

## Mapping Disease Transmission Risk: Enriching Models Using Biogeography and Ecology

A. Townsend Peterson

Johns Hopkins University Press,  
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**G**lobal human population density is increasing, as are our abilities to assemble large ecologic datasets and perform surveillance for and respond to diseases as they emerge. Consequently, multidimensional ecologic data may help us improve public health locally and globally. This engaging book empowers disease modelers and public health policy makers by introducing them to ecologic niche models as predictors of disease transmission risk.

Part I describes distributional ecology, contrasting the ecologic approach that takes into account multiple layers of distributional data with an approach that only plots disease cases or absences. Part II elaborates on the kinds of data necessary to develop ecologic models rather than arbitrarily complex "black box" models. Part III critiques poor study design and data assembly and demonstrates how not to construct a dataset. Part IV summarizes approaches to calibrating, processing, and evaluating models and the production of risk maps, warning readers about the complex factors that are associated with human society.

Peterson presents examples where models calibrated for one dataset are used to transfer rules to another dataset to assess risk. By contrasting these models with models that incorporate only disease cases, Peterson shows how to define the niche of vectors of disease where occurrence data are rich, then evaluate the potential presence of the niche in novel locales or across changing environments, yielding the risk of emergence.

In this book, Peterson has put together an easy read that demonstrates his expertise and persuasively frames disease transmission risk in terms of niche models. A reader already convinced that understanding the geography of ecologic interactions is essential to public health disease modeling may want to pick up a more technical book that addresses ecologic niche modeling in detail. For readers interested in mechanistic models, *Mapping Disease Transmission Risk* is not the right book. Peterson could have handled some of the issues about the relative value and weighting of presence and absence data by using appropriate likelihood models of the observation process itself. Bayesian analyses could obviate many of the issues of uncertainty associated with low counts and zero-observation cells. However, for readers who would like to move into the geographic mapping of disease emergence and aren't sure where to start, this book provides many dos and don'ts and references that could jump-start a project.

Peterson concludes by noting the historical link between public health and geographic mapping. As we begin to view and quantify every foot of the Earth we depend on, it becomes increasingly possible and necessary to incorporate many layers of knowledge to guide policy for human—and ecological—health. To quote Martin Luther King, Jr., "It really boils down to this: that all life is interrelated. We are all caught in an inescapable network of mutuality, tied together into a single garment of destiny. Whatever affects one directly, affects all indirectly" (1).

### Jeffrey Townsend

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### References

1. King ML Jr. A Christmas sermon on peace (1967). In: Washington JM, editor. *A testament of hope: the essential writings and speeches of Martin Luther King, Jr.* New York: HarperCollins; 1986. p. 253–8.

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## Correction: Vol. 21, No. 4

An incorrect version of the Technical Appendix was provided online for the article Population Structure and Antimicrobial Resistance of Invasive Serotype IV Group B Streptococcus, Toronto, Ontario, Canada (S. Teatiero et al.). The article has been corrected online ([http://wwwnc.cdc.gov/eid/article/21/4/14-0759\\_article](http://wwwnc.cdc.gov/eid/article/21/4/14-0759_article)).

# Mapping Disease Transmission Risk Enriching Models Using Biogeography And Ecology

**Xiang Xie**



## **Mapping Disease Transmission Risk Enriching Models Using Biogeography And Ecology:**

*Mapping Disease Transmission Risk* A. Townsend Peterson, 2014-11-26 This book illuminates new and more effective infectious disease mapping methods and integrates biogeographic and ecological factors with spatial models The author treats disease transmission areas for what they are distributions of species He argues that complex fragmented and highly irregular disease patterns can only be understood when underlying environmental drivers are considered The result is an modeling approach that challenges static spatial models and provides a framework for recasting disease mapping

*Emerging Infectious Diseases*, 2015-07      **Biodiversity and Health** Serge Morand, Claire Lajaunie, 2017-11-27 There is a gap between the ecology of health and the concepts supported by international initiatives such as EcoHealth One Health or Planetary Health a gap which this book aims to fill Global change is accelerated by problems of growing population industrialization and geopolitics and the world s biodiversity is suffering as a result which impacts both humans and animals However Biodiversity and Health offers the unique opportunity to demonstrate how ecological environmental medical and social sciences can contribute to the improvement of human health and wellbeing through the conservation of biodiversity and the services it brings to societies This book gives an expansive and integrated overview of the scientific disciplines that contribute to the connection between health and biodiversity from the evolutionary ecology of infectious and non infectious diseases to ethics law and politics Presents the first book to give a broad and integrated overview of the scientific disciplines that contribute to health From evolutionary ecology to laws and policies this book explores the links between health and biodiversity Demonstrates how ecological sciences environmental sciences medical sciences and social sciences may contribute to improve human health      Evolutionary Biology: Biodiversification from Genotype to Phenotype Pierre

Pontarotti, 2015-07-10 This book presents 20 selected contributions to the 18th Evolutionary Biology Meeting which took place in September 2014 in Marseille They are grouped under the following major themes Genotype to Phenotype Genetic Mechanisms of Diversification Evolutionary Mechanisms Speciation and Biodiversity The aims of these annual meetings in Marseille are to bring together leading evolutionary biologists and other scientists who employ evolutionary biology concepts e g for medical research and to promote the exchange of ideas and encourage interdisciplinary collaborations Offering an up to date overview of recent advances in the field of evolutionary biology this book represents an invaluable source of information for scientists teachers and advanced students      **Trash Talk** Robert William Collin, 2015-09-09 This fascinating reference offers a unique take on recycling and trash tracing the role of waste in public health climate change and sustainability around the world As the popularity of sustainability grows and climate change becomes an accepted reality experts point to trash and waste as the link between environmental and public health This detailed reference one of the most comprehensive resources available on the subject examines garbage disposal on a global level from the history of waste management to the rise of green movements and recycling programs to the environmental problems caused by incineration

and overflowing landfills According to urban planning scholar Robert William Collin accounting for waste will improve the chances for environmental protection public health and sustainability This country by country guide studies waste management practices and related topics from around the world including garbage strikes in Italy successful recycling programs in Switzerland trash in the streets of India and the garbage patch floating in the Pacific Ocean Country entries cover a brief history of garbage disposal current methods of removal recycling and waste management problems specific to the region Additional content addresses air and water pollution greenhouse gas emissions E waste and hazardous and nuclear wastes

*Applications of Novel Analytical Methods in Epidemiology* Moh A. Alkhamis, Victoria J. Brookes, Kimberly VanderWaa, 2018-12-07 The repertoire of quantitative analytical techniques in disciplines such as ecology decision science and evolutionary biology has grown in part enabled by the development and increased availability of computational resources Integration of cutting edge quantitative tools into veterinary epidemiology that have been borrowed from such disciplines has offered opportunities to advance the study of disease dynamics in animal populations to improve and guide decision making related to disease prevention control or eradication Furthermore the need to explore new analytical methods for veterinary epidemiology has been driven by the increasing availability and complexity of animal disease data The objective of this e book is to contribute to current methods in epidemiology by 1 presenting and discussing novel analytical tools that help advance our understanding of epidemiology and 2 demonstrating how inferences emerging from the application of novel analytical tools can be incorporated into decision making related to animal health The e book constitutes a collection of articles that explore the applications of a variety of analytical methods such as machine learning Bayesian risk assessment and an advanced form of social network analysis in the modern epidemiologic study of animal diseases

*Geospatial Technology for Human Well-Being and Health* Fazlay S. Faruque, 2022-03-21 Over the last thirty years or so there have been tremendous advancements in the area of geospatial health however somehow two aspects have not received as much attention as they should have received These are a limitations of different spatial analytical tools and b progress in making geospatial environmental exposure data available for advanced health science research and for medical practice This edited volume addresses those two less explored areas of geospatial health with augmented discussions on the theories methodologies and limitations of contemporary geospatial technologies in a wide range of applications related to human well being and health In 20 chapters readers are presented with an up to date assessment of geospatial technologies with an emphasis on understanding general geospatial principles and methodologies that are often overlooked in the research literature As a result this book will be of interest to both newcomers and experts in geospatial analysis and will appeal to students and researchers engaged in studying human well being and health Chapters are presenting new concepts new analytical methods and contemporary applications within the framework of geospatial applications in human well being and health The topics addressed by the various chapter authors include analytical approaches newer areas of geospatial health application

introduction to unique resources geospatial modeling and environmental pollution assessments for air water and soil Although geospatial experts are expected to be the primary readers this book is designed in such a way so that the public health professionals environmental health scientists and clinicians also find it useful with or without any familiarity with geospatial analysis

**Advancements in Understanding Zoonotic Parasitic Diseases** Rodrigo Morchón García, Simona Gabrielli, Lavinia Ciuca, Elena Carreton, Ettore Napoli, 2025-01-27 This Research Topic is a continuation of the successful topic launched in Veterinary Infectious Diseases <https://www.frontiersin.org/research-topics/13197-zoonotic-diseases-their-hosts-and-vectors> The field of zoonotic parasitic diseases which can be transmitted between animals and humans is currently experiencing significant advancements These diseases caused by viruses bacteria parasites and fungi vary widely in their symptoms and severity with some leading to severe illness or death The transmission of these parasites can occur through various sources including food domestic and wild animals and vectors However the detection treatment and control of these diseases are often complicated by a lack of comprehensive knowledge about them This issue is further exacerbated by factors such as global warming which is leading to an exponential increase in many zoonotic diseases and the exchange of animals and people through travel or purchases which can introduce new vectors to previously disease free areas The primary aim of this research topic is to enhance our understanding of zoonotic parasitic diseases including those that have the potential to become zoonotic This includes gaining a deeper understanding of their biology epidemiology and the local regional country or global advances in their diagnosis treatment and control Additionally the research topic aims to facilitate the exchange of information about these diseases particularly in relation to their proteome immunome and molecular aspects as well as new vaccinal and diagnostic tools

**Analyzing and Modeling Spatial and Temporal Dynamics of Infectious Diseases** Dongmei Chen, Bernard Moulin, Jianhong Wu, 2014-12-01 Features modern research and methodology on the spread of infectious diseases and showcases a broad range of multi disciplinary and state of the art techniques on geo simulation geo visualization remote sensing metapopulation modeling cloud computing and pattern analysis Given the ongoing risk of infectious diseases worldwide it is crucial to develop appropriate analysis methods models and tools to assess and predict the spread of disease and evaluate the risk Analyzing and Modeling Spatial and Temporal Dynamics of Infectious Diseases features mathematical and spatial modeling approaches that integrate applications from various fields such as geo computation and simulation spatial analytics mathematics statistics epidemiology and health policy In addition the book captures the latest advances in the use of geographic information system GIS global positioning system GPS and other location based technologies in the spatial and temporal study of infectious diseases Highlighting the current practices and methodology via various infectious disease studies Analyzing and Modeling Spatial and Temporal Dynamics of Infectious Diseases features Approaches to better use infectious disease data collected from various sources for analysis and modeling purposes Examples of disease spreading dynamics including West Nile virus bird flu Lyme disease pandemic influenza H1N1

and schistosomiasis Modern techniques such as Smartphone use in spatio temporal usage data cloud computing enabled cluster detection and communicable disease geo simulation based on human mobility An overview of different mathematical statistical spatial modeling and geo simulation techniques Analyzing and Modeling Spatial and Temporal Dynamics of Infectious Diseases is an excellent resource for researchers and scientists who use manage or analyze infectious disease data need to learn various traditional and advanced analytical methods and modeling techniques and become aware of different issues and challenges related to infectious disease modeling and simulation The book is also a useful textbook and or supplement for upper undergraduate and graduate level courses in bioinformatics biostatistics public health and policy and epidemiology

**Mapping Disease Risk Using Spatial Filtering Methods** Qiang Cai,2007      **Network-based Modeling for Risk Assessment of Infectious Disease Transmission** Md Mahbubul Huq Riad,2020 Infectious disease modeling is crucial to optimize surveillance preventative measures and resource allocation Simulation with infectious disease models is very convenient when the resource requirement for data collection and experimental studies are prohibitively high or even unethical A vast number of approaches have been proposed to model infectious disease transmission from different perspectives In this dissertation we investigate network based disease models for efficient resource allocation effective mitigation measures and accurate risk assessment We also investigate a filtering based parameter estimation and forecasting framework usable when proper incidence data is available First we provide a guideline for developing a network based model and simulation framework for any infectious diseases As an example we provide a step by step method for developing a spatially explicit model for infectious diseases with host demographic data We show how to devise effective mitigation strategies from simulation results using the spatially explicit model Our second contribution is developing a parameter estimation framework using a sequential Monte Carlo filter a compartmental disease model and historical incidence data Parameter estimation for any infectious disease model is crucial for accurately informing resource allocation and control measures Our method is particularly important for its adaptability to the availability of new incidence data of any epidemic This parameter estimation framework is not limited to epidemic models rather it can be used for any systems with a state space model Third we propose an ensemble Kalman filter that provides dual state parameter estimates for infectious diseases As an online inferential method the ensemble Kalman Filter can perform real time forecast during an outbreak The framework is capable of accurate short to mid term forecasts Fourth we develop a risk assessment framework for infectious diseases with a comprehensive two layer network a permanent layer representing permanent contacts among individuals and a data driven layer for temporary contacts due to movements We combine the two layer network with a compartmental model and implement a Gillespie algorithm to identify the disease evolution and assess the spatial spreading risk The proposed risk assessment framework suggests some focal points spatial for disease preparedness providing critical directions to inform interventions in the field Finally we investigate the strong correlation of the arthropod abundance and host

interaction with vector borne pathogen transmission and we developed a risk assessment framework using climate average temperature and rainfall and host demographic host density and movement data particularly suitable for regions with unreported or under reported incidence data This framework consisted of a spatiotemporal network based approach coupled with a compartmental disease model and a non homogeneous Gillespie algorithm We have identified the spatiotemporal suitability map the spatial risk map the significant incidence window and peak incidence period The outcomes of the framework comprise of weather dependent spatiotemporal suitability maps and probabilistic risk maps for spatial infection transmission This framework is capable of vector borne disease risk assessment without historical incidence data and can be a useful tool for preparedness with accurate human movement data

### **Disease Mapping with WinBUGS and MLwiN**

Andrew B. Lawson, William J. Browne, Carmen L. Vidal Rodeiro, 2003-10-31 Disease mapping involves the analysis of geo referenced disease incidence data and has many applications for example within resource allocation cluster alarm analysis and ecological studies There is a real need amongst public health workers for simpler and more efficient tools for the analysis of geo referenced disease incidence data Bayesian and multilevel methods provide the required efficiency and with the emergence of software packages such as WinBUGS and MLwiN are now easy to implement in practice Provides an introduction to Bayesian and multilevel modelling in disease mapping Adopts a practical approach with many detailed worked examples Includes introductory material on WinBUGS and MLwiN Discusses three applications in detail relative risk estimation focused clustering and ecological analysis Suitable for public health workers and epidemiologists with a sound statistical knowledge Supported by a Website featuring data sets and WinBUGS and MLwiN programs Disease Mapping with WinBUGS and MLwiN provides a practical introduction to the use of software for disease mapping for researchers practitioners and graduate students from statistics public health and epidemiology who analyse disease incidence data

*Disease Mapping* Miguel A. Martinez-Beneito, Paloma Botella-Rocamora, 2019-07-02 Disease Mapping From Foundations to Multidimensional Modeling guides the reader from the basics of disease mapping to the most advanced topics in this field A multidimensional framework is offered that makes possible the joint modeling of several risks patterns corresponding to combinations of several factors including age group time period disease etc Although theory will be covered the applied component will be equally as important with lots of practical examples offered Features Discusses the very latest developments on multivariate and multidimensional mapping Gives a single state of the art framework that unifies most of the previously proposed disease mapping approaches Balances epidemiological and statistical points of view Requires no previous knowledge of disease mapping Includes practical sessions at the end of each chapter with WinBUGs INLA and real world datasets Supplies R code for the examples in the book so that they can be reproduced by the reader About the Authors Miguel A Martinez Beneito has spent his whole career working as a statistician for public health services first at the epidemiology unit of the Valencia Spain regional health administration and later as a researcher at the public health division

of FISABIO a regional bio sanitary research center He has been also the Bayesian Hierarchical Models professor for several seasons at the University of Valencia Biostatistics Master Paloma Botella Rocamora has spent most of her professional career in academia although she now works as a statistician for the epidemiology unit of the Valencia regional health administration Most of her research has been devoted to developing and applying disease mapping models to real data although her work as a statistician in an epidemiology unit makes her develop and apply statistical methods to health data in general **The**

**Geographic Spread of Infectious Diseases** Lisa Sattenspiel, Alun Lloyd, 2009-07-26 The 1918 19 influenza epidemic killed more than fifty million people worldwide The SARS epidemic of 2002 3 by comparison killed fewer than a thousand The success in containing the spread of SARS was due largely to the rapid global response of public health authorities which was aided by insights resulting from mathematical models Models enabled authorities to better understand how the disease spread and to assess the relative effectiveness of different control strategies In this book Lisa Sattenspiel and Alun Lloyd provide a comprehensive introduction to mathematical models in epidemiology and show how they can be used to predict and control the geographic spread of major infectious diseases Key concepts in infectious disease modeling are explained readers are guided from simple mathematical models to more complex ones and the strengths and weaknesses of these models are explored The book highlights the breadth of techniques available to modelers today such as population based and individual based models and covers specific applications as well Sattenspiel and Lloyd examine the powerful mathematical models that health authorities have developed to understand the spatial distribution and geographic spread of influenza measles foot and mouth disease and SARS Analytic methods geographers use to study human infectious diseases and the dynamics of epidemics are also discussed A must read for students researchers and practitioners no other book provides such an accessible introduction to this exciting and fast evolving field **Ecology of Infectious Diseases in Natural Populations**

B. T. Grenfell, A. P. Dobson, 2008-01-21 This book is the first major synthesis of theory and empirical knowledge regarding the ecology and epidemiology of infectious diseases in natural unmanaged animal and plant populations Throughout the book the contributors develop a dialogue between the patterns observed in empirical studies of disease in natural populations and the mathematical models used to dissect and examine the observed epidemiological patterns The book is divided into a number of reviews and group reports by experts in various fields Two sections synthesize important issues relating to the dynamics of microparasites and macroparasites while the others discuss spatial patterns in disease dynamics and the evolutionary biology of parasites pathogens and their hosts This book will be of use to graduate students and specialists in mathematical biology and epidemiology **Spatial Analysis in Epidemiology** Dirk U. Pfeiffer, Timothy P. Robinson, Mark Stevenson, Kim B. Stevens, David J. Rogers, Archie C.A. Clements, 2008-05-29 This book provides a practical comprehensive and up to date overview of the use of spatial statistics in epidemiology the study of the incidence and distribution of diseases Used appropriately spatial analytical methods in conjunction with GIS and remotely sensed data can provide significant insights



into the biological patterns and processes that underlie disease transmission. In turn, these can be used to understand and predict disease prevalence. This user-friendly text brings together the specialised and widely dispersed literature on spatial analysis to make these methodological tools accessible to epidemiologists for the first time. With its focus on application rather than theory, *Spatial Analysis in Epidemiology* includes a wide range of examples taken from both medical human and veterinary animal disciplines and describes both infectious diseases and non-infectious conditions. Furthermore, it provides worked examples of methodologies using a single data set from the same disease example throughout and is structured to follow the logical sequence of description of spatial data, visualisation, exploration, modelling and decision support. This accessible text is aimed at graduate students and researchers dealing with spatial data in the fields of epidemiology, both medical and veterinary, ecology, zoology and parasitology, environmental science, geography and statistics.

Leveraging Mechanistic Models to Characterize the Dynamics of Zoonotic Infectious Diseases and Assess Intervention Strategies

Monique R Ambrose, 2018

Zoonotic diseases, which are caused by pathogens that transmit from animals into humans, are responsible for numerous ongoing public health burdens such as leptospirosis, rabies and West Nile virus infections and are also considered a probable source of future epidemics in humans. Describing and quantifying the transmission dynamics of these pathogens is vital if we wish to assess which of the many known zoonotic pathogens pose a threat to humans and which management strategies would be most effective at minimizing that threat. To conduct these assessments, it is necessary to consider the ecological dynamics and interactions driving zoonotic disease transmission. A zoonotic pathogen's impact on humans depends not only on transmission dynamics within the human population, including heterogeneities in human contacts and interactions with endemic human pathogens, but also on disease dynamics within the reservoir and at the human-reservoir interface. Because of the complex ecological interactions driving the spread of zoonotic pathogens, qualitatively and quantitatively characterizing their spread and devising rational management strategies requires combining insights from community ecology, invasion biology and classical single-host disease ecology with system-specific information about the pathways of transmission within the reservoir, within humans and between the two. Bringing together these complementary perspectives can shed light on the key processes driving transmission, which is essential for predicting how changes both purposeful interventions and natural shifts may alter the system's behavior. In this dissertation, I present three studies that use diverse methods to explore different aspects of zoonotic pathogens' disease dynamics. In chapter 1, I use a theoretical approach to explore the effects of competition between a zoonotic pathogen and a human endemic pathogen in the context of a disease eradication program. I use a deterministic compartmental model that tracks spillover and transmission of a zoonotic disease in humans as well as transmission of a partially cross-protective endemic human pathogen to examine how the presence of the zoonotic pathogen can reduce the vaccination coverage necessary to eradicate the human pathogen and how the zoonotic pathogen's prevalence is expected to change during and following a successful

eradication campaign I then use the smallpox monkeypox system as a case study to assess how the theoretical findings apply in a real world context In chapter 2 I move from theoretical explorations of disease dynamics to using real world datasets to inform mechanistic models Zoonotic disease surveillance datasets are valuable sources of information about disease dynamics but are generally difficult and expensive to obtain and are associated with a variety of data limitations This chapter develops methods to extract as much information as possible from these valuable information sources I develop a model based inference method that addresses a number of data challenges including unobserved sources of transmission both human and zoonotic limited spatial information and unknown scope of surveillance using a spatial model with two levels of mixing After demonstrating the robustness of the method using simulation studies I apply the new method to a dataset of human monkeypox cases detected during an active surveillance program from 1982 1986 in the Democratic Republic of the Congo The results provide estimates of the reproductive number and spillover rate of monkeypox during this surveillance period and suggest that most human to human transmission events occur over distances of 30 km or less Taking advantage of contact tracing data available for a subset of monkeypox cases I find that around 80% of contact traced links could be correctly recovered from transmission trees inferred using only date and location The results highlight the importance of identifying the appropriate spatial scale of transmission and show how even imperfect spatiotemporal data can be incorporated into models of zoonotic pathogens to obtain reliable estimates of transmission patterns Chapter 3 shifts from examining the dynamics of zoonotic pathogens after they have already spilled into humans to evaluating how interventions in the zoonotic reservoir could help reduce the risk of spillover occurring in the first place This chapter focuses on evaluating interventions to minimize the risk of spillover of swine origin influenza A viruses IAV S into humans in the United States In the past decade the majority of reported human infections with IAV S in the United States have been associated with individuals exposed to exhibition swine while attending agricultural shows Because these exhibition swine make up a largely distinct population within the US swine herd there is great potential to implement control practices within exhibition swine that could substantially reduce risk of spillover into humans To understand the factors that drive influenza prevalence and persistence in US exhibition swine and to evaluate the impact of potential interventions I develop a network model that characterizes disease spread into and among exhibition swine The model incorporates key structural information about the system and is informed by a unique surveillance dataset collected from shows in Ohio Michigan and Indiana including IAV S genomes from more than one hundred infected swine I use several different approaches based on both epidemiological and sequence data to estimate parameters describing transmission and to evaluate the expected impact of a set of thirty potential interventions on the risk of spillover into humans Across all approaches several interventions consistently are found to perform best at reducing projected spillover risk including requiring participants to take one or two weeks off between shows and implementing strategies to reduce transmission probabilities among swine at shows While the studies presented in these

chapters range from theoretical explorations of simplified systems to direct comparisons of intervention impacts incorporating messy real world data and complex system structure they all pursue the common goal of providing insights relevant for conceptualizing the prominent forces in a system and for using that understanding to inform decisions on control measures in a real world context

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### **Mapping Disease Transmission Risk Enriching Models Using Biogeography And Ecology Introduction**

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