Critical immunity thresholds for measles elimination

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Outline

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2. Results
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   - Comparison to serological profiles
3. Conclusions and recommendations

1. Background

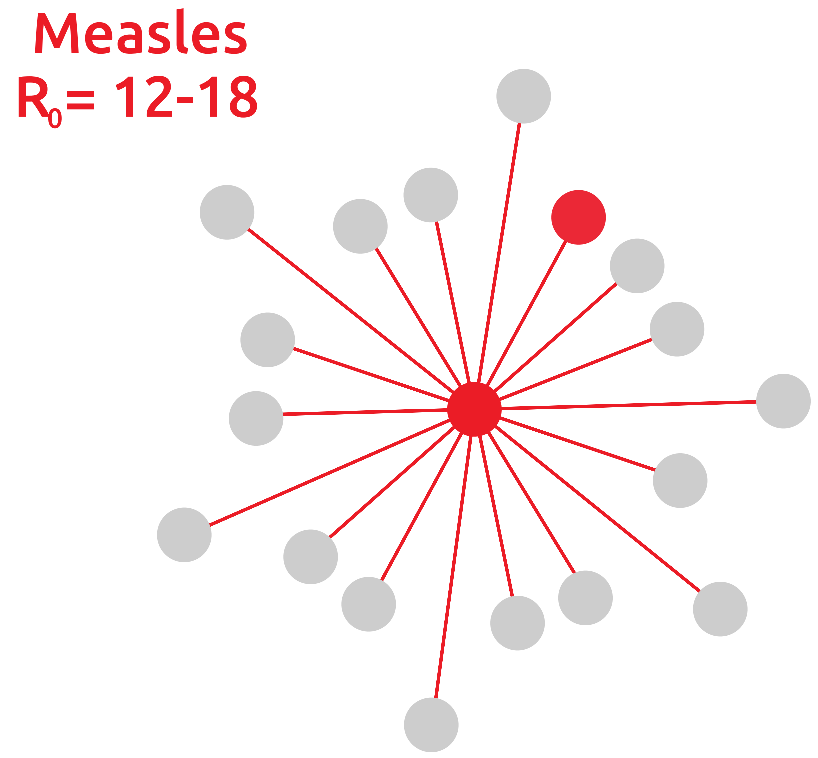
Background

- When the number of secondary infections generated by each infective person is less than 1, transmission will stop.

- To achieve this for measles, the population immune needs to be 93-95%, the herd immunity threshold.

- This is based on two assumptions:
  1. homogeneous mixing among individuals
  2. stationary, uniform immunity (through vaccination)

~~Basic~~ Reproduction number R



Herd-immunity threshold:

Vaccinate at least so many that R = 1

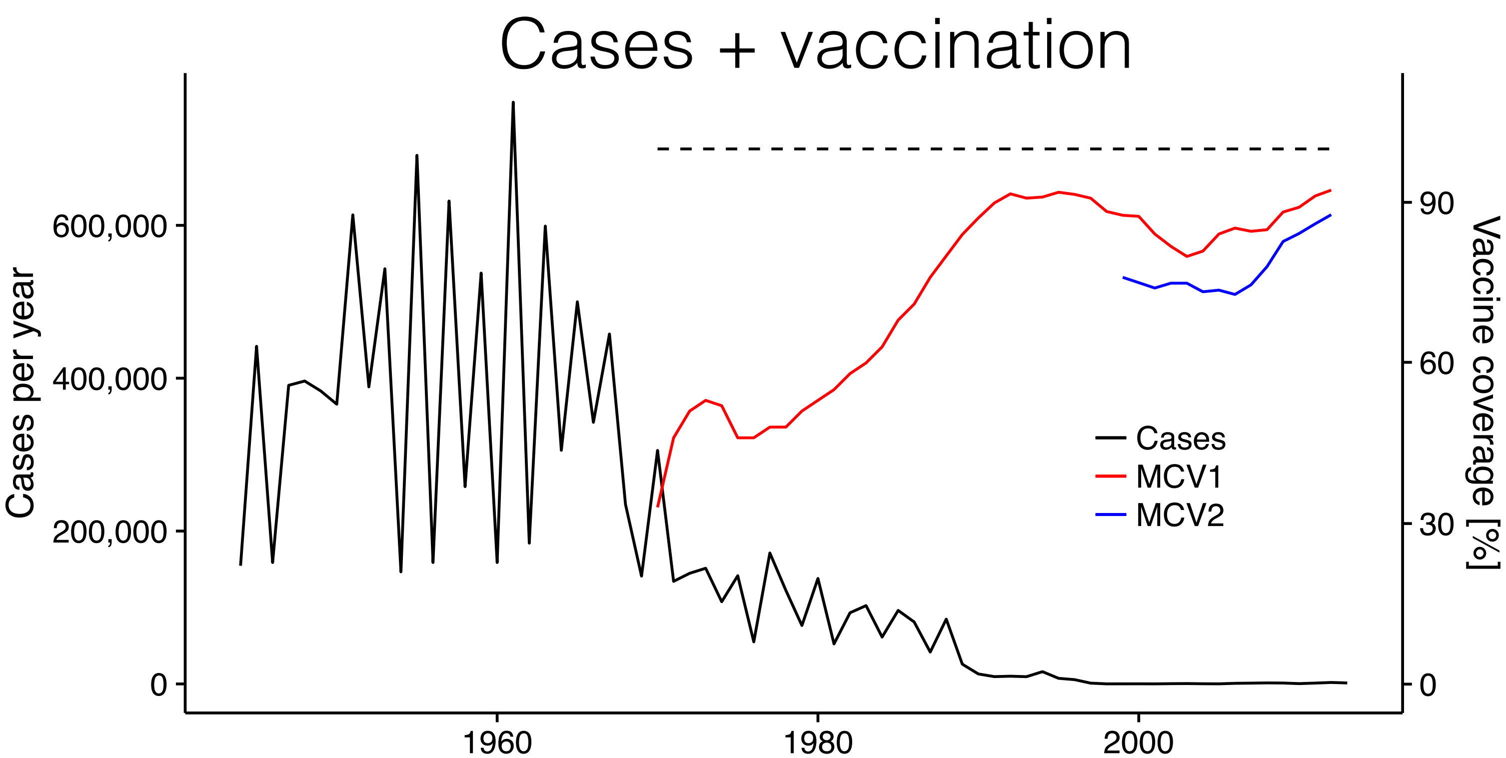
Measles: 93-95% (randomly mixing population)

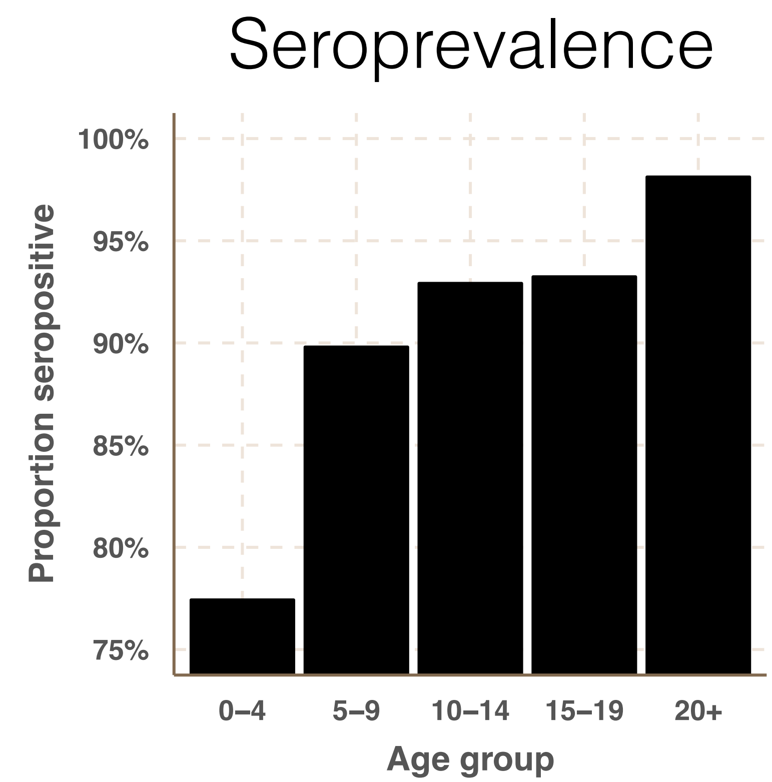
Limitations:

Population immunity reflects vaccination and case history

Mixing (person-to-person contact) is age-dependent

Measles immunity profile (e.g., UK)





Andrews, 2008

Question:

Which levels of immunity are required for elimination?

Vaccination vs immunity targets

Vaccination target

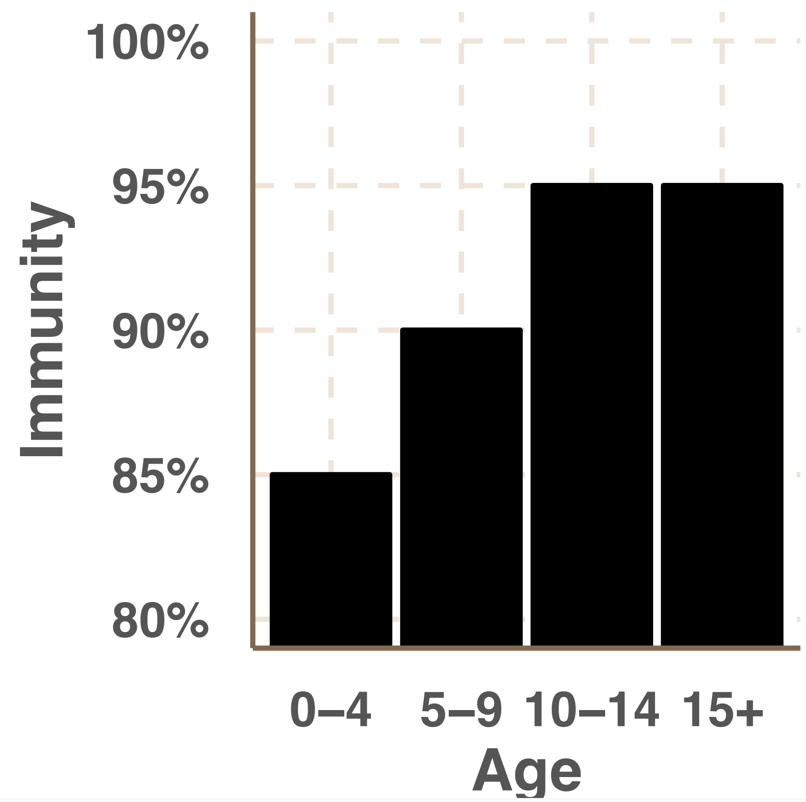
Vaccinate (e.g. 95%) in each birth cohort.

Immunity target

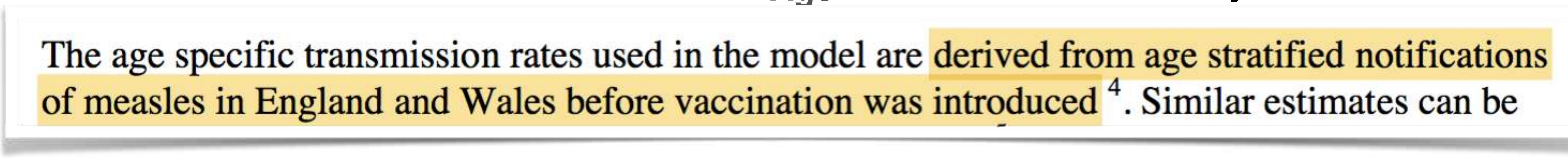
Aim for age-specific levels of immunity, including past birth cohorts.

Target immunity levels for measles

WHO European Region



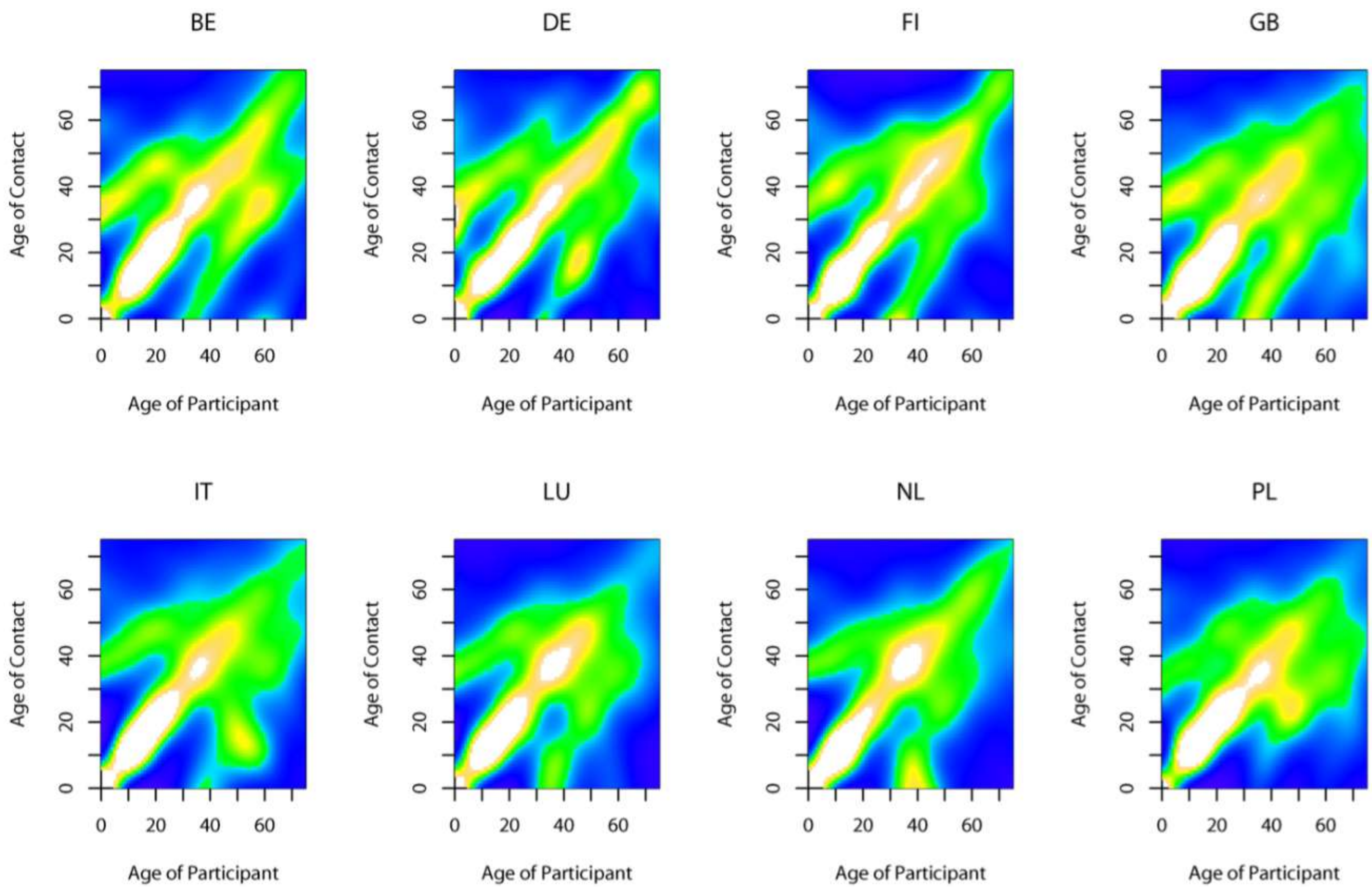
Ramsay, 1997


The age specific transmission rates used in the model are derived from age stratified notifications of measles in England and Wales before vaccination was introduced [4]. Similar estimates can be

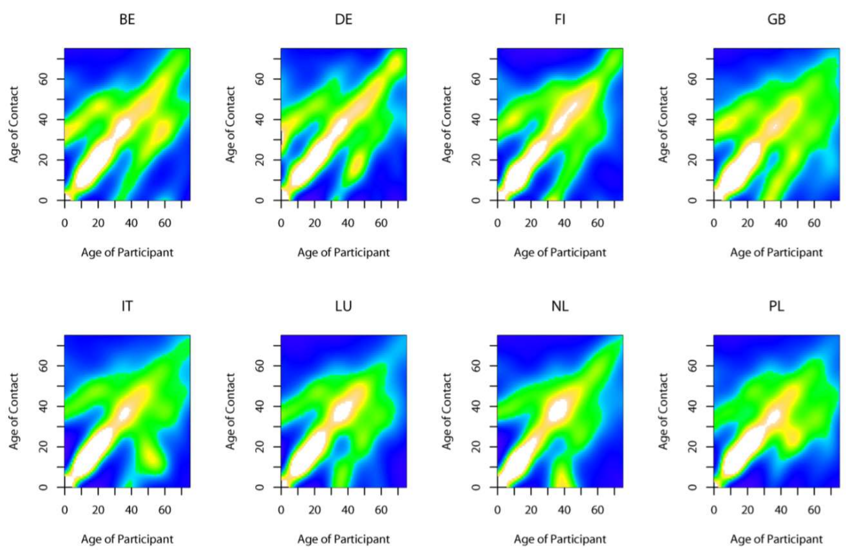
Question:

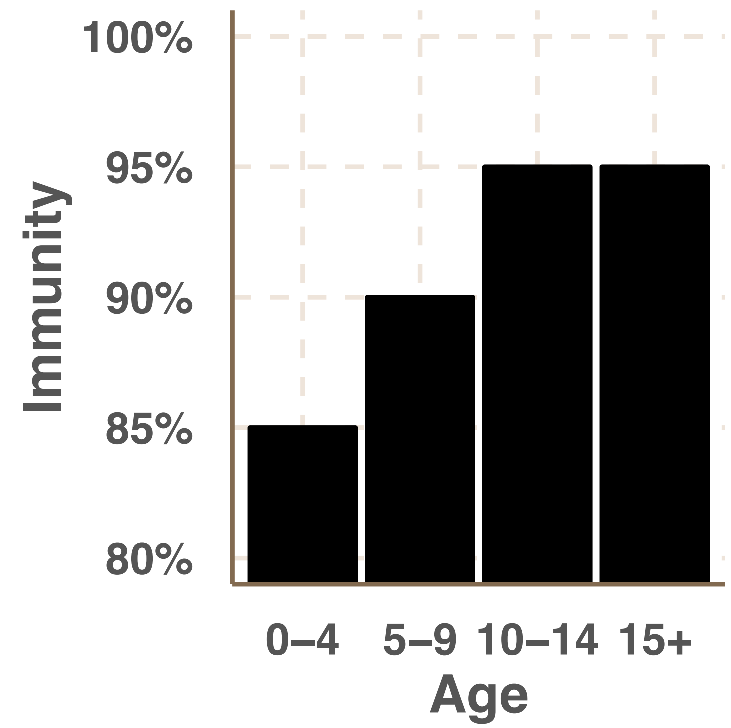
Are these appropriate? If yes, in which settings?

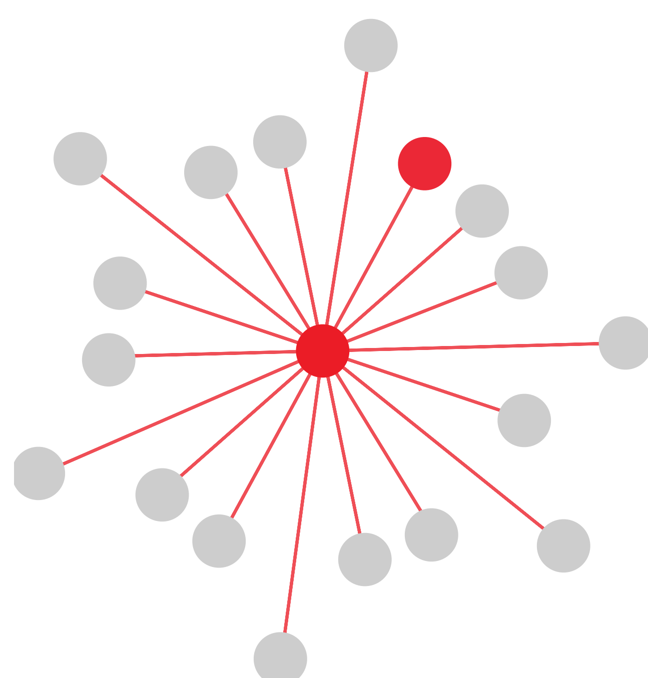
Age-specific differences in contacts



Mossong et al., 2008

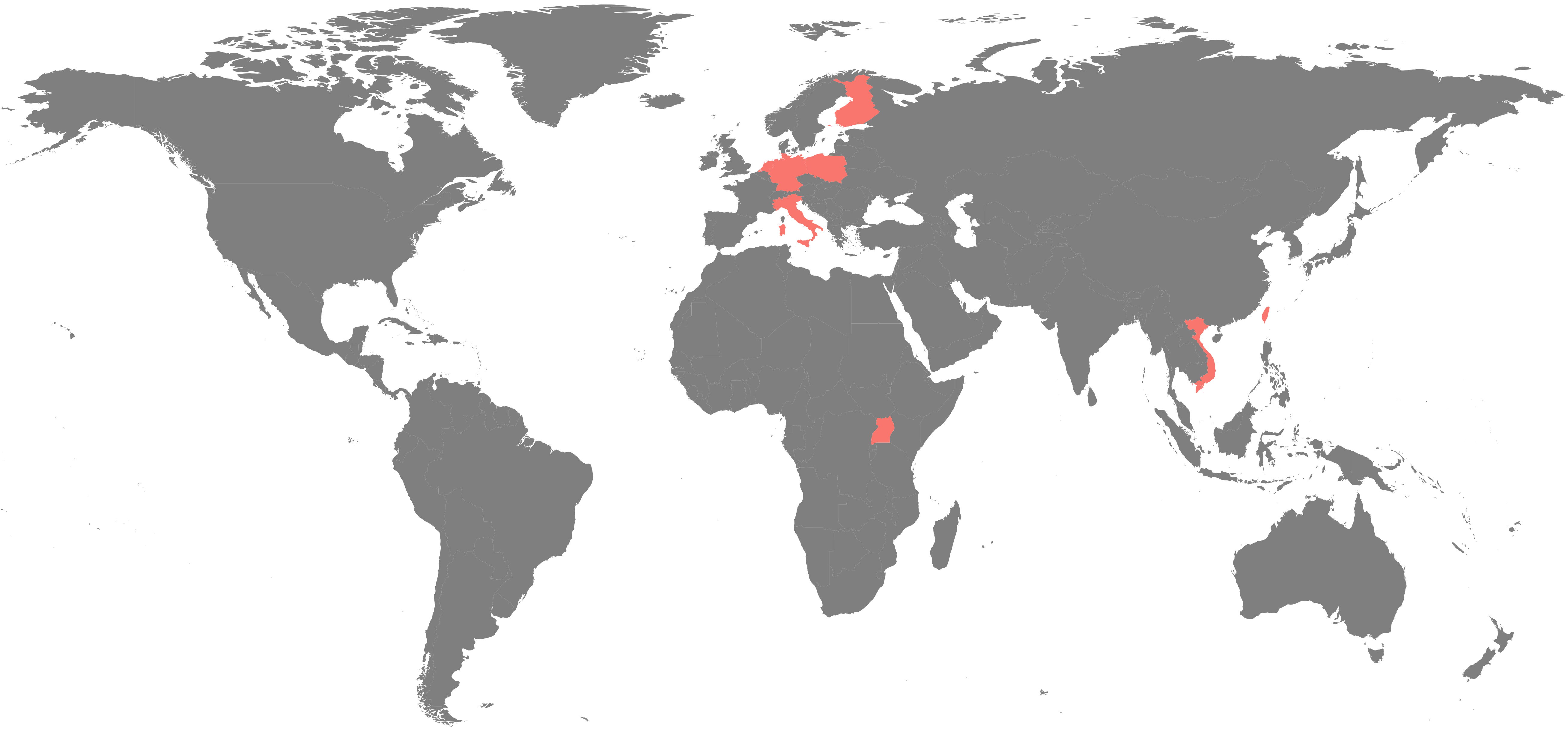






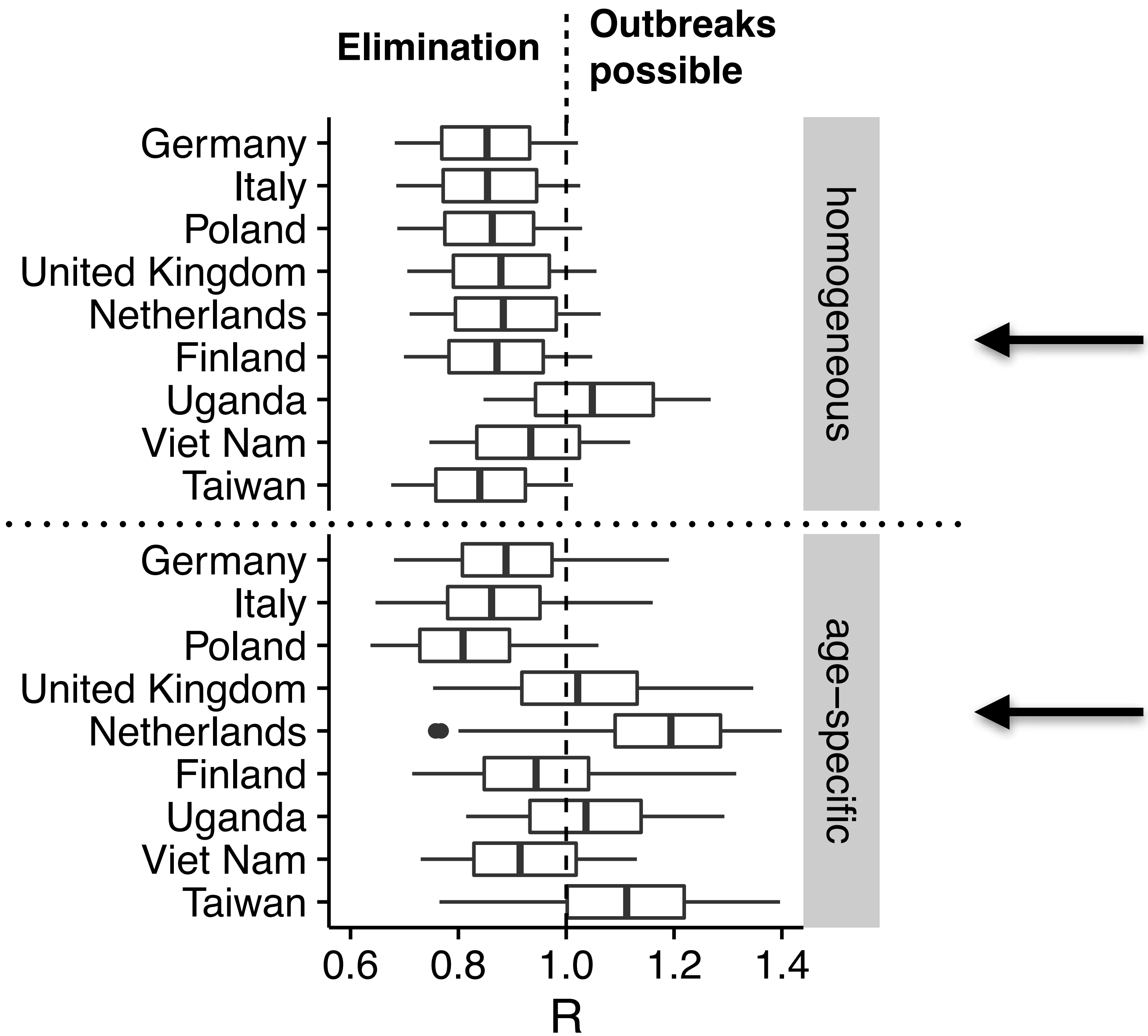
Calculate R from mixing pattern and given immunity levels

Contact data used in this study



2. Results

Results: homogeneous vs age-specific mixing

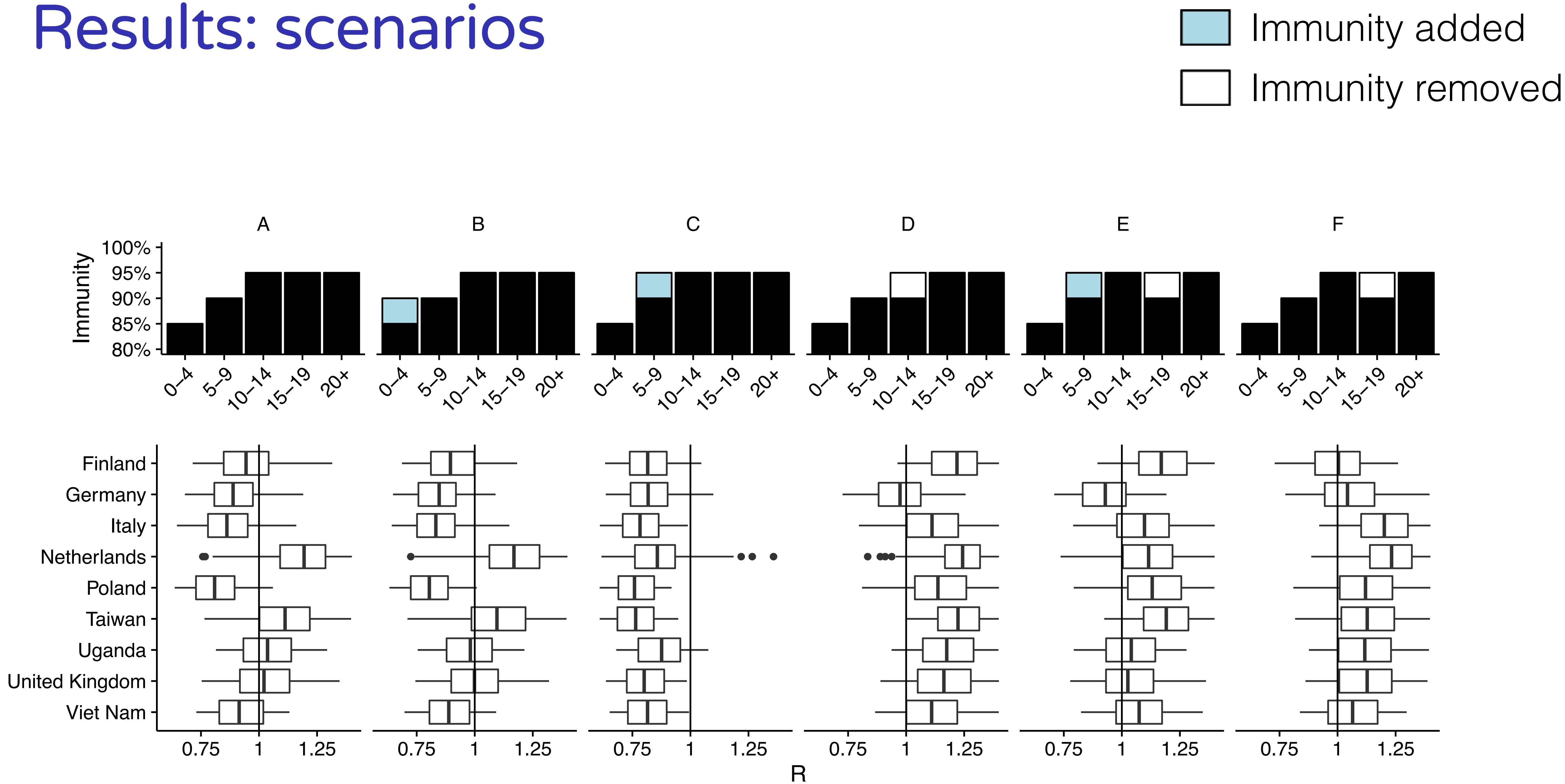


only takes into account differences in demography

takes into account observed age-specific contact patterns

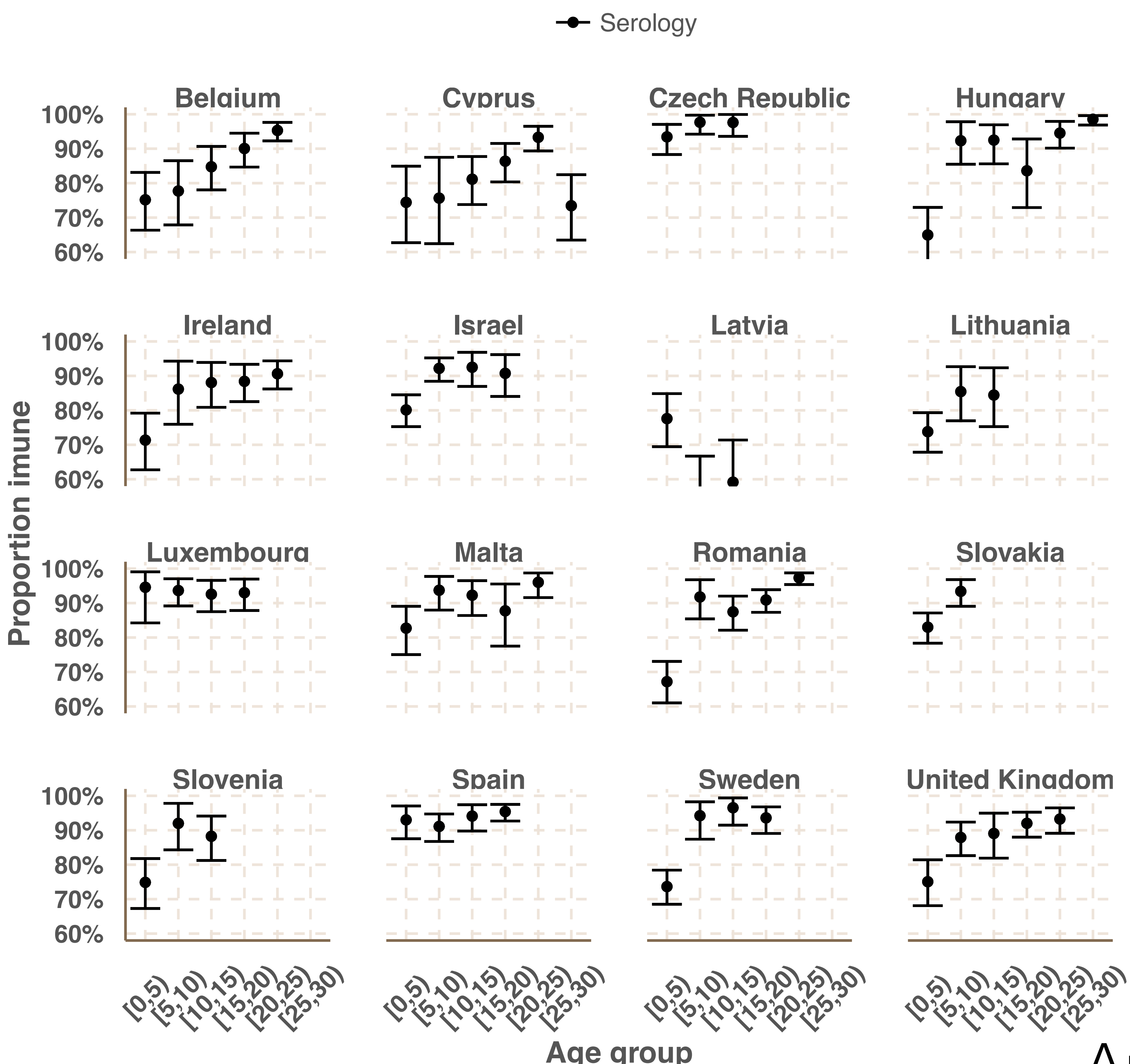
Plot shows effective reproduction number R if countries had immunity levels according to current target levels.

Results: scenarios



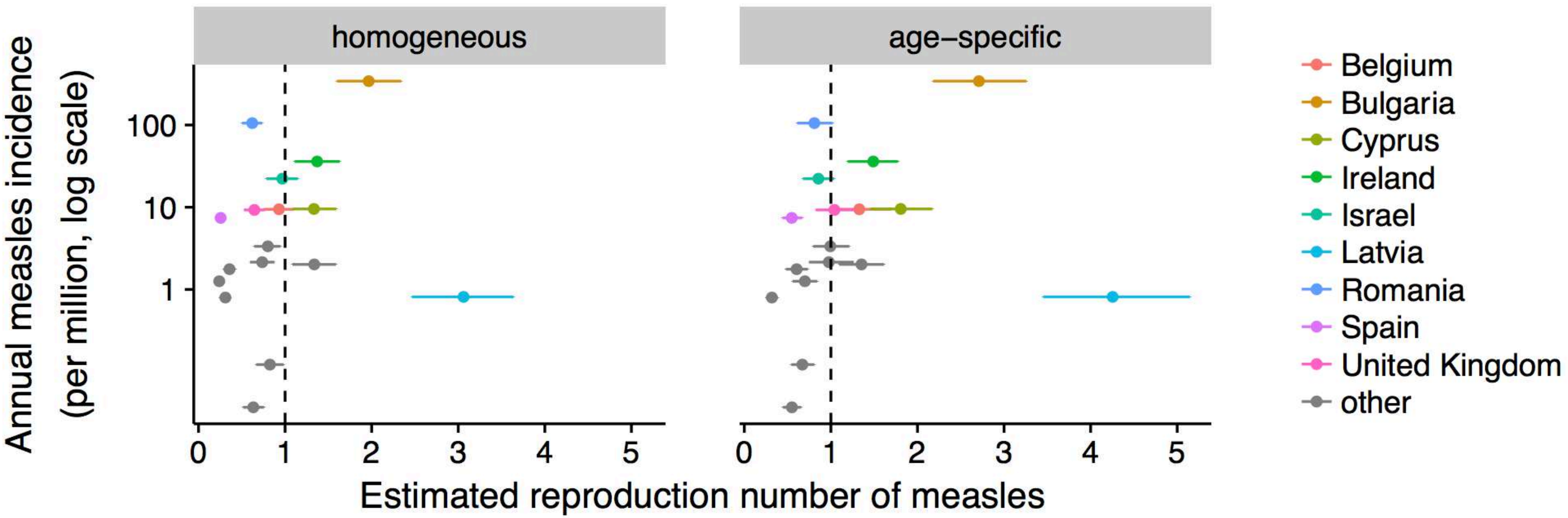
Plot shows effective reproduction number R if countries had immunity levels as shown at the top.

Finding gaps in immunity: serology

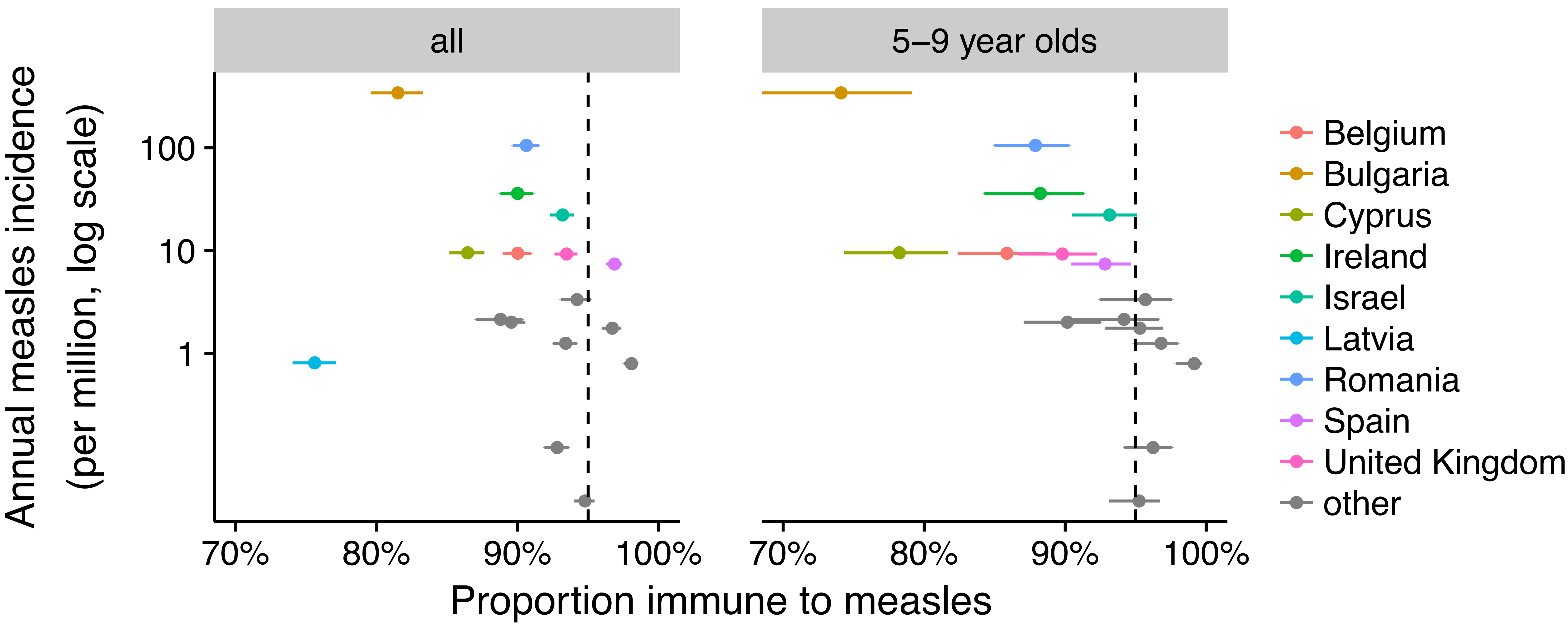


Andrews et al. (2008)

Results: homogeneous vs age-specific mixing



Estimated reproduction numbers (R) from serological studies conducted around 2000 vs cases incidence in the 10 years following.



Serological data from the around 2000 vs cases incidence in the 10 years following.

3. Conclusions and recommendations

Lessons from the United States

Measles eliminated in 2000

- Pre-elimination outbreaks in vaccinated school-aged populations (>90% uptake)
  => high vaccination levels needed to prevent outbreaks in schools.

- Lower coverage at 2nd birthday may be sufficient to prevent outbreaks IF population immunity is high among school-age children (except if there are high contact rates among preschool children, e.g, childcare)

Conclusions

- Old immunity targets are not sufficient for measles elimination.

- For elimination in all scenarios, need higher immunity levels in 5-9 year olds compared to previous targets.

- Besides, it is important to maintain high levels of immunity in older age groups.

- Serological studies can help identify gaps in in immunity in key age groups.

Limitations

- National targets don't take into account heterogeneity and clustering of susceptibles.
- Targets don't take into account waning immunity.
- Results depend on reported contact rates.
- Range of 11-18 for R_0 may not apply to all settings

Programmatic implications

- Achievements towards elimination usually expressed via coverage levels, but they only tell part of the story
- School-entry checks could be a method to identify and correct missing immunity in 5 year olds
- Serological studies could be needed to identify immunity gaps in older age groups

Measles and Rubella SAGE WG proposed recommendations (1)

1. Achieving at least 95% immunity across all age groups, geographical regions and population subgroups through coverage of at least 95% of each birth cohort with 2 doses of MCV remains the primary goal for measles elimination.

2. To achieve this, countries ideally should assess age-group specific immunity levels to identify age-groups with levels of immunity below predefined thresholds to be targeted for vaccination.

Measles and Rubella SAGE WG proposed recommendations (2)

3. Neglecting immunity gaps in children older than five years of age, adolescents and adults could make it more difficult and costly to achieve measles elimination.

4. Immunity gaps in school-aged children are important and could increase the disease burden and mortality among infants younger than 1 year of age as school-aged children are likely sources of measles virus infection within families (as siblings in school or in the future as parents). Therefore, the MR SAGE WG recommends that:

   - Countries conducting follow-up MCV vaccination campaigns should target school-age children 5-9 years of age whenever MCV coverage among this epidemiologically important age group is assessed to be significantly lower than 95%.

   - Countries should put into place school entry checks for vaccination as they are an important tool to help identify and address immunity gaps in school-age children.