Book proposal: Infectious Disease Epidemiology - A modern systems approach

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It would be helpful to know how often you've taught the class from which the book has arisen, and what book(s) you used before preparing your own teaching material.

# Author

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# Working book titles

* Infectious Disease Epidemiology - A modern systems approach
* Modern Infectious Disease Epidemiology - A (dynamical) systems approach

# Rationale and scope

**Overview**

Modern infectious disease epidemiology makes heavy use of computational model-based approaches and a dynamical systems perspective. The importance of analyzing infectious diseases in such a way keeps increasing. However, infectious disease epidemiology is still often taught mainly from a medical and classical epidemiological study design (e.g., cohort, case- control) perspective. A number of textbooks exist that approach infectious disease epidemiology from a classical epidemiological and medical perspective (e.g. (Magnus 2008; Nelson and Williams 2013; Giesecke 2017)).

While textbooks that teach a systems/model based approach to infectious diseases exist (e.g. (Anderson and May 1991; Diekmann and Heesterbeek 2000; Keeling and Rohani 2008; Vynnycky and White 2010)), those books are meant to teach students how to become modelers. As such, the books require students to work with mathematical models and write computer code. This is a significant barrier for students who do not have a strong mathematical background or prior coding experience, which applies to many students in public health and related biomedical disciplines. It limits the number of students who can or want to engage with infectious disease epidemiology by using modern, systems modeling-based approaches.

There is currently (as far as I am aware) no book that teaches infectious disease epidemiology from a systems perspective while at the same time being approachable to students without the need of doing a good bit of math and/or computer programming.

Thus the idea for this book. In this book, Infectious disease topics are discussed from a *dynamical systems perspective*, and make use of dynamical models. At the same time, students are not required to know advanced mathematics or coding and model building is not taught.

We believe that anyone working on infectious disease related topics in public health nowadays needs to have some familiarity with models. As such, this book contains and shows some models and equations. However, it introduces those models as tools for understanding infectious disease concepts, and does not try to teach the student to become a modeler. The focus is on understanding the modeling perspective and becoming an *educated consumer* of models.

**Learning Objectives**

The main goal of the book is to equip students with the knowledge to think about ID Epi in a systems way and to 'consume/interpret' results from infectious disease modeling studies. If students, after having worked through this book, want to proceed toward becoming modelers themselves, they could continue with the modeling textbooks mentioned above.

The proposed book is meant to address the following main learning objectives (more detailed objectives are listed at the beginning of each book chapter):

* Explain the importance of system dynamical thinking for the study and control of ID
* Understand how different stages of an infection play different roles influencing medical versus public health interventions
* Interpret the meaning of specific dynamic patterns seen in ID incidence and prevalence
* Explain and compute important epidemiological measures, such as reproductive number and level of herd immunity
* Know about main differences in ID transmission and how that affects control strategies
* Choose optimal ID intervention strategies based on features of specific IDs and predict the impact of different ID intervention strategies
* Understand how host heterogeneity impacts ID dynamics
* Appreciate the complexities of multi-pathogen dynamics
* Assess the role of stochasticity on ID extinction
* Understand the mechanisms and drivers of pathogen evolution and the emergence of new infectious diseases
* Evaluate the impact of connection structure between hosts on ID dynamics

**Specific Use Case Examples**

I envision several target groups and use cases for this book:

For graduate (masters and PhD) students/courses in public health, epidemiology and related areas who have an interest in ID Epi without necessarily wanting to become modelers:

* The main book for a course on ID Epi (to replace e.g. Nelson), possibly supplemented with additional reading from the primary literature. This would be for a course that teaches ID Epi from a modern, dynamical systems perspective.
* One of the books used for a course on ID Epi, together with more classical books (e.g. Nelson), to teach ID Epi in a mix of standard and model-thinking approach.
* The main book for an ID Modeling course, supplemented with further material (reading or exercises, especially the DSAIDE R package described below), to teach model building.
* One of the books used for an ID Modeling course, alongside e.g. Keeling and Rohani or Vynnycky and White.

For non-student individuals, e.g. health professionals working in places like health departments, CDC, etc.

* As self-contained reading outside a course for individuals who have learned ID Epi from a classical perspective and are increasingly exposed to model-based studies in the literature and want to better understand that approach, without wanting to become active modelers.

As example, here is how we currently cover ID Epi at our institution (College of Public Health at the University of Georgia). We currently have 3 graduate level courses (with usually a mix of MPH/MS/PhD student enrolled) that broadly cover infectious diseases:

1) Infectious Disease Epidemiology (taught by one of my colleagues for the last 5+ years), which uses a classical epidemiological/medical/disease centric approach with Nelson as textbook;

2) A course in Dynamical Systems Approaches to Infectious Disease Epidemiology which I have taught online for the last 2 years. This book originates from this class and is the main reading used there.

3) A course on Infectious Disease Modeling, also taught by myself for the last 5+ years, which in the past used Keeling and Rohani and Vynnycky and White as recommended reading. Unfortunately, I found that both books require mathematical knowledge that many of my students could not handle. Thus the books were only recommended and I mostly relied on my own materials. I have not taught the course since I wrote this book, but I plan to use this book and supplement with modeling exercises in the future, while continuing to recommend Keeling and Rohani and Vynnycky and White for those students that can handle the material.

# Readership

The main audience are students in public health and related biomedical disciplines who want to learn about infectious disease epidemiology from a modern, systems-based perspective, while not (yet) wanting to engage deeply with the math and computational aspects related to the topic.

We assume readers are familiar with basic epidemiological and public health ideas such as incidence and prevalence, basic study design such as cohort and case-control studies and clinical trials, and other basic epidemiological concepts.

We also assume readers have at least some passing knowledge of many infectious diseases, which make appearances in the book but are not described in much detail. It is likely that most readers, will have some gaps (e.g. not being familiar with a specific disease or a specific epidemiological concept). Filling such gaps does not require anything beyond some basic reading on main sources such as Wikipedia, the CDC website, or similar.

<<The information in this paragraph can be worked into the learning objectives that I suggest be added above. – DRG>>

# Competing/related books

The rationale and scope describes how I believe this book differs from existing books and covers a gap that isn't covered by any current book.

Another book worth mentioning is (Krämer, Kretzschmar, and Krickeberg 2010), which is an edited volume. It's a mix of ID topics, more conceptual/less medical than (Nelson and Williams 2013). Since each chapter is written by a different set of authors, it has the usual problem of edited books that each chapter/topic is somewhat stand-alone, with authors writing at different levels of difficulty and discussing whatever they find relevant for a given topic. Thus the whole book is not that cohesive and I consider it suitable to assign specific chapters as additional reading but wouldn't use it as a stand-alone book for teaching/learning.

A somewhat older book similar to (Krämer, Kretzschmar, and Krickeberg 2010) seems to be (Thomas and Weber 2001). It is also an edited volume and based on the TOC, convers broadly similar ground to (Krämer, Kretzschmar, and Krickeberg 2010). I do not own (Thomas and Weber 2001), thus have not yet seen/reviewed the full text.

To my knowledge, the resources that are most similar to the book in content/spirit are not textbooks but 2 online courses on Coursera, one called 'Epidemics - the dynamics of infectious diseases' developed by faculty from Penn State (State 2014), and one called 'Epidemics', developed by faculty from Hong Kong University (University 2015).

The Penn State course is 8 week long, features many very good and short videos, and is somewhat broader regarding content and discusses topics than my book. For instance 1 week of the course is devoted to within-host infection and immune response processes, something I do not cover explicitly. Almost all content is taught through the videos, with some optional reading drawn from the primary literature

The Hong Kong Course is 10 weeks long and also mainly video-based, with some optional reading drawn from the primary literature. The course discusses some topics my book doesn't touch on (e.g. communication strategies for ID interventions) while conversely I discuss topics (e.g. extinction and evolution) that are not/barely covered in the course.

I consider the relation between these courses and my proposed book somewhat complementary, i.e. those are 2 different ways of teaching similar material. In fact, in my course on this topic (see below), for every topic I cover I assign both a chapter of my book and suitable videos, many of which come from these online courses.

I have not yet performed a very thorough and systematic review of all the books out there. It is possible that I missed some that are related/similar to my proposed book. I plan to shortly do a very thorough review of what is out there. Still, I believe that whatever I find, my book will be different enough to warrant its existence.

<<I’m assuming this, last paragraph will be dropped from the finished proposal document. As useful, maybe even more useful, than surveying many more books would be to survey what people are using for teaching, because those tend to be the books recommended for independent study as well. For example, you mention Vynnycky and White briefly above; it’s probably one that merits further attention in this section. – DRG>>

# Content

A first version of the book is already written and is currently available on Github at:

<https://ahgroup.github.io/DSAIDEbook/>

<<Please also append to this document a table of contents with all the chapters you expect to have in the finished book. - DRG>>

The book currently has 18 chapters, some longer than others. Each chapter has the same structure, with a short section of suggested exercises at the end. Those exercises usually involve the computer package described below, and suggestions for reading and critically discussing papers from the primary literature.

<<Say a bit more about what the DSAIDE exercises are like. What kinds of things will readers do? Does each chapter have one extended practical, or does each chapter have a series of tasks? [Related comments: (1) Chapter 6 doesn’t really have exercises. Are these to come? (2) A lot of the exercises say “Pick an ID.” I suggest adding a section on infectious diseases to the overview that points people to useful sources of information – e.g. a few authoritative sources as well as wikipedia. (3) Lots of the exercises have people read a particular paper, then find another paper or papers or consider a different ID. But, for a book intended to be usable for independent study, the first step of these exercises feels underdeveloped. I think readers would welcome more scaffolding, e.g. leading questions, in learning how to extract pertinent information/insights from published papers before they then try to bring those insights to bear on other papers.] – DRG>>

The current form of the book was written as part of my teaching of a course on this topic. This is an online graduate level course with mostly public health students and some students from other disciplines (e.g. Ecology, Veterinary Infectious Disease, Forestry, etc.). Each chapter was covered in a week (together with other assigned materials). Students were assigned some or all of the exercises listed at the end of the chapter as weekly homework.

# Special features

Color figures are likely not needed. The book contains text boxes that are set apart from the main text and that contain more advanced material (e.g. show sets of differential equations) that students can skip without losing the ability to understand the rest.

<<The current draft feels light on visuals (leaving aside the cartoons). I’d give some thought to adding graphical representations – perhaps produced by DSAIDE? – that will help readers build up their intuition about relations between variables, parameters, etc. These would play the role filled by equations in a more mathematical book. – DRG>>

# Description of ancillary material

I have written an R package that allows students to actively explore the topics covered in the book. In the exercise section of each book chapter, the students are pointed toward the appropriate simulation in the R package. This R package is fully developed and available, a description of it can be found in (Handel 2017).

<<Say a bit more about the package: its name, DSAIDE, that it’s available on CRAN and on github. Mention briefly the four levels of use and that the book assumes “level 1” use. Is it correct that the package is all simulations i.e. there’s no analysis of real data sets? It’s worth making this clear one way or the other. At the end cite Handel (2017) for details. – DRG>>

# Proposed length of the book and its proposed completion date

A very crude word count (including TOC and references) gives around 40,000 words currently. A pdf version of the book is 106 pages. I expect the final version to grow by around 50-100% through addition of a few more chapters and adding more details to several existing chapters.

My aspirational completion date is end of summer. I have a light teaching load in spring and time over summer. This should give me enough time to finish a version that is suitable to undergo peer review. If I can't finish by end of summer, I hope to get it done at least end of year.

# Planned next steps

* I have a few topics/chapters that I want to add, I have started working on those. They are in the book draft but currently empty/incomplete.
* I want to re-visit various pertinent books/courses/resources and review them to see if there are any topics that I think should be added to my book.
* Some of the existing chapters are a bit too short, I plan to flesh them out some more.
* Everything needs further editing and cleaning up.

# Brief credentials of the author

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See website for my research and further information.

# Some other comments

The book is written in bookdown (<https://bookdown.org/>) and lives in the "R ecosystem" (markdown, pandoc, bibtex, etc.)

# References

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