaccine-preventable diseases are also discussed.
- Natural Language Processing for Biosurveillance: The chapter presents various types of national language processing techniques that have been applied to outbreak detection and characterization. Four common classes of textual data associated with healthcare visits are presented along with the applicable data processing techniques.
- Knowledge Mapping for Bioterrorism-related Literature: The chapter introduces major knowledge mapping techniques, focusing on text mining and citation network analysis methods. A case study on bioterrorism-related literature is presented.
- Social Network Analysis for Contact Tracing: The chapter illustrates how social network analysis techniques can contribute to epidemiological investigations and public health policy evaluation. A case study using the 2003 Taiwan SARS outbreak is presented.

Unit III: Decision Support and Case Studies

- Multi-Agent Modeling of Biological and Chemical Threats: The chapter presents a city-level dynamic-network model based on multi-agent systems technology, BioWar, as a computational tool to assess public health and biosecurity policies. A case study on using BioWar to assess the impact of school closures and quarantine when facing pandemic influenza is presented.
- Integrated Health Alerting and Notification: The chapter discusses a detailed case study concerning design and operation of a state-wide integrated health alerting and notification system.
- Design and Performance of a Public Health Preparedness Informatics Framework: The chapter discusses a model informatics framework aimed at supporting public health emergency preparedness and presents an evaluative study assessing this framework during a full-scale exercise simulating an influenza outbreak.
- System Evaluation and User Technology Adoption: The chapter highlights the importance of conducting system evaluation and user studies with the objective of promoting advanced IDI systems in field adoption. Two empirical studies are presented along with detailed discussions on evaluation and adoption research design, and measurement instruments.
- Syndromic Surveillance for the G8 Hokkaido Toyako Summit Meeting: The chapter reports a detailed international case study on conducting syndromic surveillance for a major event.

AUDIENCE

The goal of this book is to provide an accessible interdisciplinary IDI and biosurveillance volume that serves as a reference or as a stand-alone textbook or as a supplemental text. Upper-level undergraduates and graduate-level students from a variety of disciplines including but not limited to public health, veterinary medicine, biostatistics, information systems, computer science, and public administration and policy, will benefit from learning the concepts, techniques, and practices of IDI and biosurveillance.

Researchers, including both IDI researchers and public health/IT/public policy researchers who have an interest in IDI, will find in this book a comprehensive source of reviews of the recent advances in the field. This book is intended to help further define the field as a reference book and promote community development across disciplines and between academia and the practitioners, given the dynamic nature of current IDI and biosurveillance research.

This book provides an up-to-date review of current IDI and biosurveillance research and practice, critical evaluation of current approaches, and discussion of real-world case studies and lessons learned. The information and perspective presented should prove their utility to epidemiologists in public health and veterinary health departments and private-sector practitioners in healthcare and health IT.

We would like to acknowledge support from the following U.S. National Science Foundation grants: NSF Information Technology Research Grant IIS-0428241, "ITR-(NHS)-(DMC): A National Center of Excellence for Infectious Disease Informatics;" NSF Grant IIS-0839990, "Transnational Public Health Informatics Research: US-China Collaboration;" and NSF IIS Grant IIS-0748308, "US/China Digital Government Collaboration: US-China Infectious Disease Informatics and BioSurveillance Workshop." We also acknowledge funding support from the U.S. Department of Homeland Security through Grant 2008-ST-061-BS0002 ("DHS Center of Excellence in Border Security and Immigration") and from the National Center for Medical Intelligence.

Our work has been supported by a number of research grants in China as well: the National Natural Science Foundation of China through grants 90924302 and 60621001; the Chinese Academy of Sciences through grants 2F07C01 and 2F08N03; the Ministry of Science and Technology through grants 2006CB705500 and 2006AA010106; and the Ministry of Health through grants 2009ZX10004-315 and 2008ZX10005-013.

http://www.springer.com/978-1-4419-6891-3

Infectious Disease Informatics and Biosurveillance

Zeng, D.; Chen, H.; Castillo-Chavez, C.; Lober, W.B.; Thurmond, M. (Eds.)

2011, LI, 488 p., Hardcover
ISBN: 978-1-4419-6891-3