

# Supplemental Material: Testing and Vaccination to Reduce the Impact of COVID-19 in Nursing Homes: An Agent-Based Approach

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## Methods

### Dynamic Transmission Model

Resident and staff agents in our proposed model are represented in epidemiological classes of susceptible but not yet exposed to the disease ( $S$ ), non-infectious exposed individuals incubating the disease whose infection is currently non-detectable by testing ( $E$ ), infectious individuals with detectable disease who do not yet exhibit clinical symptoms of illness ( $I_a$ ), infectious individuals exhibiting symptoms of illness ( $I_s$ ), individuals that have recovered and can no longer infect others ( $R$ ), symptomatic individuals requiring hospitalization ( $H$ ), and individuals that succumbed to the disease ( $D$ ) (Figure 1). Transition parameters are described in Table 1 of main manuscript.

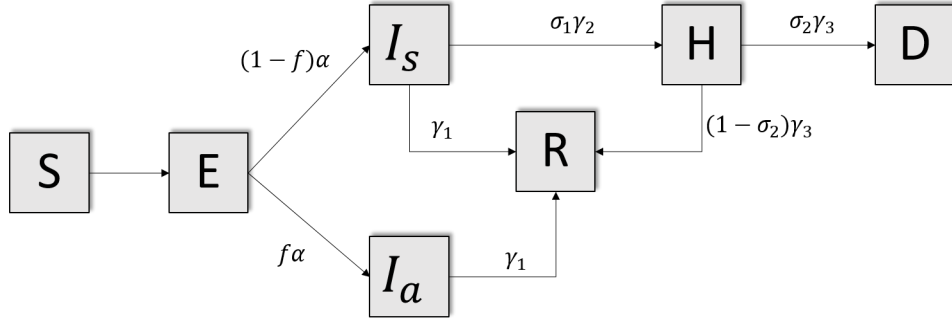


Figure 1: Epidemiological classes of the transmission model.

### Sensitivity Analysis

The parameters used to describe the course of infection in our model were obtained from a combination of clinical trials and CDC reports. To describe the average time a person remains in the non-infectious latency state we used the infection profiles estimated by He et al. [1], which in our model was described by a log-normal distribution truncated between 2 to 10 days with shape 2, and scale 3. The probability of being asymptomatic in our model is based on data reported by the CDC [2] where a high proportion of asymptomatic SARS-CoV 2 (40.7%) were detected in 9 long term facilities. For parameters involved in the transmission probability such as shedding and infection we did not find enough information, therefore we calibrated these parameters in a way that the baseline scenario will produce outbreaks with similar sizes to the ones observed in nursing homes of similar number of residents.

To conduct the sensitivity analysis we set the parameters as the ones described on the table 1 from the main text, and selected one of the target parameters to vary as described on table 2. We ran the model 200 times and summarised the simulation results. The values for the PPE effect were based on the upper and lower bounds of the estimation of the PPE effect reported by the systematic review by Chu et al. [3]. For other parameters where no references were available, such as transmission, introduction and detection probability, we varied the parameter defining a worst and best case scenario.

### Scenarios

Table 1 summarize the assumptions for the different scenarios. We analyze the impact of a variety of interventions under three rates of virus introduction which reflect the virus transmission in the community. The first scenario considers different testing periods, the second regard different vaccine efficacy, and the last one contemplates different prioritization strategies in vaccination.

Table 1: Description of interventions and parameter values.

Probability of Introduction	Low	Medium	High
Testing Frequency ( $\omega$ = Introduction probability)			
	$\omega = 0.05$	$\omega = 0.10$	$\omega = 0.15$
Testing Interval	7 days	7 days	7 days
Testing Interval	5 days	5 days	5 days
Testing Interval	3 days	3 days	3 days
Vaccine Performance ( $V_rOR$ = Odds ratio for the vaccine effect on residents, $V_sOR$ = Odds ratios for the vaccine effect on staff)			
	$\omega = 0.05$	$\omega = 0.10$	$\omega = 0.15$
Equal	$V_rOR = 0.0493$ $V_sOR = 0.0493$	$V_rOR = 0.0493$ $V_sOR = 0.0493$	$V_rOR = 0.0493$ $V_sOR = 0.0493$
Pfizer	$V_rOR = 0.0619$ $V_sOR = 0.0434$	$V_rOR = 0.0619$ $V_sOR = 0.0434$	$V_rOR = 0.0619$ $V_sOR = 0.0434$
Moderna	$V_rOR = 0.1357$ $V_sOR = 0.0441$	$V_rOR = 0.1357$ $V_sOR = 0.0441$	$V_rOR = 0.1357$ $V_sOR = 0.0441$
Vaccine Prioritization ( $V_r\%$ = Percentage of residents vaccinated, $V_s\%$ = Percentage of staff vaccinated)			
	$\omega = 0.05$	$\omega = 0.10$	$\omega = 0.15$
Equal	$V_r\% = 50\%$ $V_s\% = 50\%$	$V_r\% = 50\%$ $V_s\% = 50\%$	$V_r\% = 50\%$ $V_s\% = 50\%$
Staff Priority	$V_r\% = 30\%$ $V_s\% = 70\%$	$V_r\% = 30\%$ $V_s\% = 70\%$	$V_r\% = 30\%$ $V_s\% = 70\%$
Resident priority	$V_r\% = 70\%$ $V_s\% = 30\%$	$V_r\% = 70\%$ $V_s\% = 30\%$	$V_r\% = 70\%$ $V_s\% = 30\%$

Table 2: Results from scenario modeling using the median and 95% confidence intervals.

Scenario	Days to eradication	Attack Rate	Total Infected	Infected residents	Infected staff	Hospitalizations	Deaths
Introduction Probability & Testing Frequency							
High & 7-days	14 (7, 48)	0.02 (0, 0.1)	8 (1, 34)	2 (0, 16)	6 (1, 21)	0.5 (0, 3)	0 (0, 1)
High & 5-days	15 (5, 41)	0.02 (0, 0.07)	7 (1, 25)	1 (0, 12)	5 (1, 18)	0 (0, 3)	0 (0, 1)
High & 3-days	9 (3, 24)	0.01 (0, 0.04)	4 (1, 14)	0 (0, 6)	3 (1, 11)	0 (0, 2)	0 (0, 0)
Moderate & 7-days	14 (7, 41)	0.01 (0, 0.07)	5 (1, 23)	1 (0, 11)	3 (1, 14)	0 (0, 2)	0 (0, 0)
Moderate & 5-days	10 (5, 35)	0.01 (0, 0.07)	4 (0, 24)	0 (0, 12)	3 (0, 13)	0 (0, 2)	0 (0, 0)
Moderate & 3-days	9 (3, 30)	0.01 (0, 0.04)	3 (0, 15)	0 (0, 6)	2 (0, 10)	0 (0, 1)	0 (0, 0)
Low & 7-days	9 (7, 27)	0.01 (0, 0.04)	2 (0, 14)	0 (0, 9)	1 (0, 7)	0 (0, 2)	0 (0, 0)
Low & 5-days	9 (5, 25)	0.01 (0, 0.04)	2 (0, 13)	0 (0, 8)	1 (0, 7)	0 (0, 2)	0 (0, 0)
Low & 3-days	9 (3, 20)	0 (0, 0.02)	1 (0, 8)	0 (0, 4)	1 (0, 5)	0 (0, 1)	0 (0, 0)
Introduction Probability & Vaccine Prioritization							
High & Equal distribution	14 (7, 42)	0.02 (0, 0.11)	7 (1, 39)	1 (0, 17)	6 (1, 22)	0 (0, 3)	0 (0, 1)
High & Resident	14 (7, 56)	0.03 (0, 0.1)	9 (1, 35)	2 (0, 14)	7 (1, 22)	0 (0, 3)	0 (0, 1)
High & Staff	14 (7, 49)	0.02 (0, 0.09)	7 (1, 30)	1 (0, 15)	5 (1, 18)	0 (0, 3)	0 (0, 0)
Moderate & Equal distribution	14 (7, 42)	0.01 (0, 0.07)	5 (1, 24)	1 (0, 12)	3 (1, 15)	0 (0, 3)	0 (0, 0.05)
Moderate & Resident	14 (7, 35)	0.01 (0, 0.07)	5 (1, 24)	1 (0, 12)	4 (1, 14)	0 (0, 3)	0 (0, 1)
Moderate & Staff	14 (7, 35)	0.01 (0, 0.06)	5 (1, 22)	1 (0, 11)	3 (0, 11)	0 (0, 2)	0 (0, 0.05)
Low & Equal distribution	9 (7, 26)	0.01 (0, 0.04)	2 (0, 15)	0 (0, 9)	1 (0, 8)	0 (0, 2)	0 (0, 0)
Low & Resident	14 (7, 42)	0.01 (0, 0.07)	5 (1, 25)	1 (0, 11)	4 (0, 15)	0 (0, 3)	0 (0, 1)
Low & Staff	14 (7, 35)	0.01 (0, 0.06)	4 (1, 19)	1 (0, 10)	3 (0, 10)	0 (0, 2)	0 (0, 0)
Introduction Probability & Vaccine Performance							
High & Similar efficacy	14 (7, 42)	0.02 (0, 0.1)	7 (1, 35)	1 (0, 15)	5 (1, 20)	0 (0, 3)	0 (0, 0)
High & Reduced efficacy (Pfizer)	14 (7, 42)	0.02 (0, 0.1)	7 (1, 33)	1 (0, 15)	6 (1, 18)	0 (0, 4)	0 (0, 0)
High & Reduced efficacy (Moderna)	14 (7, 45)	0.02 (0, 0.12)	7 (1, 40)	1 (0, 19)	6 (1, 21)	0 (0, 4)	0 (0, 1)
Moderate & Similar efficacy	14 (7, 36)	0.01 (0, 0.06)	3 (1, 20)	0 (0, 8)	3 (0, 13)	0 (0, 2)	0 (0, 0)
Moderate & Reduced efficacy (Pfizer)	13 (7, 35)	0.01 (0, 0.06)	3 (1, 20)	0 (0, 6)	3 (0, 11)	0 (0, 2)	0 (0, 0)
Moderate & Reduced efficacy (Moderna)	14 (7, 36)	0.01 (0, 0.06)	3 (1, 21)	0 (0, 9)	3 (0, 14)	0 (0, 2)	0 (0, 0)
Low & Similar efficacy	9 (7, 27)	0 (0, 0.05)	1 (0, 17)	0 (0, 10)	1 (0, 8)	0 (0, 2)	0 (0, 0)
Low & Reduced efficacy (Pfizer)	9 (7, 28)	0.01 (0, 0.05)	2 (0, 16)	0 (0, 9)	1 (0, 7)	0 (0, 2)	0 (0, 0)
Low & Reduced efficacy (Moderna)	9 (7, 28)	0.01 (0, 0.05)	2 (0, 16)	0 (0, 10)	1 (0, 8)	0 (0, 2)	0 (0, 0)

## References

- [1] X. He, E. H. Lau, P. Wu, X. Deng, J. Wang, X. Hao, Y. C. Lau, J. Y. Wong, Y. Guan, X. Tan, *et al.*, “Temporal dynamics in viral shedding and transmissibility of covid-19,” *Nat. Med.*, vol. 26, no. 5, pp. 672–675, 2020.
- [2] M. Feaster and Y.-Y. Goh, “High proportion of asymptomatic sars-cov-2 infections in 9 long-term care facilities, pasadena, california, usa, april 2020,” *Emerg Inf Dis*, vol. 26, no. 10, p. 2416–2419, 2020.
- [3] D. K. Chu, E. A. Akl, S. Duda, K. Solo, S. Yaacoub, H. J. Schünemann, A. El-harakeh, A. Bognanni, T. Lotfi, M. Loeb, *et al.*, “Physical distancing, face masks, and eye protection to prevent person-to-person transmission of sars-cov-2 and covid-19: a systematic review and meta-analysis,” *Lancet*, 2020.