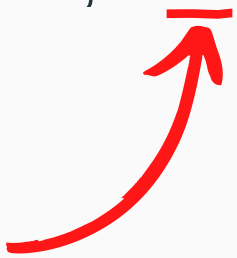
C’mon Billy, all the cool kids are doing it:

How to model the spread of epidemics

Benjamen Simon



Lancaster University

Bayes4Health

Who is this guy?

- Mathematics BSc. Statistics MSc.
- Statistics PhD.

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- OG Epidemic modeller
- 6 years

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- 6 years
- UKHSA - predicting R_0
- Swing Dancer

“I don’t really know what I’m doing”

- Unnamed Academics

Why? What? How?

Why do we model epidemics?

What is epidemic data?

- ☐ Hospital records?
- ☐ Pharmacy sales data?

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- ☐ Genetics Data?
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- ☐ Testing and Vaccination data?

What is epidemic data?

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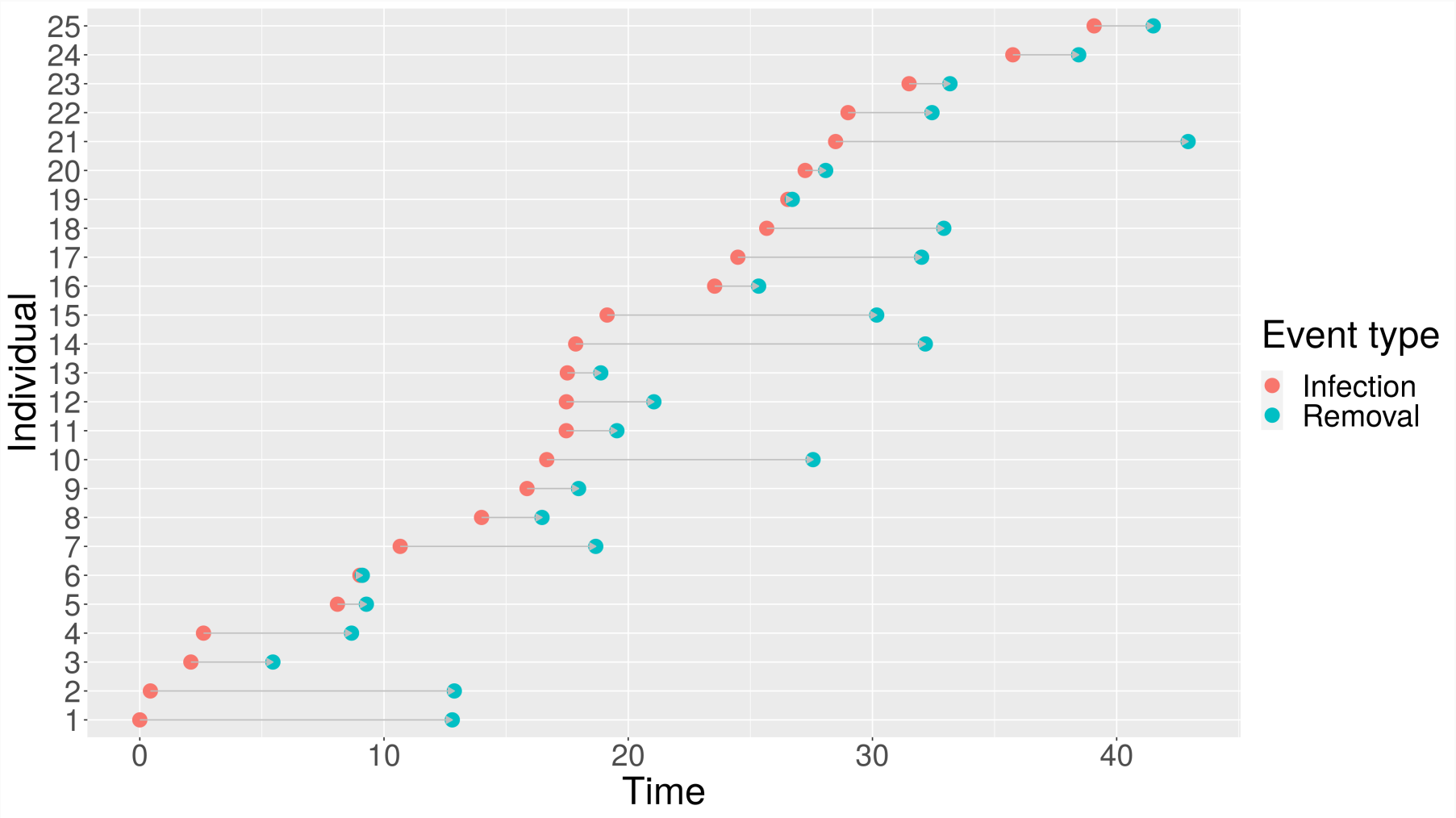
☒ All of the above

This is epidemic data

☒ Time of infection ☒ Time of removal



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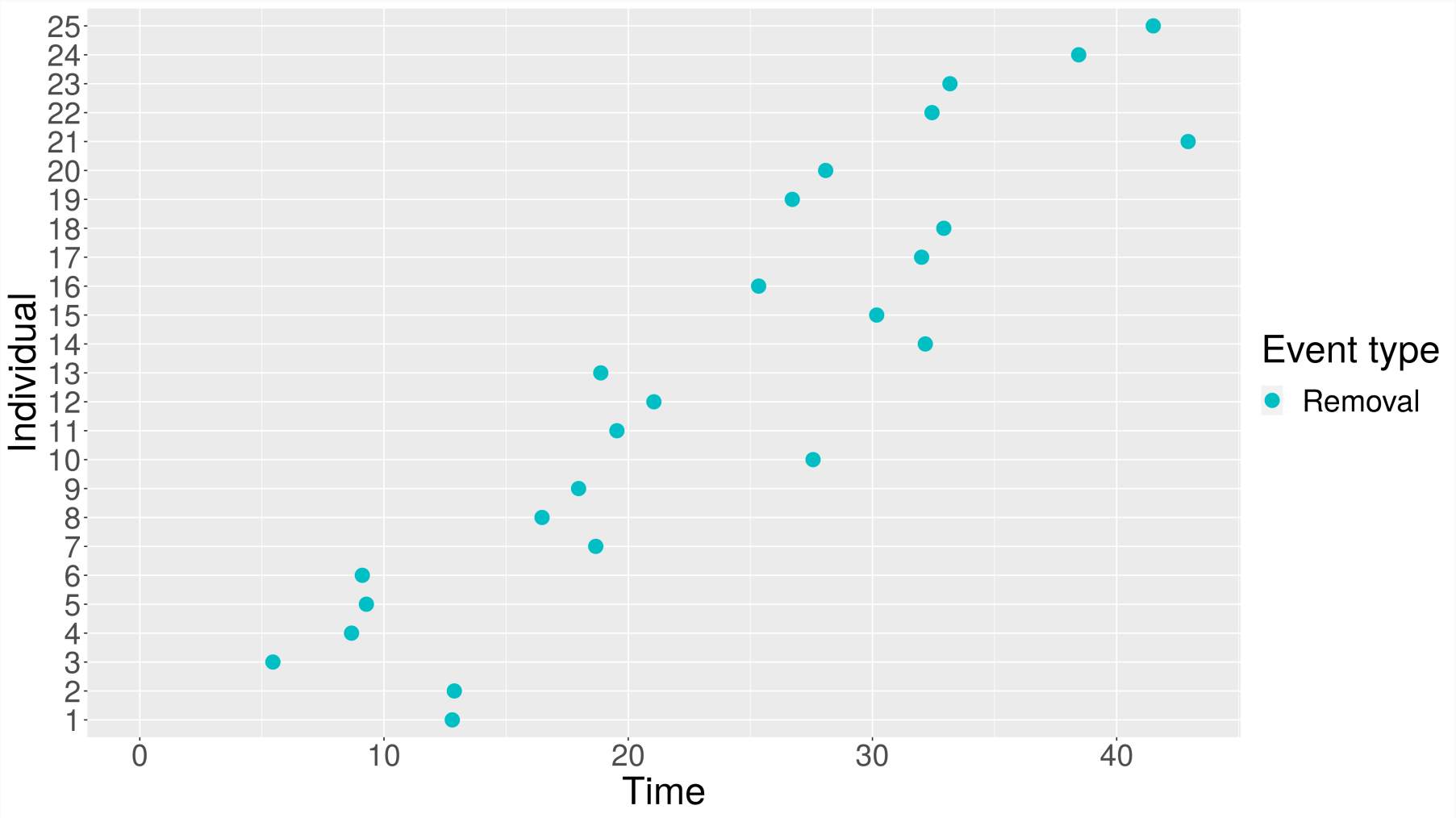
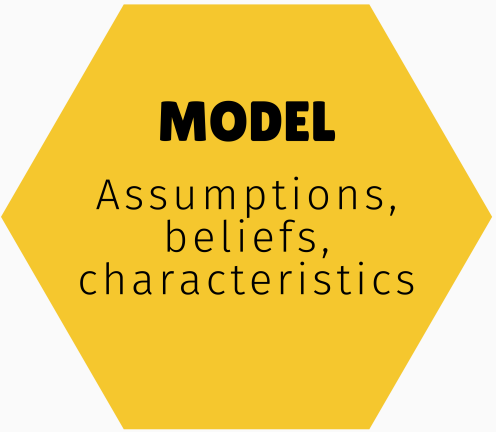
☐ Time of infection ☒ Time of removal



The process of making inference



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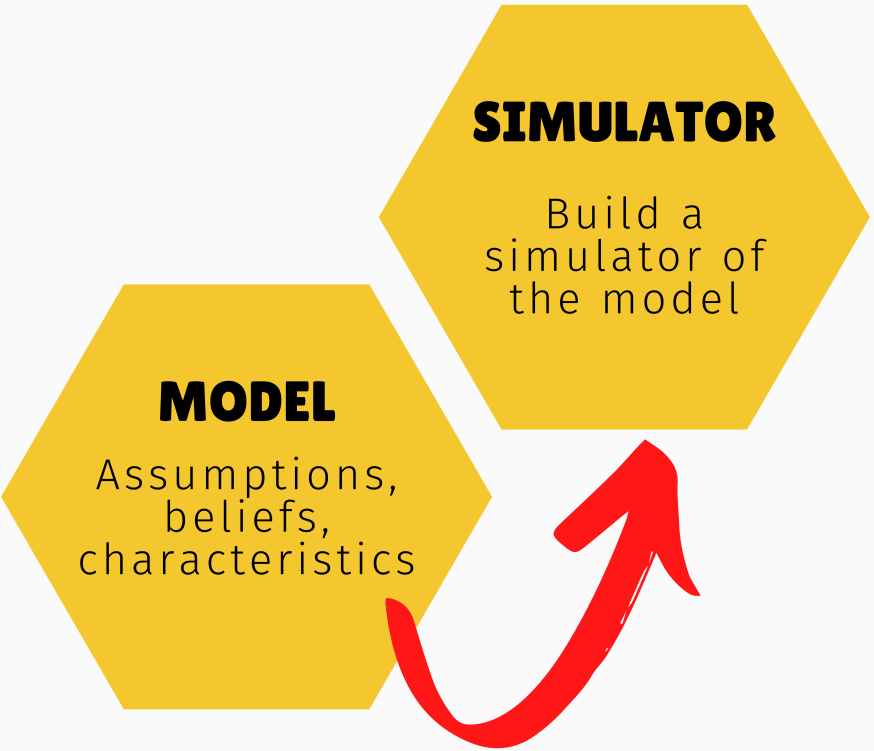

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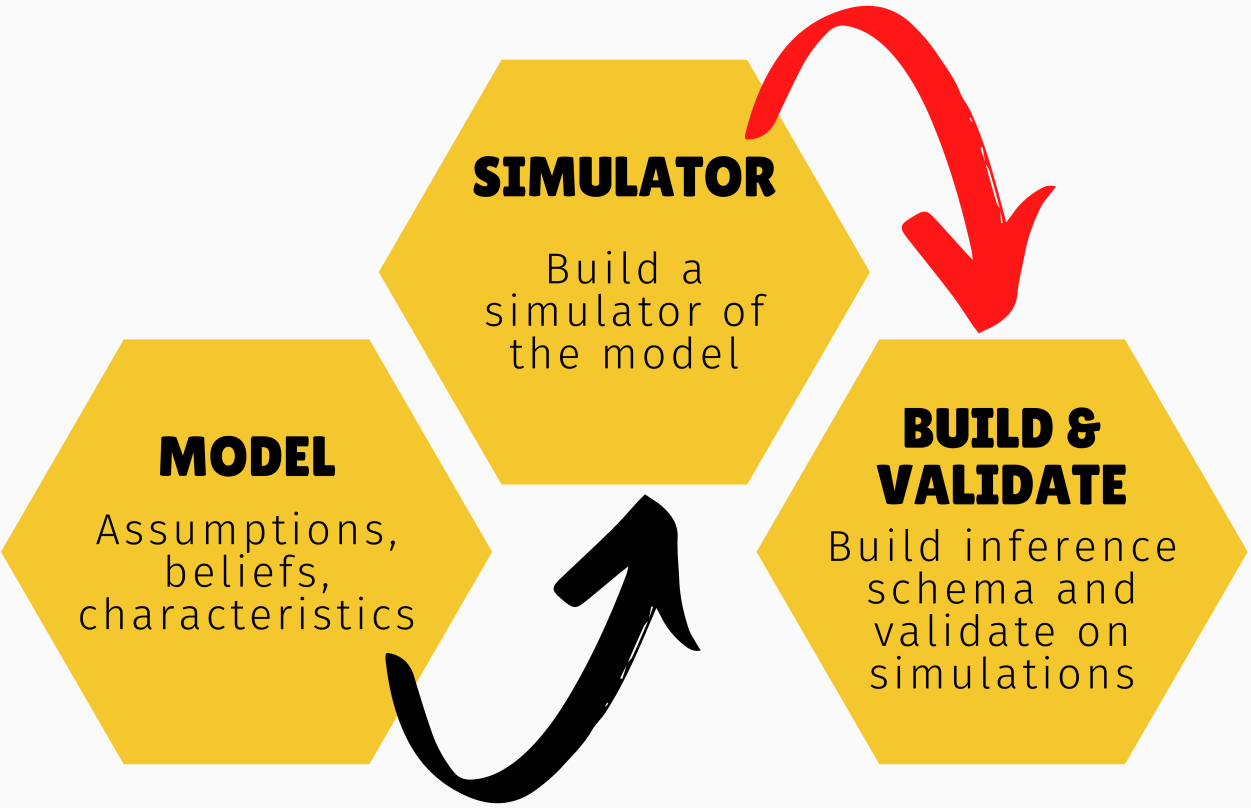

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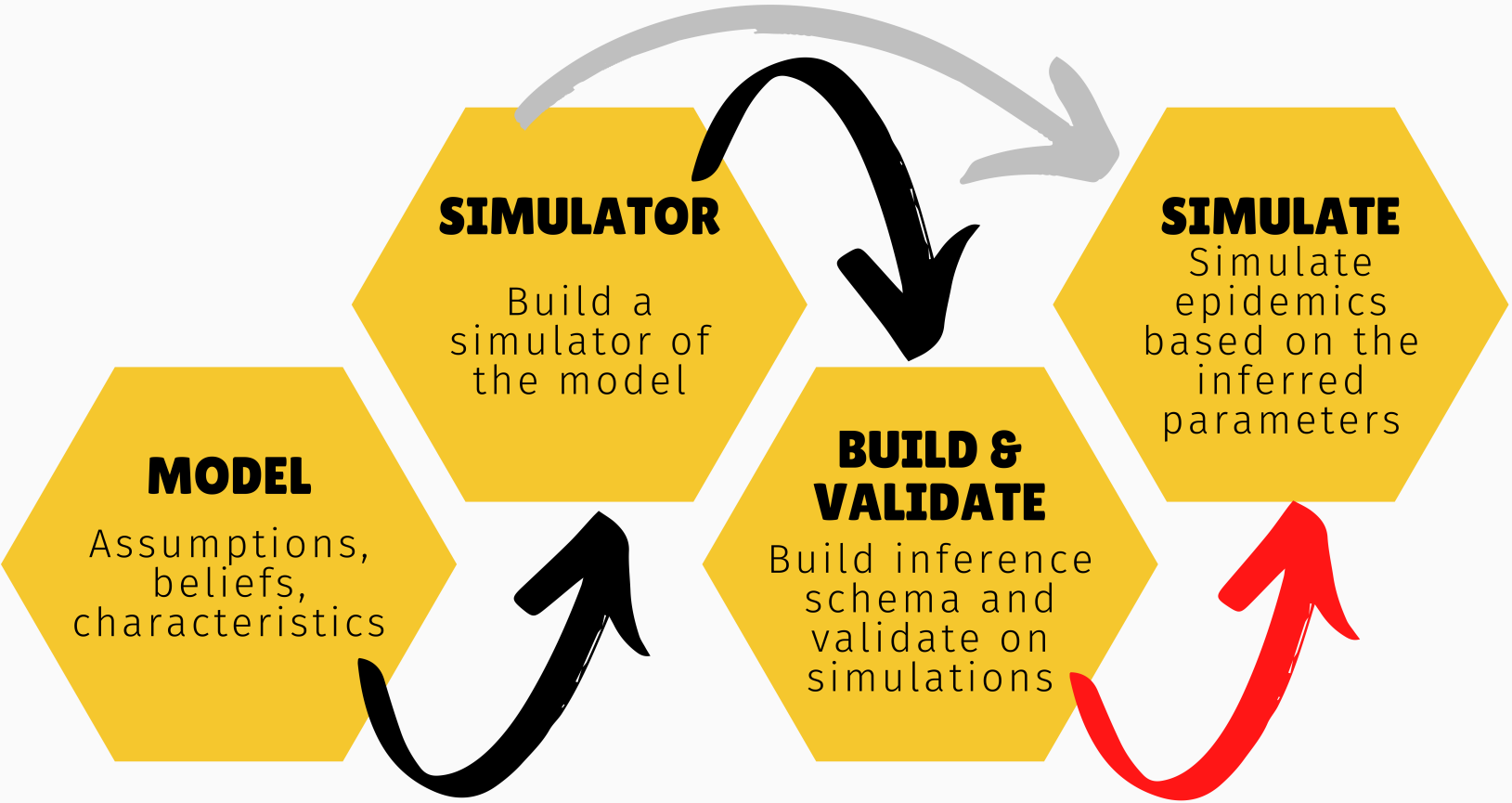

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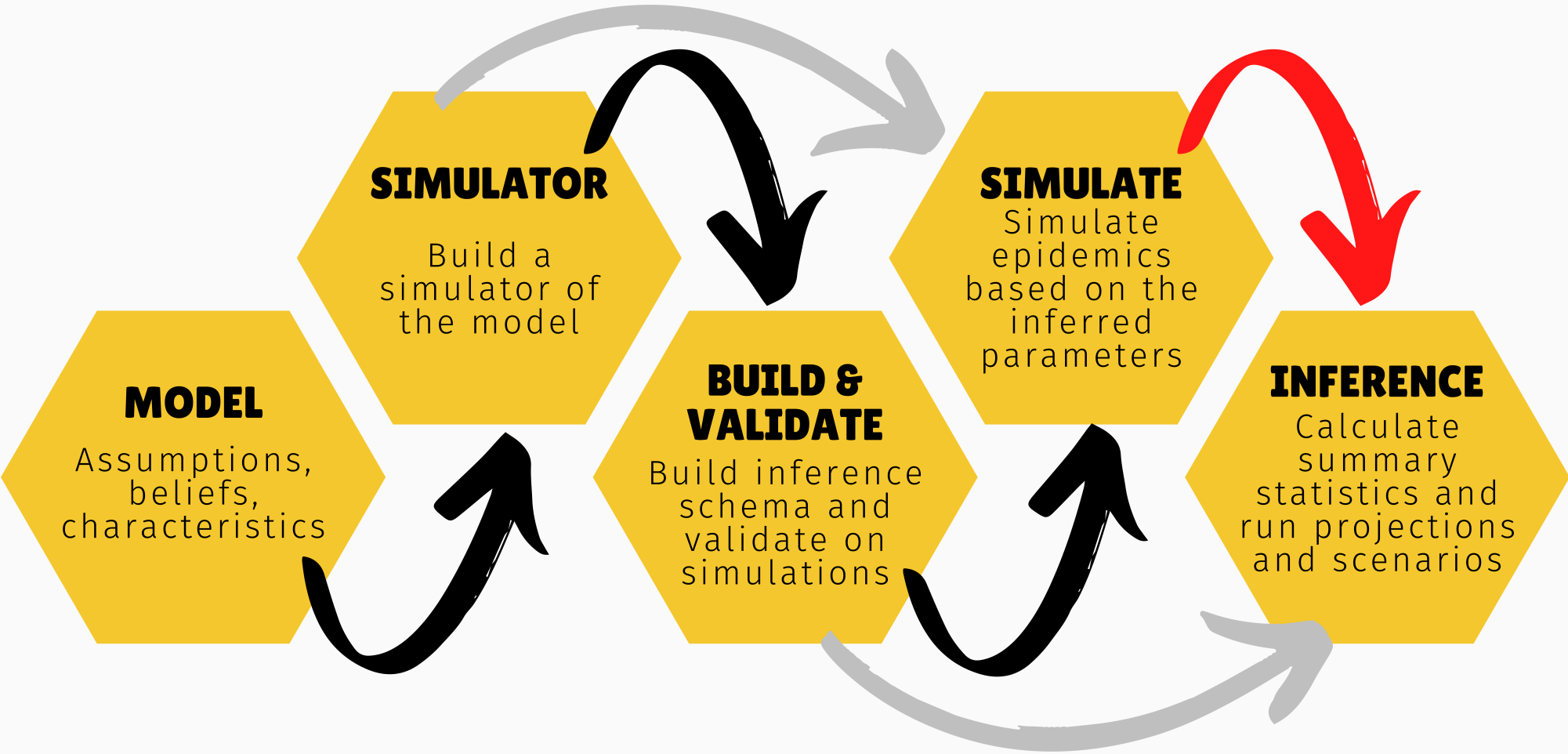
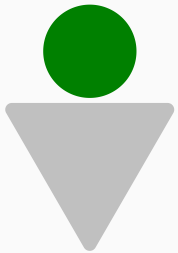


An Epidemic Model

The concept of SIR



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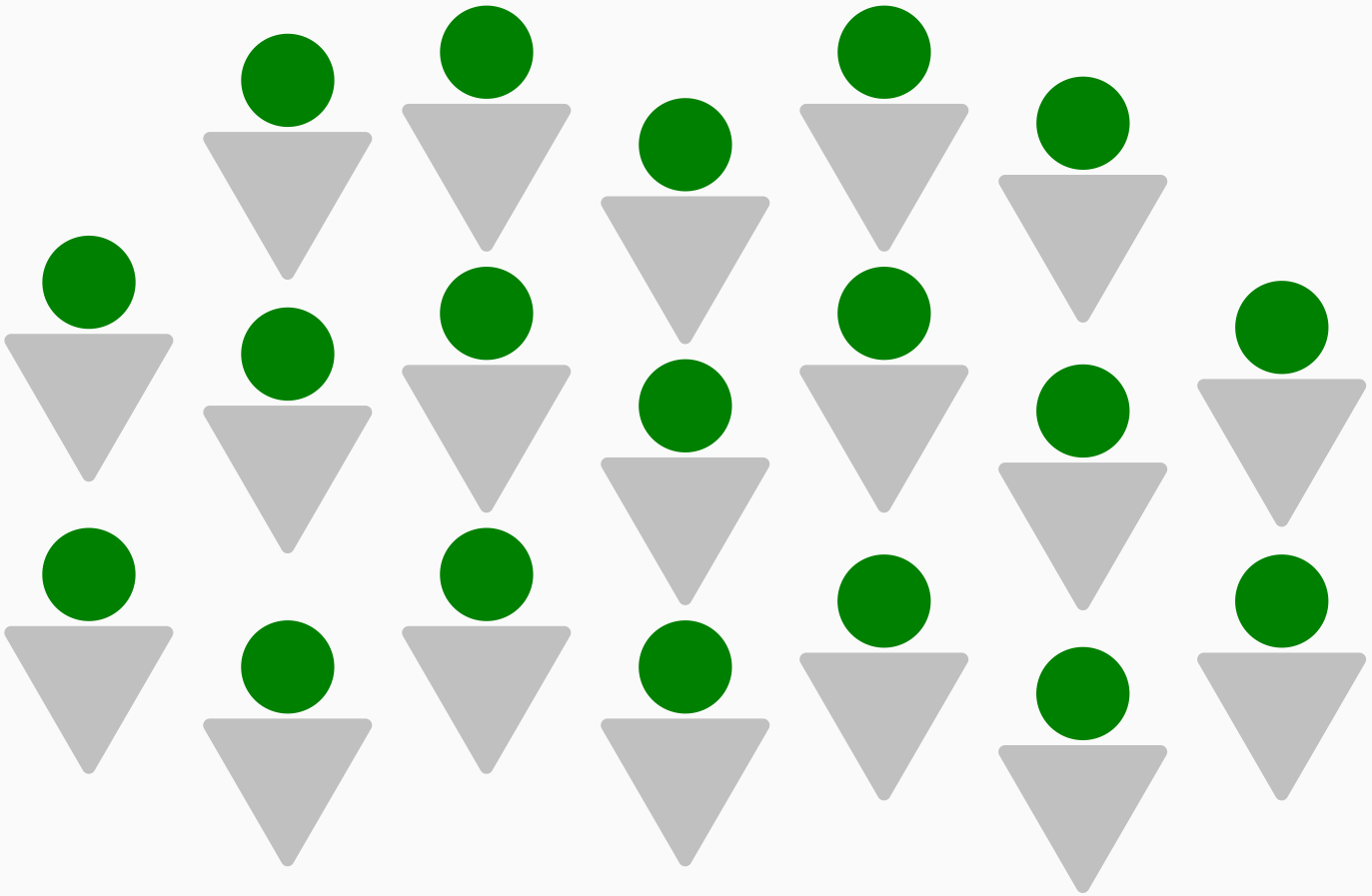

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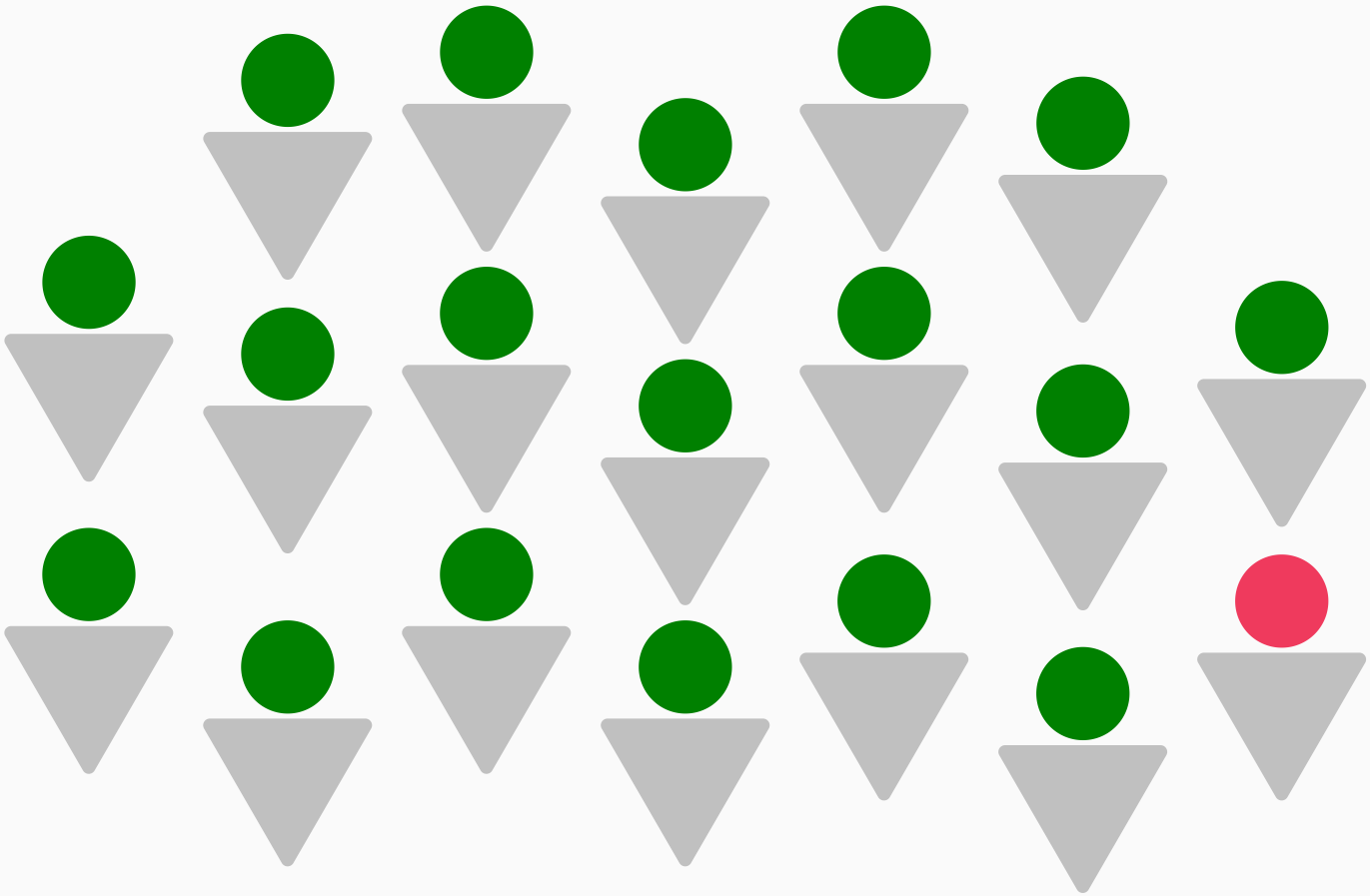

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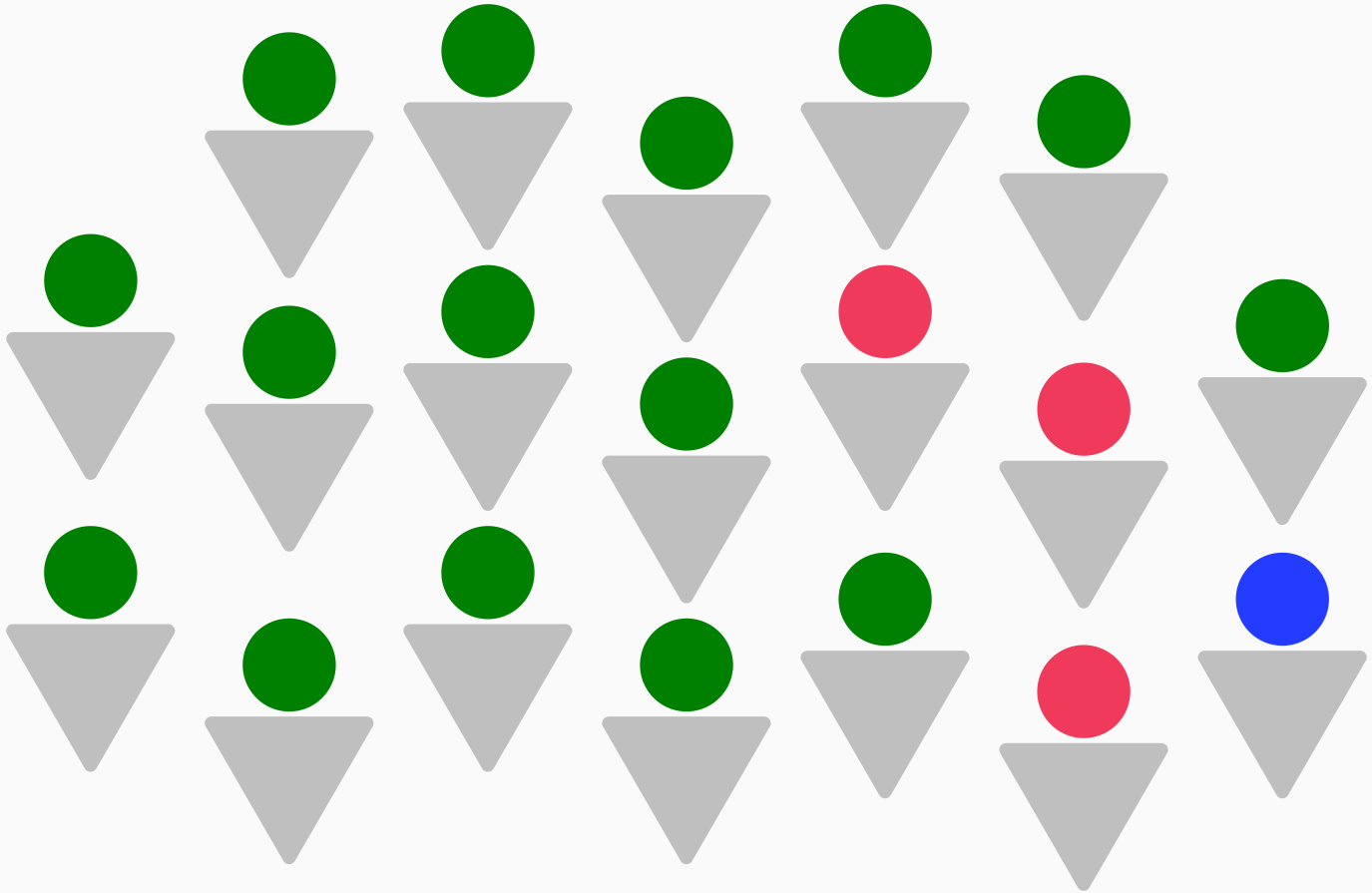

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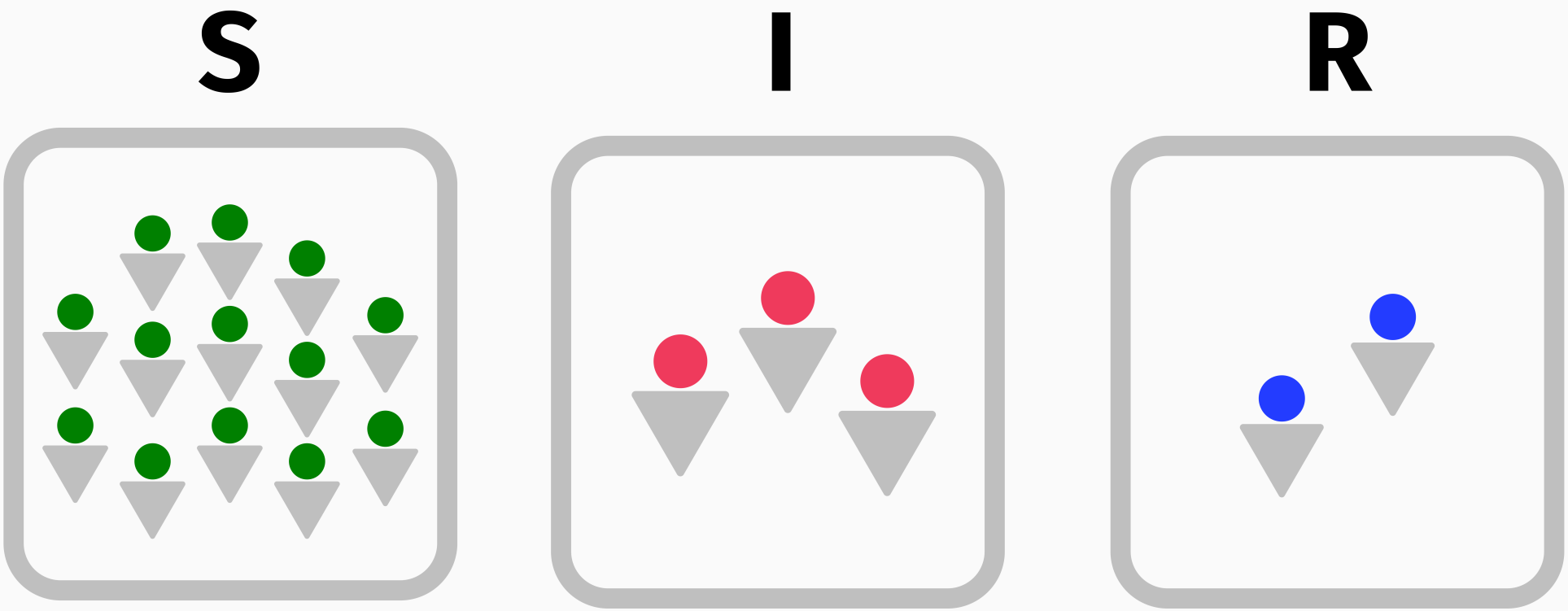

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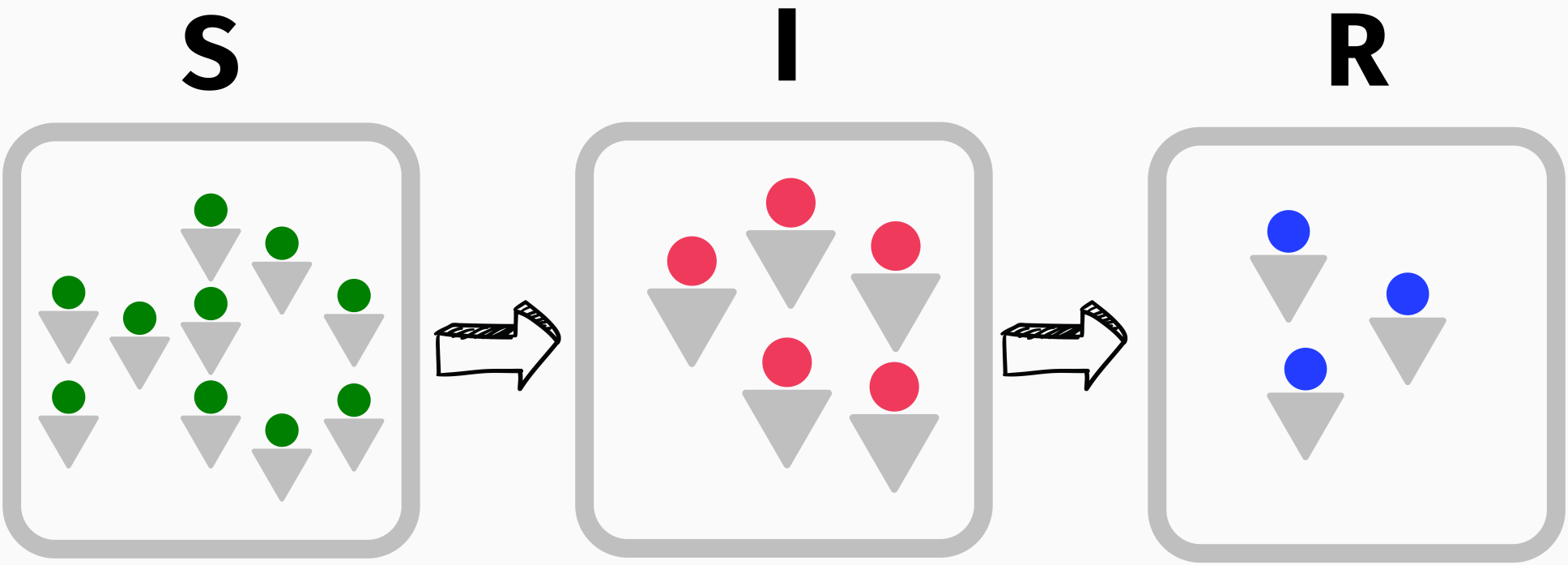

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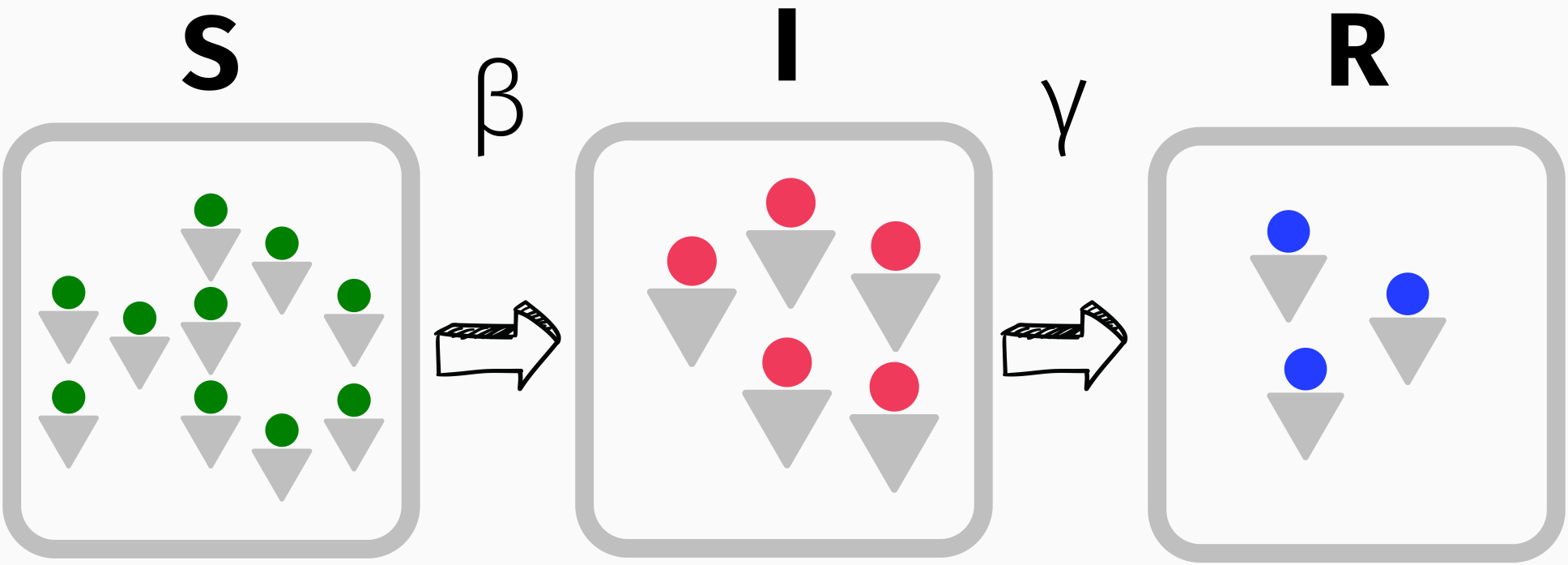

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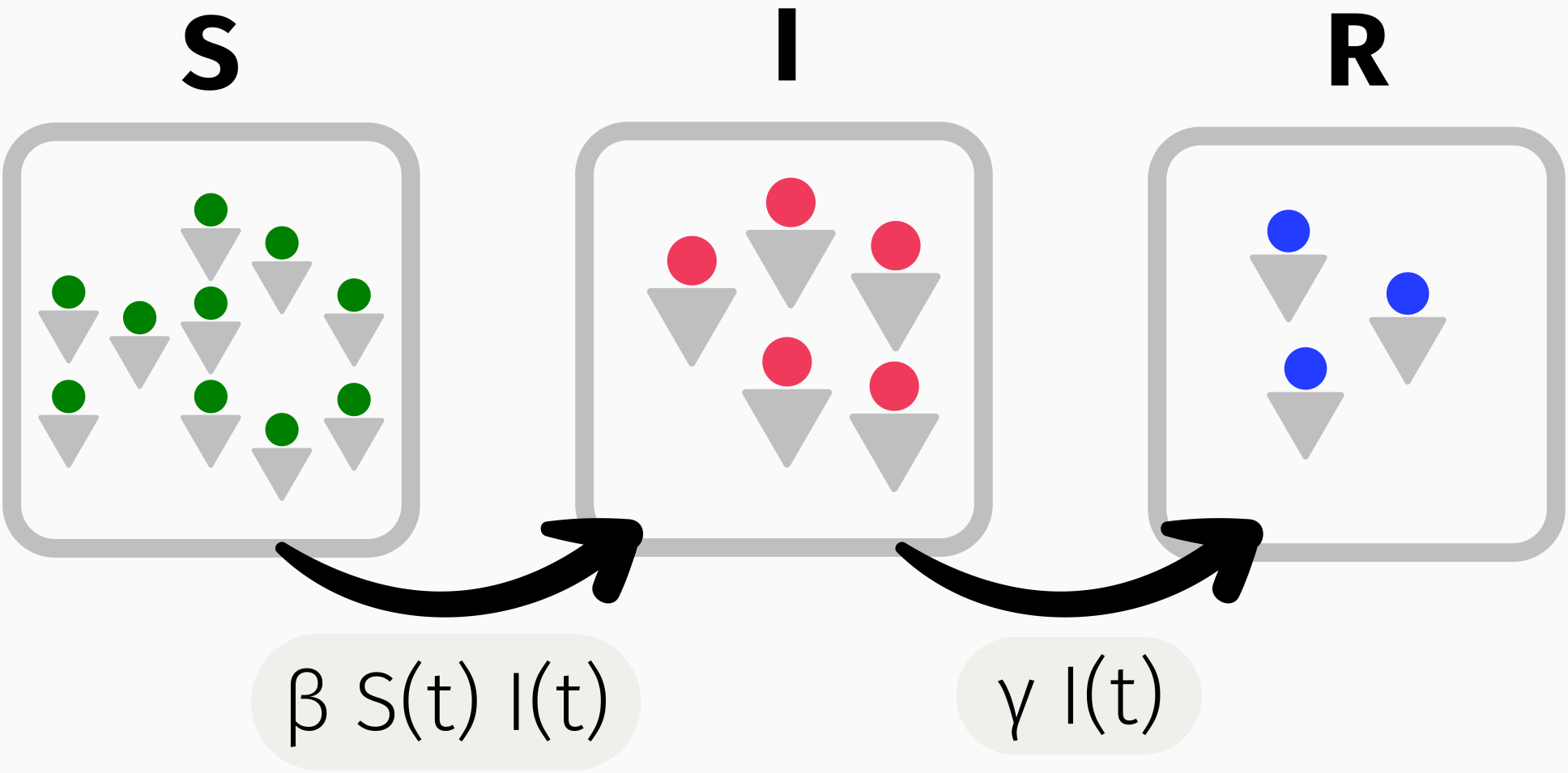

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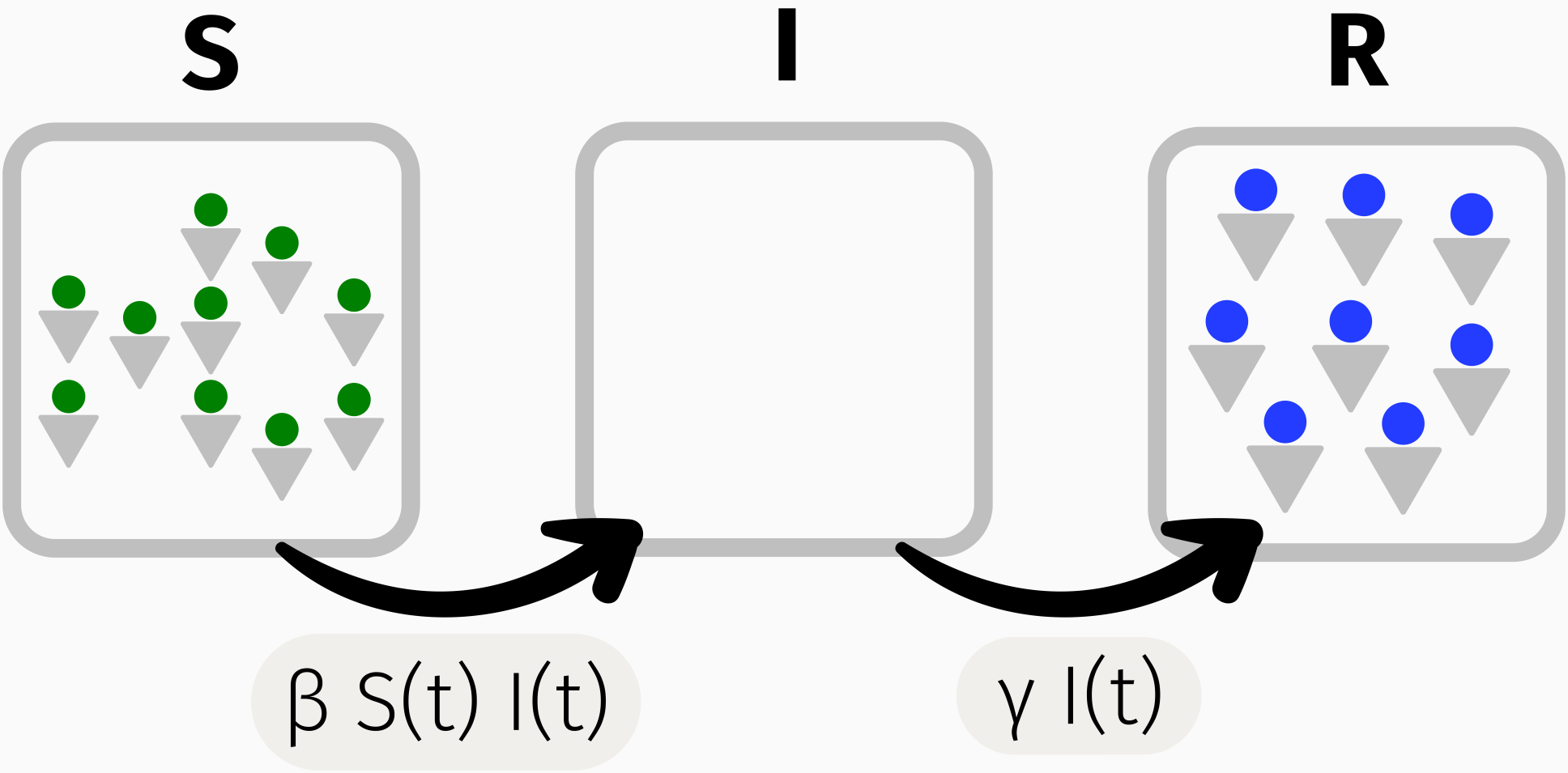

Simulating an epidemic

GSE Simulation

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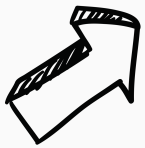
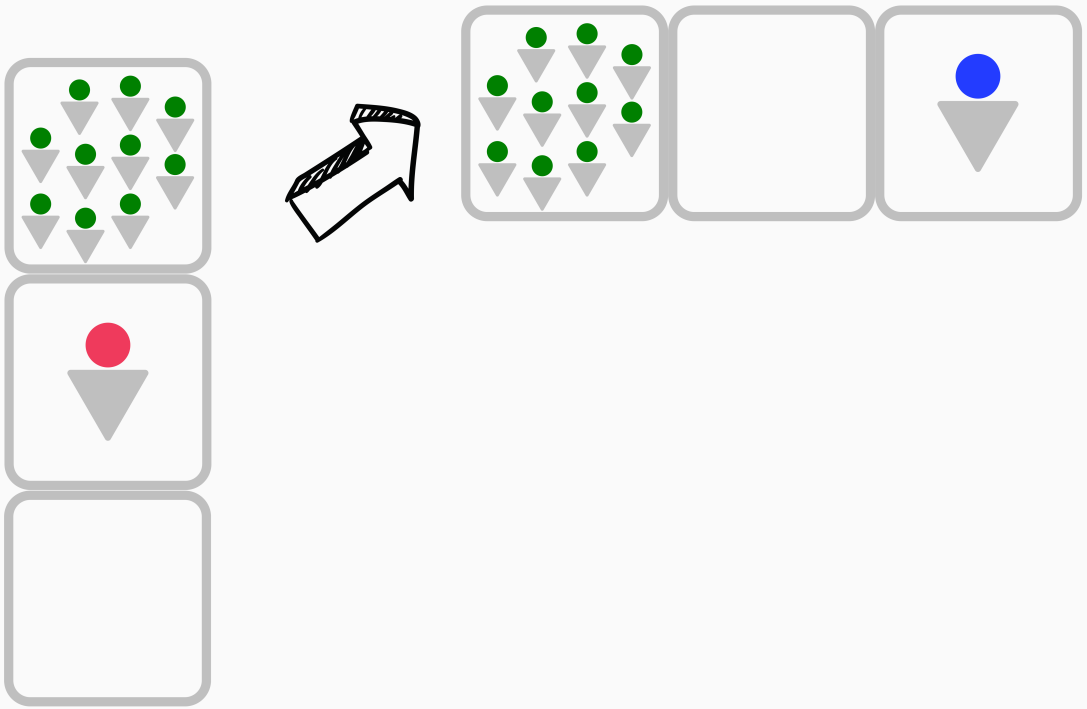


Removal Event

Infection Event

GSE Simulation



GSE Simulation

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The News

Britain welcomes its 75th Prime Minister in as many days!

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Page 4: Someone died or something??

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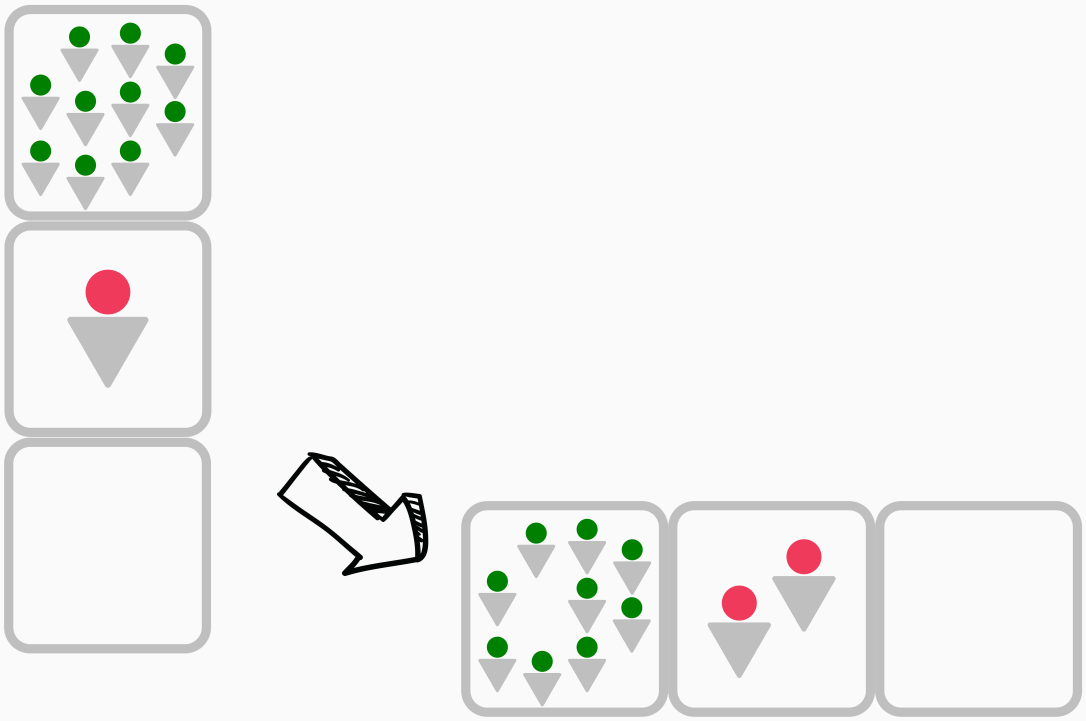

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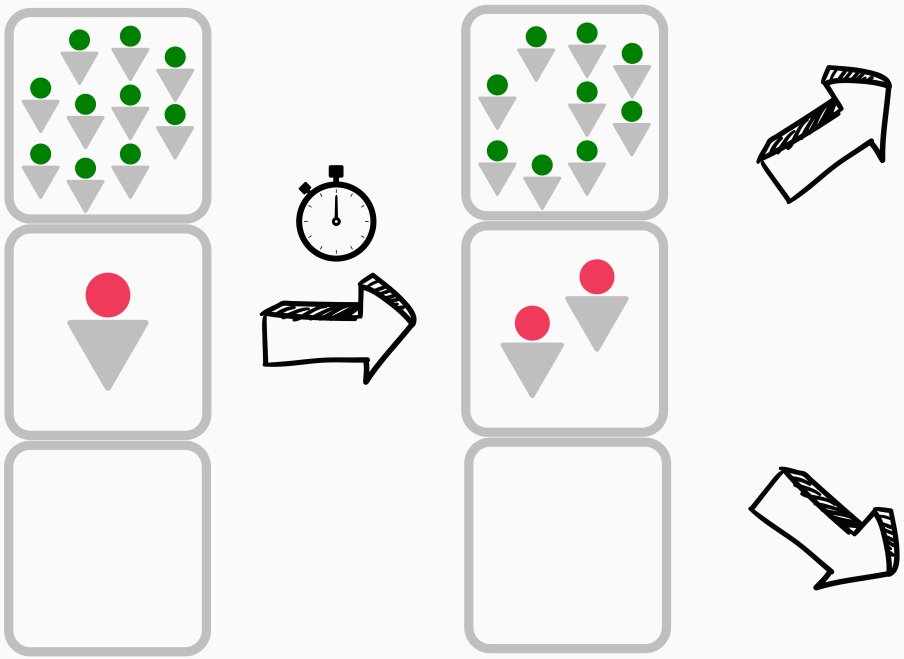

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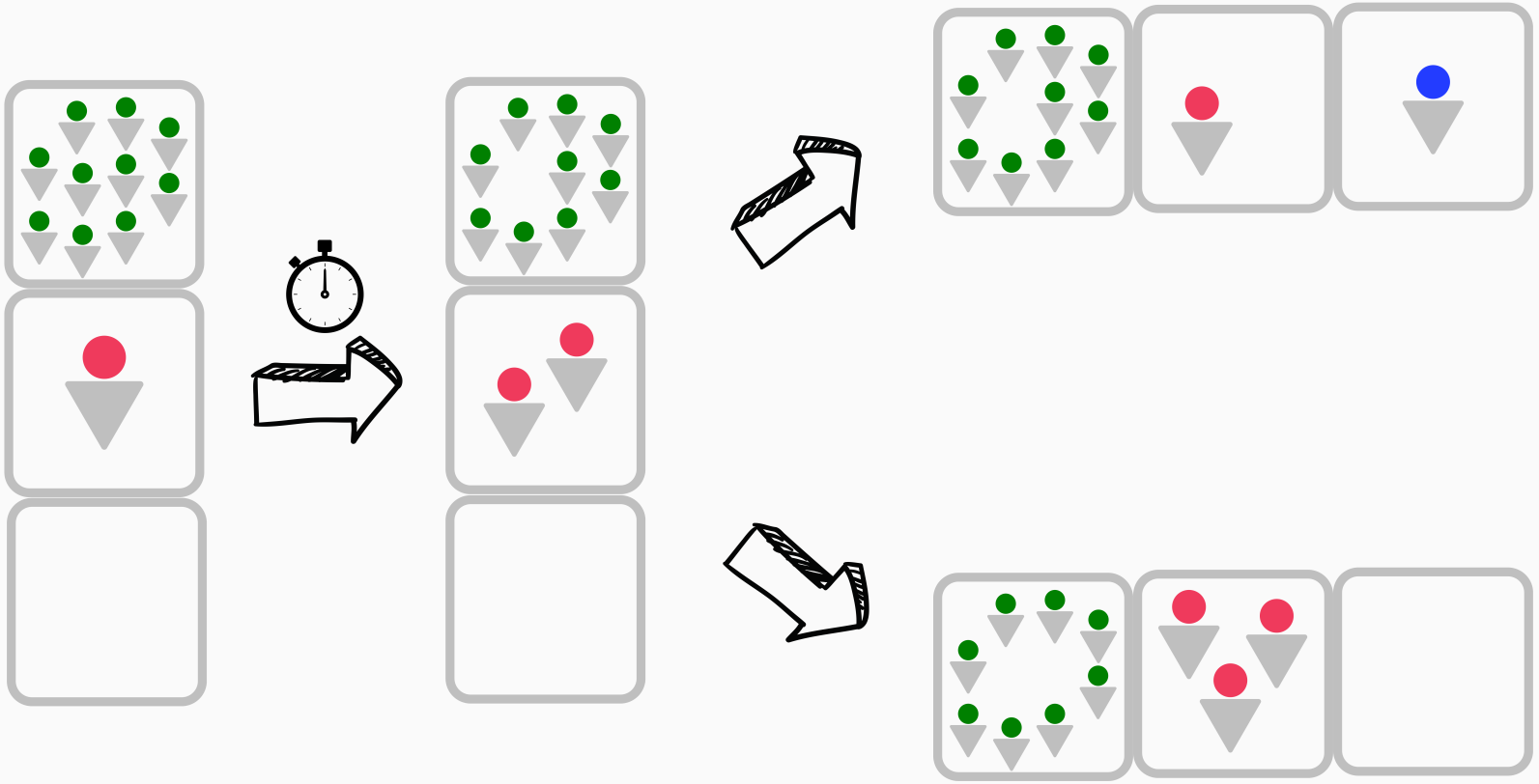

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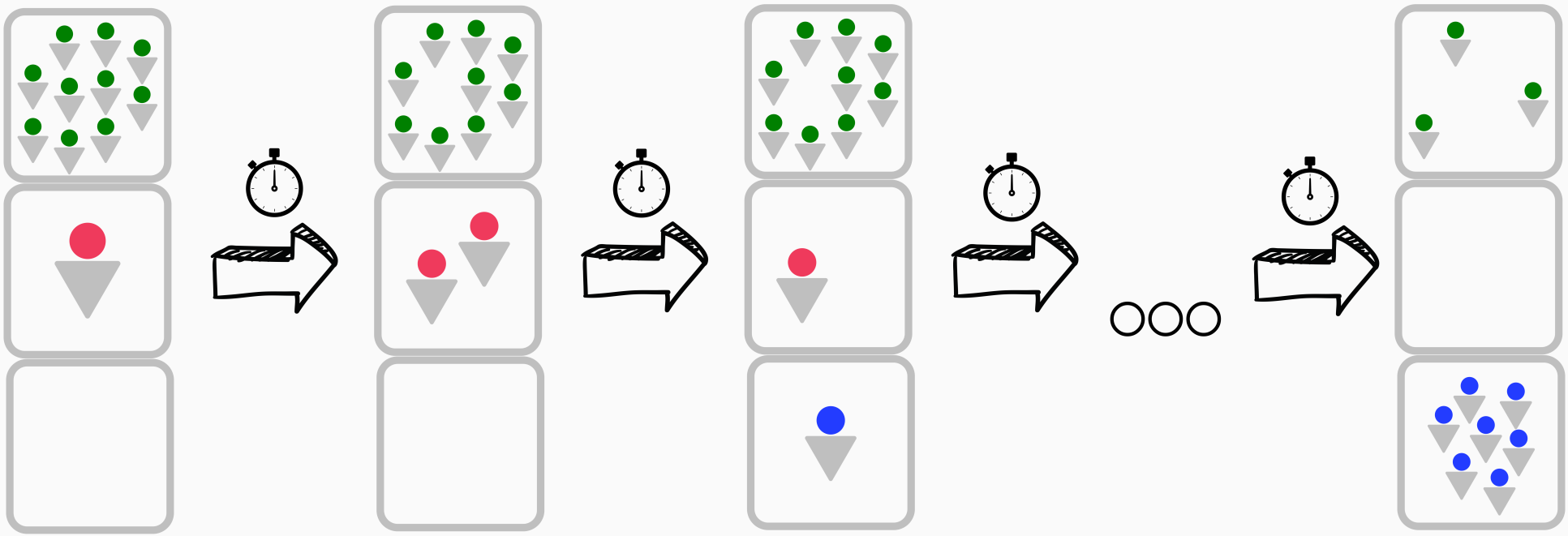
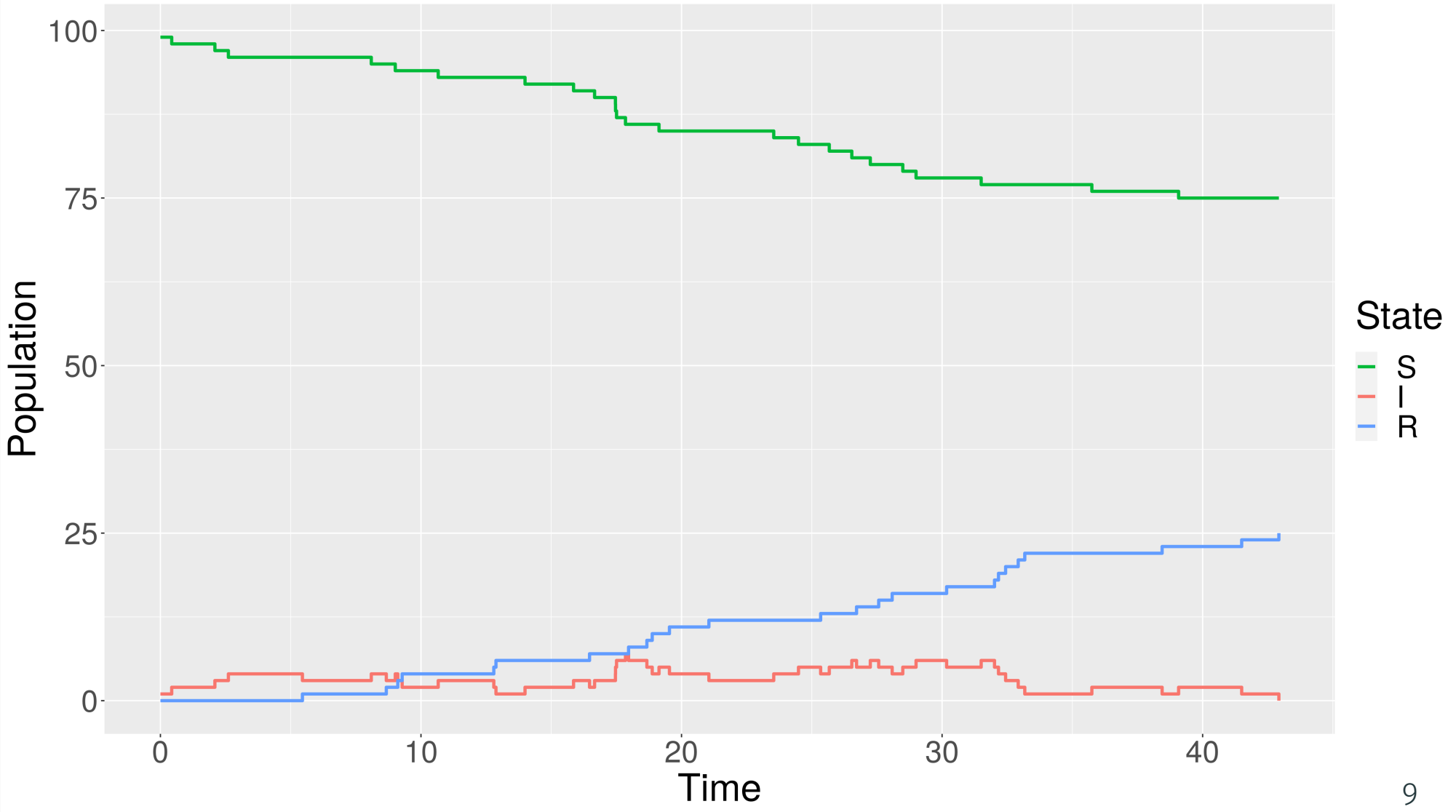


Visualising an epidemic



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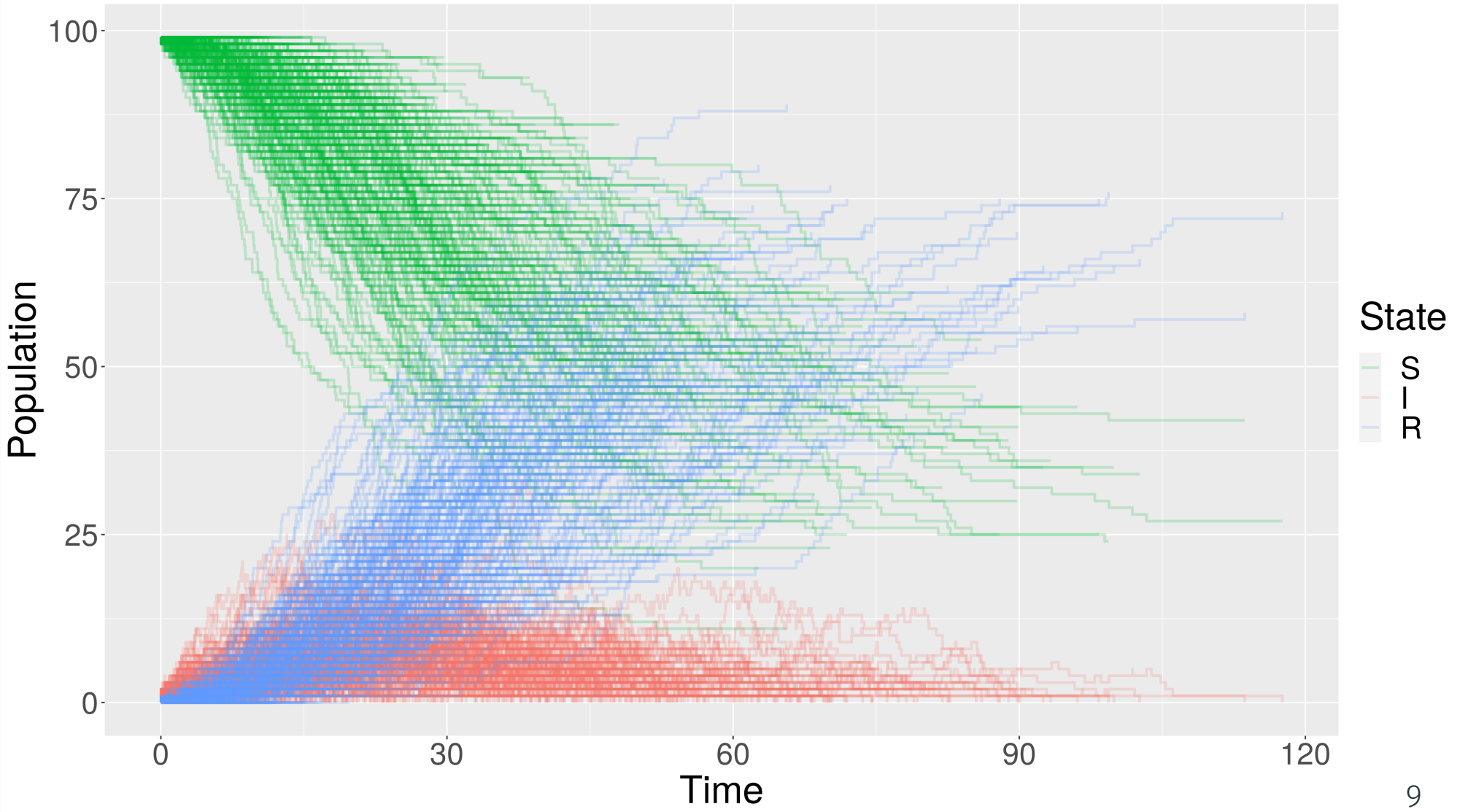

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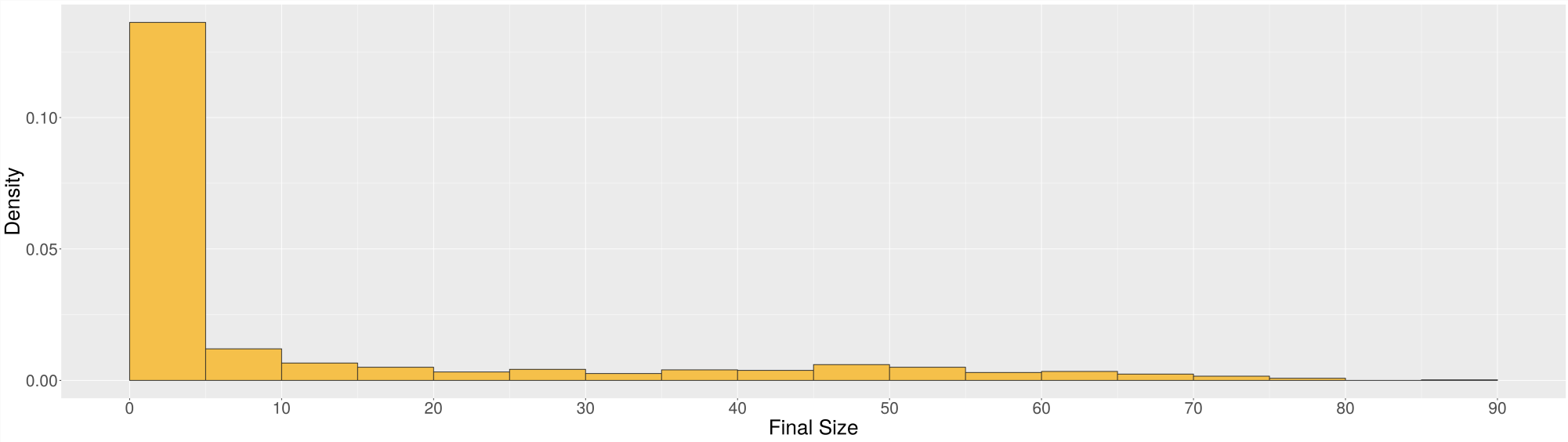

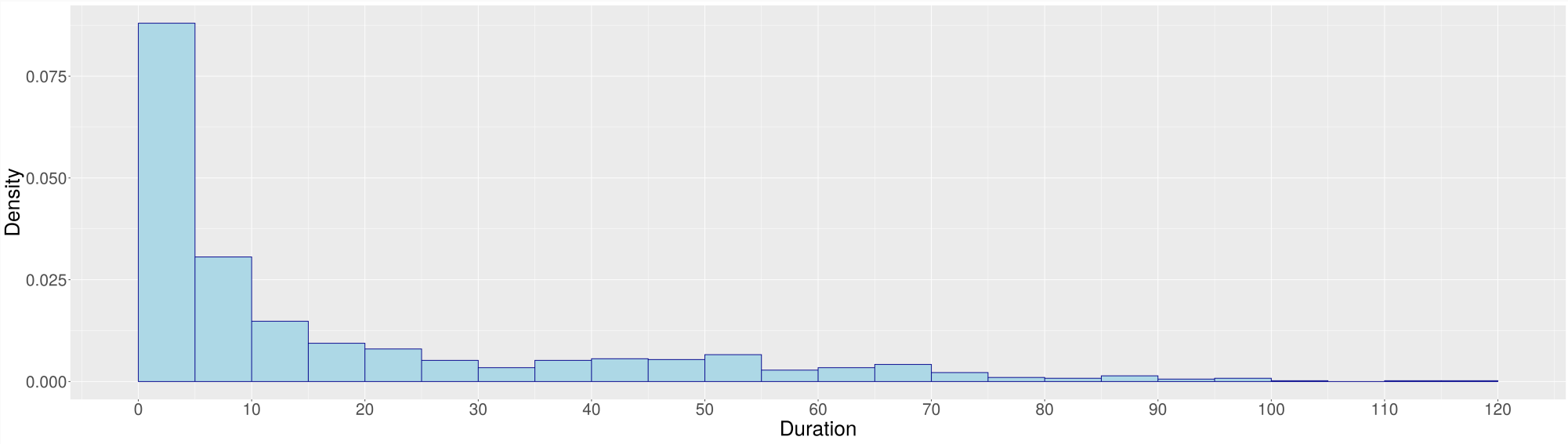

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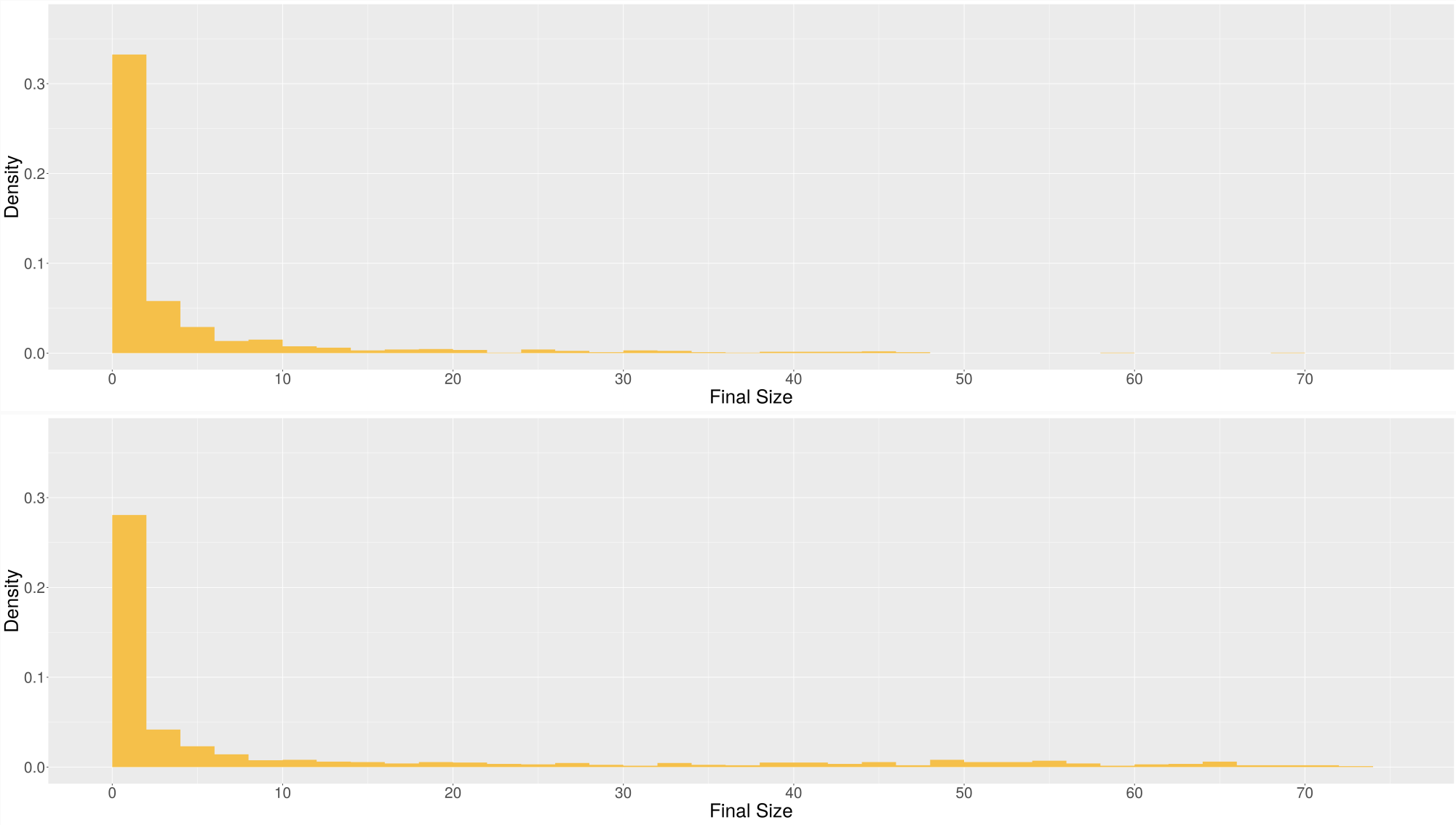

The Likelihood

Likelihood an Epidemic

- This set of Infection times and Removal times
- (given the initial conditions of the epidemic. . .
- . . . and our assumptions)
- Base it on our simulation
- Joint probabilities for each event of:
  - type of the event
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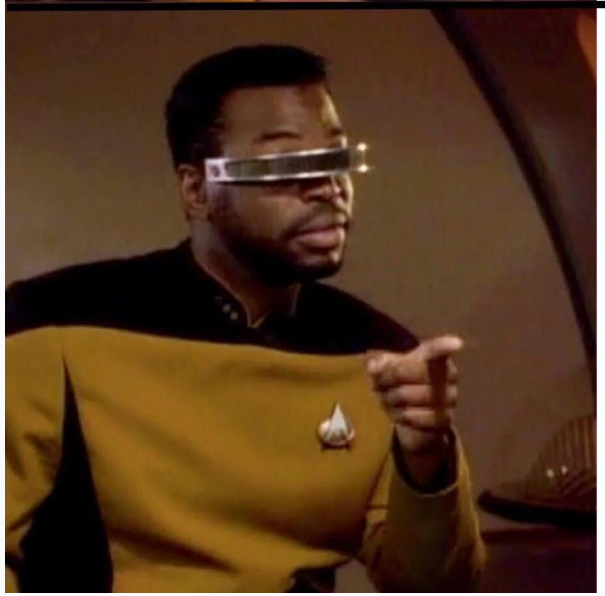
Making Inference

- MLE
- ABC



- MCMC

Intuitive: What is MCMC

Fancy	Understandable
Empirical estimation of the posterior distribution	Draw samples from the posterior to estimate mean, variance, etc.
Accounts for uncertainty through data augmentation	Find the most likely parameters across all possibilities for the missing data
Use Metropolis-Hastings steps	Fancy stats methodology to make sampling possible with some caveats

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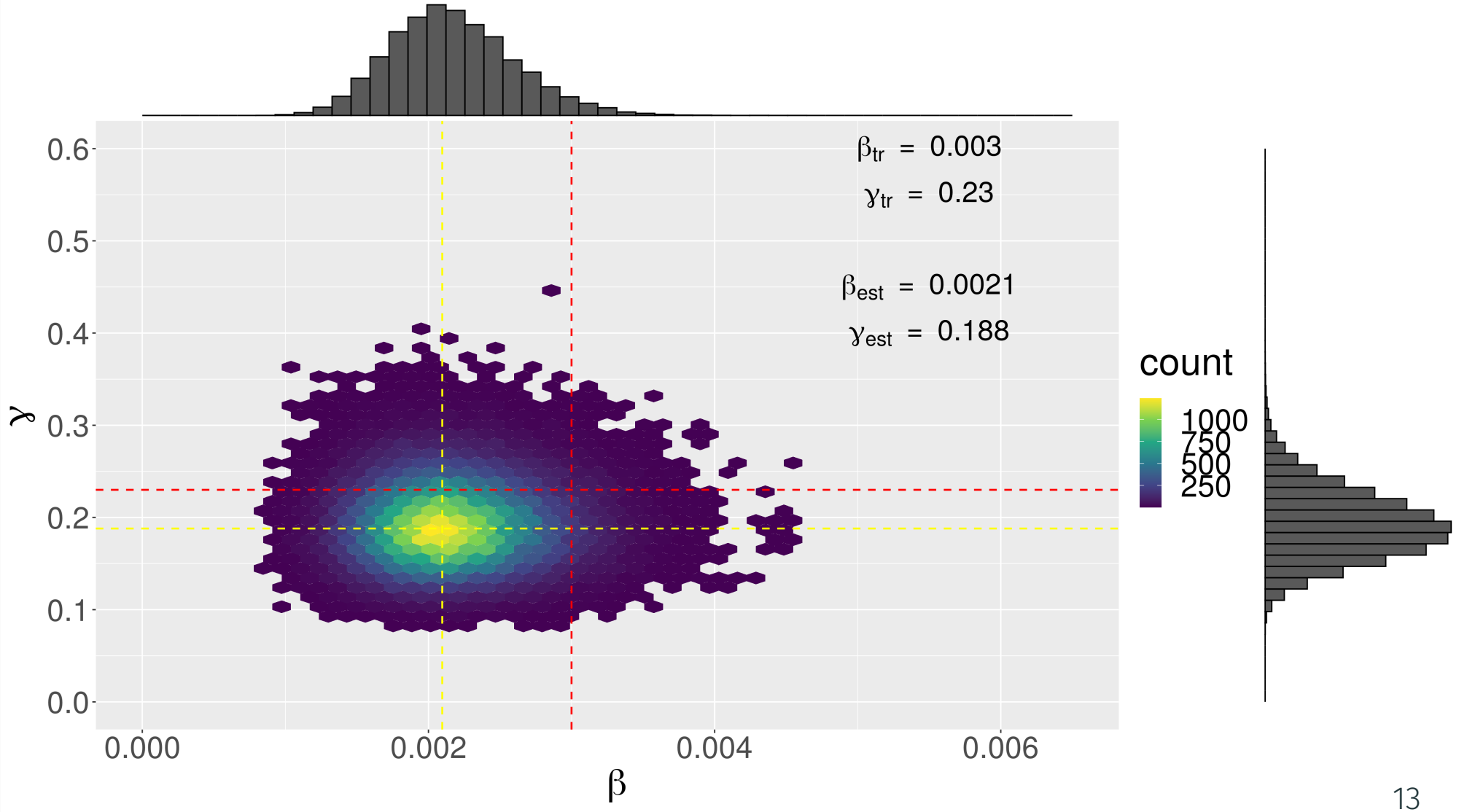
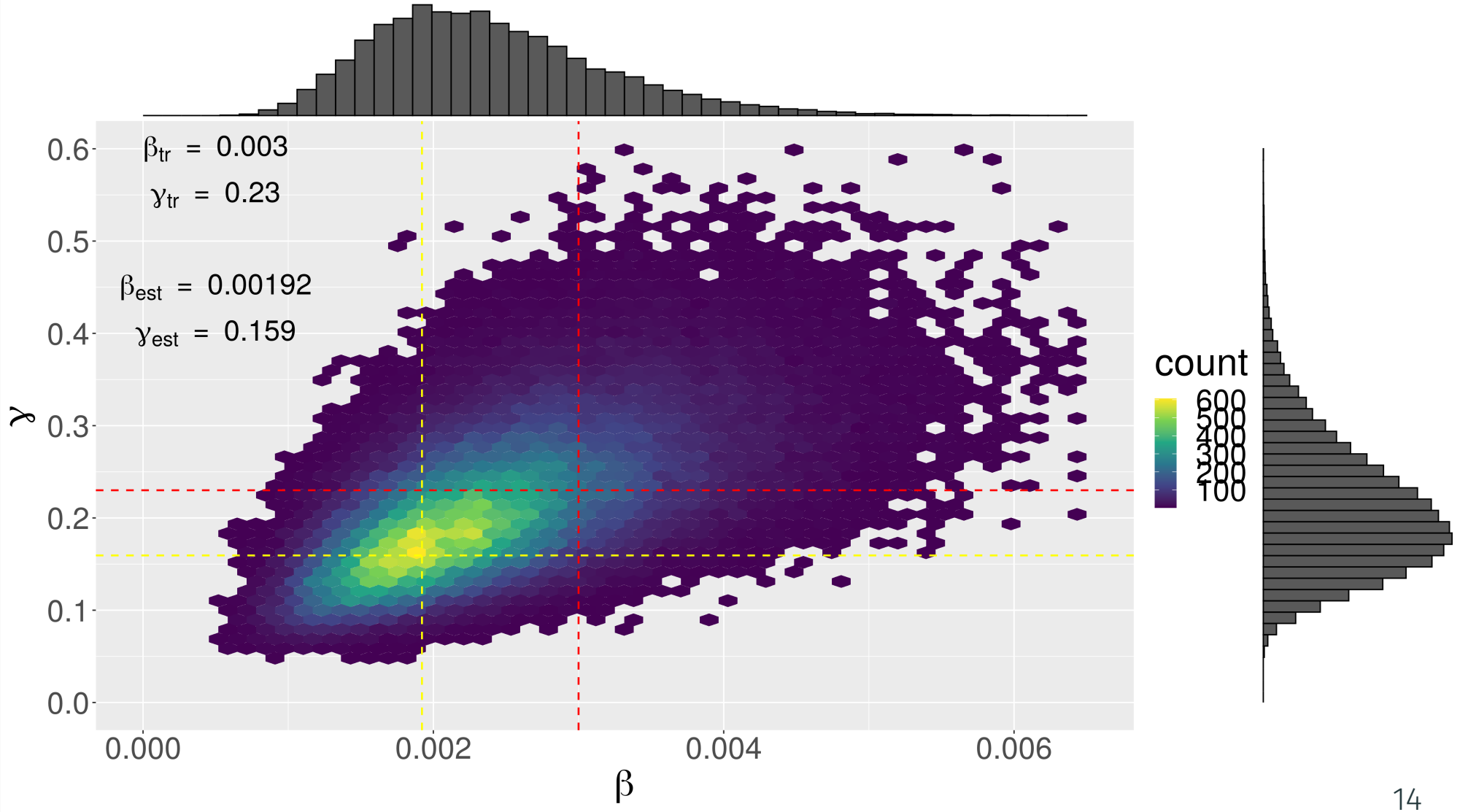
Results

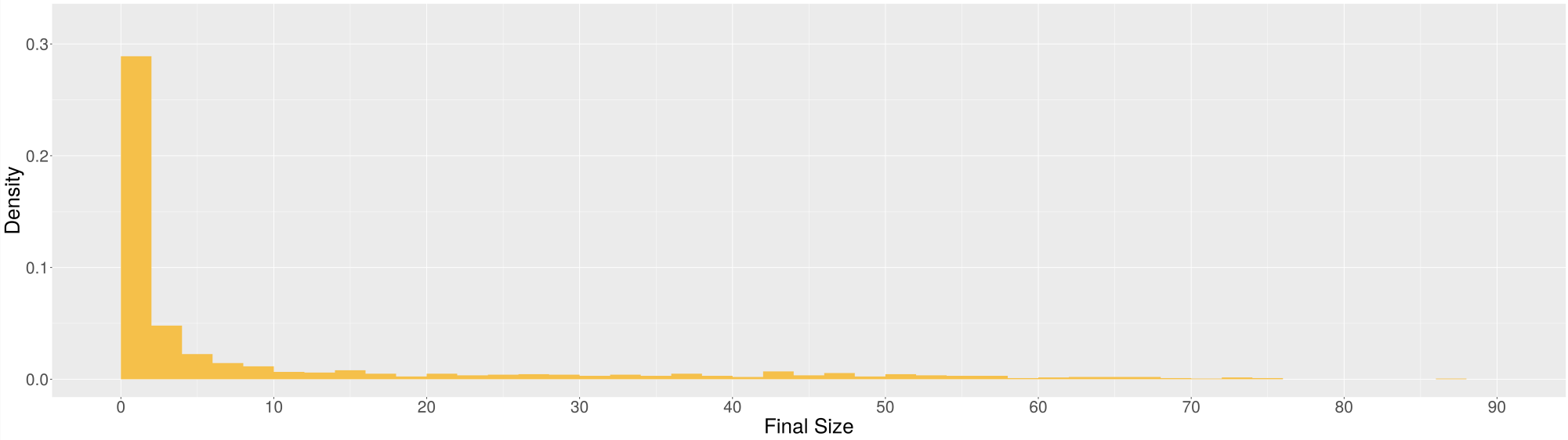
Results: Infection times known

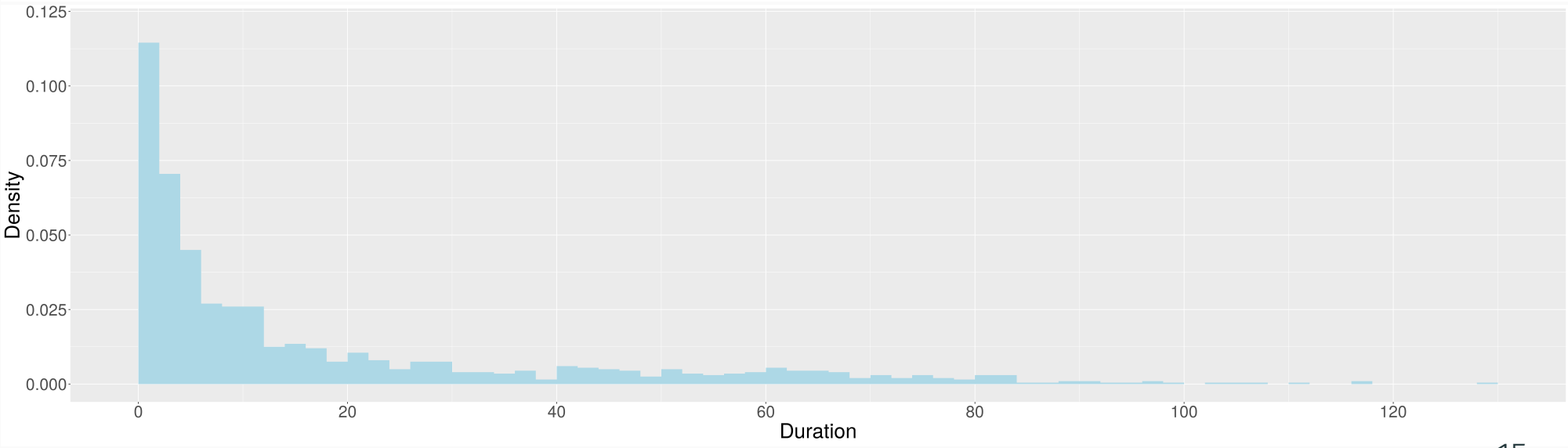


Results: Infection times unknown



Results: Simulation and Projection





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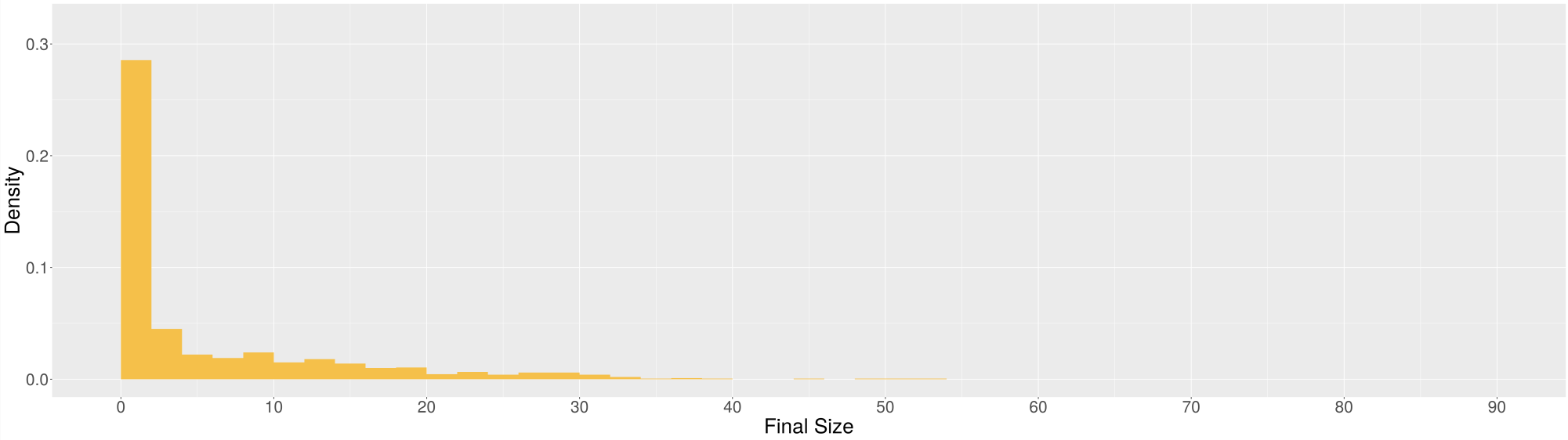

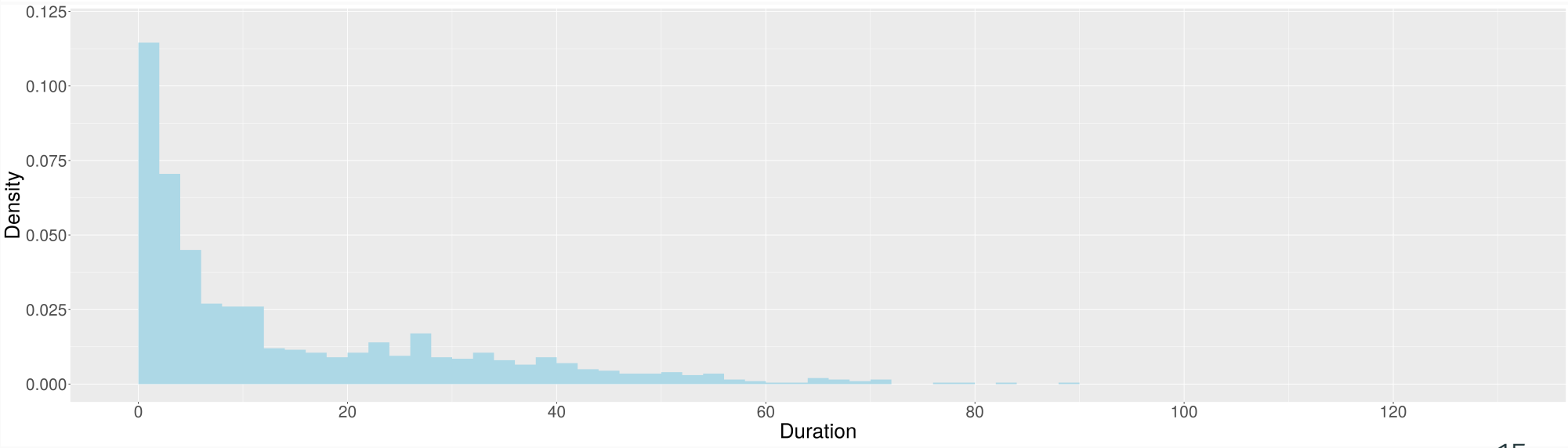

Closing thoughts

What next?

- Discrete time
- Households
- Exposed/latent states
- Asymptomatic diseases
- Heterogeneous pop.
- Meta populations
- Vectors and reservoirs
- Testing schemes

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- **Estimate:** current infections, test efficacy, new variants
- **Predict:** future deaths, hospital burdens, invention effects
- Combining results with ensemble methodology

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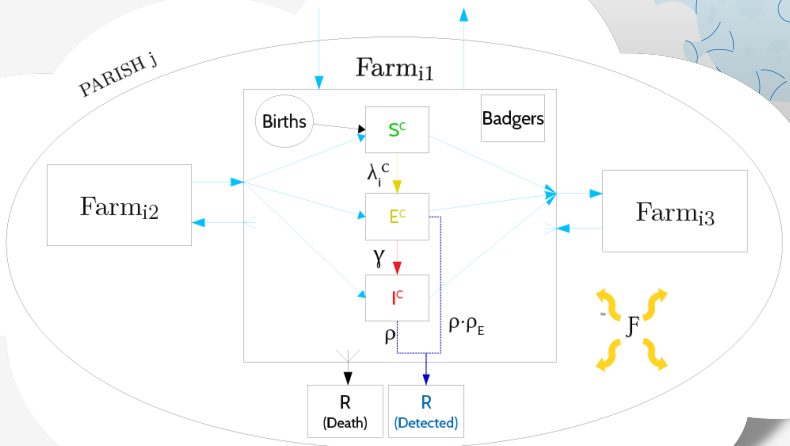
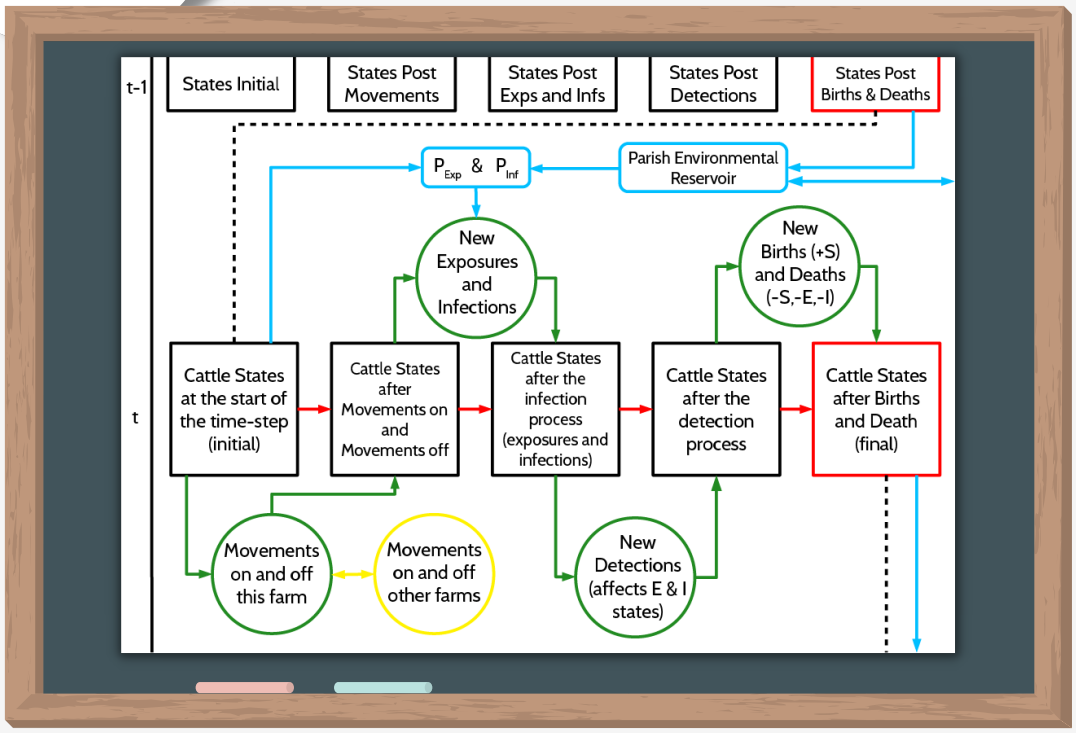
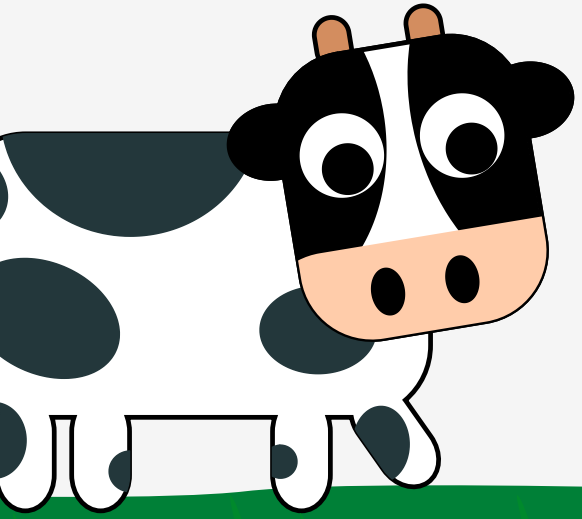
BAYES4HEALTH LANCASTER UNIVERSITY

BOVINE TUBERCULOSIS







Its not COVID, crazy!

You can contribute!

- Google search analytics data
- Air quality and traffic data
- Simple shift and scale models
- Behavioural analysis
- Dashboards and scientific communication
- Policy activism
- Economic analysis

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- Policy activism
- Economic analysis

You can contribute!

- Google search analytics data
- Air quality and traffic data
- Simple shift and scale models
- Behavioural analysis
- Dashboards and scientific communication
- Policy activism
- Economic analysis

Closing remarks

Thank you for listening!

- linkedin.com/in/benjamensimon
- github.com/BenjamenSimon
- BenjamenSimon.github.io (Under construction)