# 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.

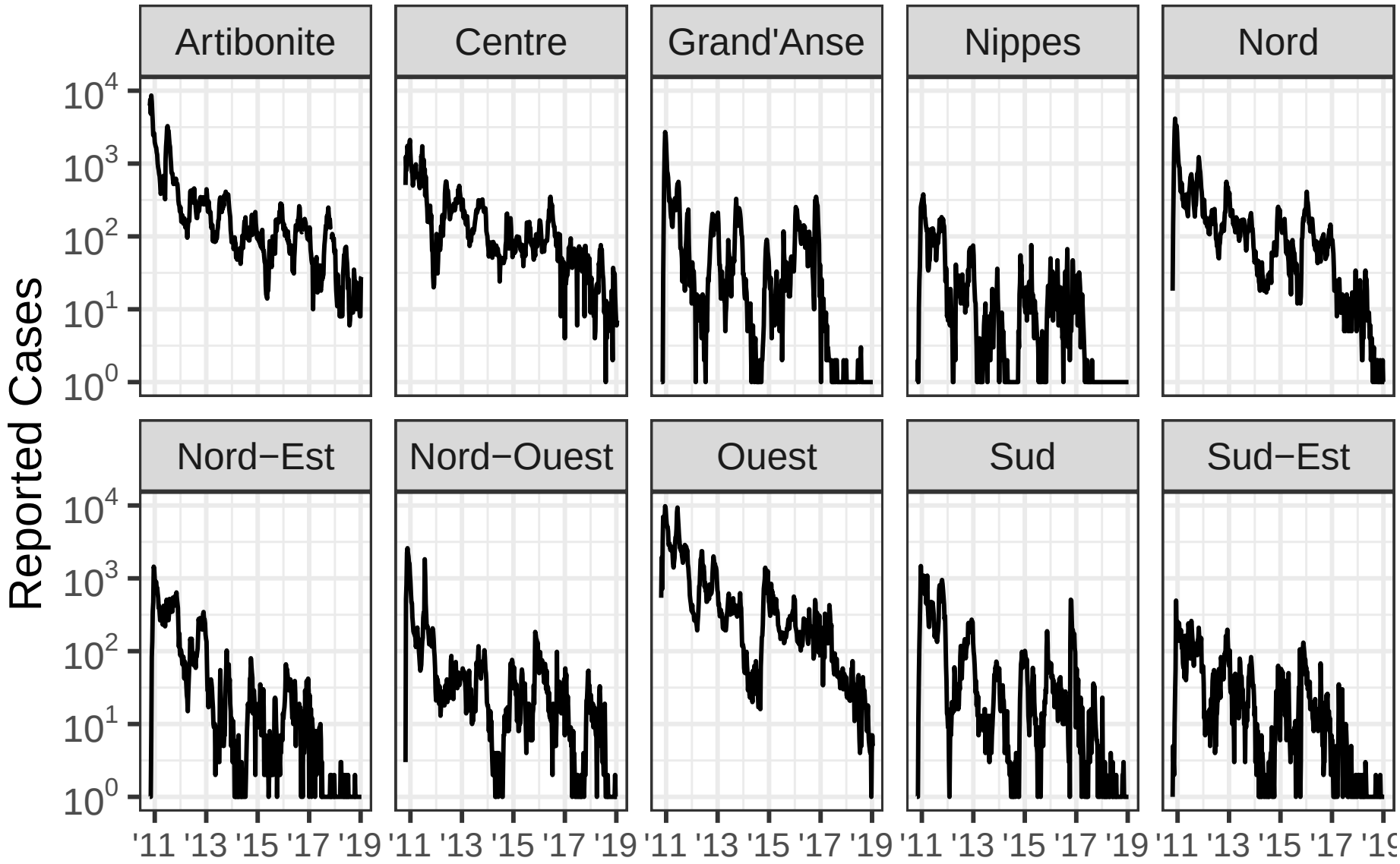
# Cholera in Haiti

- 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


Reported Cases
$10^4$
$10^3$
$10^2$
$10^1$
2011
2012
2013
2014
2015
2016
2017
2018
2019

# Data


Artibonite
Centre
Grand'Anse
Nippes
Nord
Nord−Est
Nord−Ouest
Ouest
Sud
Sud−Est
Reported Cases
$10^4$
$10^3$
$10^2$
$10^1$
$10^0$
'11 '13 '15 '17 '19

# 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

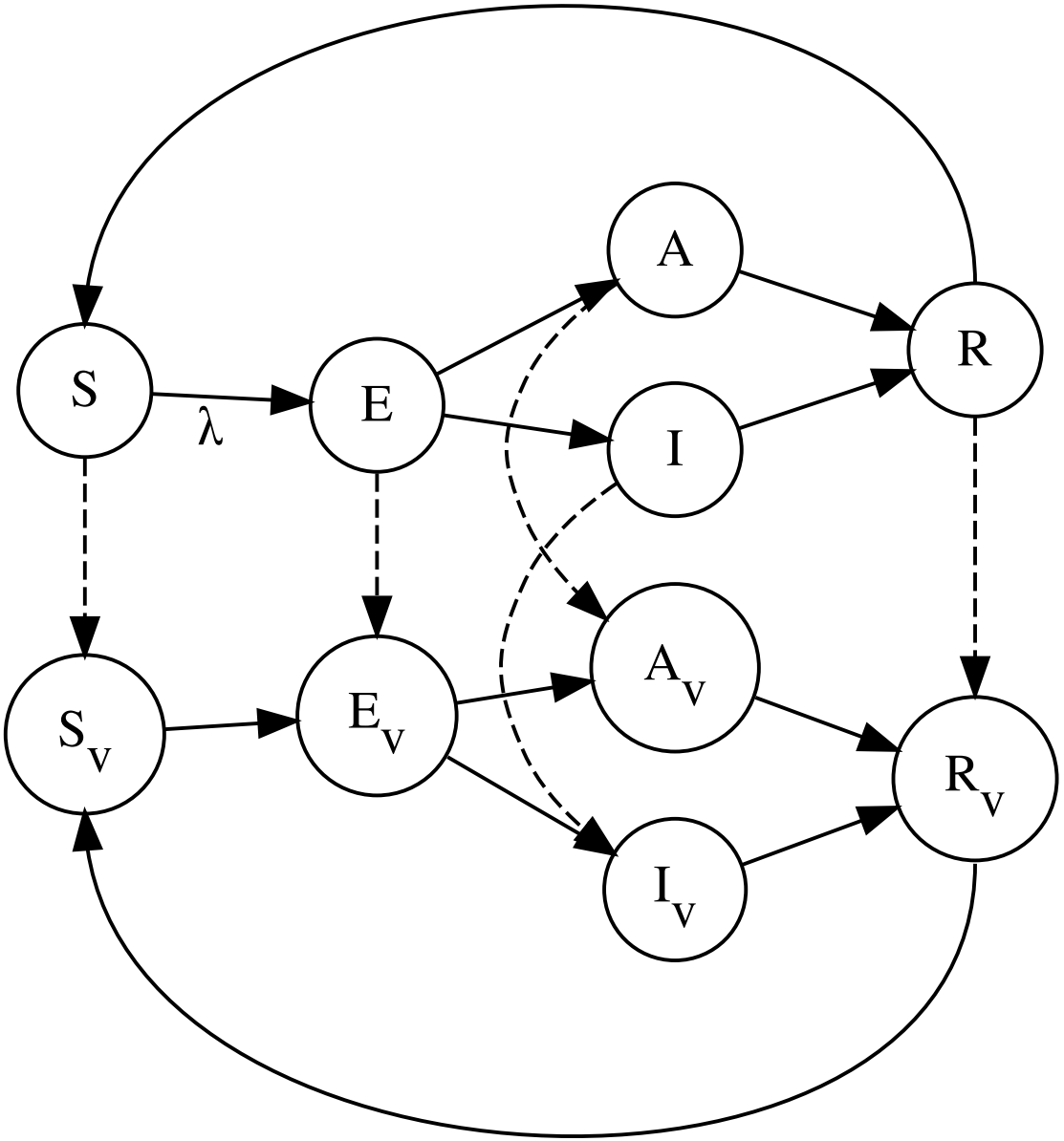
# Computing

- 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 $S \to E$ 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