

Dynamical Modeling for Infectious Disease Policy

Importance and Challenges

Jonathan Dushoff, McMaster University

UNICEF McMaster, Mar 2025

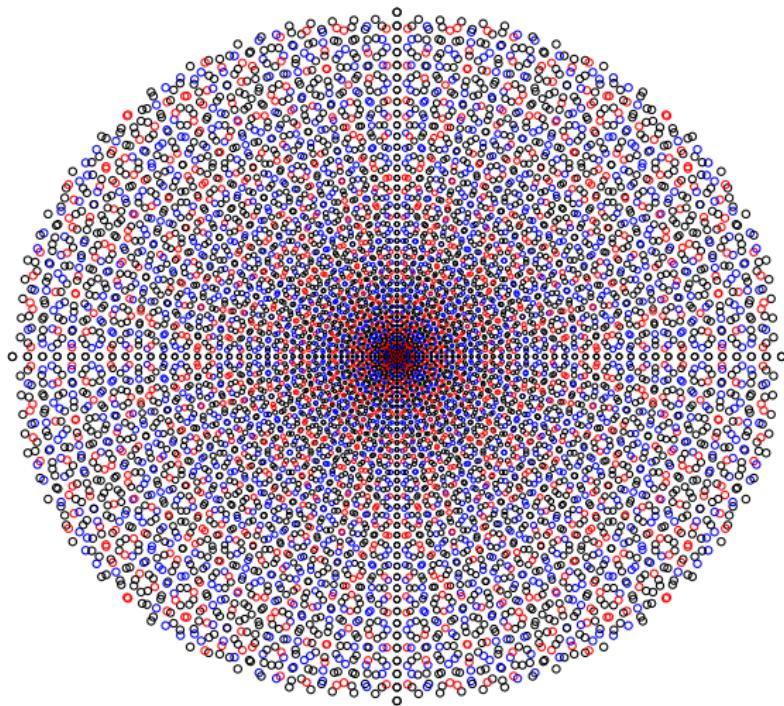
Origins



Exploration



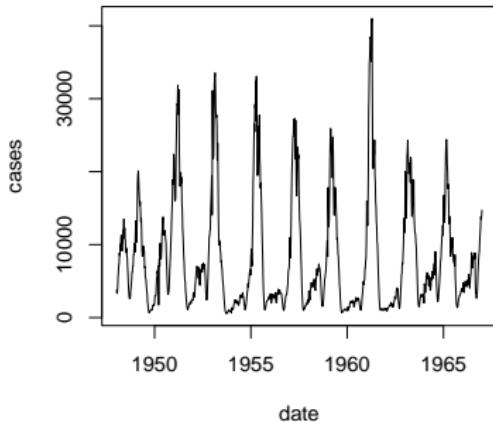
First love



Dynamical modeling connects scales



Measles reports from England and Wales

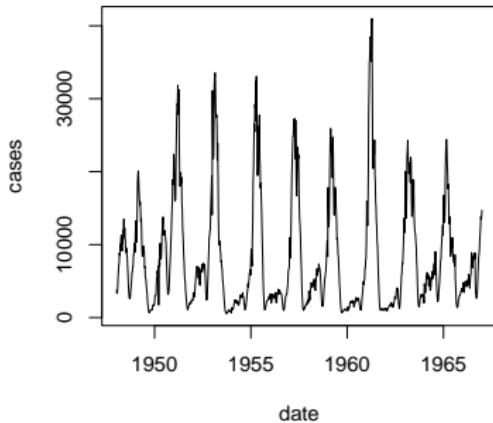


- ▶ Start with rules about how things change in short time steps

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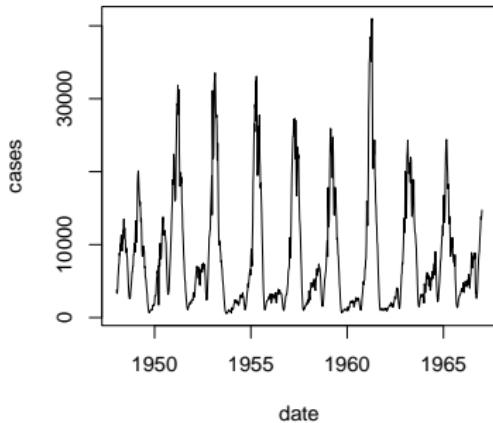


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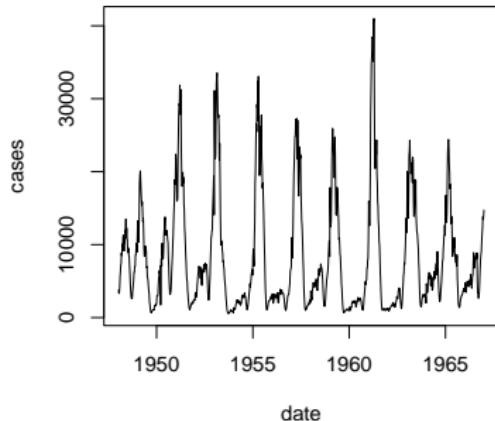


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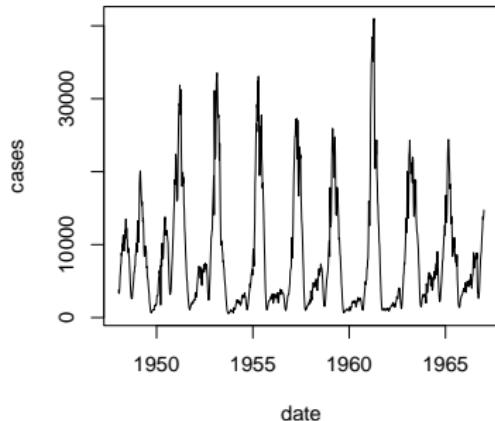


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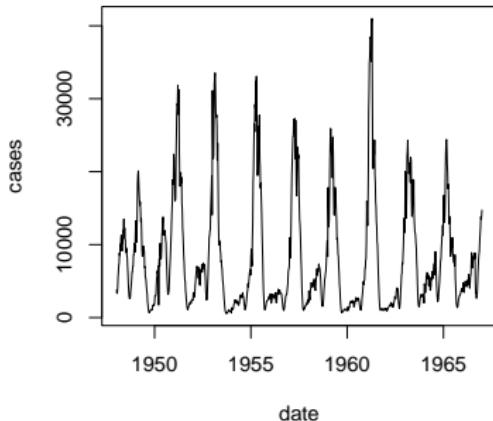


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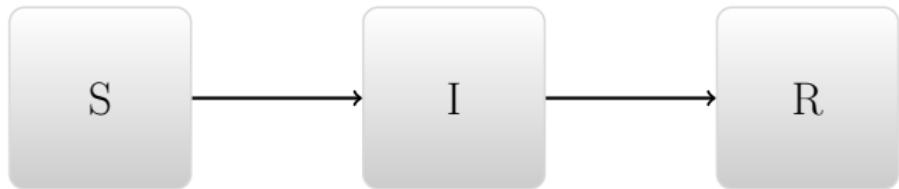
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Simple models of disease spread

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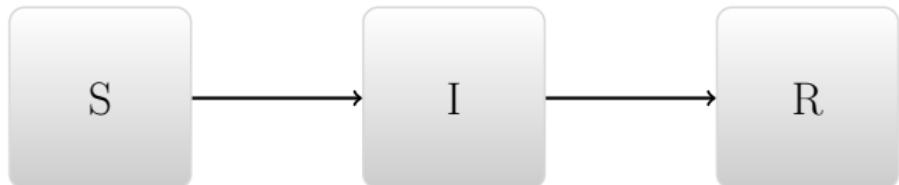
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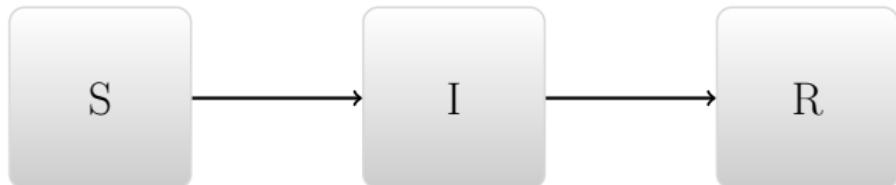
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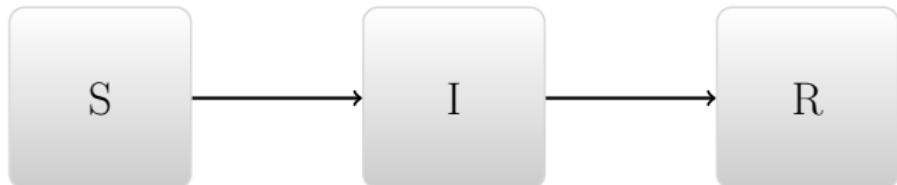
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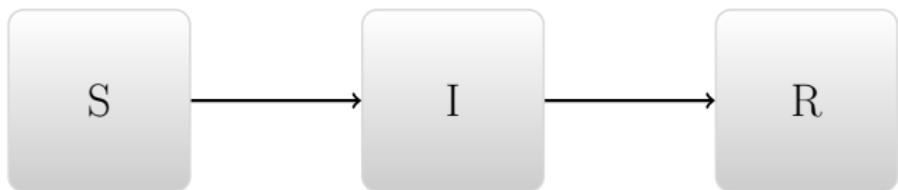
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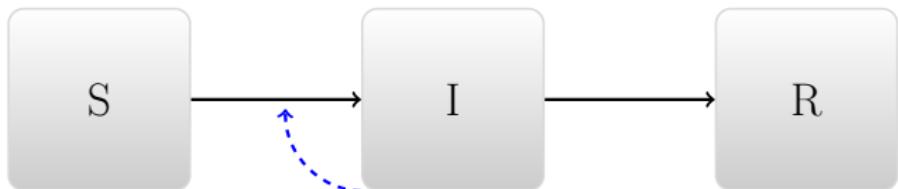


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What determines transition rates?

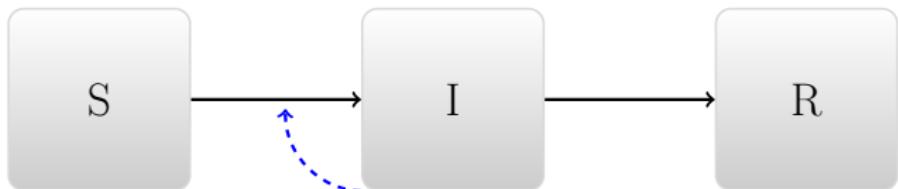


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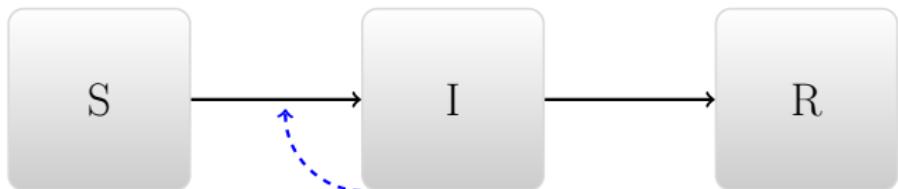
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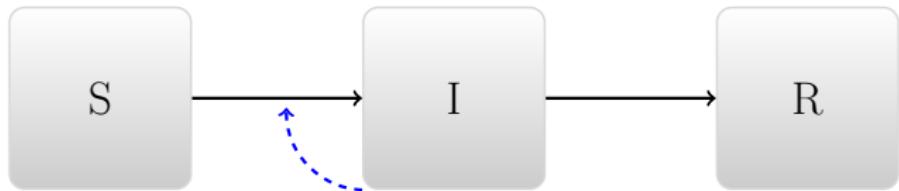
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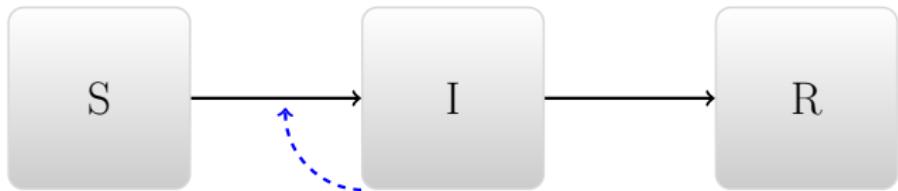
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Conceptual modeling



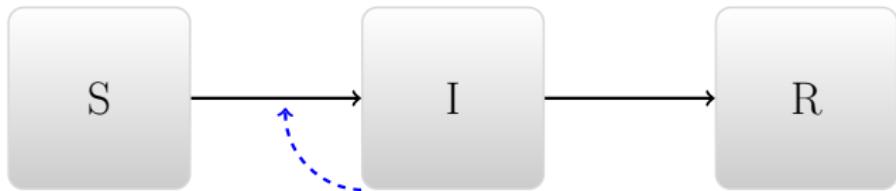
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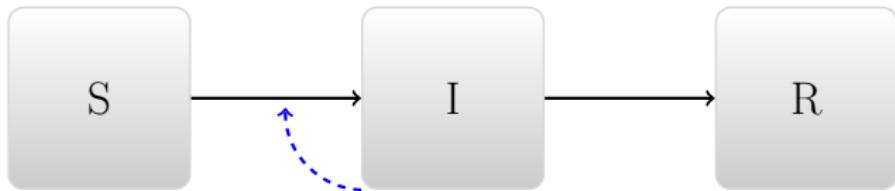
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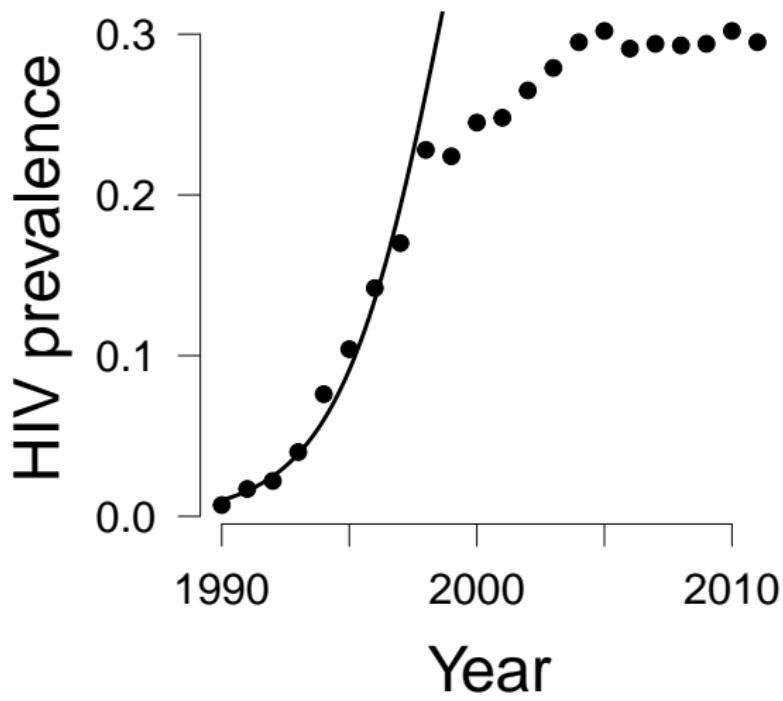
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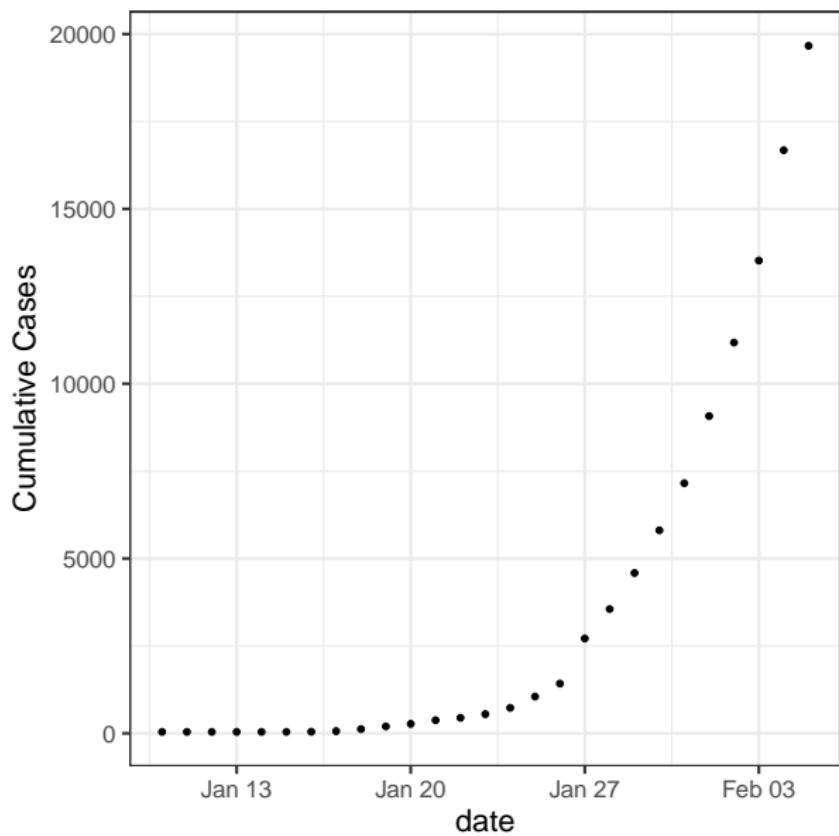
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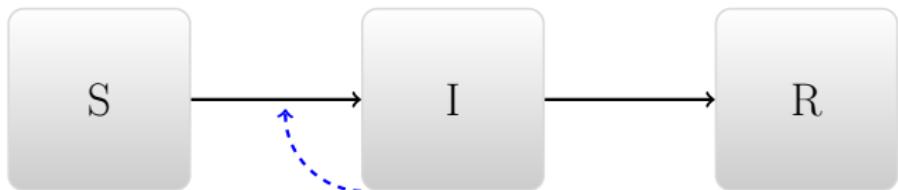
$$R_0 = 5.66$$



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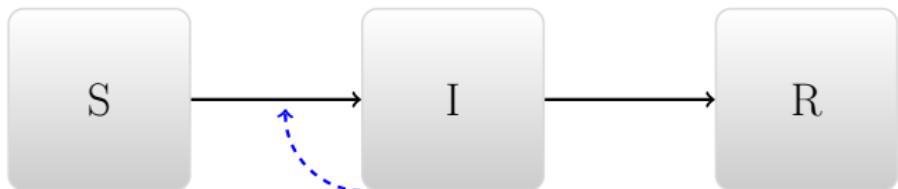


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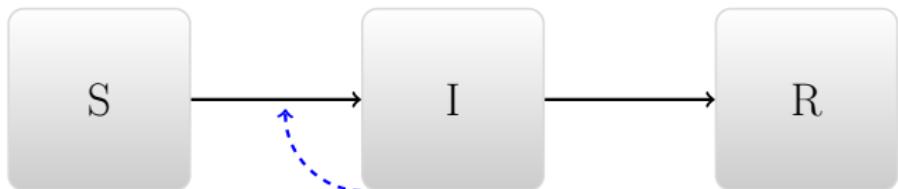
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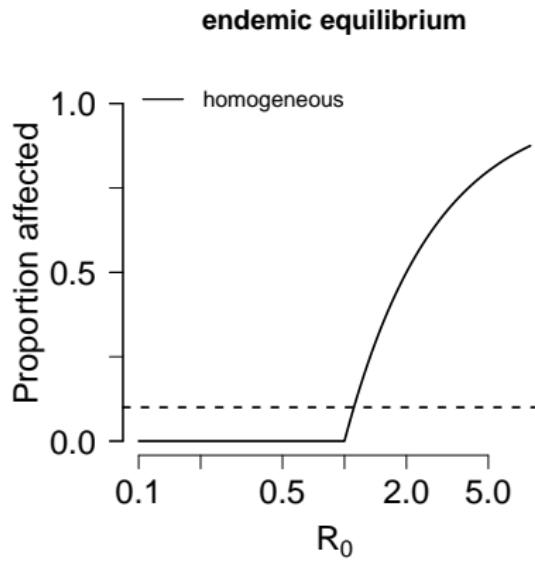
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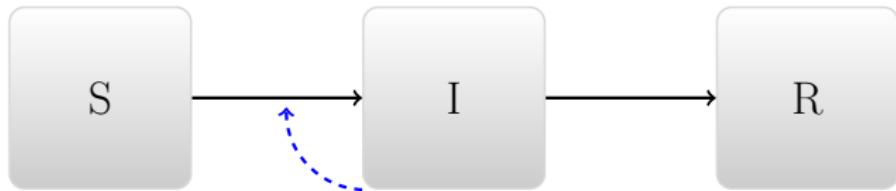
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Yellow fever in Panama

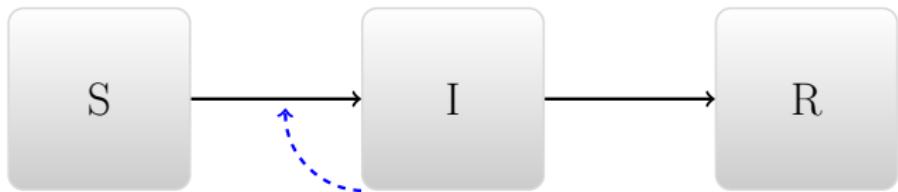


Result: not every one gets infected



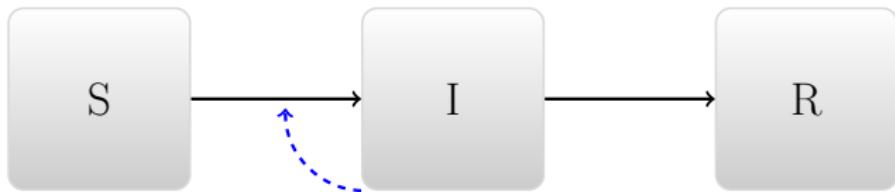
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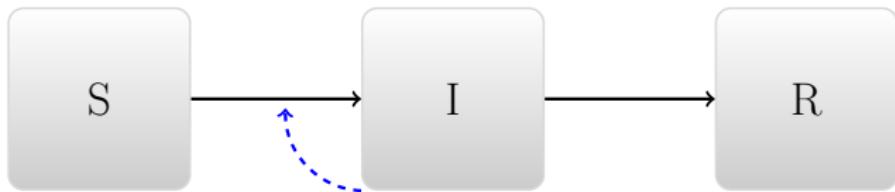
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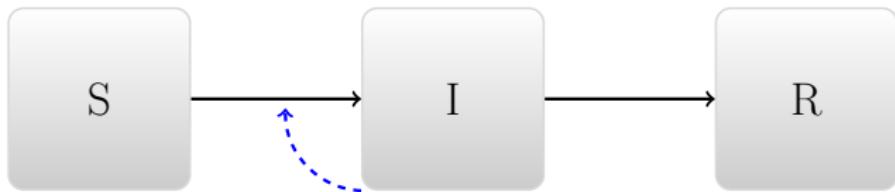
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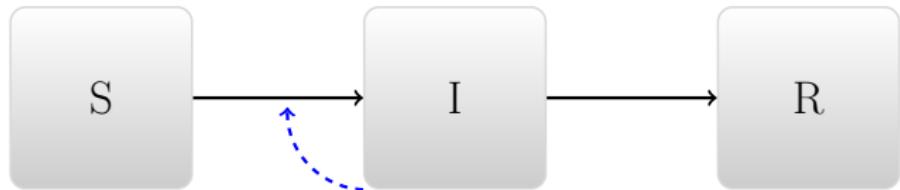
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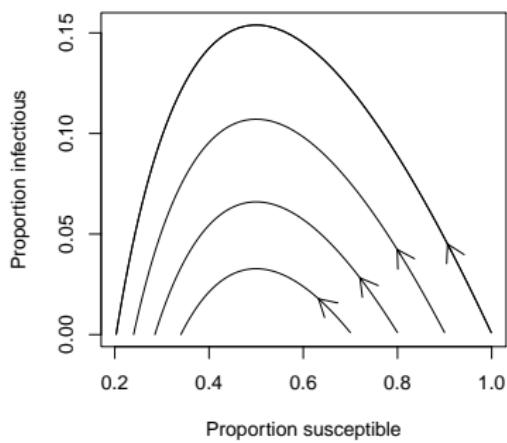
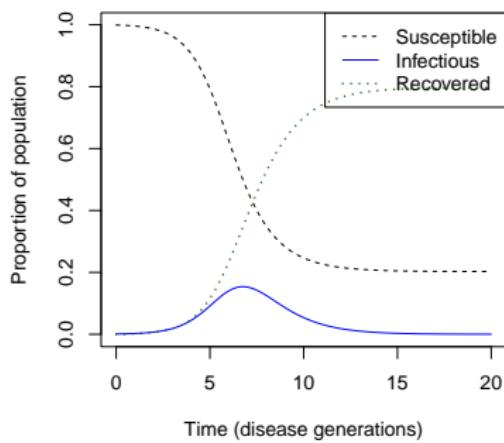
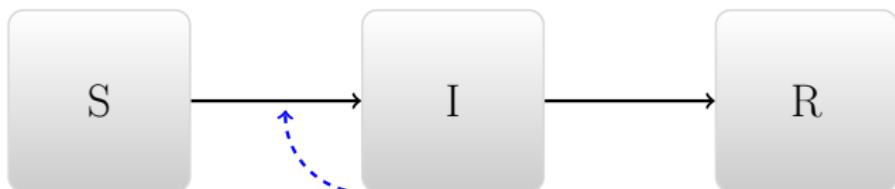


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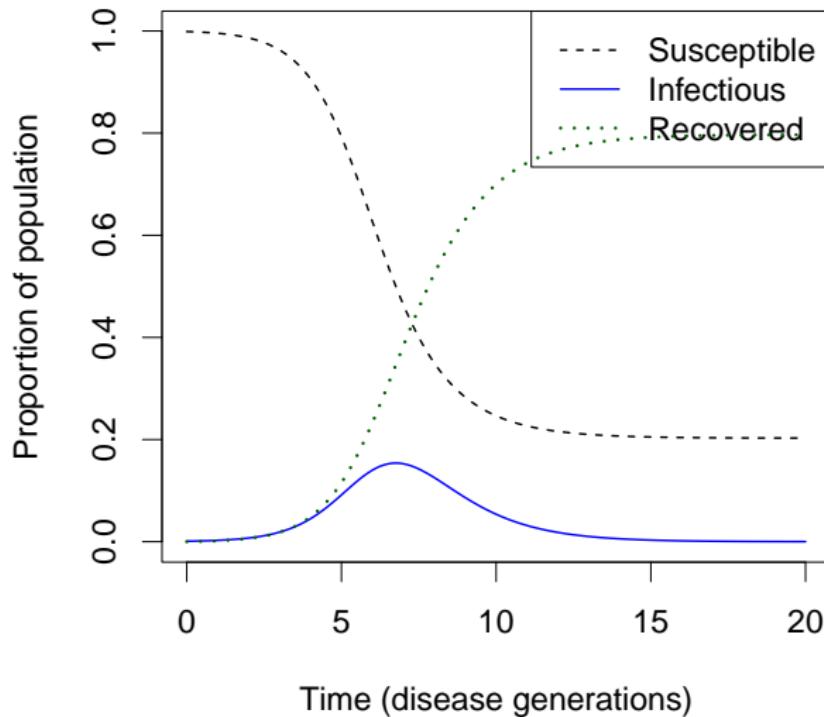
Simulations



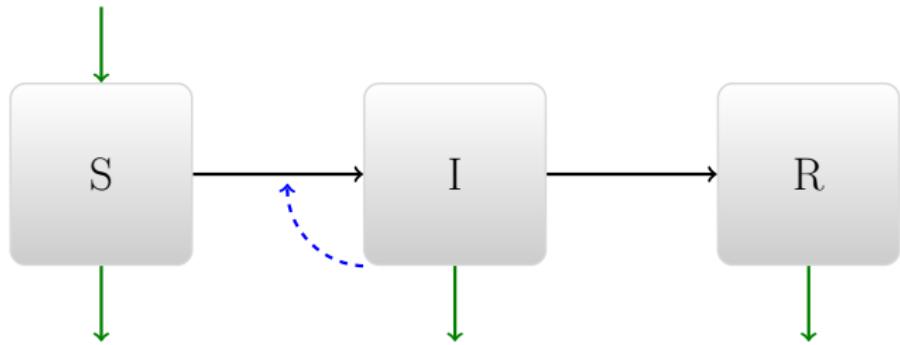
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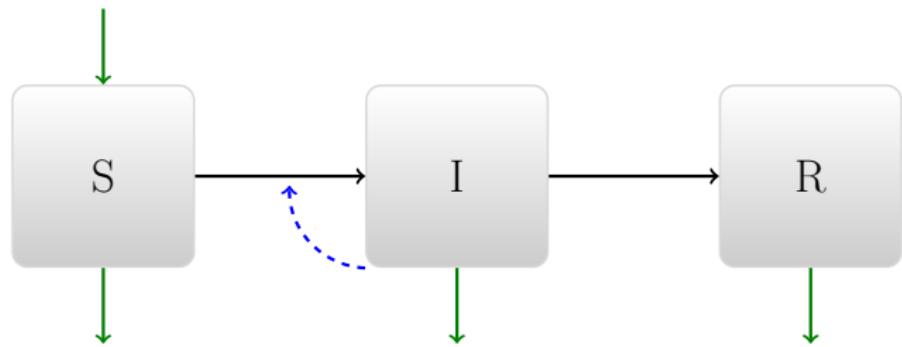


Closing the circle



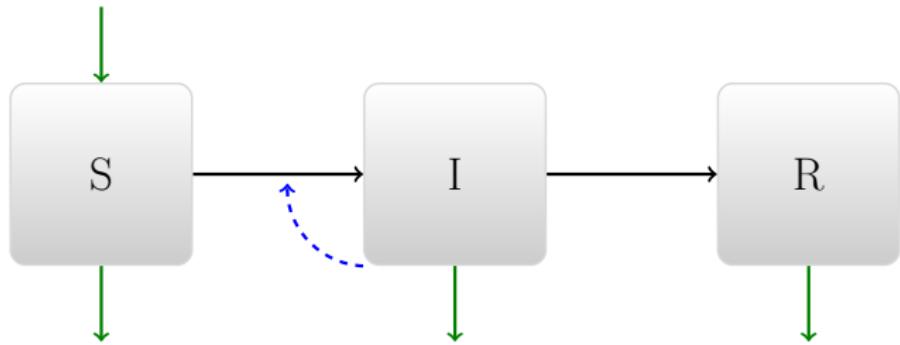
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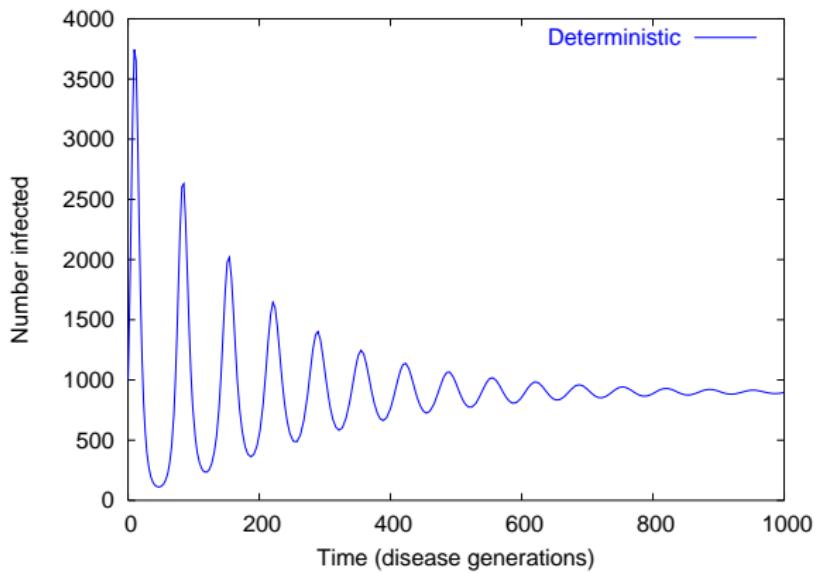
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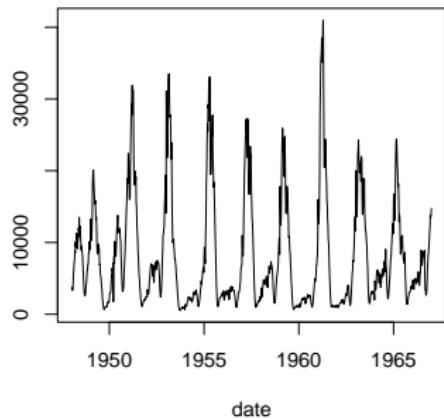
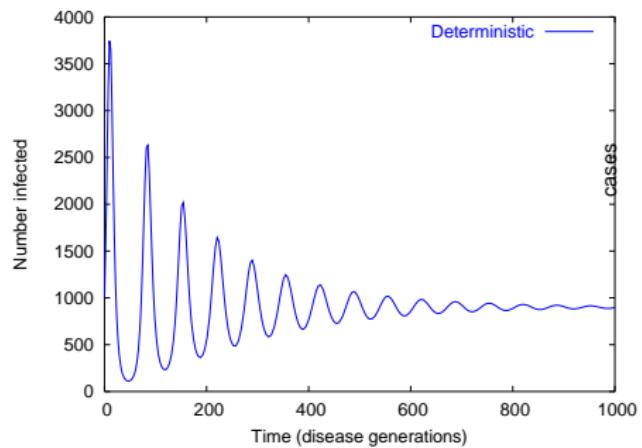
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Result: Oscillations tend to be damped



What is missing from our model world?

Measles reports from England and Wales



Example: Ebola transmission

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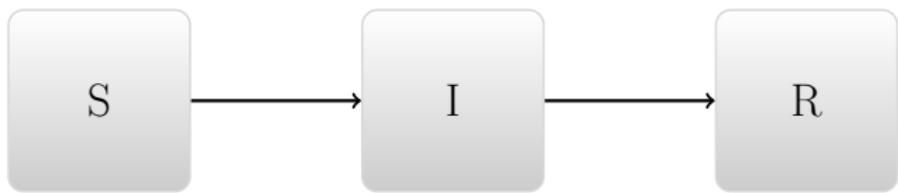


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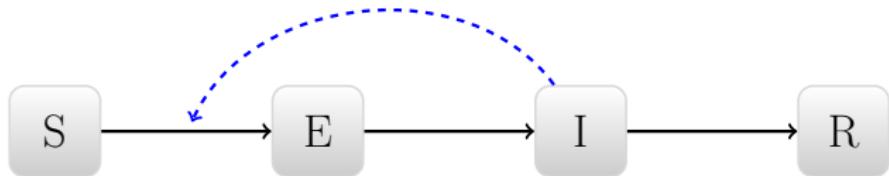
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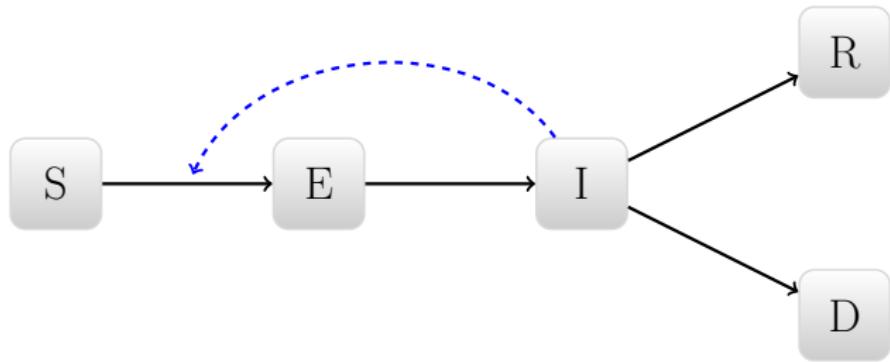
Simple disease model



Model with latent period

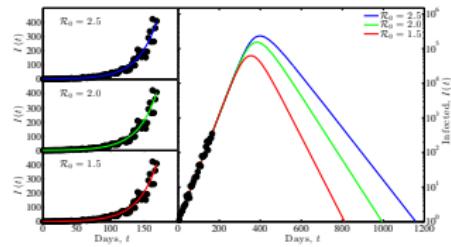


Include post-death transmission



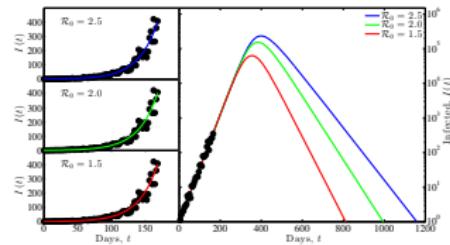
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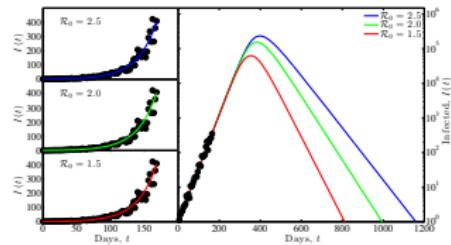
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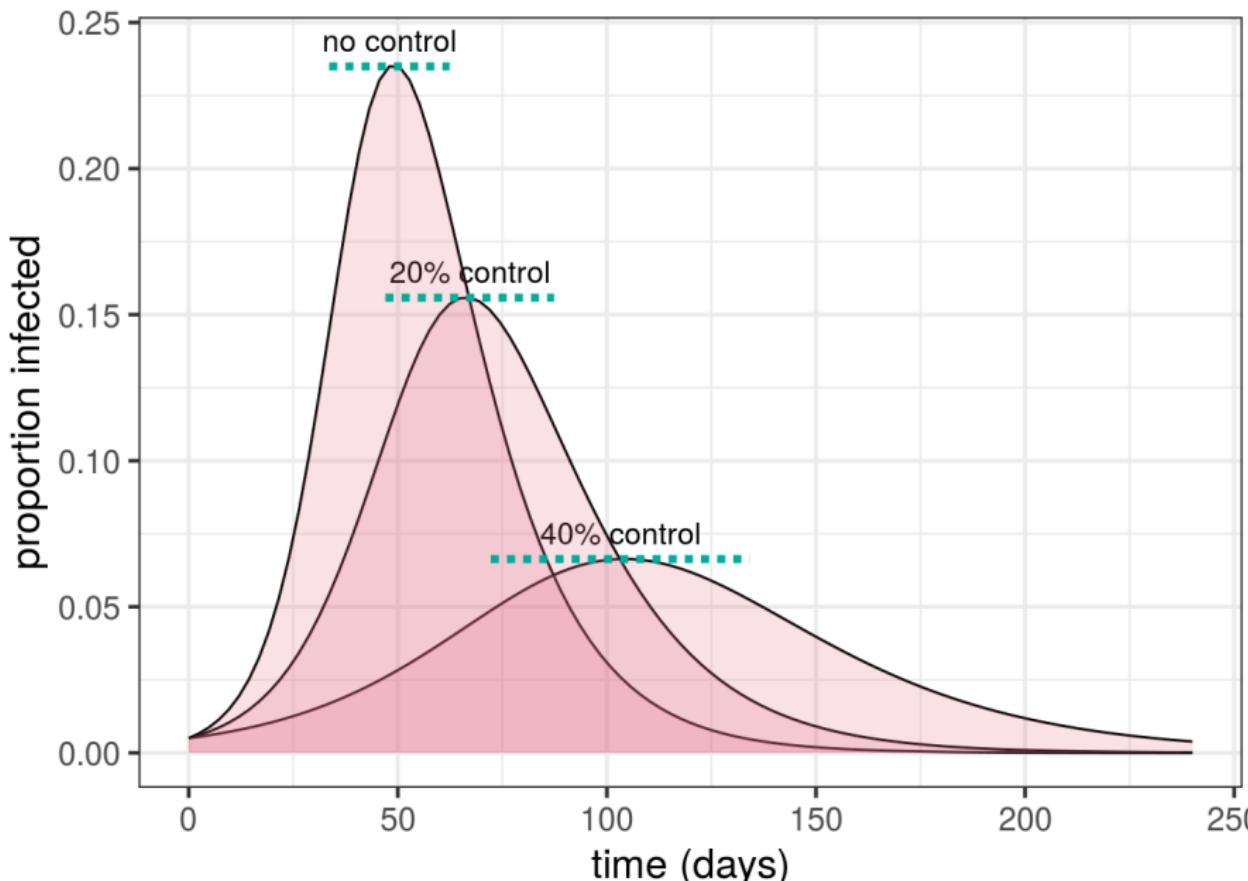


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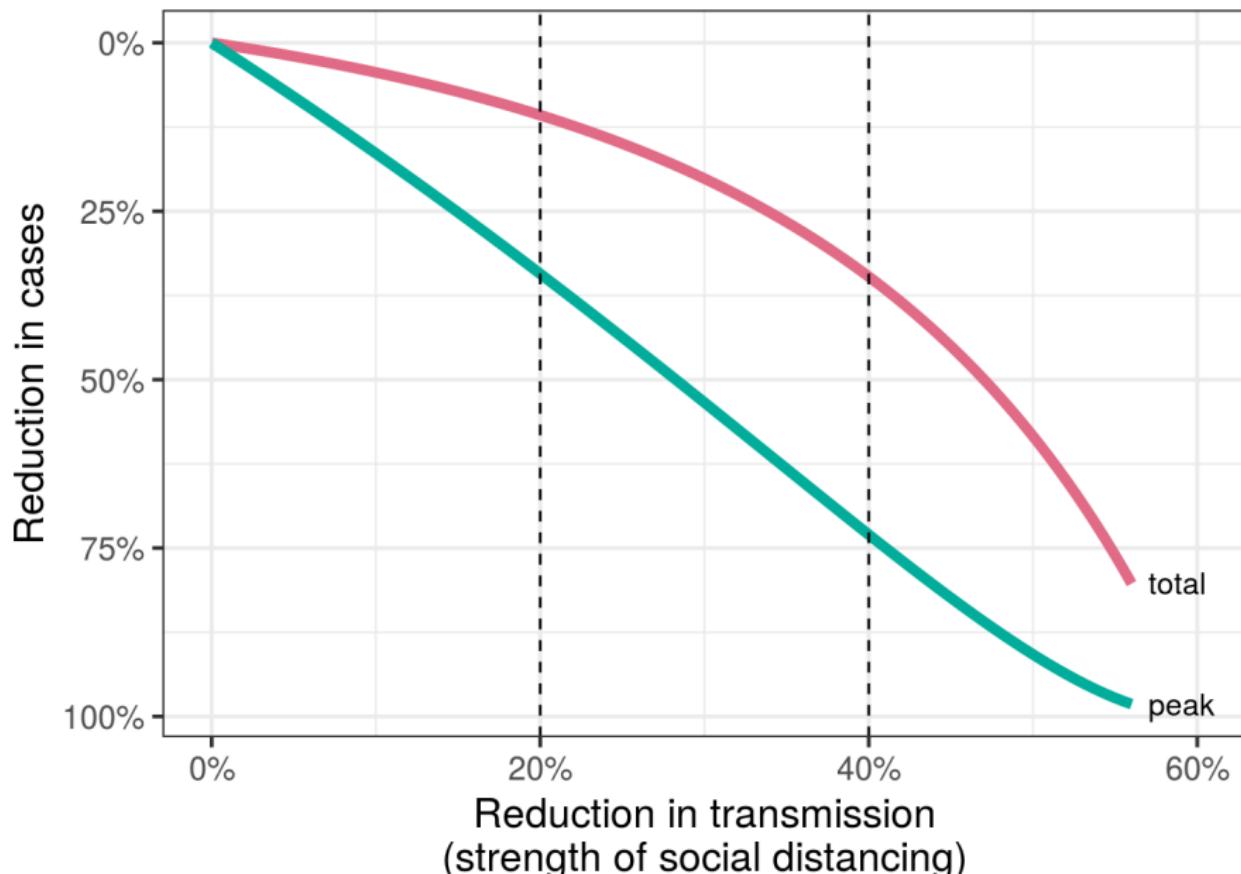
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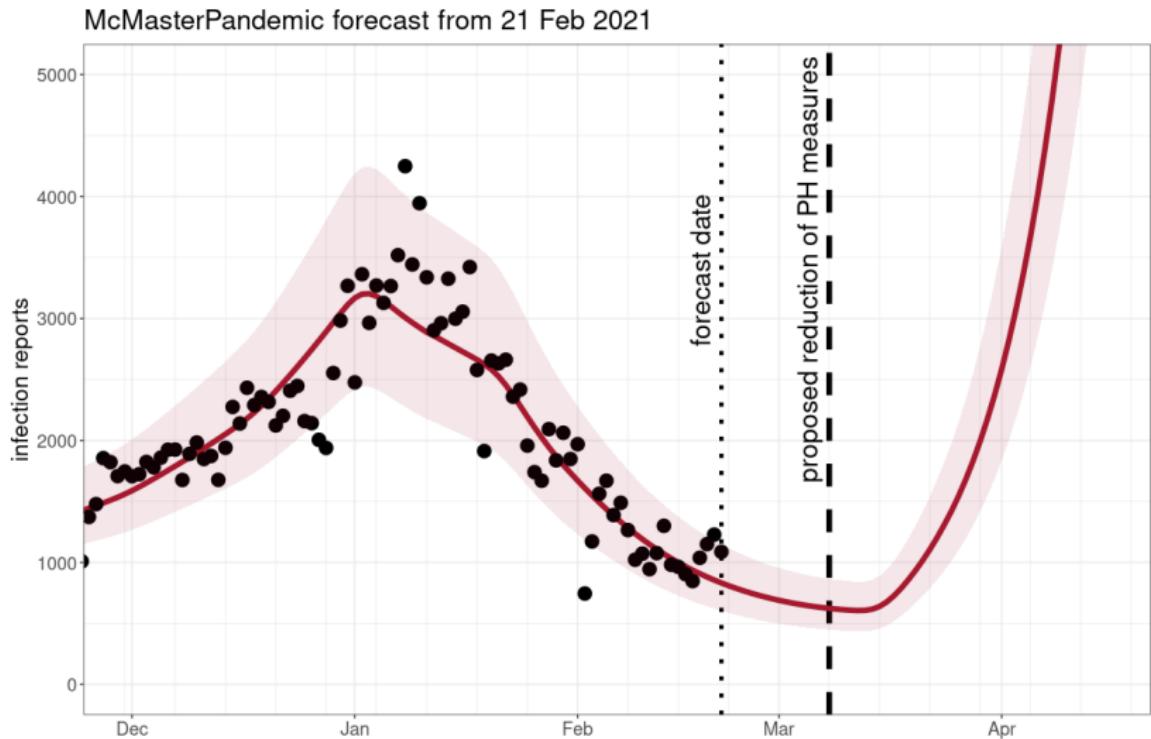
Example: COVID: flatten the curve



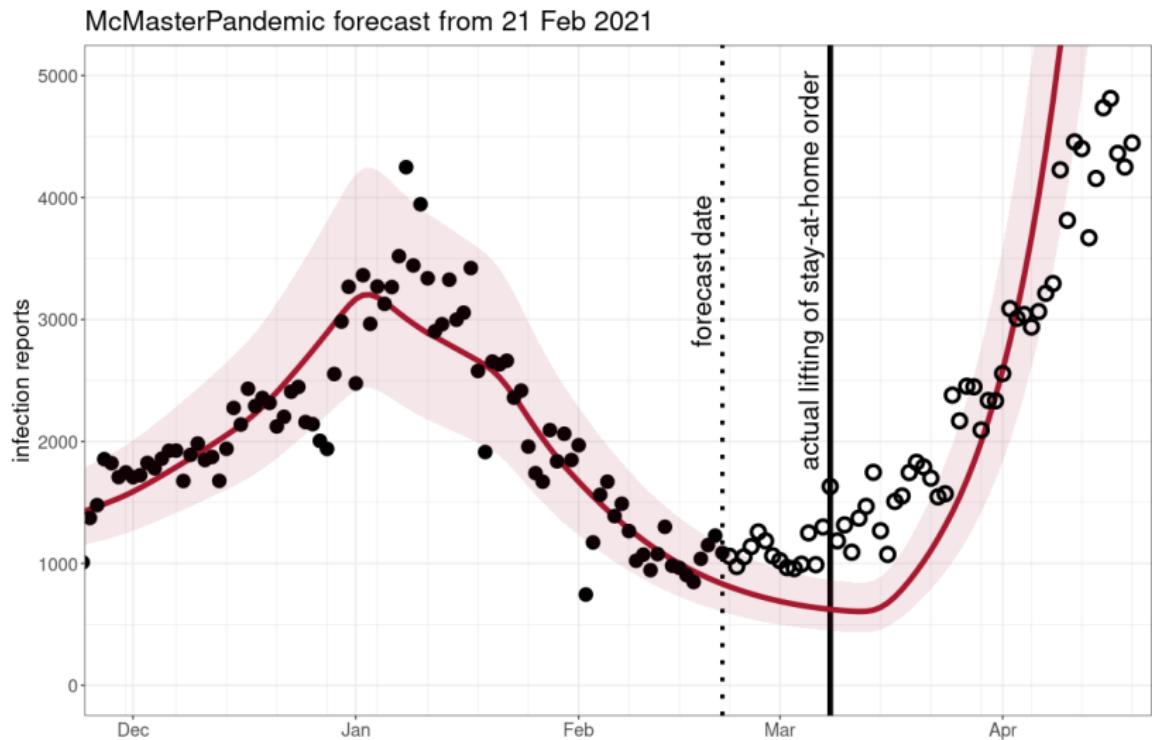
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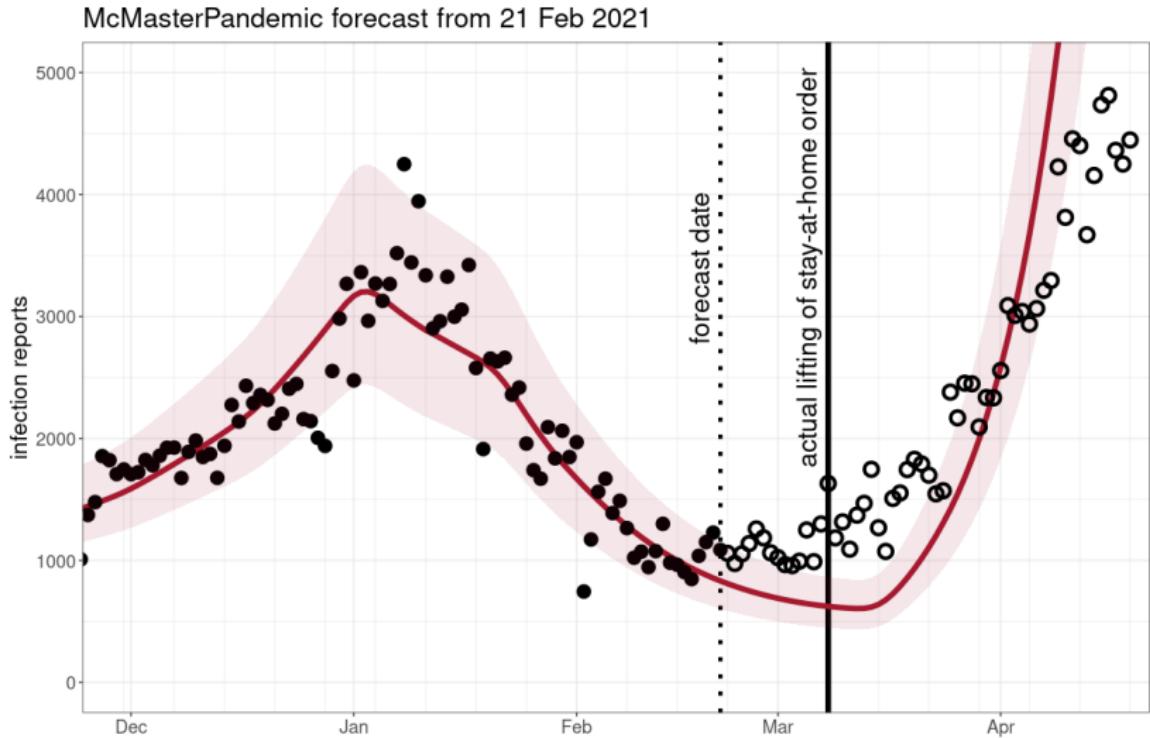
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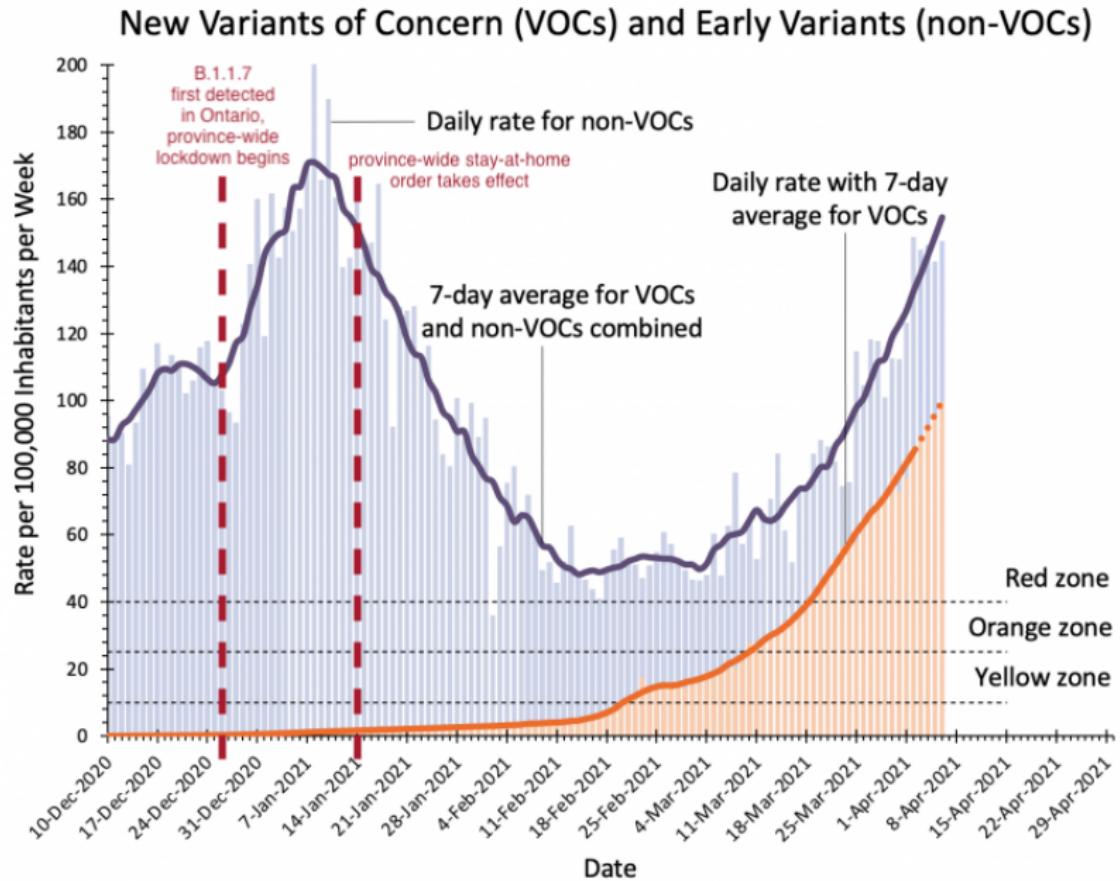
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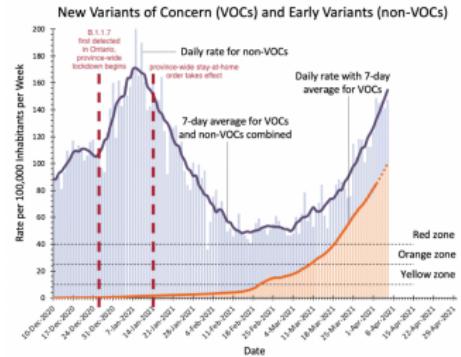


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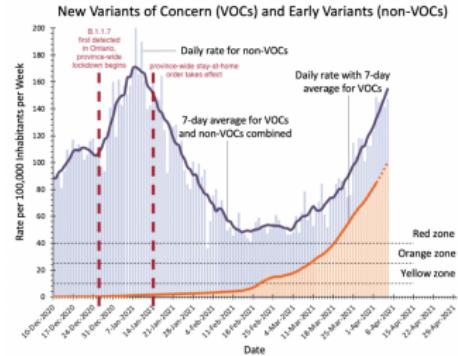
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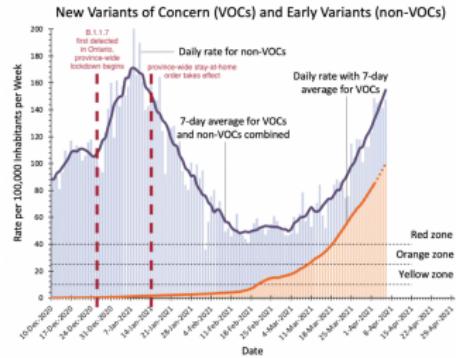
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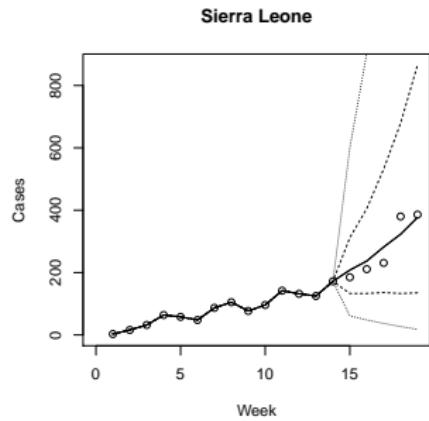
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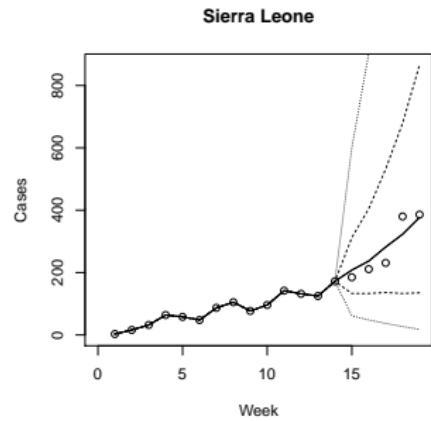
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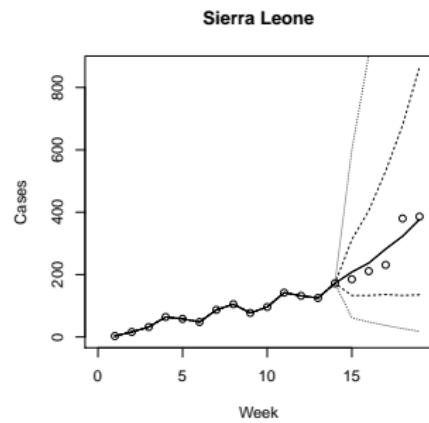
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Educational outreach



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