Using mathematical models to project future COVID-19 outbreaks in Washington State

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Background: We have developed and iteratively improved on a mathematical modeling framework which simulates the COVID-19 epidemic in Washington State and Oregon in the United States. For the past 4 years we collaborated with the Washington Department of Health and Oregon Health Authorities to investigate key questions of public health importance by analyzing safe school reopening strategies[1], efficacy profiles of vaccines which demonstrated significant reduction in the rate of symptomatic infections in clinical trials[2], the importance of the vaccine effects on infectiousness[3], and optimal allocation of available vaccine doses in order to maximize the overall population impact and their equitable distribution across age and race groups[4].

More than four years after the emergence of SARS-CoV-2, severe COVID-19 disease remains a public health concern. In King County, WA, which achieved greater than 80% primary vaccination coverage, weekly hospitalizations due to COVID-19 still passed 5 per 100K during the winter of 2023-2024. In the event of a newly emerging variant with significant immune escape, increased transmissibility, or greater severity, behavioral interventions may still be important to lower the burden on the healthcare system. In this project we use our mathematical model to demonstrate the impact that government response can have on disease burden during future outbreaks of COVID-19.

Modeling framework: We developed a complex compartmental ODE model stratifying the population by age, infection status and level of immunity fitted to data from Washington State and Oregon. It has a flexible structure incorporating changing knowledge about the durability of both natural and vaccine-derived immunity. It can also incorporate multiple concurrent variants with differing transmissibility and virulence as well as differential vaccine efficacies. Our model also includes a social distancing module which adjusts contact networks based on recent numbers of cases and/or hospitalizations. In keeping with observations from the first four waves of cases in our region, when daily hospitalizations increase above a threshold physical distancing measures are tightened, reducing contacts. Conversely, if hospitalizations fall below a reopening threshold physical distancing is gradually relaxed to levels facilitating more contacts.

Results: Our analysis highlights the importance of the features of the invading strain when proper response is planned. We found that if the new variant is more transmissible but has severity and vaccine escape equal to Omicron then we should expect a tradeoff between the timing of intervention (hospital threshold level applied) and maximum intensity of intervention (level of social distancing needed). The increase of virulence (transmissibility) resulted in larger disease burden in terms of mortality and maximum hospitalizations than a comparable increase in immune escape. We demonstrated no additional benefit from stricter social distancing measures when they are implemented late (high hospitalization thresholds), because in this case the intervention is unable to substantially curtail the propagation of the new wave.

Conclusions: Mathematical modeling analyses could be a useful tool when crafting the response to future epidemic waves. Better understanding of the properties of the newly circulating strains is critical to inform the optimal timing and strength of the intervention that is needed.

This will be presented as a poster.

References

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