Potential impact of wild poliovirus 1 introduction into South Africa

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&

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Overview

- Background: Polio
- Motivation for the project
- Methods: Transmission model
- Results: Expected number of cases under different scenarios
- Limitations
- Conclusion & next steps

SACEMA's Modelling and Analysis Response Team:

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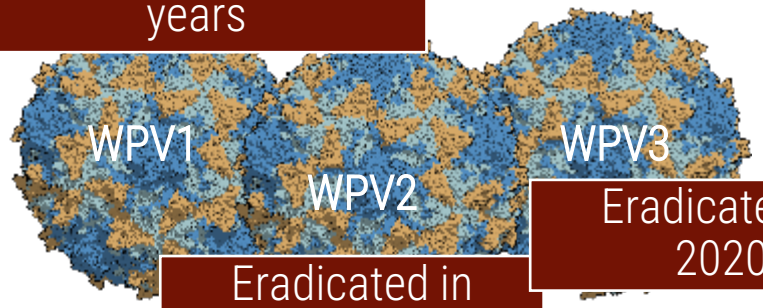
Polio is highly contagious life-threatening viral disease

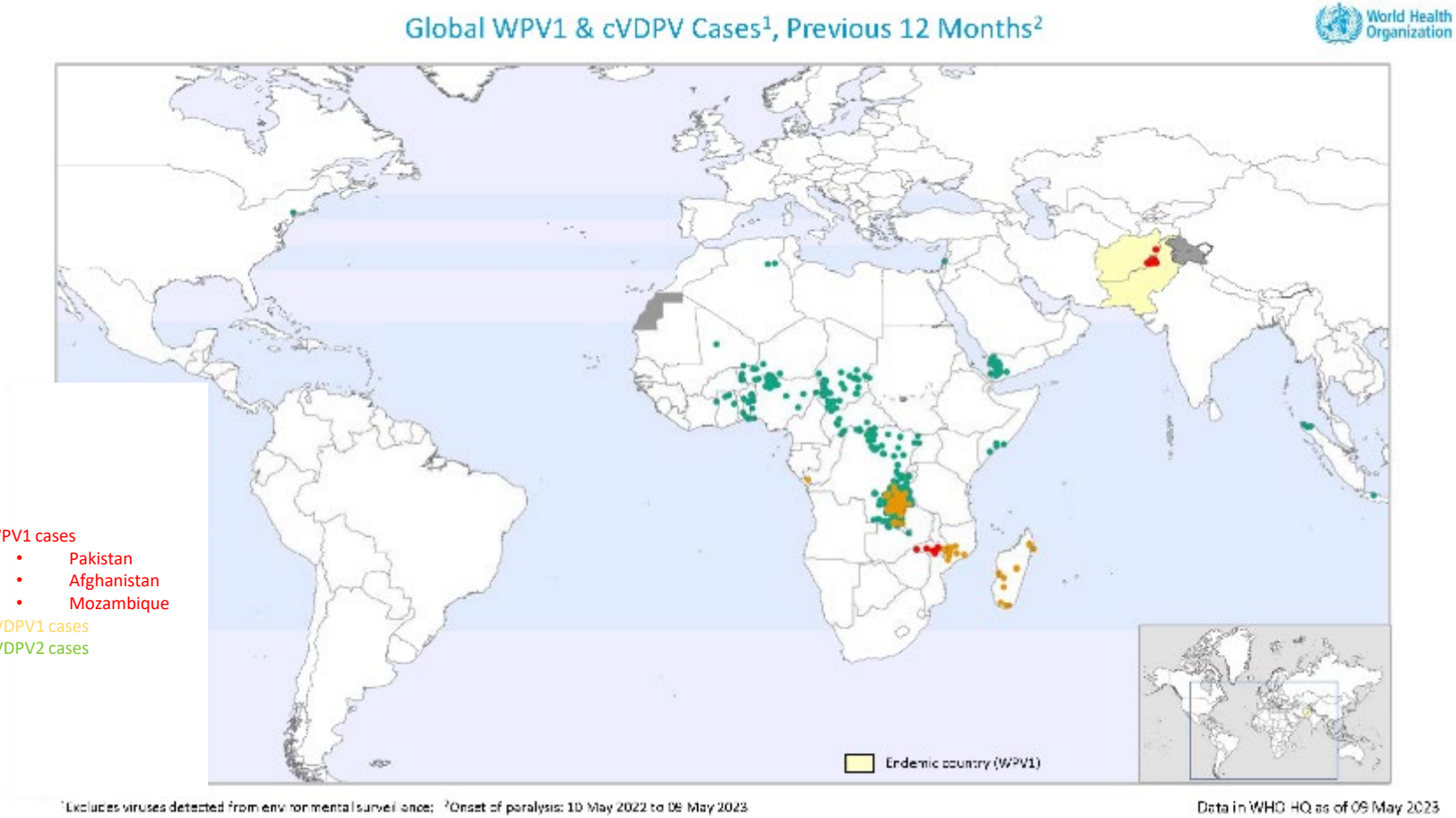
Detected in Southern Africa in the past 2 years



Eradicated in 1999

Eradicated in 2020

Cases due to wild poliovirus have decreased by over 99% since 1988

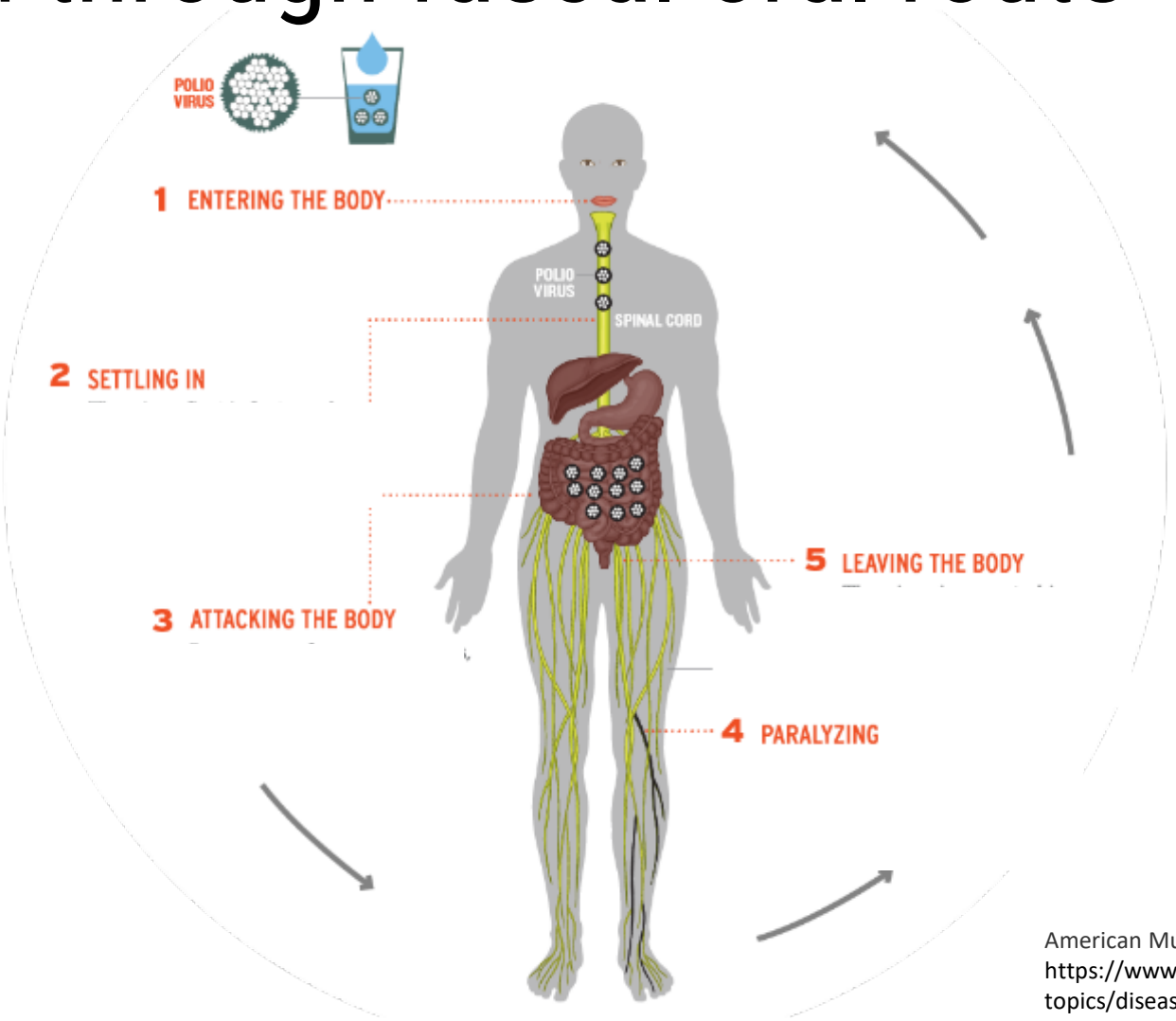


Polio is spread through faecal-oral route

1 in 200 infections result in irreversible paralysis

Individuals who are not fully immunized are at risk

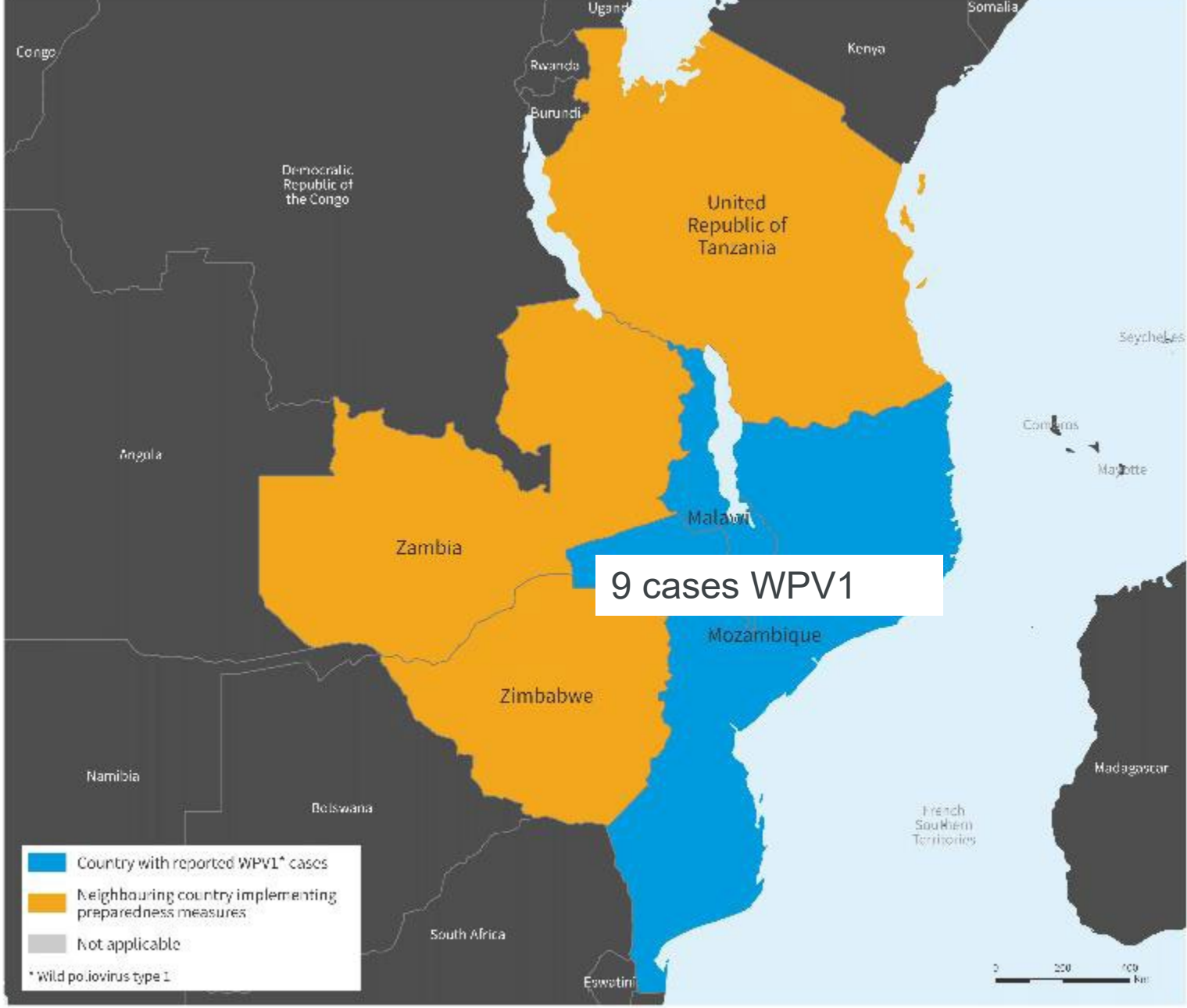
Polio is a vaccine-preventable disease



American Museum of Natural History. https://www.amnh.org/explore/science-topics/disease-eradication/countdown-to-zero/polio

South Africa is at risk of a polio outbreak

1. Last case of polio in South Africa was reported in 1989
2. Low vaccination levels
3. Frequent travel between countries currently dealing with polio outbreaks



Approach

Examine potential magnitude of poliovirus outbreaks following introduction

- Age-structured compartmental model
- Initial focus on WPV1

Scenario analysis

- Reactive SIA (following detection of a single polio case)

Model outcomes

- Number of underlying and detected AFP cases, by scenario

Transmission model

Initial population divided into groups based on infection and vaccination history

- Humoral and mucosal immunity (fully protected)
- Humoral immunity only (protected from disease; able to transmit)
- Fully susceptible

Model will be run separately for each of South Africa's 52 districts, based on district-level characterization of:

- Population age structure
- Age-structured immunity profile

Model structure

$S_{(i)}$ Fully susceptible

$V_{H(i)}$ Humoral immunity only

$G_{(i)}$ Mucosal (“gut”) and humoral immunity

Age classes are represented by $_{(i)}$

Model structure

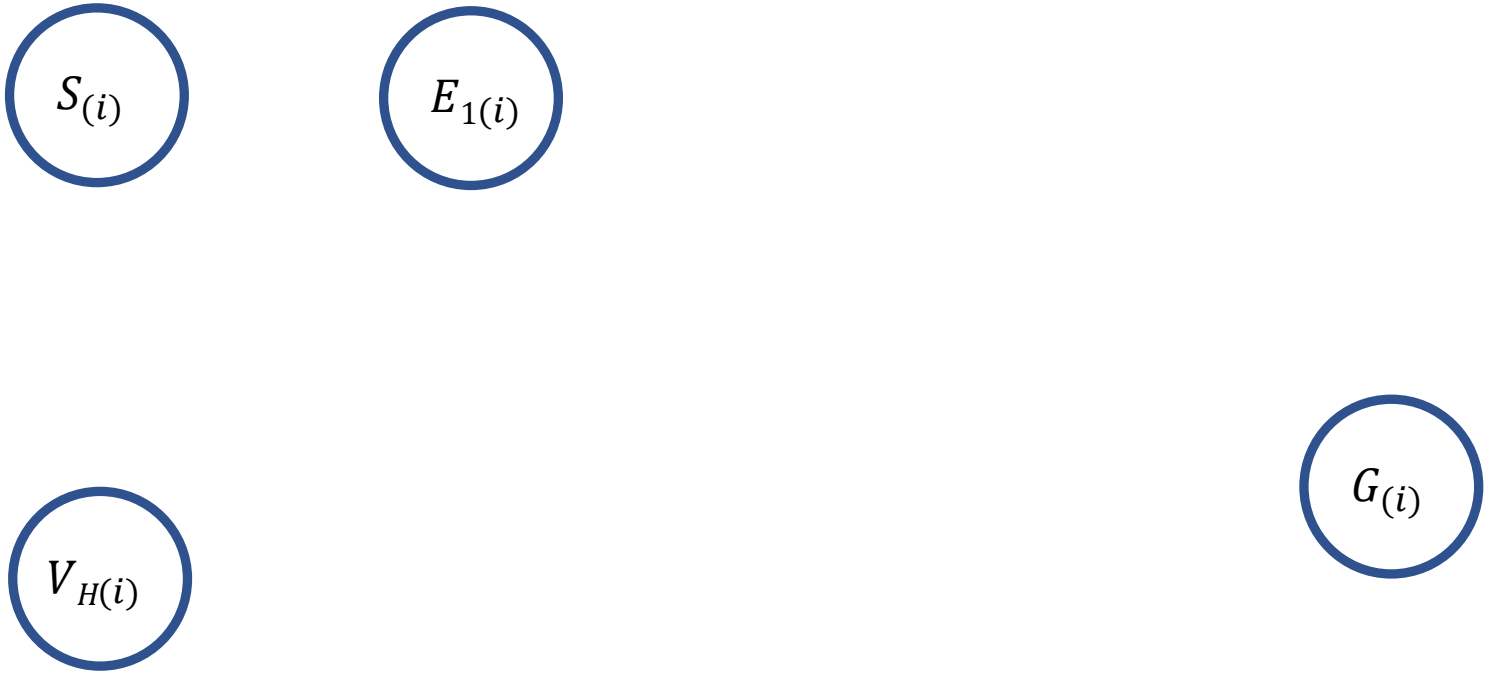
$S_{(i)}$

$V_{H(i)}$

$G_{(i)}$

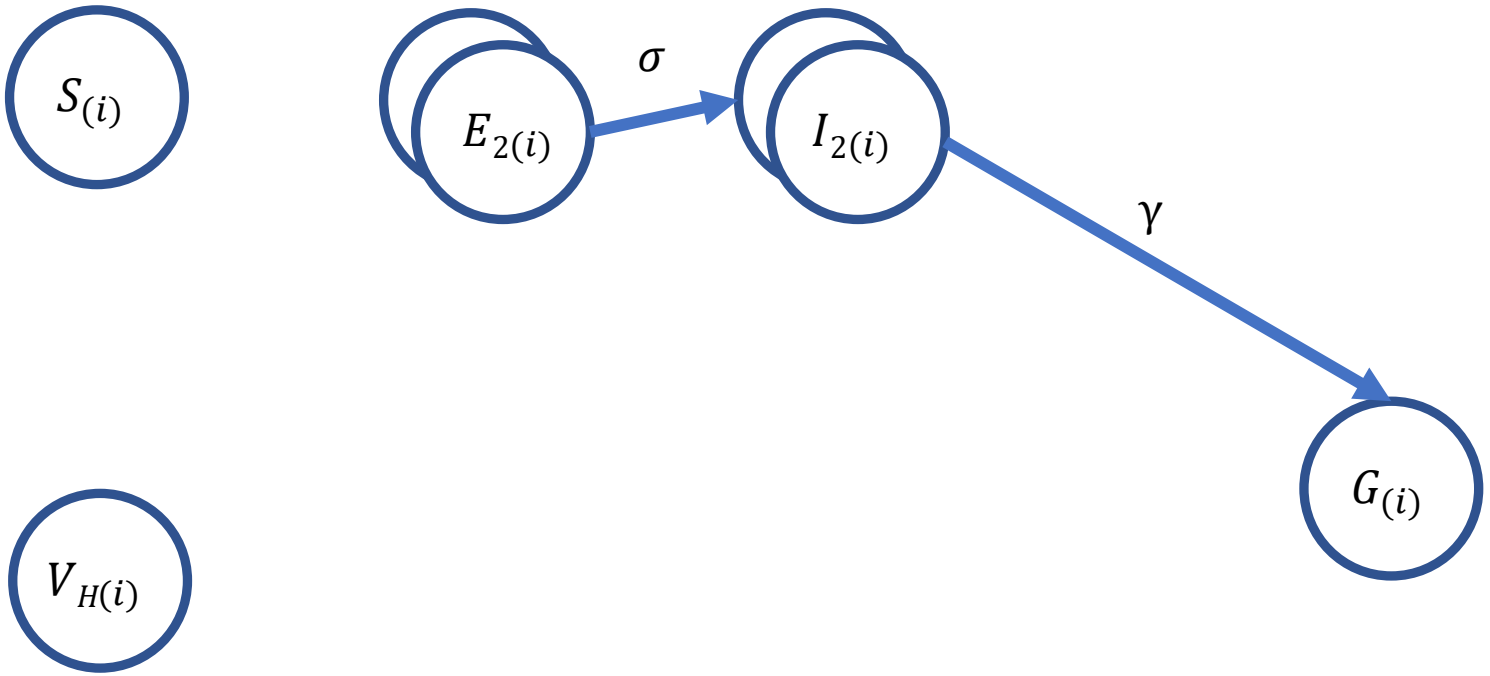
Age classes are represented by $_{(i)}$

Model structure



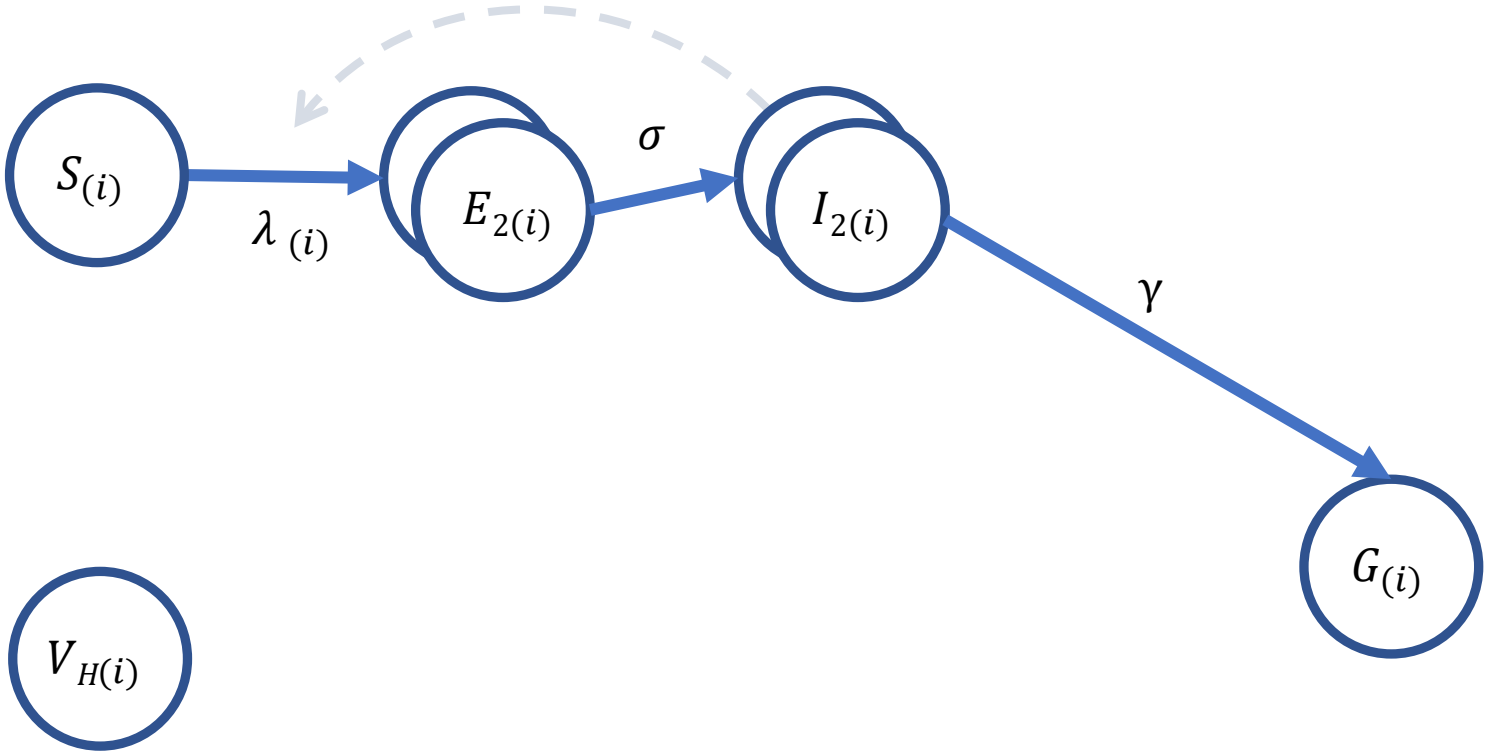
Age classes are represented by $_{(i)}$

Model structure



Stacked compartments represent box cars
Age classes are represented by $_{(i)}$

Model structure



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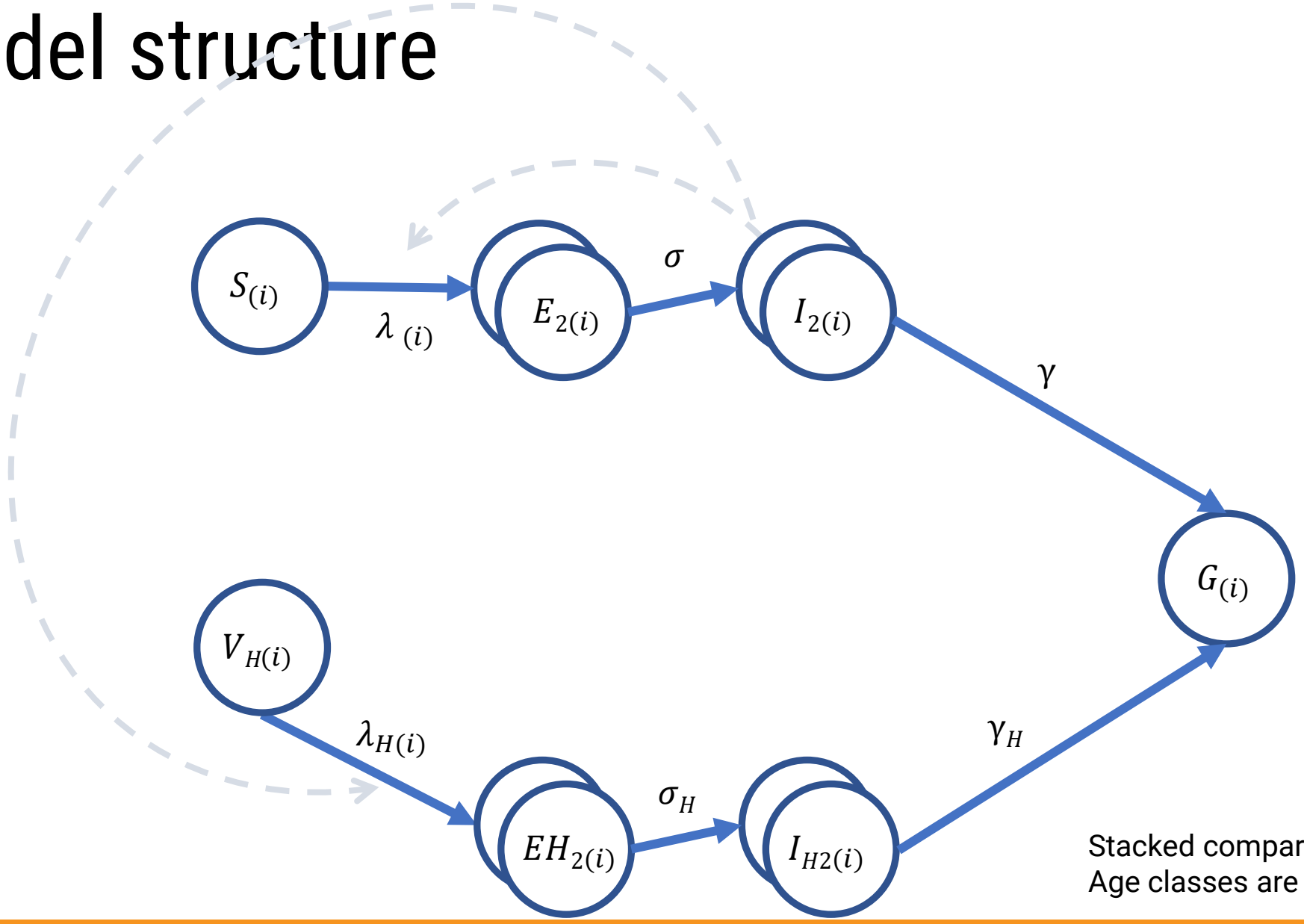

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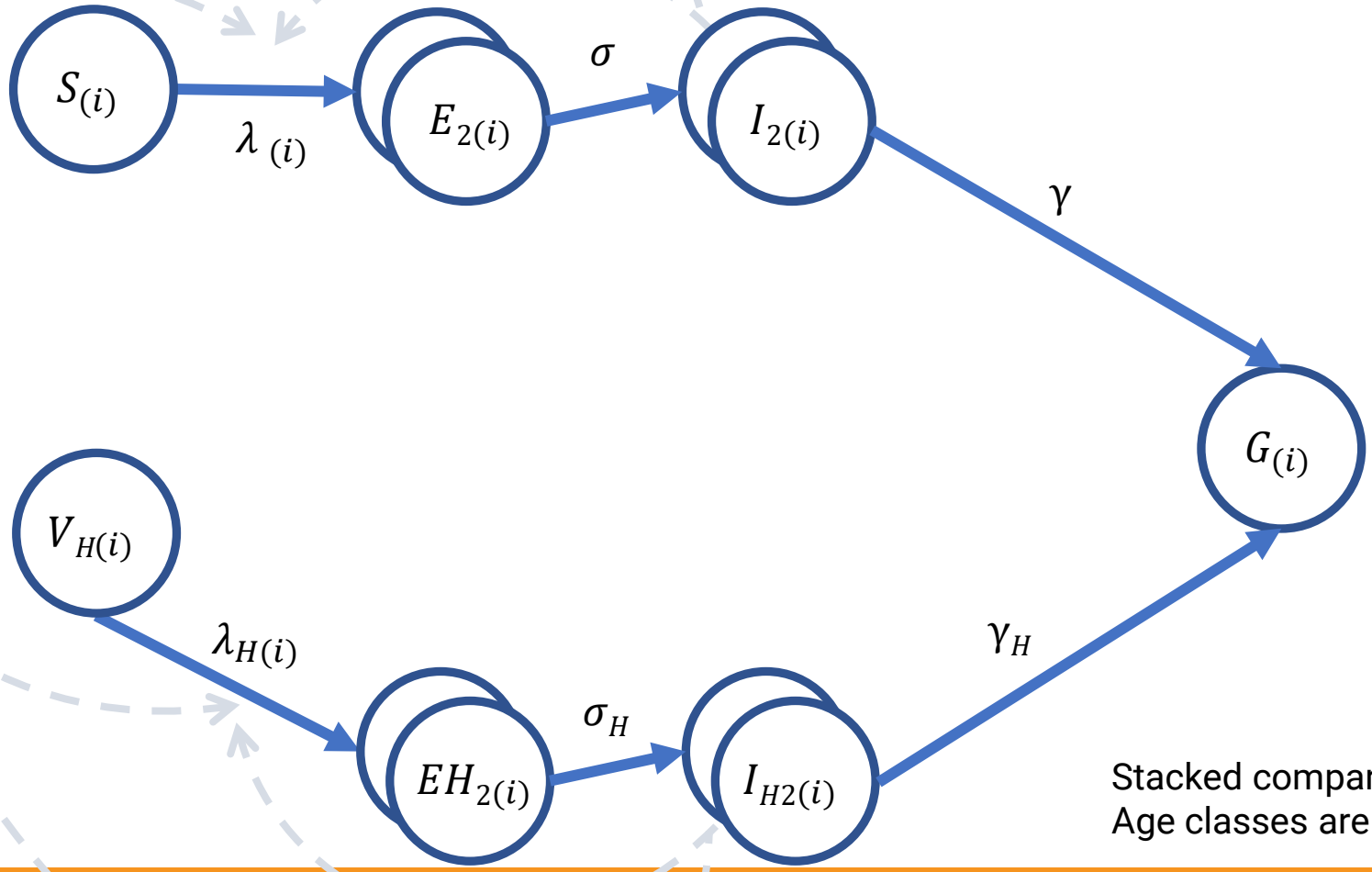

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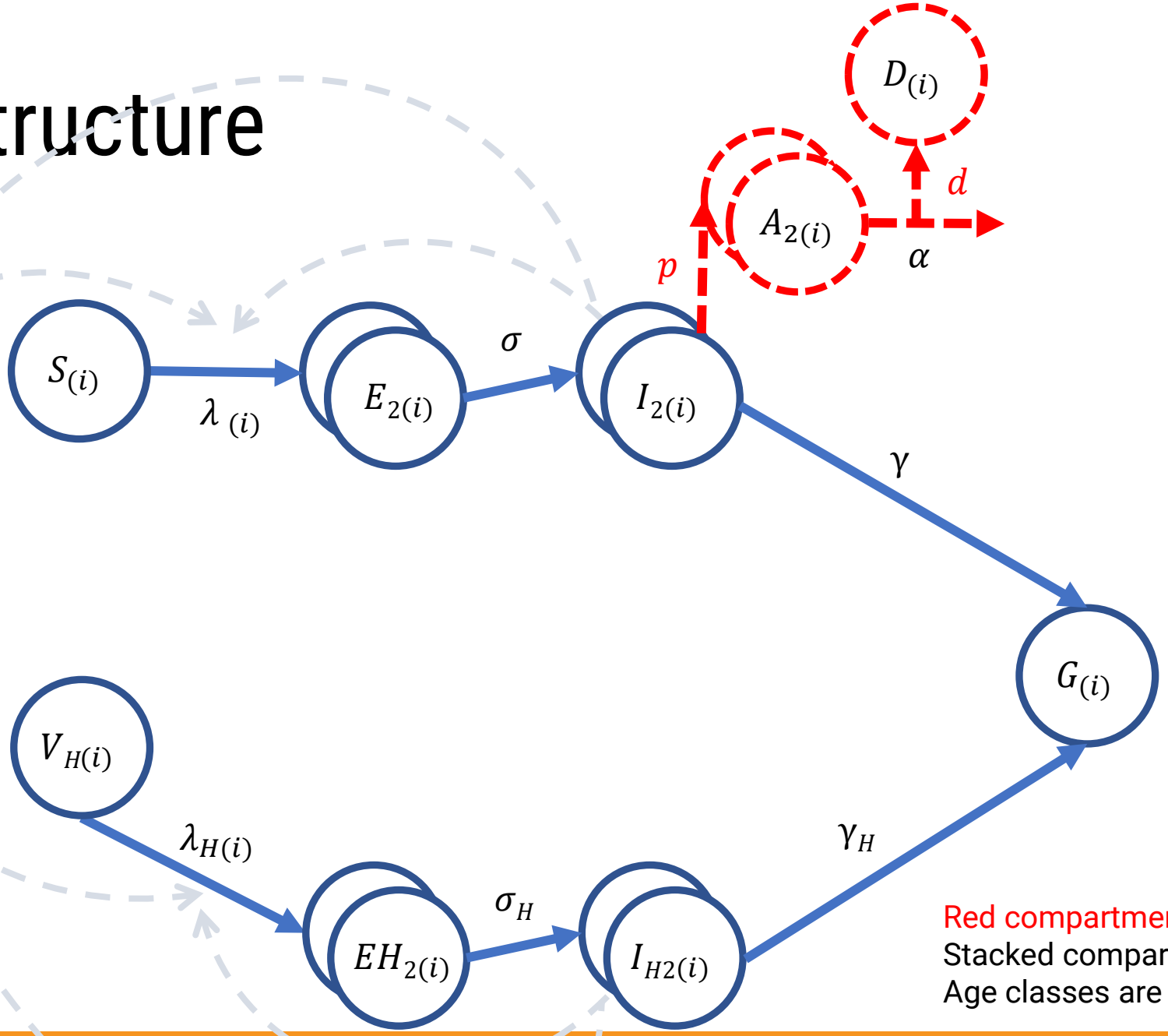
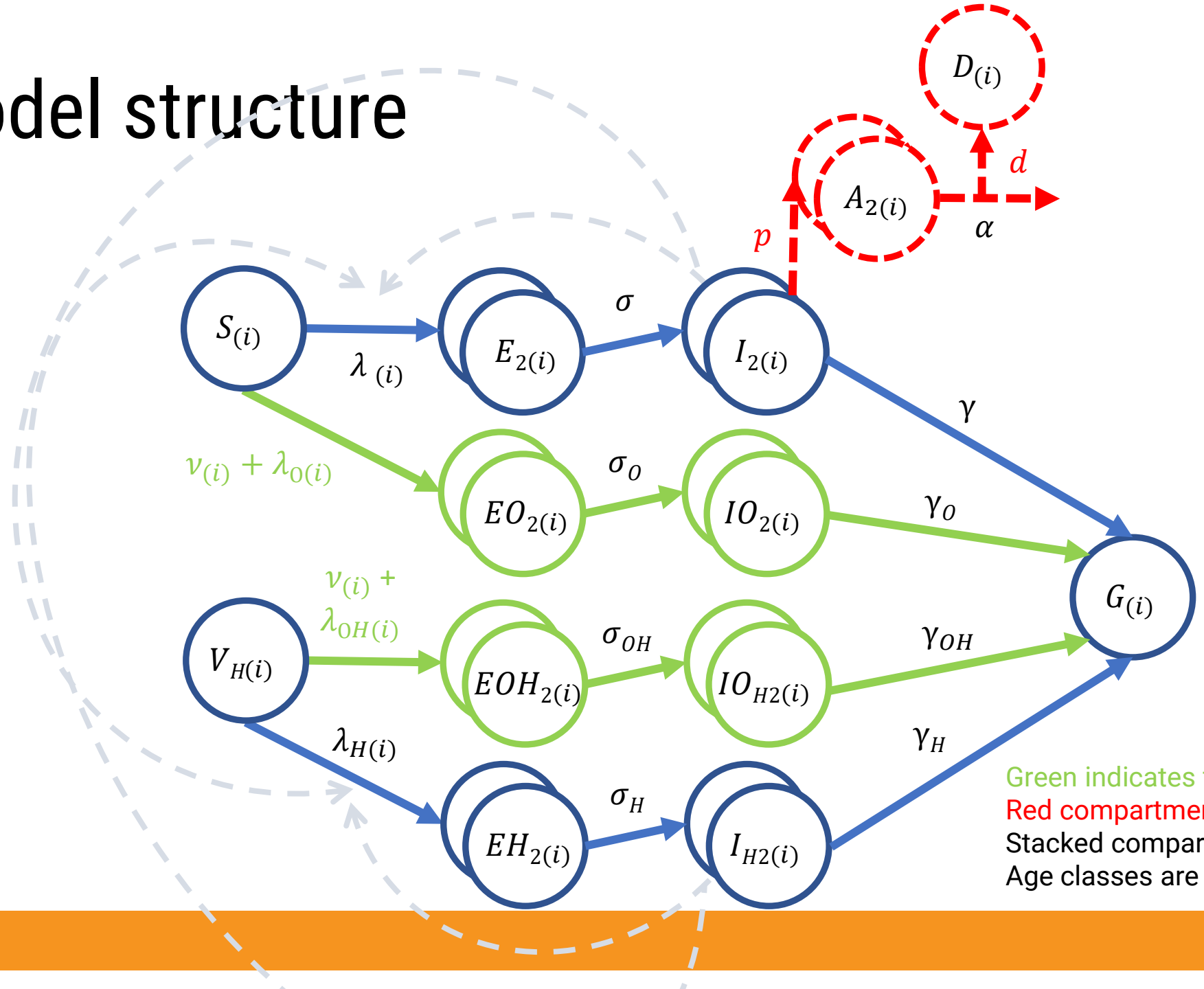
Model structure



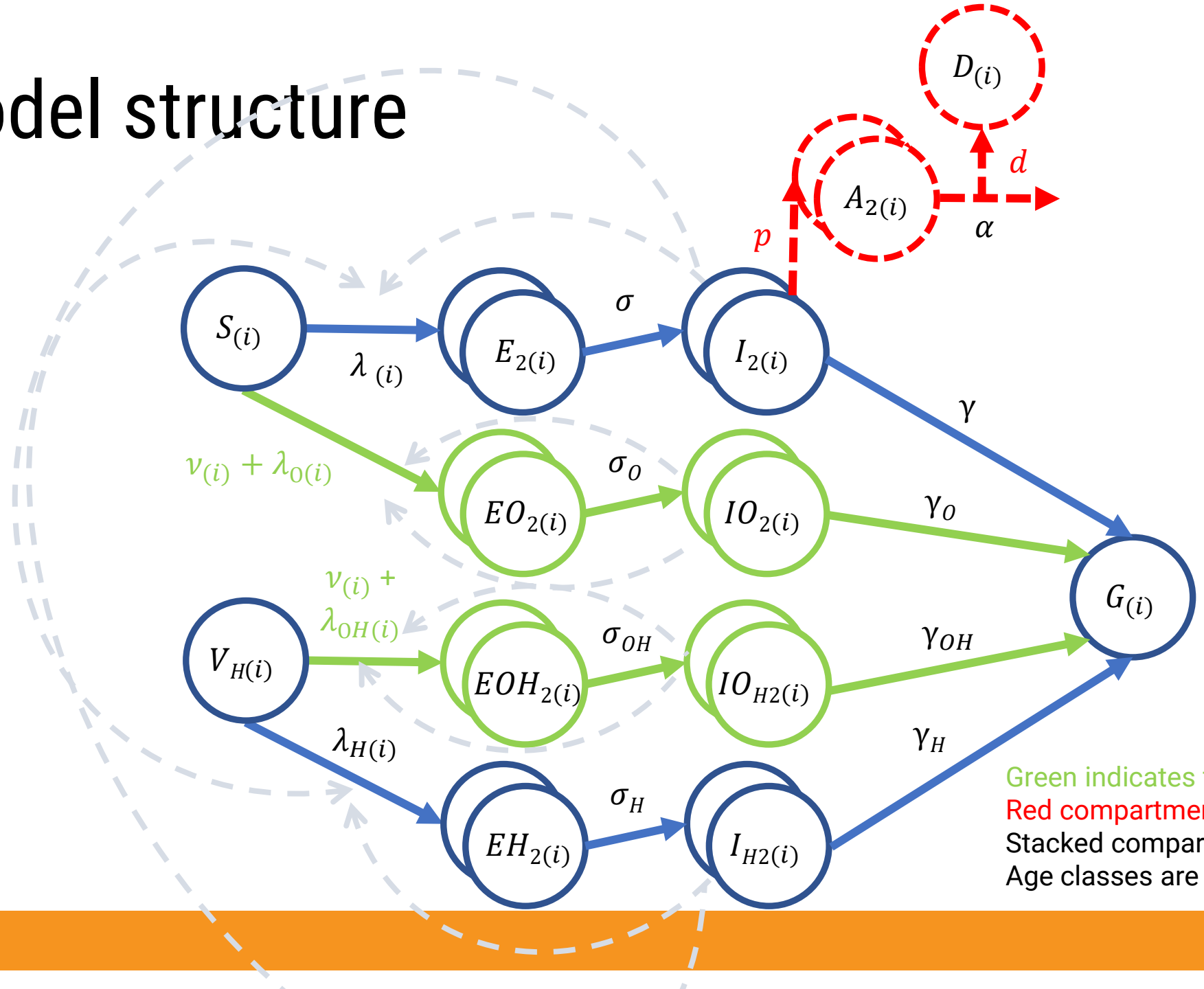
Red compartments indicate counter variables
Stacked compartments represent box cars
Age classes are represented by $_{(i)}$

Model structure



Green indicates that only exists with SIA
Red compartments indicate counter variables
Stacked compartments represent box cars
Age classes are represented by $_{(i)}$

Model structure



Green indicates that only exists with SIA
Red compartments indicate counter variables
Stacked compartments represent box cars
Age classes are represented by $_{(i)}$

Model assumptions

- Polio is introduced through a single exposed individual at the beginning of the simulation
- All reactive SIAs will use OPV. Reactive SIAs target 0-14 year olds
- We are starting with a population that has a history of routine vaccination
- Routine vaccination is not explicitly modeled due to the short time frame being considered
- The only vaccination happening directly in the model is the SIA triggered by the detection of an AFP case

Outbreak response vaccination

POLIO GLOBAL ERADICATION INITIATIVE

World Health Organization

STANDARD OPERATING PROCEDURES

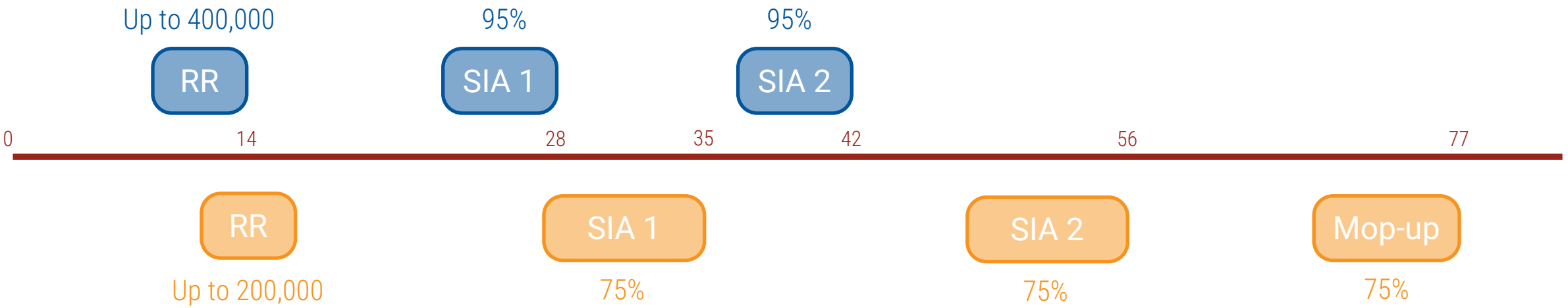
RESPONDING TO A POLIOVIRUS EVENT OR OUTBREAK

Version 4 March 2022

Proposed scenarios

Reactive SIA vaccination scenarios* for implementation (WPV1)

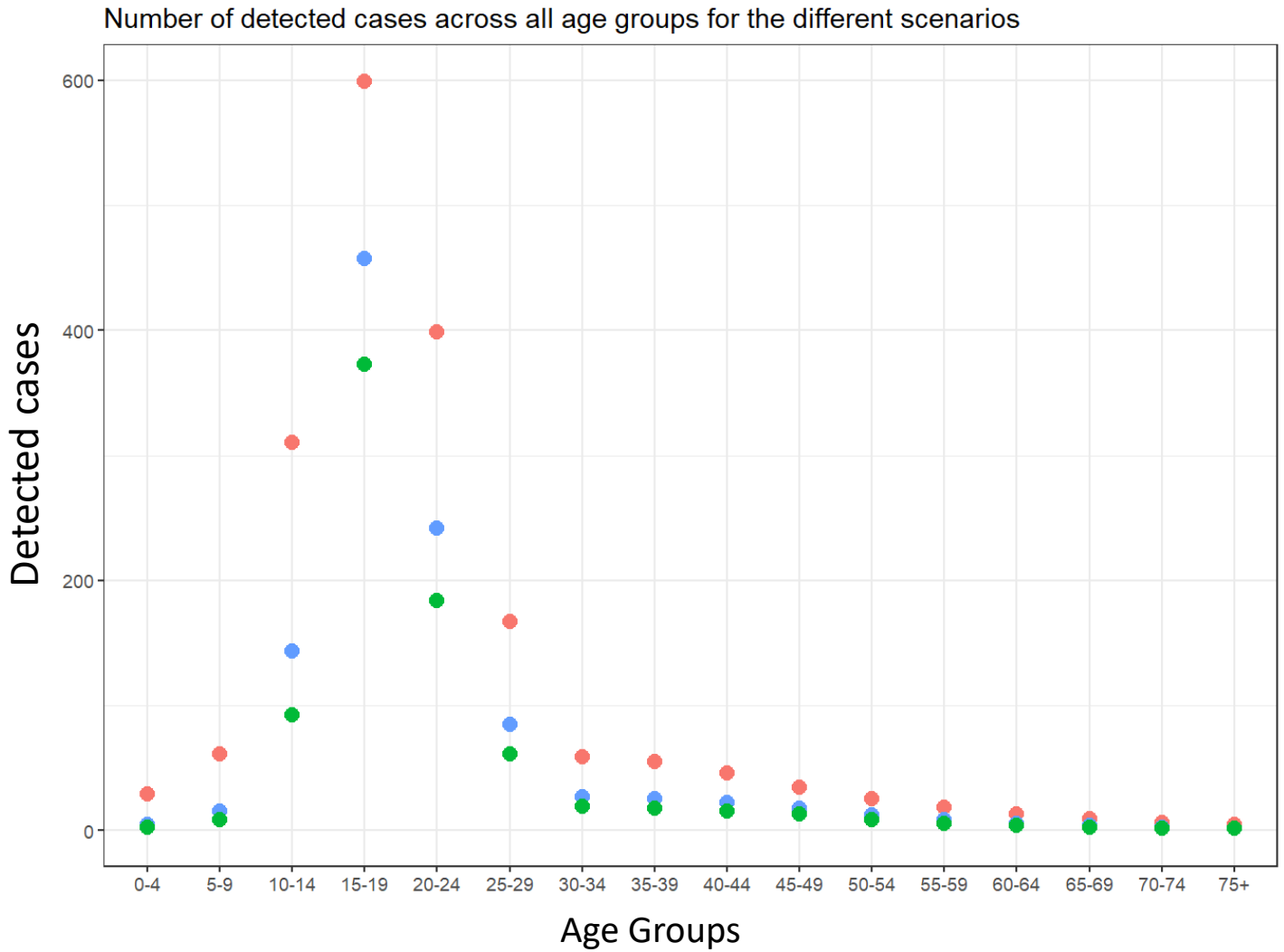
Optimistic



Pessimistic

* All scenarios assume reactive vaccination is conducted with OPV and targeting under 15s

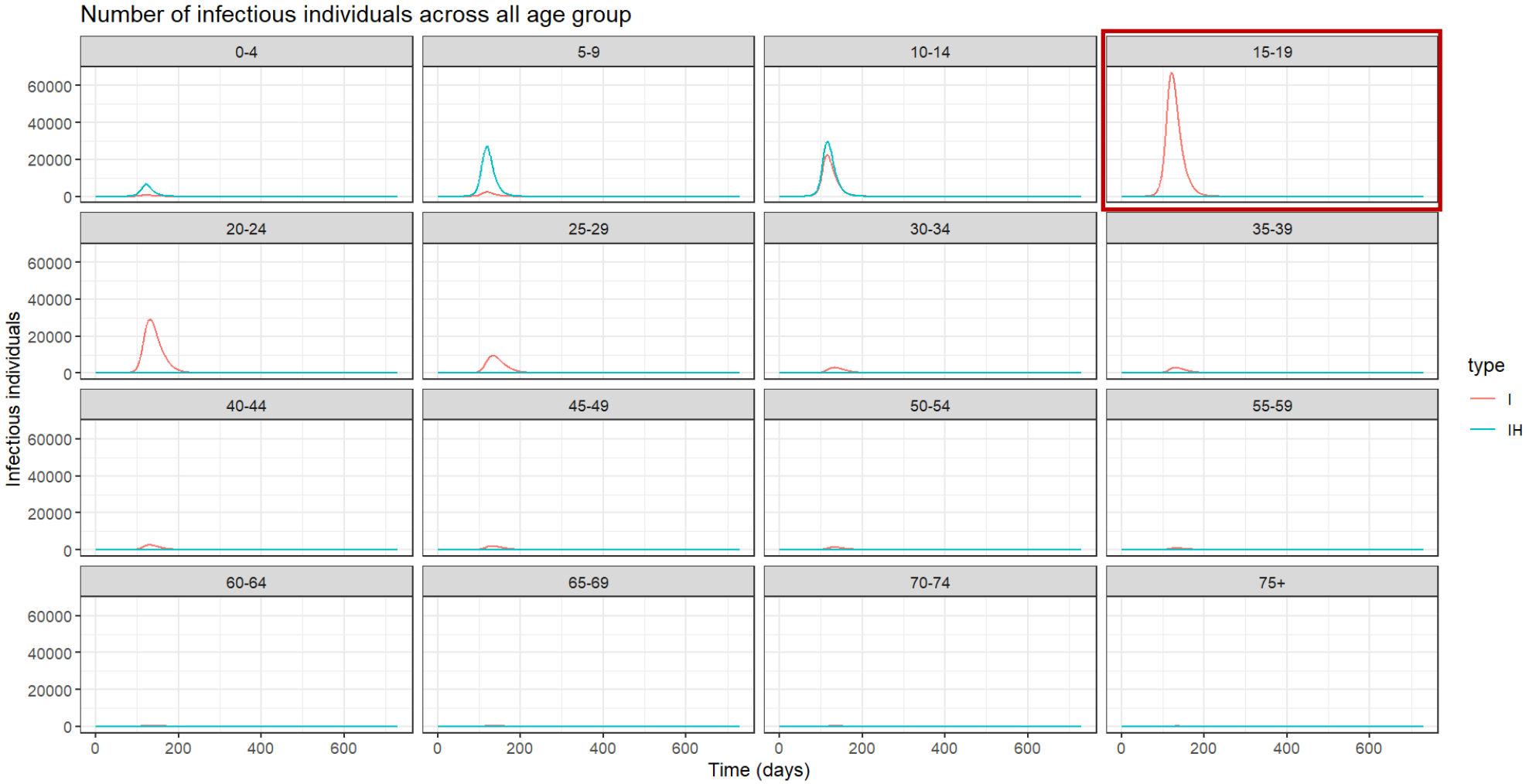
Johannesburg District: Detected cases across age groups



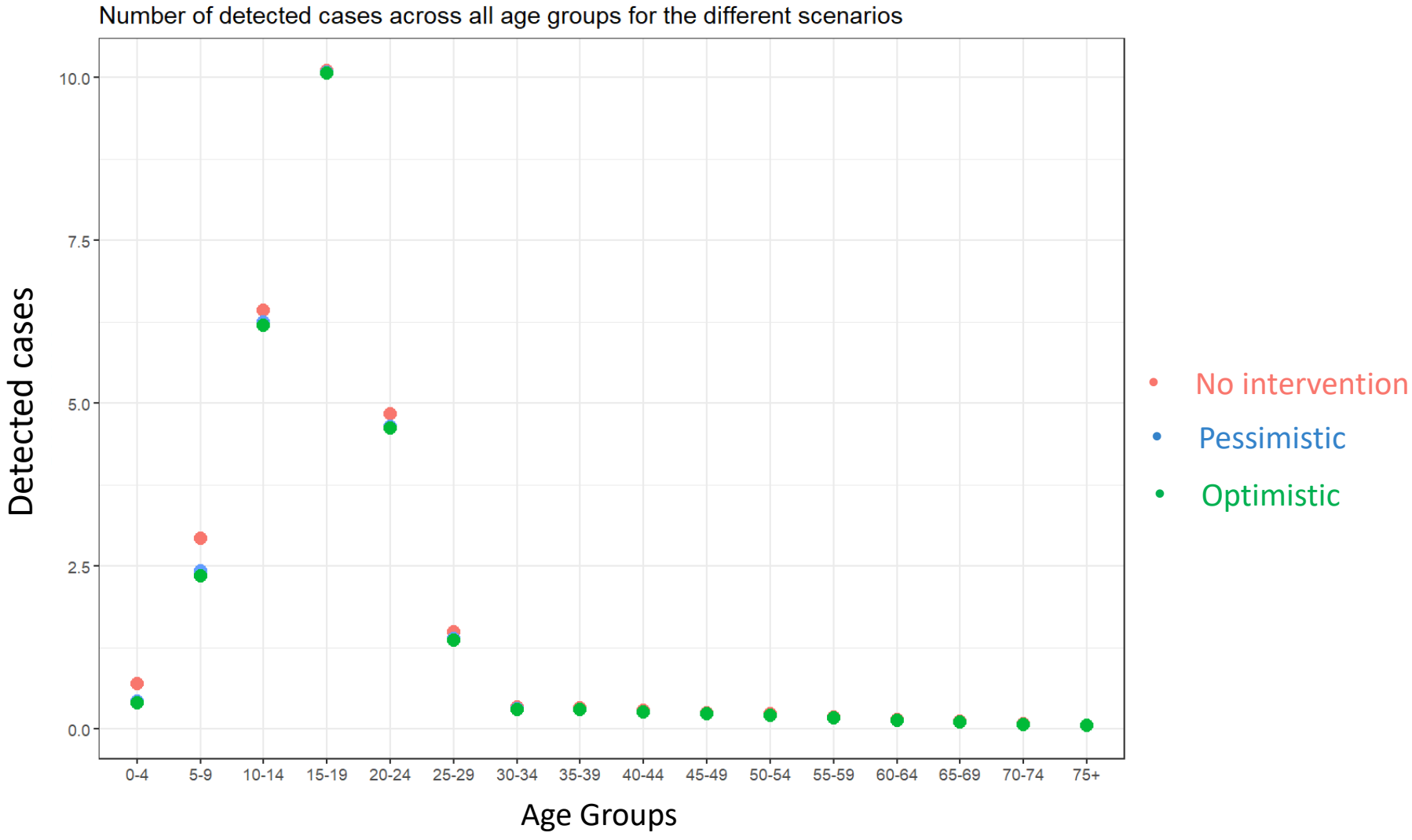
Expected to be one the districts with the highest cases

Benefits of reactive SIA seen in the age groups with the most cases

Johannesburg District: Which age group is driving the transmission?



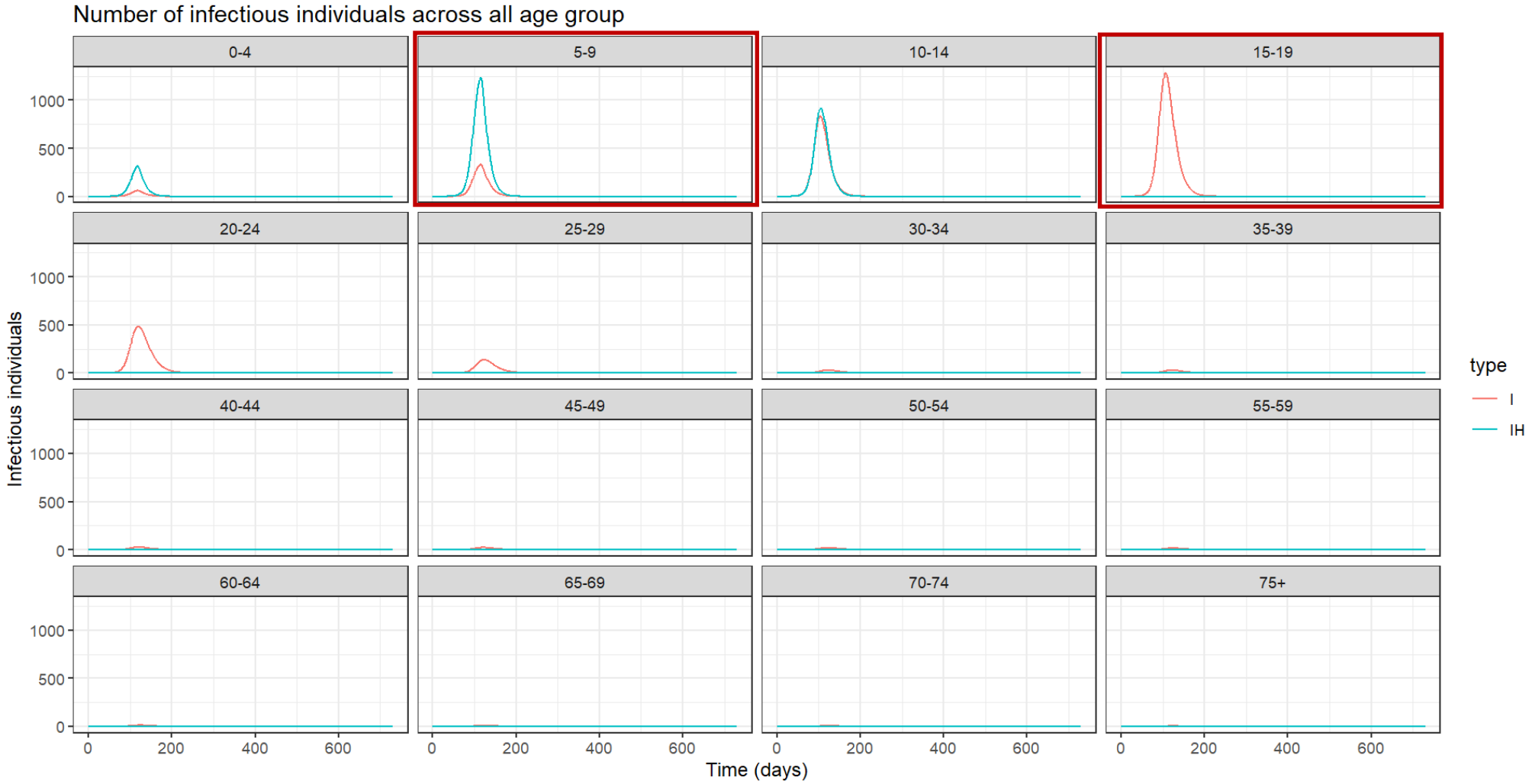
Namakwa District: Number of detected cases across age groups



Expected to be one the districts with the lowest cases

Reactive SIA will have minimal impact

Namakwa District: Which age group is driving the transmission?



Discussion and conclusion*

- The model suggests that the highest number of AFP cases would occur in the 15–19-year-old age group
- The model suggests that transmission would be driven by 5-24 year olds
- Together, these results suggest that reactive SIAs may be more effective if they target additional age groups
- The model suggests that hundreds of AFP cases could be seen in populous districts (eg Johannesburg), even under the optimistic reactive SIA scenario
- This finding suggests other interventions – such as a pre-emptive catch-up campaign – may be warranted

* The results presented are preliminary the model is still under developme

Limitations

- Deterministic model
  - No variation in the model output
  - Introductions always lead to an outbreak

- Some parameter values are preliminary
  - finalize the parameter values related to timing and intensity of OPV shedding

- Immunity estimates

Next steps

- Finalize implementation of the stochastic model
- Investigate the potential impact of including older age groups in the reactive SIAs
- Investigate the potential impact of pre-emptive catch-up campaigns
- Consider cost-effectiveness of the interventions investigated

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Thank you!

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