



Research article

Modeling the SARS-CoV-2 Omicron variant dynamics in the United States with booster dose vaccination and waning immunity

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Supplementary

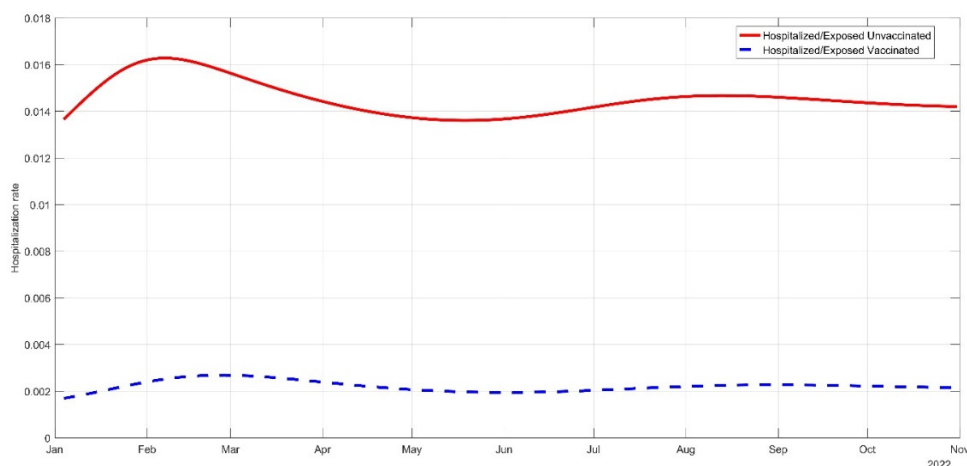


Figure S1. Hospitalization rates based on the vaccination status. The red solid line is the ratio for the unvaccinated individuals and the blue dotted line represents the ratio for the vaccinated individuals.

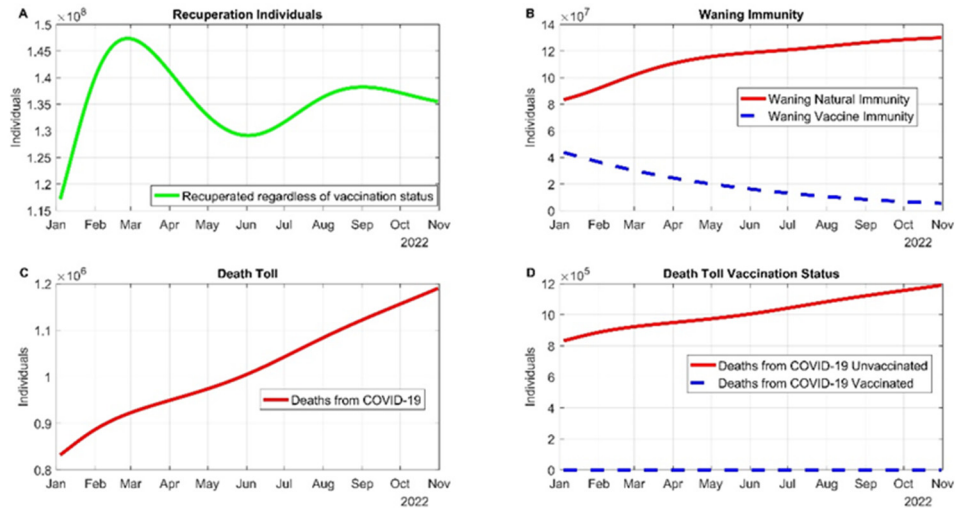


Figure S2. Simulation of the Omicron wave in the US, where 50% of the population wears a face mask regardless of the vaccination status. (A) Recovered individuals. (B) Population with waning natural immunity (red solid line) and waning vaccine immunity (blue dotted line). (C) Death toll due to COVID-19 regardless of the vaccination status. (D) Death toll due to COVID-19 based on the vaccination status. For panel D, the red solid line represents the unvaccinated population and the blue dotted line the vaccinated population.

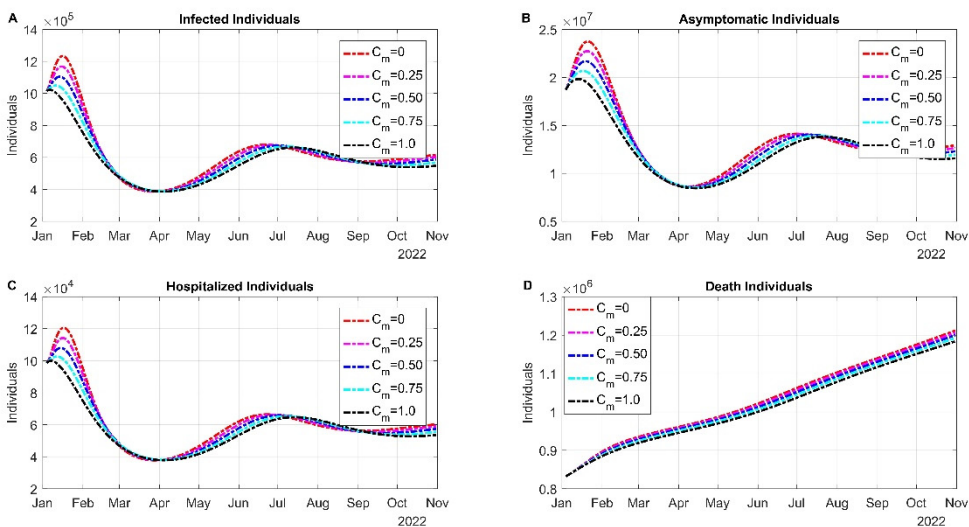


Figure S3. Evaluating the importance of the usage of the face mask with a cloth face mask with 30% efficiency for the unvaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all graphs, the red dotted line represents that 0% uses face masks. Magenta dotted line denotes that only 25% of the community uses face masks. Blue dotted line indicates that 50% of the population uses face masks, turquoise represents that 75% of the population uses face masks. Finally, the black dotted line indicate that the whole population uses face masks.

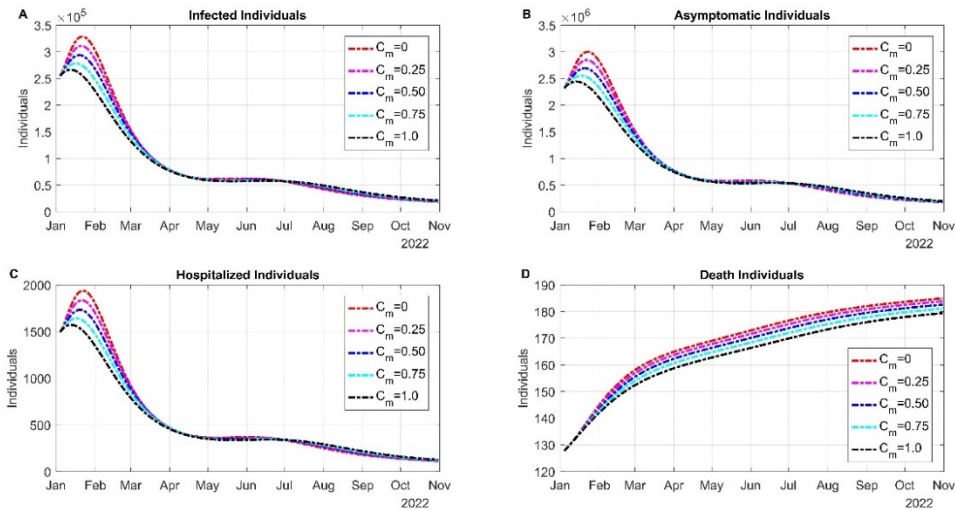


Figure S4. Evaluating the importance of the usage of the face mask with a cloth face mask with 30% efficiency for the vaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all graphs, the red dotted line represents that 0% uses face masks. Magenta dotted line denotes that only 25% of the community uses face masks. Blue dotted line indicates that 50% of the population uses face masks, turquoise represents that 75% of the population uses face masks. Finally, the black dotted line indicate that the whole population uses face masks.

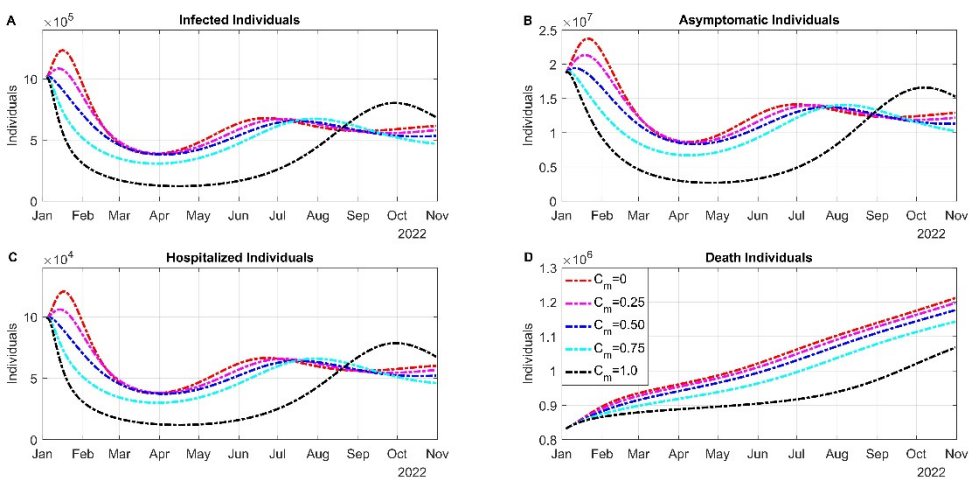


Figure S5. Evaluating the importance of the usage of the face mask with a surgical face mask with 70% efficiency for the unvaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all graphs, the red dotted line represents that 0% uses face masks. Magenta dotted line denotes that only 25% of the community uses face masks. Blue dotted line indicates that 50% of the population uses face masks, turquoise represents that 75% of the population uses face masks. Finally, the black dotted line indicate that the whole population uses face masks.

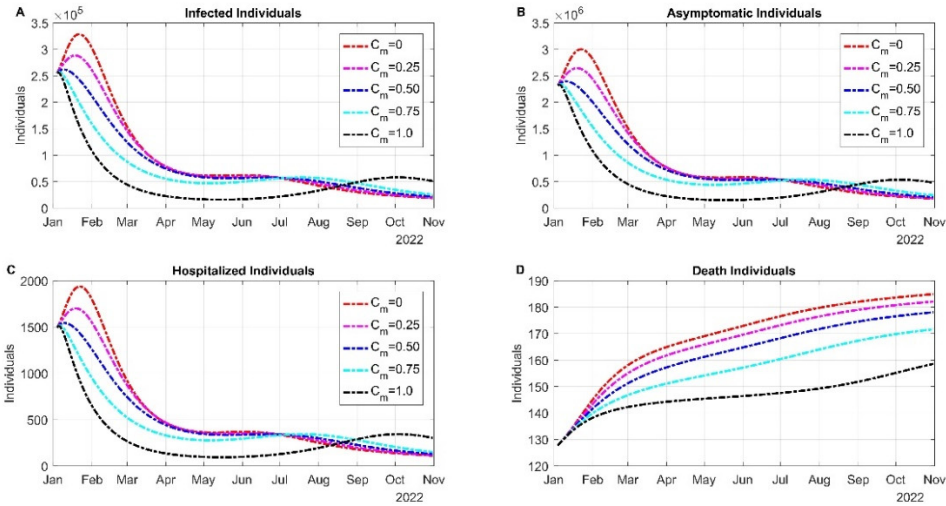


Figure S6. Evaluating the importance of the usage of the face mask with a surgical face mask with 70% efficiency for the vaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all graphs the red dotted line represents that 0% uses face masks. Magenta dotted line only 25% of the community uses face masks. Blue dotted line indicates that 50% of the population uses face masks, turquoise represents that 75% of the population uses face masks. Finally, the black dotted line indicate that the whole population uses face masks.

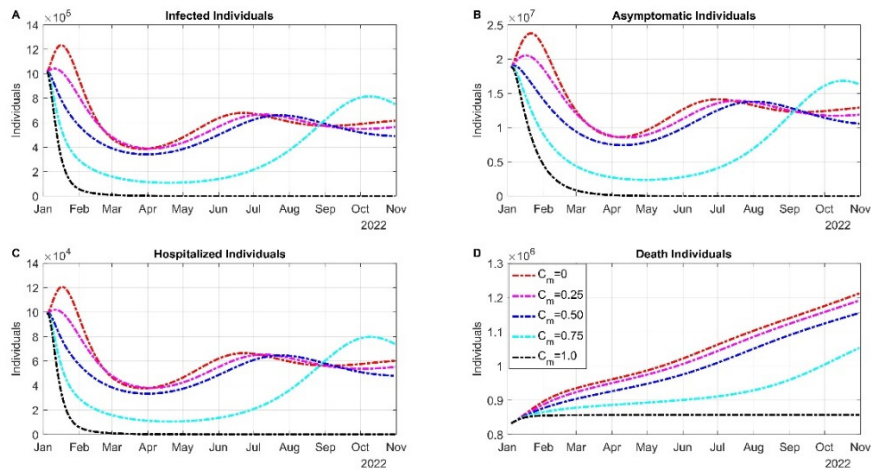


Figure S7. Evaluating the importance of the usage of the face mask with an N95 face mask with 95% efficiency for the unvaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all graphs the red dotted line represents that 0% uses face masks. Magenta dotted line only 25% of the community uses face masks. Blue dotted line indicates that 50% of the population uses face masks, turquoise represents that 75% of the population uses face masks. Finally, the black dotted line indicate that the whole population uses face masks.

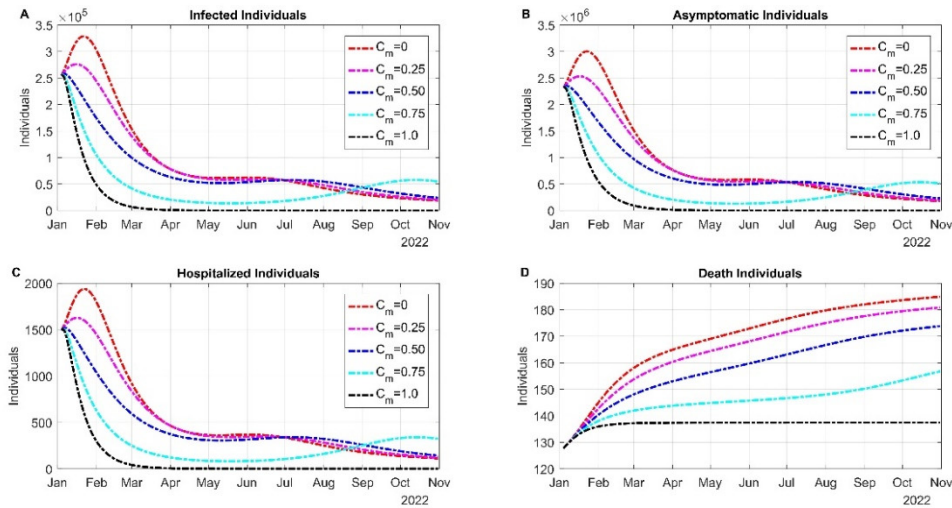


Figure S8. Evaluating the importance of the usage of the face mask with an N95 face mask with 95% efficiency for the vaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all graphs the red dotted line represents that 0% uses face masks. Magenta dotted line only 25% of the community uses face masks. Blue dotted line indicates that 50% of the population uses face masks, turquoise represents that 75% of the population uses face masks. Finally, the black dotted line indicate that the whole population uses face masks.

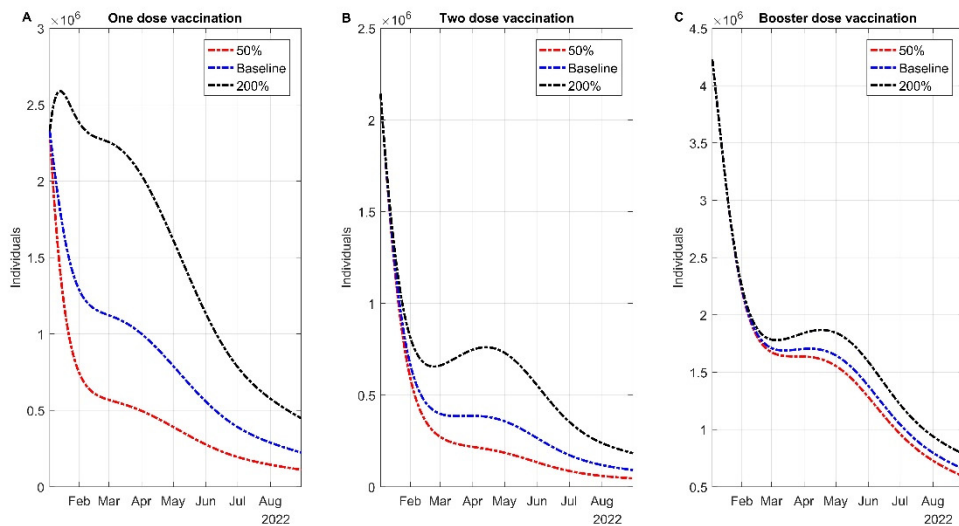


Figure S9. Global variation of the vaccination coverage. (A) The dynamics in the following months of the population vaccinated with only one dose, (B) behavior of the population vaccinated with two doses and (C) population vaccinated with a booster dose. In all panels, the red dotted line means a decrease in 50% of the vaccination rate, the blue dotted line represents the baseline vaccination rate, and the black dotted line indicates the increase of the vaccination rate to double its baseline value.

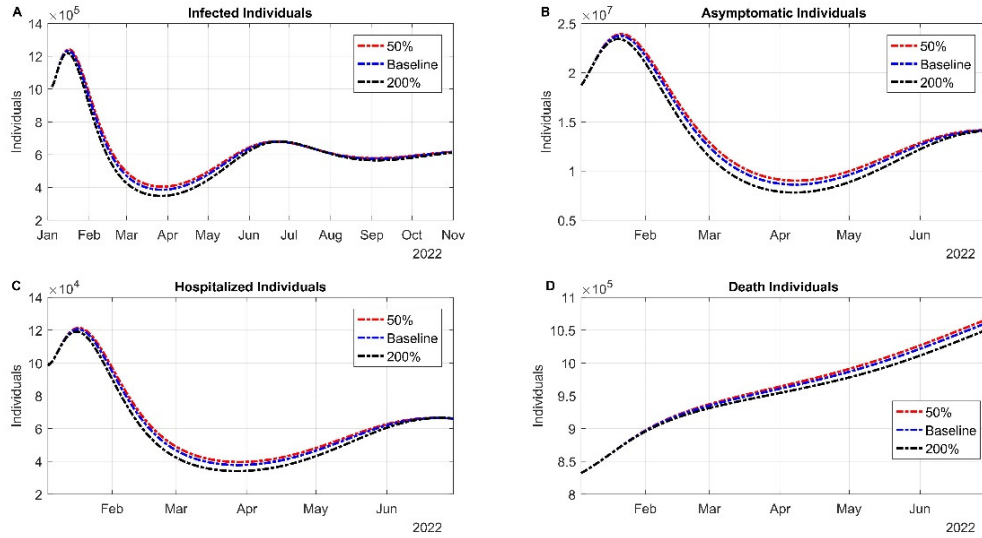


Figure S10. Dynamics of the unvaccinated population when the vaccination rate of the first dose for all three vaccines is varied. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the red dotted line represents that the vaccination is doubled, blue dotted line denotes that the vaccination rate is kept at its current rate, and the black dotted line represents that the vaccination rate is reduced to 50% of the current rate.

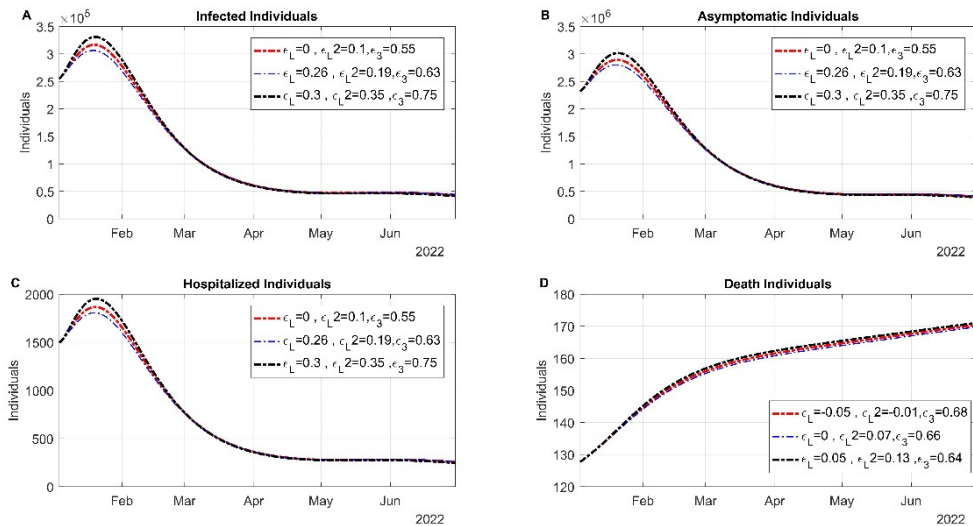


Figure S11. Dynamics of the vaccinated population when the vaccine effectiveness of all three vaccines used in this model is varied. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the red dotted line represents the lower efficiency, blue dotted line denotes the baseline efficiency, and the black dotted line indicates a higher efficiency.

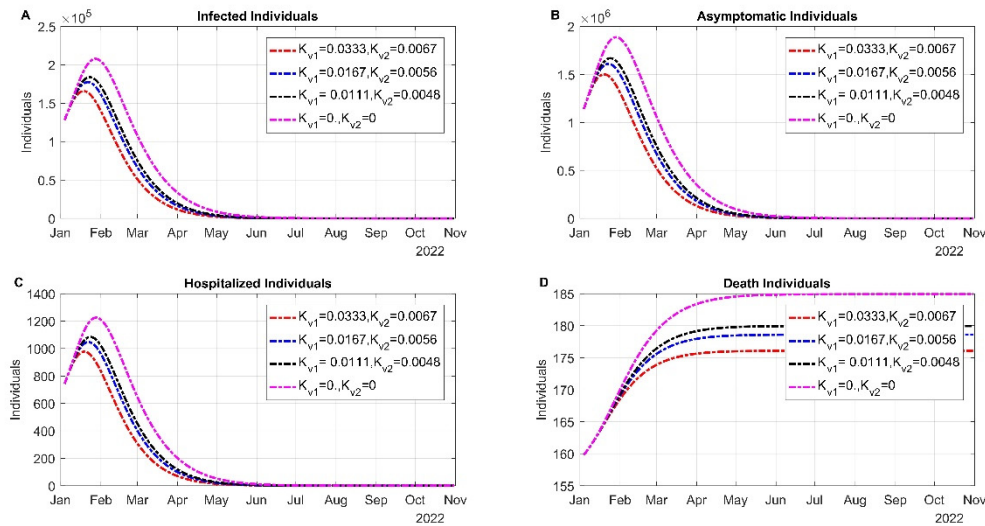


Figure S12. Dynamics of the vaccinated population when the waning rate of acquired immunity is varied. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the red dotted line means that the immunity wanes in 7 months, the blue dotted line in 9 months, the black dotted line in 11 months; finally, the magenta dotted line means that the acquired immunity does not wane over time.

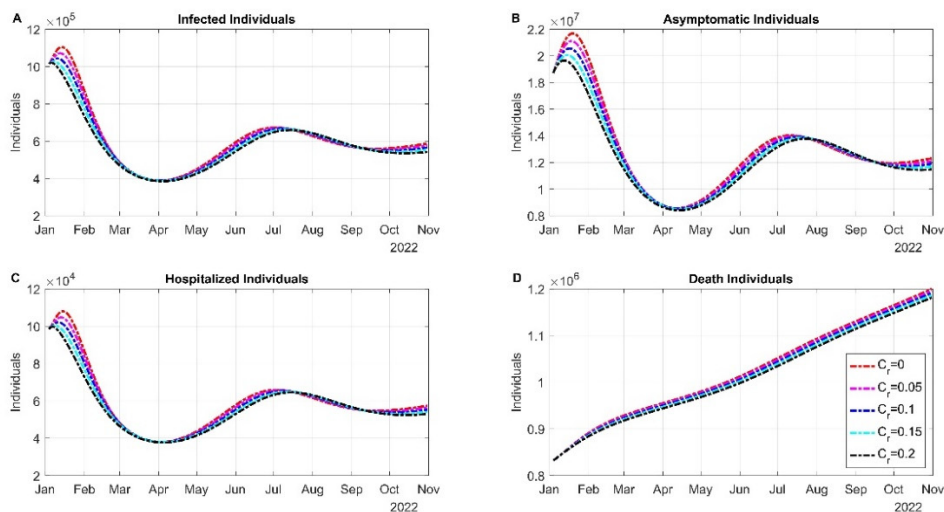


Figure S13. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 30% of efficiency for the unvaccinated community. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the red dotted line means that that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

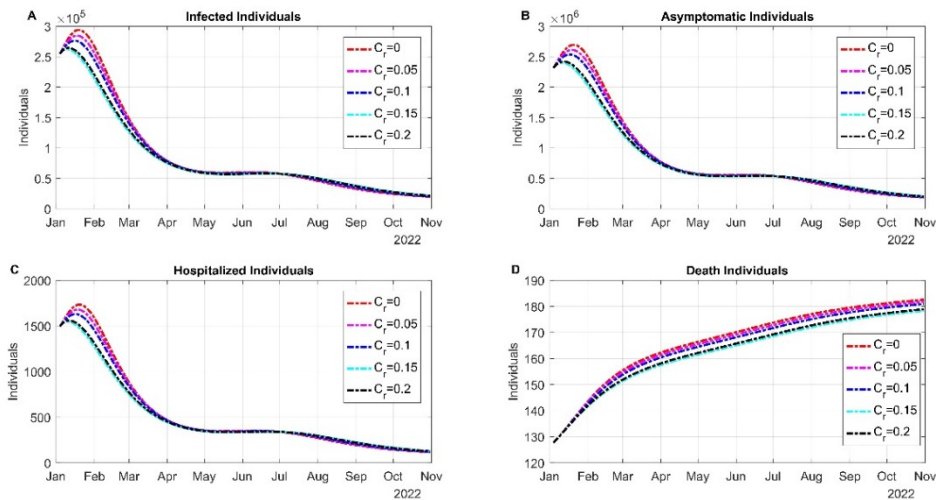


Figure S14. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 30% of efficiency for the vaccinated community. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (B) death toll of COVID-19. In all panels, the red dotted line means that that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

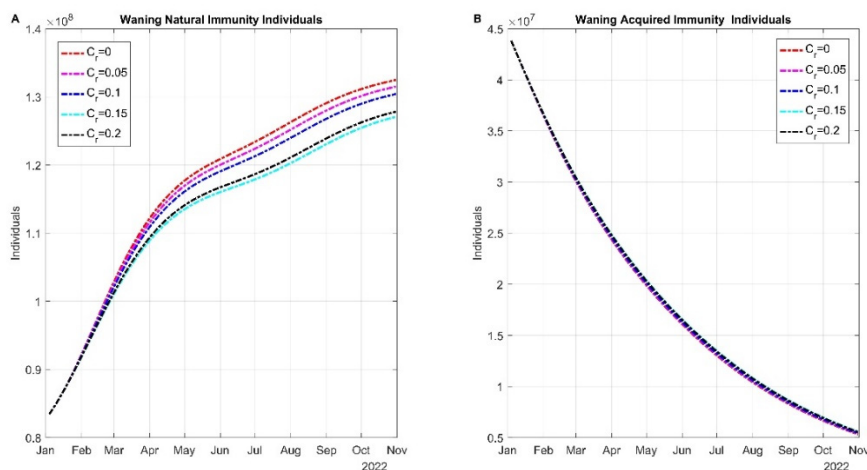


Figure S15. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 30% of efficiency for the waning of immunity. (A) Dynamics of the waning natural immunity for the unvaccinated community, (B) dynamics of the acquired waning immunity for the vaccinated community. In all panels, the red dotted line means that that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

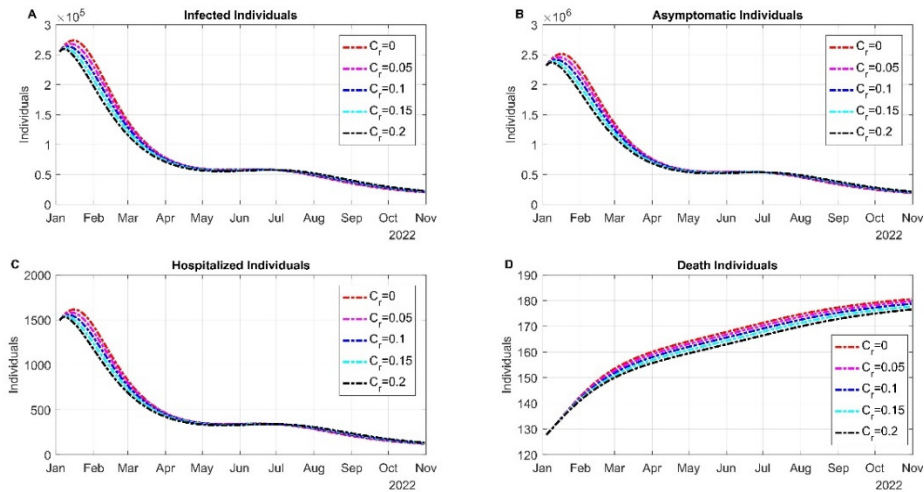


Figure S16. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 50% of efficiency for the vaccinated community. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (B) death toll of COVID-19. In all panels, the red dotted line means that that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

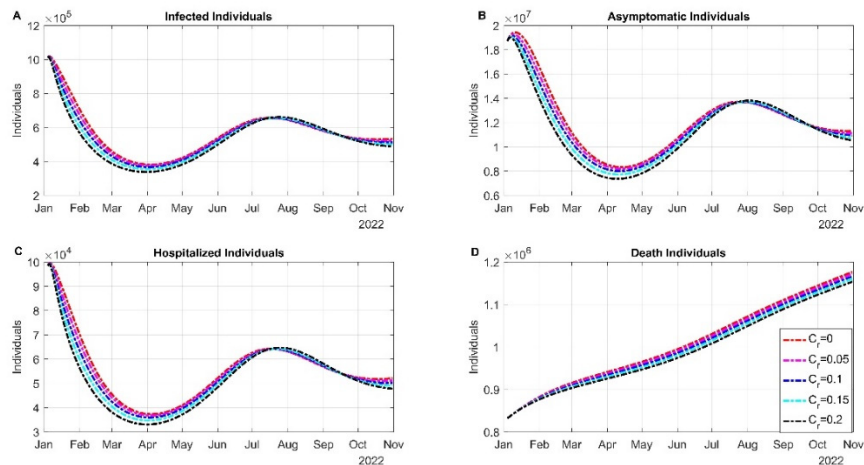


Figure S17. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 70% of efficiency for the unvaccinated community. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (B) death toll of COVID-19. In all panels, the red dotted line means that that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

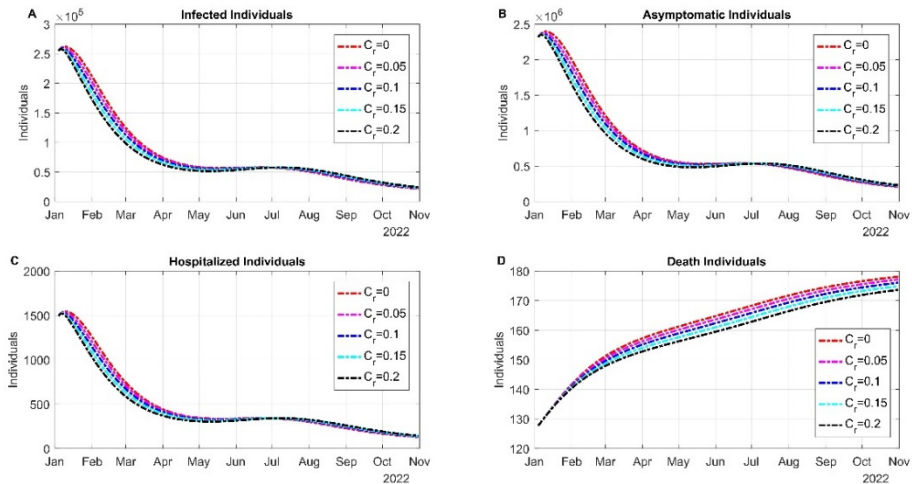


Figure S18. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 70% of efficiency for the vaccinated community. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the red dotted line means that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

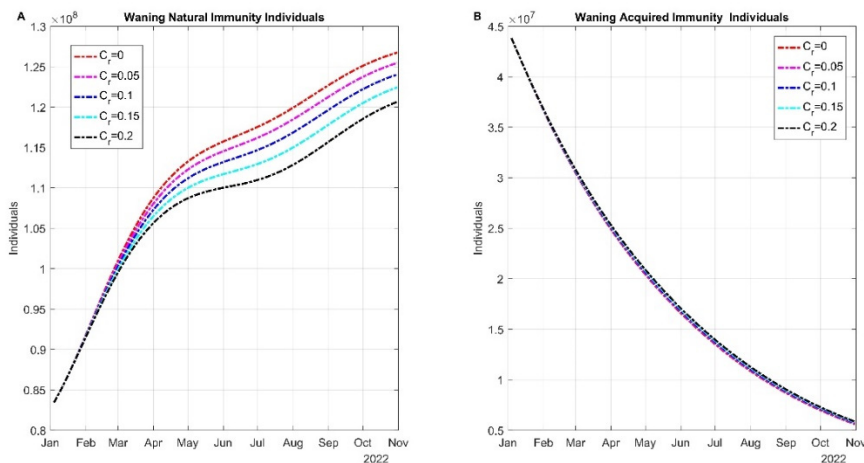


Figure S19. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 70% of efficiency for the waning of immunity. (A) Dynamics of the waning natural immunity for the unvaccinated community, (B) dynamics of the acquired waning immunity for the vaccinated community. In all panels, the red dotted line means that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

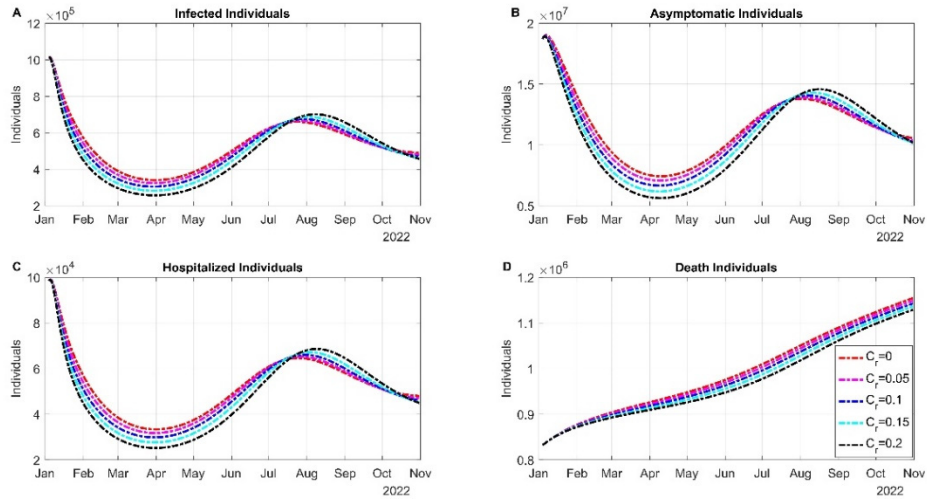


Figure S20. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 95% of efficiency for the unvaccinated community. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (B) death toll of COVID-19. In all panels, the red dotted line means that that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

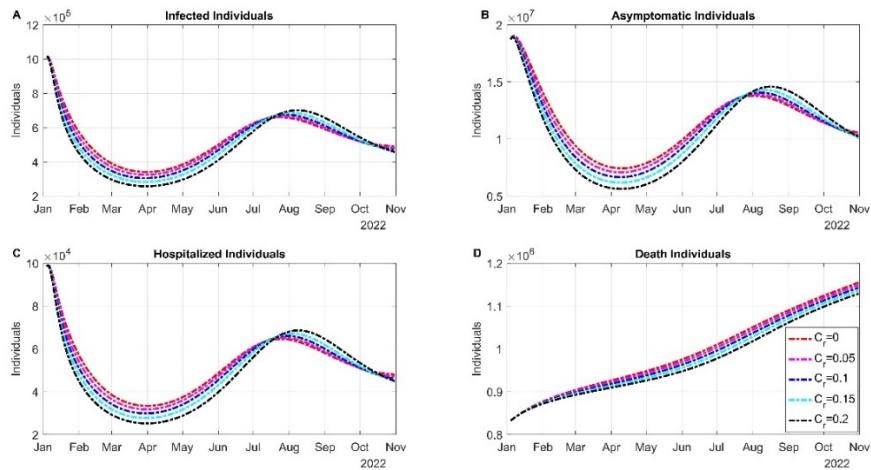


Figure S21. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 95% of efficiency for the vaccinated community. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the red dotted line means that that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

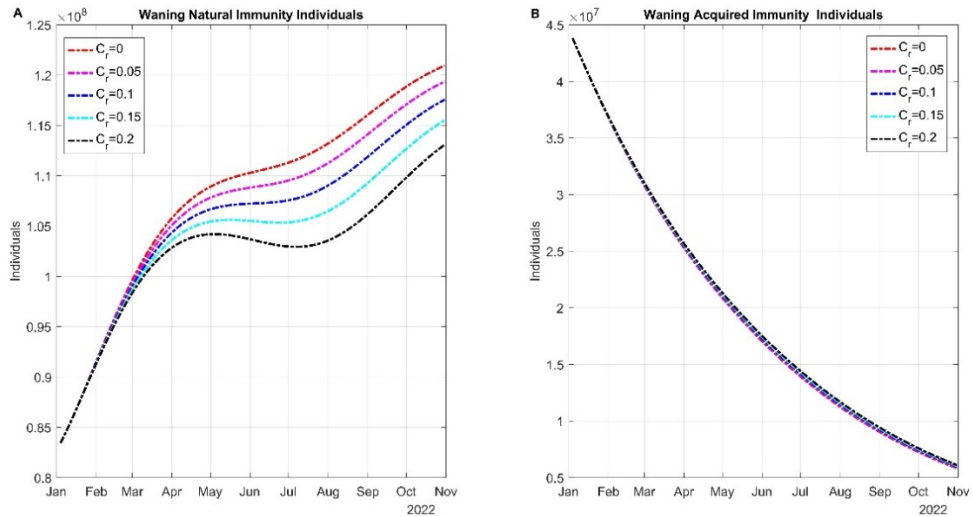


Figure S22. Varying the use of other non-pharmaceutical strategies in a population where 50% of the population uses a face mask with 95% of efficiency for the waning of immunity. (A) Dynamics of the waning natural immunity for the unvaccinated community, (B) dynamics of the acquired waning immunity for the vaccinated community. In all panels, the red dotted line means that there is no use of other NPI's, the magenta dotted line means that there is certain use of NPI's, the blue dotted means a high use of NPI's, the turquoise dotted line means a higher implementation of NPI's, and the black dotted line means the maximum use of face masks.

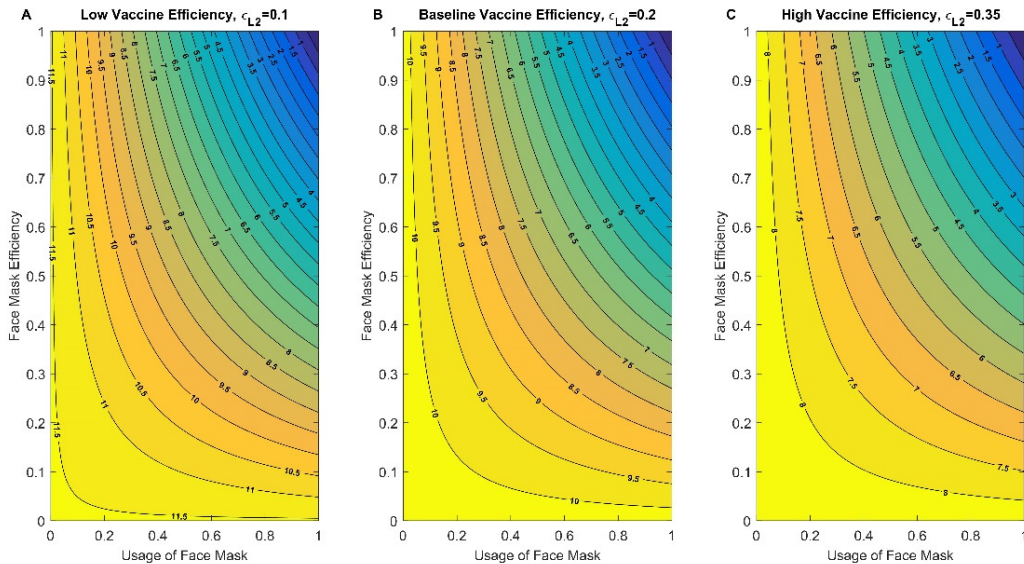


Figure S23. Contour plot of the basic reproduction number as a function of the use of face masks (C_m) and the face mask efficiency (ϵ_m) combined with the variation of vaccine effectiveness for a two-dose scheme. (A) Low efficiency of the two-dose scheme, (B) baseline efficiency of the two-dose scheme and (C) high efficiency of the two-dose scheme.

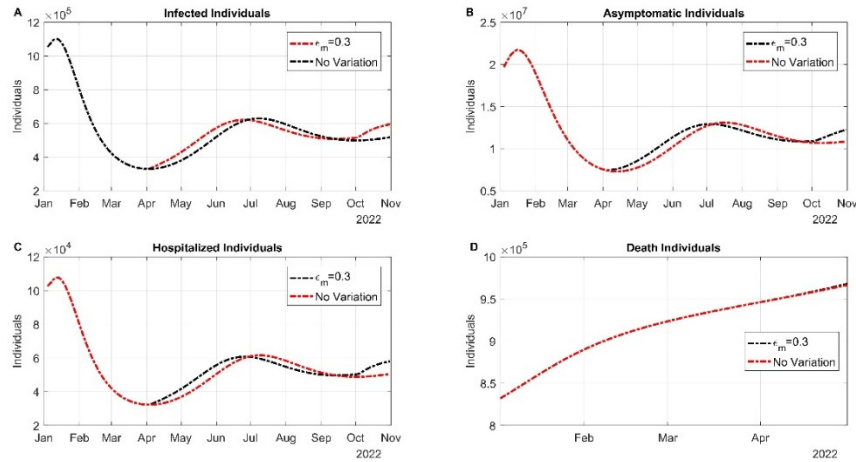


Figure S24. When can we stop using a face mask simulation using a cloth face mask with a 30% efficiency for the unvaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the black dotted line means the scenario when 50% of the population wears a cloth face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

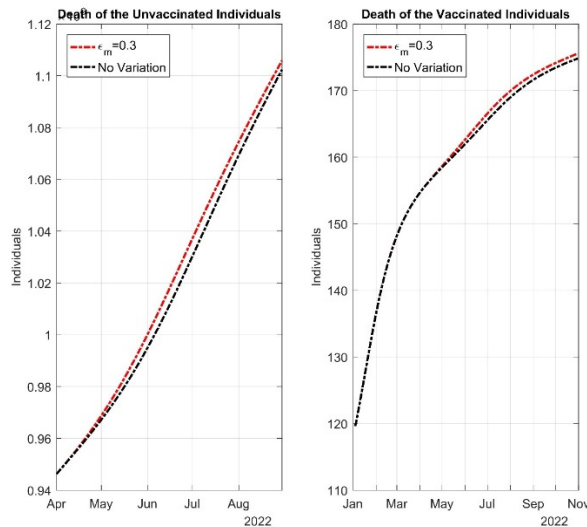


Figure S25. When can we stop using a face mask simulation using a cloth face mask with a 30% efficiency for the vaccinated and unvaccinated populations. Left panel: Dynamics of the global deaths in the vaccinated population the waning natural immunity for the unvaccinated community. Right panel: Dynamics of the global deaths of COVID-19 in the population of vaccinated individuals. In all panels, the black dotted line means the scenario when 50% of the population wears a cloth face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

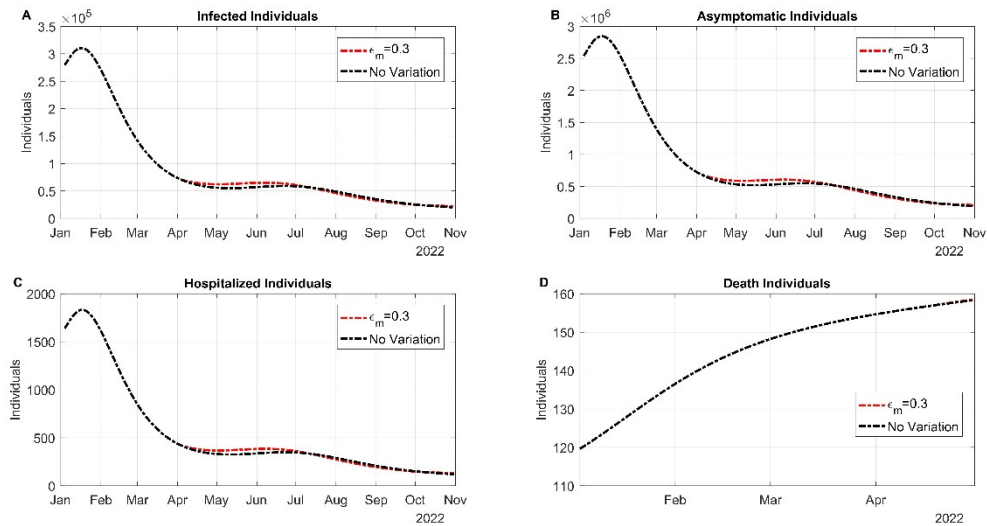


Figure S26. When can we stop using a face mask simulation using a cloth face mask with a 30% efficiency for the vaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the black dotted line means the scenario when 50% of the population wears a cloth face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

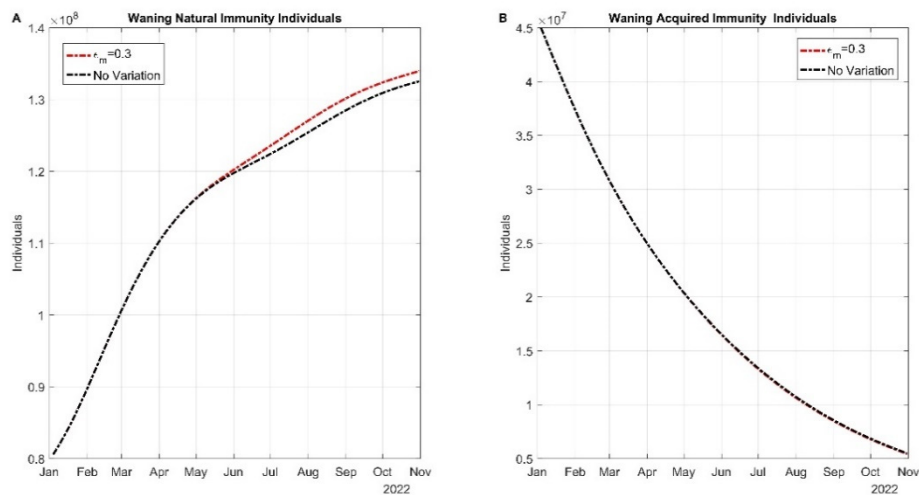


Figure S27. When can we stop using a face mask simulation using a cloth face mask with a 30% efficiency for the population with waning immunity. (A) Dynamics of the waning natural immunity for the unvaccinated community. (B) Dynamics of the acquired waning immunity for the vaccinated community. In all panels, the black dotted line means the scenario when 50% of the population wears a cloth face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

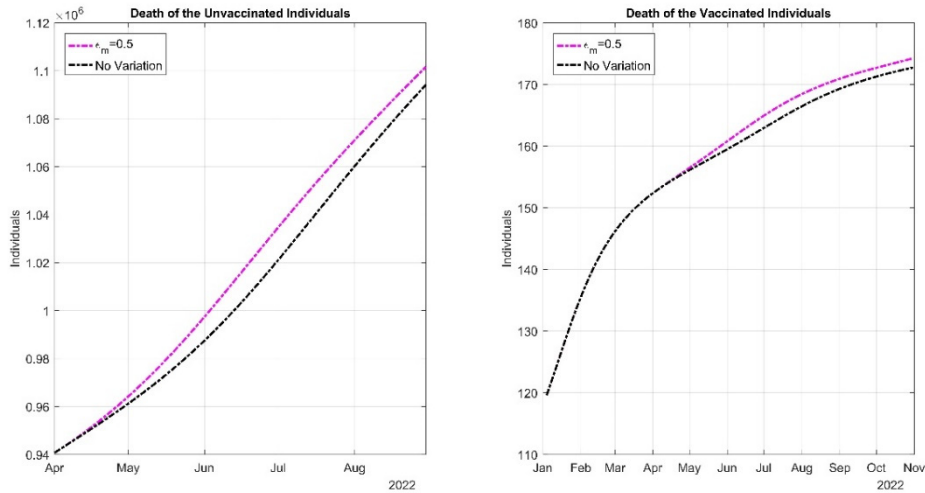


Figure S28. When can we stop using a face mask? Simulation using a cloth face mask with a 50% efficiency. Left panel: Dynamics of the global deaths in the unvaccinated population. Right panel: Dynamics of the global deaths of COVID-19 in the population of vaccinated individuals. In all panels, the black dotted line means the scenario when 50% of the population wears a cloth face mask; meanwhile, the magenta dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

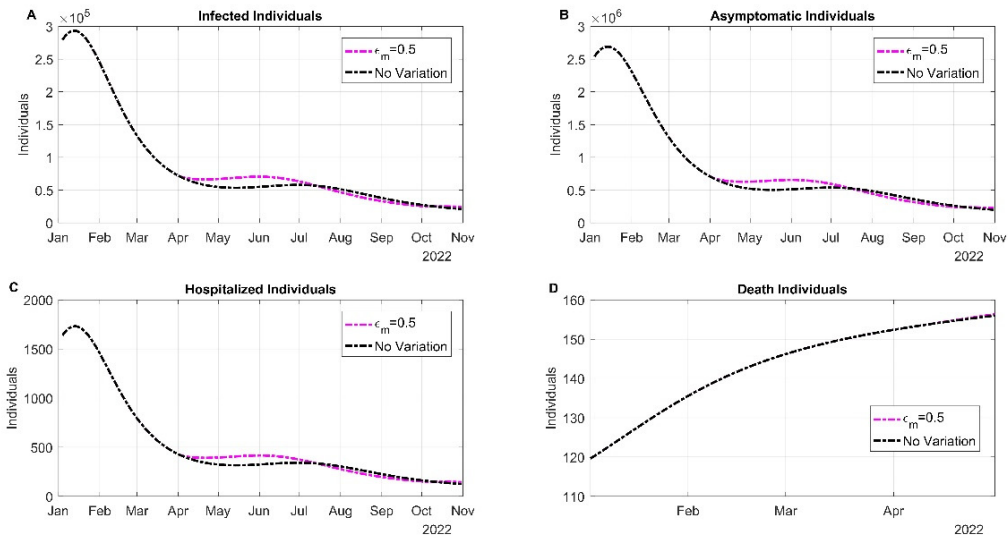


Figure S29. When can we stop using a face mask simulation using a cloth face mask with a 50% efficiency for the vaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the black dotted line means the scenario when 50% of the population wears an improved cloth face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

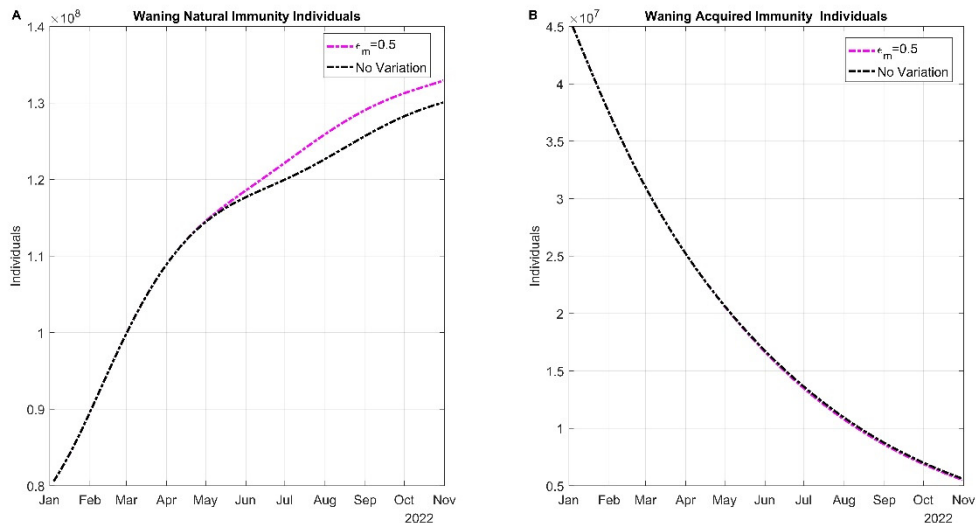


Figure S30. When can we stop using a face mask? Simulation using a cloth face mask with a 50% efficiency. (A) Dynamics of the waning natural immunity for the unvaccinated community, (B) dynamics of the acquired waning immunity for the vaccinated community. In all panels, the black dotted line means the scenario when 50% of the population wears a cloth face mask; meanwhile, the magenta dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

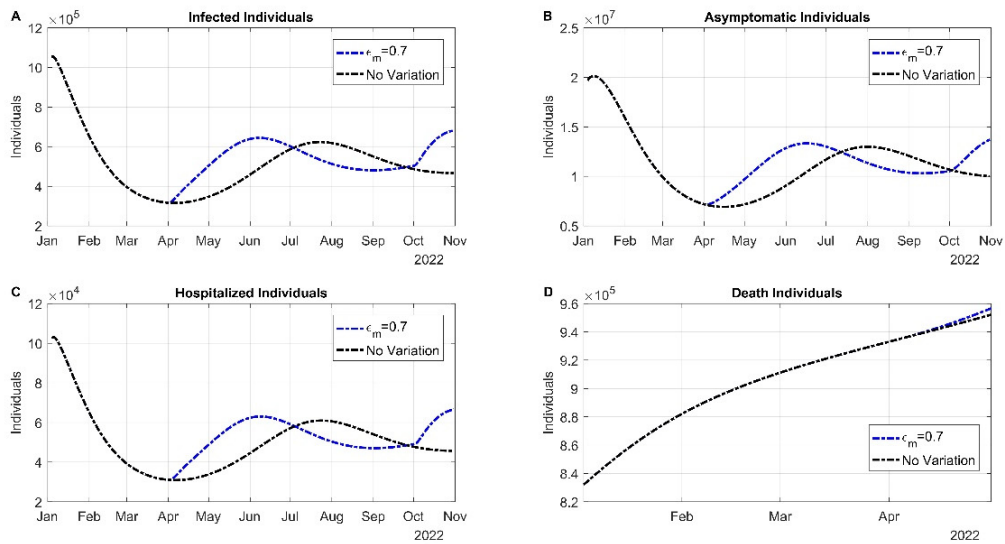


Figure S31. When can we stop using a face mask simulation using a cloth face mask with a 70% efficiency for the unvaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the black dotted line means the scenario when 50% of the population wears a surgical face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

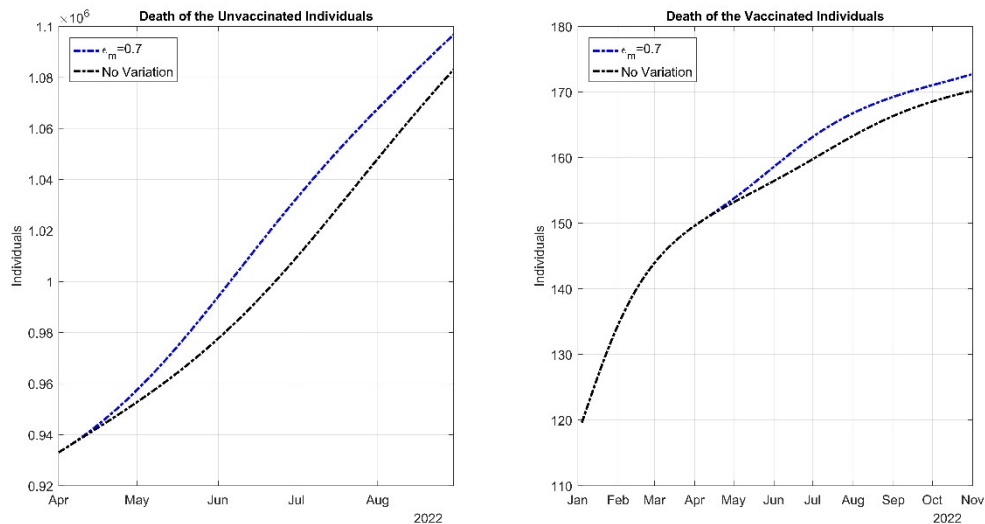


Figure S32. When can we stop using a face mask? Simulation using a cloth face mask with a 70% efficiency. Left panel: Dynamics of the global deaths in the unvaccinated population. Right panel: Dynamics of the global deaths of COVID-19 in the population of vaccinated individuals. In all panels, the black dotted line means the scenario when 50% of the population wears a surgical face mask, meanwhile the blue dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

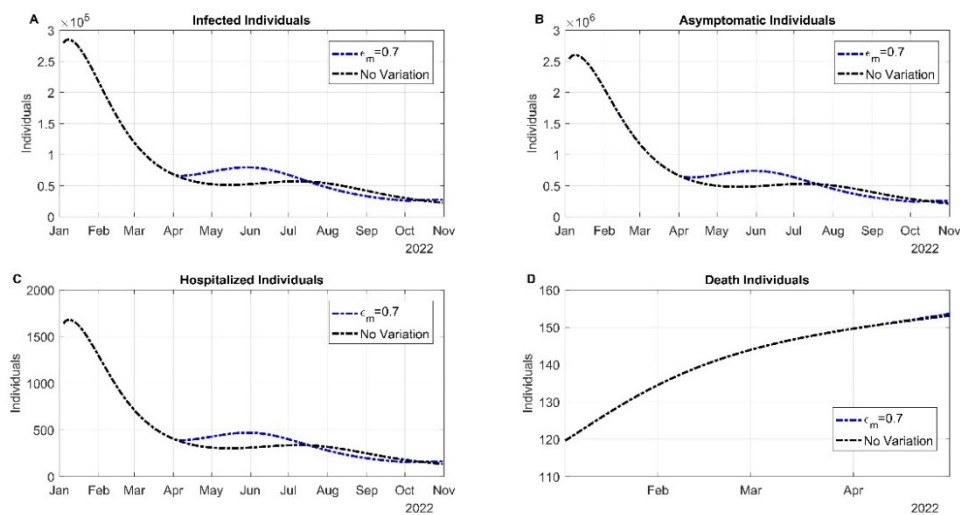


Figure S33. When can we stop using a face mask simulation using a cloth face mask with a 70% efficiency for the vaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the black dotted line means the scenario when 50% of the population wears a surgical face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

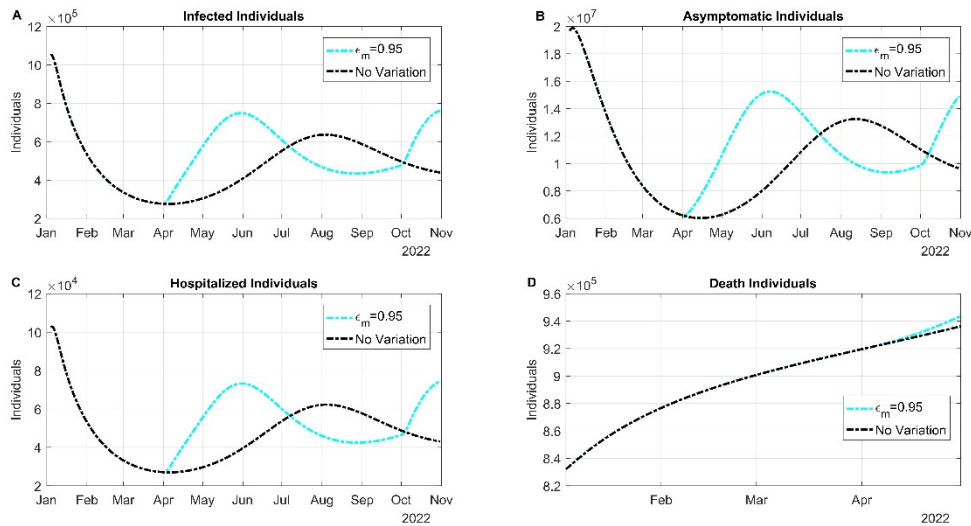


Figure S34. When can we stop using a face mask simulation using a cloth face mask with a 95% efficiency for the unvaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the black dotted line means the scenario when 50% of the population wears a N95 face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

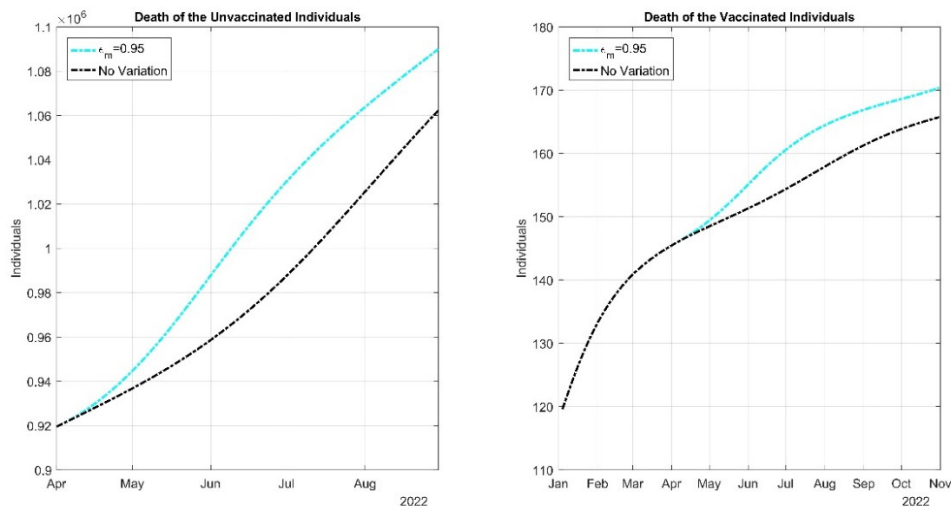


Figure S35. When can we stop using a face mask? Simulation using a cloth face mask with a 95% efficiency. Left panel: Dynamics of the global deaths in the unvaccinated population. Right panel: Dynamics of the global deaths of COVID-19 in the population of vaccinated individuals. In all panels, the black dotted line means the scenario when 50% of the population wears a cloth face mask; meanwhile, the turquoise dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

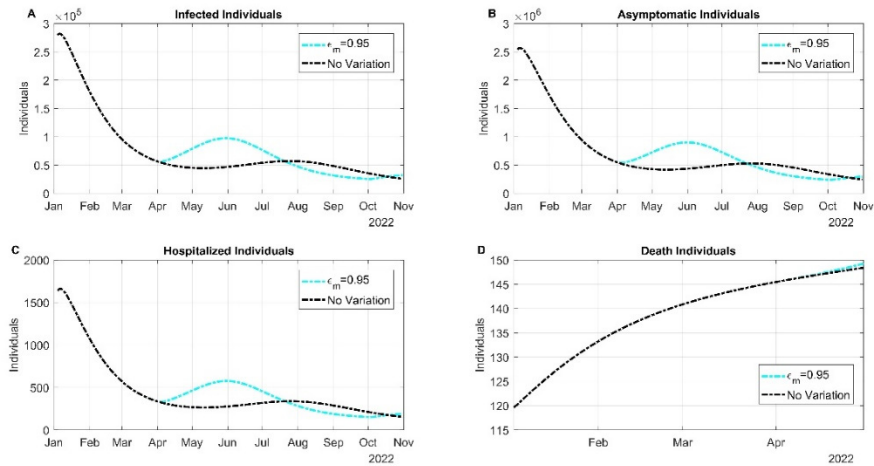


Figure S36. When can we stop using a face mask simulation using a cloth face mask with a 30% efficiency for the vaccinated population. (A) Dynamics of the infected symptomatic individuals, (B) asymptomatic infected individuals, (C) variation of hospital admission and (D) death toll of COVID-19. In all panels, the black dotted line means the scenario when 50% of the population wears a N95 face mask; meanwhile, the red dotted line means that in April only 25% of the population wears face masks, and by October 2022 nobody uses a face mask.

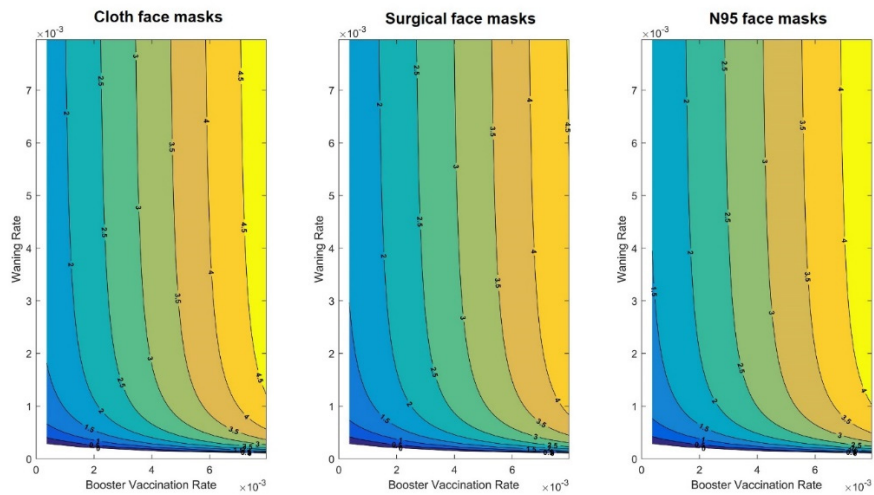


Figure S37. Contour plot of the control reproduction number as a function of the booster rate ρ_4 and the waning rate of acquired immunity K_v combined with the variation of face mask efficiency. (A) Cloth face masks (low efficiency). (B) Surgical face masks (moderate efficiency). (C) N95 face masks (high efficiency).

