Model-based policy-making for containing COVID-19 in universities

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Background: As universities are preparing to open and hold in-person classes in Fall 2021, they deal with the important questions of how COVID-19 trajectory will look like in their universities, and what can be done to make the education experience more pleasant for the students and employees while keeping them safe and healthy. In this paper, I report on an ongoing project at Virginia Tech, started in April 2020, with the purpose of developing a simulation model to inform covid-related policy-making at the university. Since the beginning of the project, the model structure and the outcomes are reported in two articles [1, 2] and various inputs and suggestions are offered to our university administration.

Modeling: The model structure is following conventional SEIR model structures (Susceptible, Exposed, Infected, and Removed) in its compartmental format [3] with three major adjustments: 1) the model includes testing and the process of diagnosis, 2) it represents the physics of transmission in a university setting in a college town, and 3) it includes a mechanism to represent behavioral responses of students, employees, and administration to growing (or declining) cases. Such behavioral mechanisms are previously documented and validated [4-7]. Th weather impact on virus transmission is also considered [8]. Mathematical equations are consistent with the reported structure in my previous paper [1] with one major addition: vaccination. The addition of vaccination to SEIR structures is straightforward and includes an outflow from the “S” stock to another stock that represents the vaccinated population, and includes adjustments for vaccine availability and its effectiveness [9].

Data: Time series from Virginia Tech are used for model calibration. The model parameters come from two main sources of CDC [10] (for virus-related parameters) and Virginia Tech (for operations-related parameters). The model fairly replicates the past trends (Figure 1).

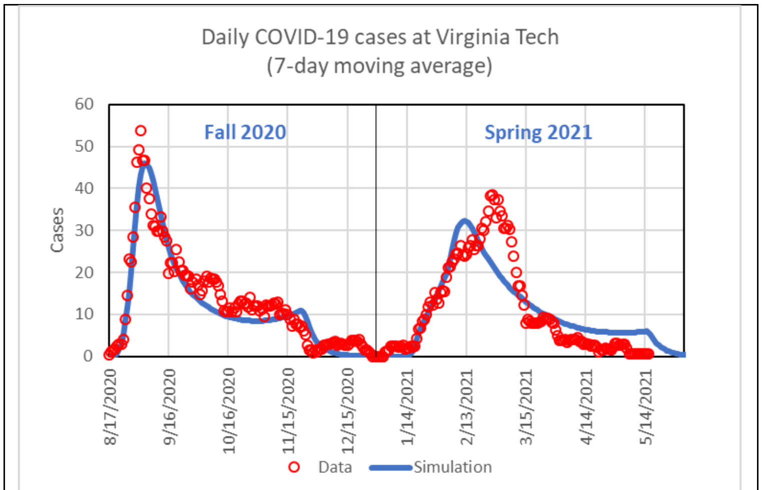

Figure 1. Replication of past data

For the Fall 2021 analysis, vaccine effectiveness in base run simulations assumed at 90%, however, in our scenario tests, and for the new variants, we test a lower effectiveness too. As more information become available about new variants the model, and results, can be further updated.

Results and outcomes: The project aimed at providing ongoing inputs to the university. Overall, we provide an example of how simulation models can help improve community health and have an impact on decision making [11]. I also developed a web app, a management flight-simulator, for the purpose of education and for what-if analysis. The app is a simplified version of the main model. In addition, there are several points about managing pandemics in university settings, and modeling in general, that can be mentioned.

- First, it is critical to capture behavioral responses to an ongoing pandemic in models of infectious diseases. Without such mechanisms model estimations are unrealistic. This is in contrast to the dominant mode of modeling in operations research or epidemiology which assumes constant parameter values for concepts that can change due to people's responses to an evolving problem or opportunity [12].
- Second, in line with many other studies, we show that non-pharmaceutical interventions are important [13-15], but what is even more important is the simultaneous implementation of the policies [1]. The system is complex and the additive effect of multiple policies is non-linear. In simple words, one gains much more from implementing multiple policies.
- Third, communication is critical. Students and employees in this particular case change their risk perceptions and behaviors, influencing the future state of the disease. Thus, covid data should be updated on a daily basis, and effective messages should be frequently communicated with the students and employees about the state of the disease and preventive measures.
- Fourth, making an impact through modeling requires community engagement. Molders need to collaborate with other scientists and with stakeholders for making more realistic models and more useful outcomes [16]. This project included a close and continuous communication with the university administration which helped enriching the model.
- And, fifth, moving forward, vaccination is the key (Figure 2). Number of cases, quarantine and isolation capacities, and the probability of death among elderly sharply decline as vaccination rates increase. Having access to vaccines in the US, it is a reasonable and effective policy choice to make vaccination mandatory for the students and employees. Mandatory vaccination should be implemented soon enough so the Fall semester starts with a maximum fraction of vaccinated individuals. When all vaccinated, contact rate variables in the model, and possibly in the reality, increase depicting a better and healthier social life. While the university still should be vigilant and the general preventive measures (e.g., masking in indoor spaces and avoiding crowds), should be still in place, mass vaccination can play as a leverage point for maintaining a safe environment and providing a joyful educational experience. Happy students, healthy community, effective learning!

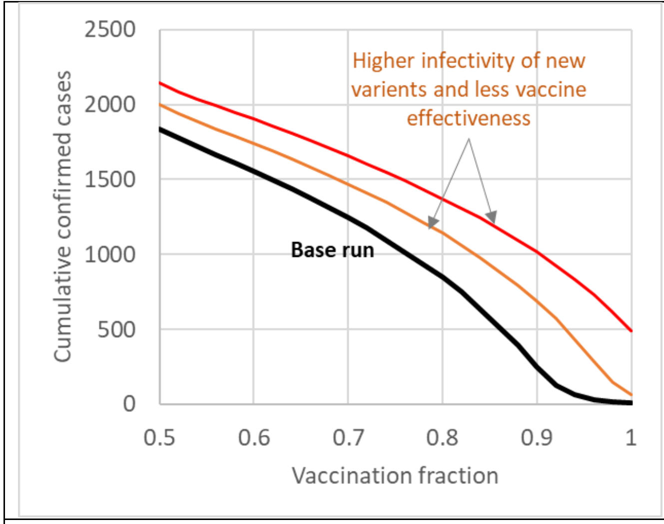

Figure 2. Effect of vaccination on Fall 2021 cumulative cases in three scenarios (Base run: new variant multiplier (m)=1.5, vaccine effectiveness (ve)=90%; Orange line: m=1.75, ve=85%; Red: m=2, ve=80%).

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