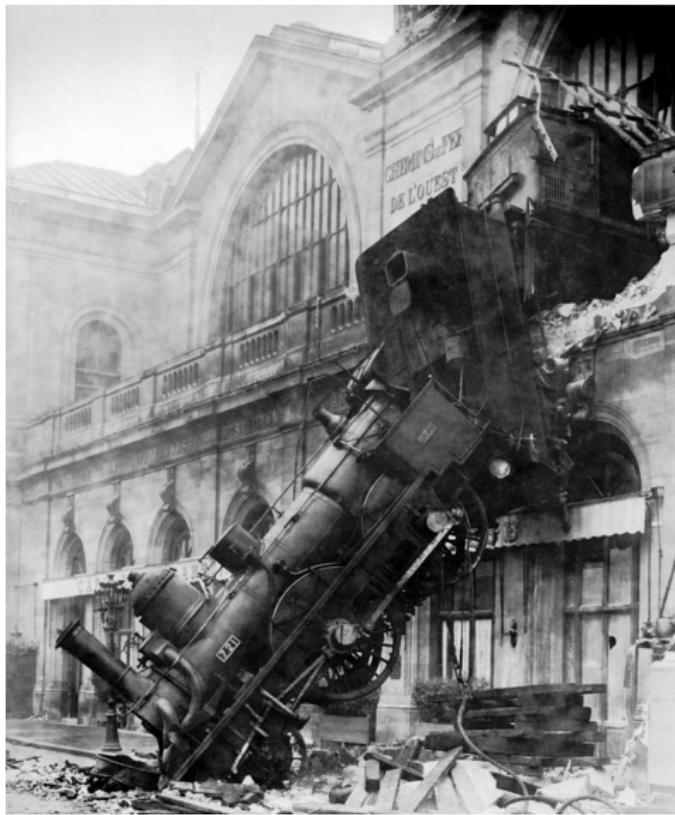


The dynamics of infectious disease outbreaks

Jonathan Dushoff

McMaster University
Department of Biology Seminar Series
Feb 2020



Novel Coronavirus: What do we need to know?

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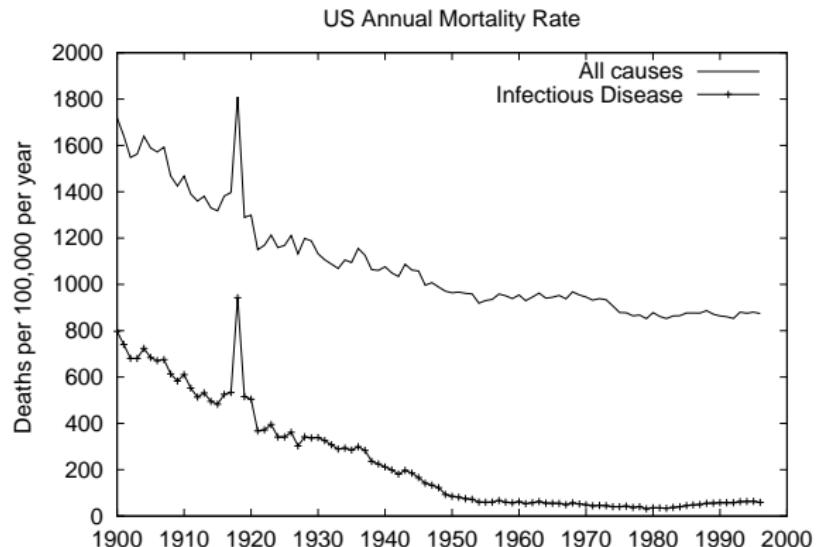
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Dushoff, from Armstrong et al.

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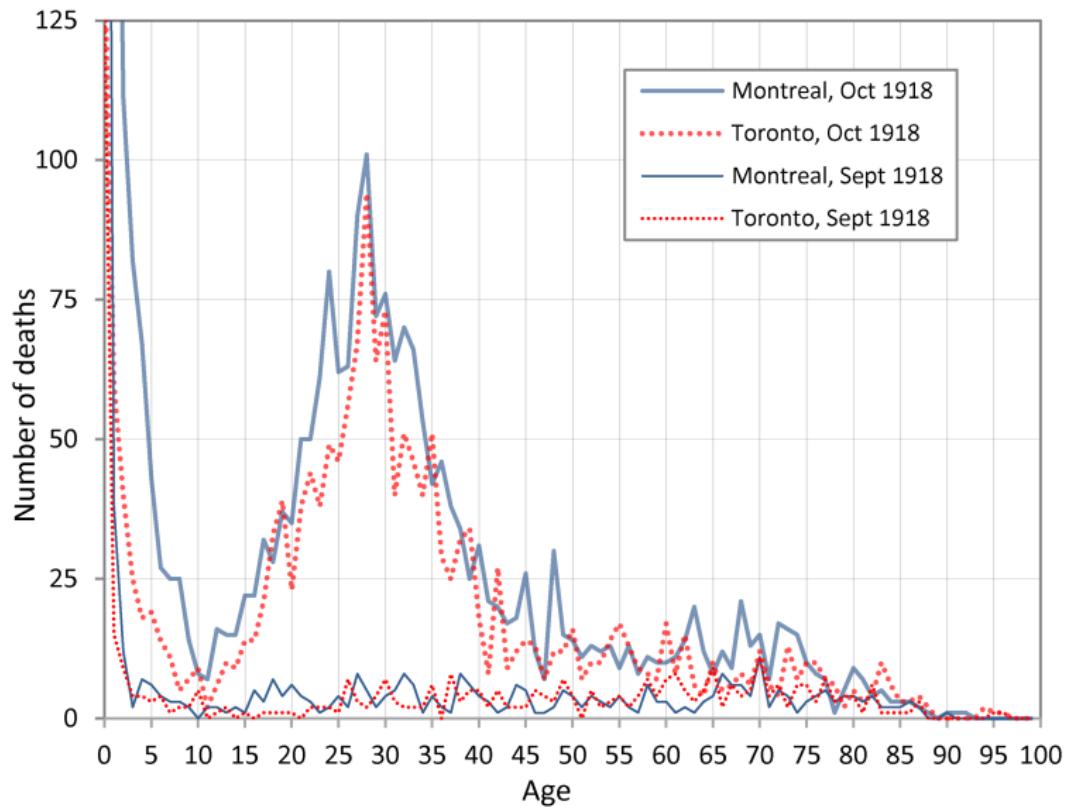
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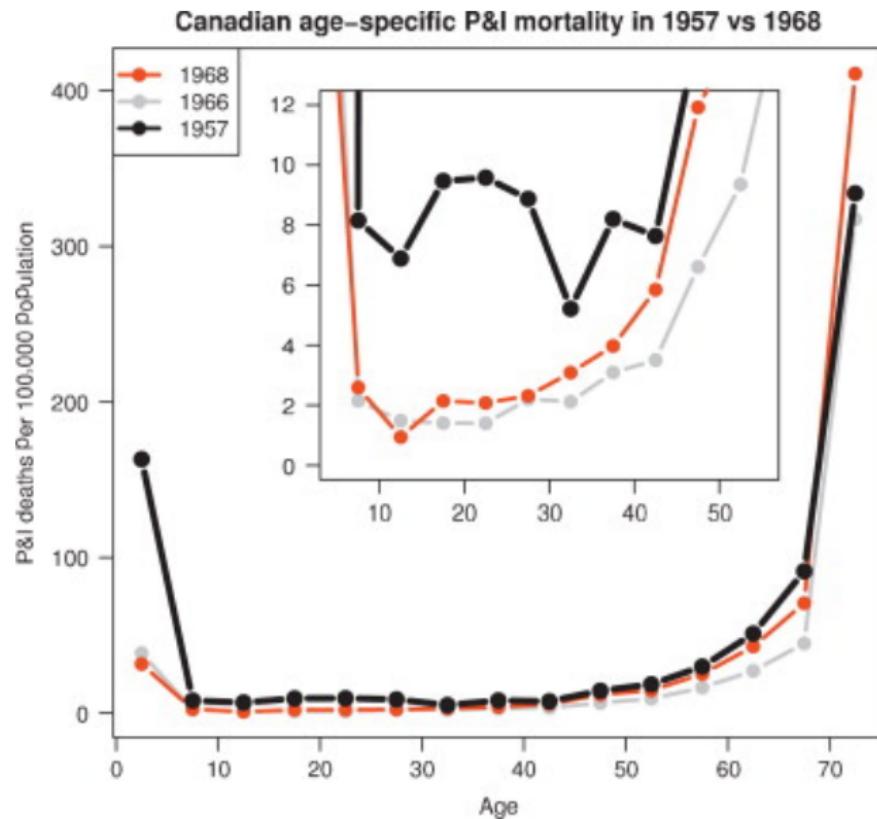
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1918 Age distribution



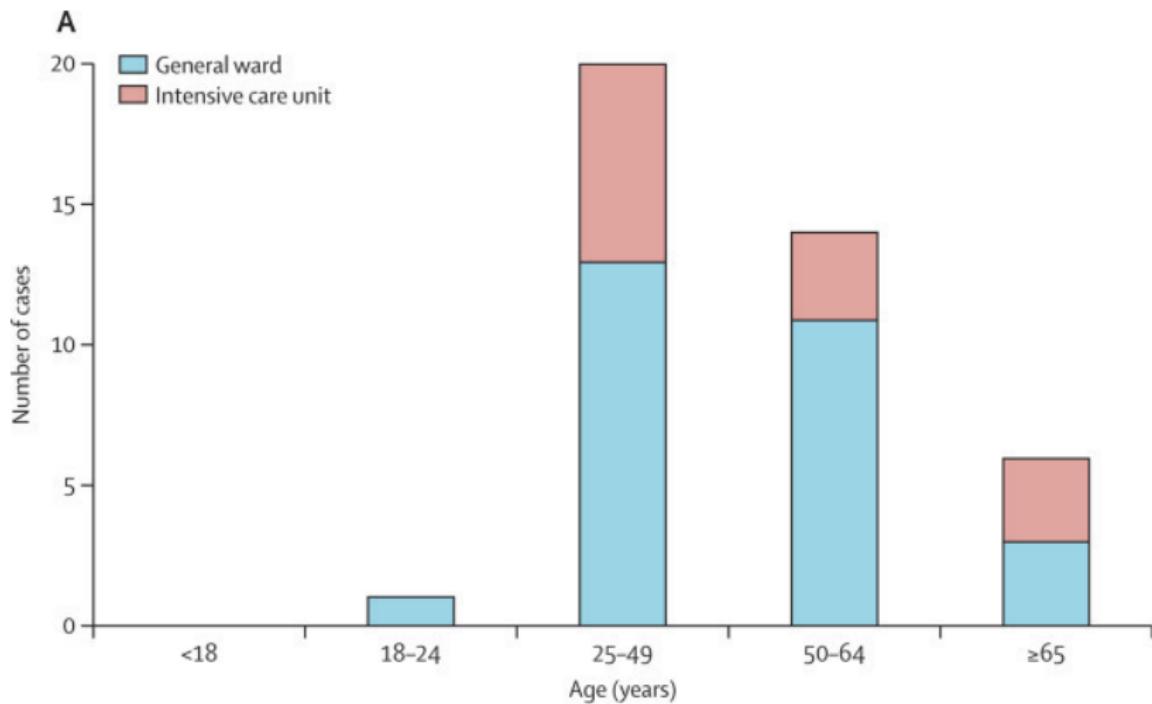
Gagnon et al. 10.1371/journal.pone.0069586

Influenza Age distribution



Ma et al. 10.1016/j.jtbi.2011.08.003

What do we know?



Huang et al. 10.1016/S0140-6736(20)30183-5

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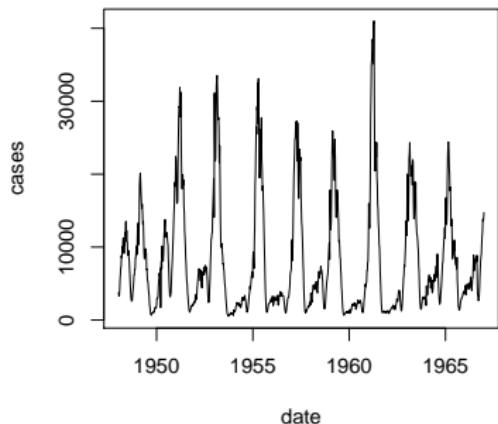
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Dynamical modeling connects scales



Measles reports from England and Wales

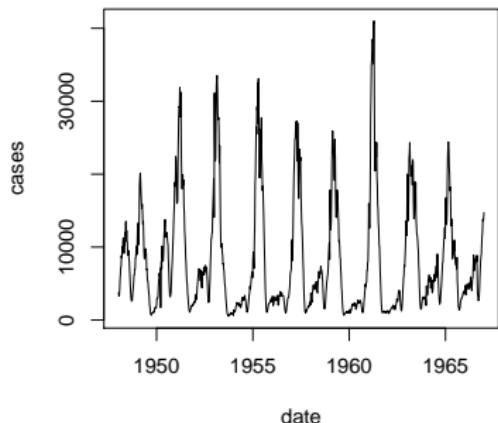


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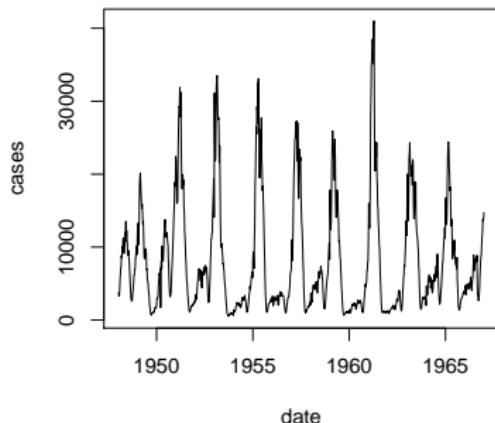


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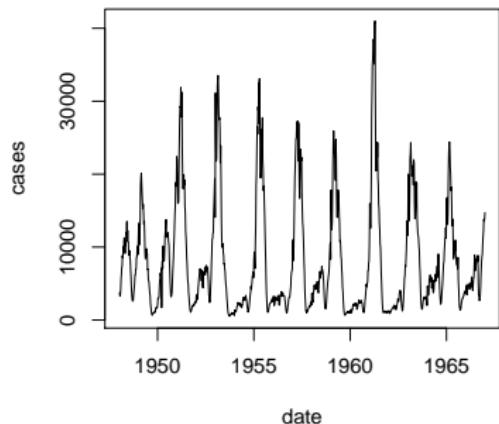


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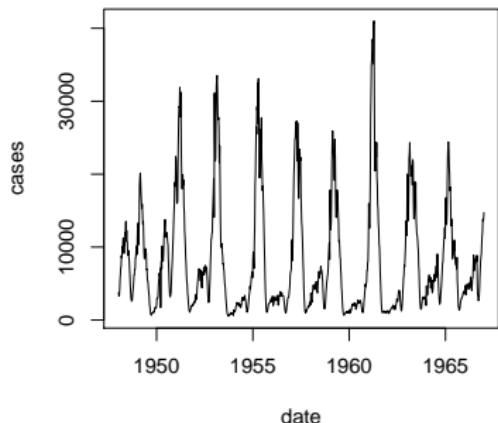


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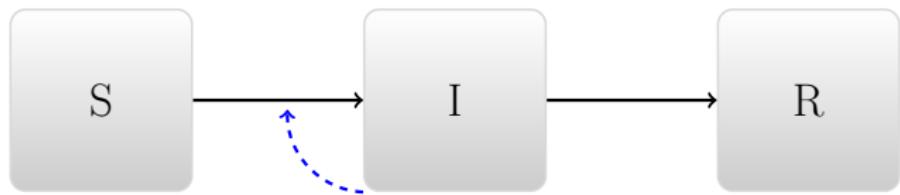


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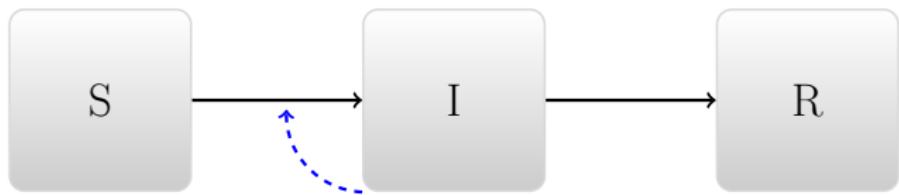
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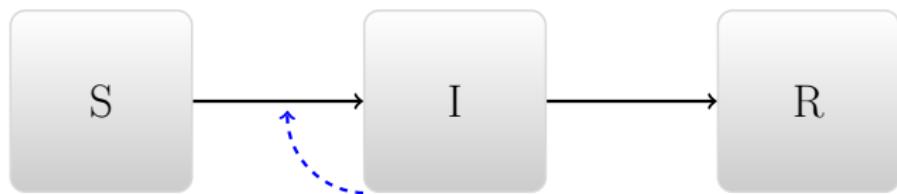
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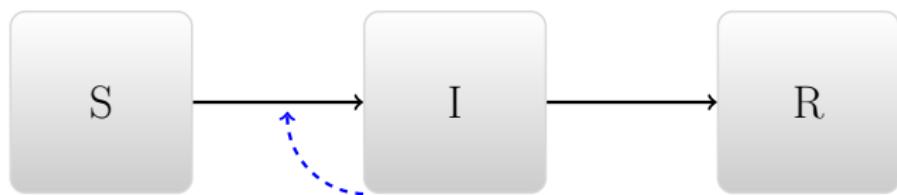
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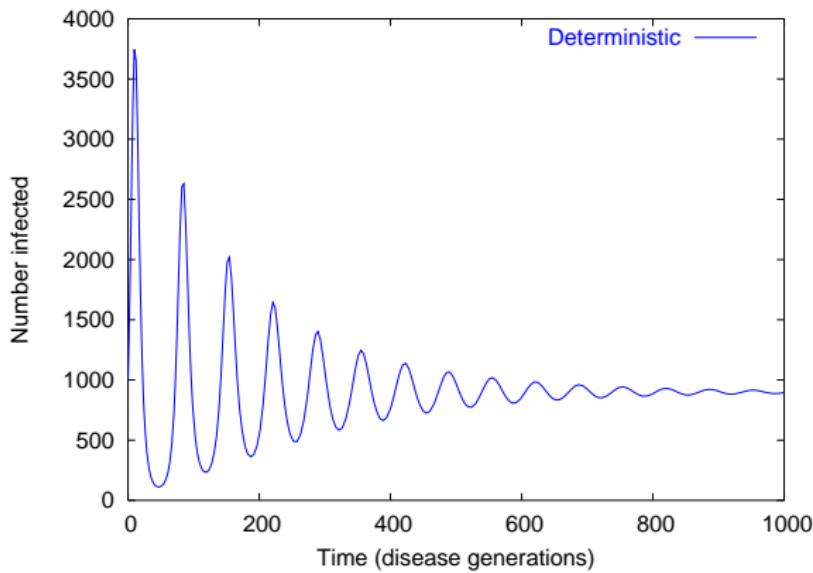
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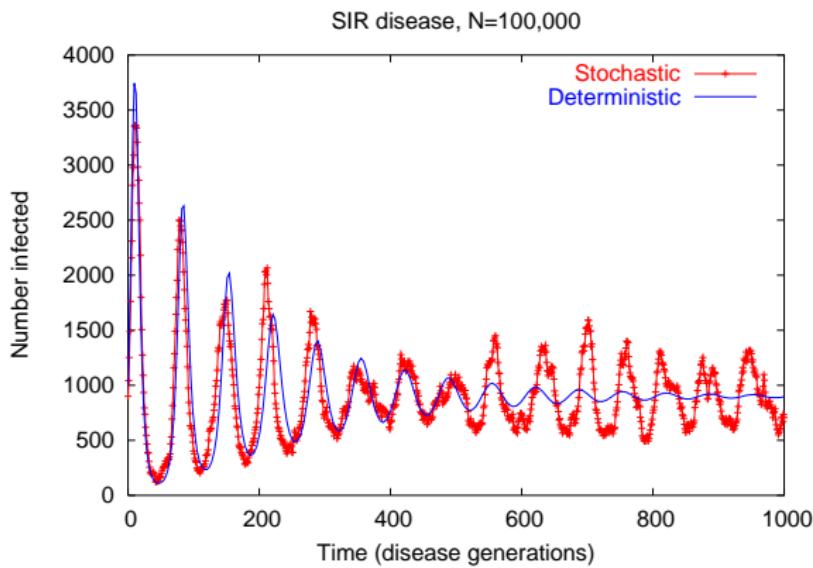


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Differential equation implementation



Individual-based implementation



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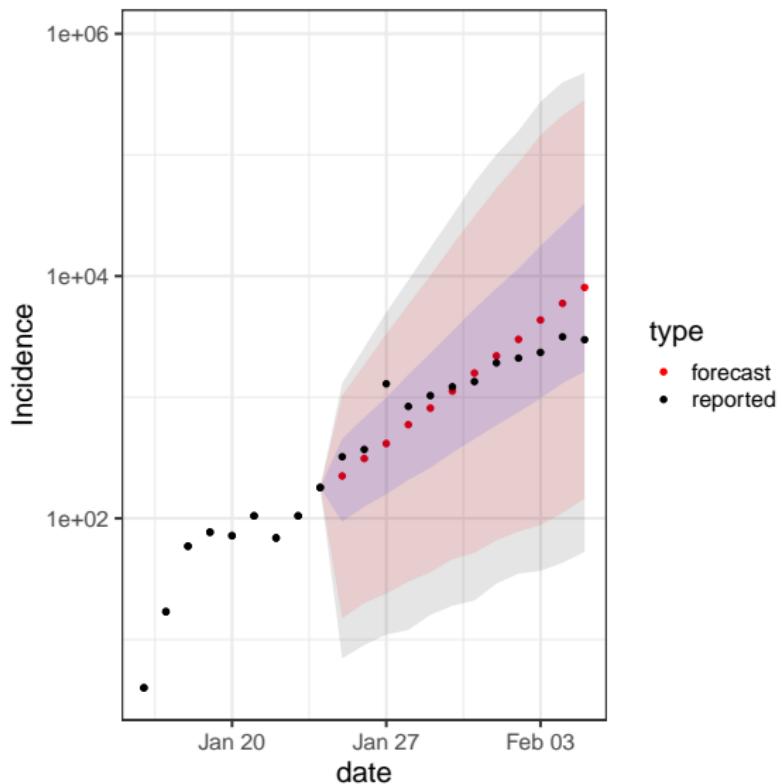
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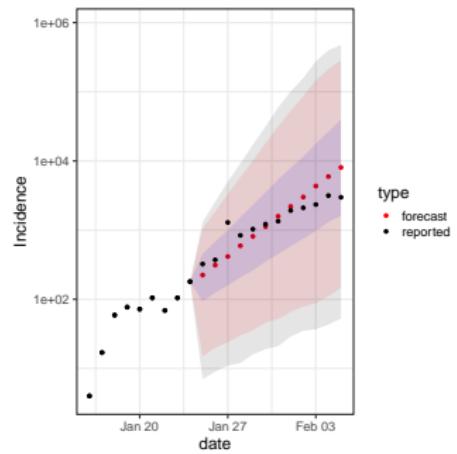
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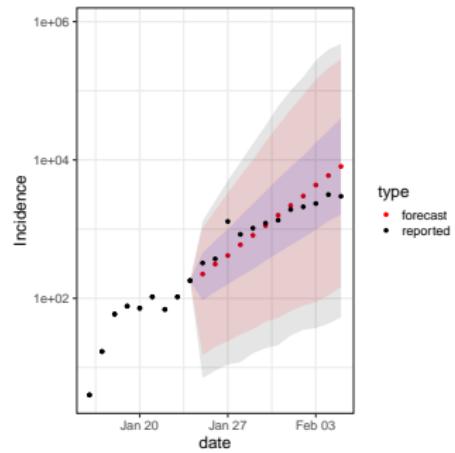
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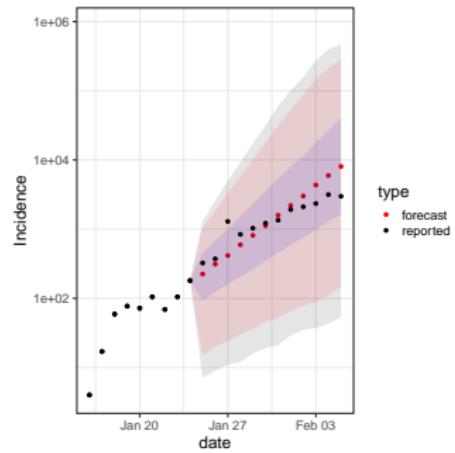
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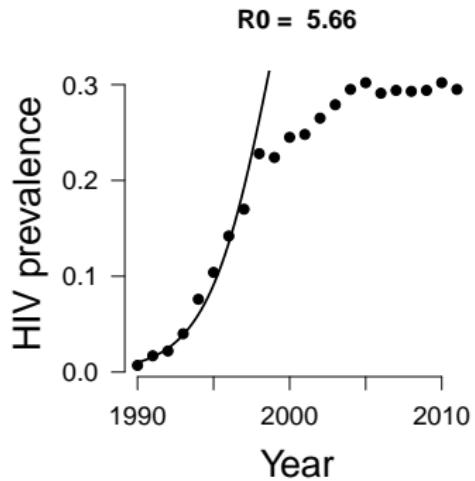
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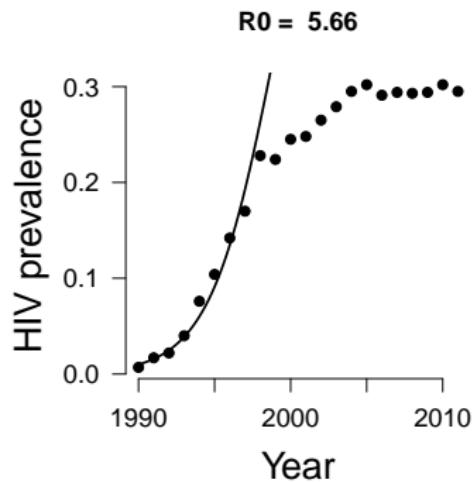
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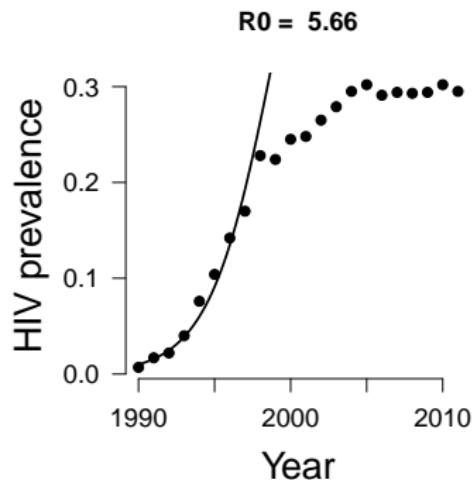
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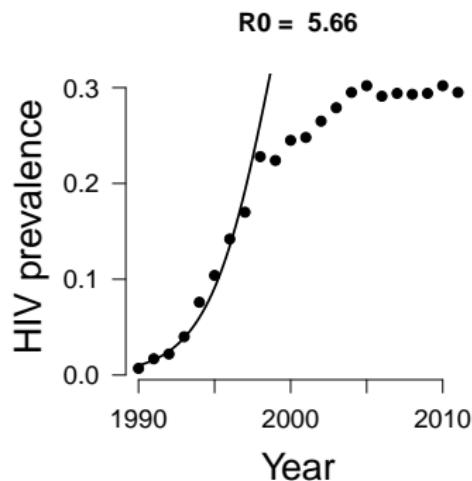
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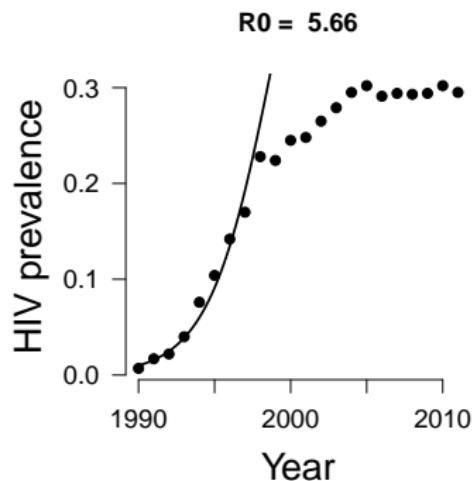
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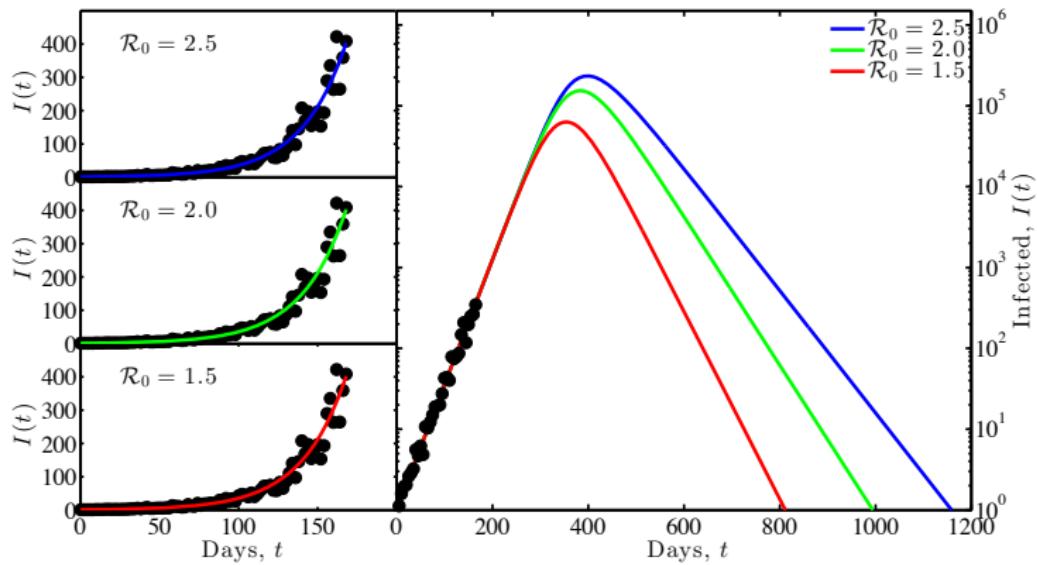


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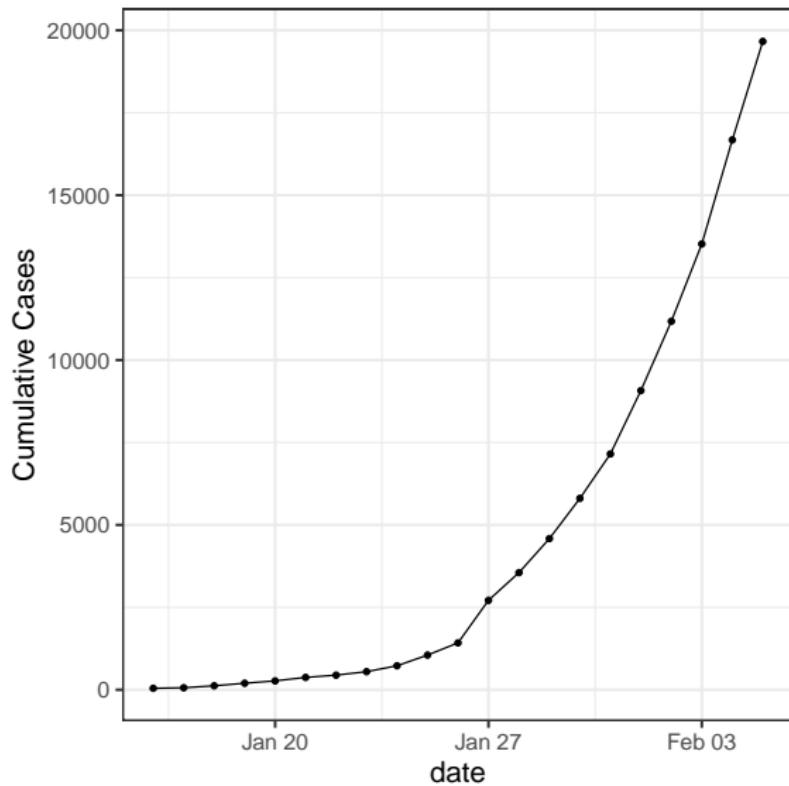
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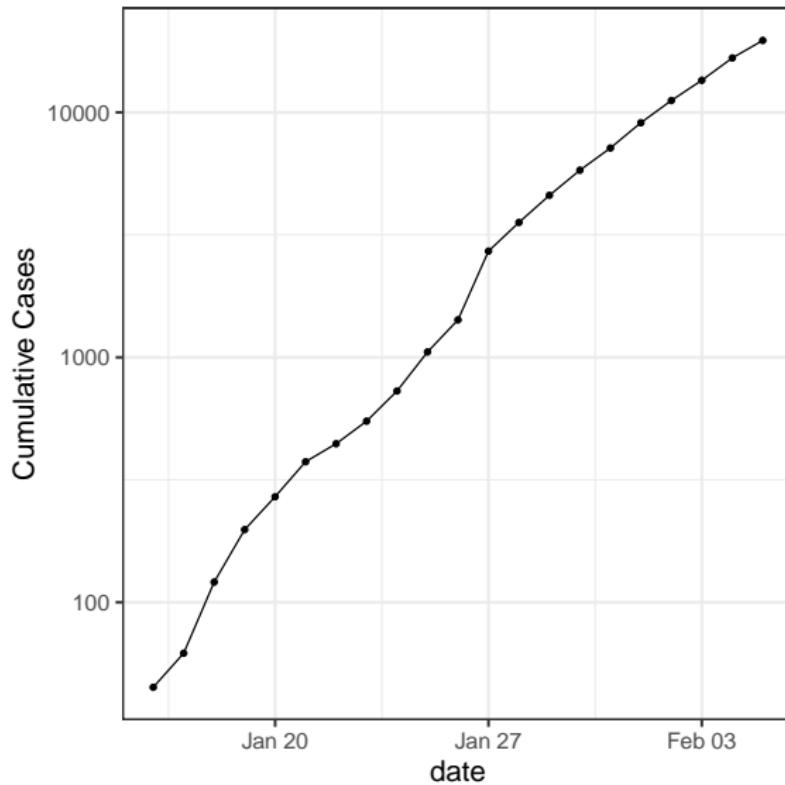
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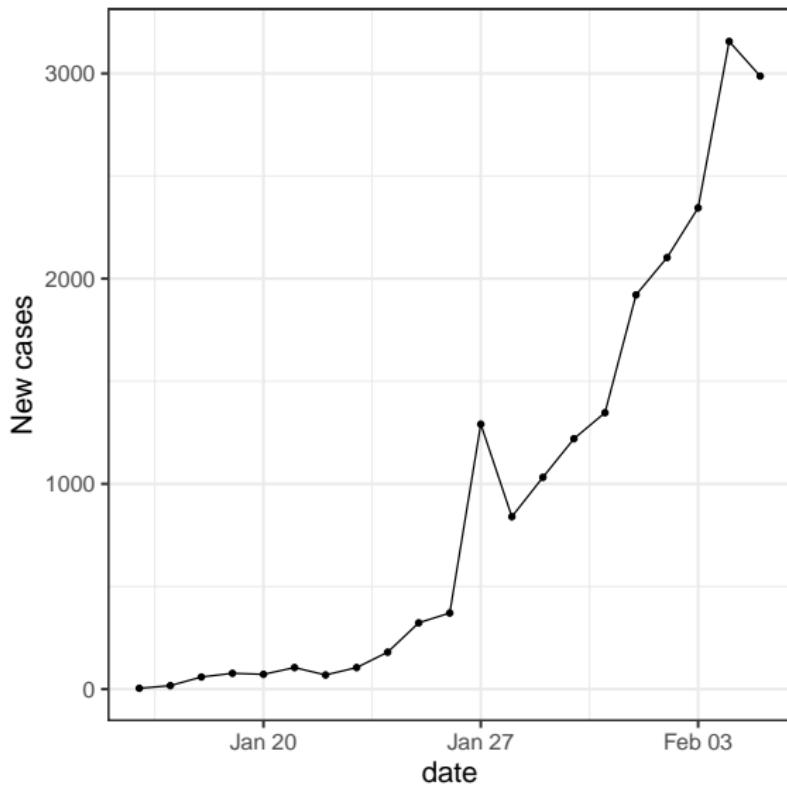
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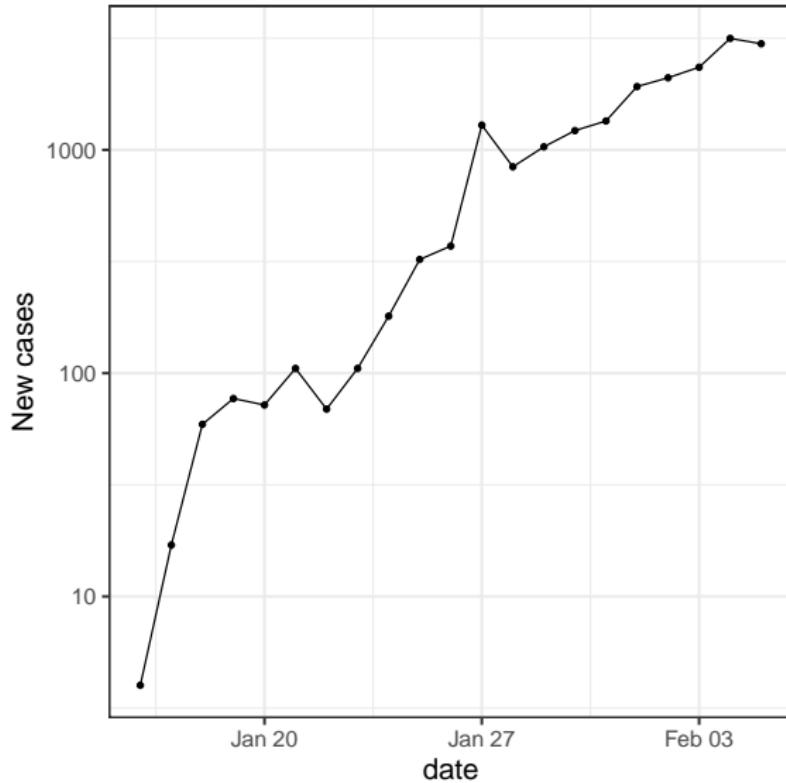
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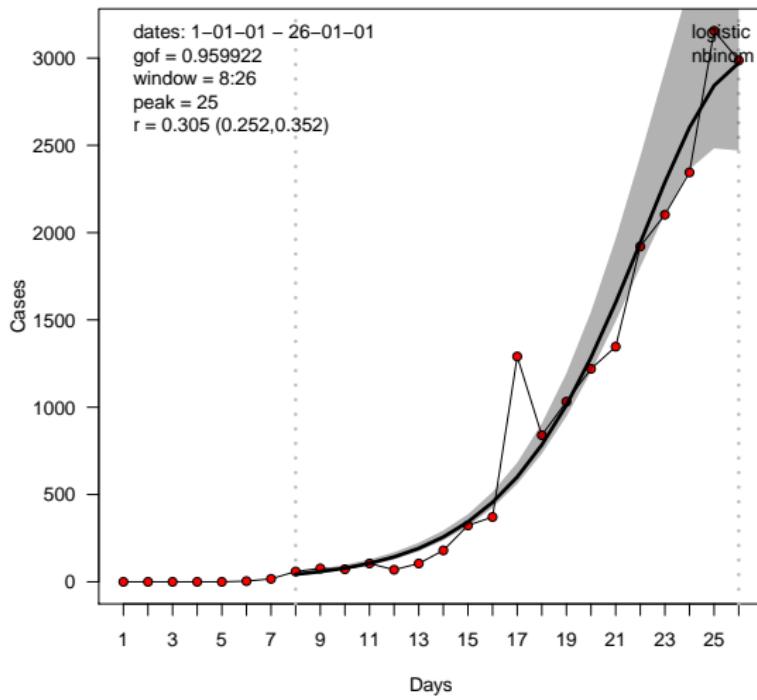
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Ma et al., 10.1101/211538-013-9918-2

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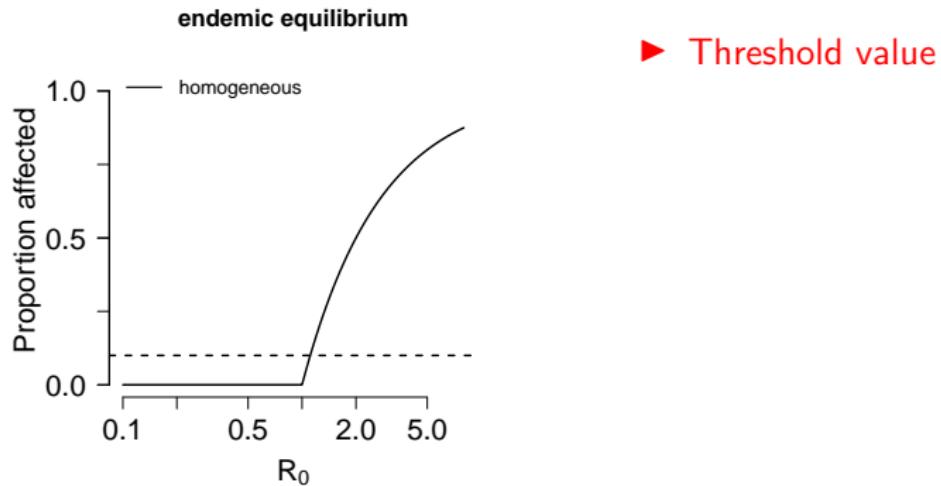


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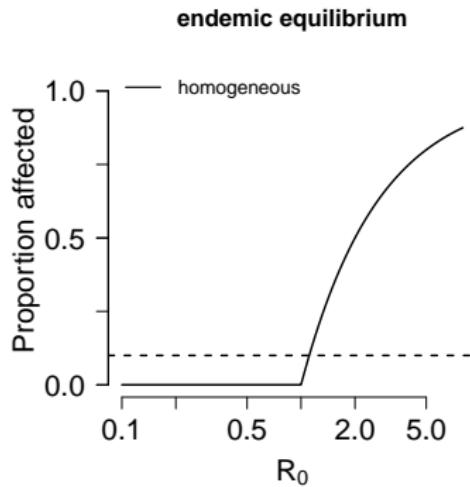
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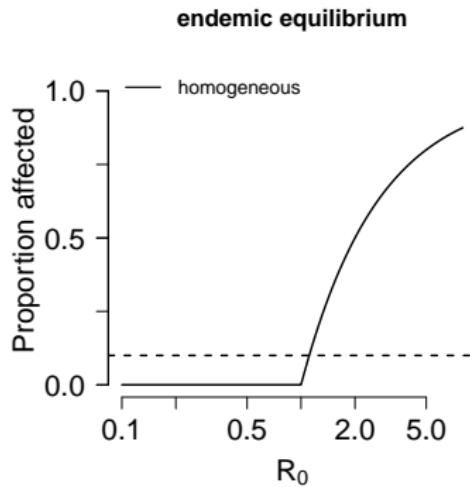


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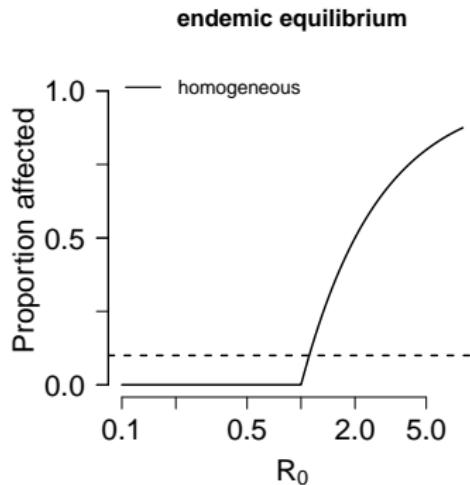
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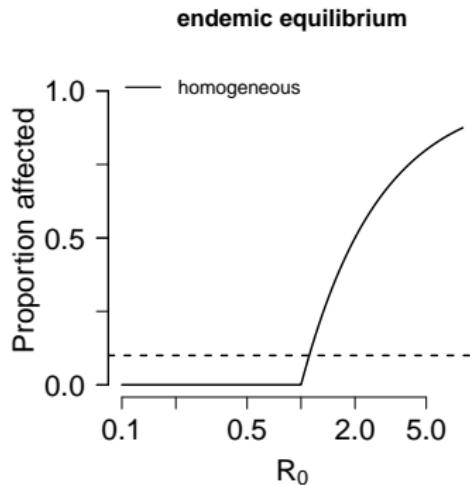
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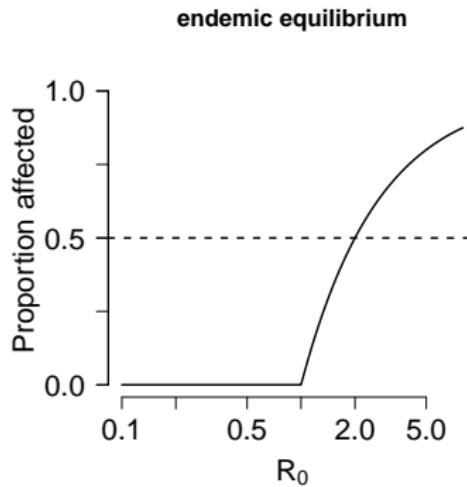
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Yellow fever in Panama



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Linking

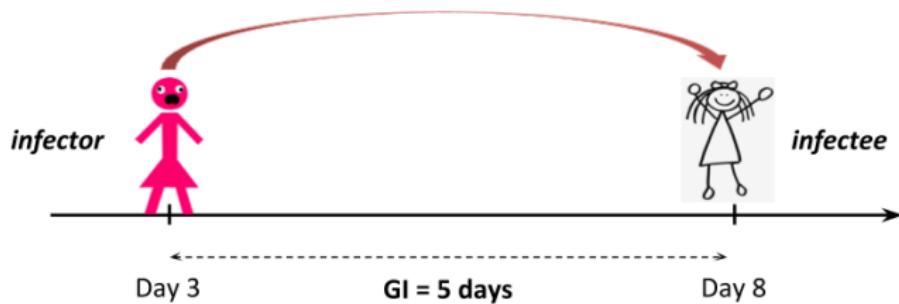
- ▶ We're very interested in the relationship between little r and \mathcal{R} .
- ▶ We might have good estimates of r and want to know more about equilibrium burden or expected outbreak size
 - ▶ e.g., West African Ebola outbreak, HIV in Africa
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How long is a disease generation?

Definition

Generation Interval:

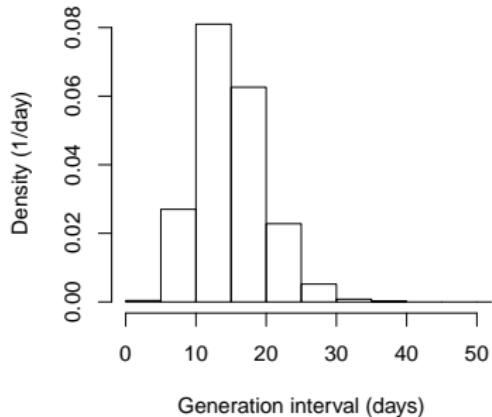
Interval between the time that an individual is infected by an infector and the time this infector was infected



Generation intervals

- The generation distribution measures the time between generations of the disease

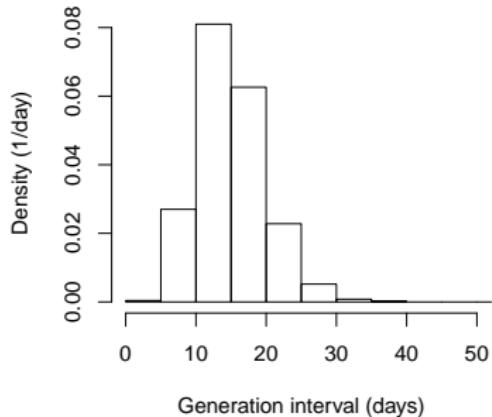
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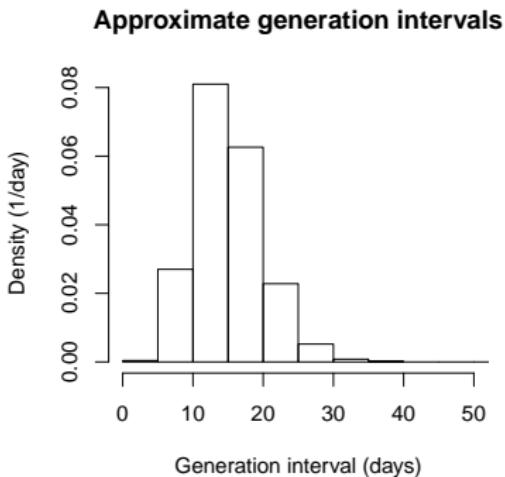
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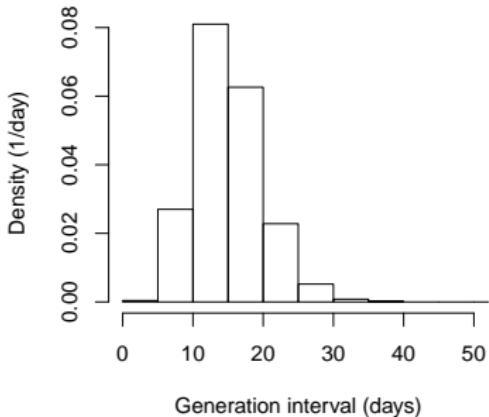
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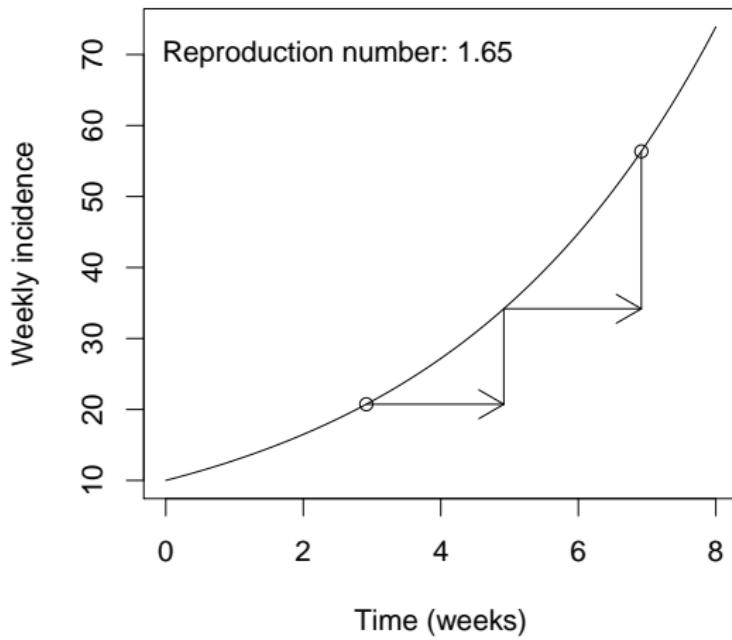
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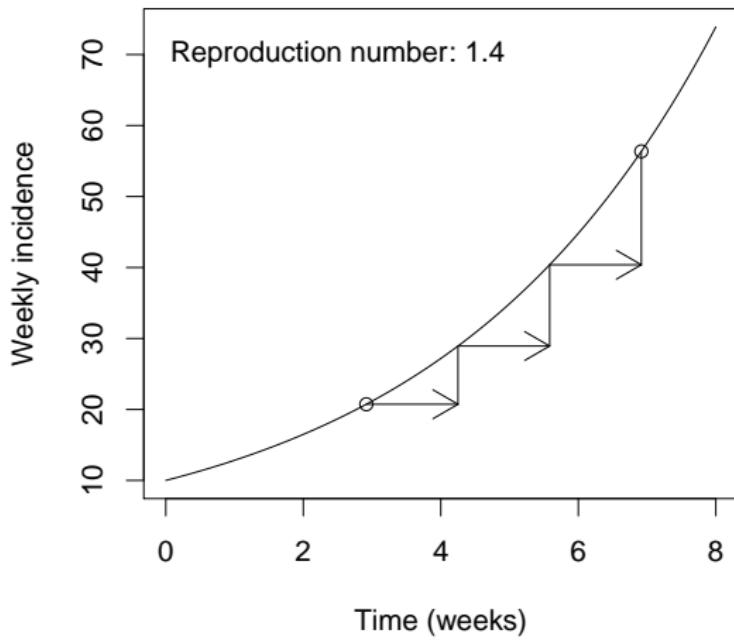
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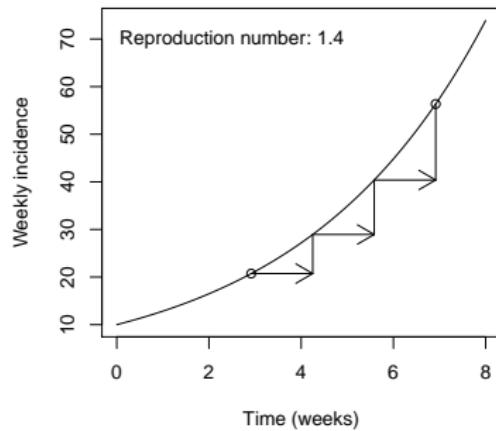
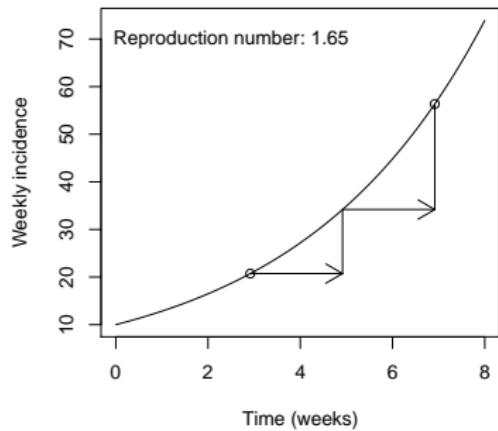
Generations and \mathcal{R}



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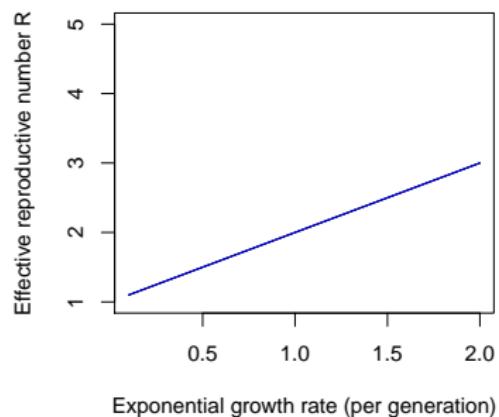
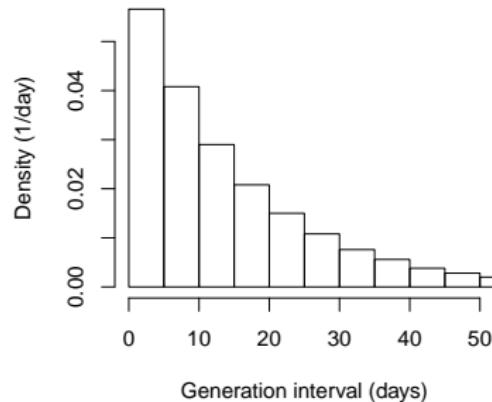
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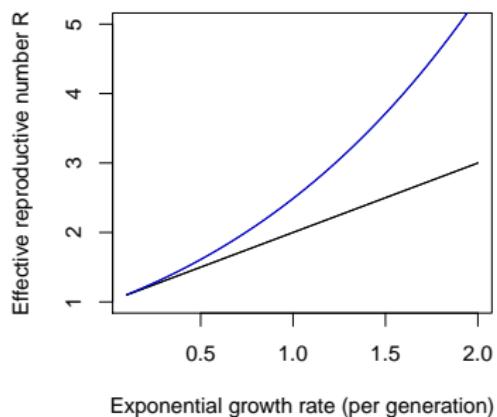
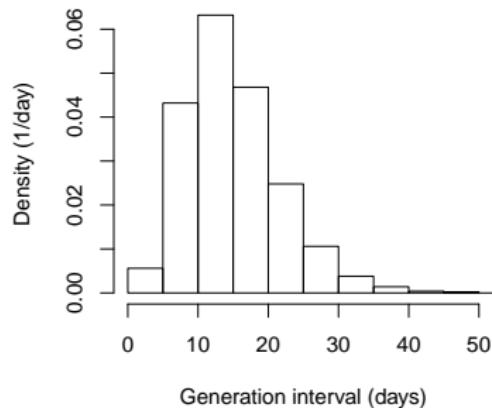
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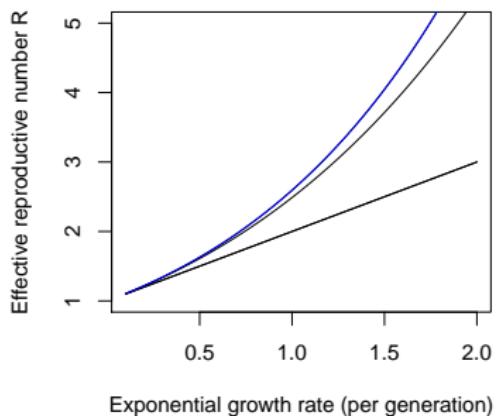
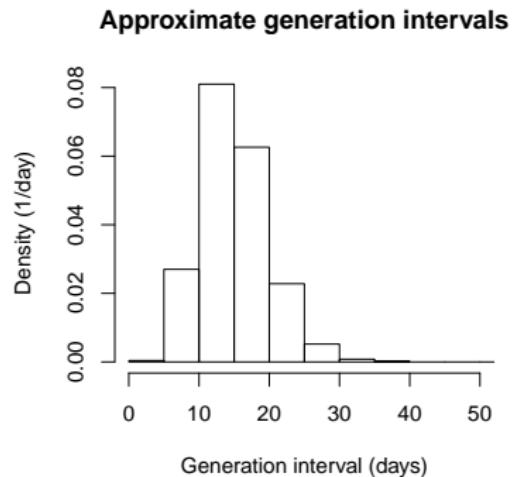


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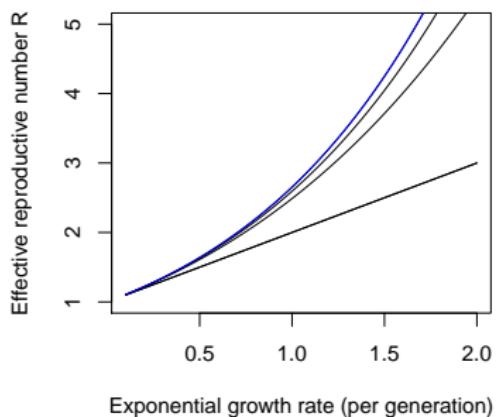
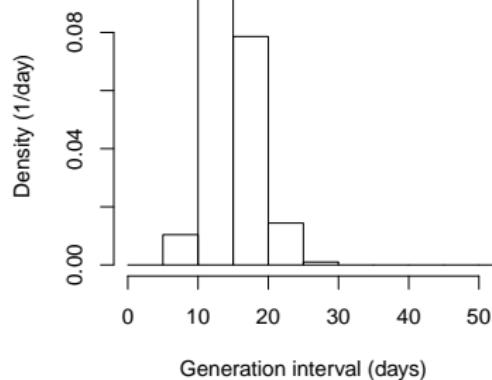


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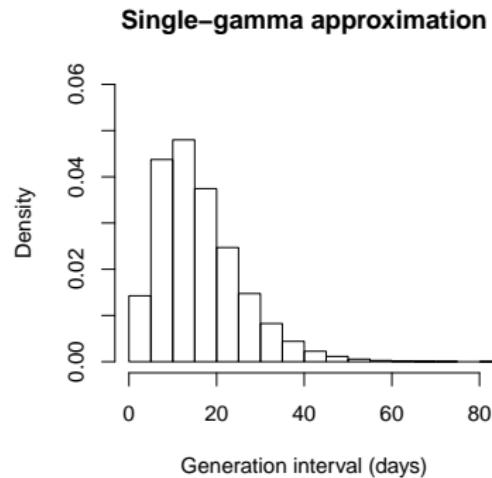
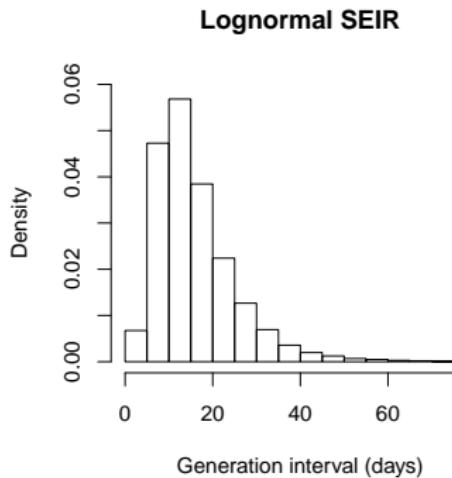
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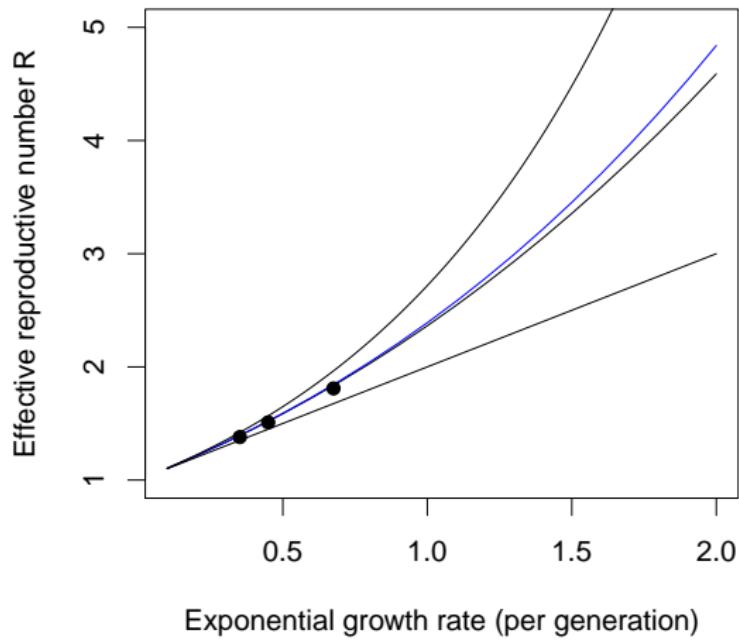
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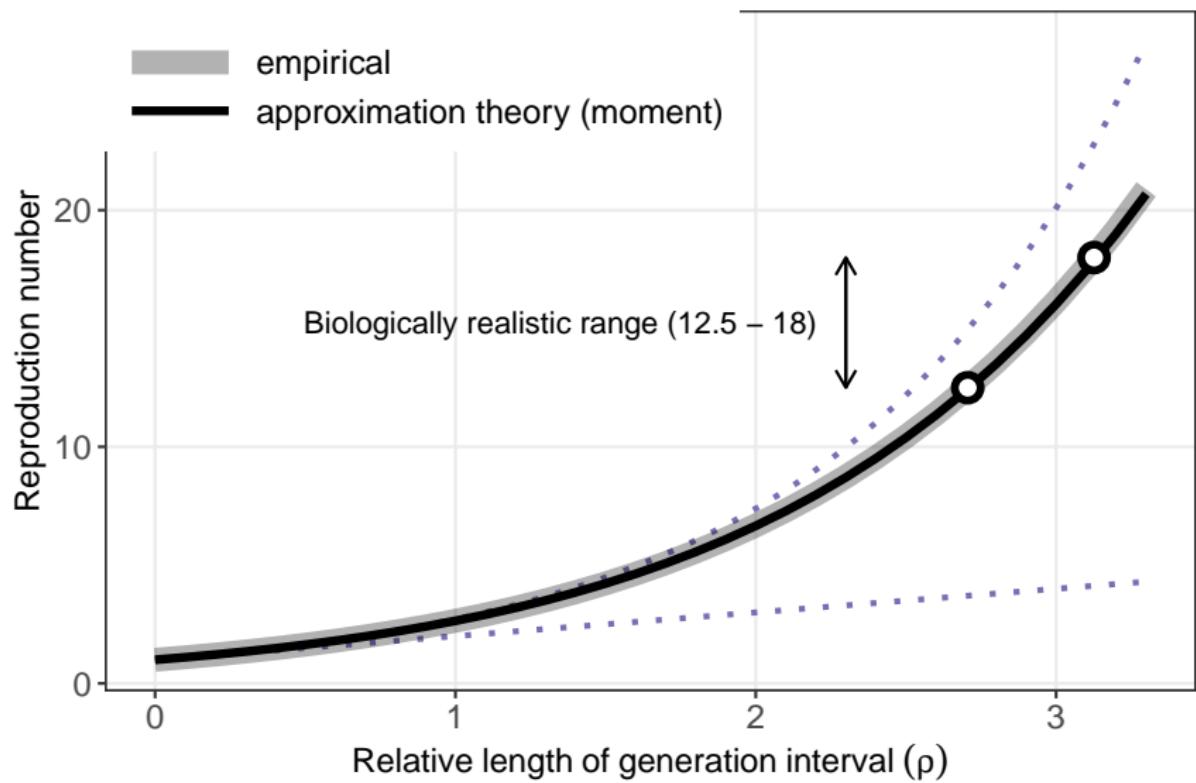
Ebola distribution



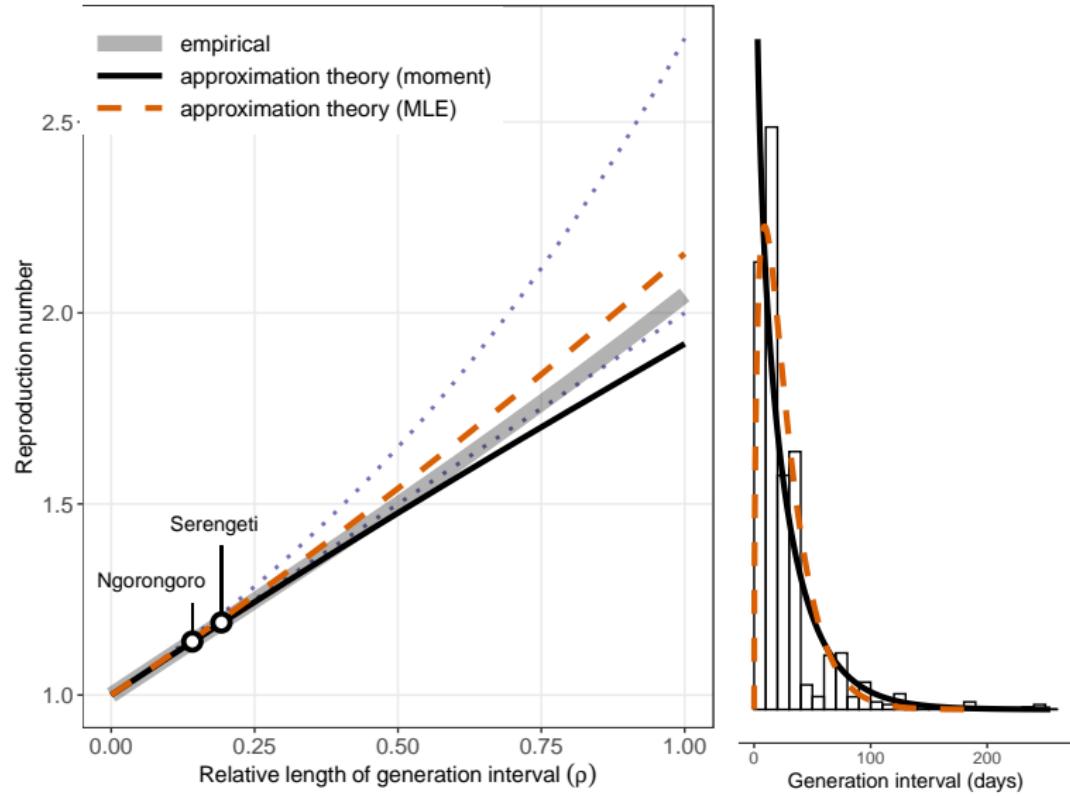
Ebola curve



Measles curve



Rabies curve



Outline

How deadly?

Dynamical modeling

Speed and strength

Epidemic

Epidemic strength

Linking

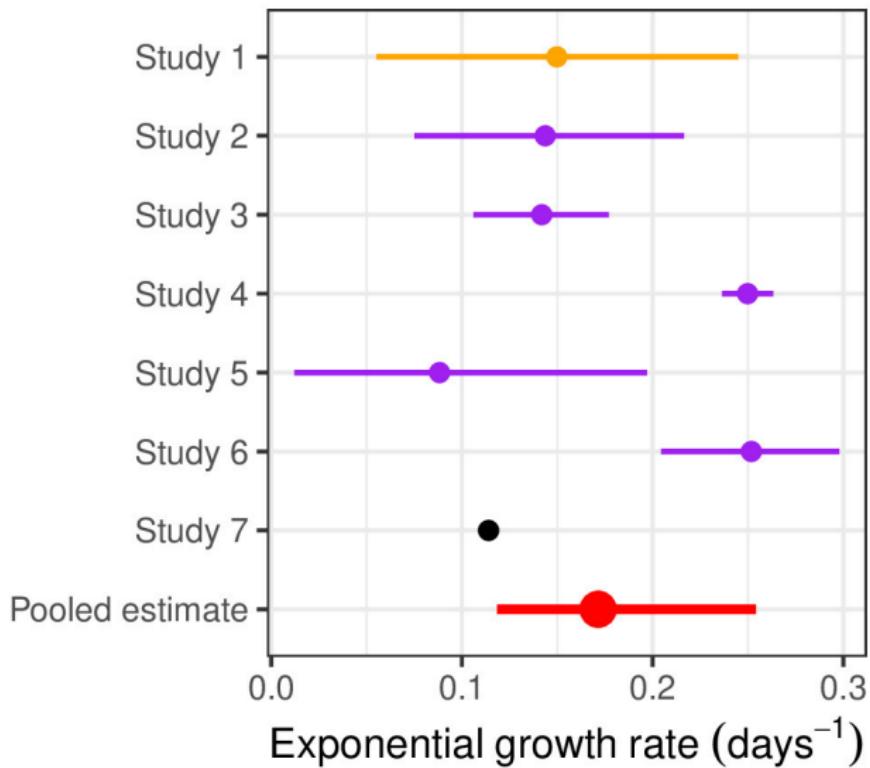
Propagating error in novel coronavirus

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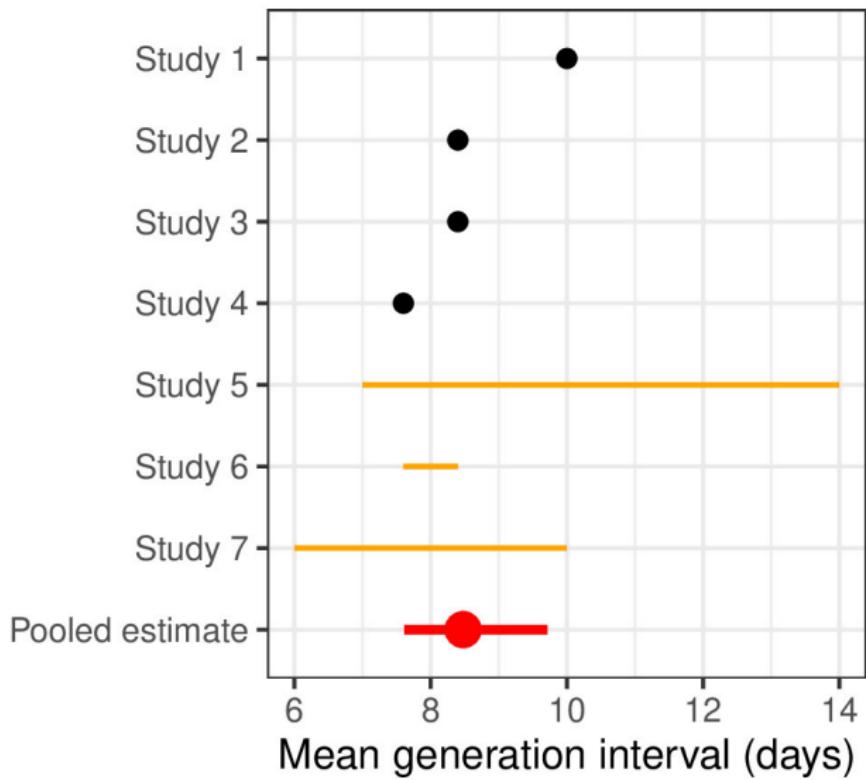
Measuring generation intervals



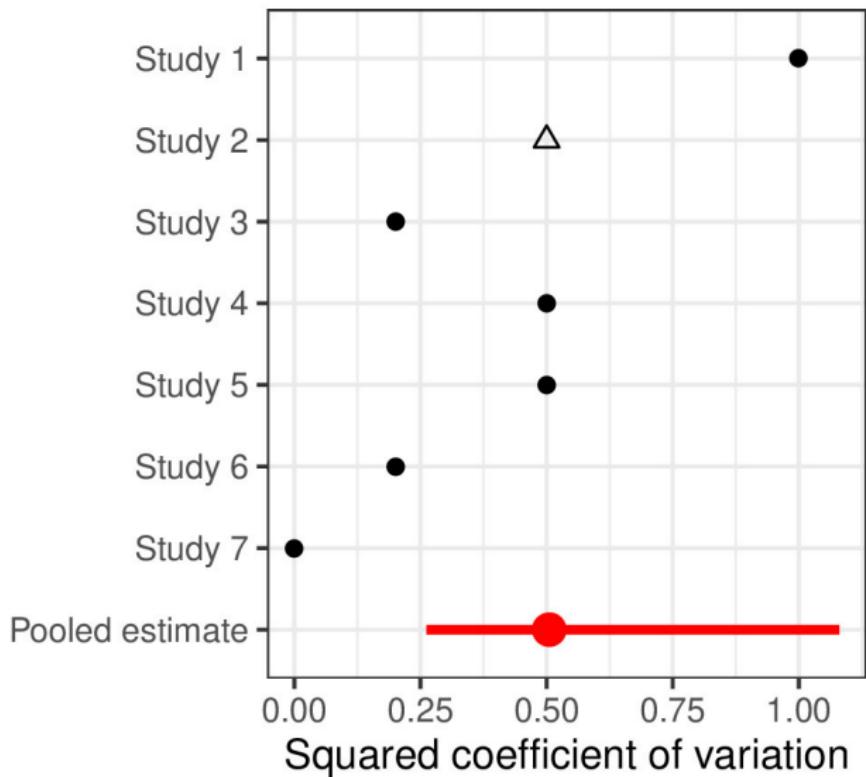
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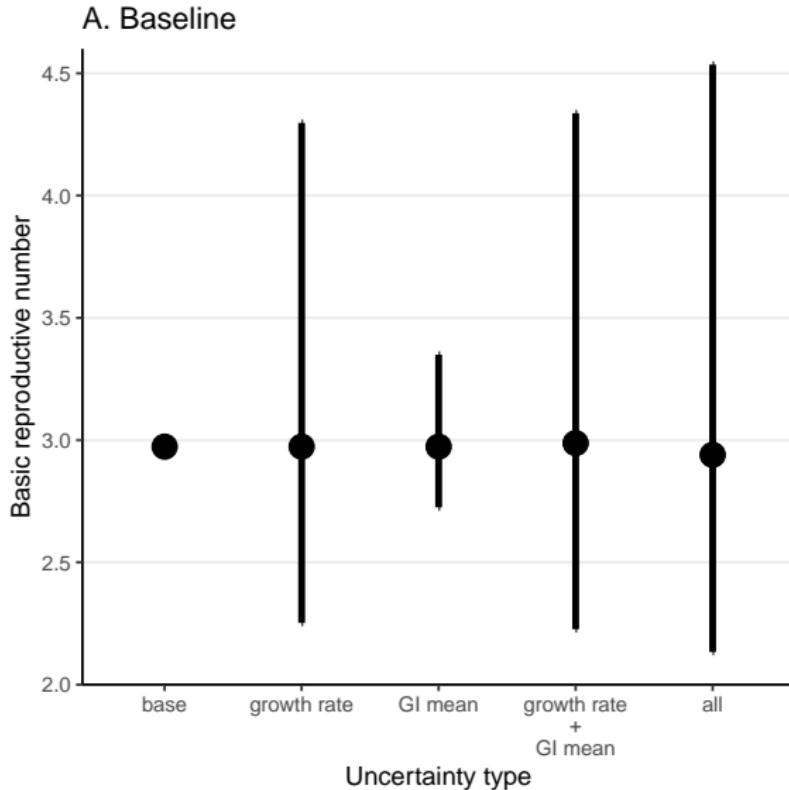
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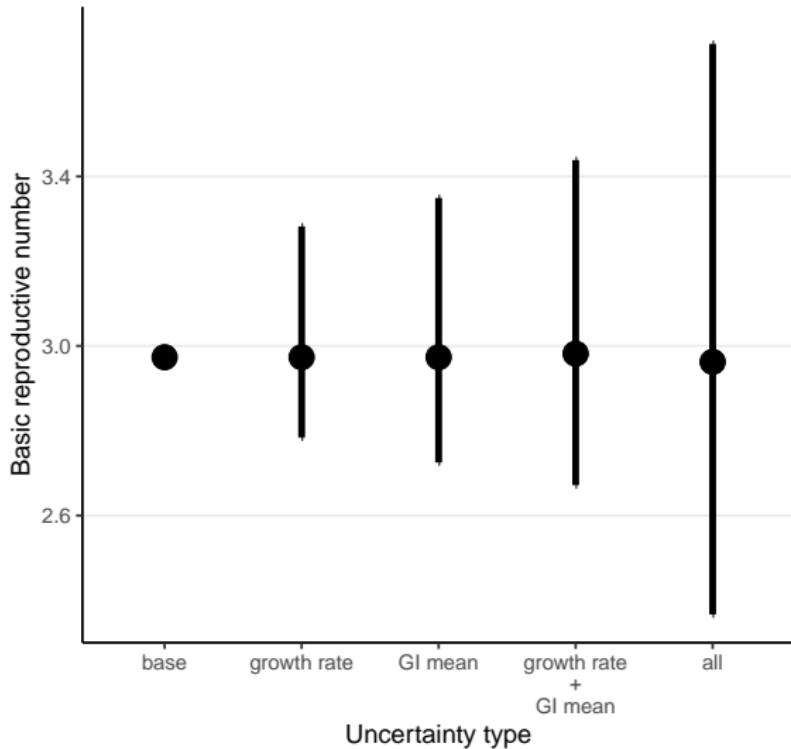


Propagating error



Propagating error

B. Reduced uncertainty in the growth rate



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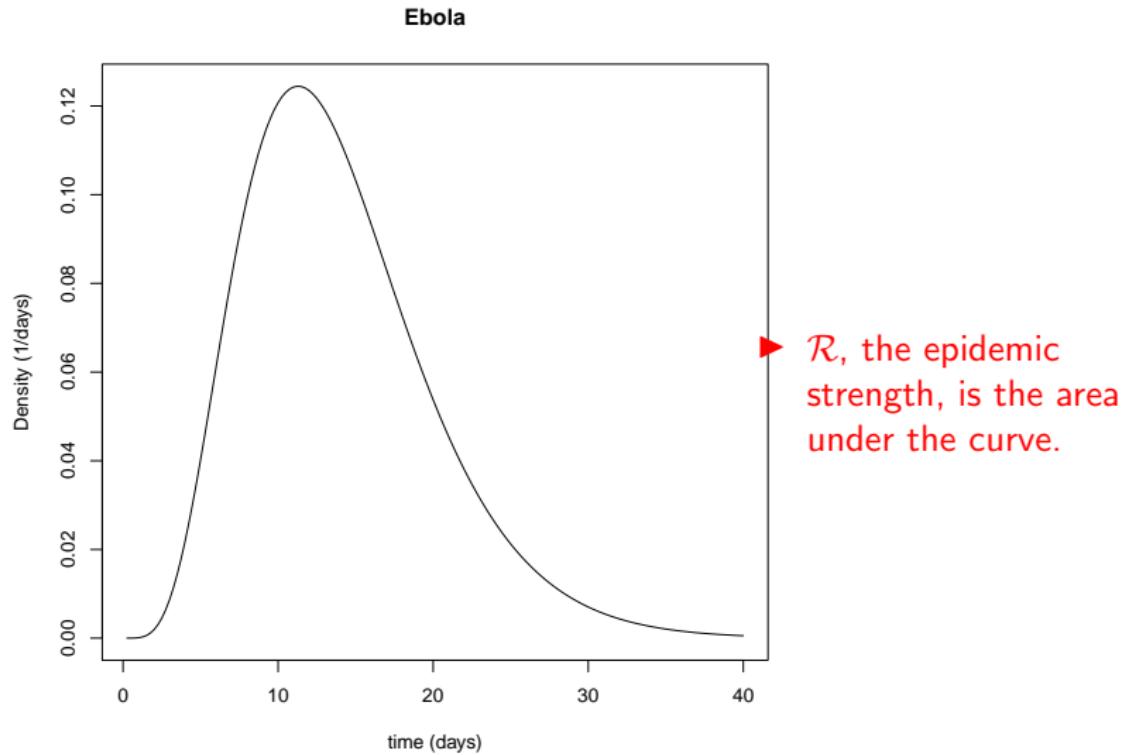
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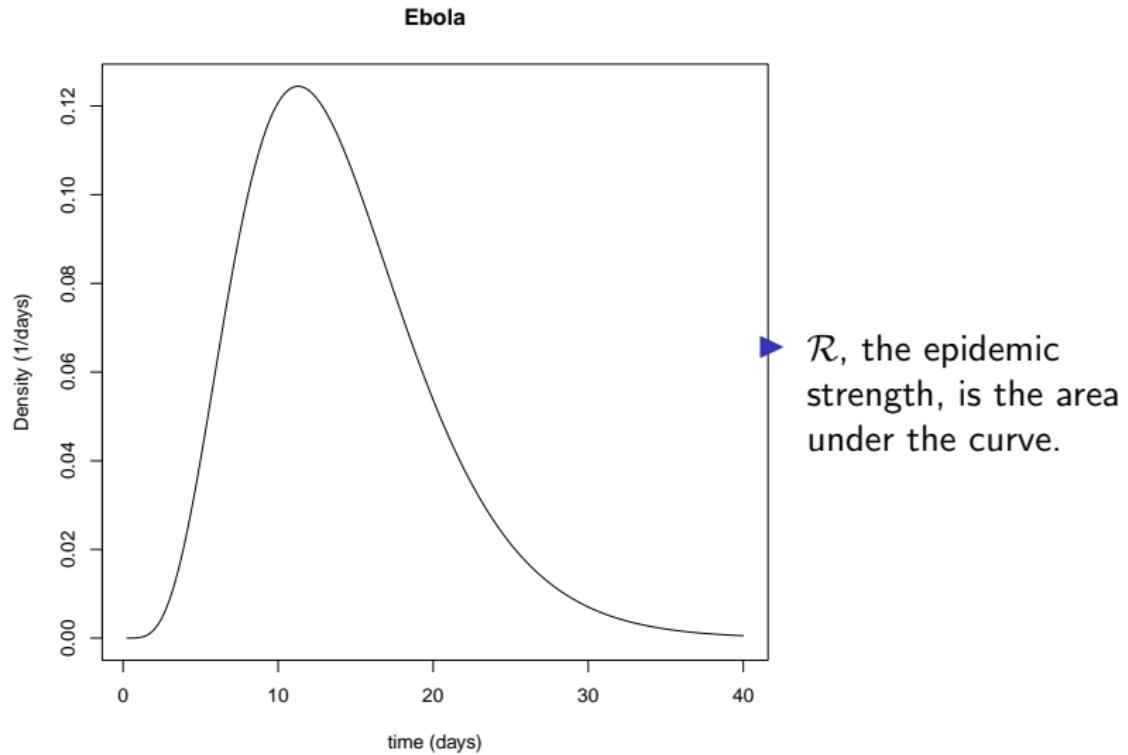
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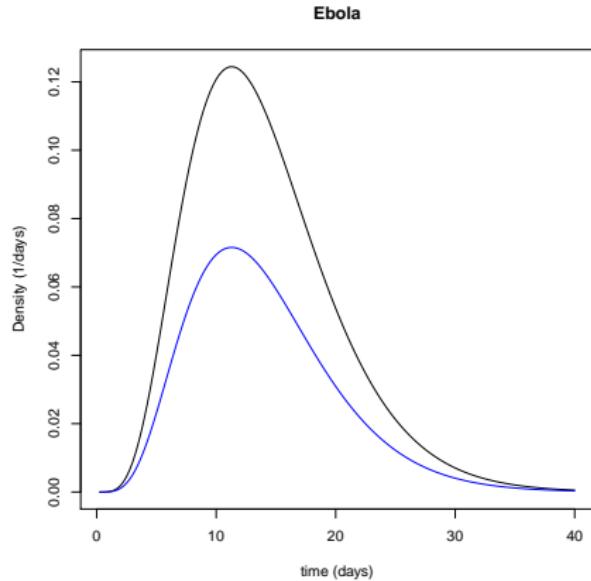
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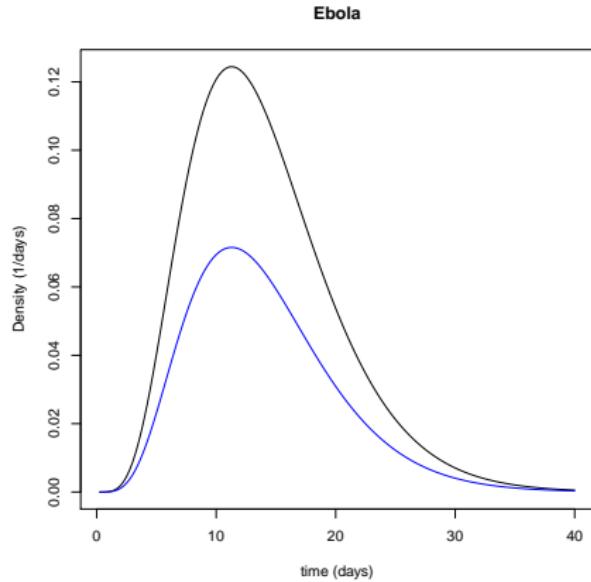


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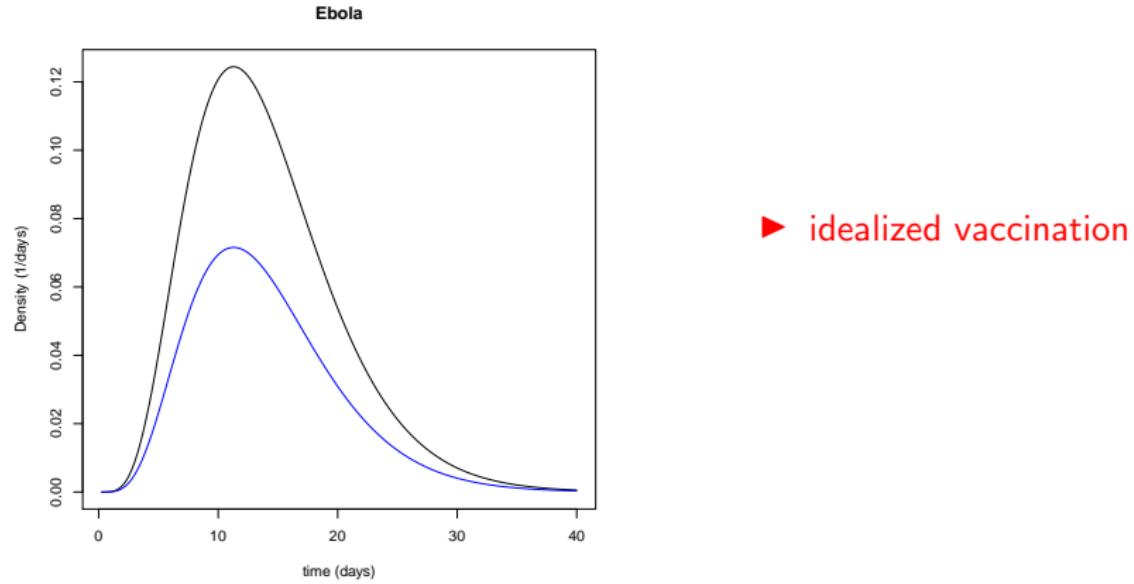
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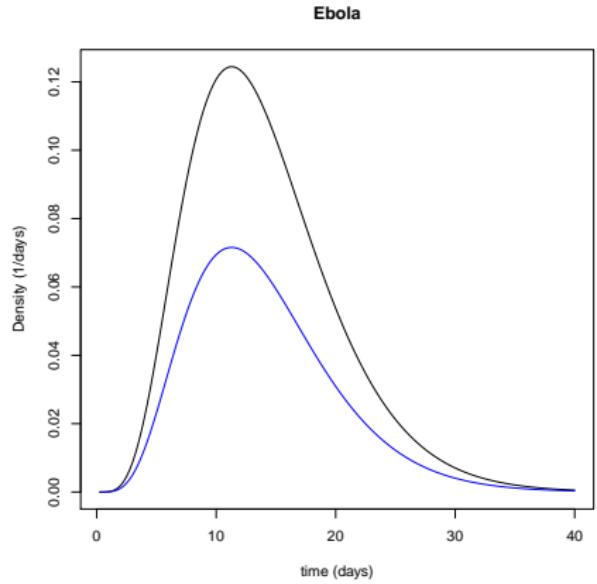


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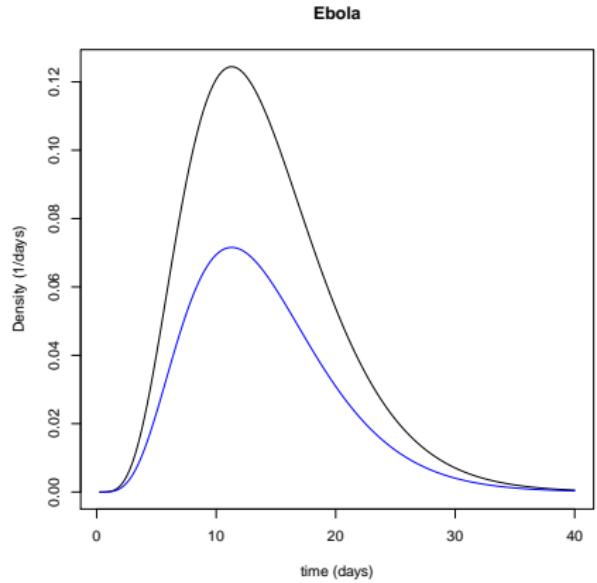


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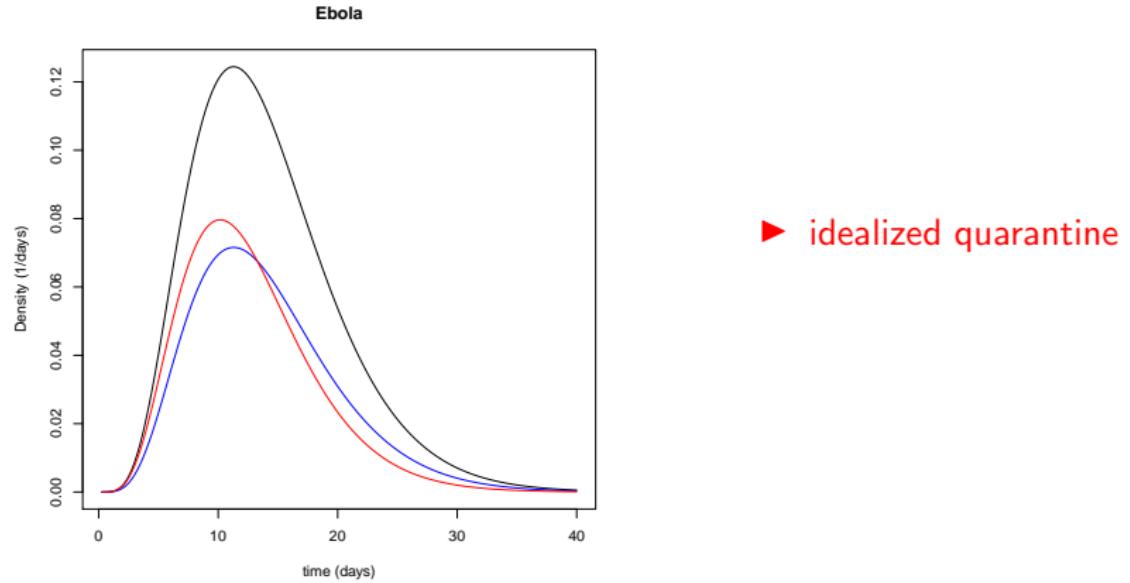
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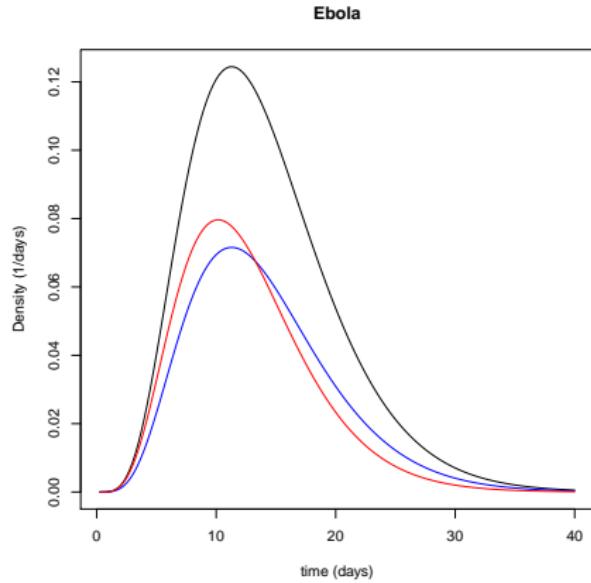


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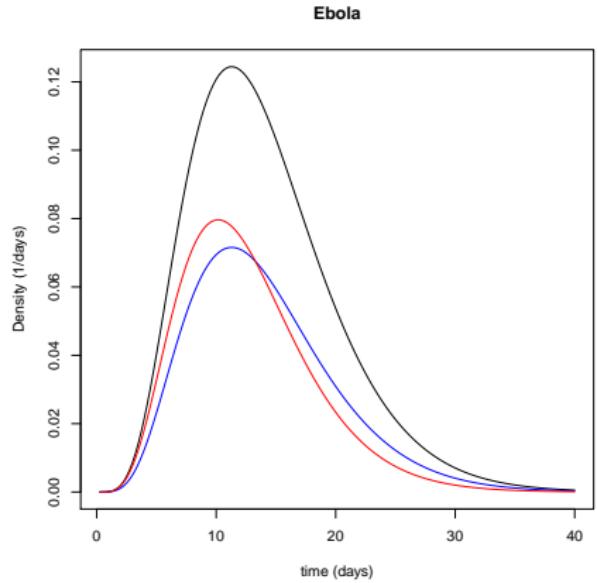


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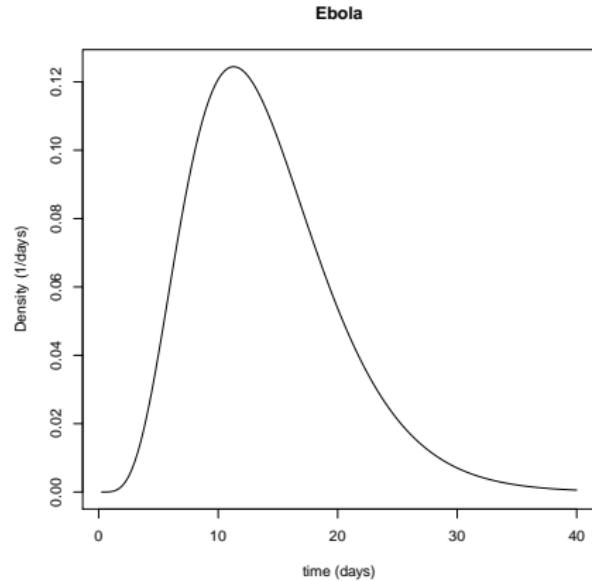
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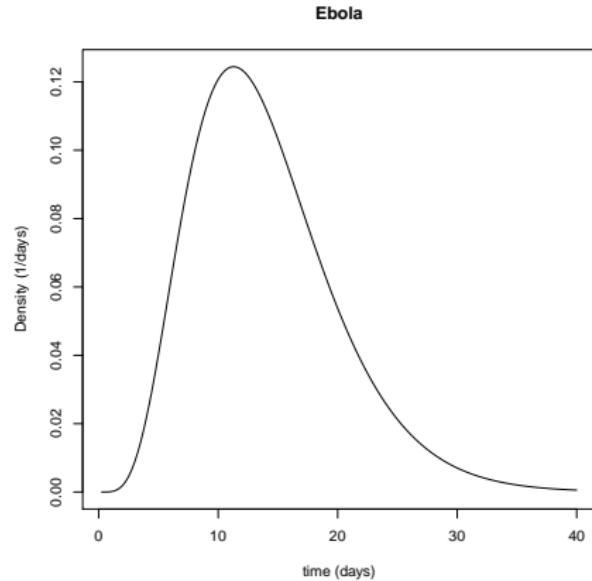
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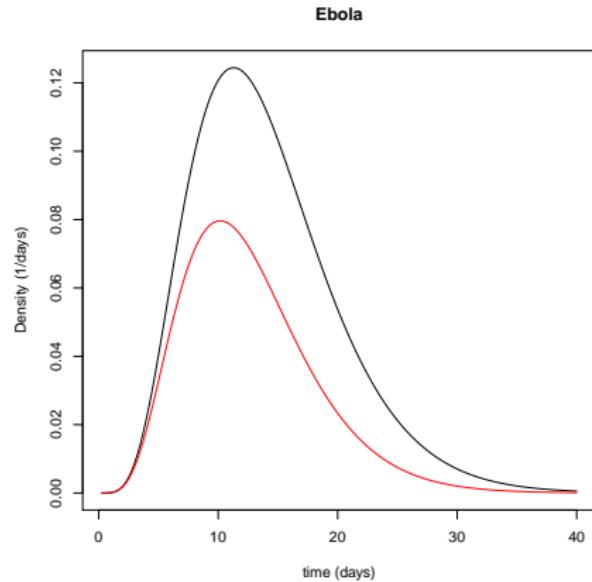
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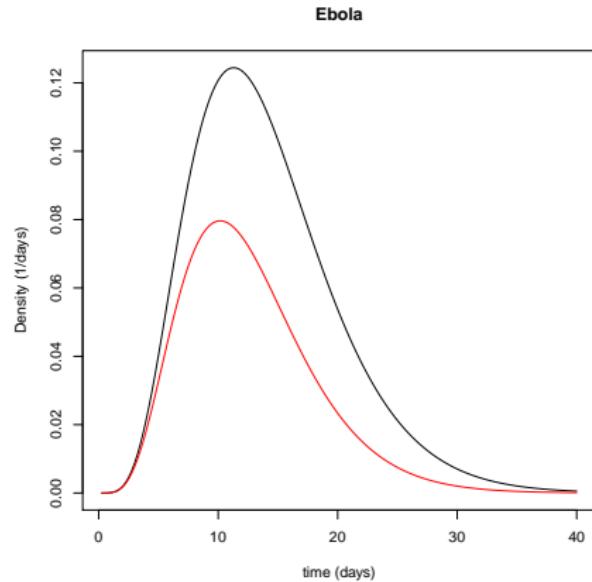
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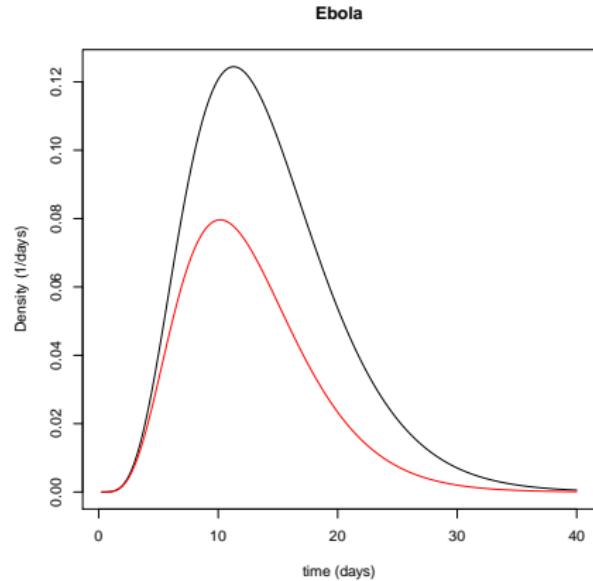
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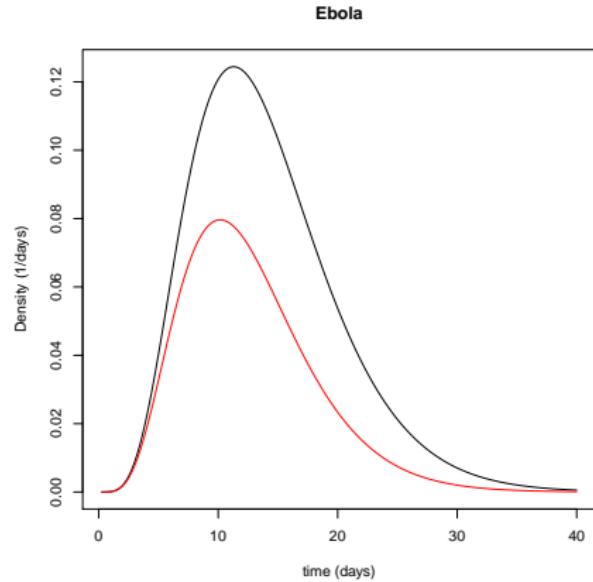
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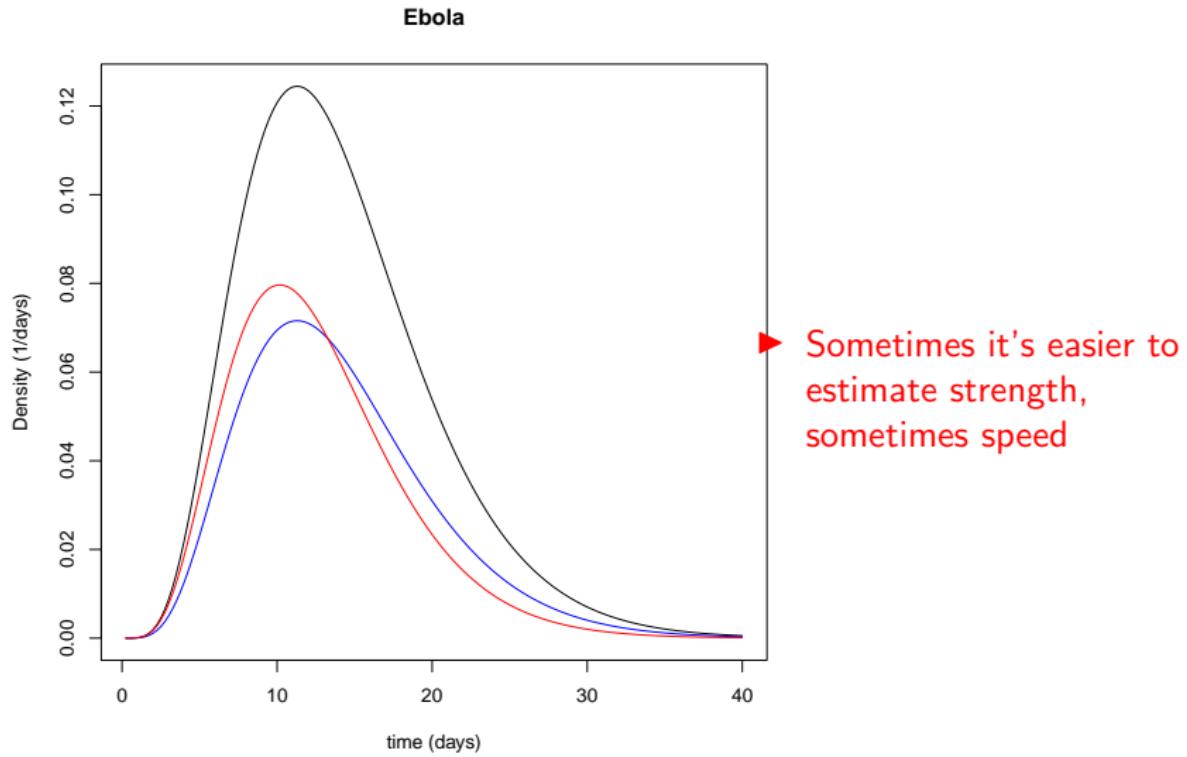
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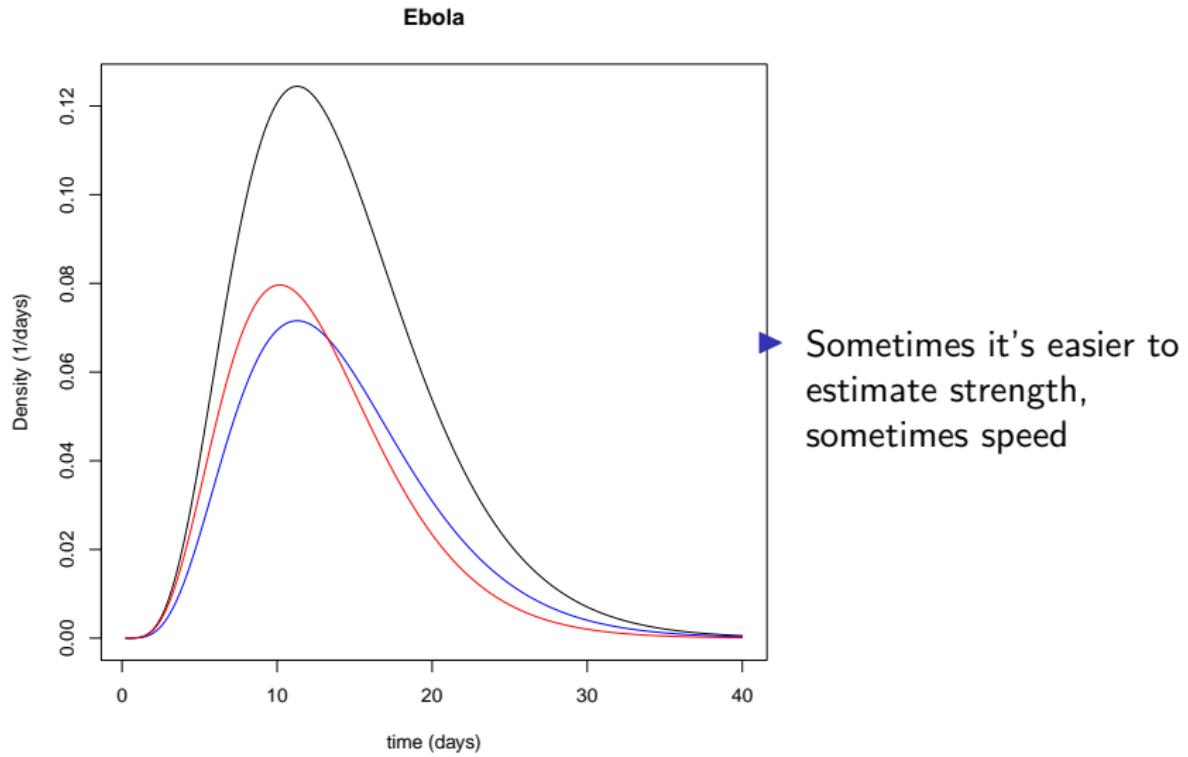


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Different interventions



Different interventions



Measuring the intervention



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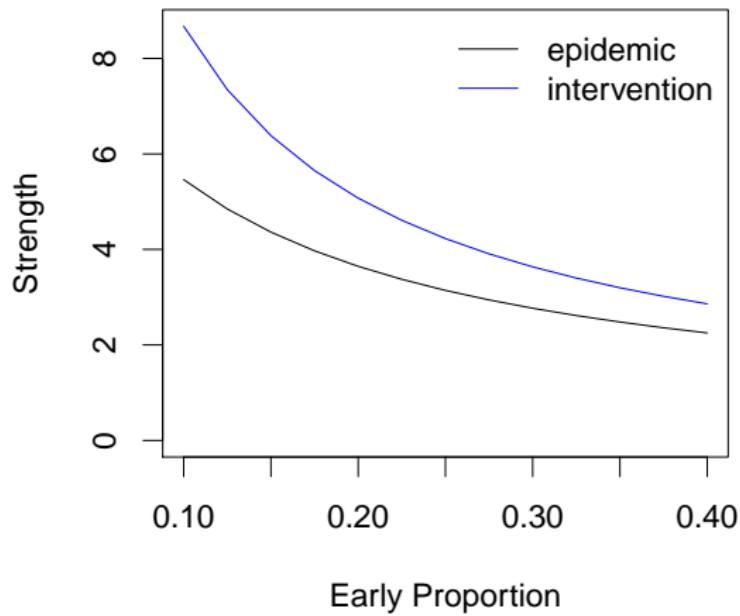
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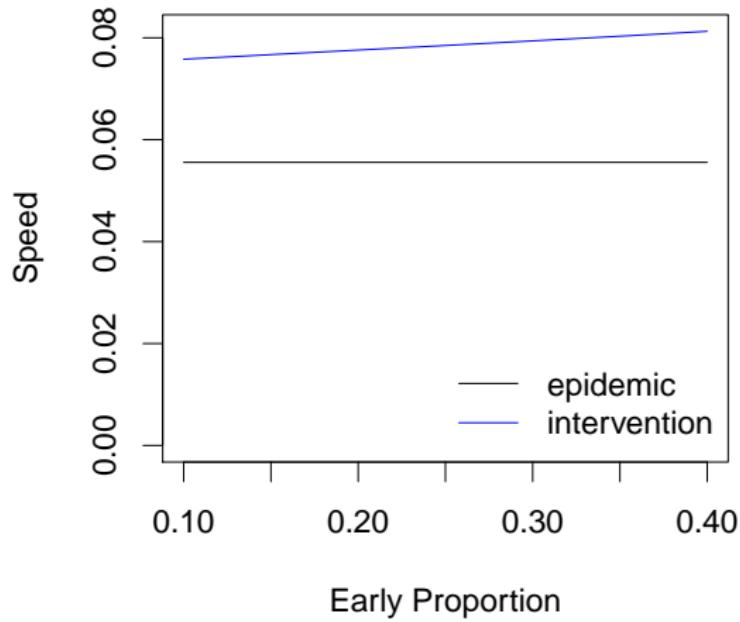
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Outline

How deadly?

Dynamical modeling

Speed and strength

Epidemic

Epidemic strength

Linking

Propagating error in novel coronavirus

A false dichotomy

Measuring generation intervals

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► Ad hoc methods

Measuring generation intervals



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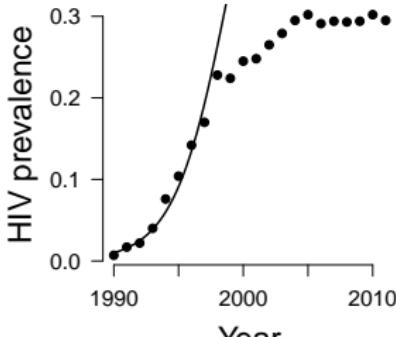
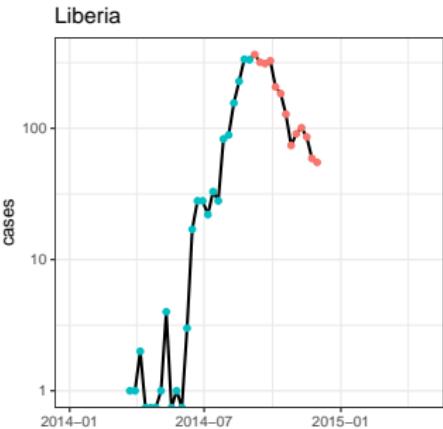
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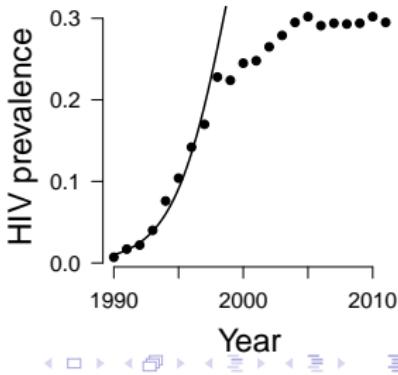
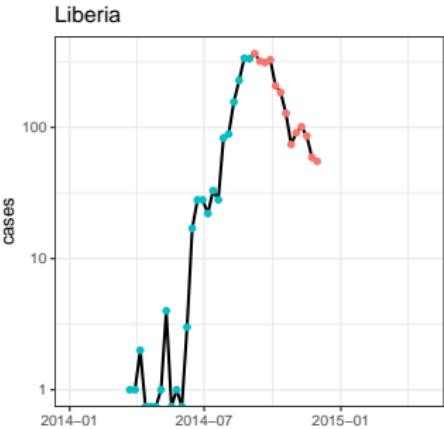
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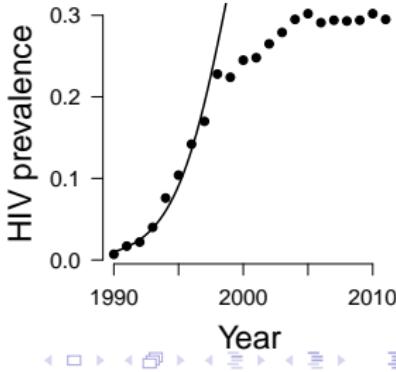
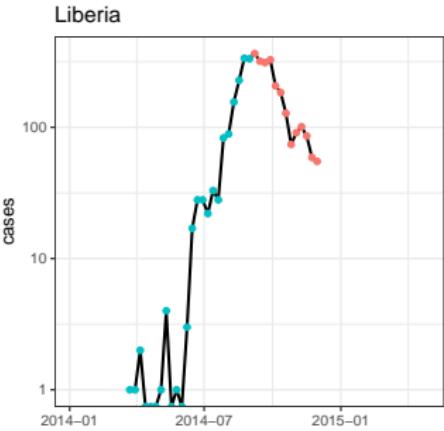
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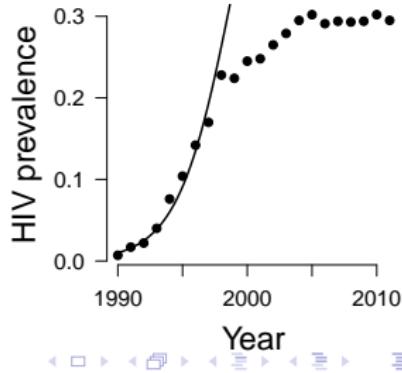
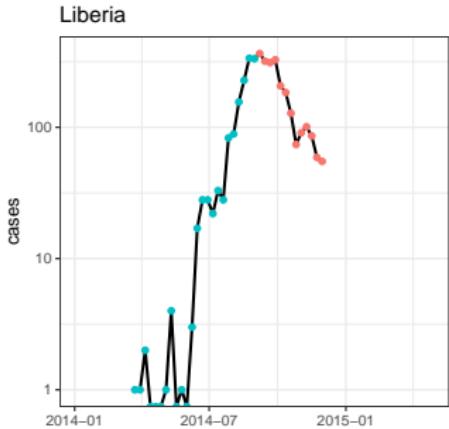
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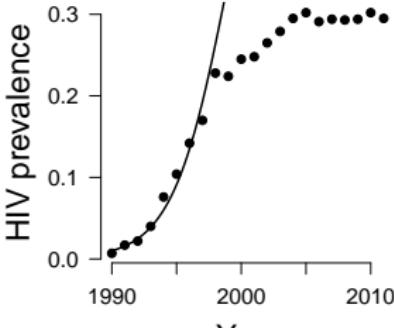
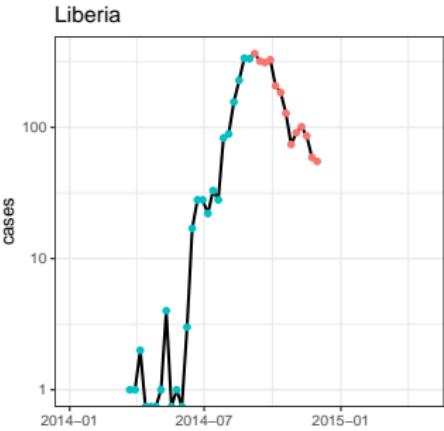
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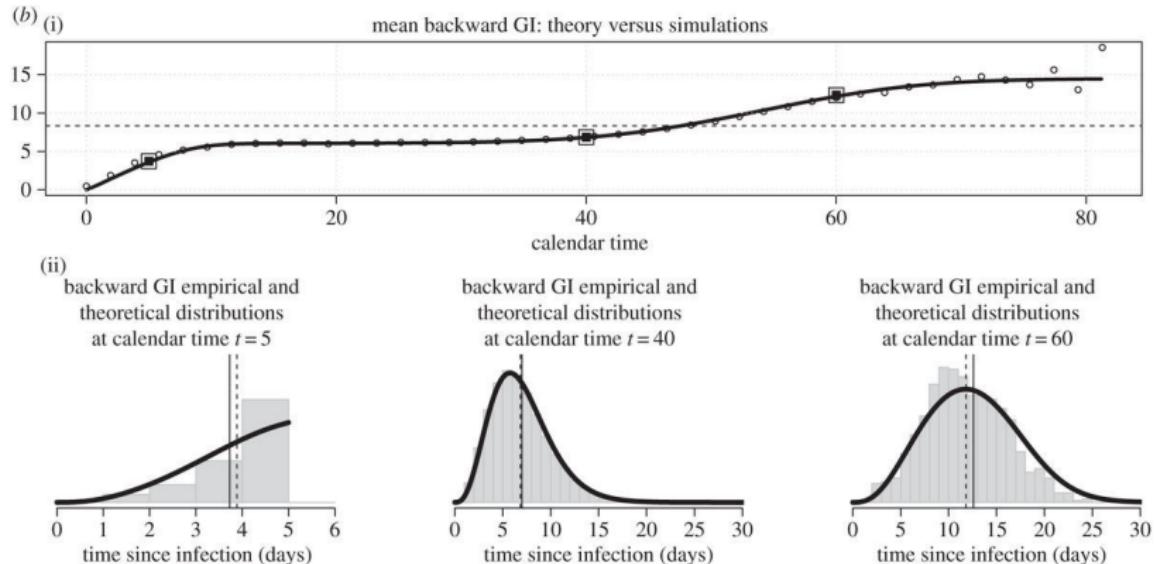


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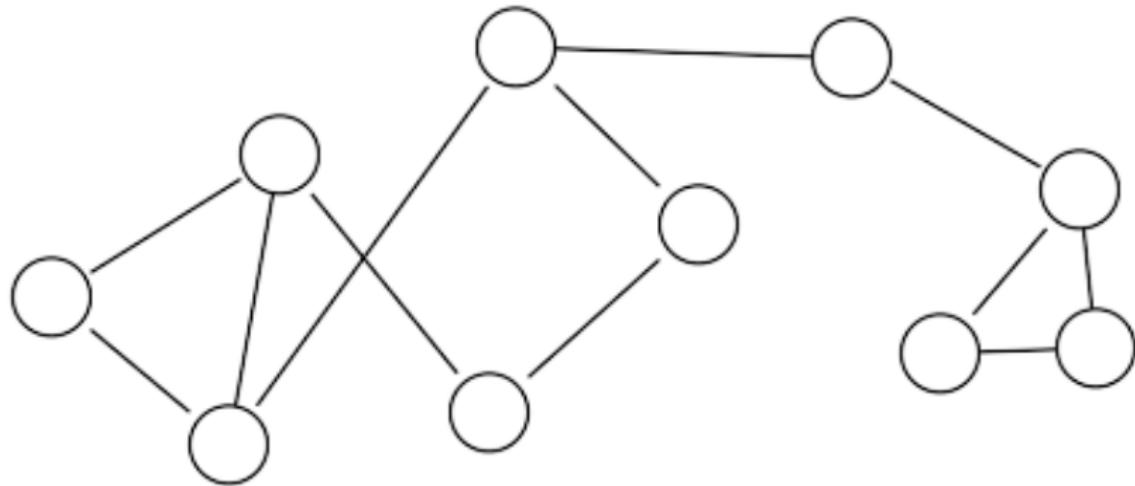
Champredon and Dushoff, 2015. DOI:10.1098/rspb.2015.2026

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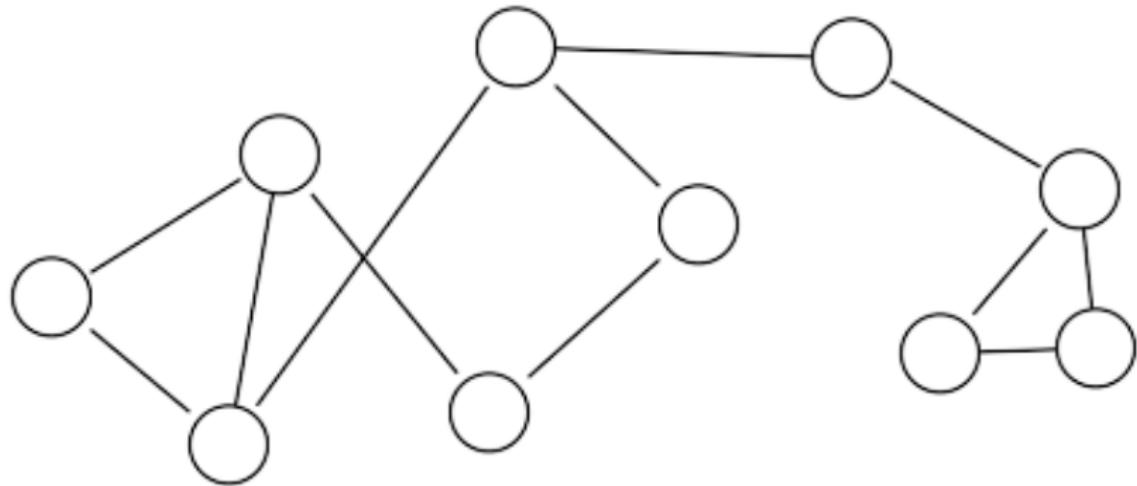
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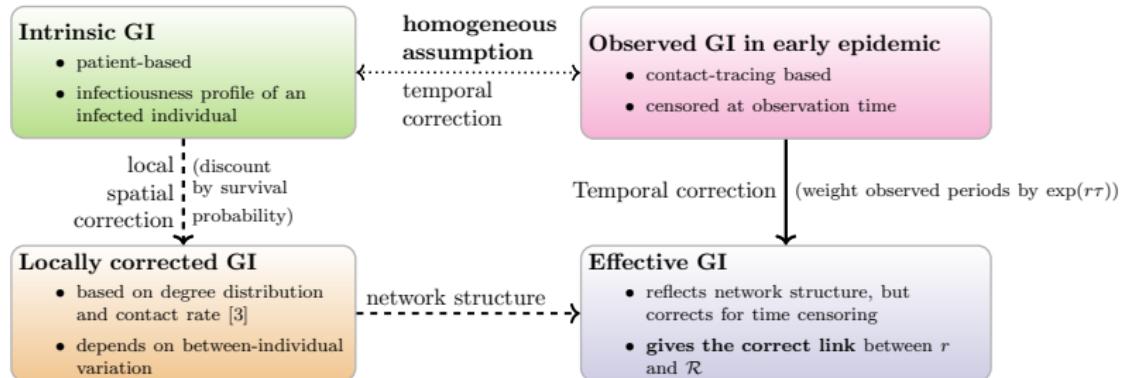
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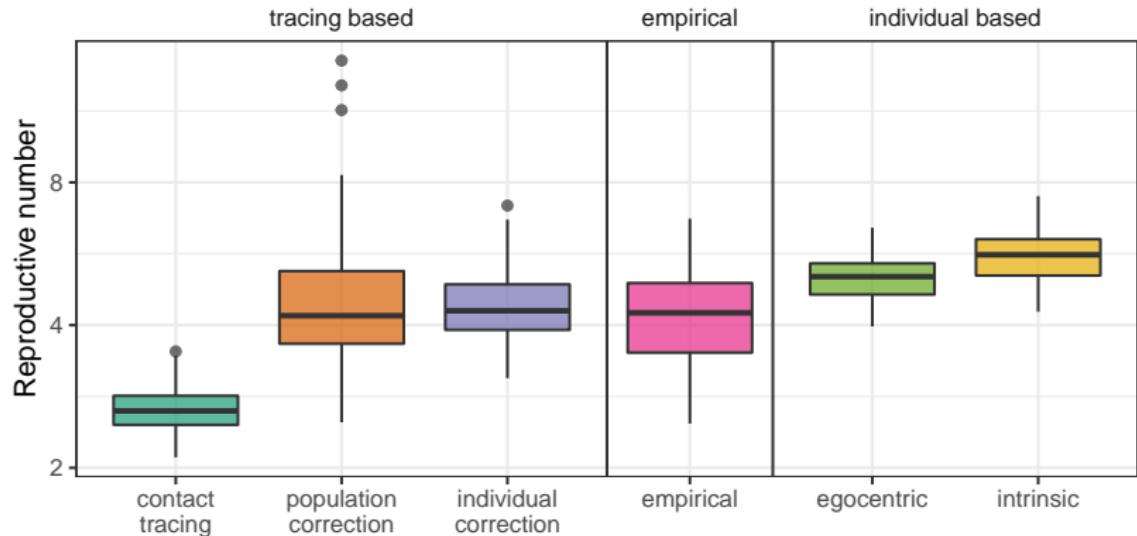
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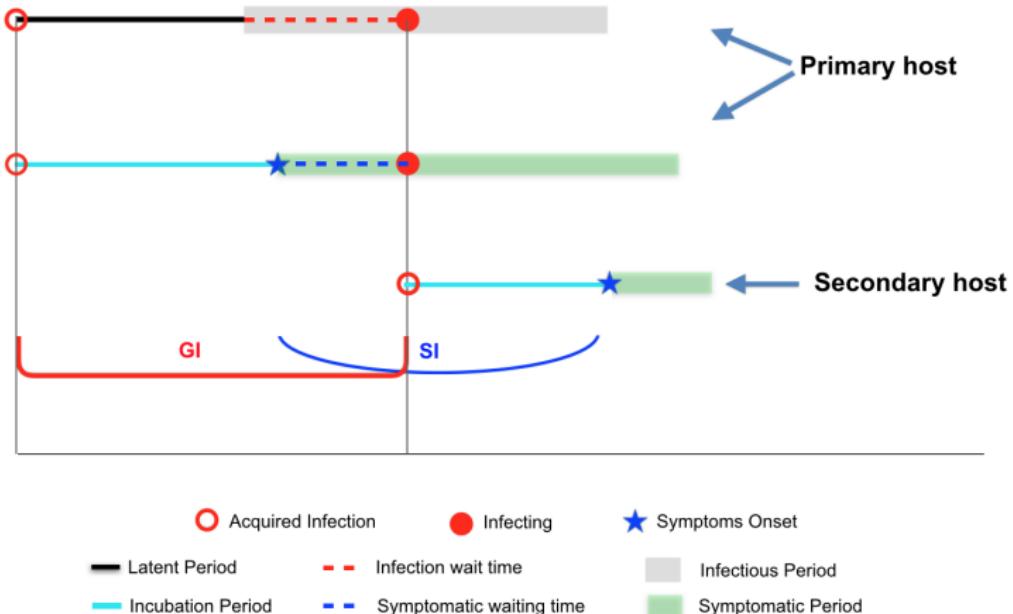
Observed and estimated intervals



Outbreak estimation



Serial intervals



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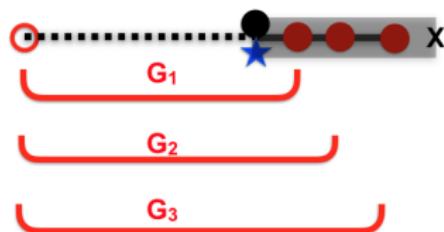
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Single Transmission



Multiple Transmissions



○ Getting Bitten

● Become Infectious

★ Clinical Signs

● Contact/Biting

··· Incubation Period

— Infectious Period

— Waiting Time

X Removed

Rabies

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Rabies

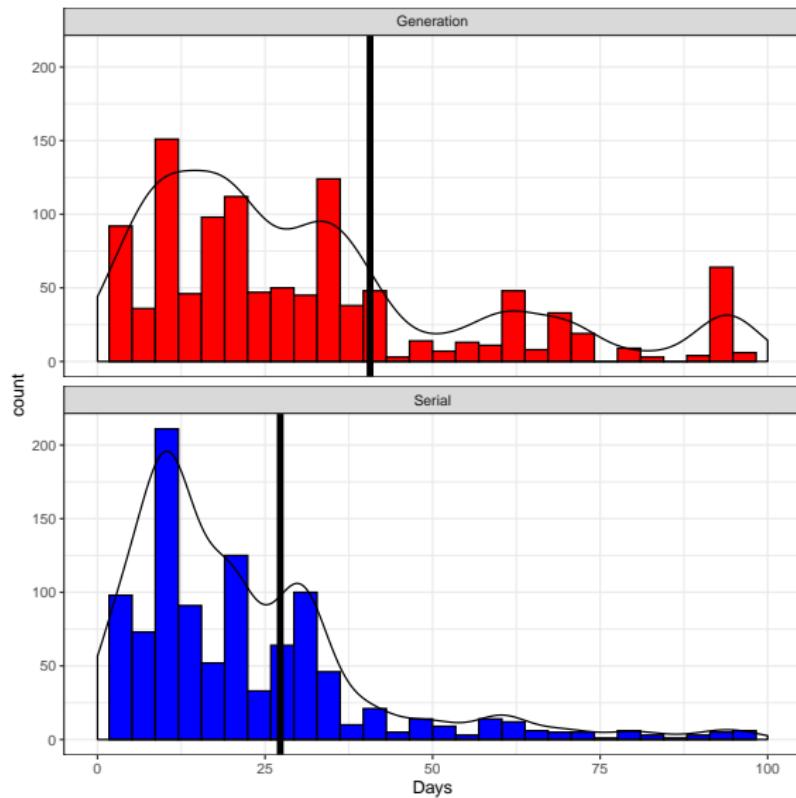
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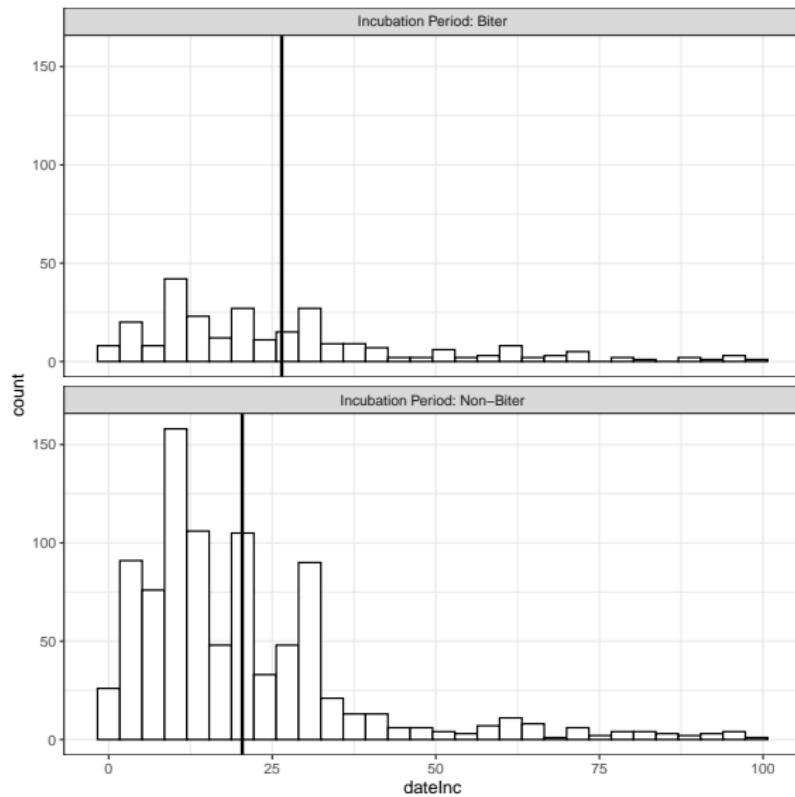
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