

Informing Policy via Dynamic Models: Cholera in Haiti

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Section 1

Introduction

Advantages of Statistical Modeling

- Nonlinear-dynamic statistical models have proven to be a useful tool for modeling infectious disease outbreaks (TODO: CITE)
- Most common examples are SIR models and their various extensions.
- These models enable the modeling of scientifically meaningful states, prediction of the future of the outbreak, and modeling the potential effects of interventions (such as vaccinations) (TODO: CITE)

Concerns

- Despite their utility, there exist many cautionary warnings against the use of these types of models (TODO: CITE).
- Concerns include:
 - TODO
 - TODO
 - TODO
- Despite these warnings, there is very little practical advice on how to approach these issues.

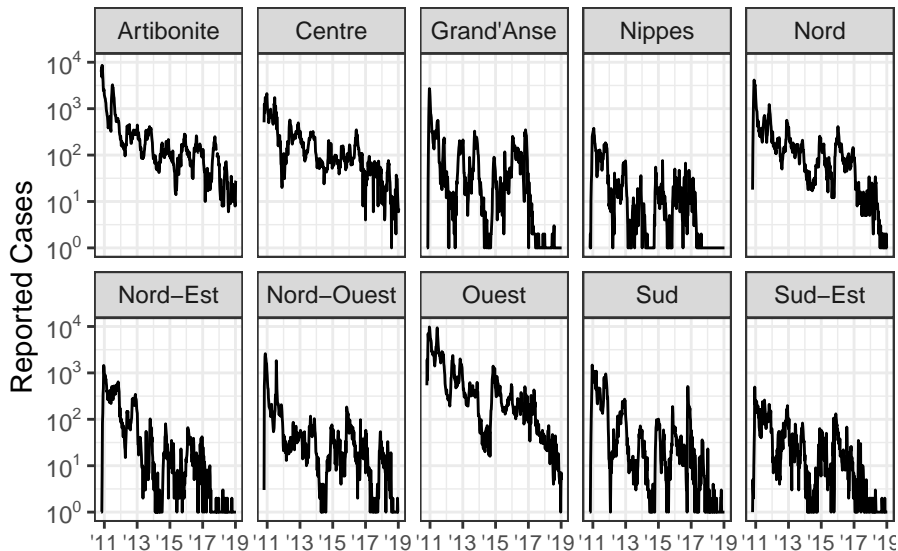
Cholera in Haiti

- We consider the 2010-2019 cholera outbreak in Haiti.
- Cholera was introduced to Haiti in 2010 following the devastating earthquake of the same year.
- Although some new cases have been detected, there were no recorded cholera cases in Haiti between February, 2019 and September 2022 (TODO: Cite).

Data



Data



Models

- We build on the study by Lee et. al (2020), in which four independent teams built non-linear models to describe cholera dynamics.

	Model 1	Model 2	Model 3	Model 4
Deterministic / Stochastic	Stochastic	Deterministic	Stochastic	Agent Based
Spatial Model	No	Yes	Yes	Yes
Fitting Method	IF2	Trajectory Matching	PIF / IF2	NA

Section 2

Model Fitting

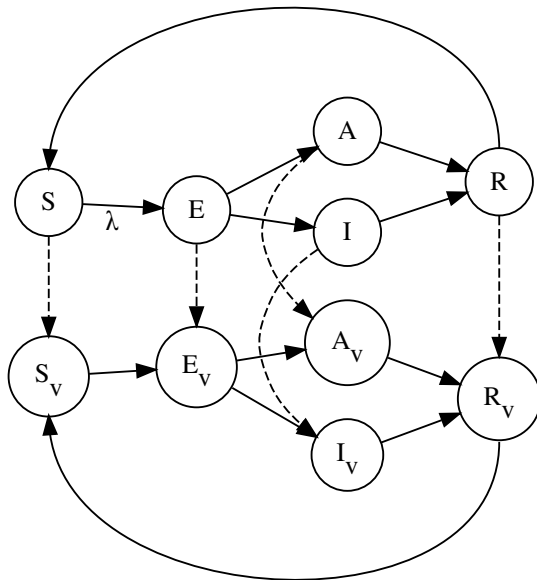
Computing

- Parameters of nonlinear dynamic models are often fit by finding their posterior distribution or by maximizing some objective measure.
- Because of the non-linear nature of the models, this can be computationally expensive.
- Great care should be taken to determine the necessary amount of computation needed to solve the problem at hand.

Nested Models

- Non-linear dynamic models make assumptions about the dynamics of the system in question.
- Consider testing scientifically meaningful nested hypothesis.
- For example, we consider adding a linear trend in transmission to Model 1 in order to account for the apparent decrease in cholera cases.

Model 1



Model 1 (Continued. . .)

- Individuals move $S \rightarrow E$ at time t with a rate of $\lambda(t)$, where:

$$\lambda(t) = (I + \epsilon A)^\nu \frac{d\Gamma(t)}{dt} \beta(t)/N,$$

$$\log \beta(t) = \sum_{j=1}^6 \beta_j s_j(t) + \xi \bar{t}$$

- $\frac{d\Gamma}{dt}$ is multiplicative Gamma white-process noise, $\epsilon, \nu, \xi, \beta_{1:6}$ are parameters to be estimated, $s_{1:6}(t)$ are a B-spline basis.

Section 3

Model Diagnostics

Don't just rely on simulations

For me

Section 4

Model Forecasts

Section 5

Reproducibility