

Supplementary Material

Modelling the end of a Zero-COVID strategy using nirmatrelvir/ritonavir, vaccination and NPIs in Wallis and Futuna

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Description of the model

The scheme Figure S1 represents the stochastic compartmental model used in the article.

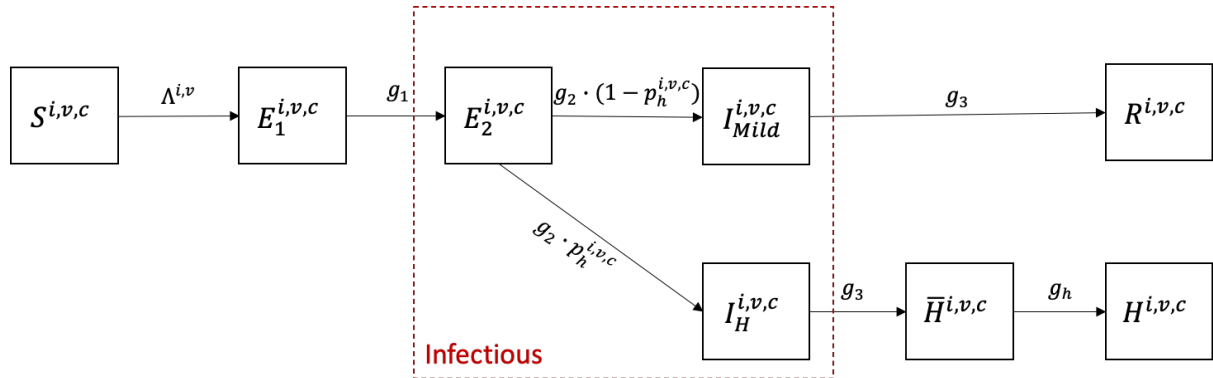


Figure S1: Scheme of the compartmental model.

The superscript letters have the following meaning:

- i is the index of the age group (0-4 y.o., 5-9 y.o., 10-14 y.o., 15-19 y.o., 20-24 y.o., 25-29 y.o., 30-34 y.o., 35-39 y.o., 40-44 y.o., 45-49 y.o., 50-54 y.o., 55-59 y.o., 60-64 y.o., 65-69 y.o., 70-74 y.o., older than 75 y.o.)
- v is the index of the vaccination status (2 old doses, 3 old doses, 2 recent doses, 3 recent doses or 4 doses)
- c is the index of the comorbidity risk group (low, intermediate, high)

Definitions of compartments:

- S contains people susceptible to be infected
- E_I contains people infected to but not yet infectious
- E_2 contains people infectious who will develop a mild or severe disease
- I_{Mild} contains infectious people who develop a mild disease
- I_H contains infectious people who develop a severe disease requiring an hospitalisation
- $\bar{H}$ contains people who develop a severe disease but are no longer infectious
- H contains hospitalised people
- R contains people who recover from a mild disease

Definitions of transition rates in $days^{-1}$:

- $\lambda^{i,v} = \frac{intro_w}{7S(0)} + p(1 - VE_{sus}^v) \sum_j c_{i,j} \sum_{v'} (1 - VE_{inf}^{v'}) \frac{E_2^{j,v',c} + I_{Mild}^{j,v',c} + I_H^{j,v',c}}{N_j}$, where
 - p is the probability of infection per contact
 - c is the contact matrix between age groups
 - N_j is the number of individuals in age group j
- $g_1 = 1/2.5$
- $g_2 = 1$
- $g_3 = 1/2$
- $g_h = 1/4$
- $p_h^{i,v,c} = p_h(a, c)(1 - VE_{sev}^v)(1 - p_t^{i,c} + p_t^{i,c}(1 - TE))$, where
 - VE_{sev}^v is the vaccine effectiveness against hospitalisation
 - $p_t^{i,c}$ is the probability that an individual in the age group i and the comorbidity group r receive the treatment
 - TE is the treatment effectiveness against hospitalisation
- $intro_w$ is the average number of infections introduced per week
- $S(0) = \sum_{j,v,c} S^{j,v,c}(0)$

Numerical analysis

For each scenario, we performed 500 simulations over 200 days, on a uniform time subdivision with a mesh of 0.1 day. We defined 95% uncertainty intervals as quantiles 0.025 and 0.975 of the distributions.

We used R (version 4.1.1) with Odin (version 1.2.4) to build and run the model and Tidyverse (version 1.3.1) for all statistical analyses and plots.

Table of comorbidity risk group by age in Wallis And Futuna

Age group	Low risk	Intermediate risk	High risk	Population
18-29	36%	43%	21%	1475
30-39	23%	50%	27%	1354
40-49	19%	47%	34%	1762
50-59	15%	44%	41%	1441
60+	17%	36%	47%	1909

Table S1: Population and prevalence of comorbidity risk groups in Wallis and Futuna by age group.

Probability of hospitalisation adjusted by comorbidity in Wallis and Futuna

Let $p_h^f(a)$ be the probability of hospitalisation in the age group a in metropolitan France.¹ We denote $p^f(a, c)$ the proportion of individuals in the comorbidity risk group c and in the age group a in metropolitan France. Let RR_c be the relative risk of hospitalisation in the comorbidity risk group c . Then, the probability of hospitalisation in the comorbidity risk group c and the age group a is:

$$p_h(a, c) = p_h^f(a) \frac{RR_c}{\sum_c p^f(a, c) RR_c}.$$

Adjustment of the contact matrix of Fiji to the Wallis and Futuna demography

Here, we describe the density correction used to compute the Wallis and Futuna contact matrix from the contact matrix of Fiji available in Prem et al.² This adjustment is detailed in Arregui et al³ but we give the formula here for the sake of clarity.

Let $c'_{i,j}$ (resp. $c_{i,j}$) be the average number of contacts that an individual in the age group i has with individuals in the age group j per day in Fiji (resp. in Wallis and Futuna), N'_j (resp. N_j) the population in the age group j in Fiji (resp. in Wallis and Futuna), and N' (resp. N) the total population in Fiji (resp. in Wallis and Futuna). Then, we assume that $c_{i,j} \frac{N_j}{N} = c'_{i,j} \frac{N'_j}{N'}$, which allows us to obtain the contact matrix in Wallis and Futuna as:

$$c_{i,j} = c'_{i,j} \frac{N'_j N}{N_j N'}.$$

Sensitivity analysis with respect to the average duration of hospital stay

We conducted a sensitivity analysis with respect to the average duration of hospital stay. It is 11 days on average in our baseline scenario, but could be shorter for example if some patients receive care at home.

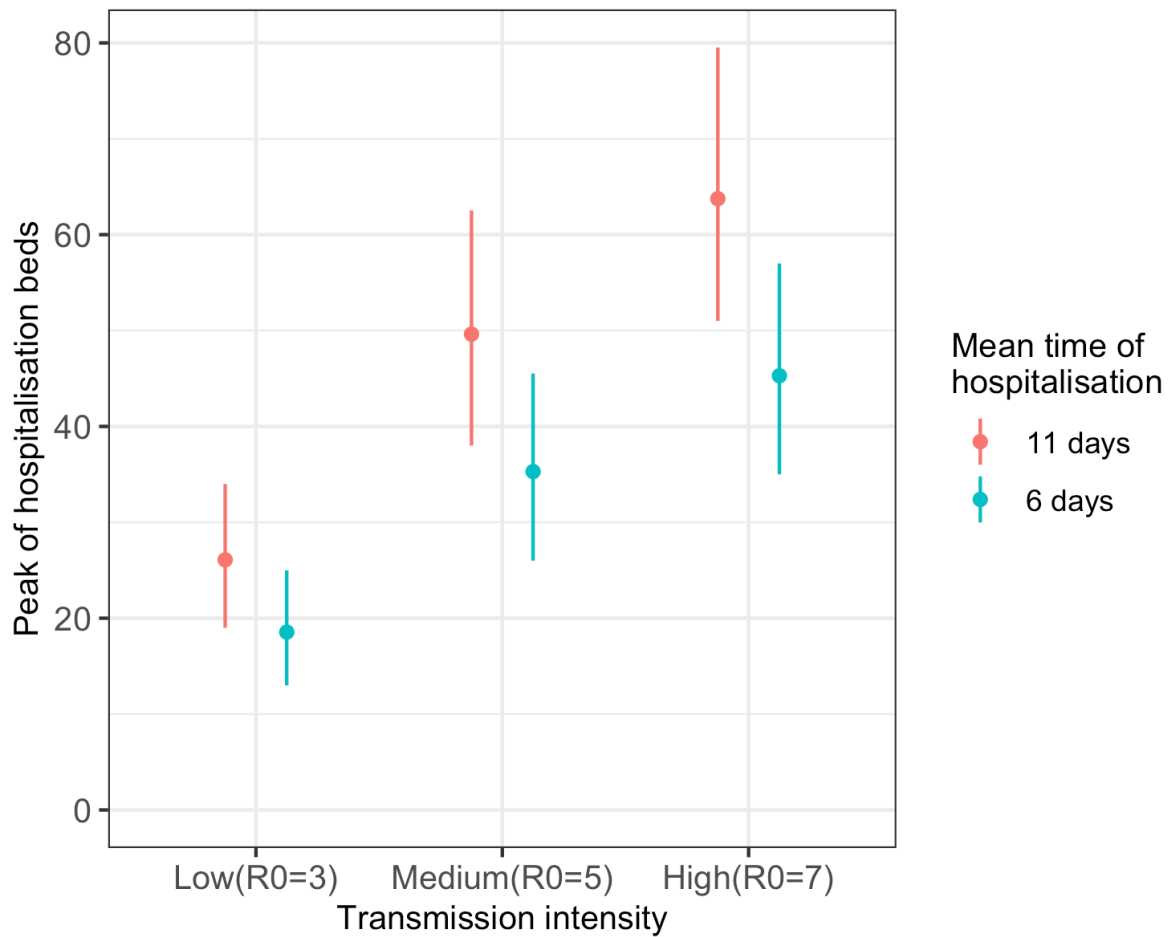


Figure S2: Peak number of hospital beds ,necessary at the peak with different average durations of hospital stay. The dots represent the means and the vertical bars the 95% uncertainty intervals.

Epidemic observed in Wallis and Futuna after reopening

An epidemic started in Wallis and Futuna after partial reopening on June 23, 2022. We estimated the observed doubling time at the beginning of the epidemic of 3.33 days (95% confidence interval [2.8-4]) (Figure S2).

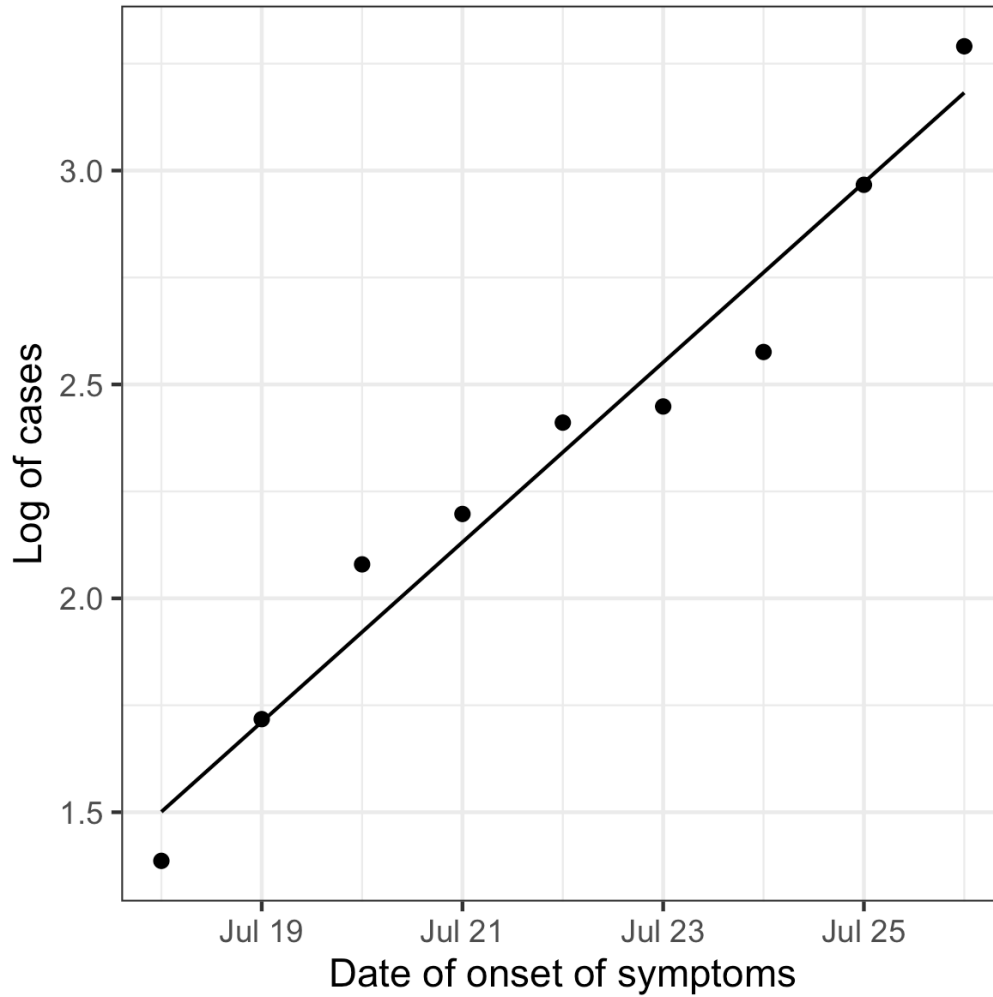


Figure S3: Estimation of doubling time in Wallis and Futuna between July 18 and 26, 2022. The dots are the log of the rolling average of cases from July 18 to 26, 2022. The line is the linear regression computed from the dots. The doubling time is the $\log(2)/a$, where a is the slope of the line.

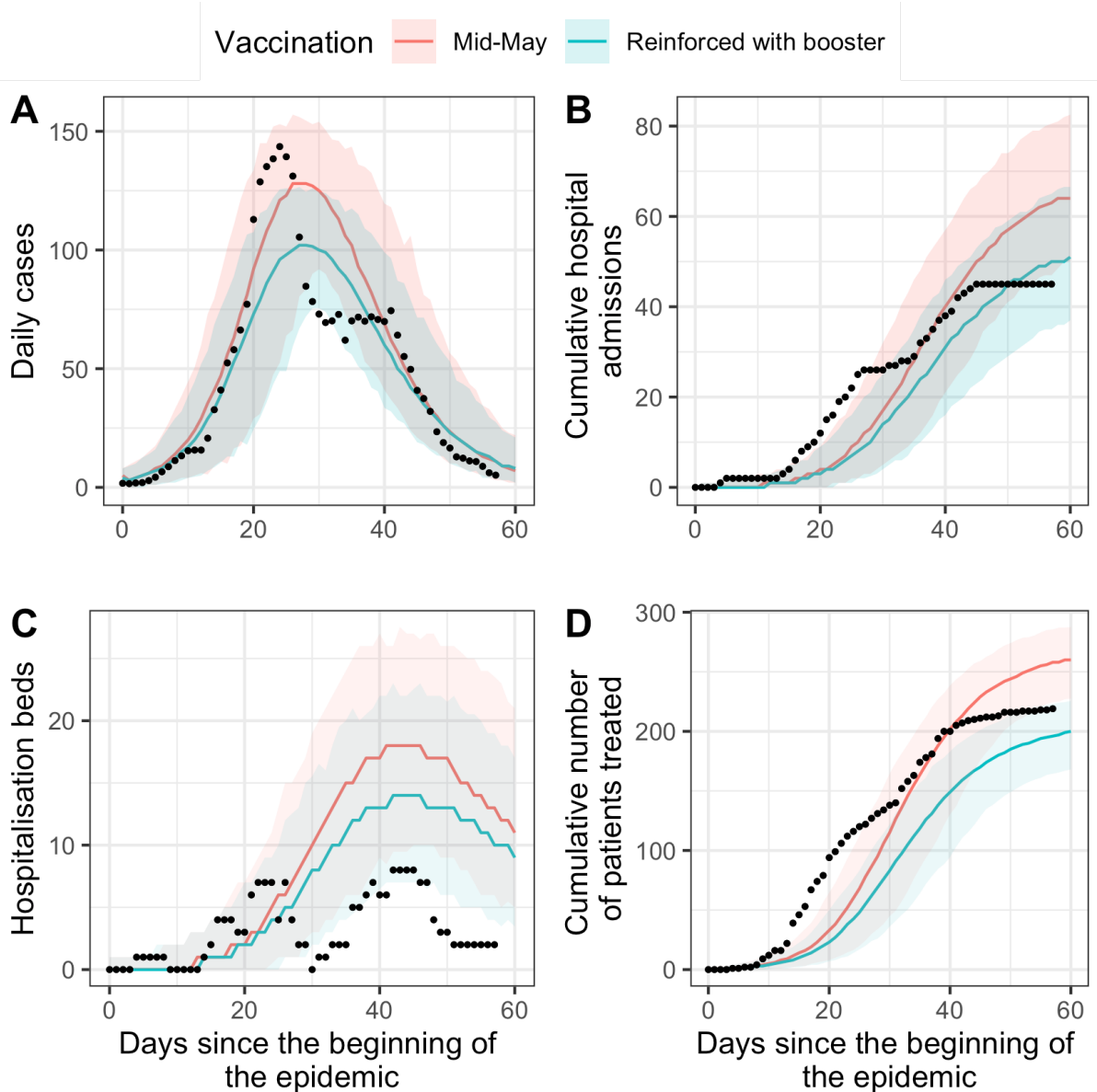


Figure S4: Comparison of the epidemic dynamics observed after the reopening in Wallis and Futuna with the projections of our model for a low transmission intensity. The black dots represent the data observed in Wallis and Futuna after the reopening of the islands and the curves are the simulated scenarios for a low transmission intensity ($R_0=3$).

References

- 1 Lapidus N, Paireau J, Levy-Bruhl D, *et al.* Do not neglect SARS-CoV-2 hospitalization and fatality risks in the middle-aged adult population. *Infect Dis Now* 2021; **51**: 380–2.
- 2 Prem K, van Zandvoort K, Klepac P, *et al.* Projecting contact matrices in 177 geographical regions: An update and comparison with empirical data for the COVID-19 era. *PLoS Comput Biol* 2021; **17**: e1009098.
- 3 Arregui S, Aleta A, Sanz J, Moreno Y. Projecting social contact matrices to different demographic structures. *PLoS Comput Biol* 2018; **14**: e1006638.