End-of-Year Projections for COVID-19 in Florida

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In summer 2021, the delta variant of concern (VOC) of SARS-CoV-2 was first detected in Florida, and accounted for over 70% of reported cases by mid-July [1, 2]. The delta variant has driven a major wave of COVID-19 cases and hospitalizations. As anticipated in our August 14 report, behavioral and policy responses to the delta wave have been modest in Florida, resulting in an epidemic wave mitigated primarily by vaccinations.

In the results presented here, we do not consider VOCs that might be introduced after delta, potentially driving winter 2021-2022 transmission. Because infections appear to confer broad cross-immunity against all strains that lasts at least a few months [3], the large delta wave experienced in Florida likely means that another wave will not happen in 2021.

The emergence of new VOCs appears to be the rule rather than the exception, however, so we anticipate that another wave will happen, probably in the first half of 2022. We do not model 2022 here, because a meaningful projection would require some knowledge of timing, infectiousness, and vaccine efficacy for the next VOC.

In this report, we have revised our projection of the delta wave downward to reflect revisions to the reported case data provided by the Centers for Disease Control and Prevention and the Florida Department of Health. Data available in early August suggested that the growth of the delta wave had not begun to slow at that point. As reported cases have subsequently been revised downward for early August, we have re-fit our model accordingly.

Results

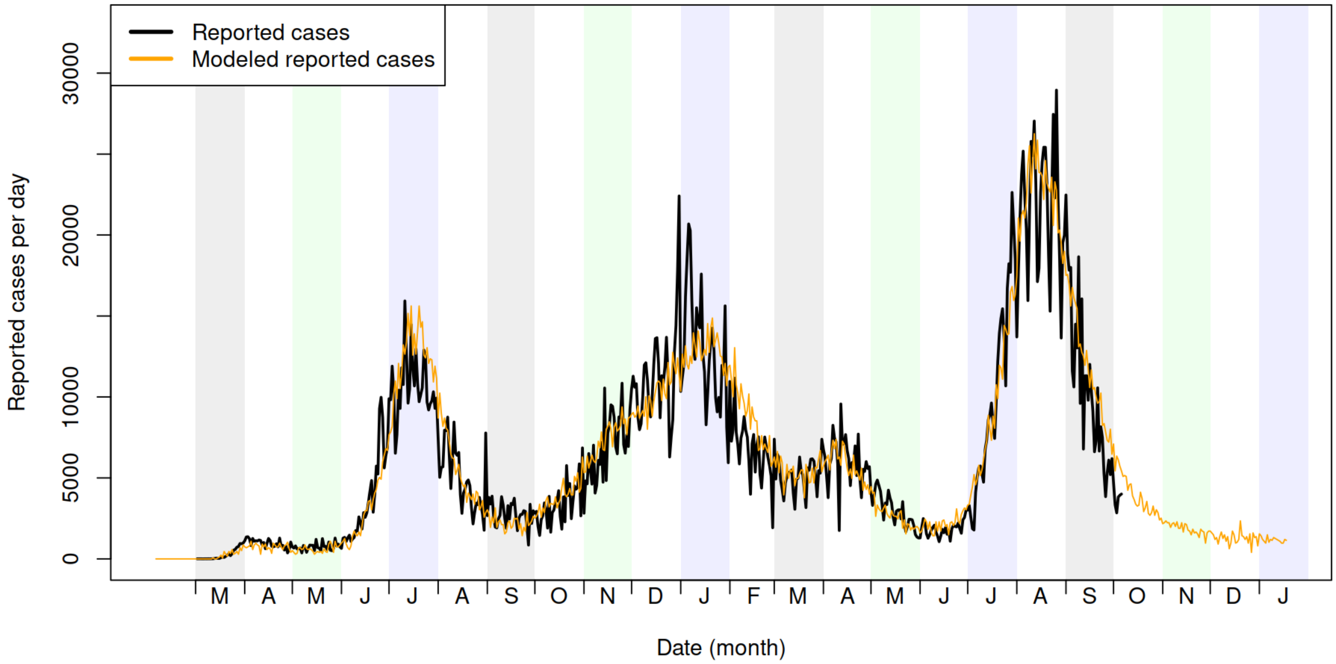

Figure 1: Reported daily cases for Florida, modeled (yellow) compared to empirically reported cases in the state of Florida (black). Our August 14 report projected a peak of 33,000 reported cases per day for the entire state. Here we show a peak of 25,000 cases per day, or about 114 reported cases per day per 100,000 residents.

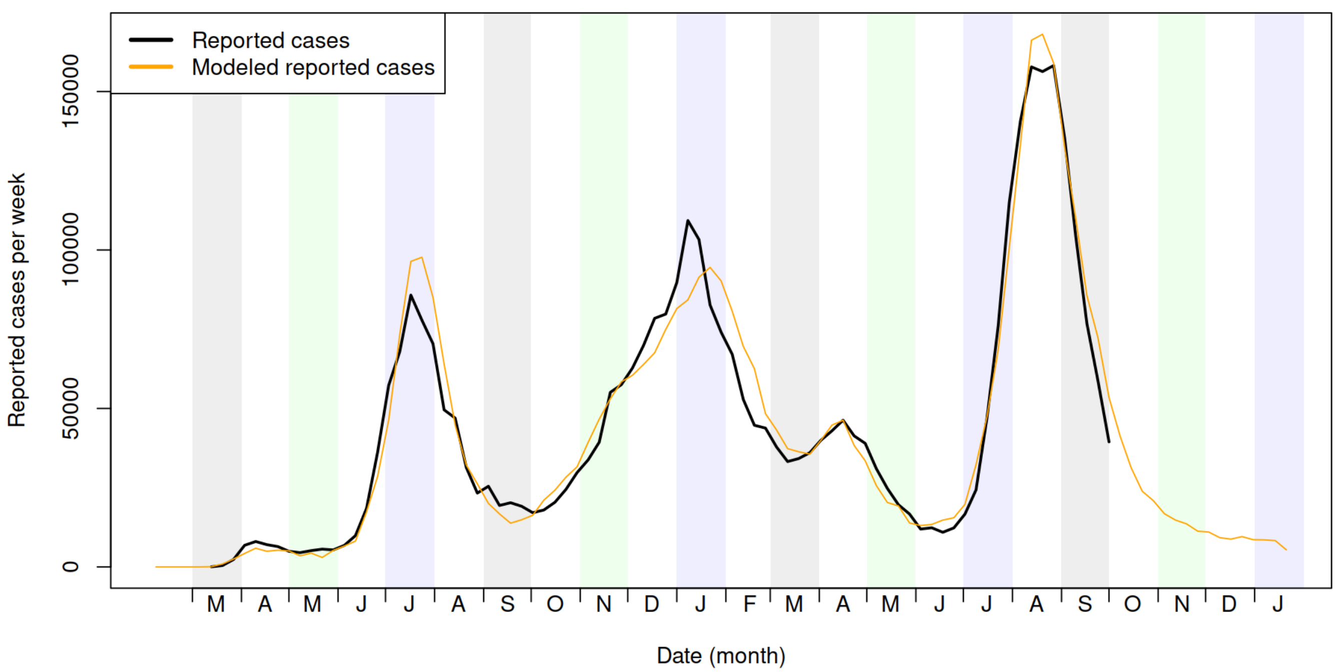

Figure 2: Reported weekly cases for Florida, modeled (yellow) compared to empirically reported cases in the state of Florida (black). Incomplete weeks in the reported data at the beginning and end of the time series have been omitted.

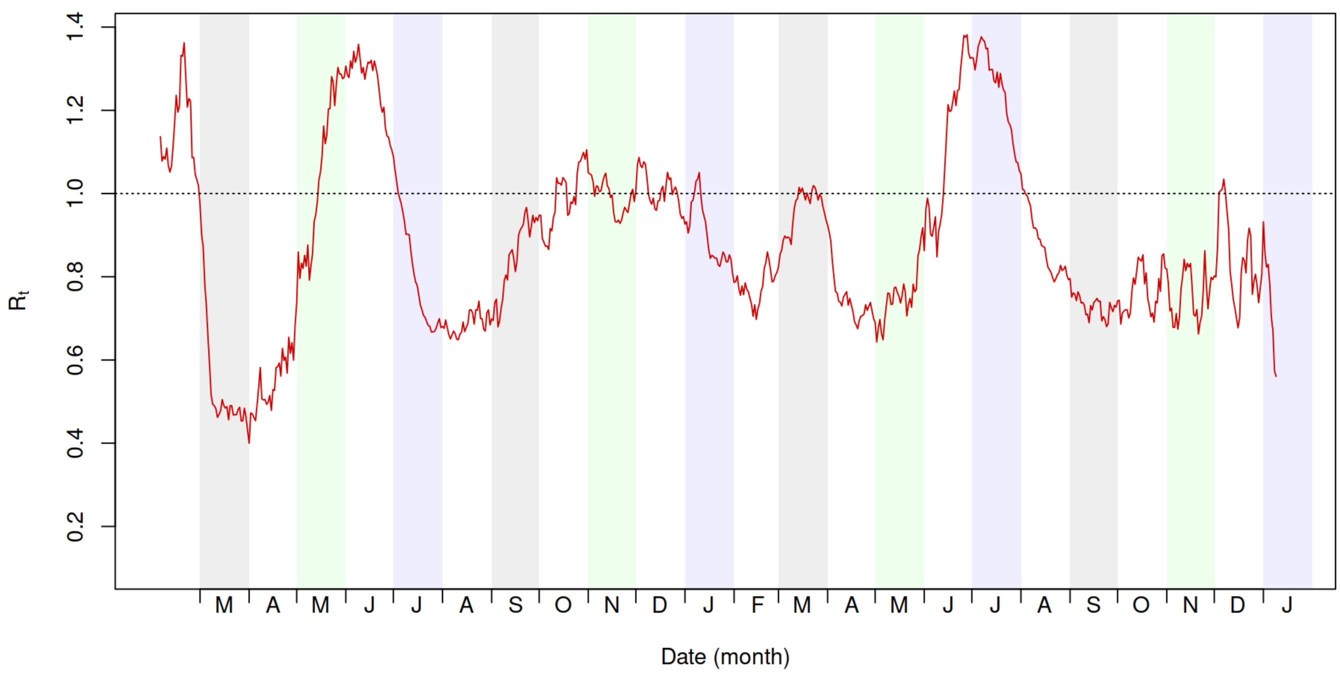

Figure 3: Time-varying reproduction number (R_t) measured from our model. R_t is the average number of infections that will be directly caused by each person infected on a given day. Note that R_t corresponds to how rapidly an epidemic is growing, and not when the most infections are reported, and thus is highest at roughly the halfway point during the growth phase of an epidemic wave. As long as R_t stays below 1, COVID-19 incidence will trend downward.

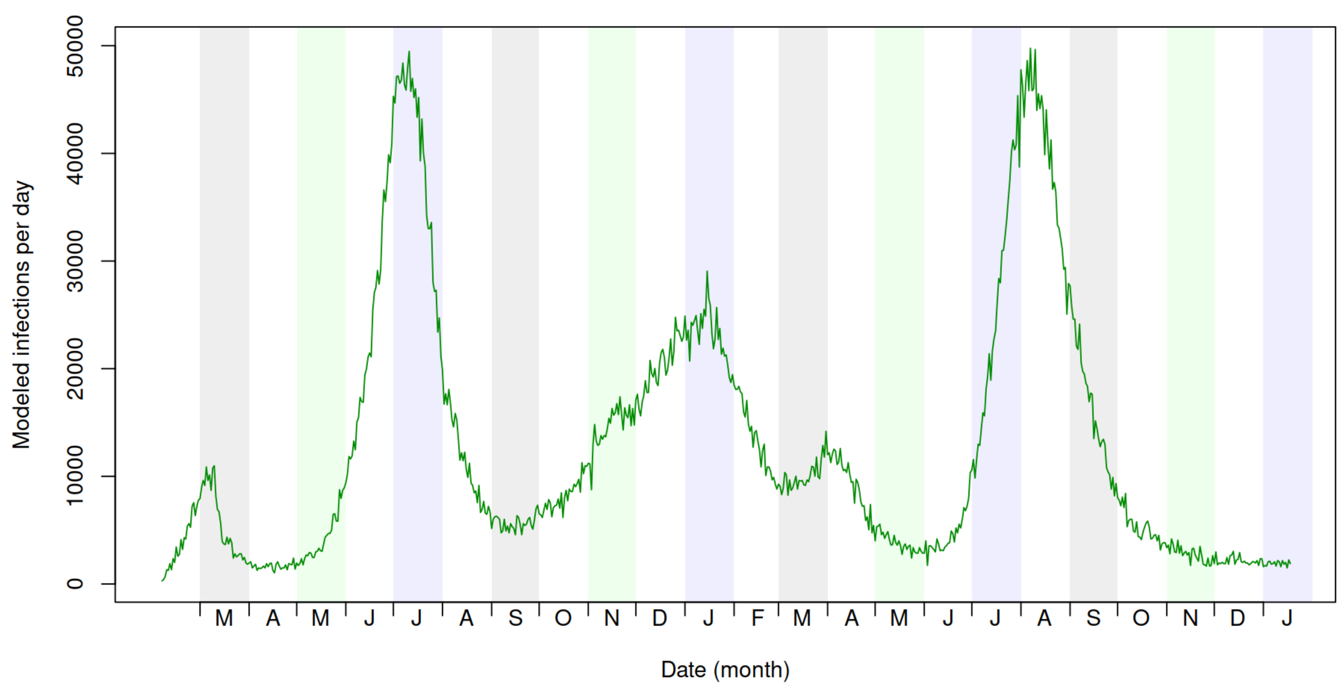

Figure 4: Total (both asymptomatic and symptomatic) infections for Florida from our model. Note that availability of testing and reporting lags have changed during the course of the pandemic; these effects are taken into account in, e.g., Fig. 2, but this figure assumes perfect, instantaneous detection of all infections. As a result, we see that the model suggests the summer 2020 and delta waves were actually similar in size, despite differences in reported cases.

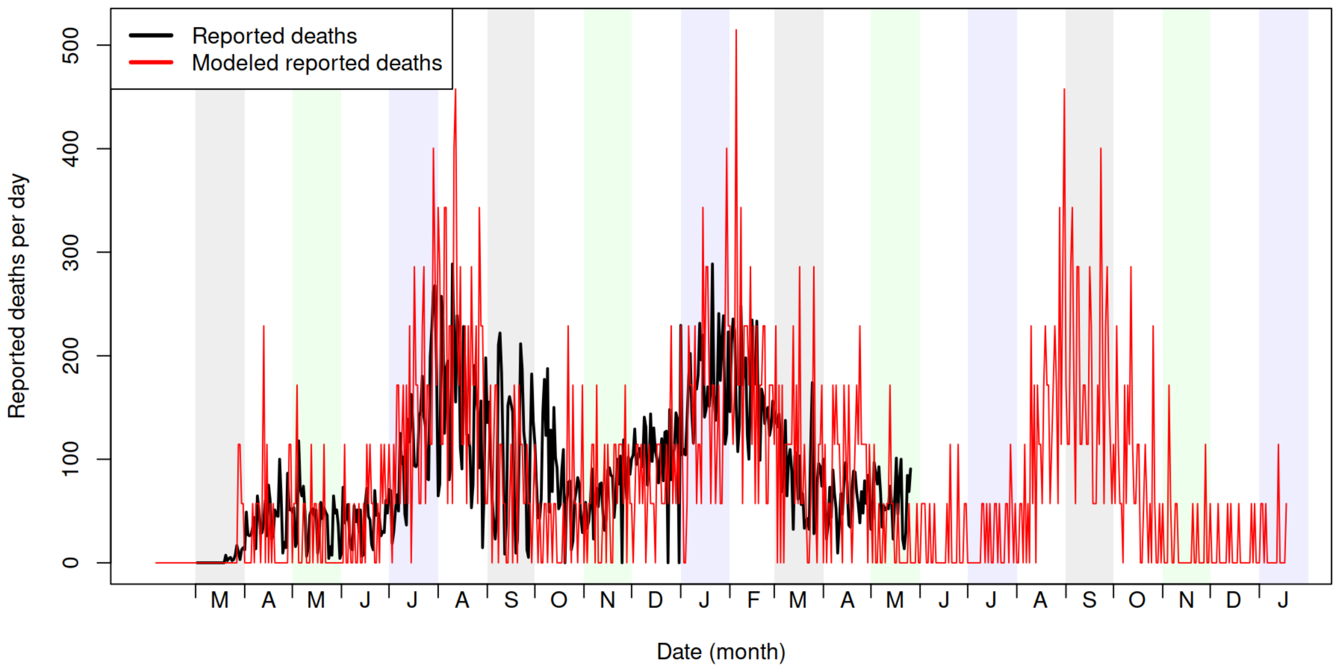

Figure 5: Reported daily deaths for Florida, modeled using the ABM (red) compared to empirically reported deaths in the state of Florida (black). Empirical death data transitioned from date of reporting to date of death beginning in June 2021, and thus, the empirical data has been truncated in order to maintain compatibility with model data streams.

Methods

We have developed a detailed simulation model to serve as a tool for assessing the COVID-19 epidemic in Florida. The model is a data-driven, stochastic, discrete-time, agent based model with an explicit representation of people and places [4]. Households in the model are sampled from census and survey data in order to establish a realistic distribution of age, sex, comorbidity, employment and school-attendance status. Activities and interaction patterns affect how likely someone is to be exposed in the model, and age, health status, and healthcare seeking behavior affect how severe a person's infection is likely to be. People go to work or school, visit friends, and patronize businesses in the model. The simulation includes closure of non-essential businesses, reduced school attendance, and changes in behaviors during the course of the pandemic. Our full Florida model represents 20.6 million people residing in 11.2 million households and 3.8 thousand long-term care facilities and who work in 2.3 million workplaces and attend 7.6 thousand schools. However, for this simulation study, we created a smaller, representative sample of the entire synthetic population totalling 375,000 people. We rescale the output from the model in order to estimate the cases and deaths for the entire state.

During each simulated day, infectious and susceptible individuals can aggregate in households, workplaces (both as employees and as customers), schools, long-term care facilities, and hospitals at different times in the day (Fig. 6). When susceptible and infectious people come together at the same location, there are new opportunities for the transmission of the virus.

If an individual becomes infected, the progression of the infection follows an $SEIRD$ model where people progress through susceptible (S), exposed (E), infected (I), recovered (R), and dead (D) states. Additionally, infected individuals can develop mild (I_A), severe (I_M), or critical (I_C) symptoms (Fig. 6. People who become ill can may seek healthcare, resulting in that individual receiving hospital care (for severe symptoms) or ICU care (for critical symptoms), which in turn lowers the risk of death.

Beyond non-pharmaceutical interventions (e.g. business or school closures, social distancing, stay-at-home orders), the model also represents vaccination of the synthetic population. In our model, we simulate a generalized mRNA vaccine (Table. 1) that performs similarly to the BioNTech and Moderna mRNA vaccines that have been used in Florida [5]. We simulate a rollout of vaccines that begins in January, 2021, with vaccine availability and campaign phases reflecting the vaccine rollout that has occurred in Florida (i.e. starting with healthcare workers and older members of the population and progressively widening eligibility to younger age groups).

	Wildtype Dose 1 | Dose 2	Alpha Dose 1 | Dose 2	Delta Dose 1 | Dose 2	Details
VE_S	0.4 | 0.8	0.21 | 0.76	0.14 | 0.67	Efficacy against susceptibility
VE_P	0.67 | 0.75	0.35 | 0.71	0.23 | 0.63	Efficacy against pathology (given infection)
VE_H	0.9 | 1.0	0.9 | 1.0	0.9 | 1.0	Efficacy against severe outcomes (given infection)
VE_I	0.4 | 0.8	0.2 | 0.5	0.1 | 0.1	Efficacy against infectiousness

Table 1: Vaccine efficacy (VE) values assumed in our model, based on estimates from multiple Phase III trials and other published sources [5]. VE_S and VE_P estimates against delta have been revised since the August 14 report.