Modelling for beginners

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Doherty Institute

THE UNIVERSITY OF MELBOURNE

The Royal Melbourne Hospital

A joint venture between The University of Melbourne and The Royal Melbourne Hospital

What are models?

- A model is a simplified representation of the world
- Infectious disease models help us understand patterns of disease by representing the **dynamic process** by which they spread (using equations and/or computational algorithms)

The classic SIR model

The Susceptible, Infectious, Recovered (SIR) model is one of the simplest disease models, proposed almost 100 years ago[1] and still the basis of infectious disease modelling today.

The SIR model sorts individuals into three compartments based on their disease state:

Susceptible – can be infected

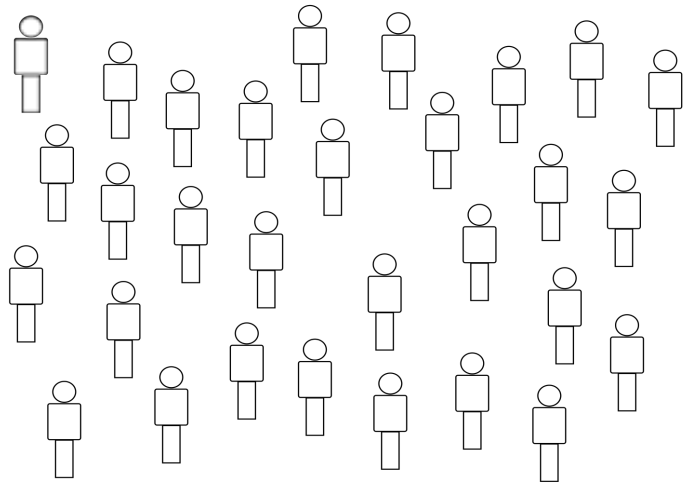
Infectious – can infect others

Recovered (or Removed) – cannot be infected nor infect others

[1] Kermack, WO & McKendrick, AG.(1927). *Proceedings of the Royal Society A*. **115**(772): pp 700–721.

SIR model: sorting individuals

- A major assumption of the classic SIR compartmental infectious disease model is that individuals only differ by their disease state



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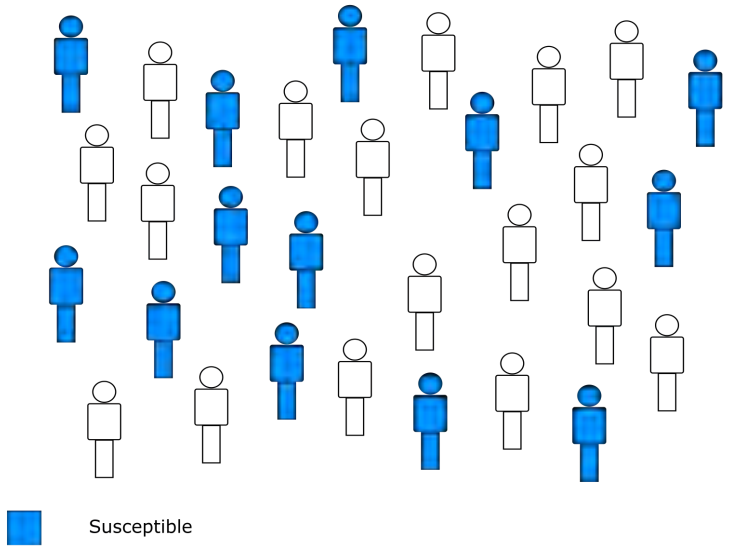

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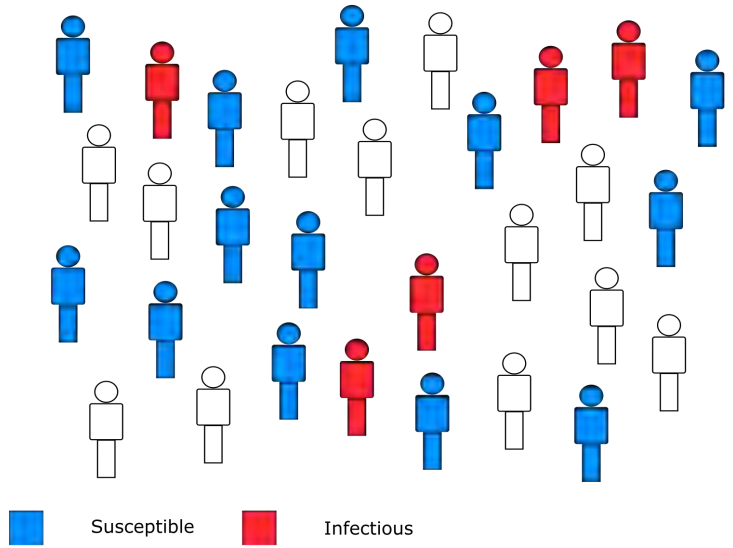

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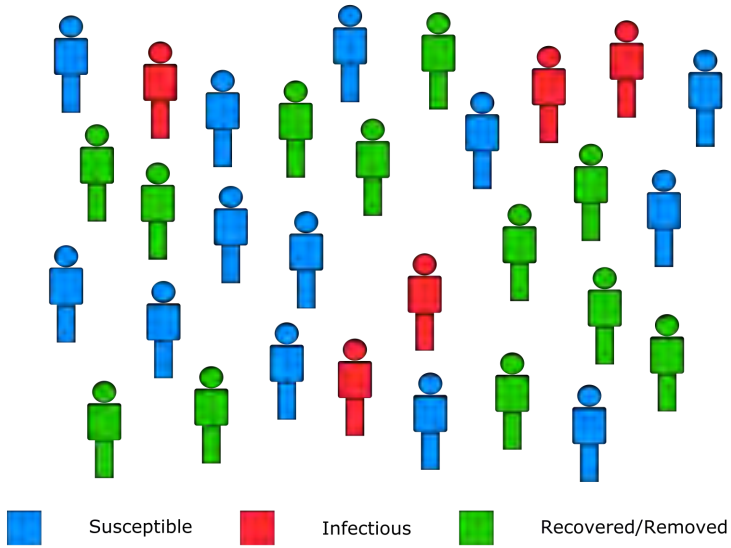
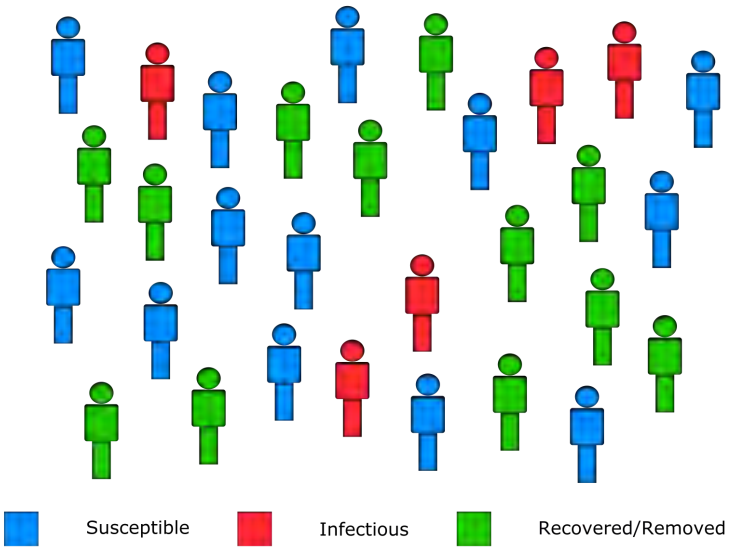
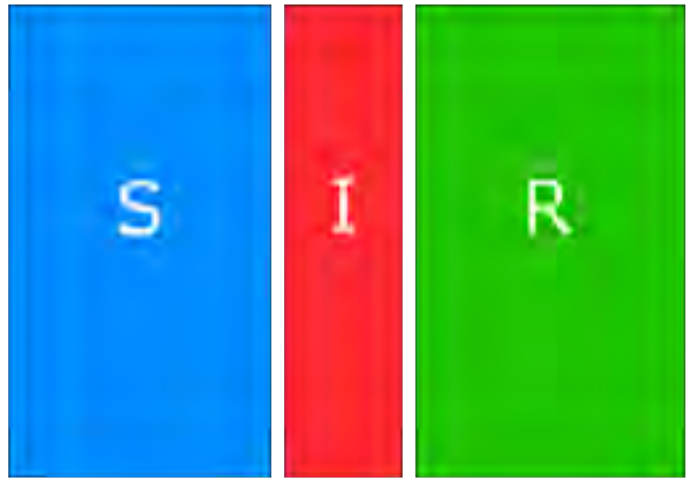


SIR model: grouping individuals

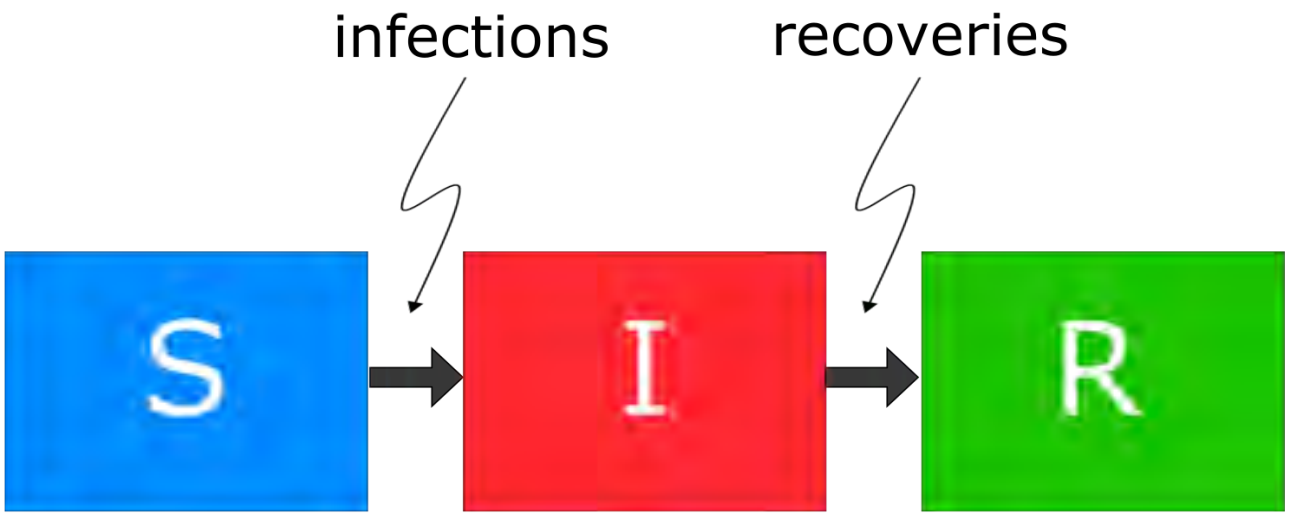
Since the only difference between individuals in our population is their disease status, we can group all of the individuals with the same disease status together.





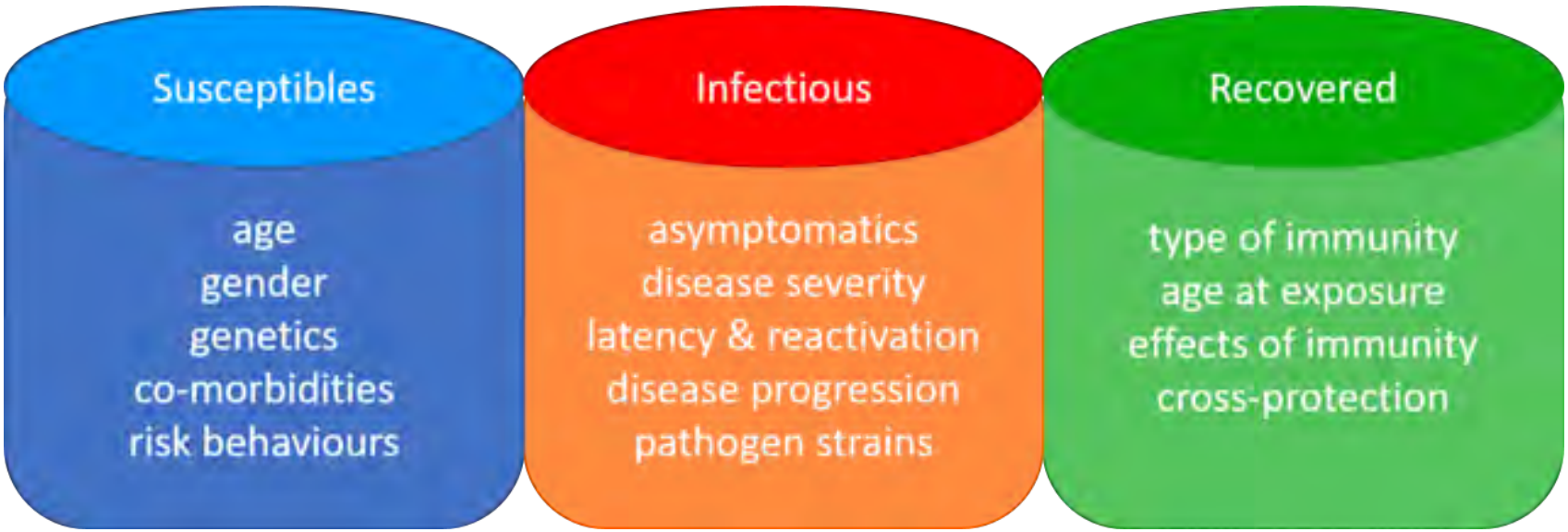
SIR model: model schematic

- We consider the events that occur that cause individuals to change their disease state
- We use differential equations to track how the population in each compartment is changing

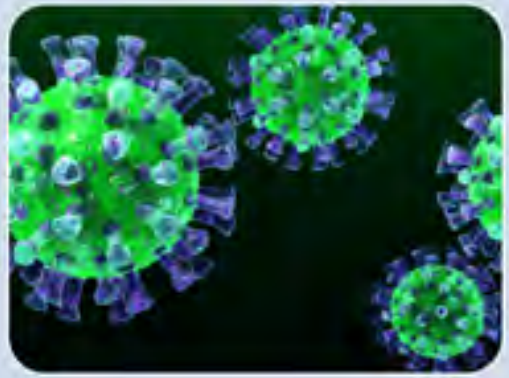


Adding complexity to the SIR model

- The classic SIR model forms the basis of many infectious disease models.
- To match real world scenarios, it is almost always necessary to add complexity to models.



What information do we need to build transmission models?



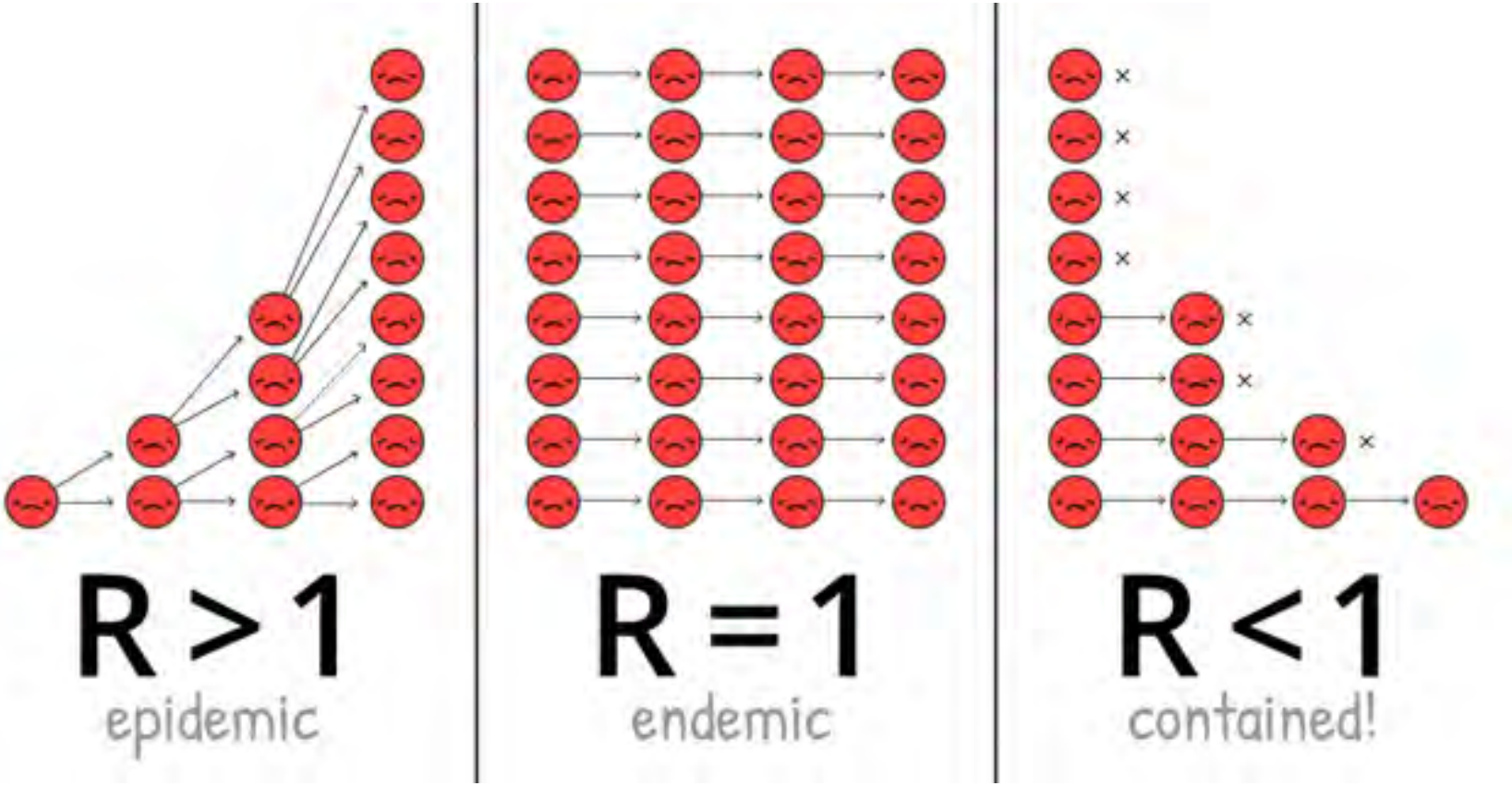
Natural history of the disease e.g. transmissibility; latent period; infectious period; immunity

Population characteristics and behaviours e.g. size; age distribution; number of contacts; risk groups

Treatments and interventions e.g. coverage; effectiveness; type of impact

The **effective** reproduction number (R_{eff})

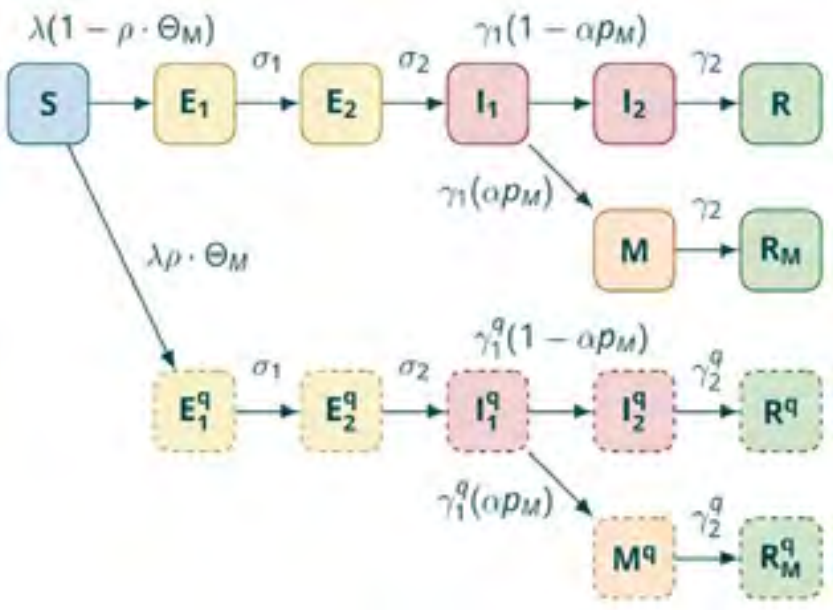
The time-varying expected number of secondary cases produced by a single (typical) infection in a population that is **not fully-susceptible** to infection



Source:https://ncase.me/covid-19/

Modelling COVID-19 in Australia
Two examples from the Doherty Modelling Group

Preparedness modelling: early 2020



- SIR-like compartmental model
- Infected but not infectious (E)
- Pre-symptomatic infectiousness (I_1)
- Interventions: Quarantine (dashed) & Isolation (M)

Source: Moss et al. (2020) Emerg Infect Dis. https://doi.org/10.3201/eid2612.202530

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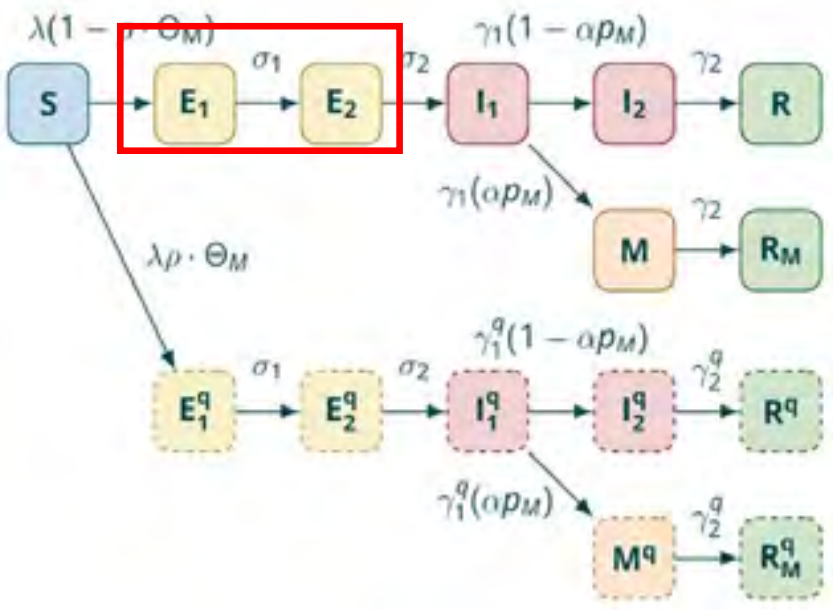

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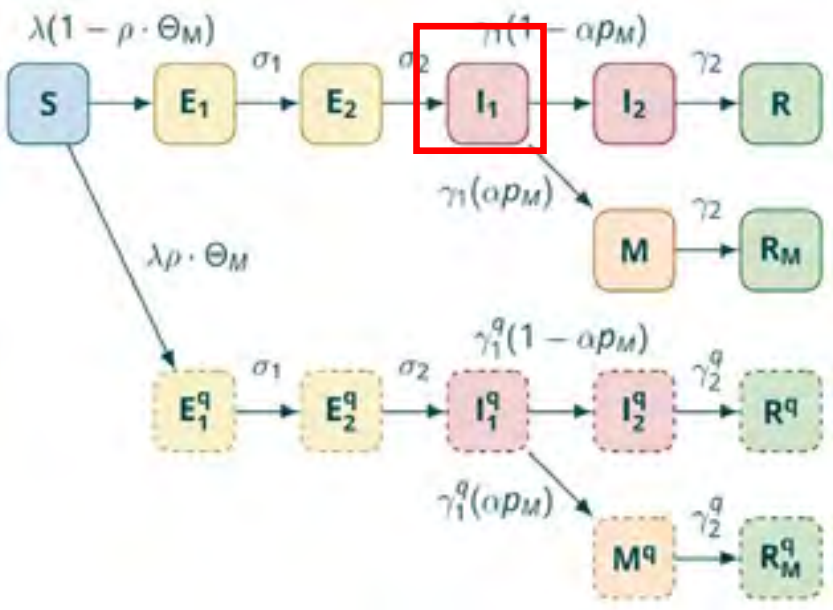

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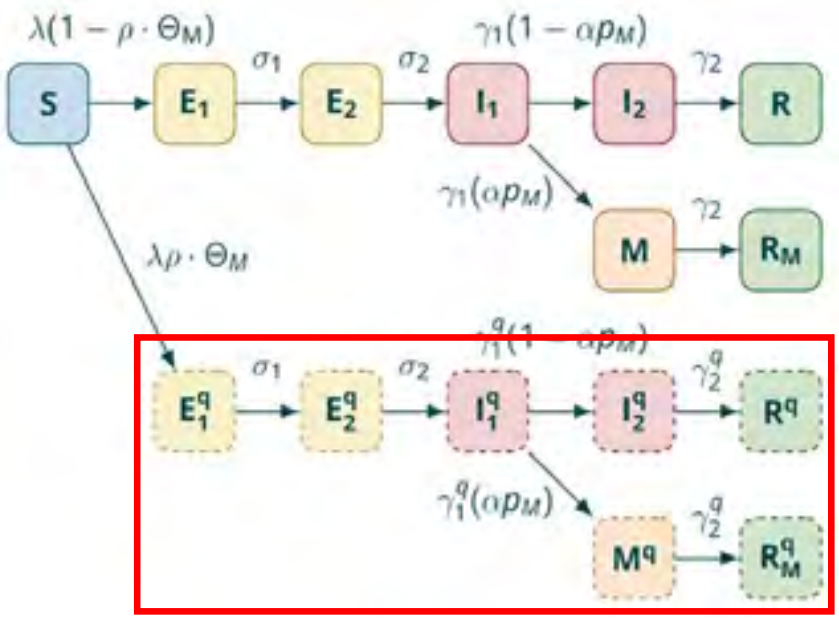

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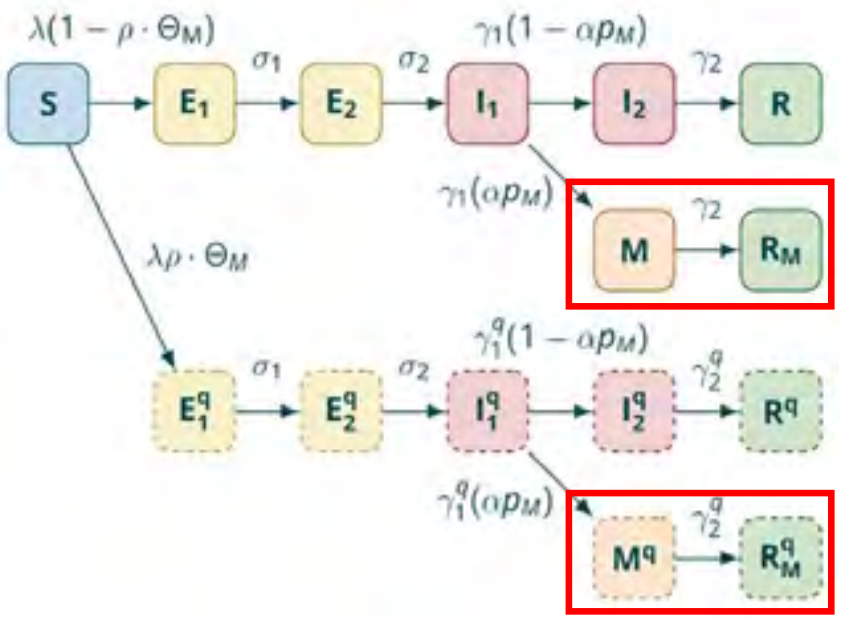

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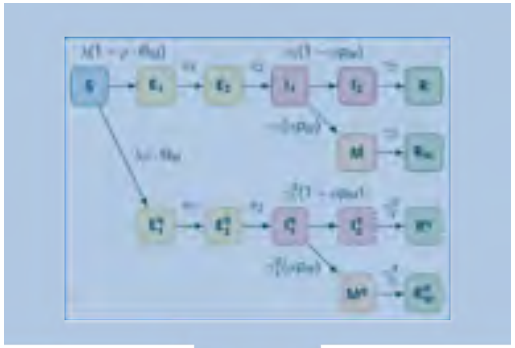
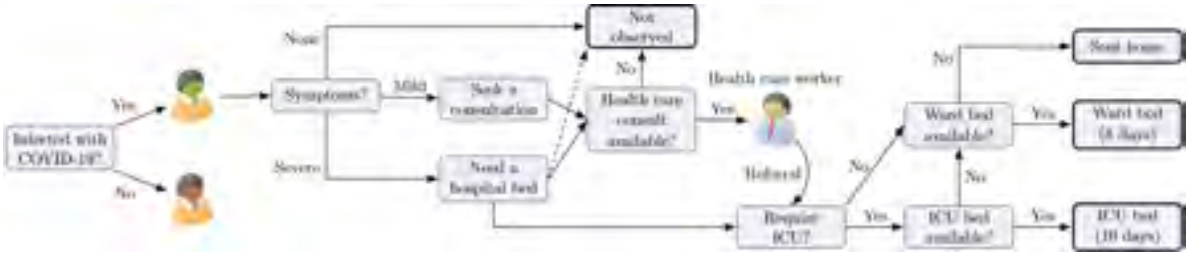


Daily presentations split into mild and severe



Output: Daily usage numbers for each health care channel

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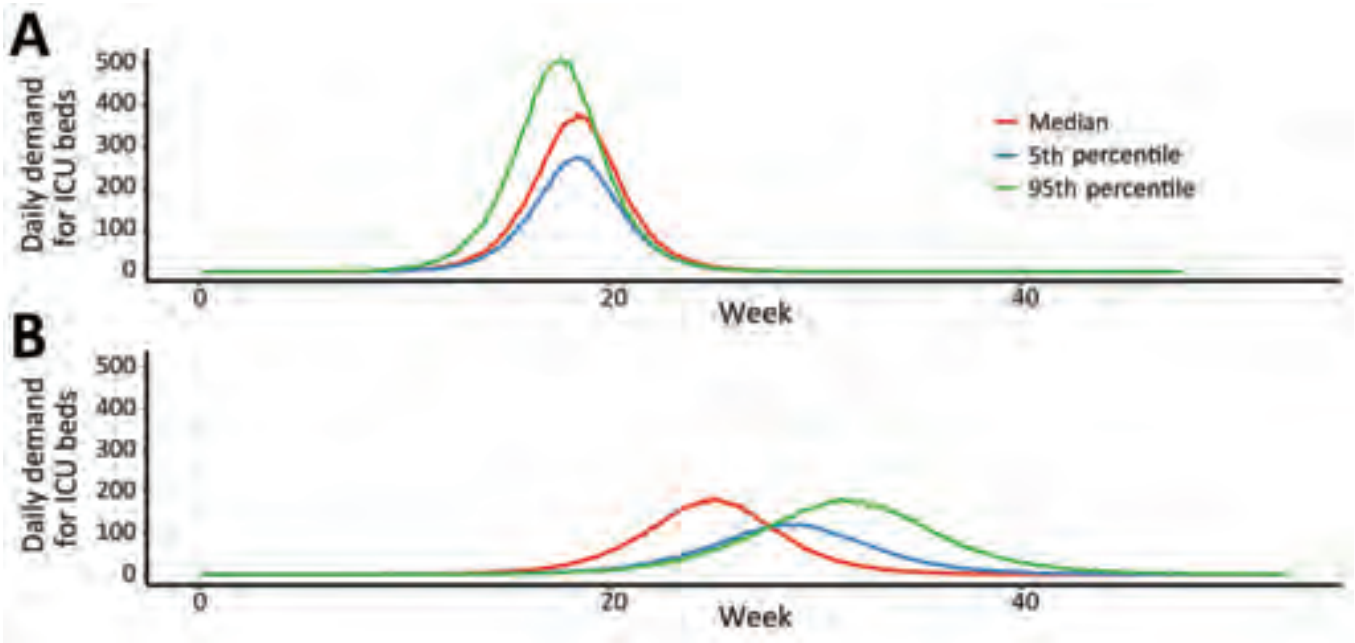

A Daily ICU demand: Unmitigated COVID-19 epidemic

B Daily ICU demand: Case isolation and quarantine

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Transitioning Australia's COVID-19 response: mid-2021

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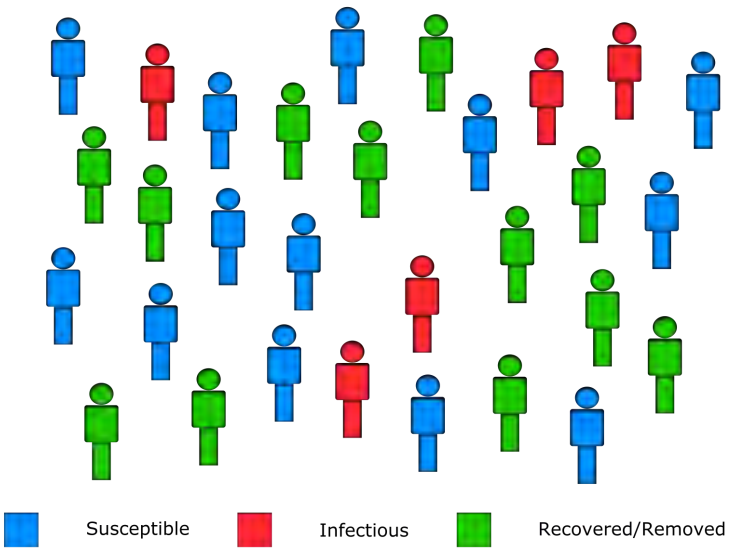

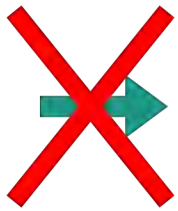

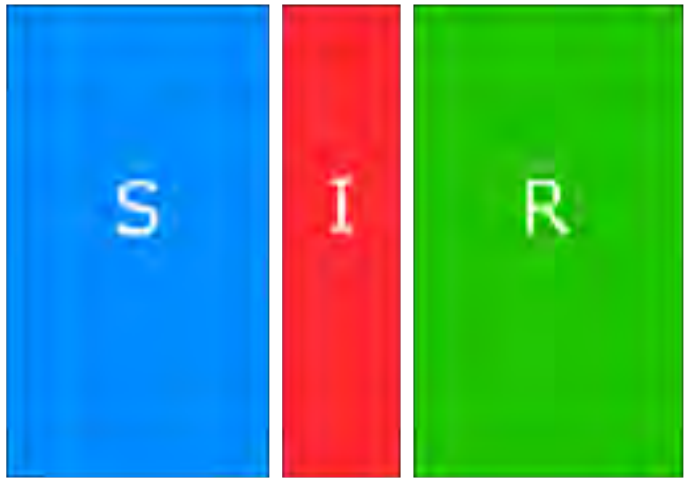

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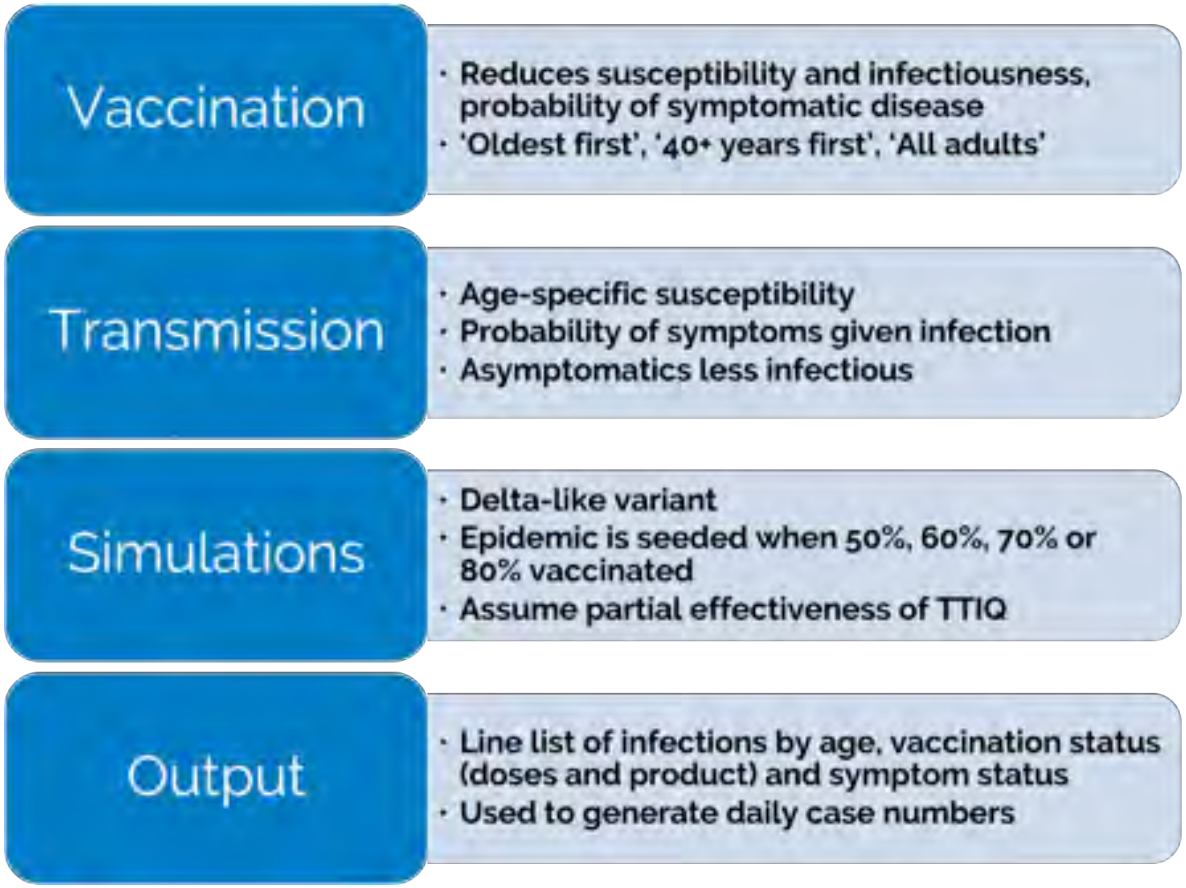

Source: Doherty Modelling Report Revised 10th August 2021
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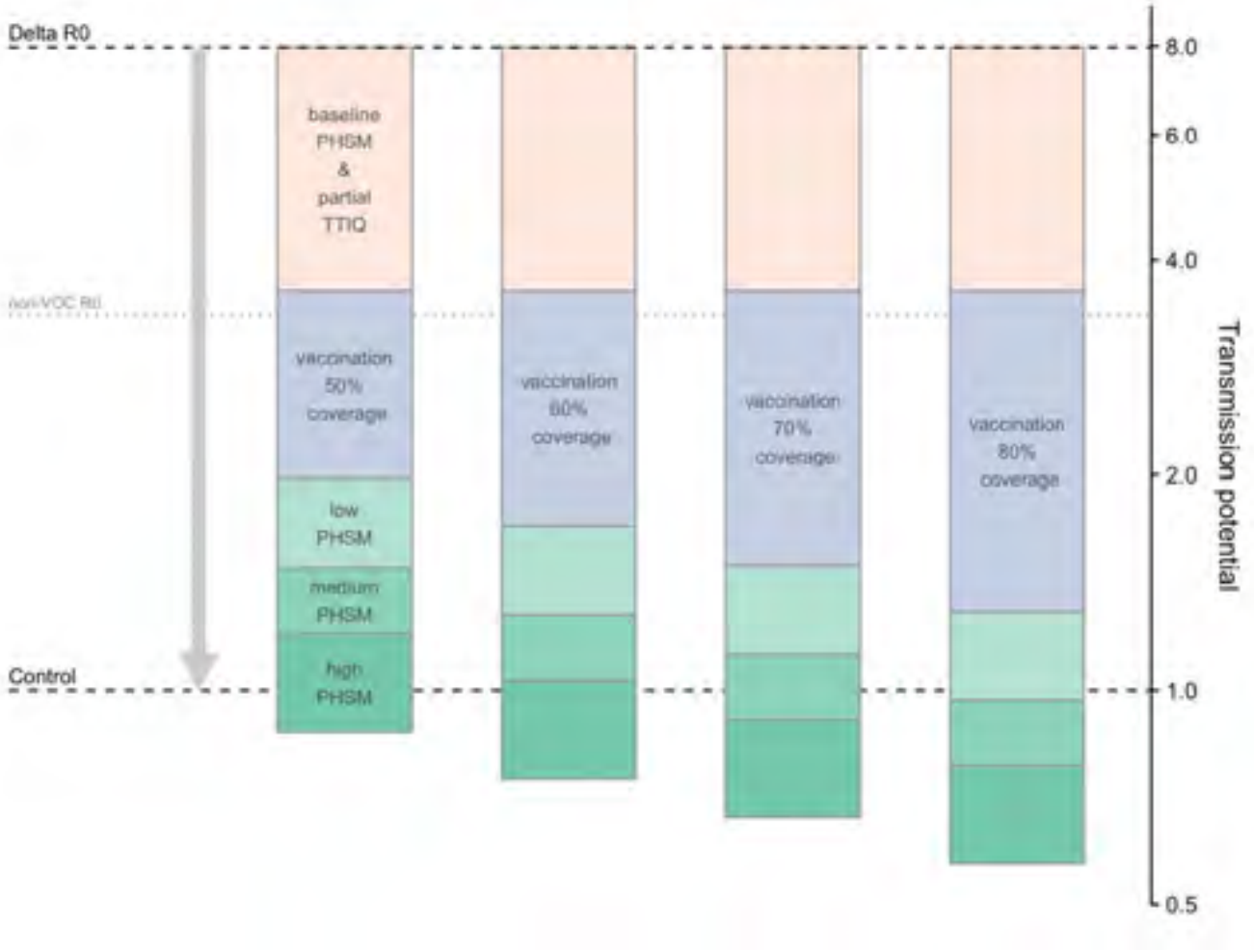

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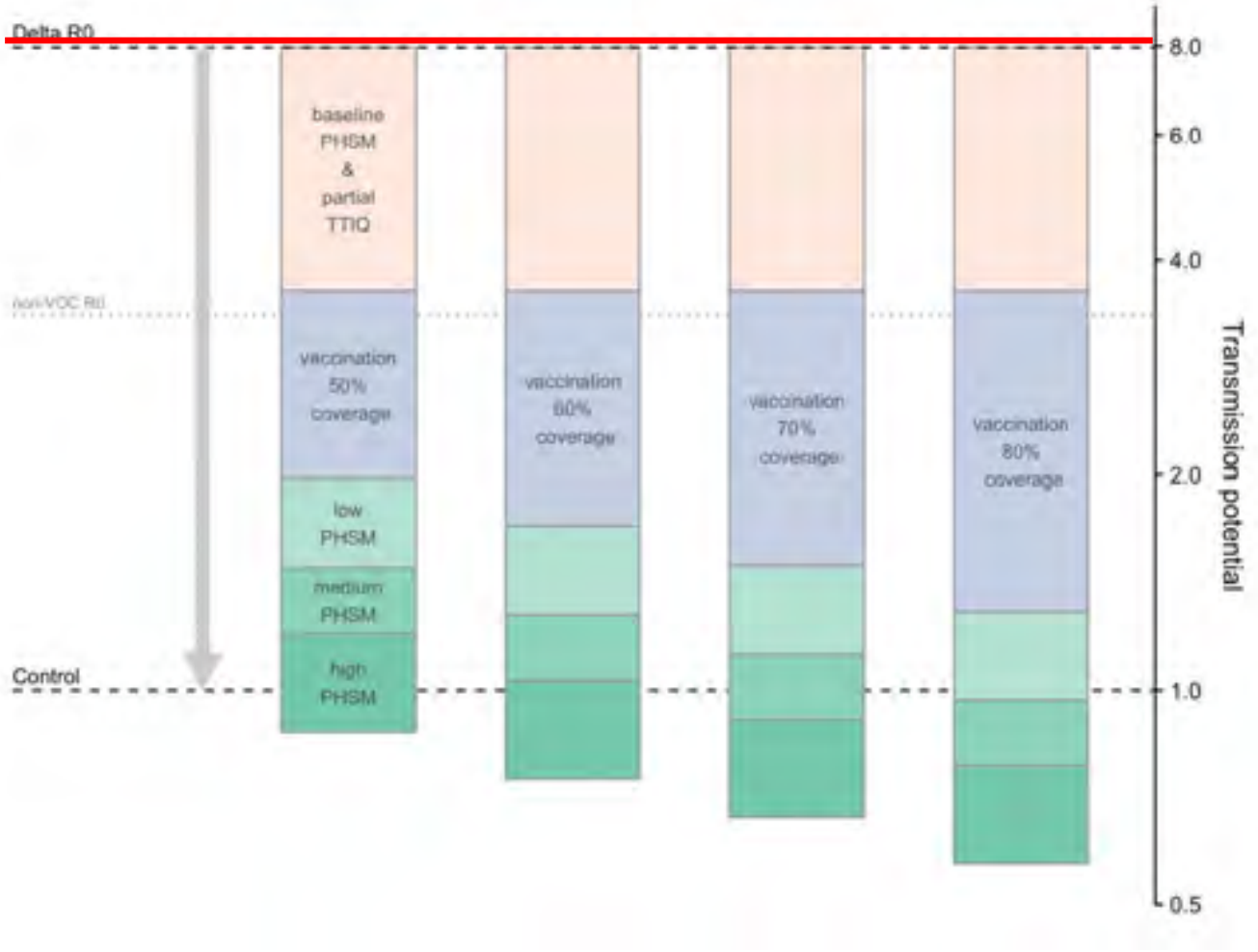

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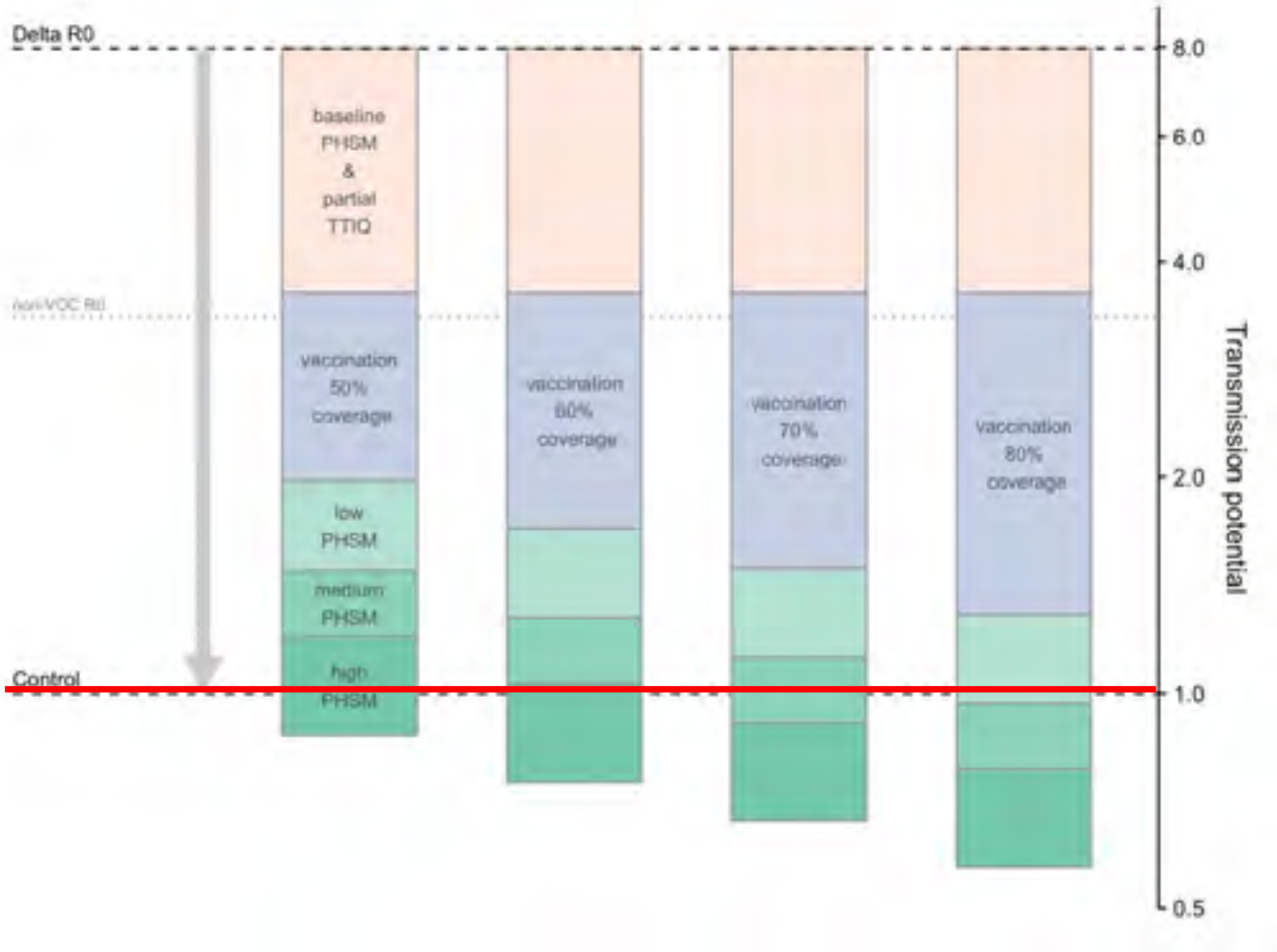

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Summary

- Mathematical and computational models for COVID-19 have helped us to understand what measures are required to minimise the consequences of COVID-19 transmission
- COVID-19 is a rapidly changing situation, and we need to be continually updating models as new information becomes available
- The models described here represent epidemiologic modelling of scenarios used to ask 'what if' particular actions were taken — they are NOT predictive forecasts

Acknowledgements

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- Emily Eriksson
- Vanessa Bryant

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- Laura Bannerman
- Olivia McIntyre

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