

Targeted catch-up immunization for measles can make a difference: an individual-based modeling study



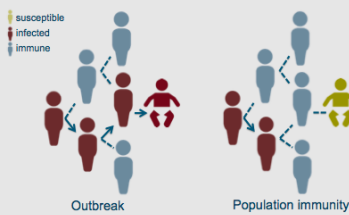
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Introduction

High immunization coverage at the community level is important to protect individuals who cannot be vaccinated due to medical reasons or age (e.g., the very young). Adolescents and young adults provide through their highly active social life an avenue for measles to resurge in large outbreaks upon re-introduction in Belgium.



Methods

1. Initialized an open-source individual-based model, Stride [2], with a synthetic population for Belgium (Flanders) using **reference households and census data** on demography and commuting behavior (size 1.6 million).
2. Calibrated social contacts patterns in **households, workplaces, schools and the general community**, based on contacts >15min with physical contact from survey data from 2010-2011 (Flanders) [2].
3. Applied the natural history of **measles** [3] and calibrate the transmission probability, given contact, to the basic reproduction number.
4. Tuned the **population immunity** and susceptibility based on seroprevalence data [4], vaccination strategies or clustering assumptions:

Scenario	Details
Random susceptibility	Immunity and susceptibility is randomly distributed over the population, according to the Belgian age profile
Clustered susceptibility	Probability to have an additional susceptible sibling (1-17 years) in a household, ranging from 0.1 - 0.9
Cocoon vaccination	Target adults 18-40 years of age with a newborn (age <1 year) with coverage 65%
Catch-up vaccination (4%)	Target adults 18-40 years of age, with similar coverage as "cocoon" (=4% of this age group)
Catch-up vaccination (65%)	Target adults 18-40 years of age, with a coverage of 65%

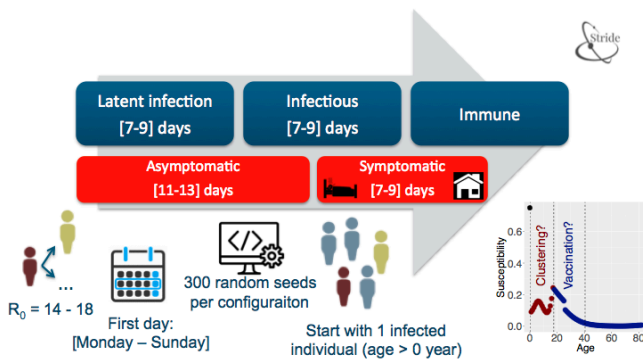


Figure 1: Disease dynamics and model setup.

Results

The social contact patterns in the individual-based simulator clearly shows the general **assortative mixing by age**, the child-adult relationships, the school and work setting, and the general mixing in the community (Figure 2).

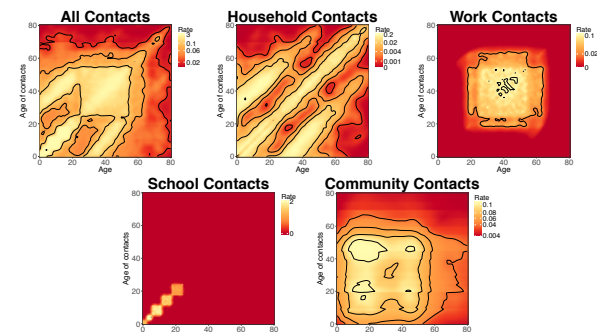


Figure 2: Social contact rates per location type, based on 10 000 individuals from the synthetic population, analyzed with the open-source social mixR [5] and INLA packages [6].

Figure 3 presents the outbreak size of measles epidemics for different clustering scenarios. The results vary due to **stochastic events**, which are captured by different realizations, **parametric uncertainty** on the basic reproduction number (R_0) and different days of the week (Monday-Sunday) to introduce the index case. In addition, Figure 3 shows also the predicted relative incidence of measles in **newborns** assuming different vaccination scenarios. The cocoon vaccination strategy appears to be on average **more effective** compared to a general catch-up campaign. Increasing the catch-up coverage has limited effect.

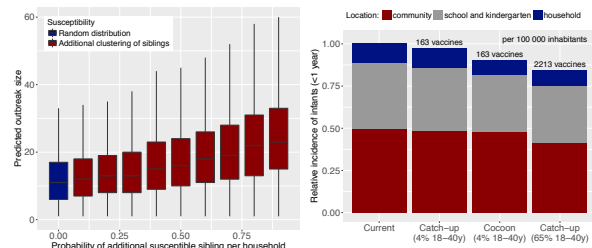


Figure 3: The predicted outbreak size according to the clustering of susceptible siblings (left) and the relative incidence in newborns (<1 year) with catch-up and cocoon vaccination strategies with respect to the current situation (right).

Summary

- Clustering of **susceptible siblings** can double the outbreak size of measles epidemics, despite a high population immunity.
- Protection of newborns via a **cocoon vaccination** strategy, which targets new parents (similar to pertussis), is most effective.
- Using open-source methods, we were able to reproduce and analyze **social contact patterns** from a synthetic population.

Acknowledgments

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References

- [1] Kuylen et al, Procedia Computer Science (2017) [2] Willem et al, Plos ONE (2012) [3] Liu et al, BMC Public Health (2012) [4] Hens et al, Euro Surveillance (2005) [5] <https://github.com/sbfnk/socialmixr> [6] <http://www.r-inla.org>