Estimation of the effective reproduction number of a measles outbreak in Guinea, 2017

Natalie Linton,[1,2] Mory Keita,[3] Hiroshi Nishiura[1]

[1] Graduate School of Medicine, Hokkaido University
[2] Centre for Research on the Epidemiology of Disasters
[3] World Health Organization, Guinea Office

Objective

Assess the association between **outbreak response vaccination (ORV)** campaigns and the **effective reproduction number (R_t)** of measles during a nationwide outbreak in Guinea.

Background

The **measles virus** is spread through droplets (e.g., via coughing) but can also become airborne.

Measles is a **vaccine-preventable** disease. 2016 vaccination coverage in Guinea: **48%** (target: 95%)

A nationwide outbreak began early January 2017 following **disruptions to vaccination** during the 2014–2016 Ebola epidemic (1)

Outbreak response vaccination (ORV) campaigns were implemented to reduce transmission, morbidity, and mortality (2):

Guinea measles ORV campaigns in 2017

Campaign	Campaign dates	# of health districts	Target age (months)	Number vaccinated
1	Mar 13–19	1	6–119	148,344
2	Apr 9–17	5	6–119	662,733
3	Apr 25–May 1	22	6–59	1,315,918

ORV campaign success is quantifiable using the **effective reproduction number R_t**, which estimates the average number of secondary cases produced by an infectious individual within a partially immune population.

Methods

We **estimated R_t** for all measles cases with illness onset in calendar year 2017 using a pulse time-dependent step function…

$$R_t = \begin{cases} R_1, & \text{for } t < t_0 \\ R_2, & \text{for } t_0 \le t < t_1 \\ R_3, & \text{for } t_1 \le t < t_2 \\ R_4, & \textit{otherwise} \end{cases}$$

…and generalized renewal equation…

$$E(i_t) = R_t \sum_{i=1}^{t-i} i_{t-s} g_s$$

$E(i_t)$ = estimated incidence at time t
R_t = reproduction number at time t
i_{t-s} = incident cases at time t
g_s = probability mass function of the measles virus generation time using a gamma distribution

…and minimized the negative log likelihood.

- 95% confidence intervals were computed using profile likelihood.
- Akaike information criterion (AIC) values and visual model fit were used to select the final model.

References

(1) Takahashi S, et al. The growing risk from measles and other childhood infections in the wake of Ebola. Science. 2016;347(6227):1240–2.

(2) Minetti A, et al. Measles outbreak response immunization is context-specific: Insight from the recent experience of Médecins Sans Frontières. PLoS Medicine. 2013;10(11):1–4.

Results

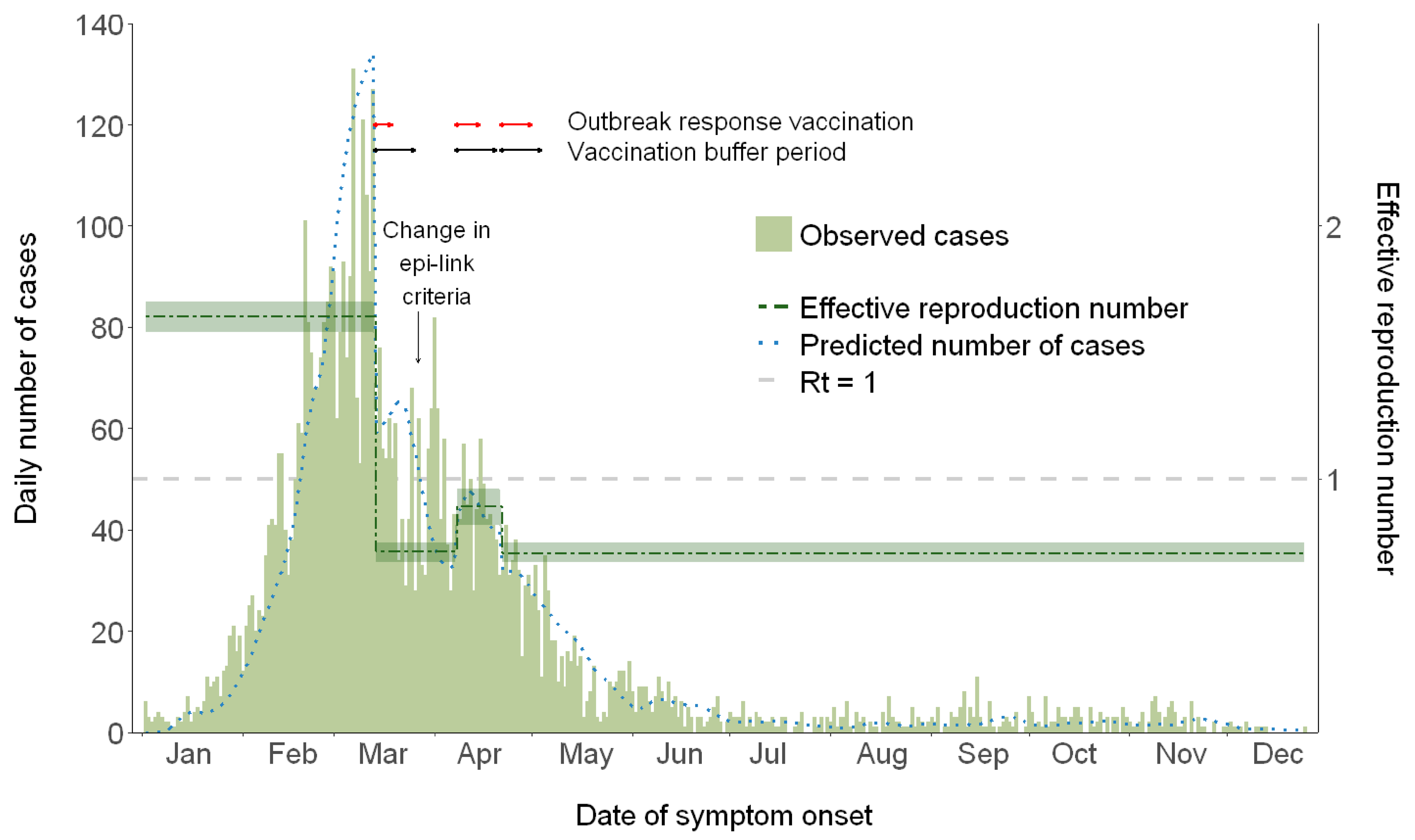
5,932 measles cases

- Median age: 2 years (96% < 15 years)
- Case-fatality rate: 0.5%
- Unvaccinated: 74.7%

Effective reproduction number based on ORV campaign timing

Timing of analysis	Measles effective reproduction number (95% CI)	
Start of ORV campaign	Four parameters	Two parameters
Before ORV	1.64 (1.58–1.70)	1.64 (1.58–1.71)
ORV campaign 1	0.71 (0.67–0.75)	0.75 (0.73–0.78)
ORV campaign 2	0.89 (0.82–0.96)	↓
ORV campaign 3	0.71 (0.67–0.75)	↓
AIC	2579	2654

Measles outbreak cases and effective reproduction number, 2017



Discussion

- The model captured the peaks of the outbreak well, but does not account for spatial heterogeneity of cases.
- Model fit was better when cutpoints were set to the beginning of each ORV campaign (AIC=2579) rather than the end of the buffer period (2 weeks after the beginning of a campaign, AIC=3204).

Conclusions

- ORV implementation coincided with the decrease in R_t to < 1.
- Calculation of R_t from case count data using basic modeling methods can help decision makers and those in field understand progress of an outbreak and make decisions about initiating further control measures.

Acknowledgements

Joris Adriaan Frank van Loenhout, Maria Moitinho de Almeida, Julita Gil Cuesta, Debarati Guha-Sapir

Contact: nlinton@gmail.com
nishiurah@med.hokudai.ac.jp