COVID-19 in Colorado, 5/12/2022

Prepared by the Colorado COVID-19 Modeling Group

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Key Messages

- The COVID-19 pandemic is on a relatively slow upward trend in Colorado as indicated by percent positivity, wastewater concentration, and hospital count.
- Colorado lags 1-2 weeks behind New York and Pennsylvania in the timing of the arrival of BA.2.12.1. These states have already experienced growth of numbers of cases and hospitalizations for more than a month. In such other regions, hospitalizations began to increase approximately 5.5 weeks after the introduction of BA.2.12.1 into the population and have continued to increase during weeks 6-9. Colorado is starting week 8 and is experiencing a rising epidemic curve.
- The Omicron subvariant BA.2.12.1 has likely become predominant and is likely driving the rise with its increased transmissibility over BA.2.
- Projections indicate that the number of people hospitalized with COVID-19 could reach 500 or higher by mid-June.
- Considerable uncertainty about the epidemiology of BA.2.12.1 remains. The model results are sensitive to uncertain parameter assumptions.
- Assuming high immune escape from Omicron, peak demand for state-reported PCR and rapid tests could reach up to 50,000 test encounters daily in late June. Again, these estimates are sensitive to model assumptions.

Introduction

This report considers the course of COVID-19 in Colorado as we enter summer. Following the Omicron wave of December 2021/January 2022, COVID-19 had receded by March. The state saw the lowest number of Coloradans hospitalized with COVID-19 since the start of the pandemic (77 statewide) on April 12, 2022. Two other key indicators, the test-positivity rate and viral concentration in wastewater, similarly reflected this decline. In the modeling report we released on April 20, which was based on data through early April, we commented on the lull, but cautioned that a rise in the epidemic curve might be underway. The main concern at the time was the dominance of the BA.2 variant, more transmissible than the original BA.1 Omicron variant. Over the ensuing weeks, the Omicron subvariant, BA.12.12.1, has emerged and grown in much of the United States and has reached Colorado. Since last month's report, the key indicators consistently show a rising epidemic curve in Colorado that likely reflects the growth of BA.2.12.1, even more transmissible than BA.2.

This report addresses:

1. Evidence of a rising epidemic curve in Colorado;
2. The likely impact of BA.2.12.1 on SARS-CoV-2 infections and hospitalizations in Colorado over the next two months;
3. The immunity profile of the Colorado population against infection and severe disease caused by BA.2.12.1;
4. The anticipated need for testing in Colorado as the epidemic curve rises over the next two months.

To address these issues, we used COVID-19 hospital, vaccination, and case data and a mathematical model of the virus tailored to Colorado. We conducted a review of the emerging literature on BA.2.12.1, as well as BA.1 and BA.2 to assess what is known about the infectiousness, immune escape and virulence of this variant and incorporated that information into model simulations. Details on the model and updates are provided in the Appendix.

BA.2.12.1 is a highly infectious variant that is rapidly displacing other SARS-CoV-2 variants in Colorado and elsewhere in the United States.

What we know about BA.2.12.1. BA.2.12.1 is rapidly displacing BA.2 in the United States, now accounting for an estimated 43% of SARS-CoV-2 infections nation-wide, and over 66% of infections in the New York and New Jersey area (US CDC). The growth of BA.2.12.1 in Colorado through mid-April, and more recent growth in the United States, suggests that BA.2.12.1 will soon account for over 50% of SARS-CoV-2 infections in Colorado. Both BA.2 and BA.2.12.1 are sublineages of the Omicron variant. (BA.1 is the initial Omicron variant that predominated in December 2021 and January 2022). BA.2.12.1 is more prevalent in North America than in other regions of the world (GISAID). It has been detected on the continents of Europe, Asia, and Australia, but at very low levels.

BA.2.12.1 has a clear growth advantage over BA.2, which has a growth advantage over BA.1. The US CDC estimates BA.2.12.1 is 25% more infectious than BA.2; however, analyses supporting this particular estimate are not yet publicly available. BA.2 is estimated to be approximately 1.2 to 1.5 times more infectious than BA.1 (UKHSA, 3/11/2022; Lyngse et al preprint; Yamasoba et al 2022). A preprint (Cao et al) suggests that there is greater immune escape such that people with prior Omicron infection or vaccinations may be more susceptible to BA.2.12.1 than BA.2. Increased immune escape and/or infectiousness may explain the rapid growth of BA.2.12.1. At the moment, little is known about the virulence of BA.2.12.1; however, studies of BA.2 suggest that BA.2 is similar to BA.1 in terms of virulence, vaccine effectiveness and immune escape (UKHSA; Kirsebom et al preprint; Yu et al 2022).

Case and hospitalization growth. Reported SARS-CoV-2 cases and COVID-19 hospitalizations have increased in New York and Pennsylvania, both states where BA.2.12.1 arrived earlier than in Colorado (Figures 1 and 2). In these regions, COVID-19 hospitalizations began to increase approximately 5.5 weeks after the introduction of BA.2.12.1 and have continued to increase during weeks 6 to 9. Colorado lags one to two weeks behind New York and Pennsylvania in the arrival of BA.2.12.1. Eight weeks after BA.2.12.1 was first detected in Colorado, reported cases have begun to increase; however, Colorado has not experienced an increase in COVID-19 hospital demand at the pace observed in New York and Pennsylvania.

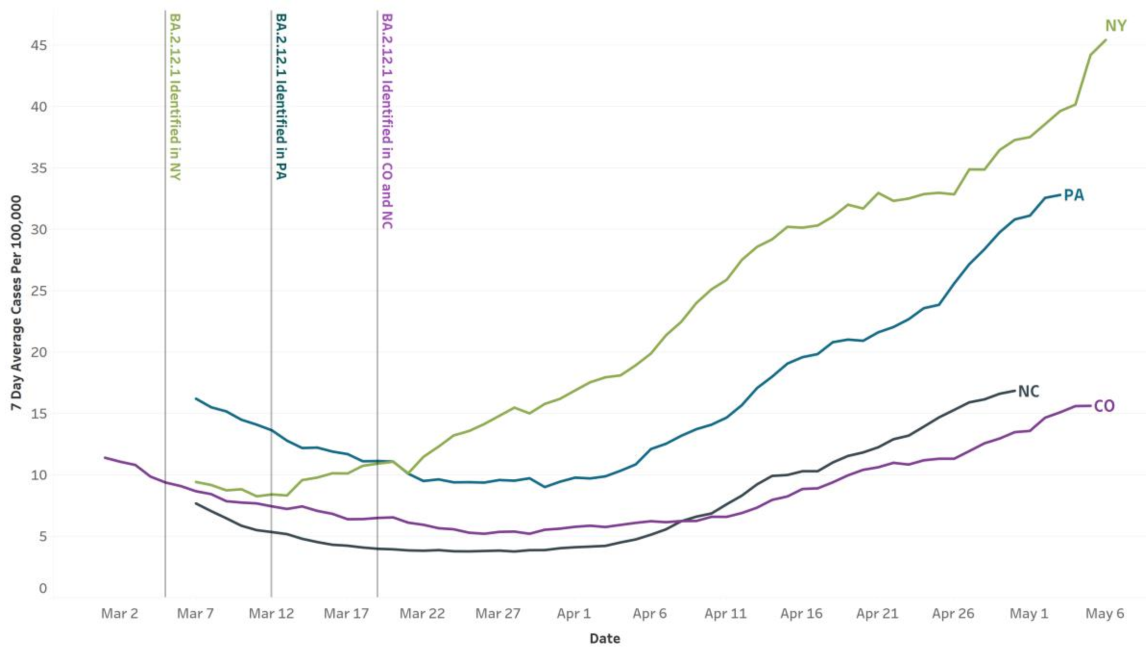


Figure 1. Date BA.2.12.1 was first identified and growth of reported SARS-CoV-2 cases (7-day average per 100k) in Colorado, New York, Pennsylvania, and North Carolina.

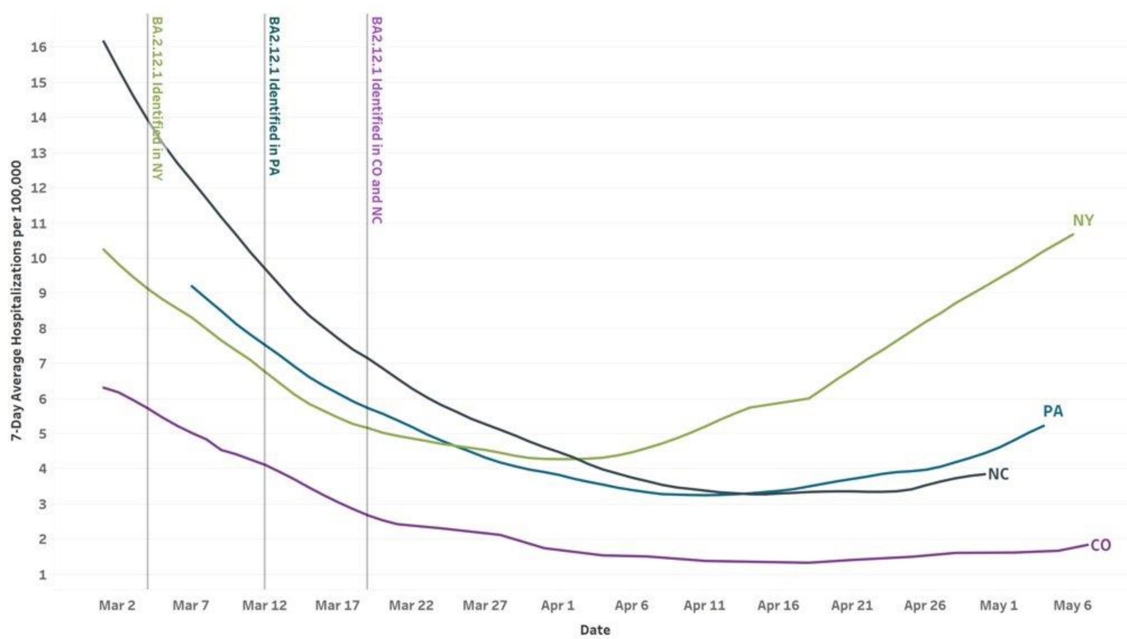


Figure 2. Date BA.2.12.1 was first identified and COVID-19 hospitalizations (7-day average per 100k) in Colorado, New York, Pennsylvania, and North Carolina.

COVID-19 infections are increasing in Colorado, likely due to BA.2.12.1.

Signs of increasing SARS-CoV-2 in Colorado. Percent positivity, COVID-19 hospital demand and wastewater surveillance indicate an increase in SARS-CoV-2 infections. Percent positivity has increased from a low of 2.6% (7-day moving average) on March 17, 2022, to 6.8% as of May 9, 2022. Wastewater data also indicate increasing infections, as described below. COVID-19 hospital demand has increased, from a pandemic low of 77 patients hospitalized with COVID-19 on April 12 to 116 on May 10. Changes in testing protocols at hospitals may be impacting the reported COVID-19 hospitalization numbers.

Notably, the number of people hospitalized with COVID-19 and recent deaths due to COVID-19 remain at the lowest levels seen during the pandemic, indicating relatively low levels of severe disease in Colorado currently.

Signs of increasing SARS-CoV-2 in wastewater. The concentration of SARS-CoV-2 in wastewater is another useful indicator of epidemic trends. Wastewater analyses measure the number of SARS-CoV-2 copies per liter in wastewater samples obtained at various sites across the state. Wastewater concentrations correlate with case rates (see report on 02/16/2022) and percent positivity (Figure 3). To examine the SARS-CoV-2 concentrations in wastewater, we first average readings across multiple sites within a local public health agency (LPHA) region. Second, we calculate the moving average over a window of five samples (approximately once every three days) to smooth the data and reduce the inherent variation in wastewater samples. Figure 3 shows the trend in the county population-weighted LPHA region percent positivity and wastewater concentrations rescaled for comparison with percent positivity. Figure 3 shows that wastewater concentrations have declined significantly since the Omicron wave peak; however, wastewater concentrations are increasing in several regions across the Front Range including Central, Metro, and gradually in the Northeast.

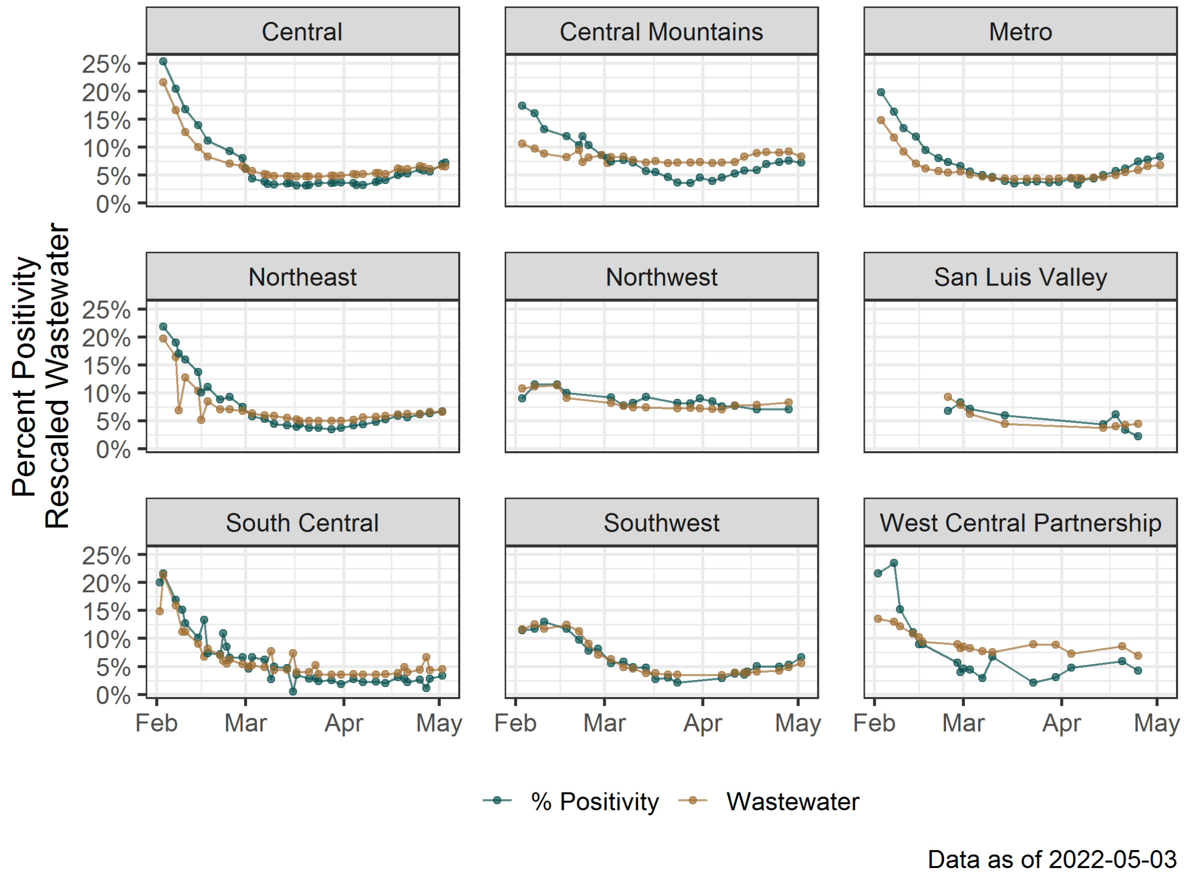


Figure 3. Trends in percent positivity and SARS-Cov-2 in wastewater for Colorado LPHA regions that sample wastewater. Wastewater samples measure the number of SARS-CoV-2 copies per liter in a wastewater sample at various sites across the state. We average daily measurements of sites within a region and then calculate a 5-sample moving average to reduce variation over time. Note that wastewater analysis is expanding to new regions of the state so that earlier data may be missing from some regions. Data source: https://covid19.colorado.gov/covid-19-monitoring-in-wastewater

We estimate that the number of people currently infected with SARS-CoV-2 is increasing (Figure 4). We estimate that 1 in 108 to 1 in 149 Coloradans (about 673 to 922 out of every 100,000) are currently infected with SARS-CoV-2 (Figure 4). The previous estimate for April 12 was 1 in 375. These estimates are generated using our mathematical model of SARS-CoV-2 in Colorado and are sensitive to model assumptions, including assumptions about the probability that an infected individual will be symptomatic and require hospital care, assumed to vary by age, and the characteristics of BA.2.12.1. In light of this uncertainty, we have produced a range of model estimates, all of which show an estimated increase in infection prevalence in the last month. A detailed description of model assumptions is provided in the Appendix.

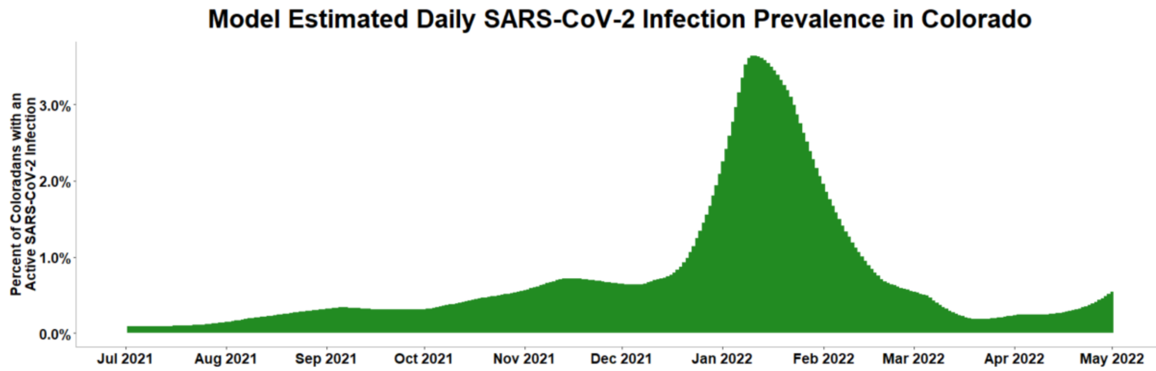


Figure 4. Estimated prevalence of SARS-CoV-2 infection in Colorado from July 2021 to present. The number of infectious individuals is inferred using the SEIRV model and COVID-19 hospitalizations. For illustrative purposes, this plot shows the estimated 1 in 108 individuals currently infected, based on the high-immune escape scenario described below.

We project an increase in COVID-19 hospital and testing demand in the weeks ahead.

Model simulations. We generated projections of the potential course of SARS-CoV-2 in Colorado over the next eight weeks to assess potential COVID-19 hospital demand and testing needs. These projections account for the continued growth of BA.2.12.1. As noted above, there are a number of uncertainties regarding the characteristics of BA.2.12.1. To account for these, we ran two sets of projections:

- **High immune escape.** In this scenario, we assume prior Omicron infection (BA.1 or BA.2) is not highly protective against BA.2.12.1 infection. In other words, Omicron BA.1 or BA.2 infection protects against BA.2.12.1 infection to the same degree that prior variant infections protect against Omicron BA.1 or BA.2 infection.
- **Low immune escape.** In this scenario, we assume prior Omicron infection protects against future Omicron infection. In other words, Omicron BA.1, BA.2 or BA.2.12.1 infections all protect similarly against a second Omicron infection.

In addition, we ran simulations accounting for two sources of uncertainty that impact model projections: Omicron severity and BA.2.12.1 infectiousness. In the simulations, we assume that Omicron BA.2.12.1 is 1.25 times more infectious than BA.2. We also assume that Omicron infections in comparison with Delta are less likely to result in symptomatic infections and, if symptomatic, in hospitalization. In model simulations we varied these assumptions by 5% and 10% to account for uncertainties in key model parameters. A detailed description of model assumptions is provided in the Appendix.

Projected hospital demand. We project that the number of people hospitalized with COVID-19 in Colorado could reach or exceed 500 by mid-June (Figure 5). Projected demand is higher in scenarios where we assume BA.2.12.1 has high immune escape and lower in scenarios where we assume prior Omicron infection protects against BA.2.12.1. Considerable uncertainty about the epidemiology of BA.2.12.1 remains. The model results are sensitive to values selected for these uncertain model parameters.

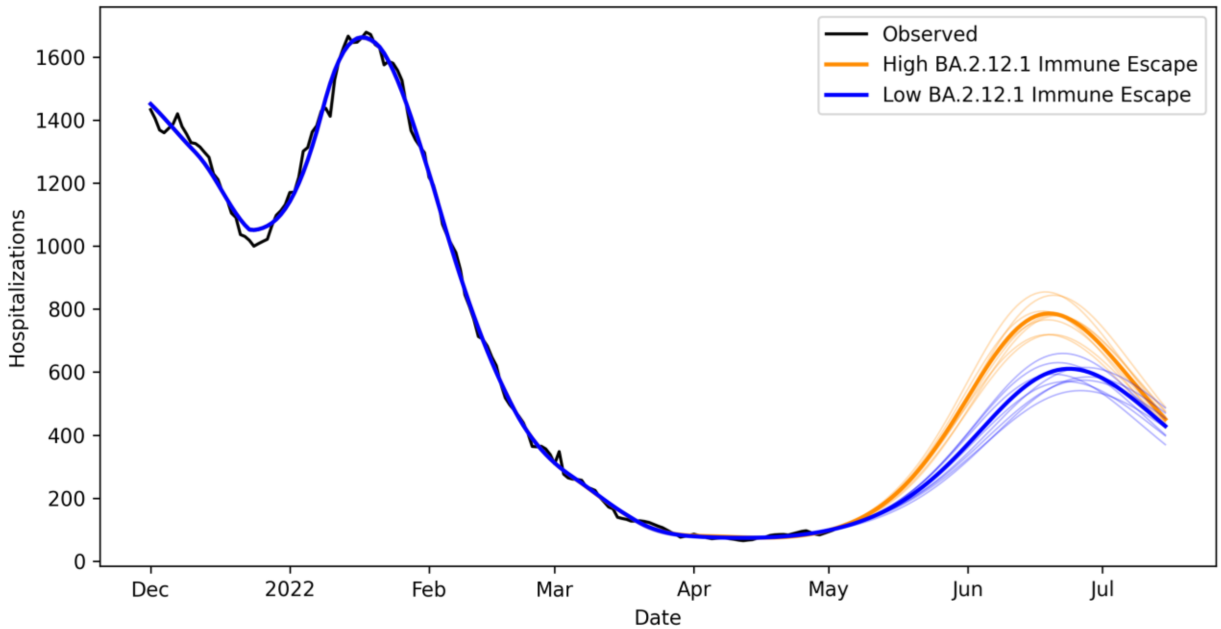


Figure 5. Projected COVID-19 hospital demand over the next 8 weeks, accounting for growth of BA.2.12.1. Due to uncertainties in the characteristics of BA.2.12.1, projections were generated for two different assumptions about BA.2.12.1. In the high immune escape scenario (orange lines), we assume prior Omicron infection is not highly protective against BA.2.12.1. In the low immune escape scenario (blue lines), we assume prior Omicron infection is protective against BA.2.12.1 infections. These projections include 5% variability in assumptions regarding Omicron severity and BA.2.12.1 infectiousness

Estimated immunity. We estimate that immunity to infection with BA.2.12.1 is approximately 65-70% in the Colorado population, assuming BA.2.12.1 has high immune escape (Figure 6). Immunity to severe disease is well above 80% in the Colorado population overall and somewhat higher among those 65+. If BA.2.12.1 has low immune escape, immunity would be higher. Immunity acquired from vaccinations and BA.1 infection has been slowly declining since February. If infections continue to spread in the next eight weeks, population immunity to BA.2.12.1 will be higher by July because of immunity acquired by infection.

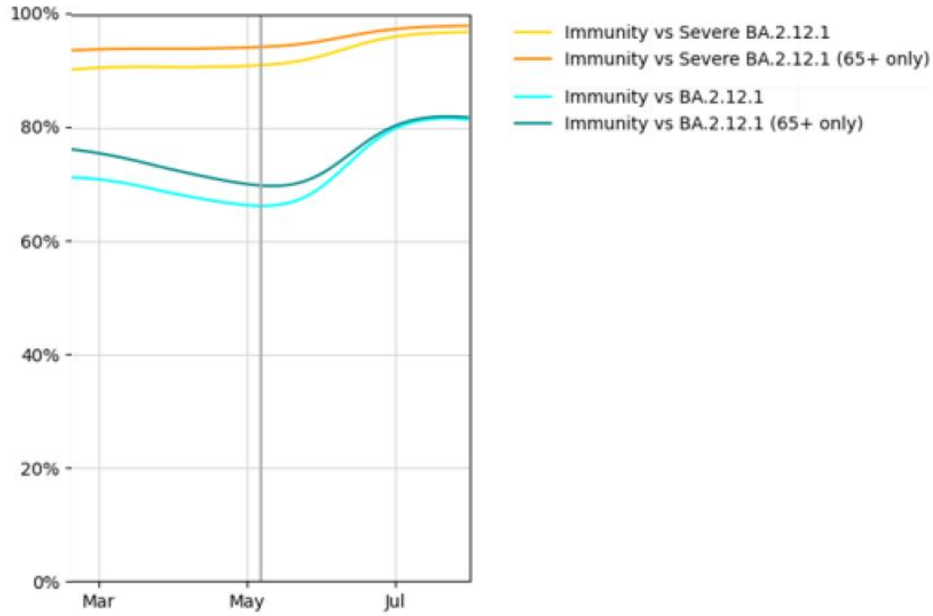
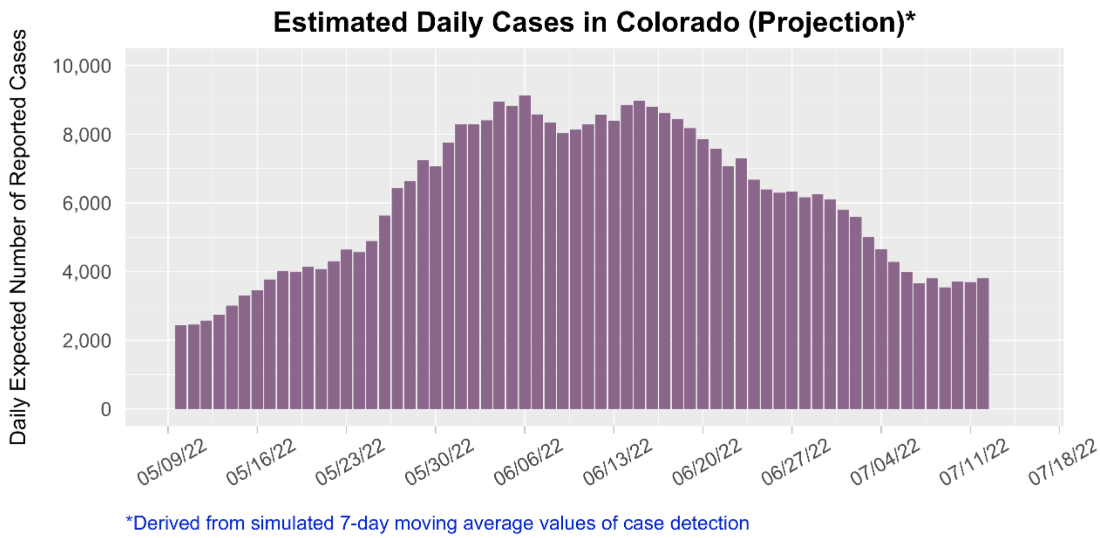


Figure 6. Estimated percent of the Colorado population with immunity to BA.2.12.1 infection (blue lines) and the percent of the population protected against severe disease (orange lines). Estimates are generated using our mathematical model of SARS-CoV-2 in Colorado and model assumptions have been updated to reflect the latest scientific evidence regarding vaccine- and infection-acquired immunity. The vertical line marks May 10, 2022.

Projected testing demand. We used our model as well as historical surveillance data to generate estimates of the peak number of reported cases and tests needed over the next eight weeks. Briefly, we generated these estimates using the model-estimated number of true infections, the recent estimated case detection rate and percent positivity. Case detection rates (the number of reported cases divided by the model-estimated number of infections) have ranged from 10% to 20% from February to April 2022, a decline from earlier in the pandemic which likely reflects recent shifts in testing behaviors, including increased use of at-home testing. Our algorithm also accounts for the historical trend that the percent positivity increases as infections increase, as well as random variation. Estimated infections are based on the high-immune escape scenarios. Details are provided in the Appendix.

We estimate that approximately 8,000 to 9,000 SARS-CoV-2 cases will be reported at the peak and capacity to accommodate approximately 45,000 tests per day may be needed (Figure 7). Peak demand is expected to occur in June. These estimates are based on current information regarding BA.2.12.1, as our understanding of this subvariant is evolving rapidly, these estimates will be updated as more information on BA.2.12.1 emerges. These estimates are also sensitive to our assumptions about future test-seeking patterns and disease severity.



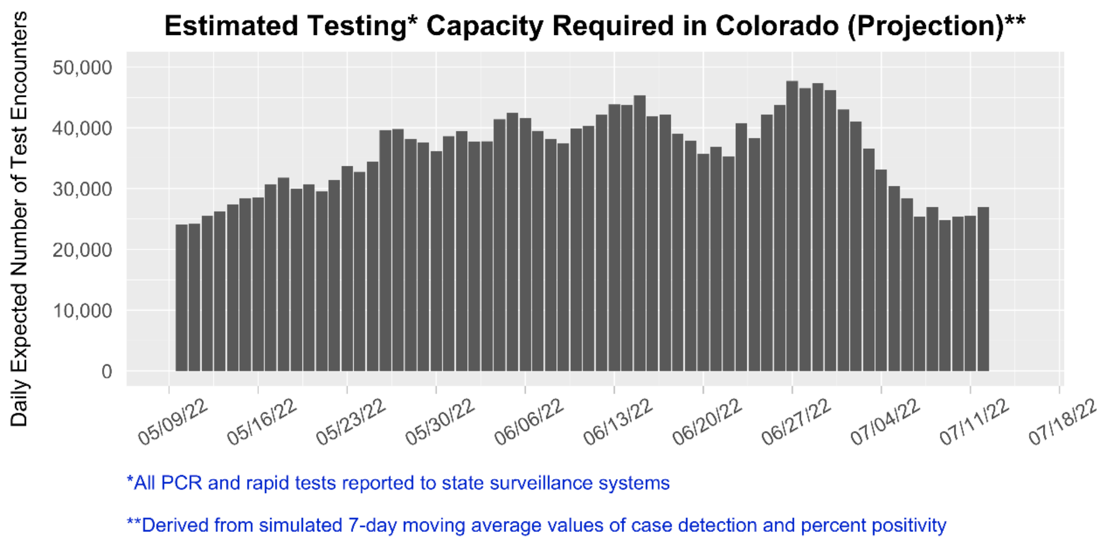


Figure 7. Expected number of reported cases (top panel) and test encounters (bottom panel) per day in Colorado through mid-July, assuming daily case detection ranges from 10% and 20%. Random variation is introduced such that these graphs show general trends and uncertainties, rather than precise daily estimates.

Other variants on the horizon

BA.4 and BA.5 are two Omicron subvariants that emerged in South Africa between November 2021 and January 2022 (Tegally et al preprint) In South Africa, BA.4 and BA.5 have displaced BA.2 and now account for approximately half of SARS-CoV-2 sequences from South Africa (Cao 2022). BA.4 and BA.5 appear to have a modest growth advantage over BA.2, but the mechanism driving this growth is unclear, with preliminary evidence suggesting it may be due to immune escape (Tegally et al preprint, Khan et al preprint, Xie et al preprint, UKHSA Risk Assessment 4/28/2022).

The implications of BA.4 and BA.5 for other regions are unclear at present. The variants have been detected in the United States by they remain rare (<1%), and there has not been meaningful growth of these variants. The situation is similar for the United Kingdom and other regions (UKHSA Technical Briefing 41, GISAID). We will continue to monitor these variants moving forward.

Appendix

The model is an age-structured SEIRV (susceptible-exposed-infected-recovered-vaccinated) infectious disease transmission model that has been calibrated to Colorado-specific data whenever possible. For example, the length of time that a COVID-19 patient is assumed to spend in the hospital varies by age and over time and is based on data provided by Colorado hospitals. Code is available on GitHub at https://github.com/CSPH-COVID/covid-models.

This report is based on COVID-19 hospitalization data through 5/03/2022 and vaccination data through 05/06/2022.

Recent model updates

The model has been updated to reflect our latest understanding of the Omicron variant and subvariants. We caution that the pace of subvariant emergence in 2022 has posed a particular challenge for efforts to model SARS-CoV-2, in that there remain uncertainties about BA.1, BA.2 and now BA.2.12.1 and these uncertainties compound as these variants are sequentially introduced in model simulations.

- The severity of Omicron variants was adjusted upward from April's model based on the latest information available. In our model, severity includes percent symptomatic and probability of hospitalization if symptomatic. We assume severity is 30% lower than Delta variant for unvaccinated individuals and 65% lower than Delta variant for vaccinated individuals (e.g., Bager et al 2022; Paredes et al 2022; Nyberg et al Lancet).
- The infectiousness of Omicron BA.1 variant was adjusted slightly downward from April's model based on the latest information available. Omicron BA.1 is now assumed to be 2.25x more infectious relative to Delta variant
- The infectiousness of Omicron BA.2 variant was adjusted upward from April's model. Omicron BA.2 is now assumed to be 1.5x more infectious relative to Omicron BA.1
- As discussed in the text, above, the characteristics of BA.2.12.1 are relatively less certain. We assume Omicron BA.2.12.1 is 1.25x more infectious relative to Omicron BA.2.
- In the high immune escape scenario, we assume individuals with a recent Omicron infection have a 10% chance of BA.2.12.1 infection relative to someone in the same age group with no immunity (no vaccination and no prior infection). Individuals with an early Omicron infection currently have an 80% chance of BA.2.12.1 infection relative to someone with no immunity
- In the Low immune escape scenario, we assume individuals with a recent Omicron infection cannot become infected with BA.2.12.1. Individuals with an early Omicron infection currently have a 20% chance of BA.2.12.1 infection relative to someone with no immunity

We have not yet included fourth vaccinations in our model. Work is underway to include these in future reports.

Estimating reported SARS-CoV-2 cases and testing demand. We used the following equations to estimate future daily number of reported cases and testing needs.

$$reported\ cases = model\ estimated\ true\ infections\ \times case\ detection\ rate$$

$$test\ encounters = \frac{model\ estimated\ true\ infections \times case\ detection\ rate}{percent\ positivity}$$

The **model-estimated number of true infections** per day was generated from the model using the high-immune escape scenario for BA.2.12.1.

The **case-detection rate** is defined as the proportion of model-estimated number of true infections that are reported by state surveillance systems. In other words, it is the daily number of reported infections divided by the model-estimated number of infections (Figure A1). The case-detection rate has declined in recent months, likely reflecting a combination of increased asymptomatic infections that go untested, at-home testing and overall shifts in testing behaviors. Based on the observed proportion of reported cases to model-estimated true infections from February through April 2022, we estimate that the case detection rate during the projection period is between 10% and 20% on any given day. These values were simulated from a random uniform distribution and utilized as a 7-day moving average.

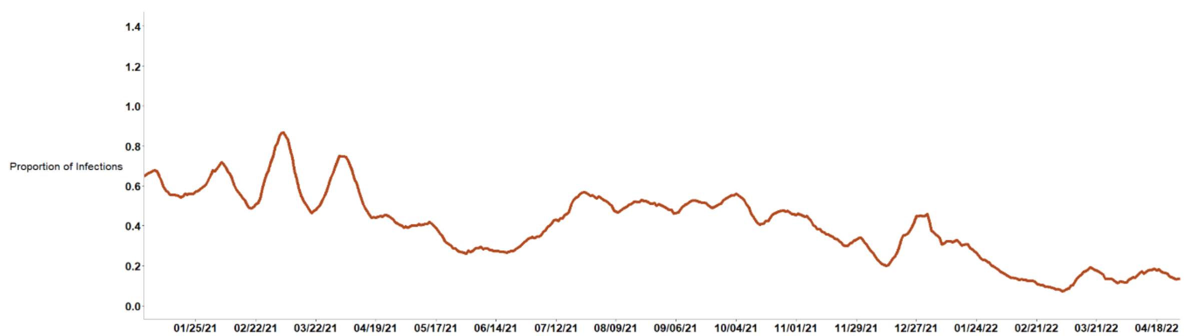


Figure A1. The estimated case detection rate since January 2021, estimated as the daily number of reported infections divided by the model-estimated number of infections.

Test positivity. Test positivity is defined as the proportion of total tests administered by state and commercial labs that return a positive result. Generally, percent positivity increases as infections increase. Because of this, we based simulated values for test positivity rate on the density of model-estimated true infections. The simulated values for test positivity rate on any given day were as follows:

- If infections per 100K are below 100, test positivity ranges from 2-4%.
- If infections per 100K are between 100 and 200, test positivity ranges from 4-8%.
- If infections per 100K are between 200 and 400, test positivity ranges from 8-12%.
- If infections per 100K are between 400 and 800, test positivity ranges from 12-16%.
- If infections per 100K are greater than 800, test positivity ranges from 16-30%.

These values were simulated from a random uniform distribution and utilized as a 7-day moving average.