Estimating immunity to wild poliovirus type 1 in South Africa

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&

SACEMA's Modelling and Analysis Response Team

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Overview

1. Context & Aim
2. Data sources
3. Overall workflow
4. Estimation of immunity pre-2009
5. Results and Discussion

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Model structure

$S_{(i)}$ Fully susceptible

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

$G_{(i)}$ Gut (mucosal) and humoral immunity

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

Aim

- Estimate levels of **gut** and **humoral immunity** to WPV1 at the district level, in five-year age bands
- Provide initial conditions to SACEMA's poliovirus transmission model
- Help motivate for and inform public health interventions such as catchup campaigns

Vaccination for wild poliovirus type 1

Vaccination schedule

Age of child	Vaccine type
At birth	OPV 0
6 weeks	OPV 1 IPV 1
10 weeks	IPV 2
14 weeks	IPV 3
18 months	IPV 4

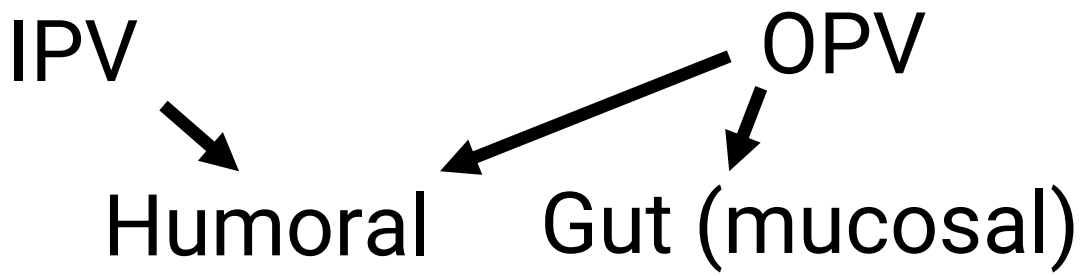
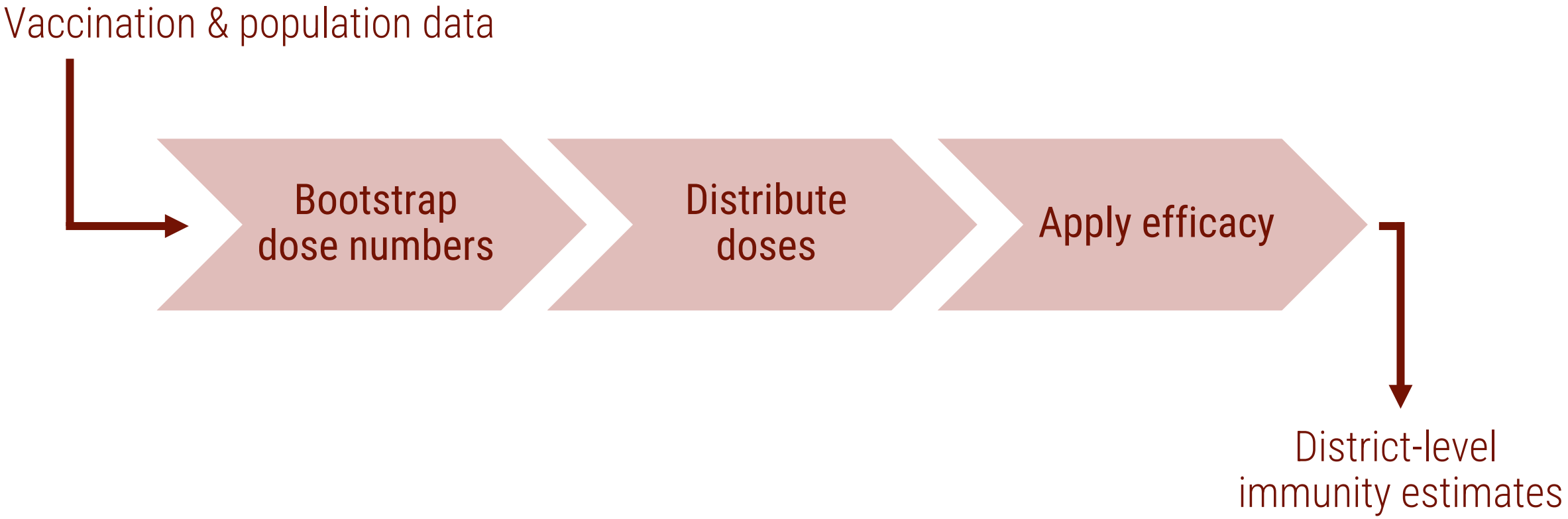


Image source: Bing image generator

Data Sources

- **NDoH**: IPV1-4 and OPV0-1 doses at district-level 2009 – July 2022; missing some years
- **WCDoH**: birth-dose BCG and IPV1 at facility-level in WC 2009 – July 2022
- **Schoub et al. 1998**: 1995 nationally representative seroprevalence survey of 12 - 35 month old children (province-level)
- **Statistics South Africa**: district-level live births 1998-2020
- **Thembisa model**: population size estimates per province, per age

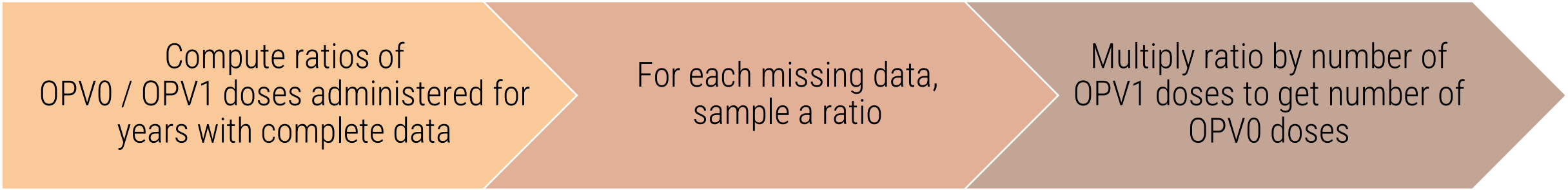
Overall workflow



Bootstrap for missing doses

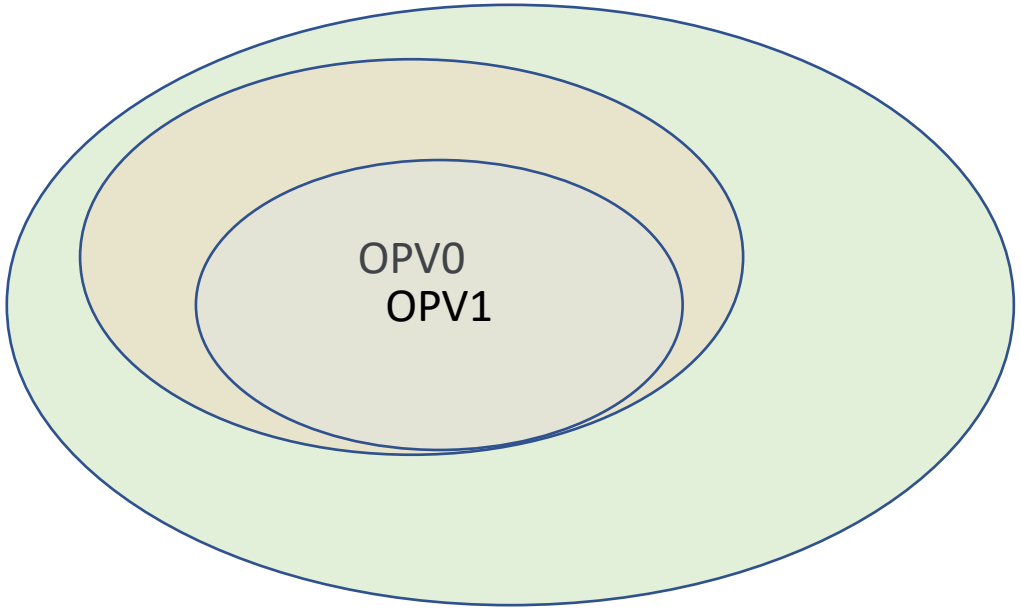
Data from NDoH was incomplete; e.g.,

- All provinces: no OPV0 data for 2009-2019

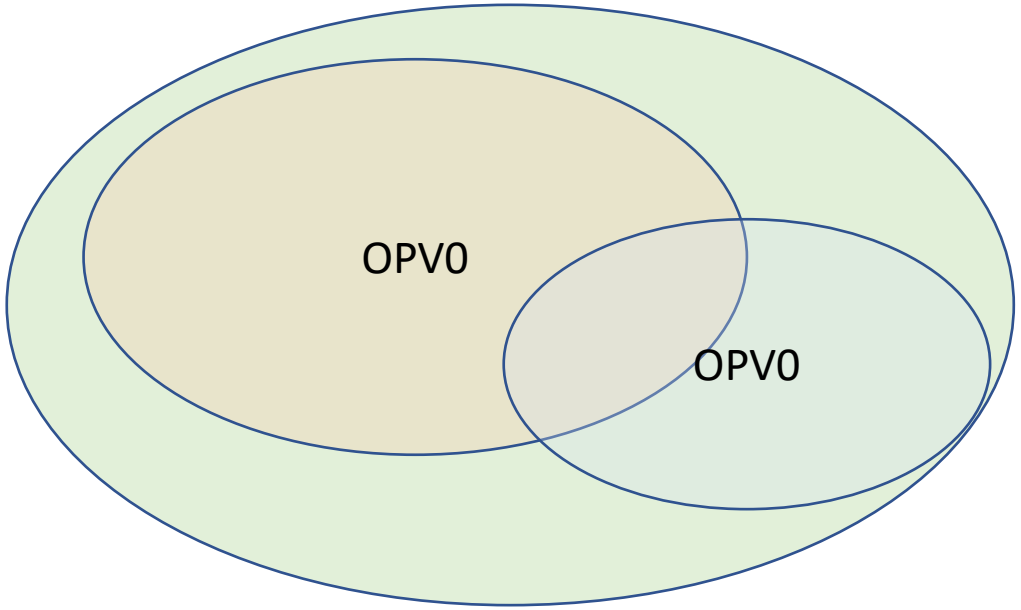


Distribute doses

ORGANIZED



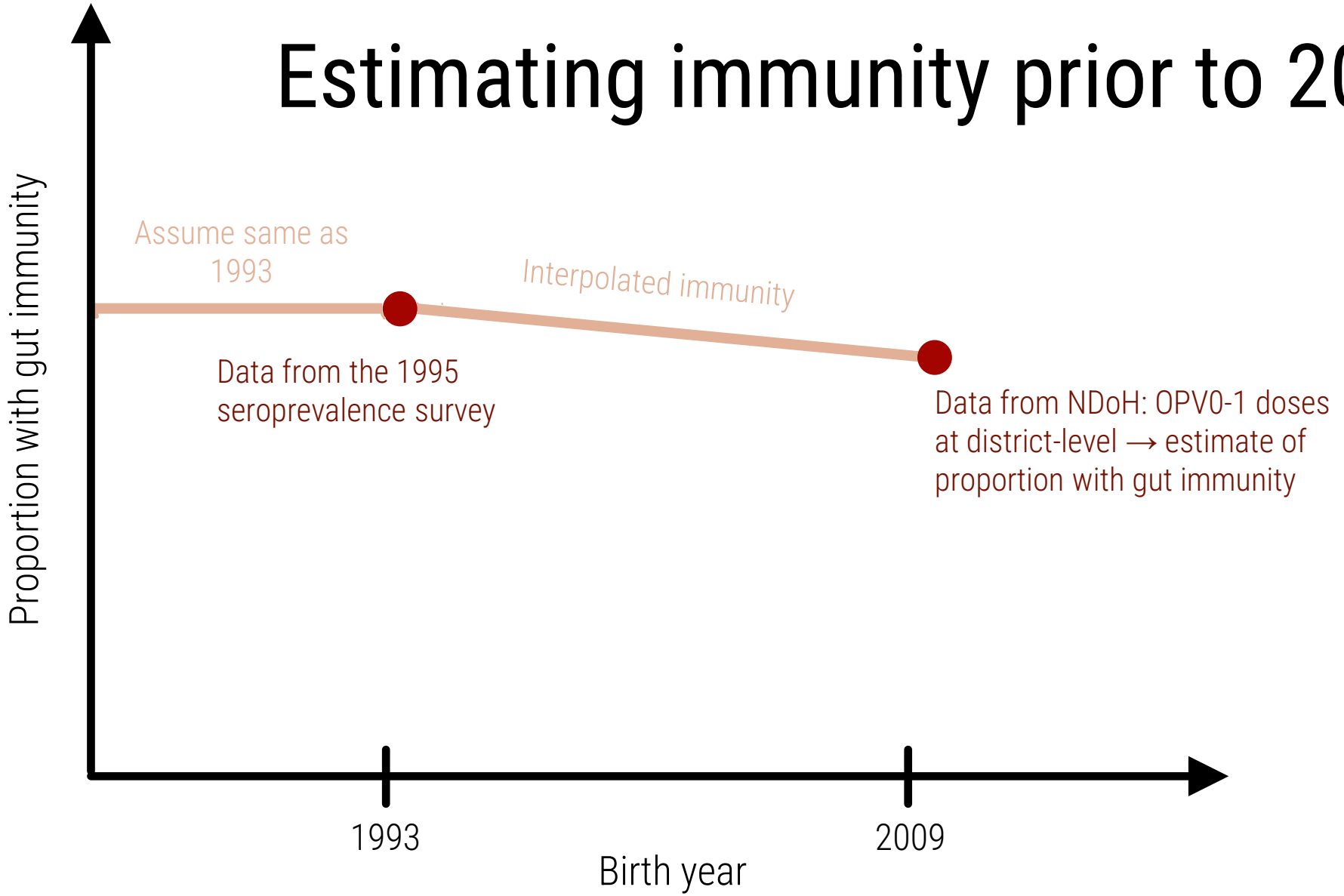
RANDOM



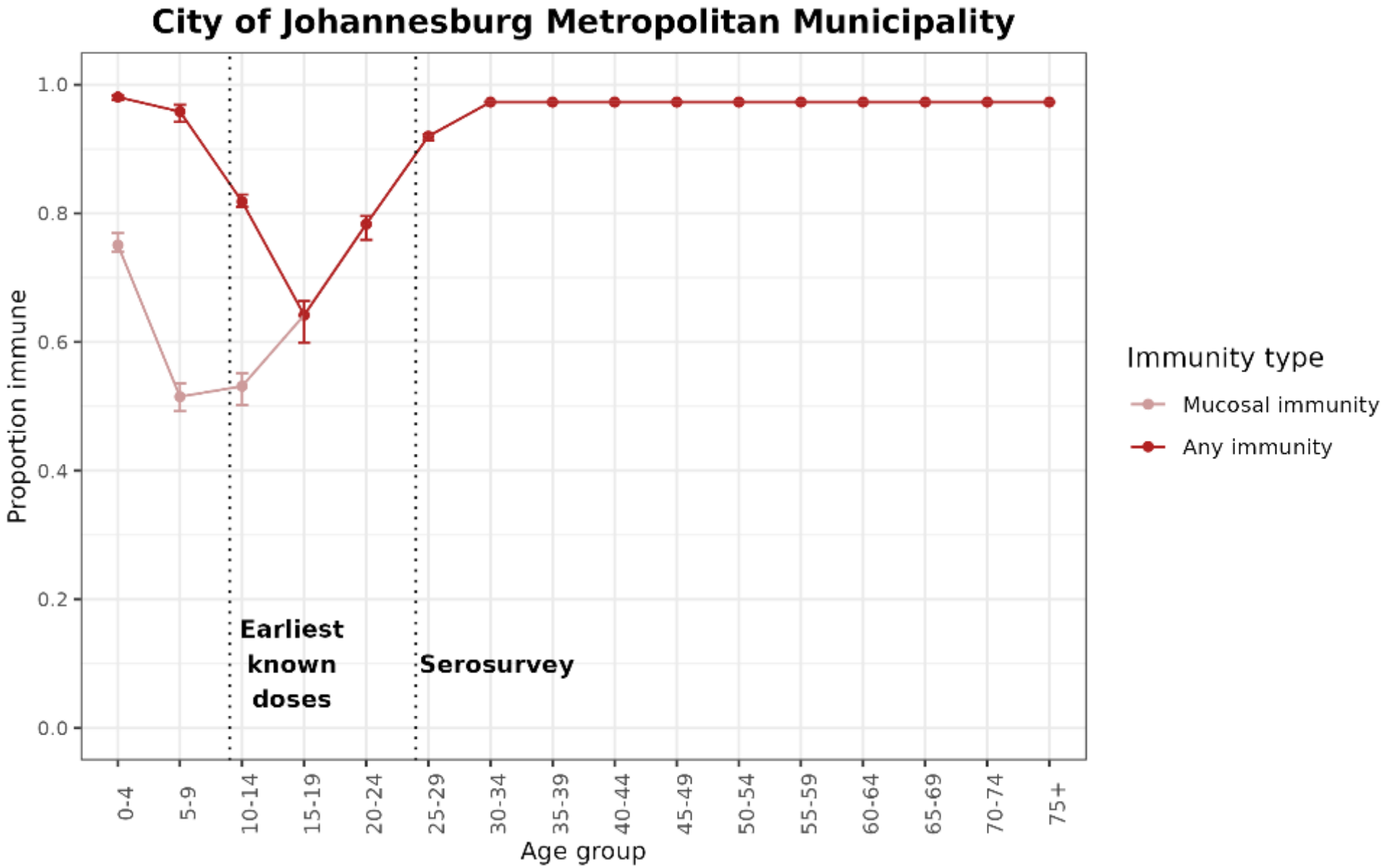
Putting the pieces together

- Assume fixed per-dose efficacy for bOPV and tOPV
- Specify independently 1- 2- 3- and 4-dose efficacy for IPV
- Calculate number of children with gut and humoral immunity per birth year
- Calculate proportion immune per age group (0-4, 5-9, etc.)
- Calculate proportion immune for humoral immunity only:
  - prop_hum * (1-prop_gut)

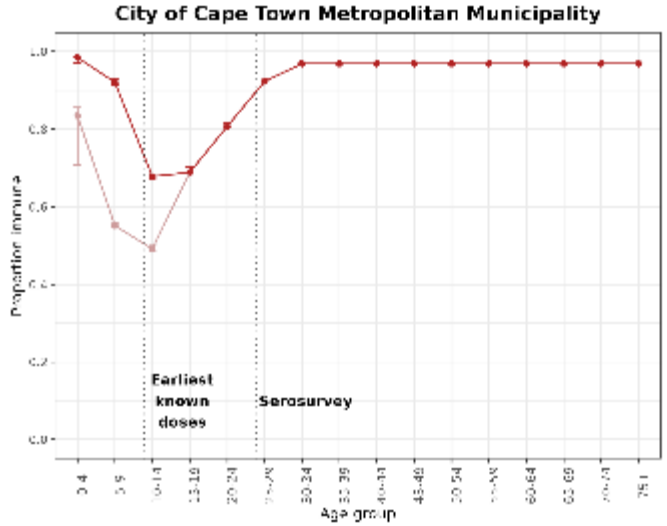
Estimating immunity prior to 2009

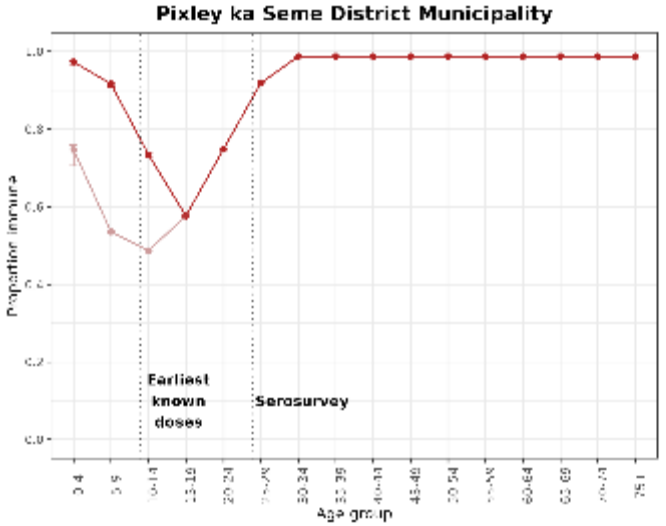


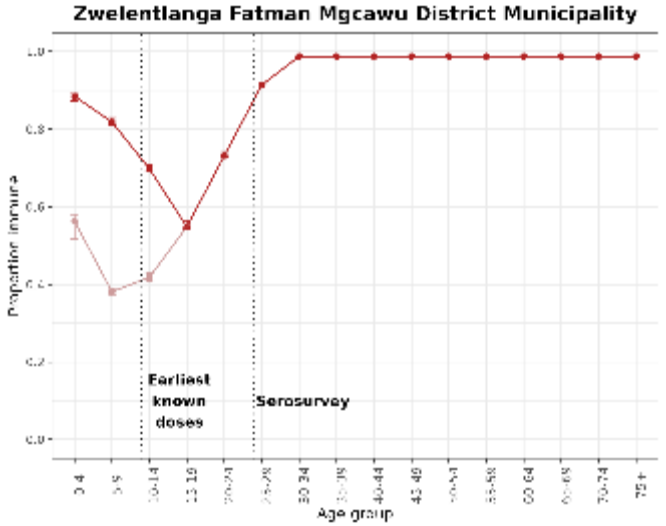
Results

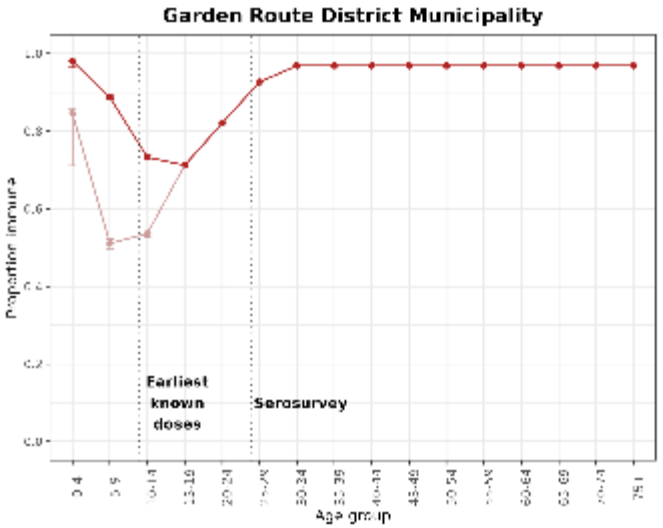

City of Johannesburg Metropolitan Municipality
Proportion immune
1.0
0.8
0.6
0.4
0.2
0.0
Earliest known doses
Serosurvey
0-4
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75+
Age group
Immunity type
Mucosal immunity
Any immunity

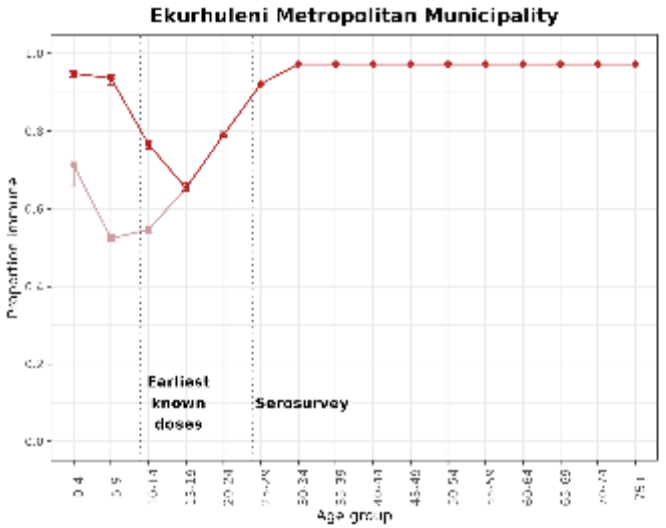
Age-structured immunity estimates

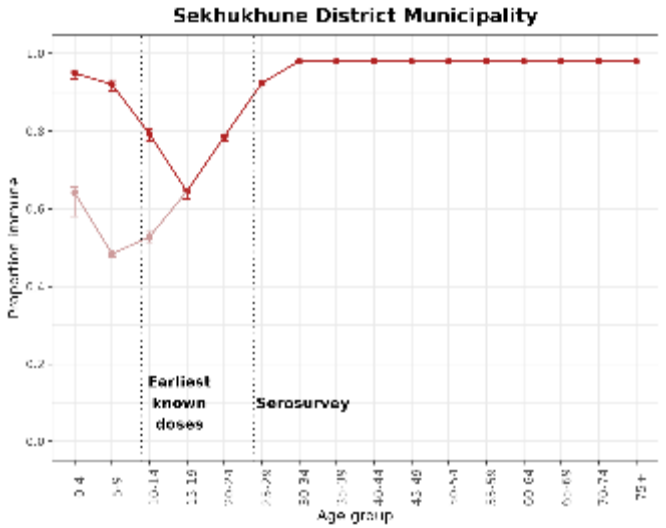








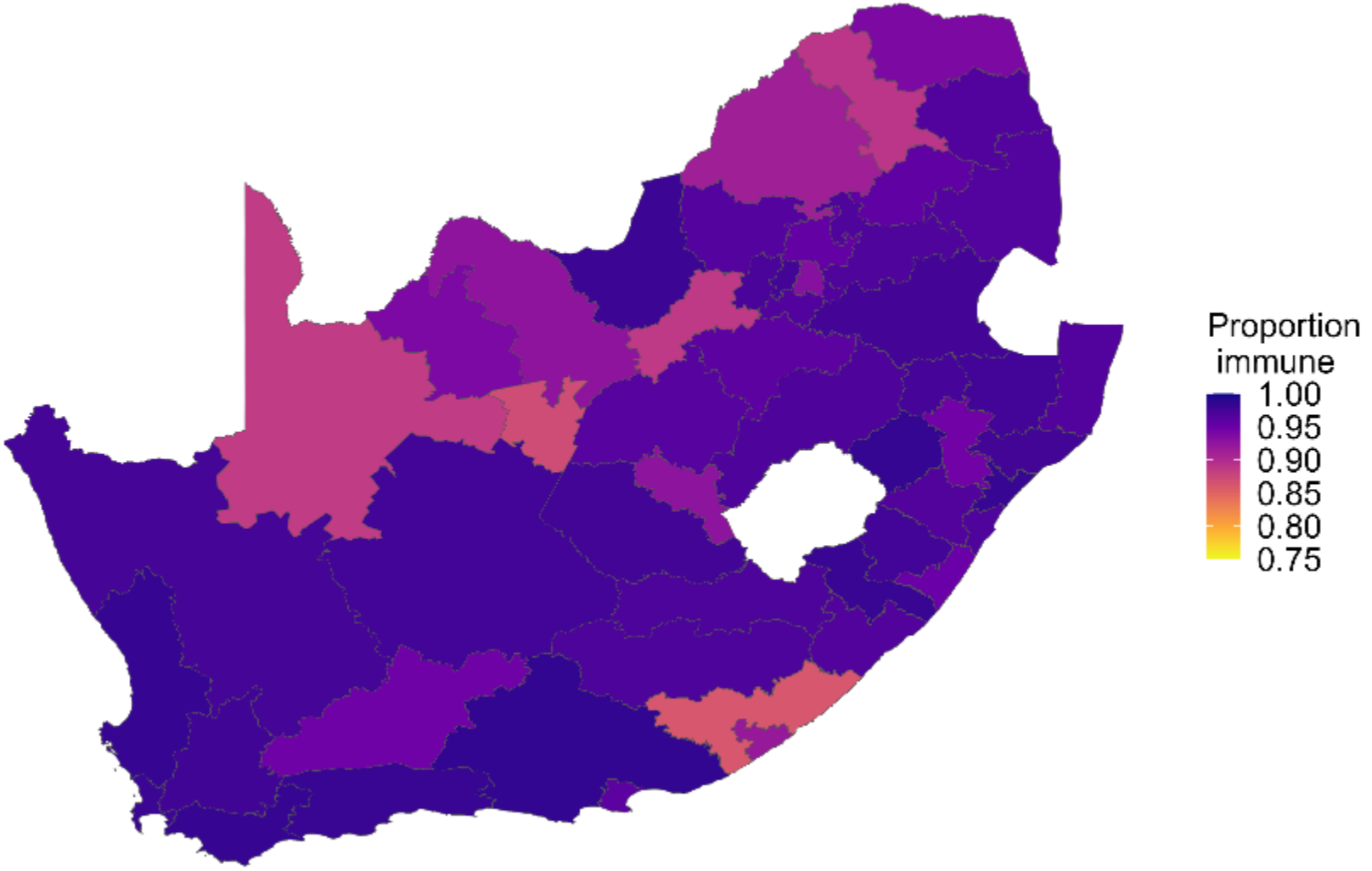




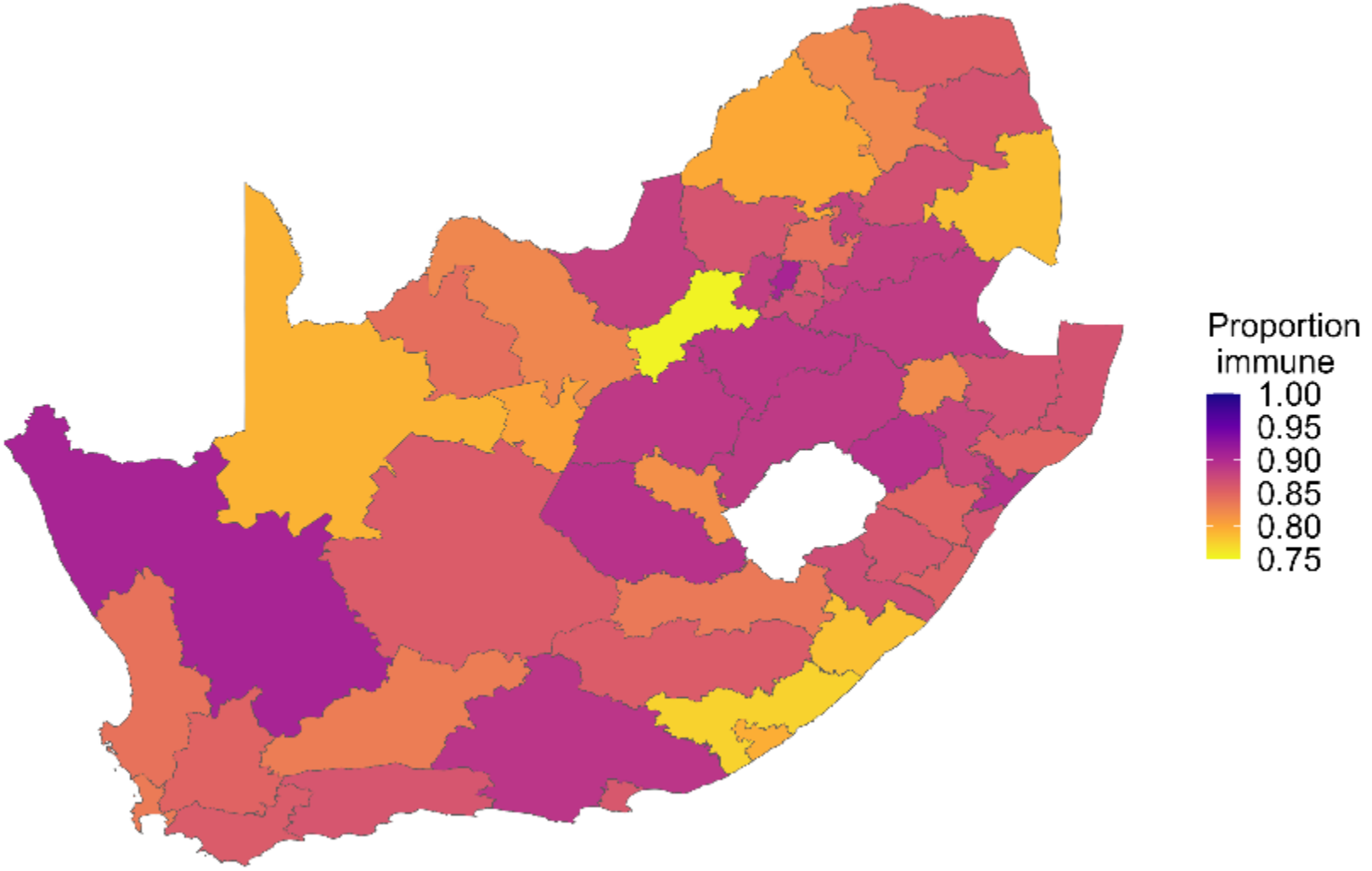
Immunity type

- Mucosal immunity
- Any immunity

Proportion of under-5’s with gut or humoral immunity to WPV1



Proportion of under-15's with gut or humoral immunity to WPV1



Discussion

- Concerning risk for widespread AFP
- 10-24 year olds at highest risk
- Younger children mostly protected but gap in gut immunity could amplify an outbreak
- Wider age range should be considered for catchup campaigns

Limitations

- Missing data
  - Routine vaccination pre-2009
  - Catchup campaigns
- Live births
- Efficacy assumptions
- Assume doses administered < live births

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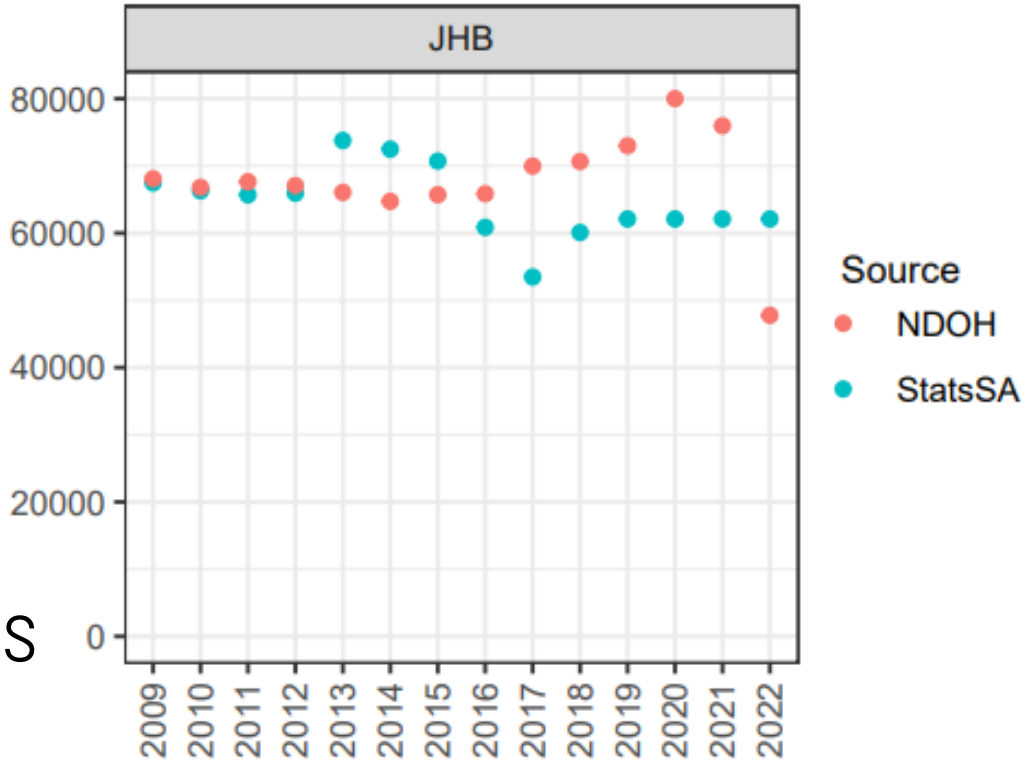

Limitations

- Missing data
  - Routine vaccination pre-2009
  - Catchup campaigns
- Live births
- Efficacy assumptions
- Assume doses administered < live births

Next steps

- Incorporating data on catchup campaigns
- Improving live births estimates
- Validation on intermediate results
  - Zero-dose babies
  - WHO/UNICEF estimates of national immunization coverage
- cVDPV2

Acknowledgements

- SACEMA/NICD Polio Working Group:
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SMART
SACEMA's Modelling & Analytics Response Team

health
Department:
Health
REPUBLIC OF SOUTH AFRICA

Western Cape Government
Health
FOR YOU

NATIONAL INSTITUTE FOR COMMUNICABLE DISEASES
Division of the National Health Laboratory Service

Thank you!

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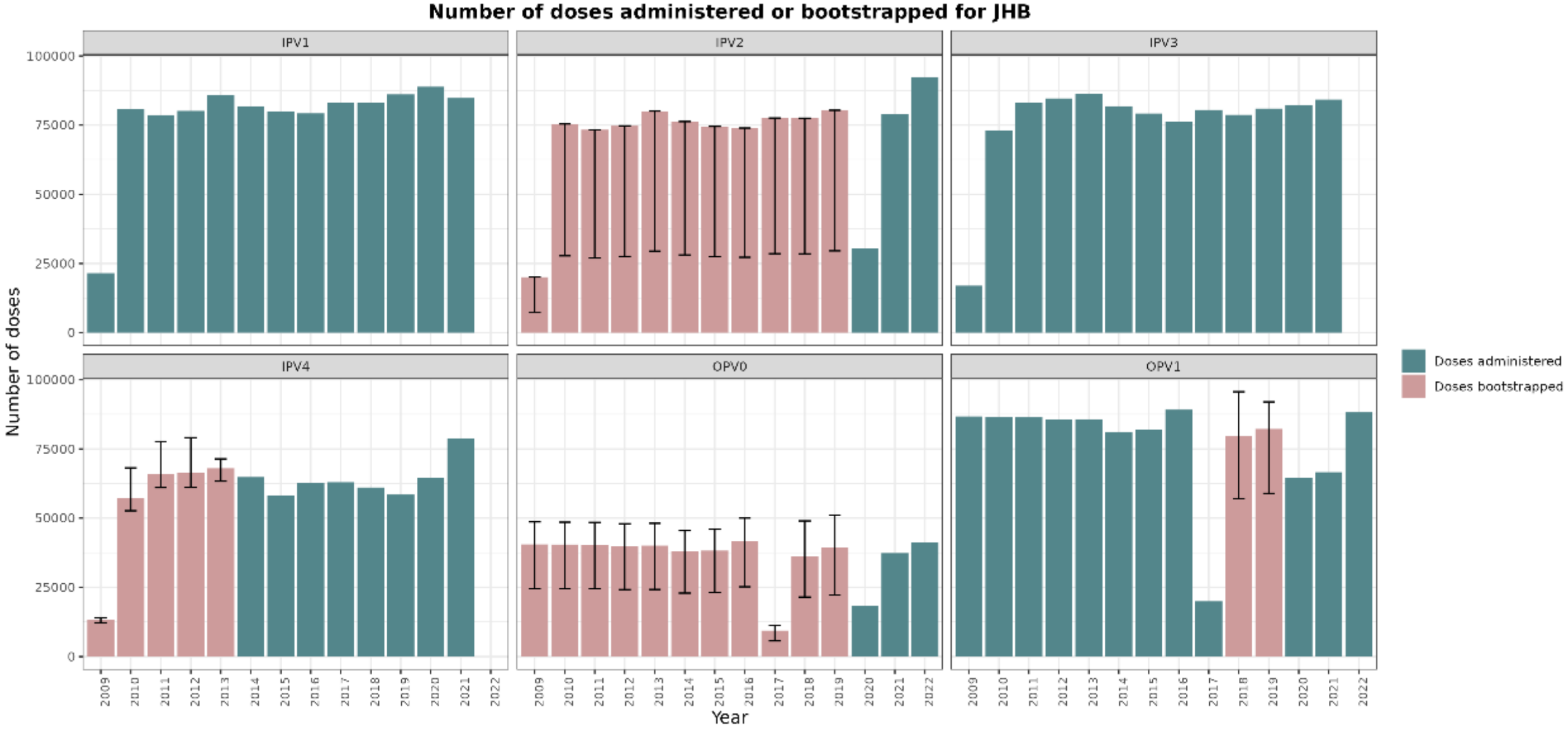
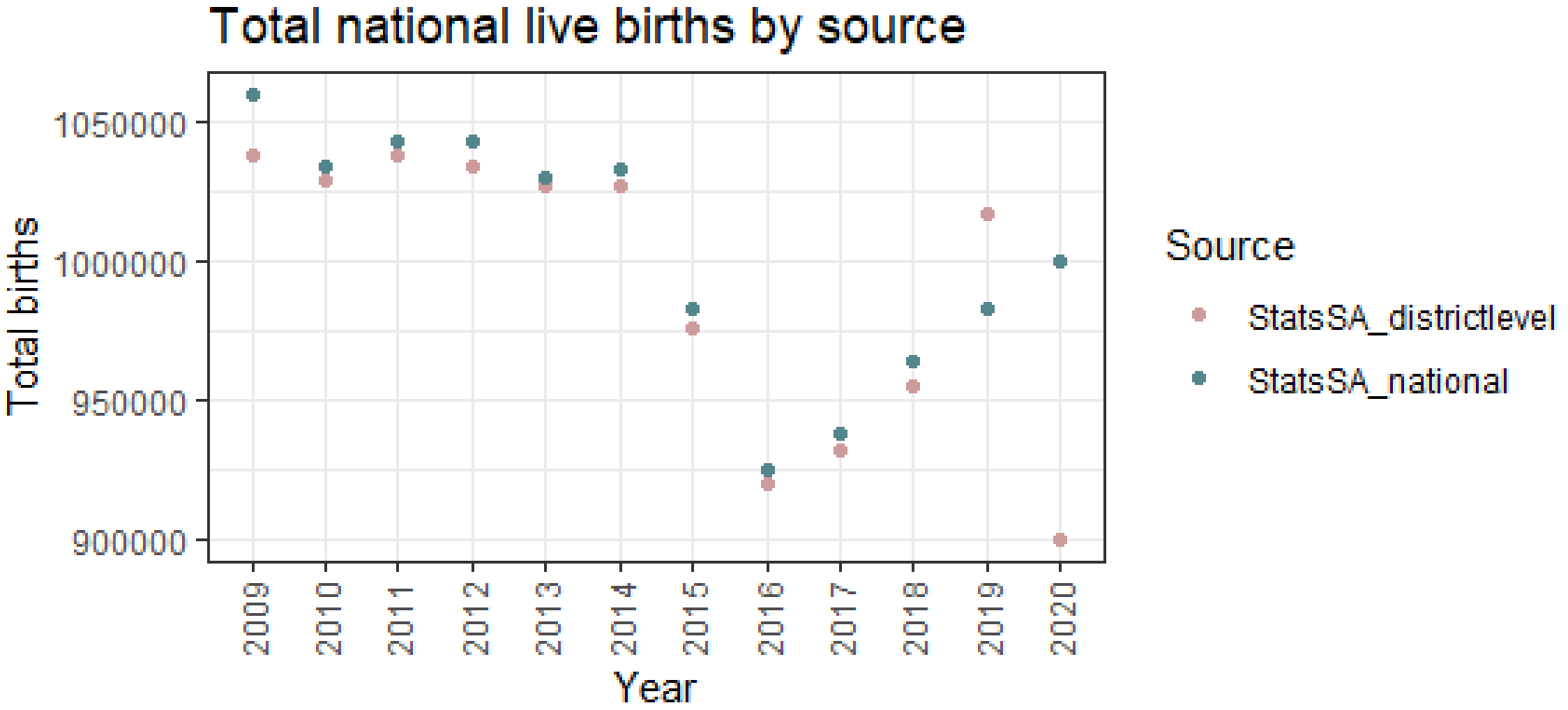
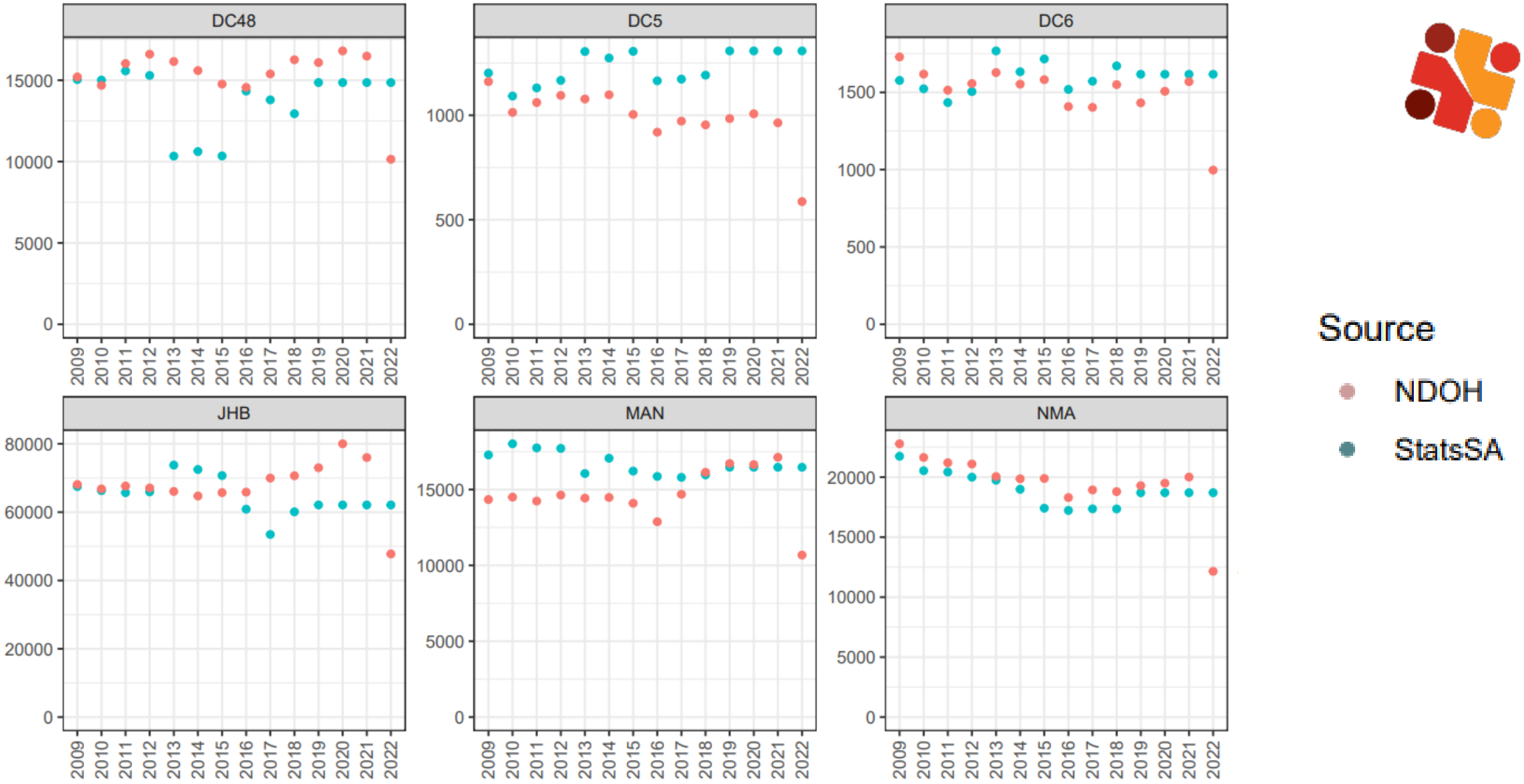

Number of doses administered or bootstrapped for JHB
IPV1
IPV2
IPV3
IPV4
OPV0
OPV1
Number of doses
100000
75000
50000
25000
0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Year
Doses administered
Doses bootstrapped


Total national live births by source
Total births
1050000
1000000
950000
900000
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Year
Source
StatsSA_districtlevel
StatsSA_national


DC48
DC5
DC6
JHB
MAN
NMA
Source
NDOH
StatsSA

Estimating immunity given dose distribution

- Assume fixed per-dose efficacy for bOPV and tOPV
- Specify independently 1- 2- 3- and 4-dose efficacy for IPV
- Compute number immune based on annual doses given
- Divide by annual live births to get proportion immune
- Use province-level population size estimates to combine birth years into age groups