Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

August 3rd, 2022

(data current to July 30th – August 2nd)

Biocomplexity Institute Technical report: TR BI-2022-1638

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About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others

Points of Contact

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Overview

- **Goal**: Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

Key Takeaways

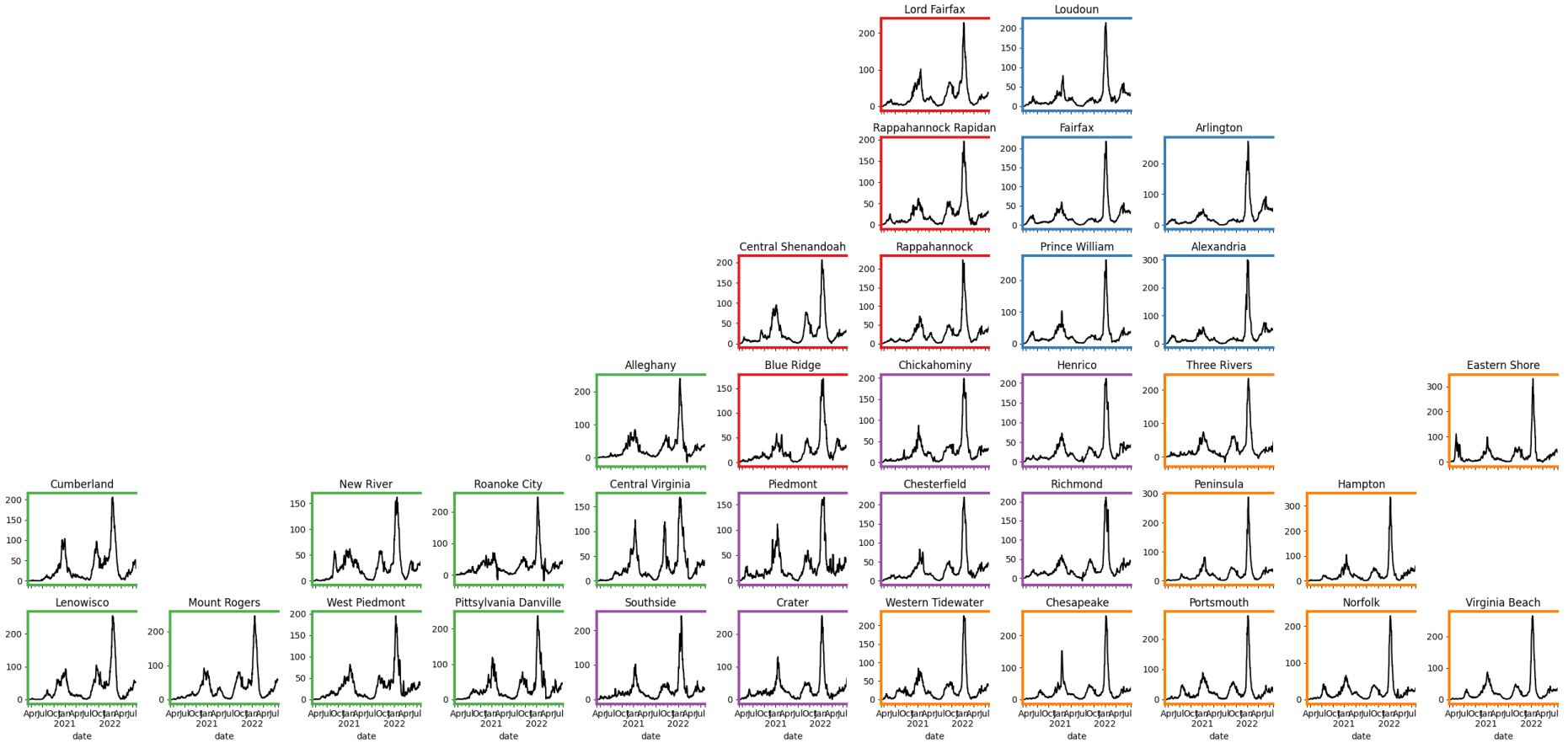
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

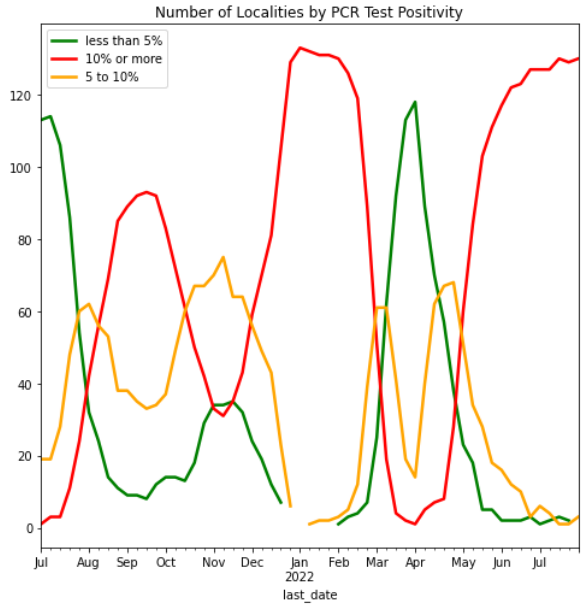
- **Case rates remain high though stable, hospitalizations rise though the pace of growth has slackened**
- VA weekly case rate is flat, remaining at 250/100K from 250/100K
  - US weekly case rate is down to 240/100K from 263/100K
  - VA hospital occupancy (rolling 7 day mean of 776 up from 754 a week ago) continues to rise, but now at a slower pace
- Trends in Severity of those hospitalized continue to decline
- Sub-variant prevalence evolves as expected, BA.4.6 now highlighted on CDC variant tracker
- Projections from last week remain largely on target

The situation continues to change. Models continue to be updated regularly.

Situation Assessment

Case Rates (per 100k) and Test Positivity





County level RT-PCR test positivity

Green: <5.0% (or <20 tests in past 14 days)

Orange: 5.0%-10.0% (or <500 tests and <2000 tests/100k and >10% positivity over 14 days)

Red: >10.0% (and not "Green" or "Yellow")

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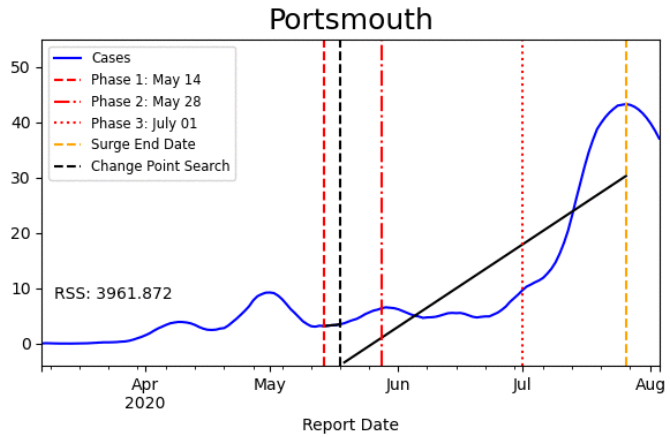
District Trajectories

Goal: Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

Method: Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

Hockey stick fit

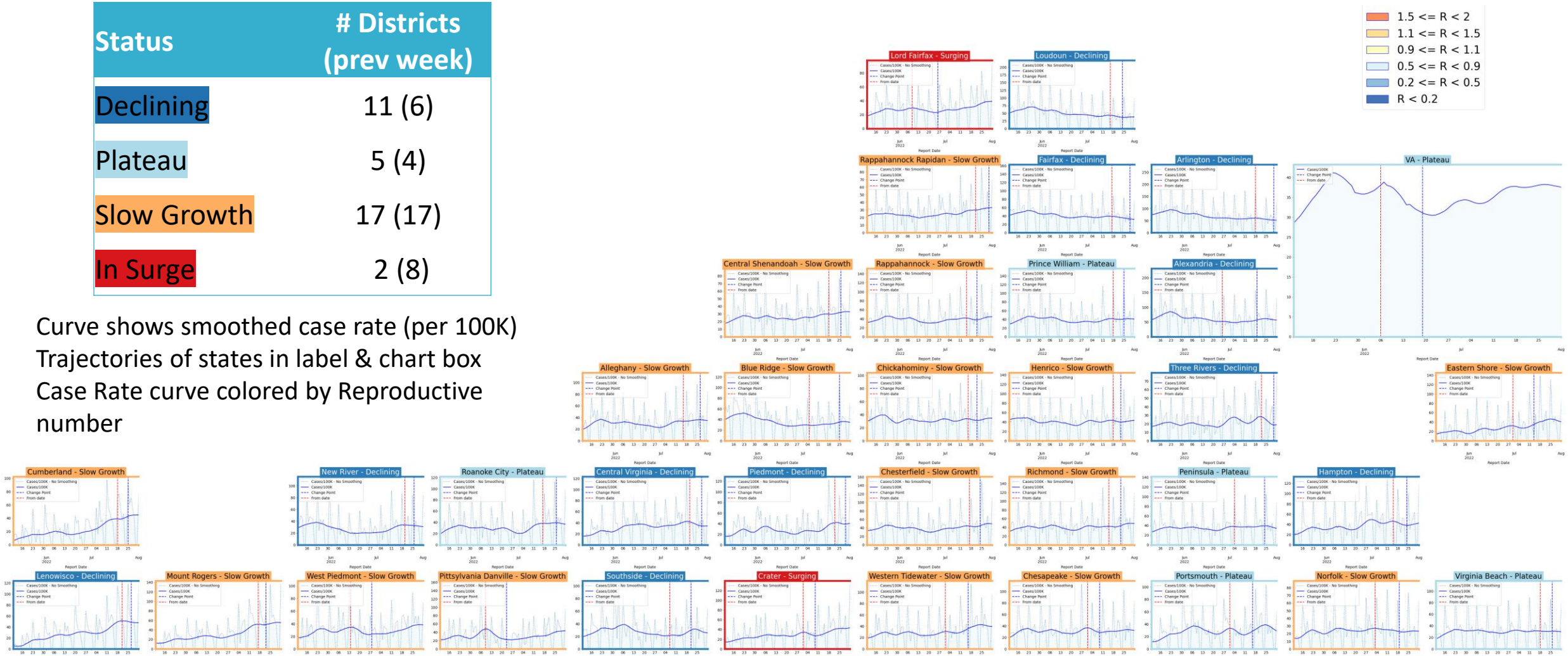


Trajectory	Description	Weekly Case Rate (per 100K) bounds
Declining	Sustained decreases following a recent peak	below -0.9
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	11 (6)
Plateau	5 (4)
Slow Growth	17 (17)
In Surge	2 (8)

Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive number



CDC's new COVID-19 Community Levels

What Prevention Steps Should You Take Based on Your COVID-19 Community Level?

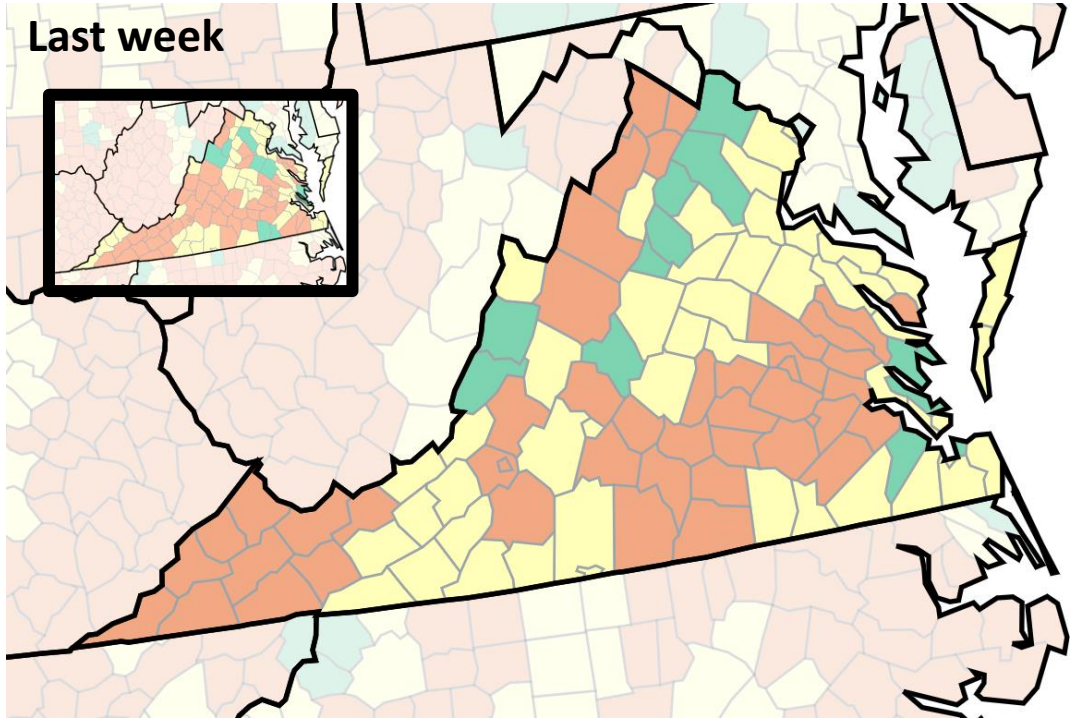
Low	Medium	High
• Stay up to date with COVID-19 vaccines • Get tested if you have symptoms	• If you are at high risk for severe illness, talk to your healthcare provider about whether you need to wear a mask and take other precautions • Stay up to date with COVID-19 vaccines • Get tested if you have symptoms	• Wear a mask indoors in public • Stay up to date with COVID-19 vaccines • Get tested if you have symptoms • Additional precautions may be needed for people at high risk for severe illness

People may choose to mask at any time. People with symptoms, a positive test, or exposure to someone with COVID-19 should wear a mask.

COVID-19 Community Levels – Use the Highest Level that Applies to Your Community

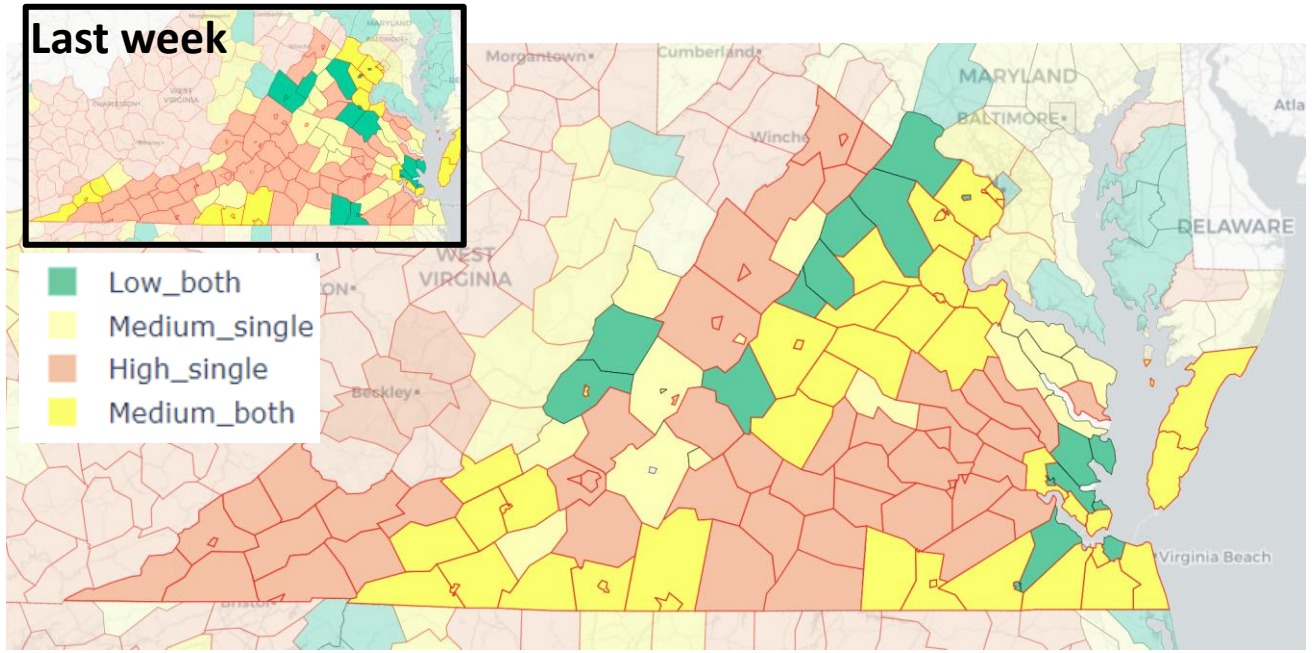
New COVID-19 Cases Per 100,000 people in the past 7 days	Indicators	Low	Medium	High
Fewer than 200	New COVID-19 admissions per 100,000 population (7-day total)	<10.0	10.0-19.9	≥20.0
	Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)	<10.0%	10.0-14.9%	≥15.0%
200 or more	New COVID-19 admissions per 100,000 population (7-day total)	NA	<10.0	≥10.0
	Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)	NA	<10.0%	≥10.0%

The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days



[CDC Data Tracker Portal]

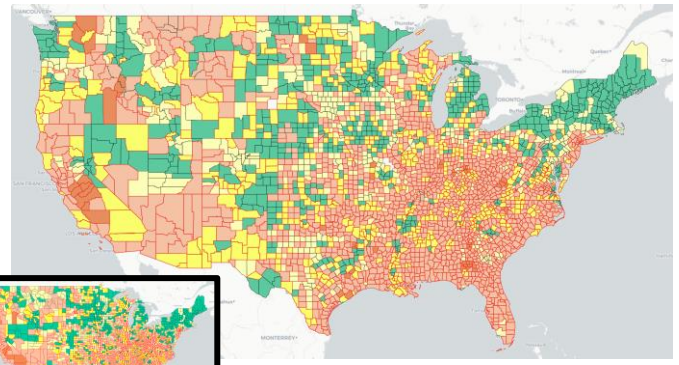
CDC's new COVID-19 Community Levels



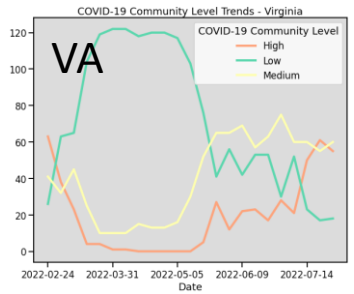
Red outline indicates county had 200 or more cases per 100k in last week

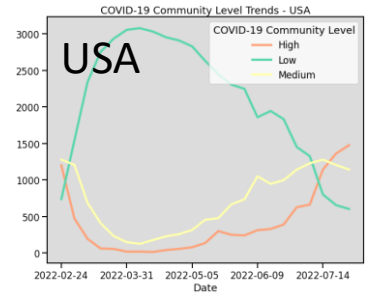
Pale color indicates either beds or occupancy set the level for this county

Dark color indicates both beds and occupancy set the level for this county



Last week





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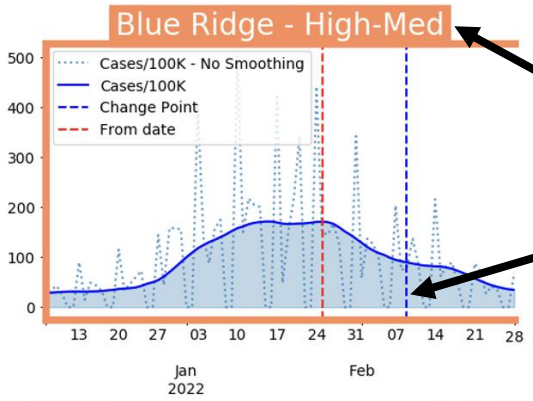
Data from: CDC Data Tracker Portal

District Trajectories with Community Levels

Community Level (Title Color)
- High
- High-Med
- Med-High
- Medium
- Med-Low
- Low-Med
- Low

Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory

Trajectory (Curve Shading)
- In Surge
- Slow Growth
- Plateau
- Declining



District's Aggregate Community Level

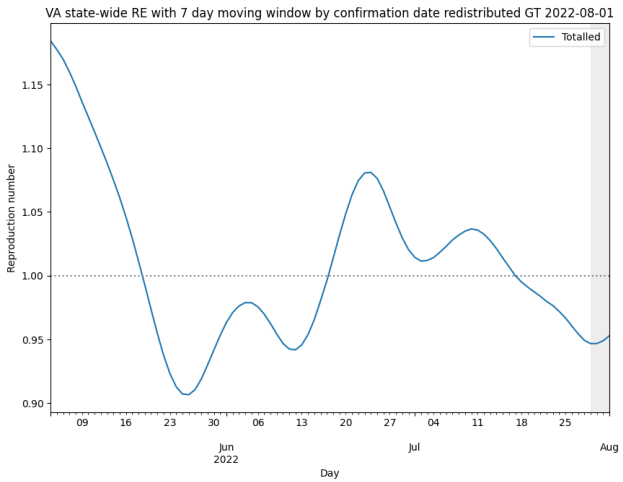
Aggregate level a simple mean of all levels for counties in district

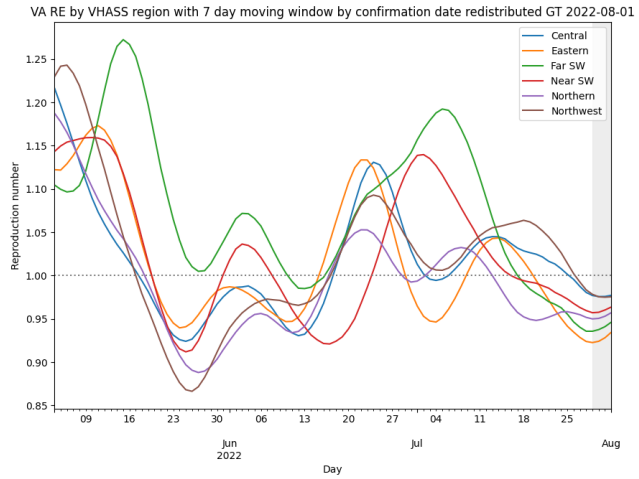
Case rate Trajectory

Estimating Daily Reproductive Number –
Redistributed gap

August 1st Estimates

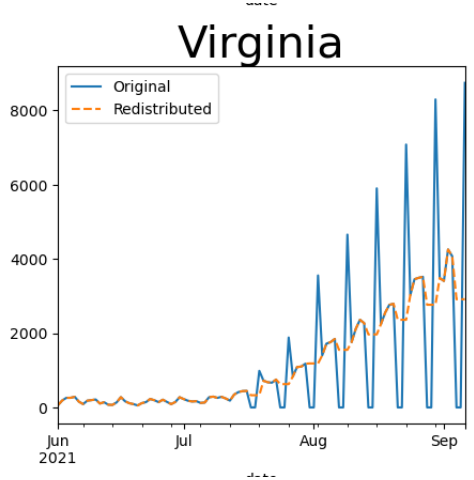
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.955	-0.024
Central	0.975	-0.032
Eastern	0.936	-0.075
Far SW	0.941	-0.009
Near SW	0.959	-0.011
Northern	0.957	0.013
Northwest	0.973	-0.048





Skipping Weekend Reports & holidays biases estimates

Redistributed "big" report day to fill in gaps, and then estimate R from "smoothed" time series



Methodology

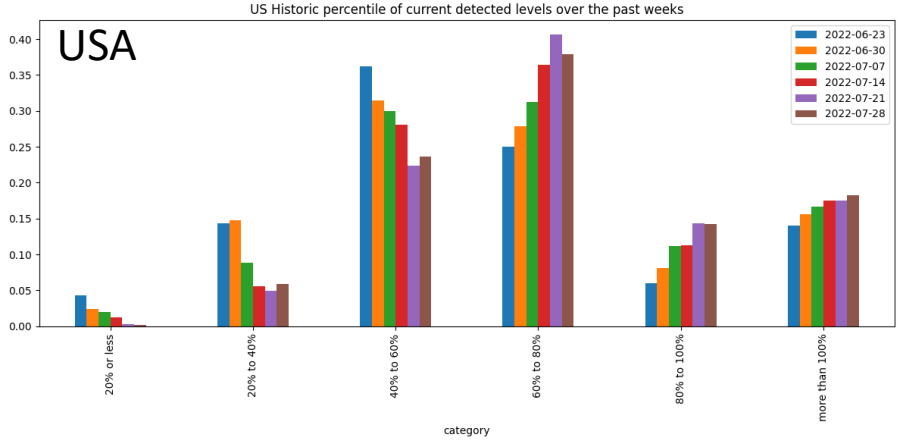
- Wallinga-Teunis method (EpiEstim[1]) for cases by **<u>confirmation date</u>**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

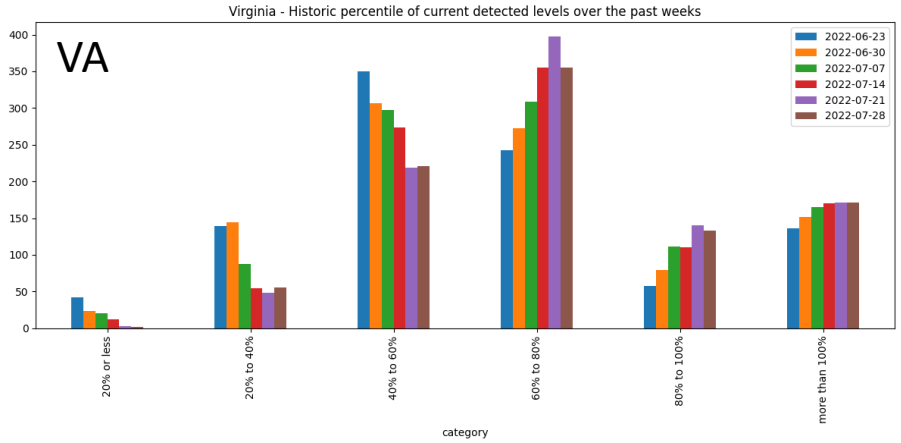
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

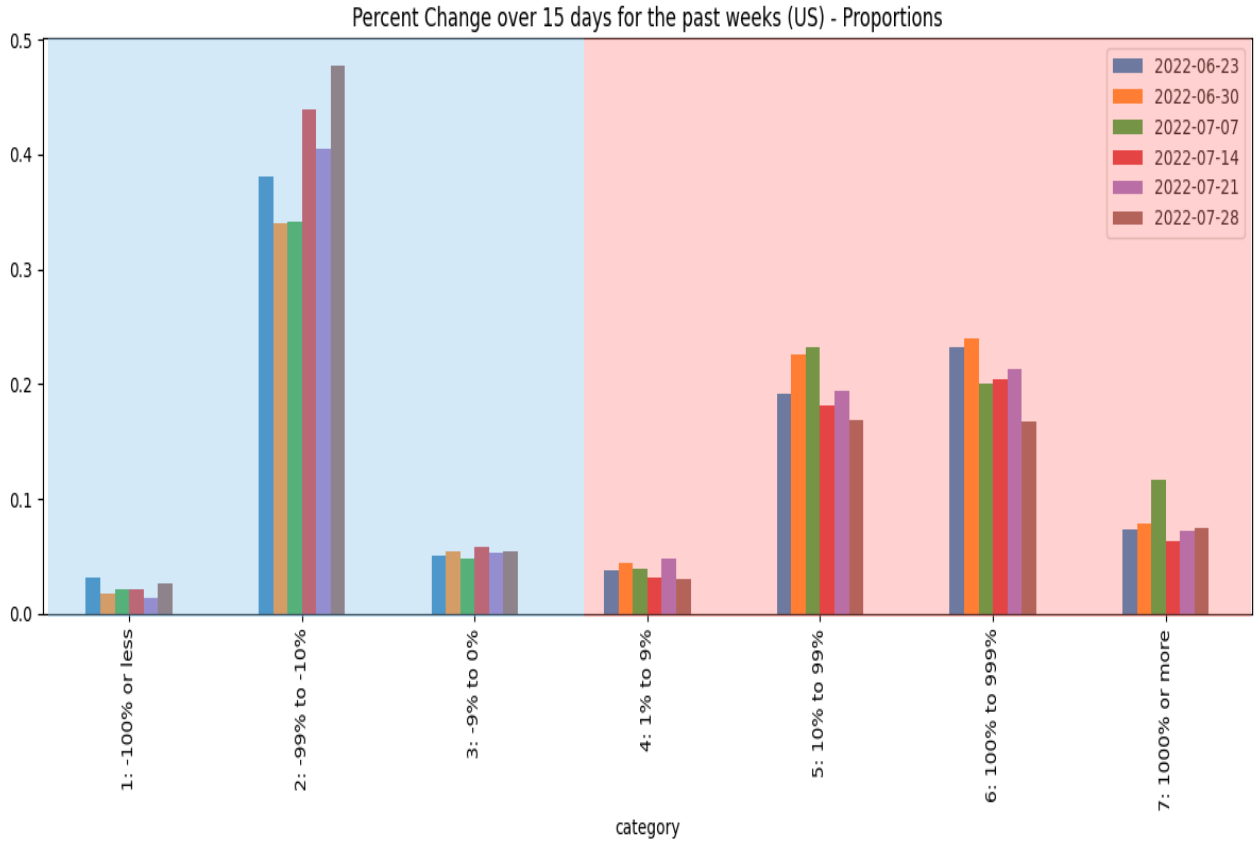
Wastewater Monitoring

Wastewater provides a coarse early warning of COVID-19 levels in communities

- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago
- Current virus levels are at or exceeding max of previous historical levels, has slowed, though more sites are entering upper quintiles



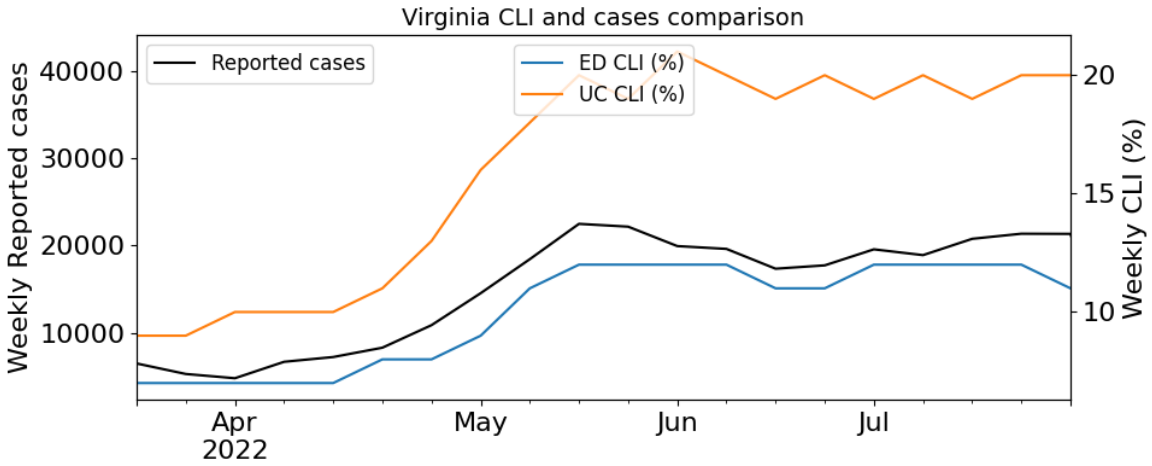


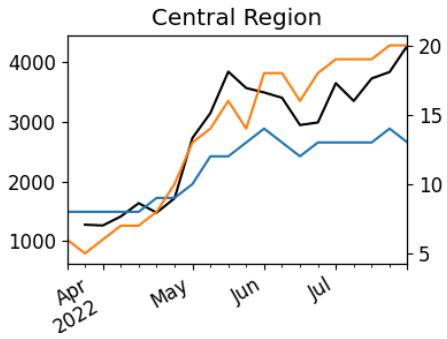


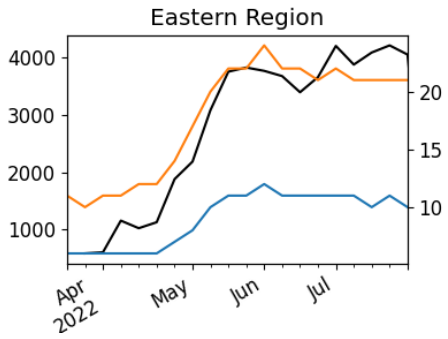
COVID-like Illness Activity

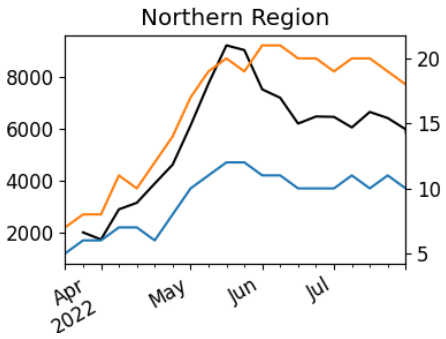
COVID-like Illness (CLI) gives a measure of COVID transmission in the community

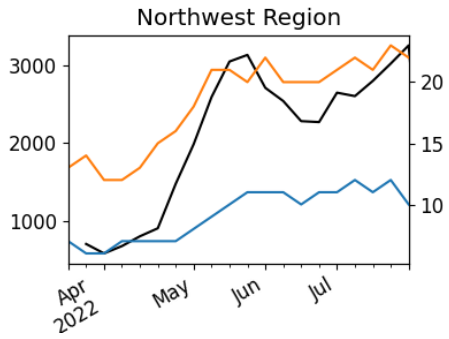
- Emergency Dept (ED) based CLI is more correlated with case reporting
- Urgent Care (UC) is a leading indicator but prone to some false positives
- **Current trends in UC CLI have plateaued for last 11 weeks state-wide, mixed by region**

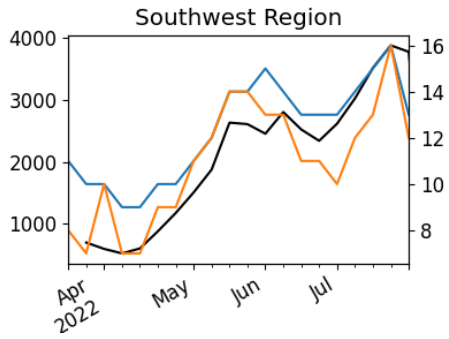








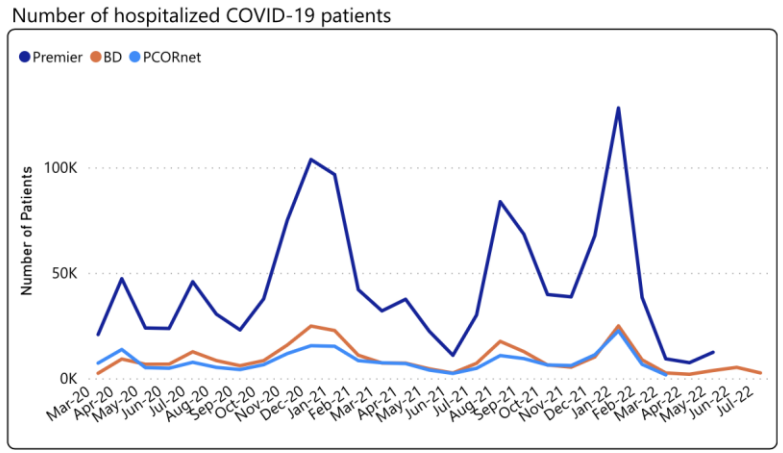


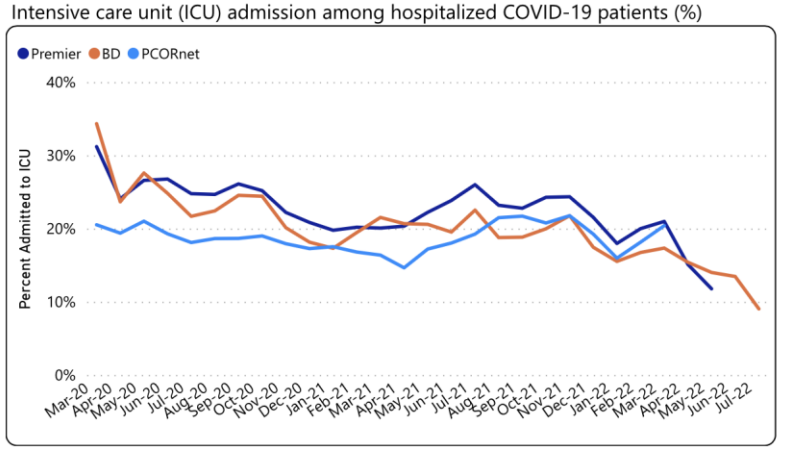


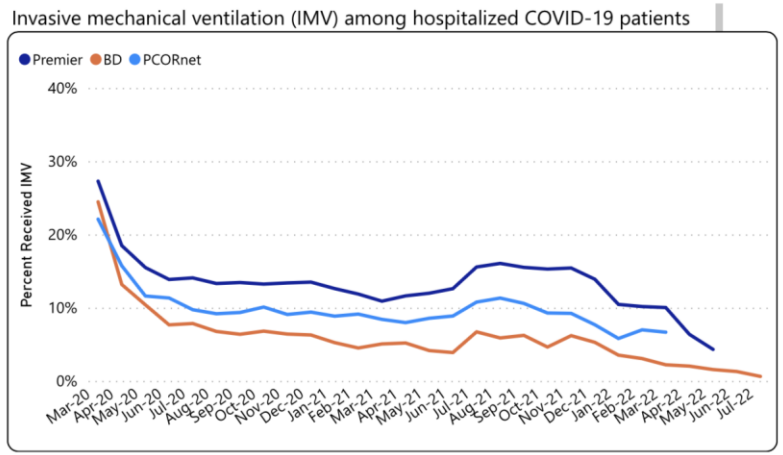
Cases and Hospitalizations – Age Distribution

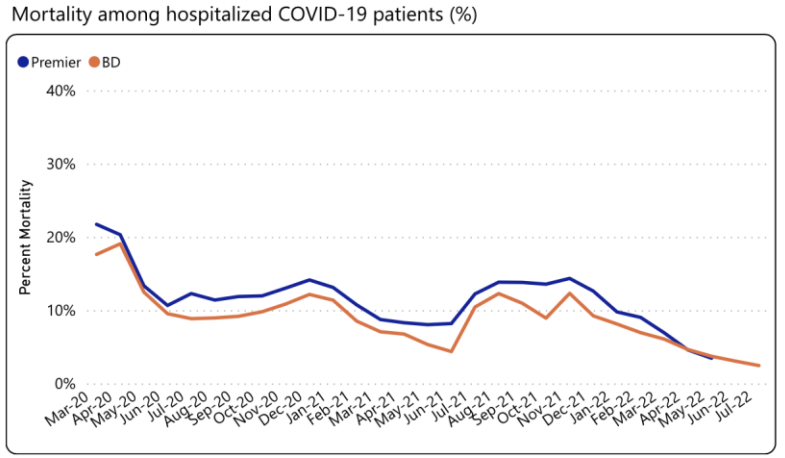
Proportion of most severe outcomes decreasing among those who are hospitalized

- ICU has declined from ~20% of hospitalized to nearly 10% since the first wave of Omicron
- Similar levels of decline experience for mechanical ventilation and death









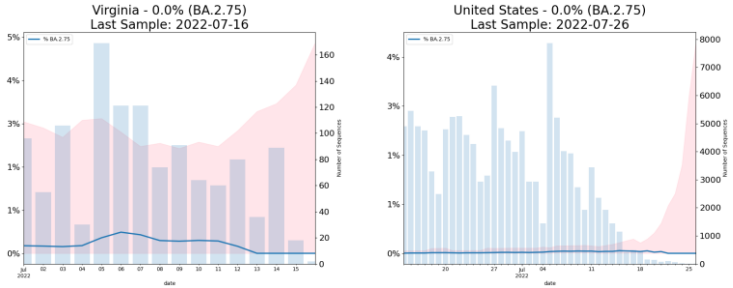
SARS-CoV2 Variants of Concern

Emerging new variants will alter the future trajectories of pandemic and have implications for future control

- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations

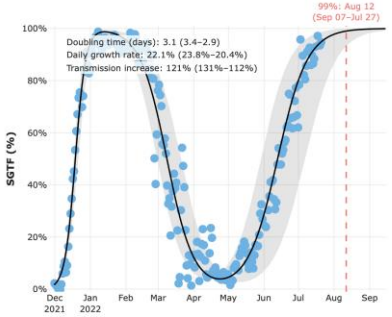
Omicron Updates (Region 3)

- BA.2.12.1 growth has continued to decline, shrinking to 11% from 25% last week
- BA.4 stagnated at 15-19% for past 4 weeks
- BA.5 continues to grow rapidly, nowcasted at 53% (up from 56% last week)
- BA.4 and BA.5 have same mutation as BA.1 that produces S-gene target failure, so can be tracked in more real time with SGTF from some PCR tests

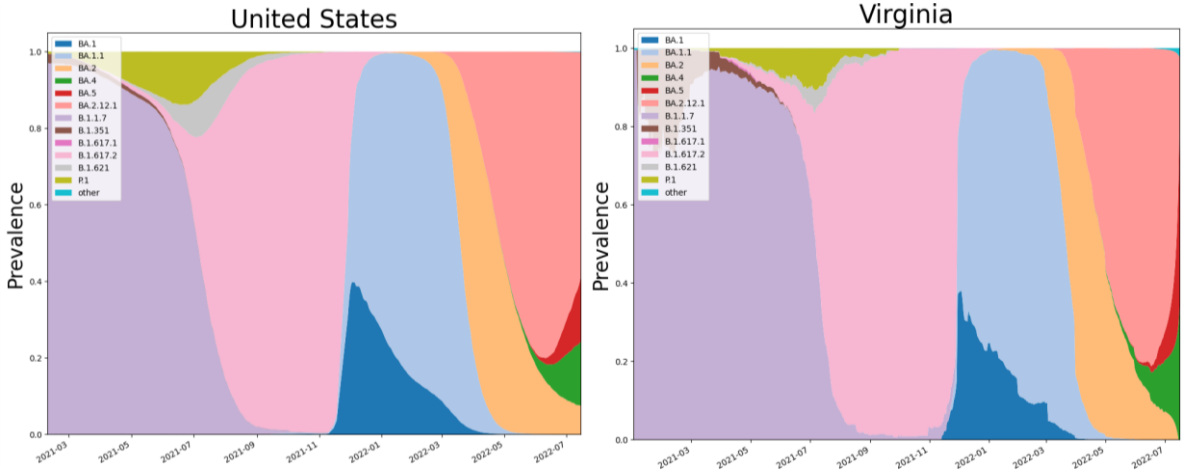


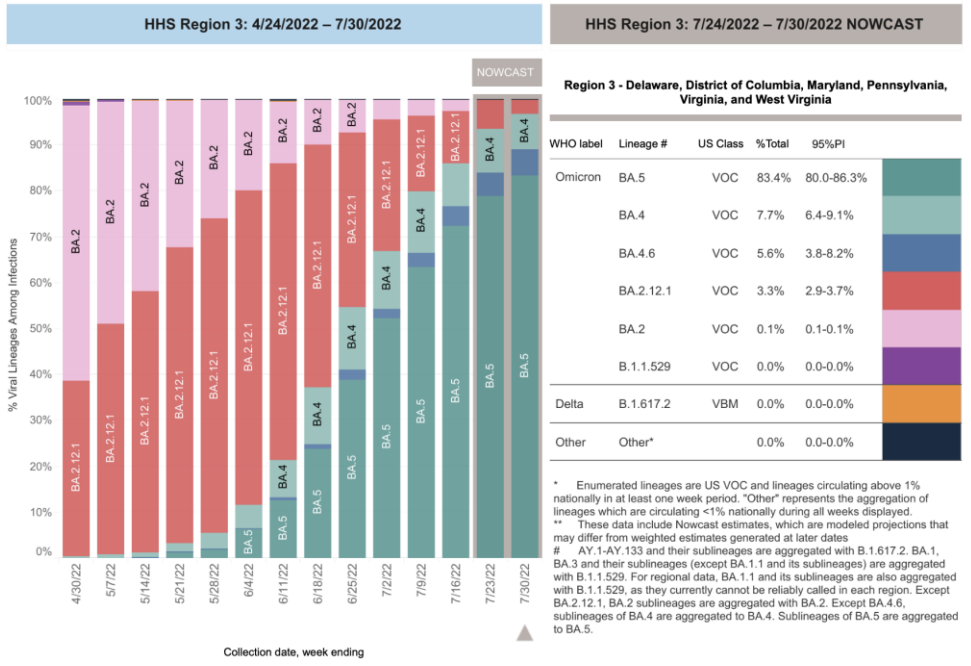
BA.2.75 detected in US (very limited samples)

[SGTF in San Diego]



Currently estimated to be nearly 100%% in San Diego

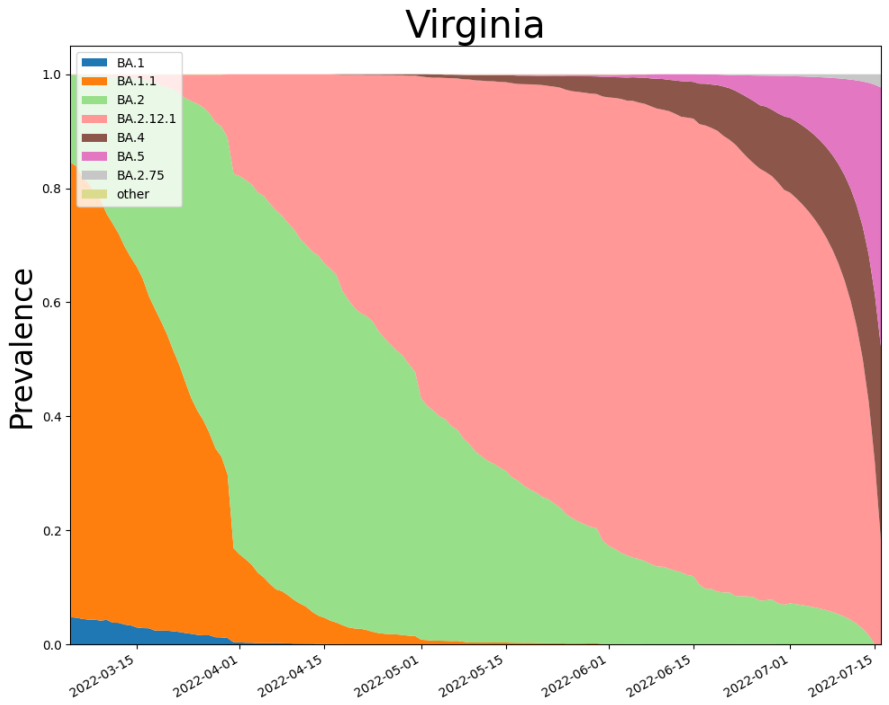


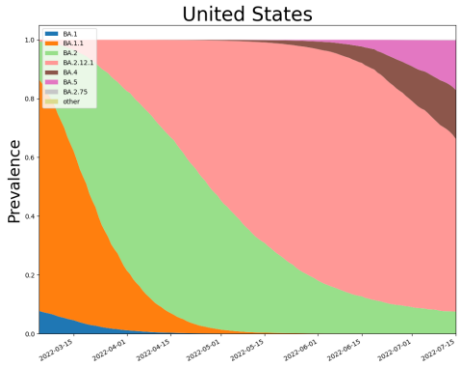


[CDC Variant Tracking]

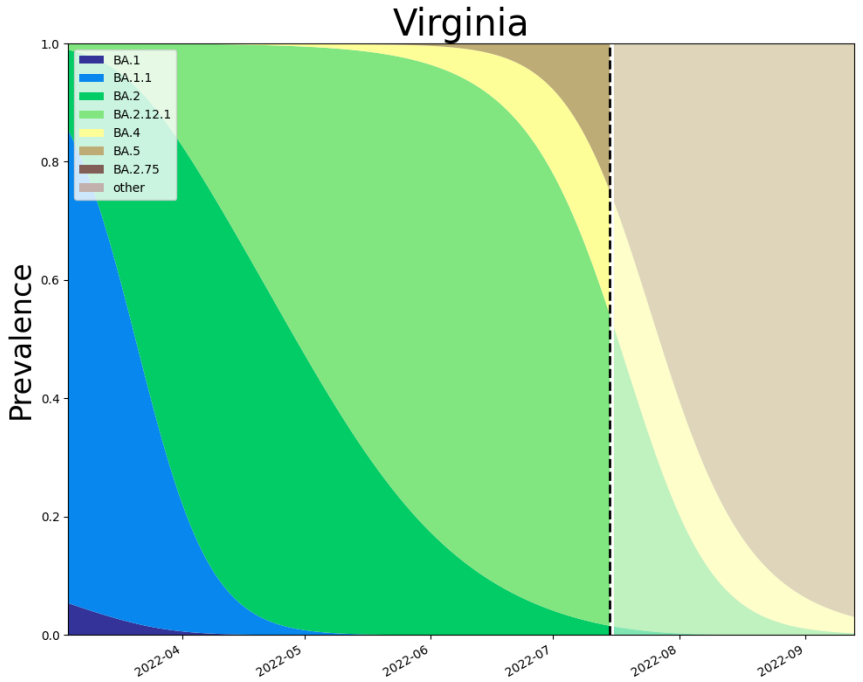
SARS-CoV2 Omicron and Sub-Variants

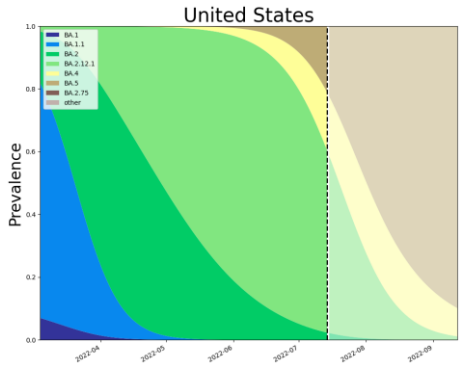
As detected in whole Genomes in public repositories





VoC Polynomial Fit Projections





Note: Data lags force projections to start in past. Everything from dotted line forward is a projection.

Pandemic Pubs

1. Acute COVID-19 was associated with net increased cardiovascular disease incidence (5.82, 4.82 to 7.03)
2. More than ninety percent in the Geneva population have developed anti-SARS-CoV-2 antibodies through vaccination and/or infection, but less than half have antibodies with neutralizing activity against BA.5 subvariant
3. Study among Rhode Island residents suggest that among people who have recovered from COVID-19, subsequent completion of the primary vaccination series reduced the risk of reinfection by approximately half.
4. Booster vaccination with mRNA-1273 COVID-19 vaccine was more effective than BNT162b2 in preventing infection and COVID-19 hospitalisation during the first 12 weeks after vaccination, during a period of Delta followed by Omicron variant dominance.

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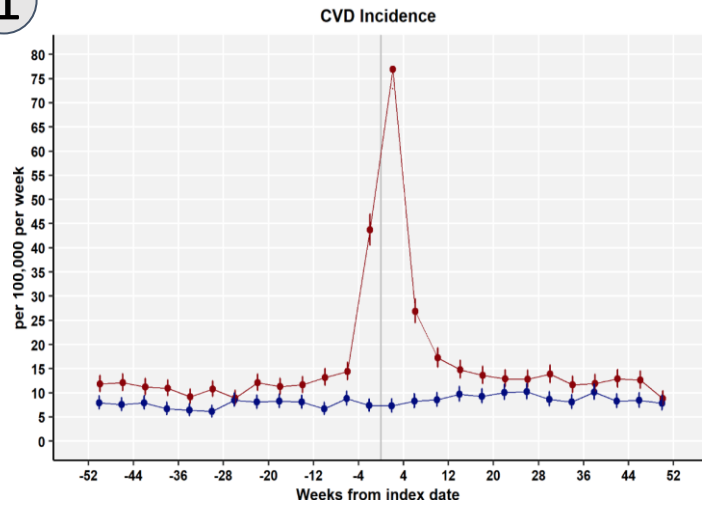
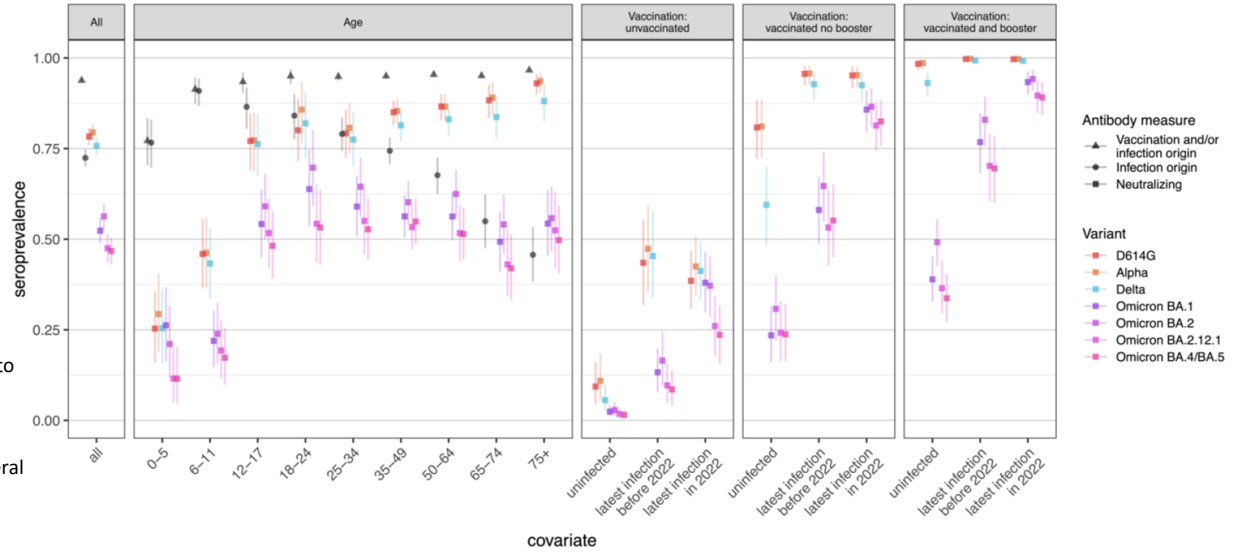


Researchers at Kings College London cohort study from 2020 to 2021 analysing electronic records for 1,356 United Kingdom family practices with a population of 13.4 million. Participants were 428,650 COVID-19 patients without DM or CVD who were individually matched with 428,650 control patients on age, sex, and family practice and followed up to January 2022.study of that found that CVD was increased early after COVID-19 mainly from pulmonary embolism, atrial arrhythmias, and venous thromboses. DM incidence remained elevated for at least 12 weeks following COVID-19 before declining. People without preexisting CVD or DM who suffer from COVID-19 do not appear to have a long-term increase in incidence of these conditions.
https://journals.plos.org/plosmedicine/article/authors?id=10.1371/journal.pmed.1004052

Researchers in Geneva conducted a population-based serosurvey between April 29th and June 9th, 2022, recruiting children and adults of all ages from age-stratified random samples of the Geneva general population. Among the 2521 individuals included in the analysis (55.2% women; 21.4% aged <18 years and 14.2% aged ≥65 years), overall seroprevalence of antibodies was 93.8%. Estimates of neutralizing antibodies based on a representative subsample of 1160 participants ranged from 79.5% against the Alpha variant to 46.7% against the Omicron BA.4/BA.5 subvariants. Despite having high seroprevalence of infection-induced antibodies (76.7% for ages 0-5 years, 90.5% for ages 6-11 years), children aged <12 years had substantially lower neutralizing activity than older participants, particularly against Omicron subvariants. Higher levels of neutralization activity against pre-Omicron variants were associated with vaccination, higher levels of neutralization activity against Omicron subvariants were associated with booster vaccination alongside recent infection.
https://www.medrxiv.org/content/10.1101/2022.07.27.22278126v1



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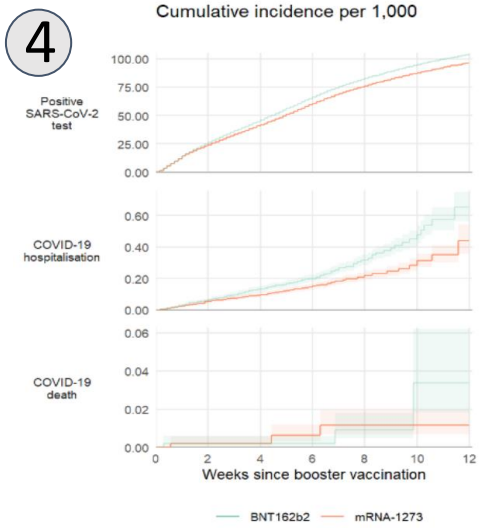
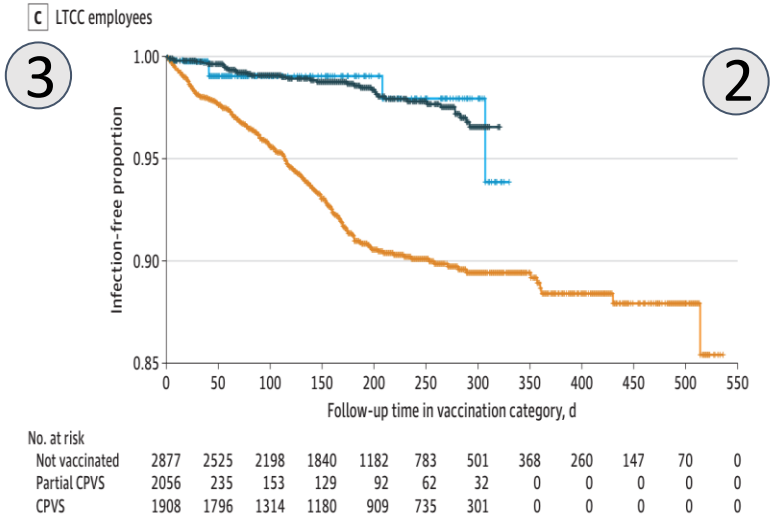


Oxford study: eligible if boosted between 29 October 2021 and 31 January 2022. 1,528,431 people were matched in each group, contributing a total 23,150,504 person-weeks of follow-up. The 12-week risks per 1,000 people of positive SARS-CoV-2 test were 103.2 (95%CI 102.4 to 104.0) for BNT162b2 and 96.0 (95.2 to 96.8) for mRNA-1273:
https://www.medrxiv.org/content/10.1101/2022.07.29.22278186v1

3

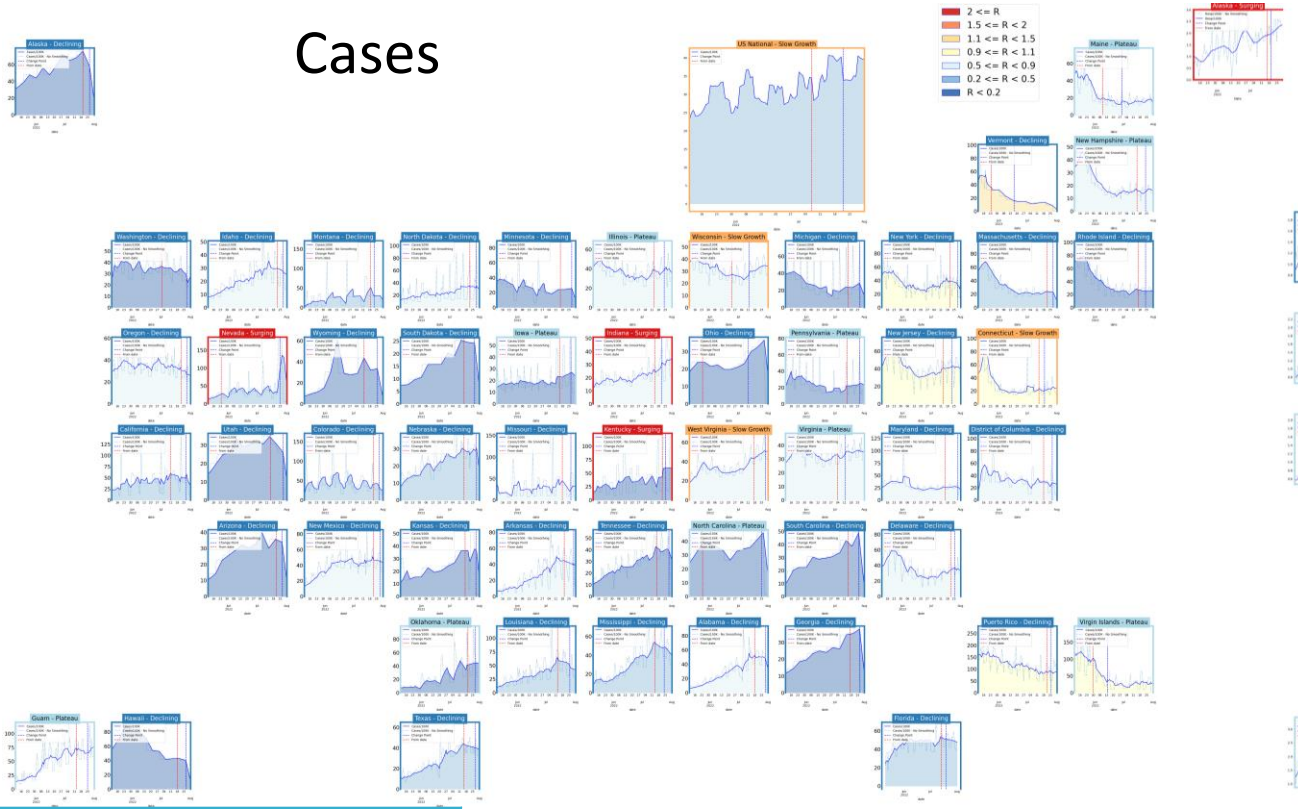


In this cohort study of more than 95 000 Rhode Island residents from March 2020 to December 2021, including residents and employees of long-term congregate care (LTCC) facilities, completion of the primary vaccination series after recovery from COVID-19 was associated with 49% protection from reinfection among LTCC residents, 47% protection among LTCC employees, and 62% protection in the general population during periods when wild type, Alpha, and Delta strains of SARS-CoV-2 were predominant.
https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2794702

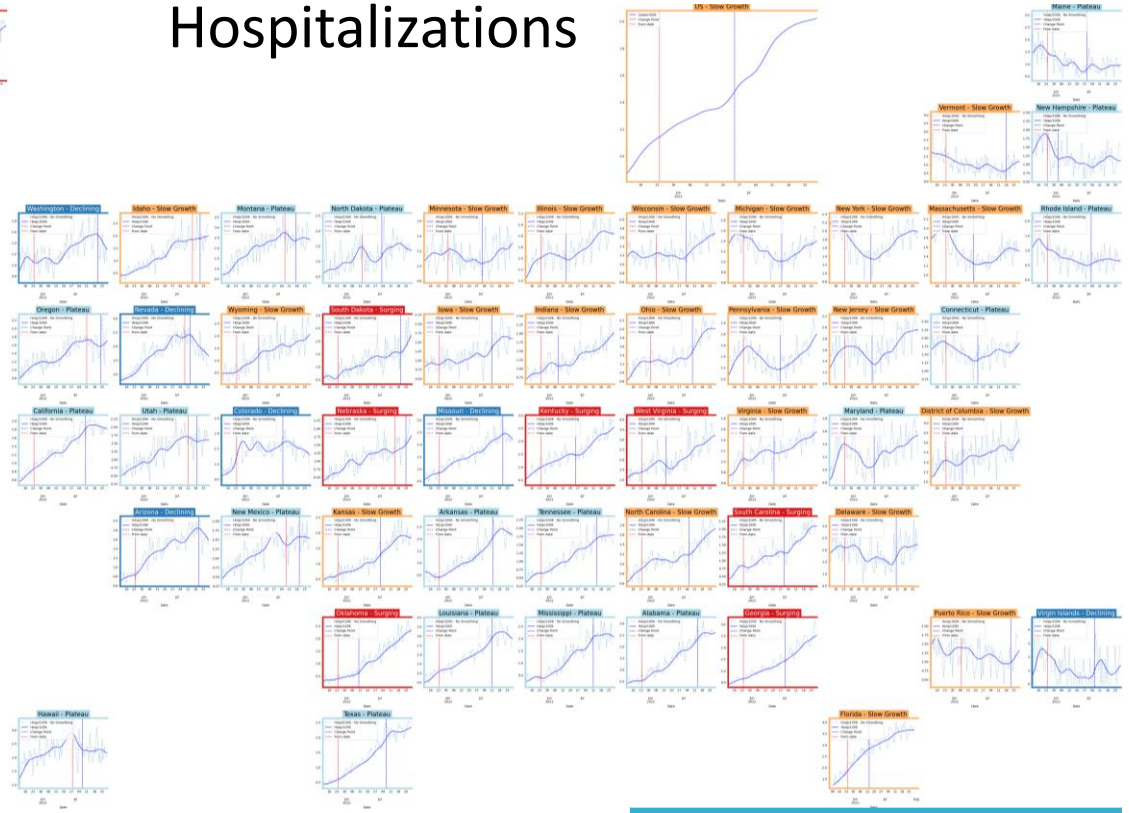
2

United States Case & Hospitalizations

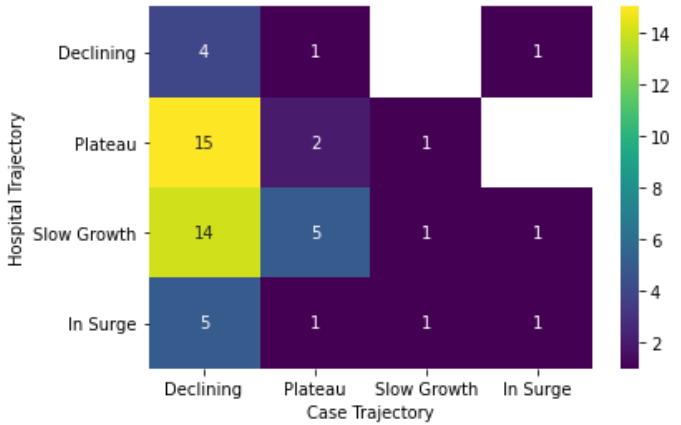
Cases



Hospitalizations



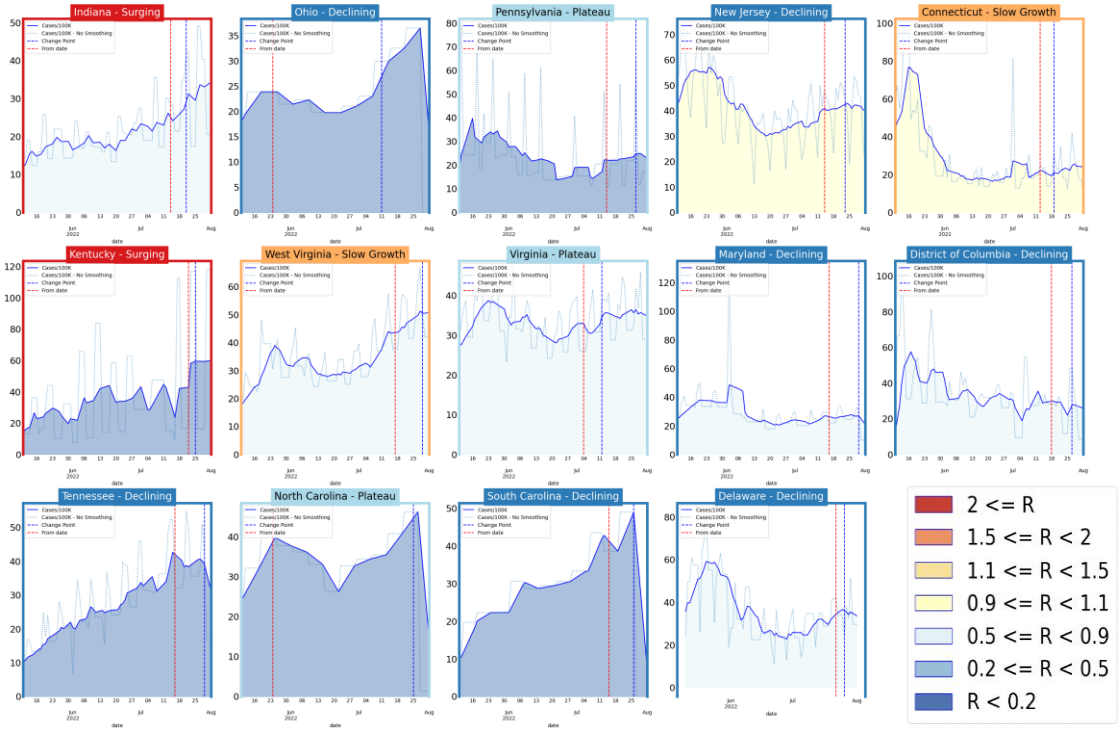
Status	# States
Declining	38 (37)
Plateau	9 (10)
Slow Growth	3 (4)
In Surge	3 (3)



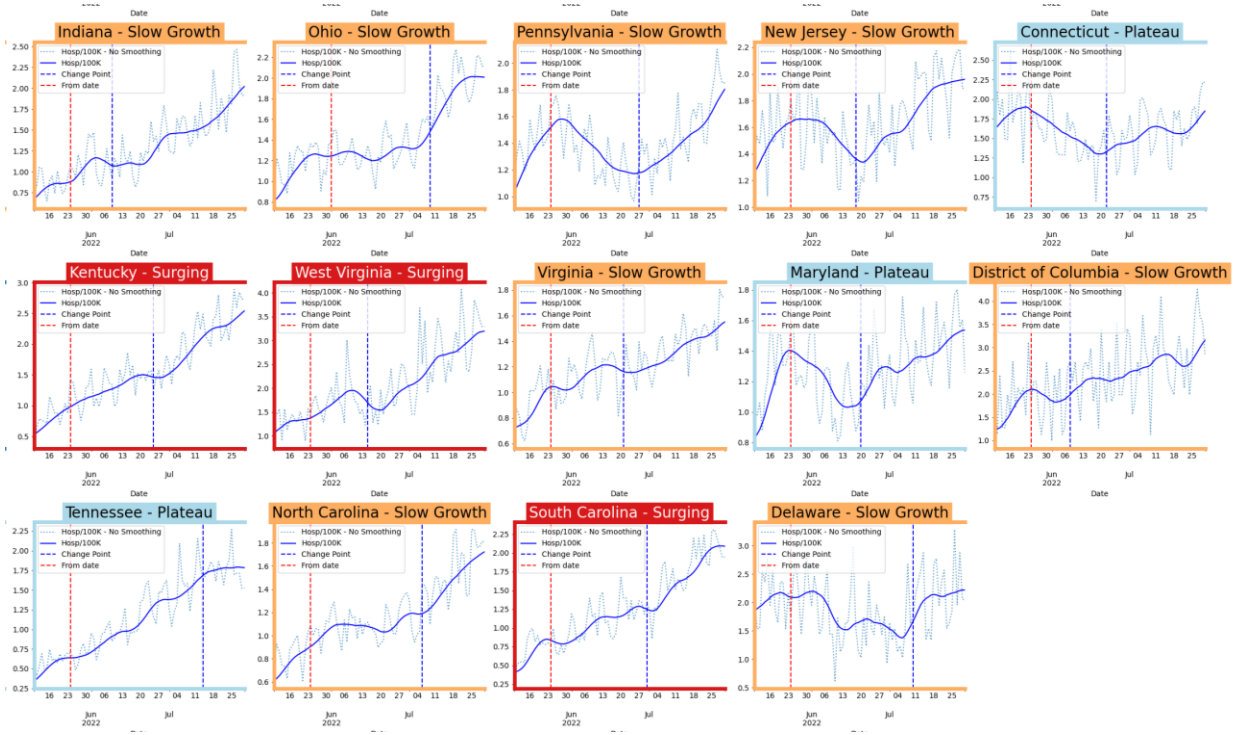
Status	# States
Declining	6 (3)
Plateau	18 (13)
Slow Growth	21 (25)
In Surge	8 (12)

Virginia and Her Neighbors

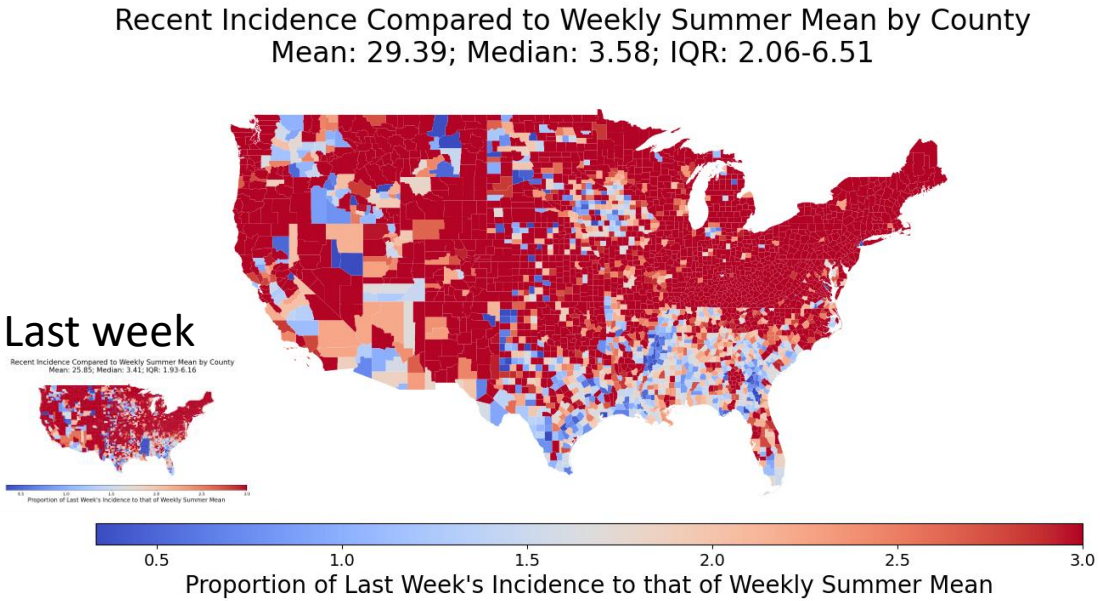
Cases

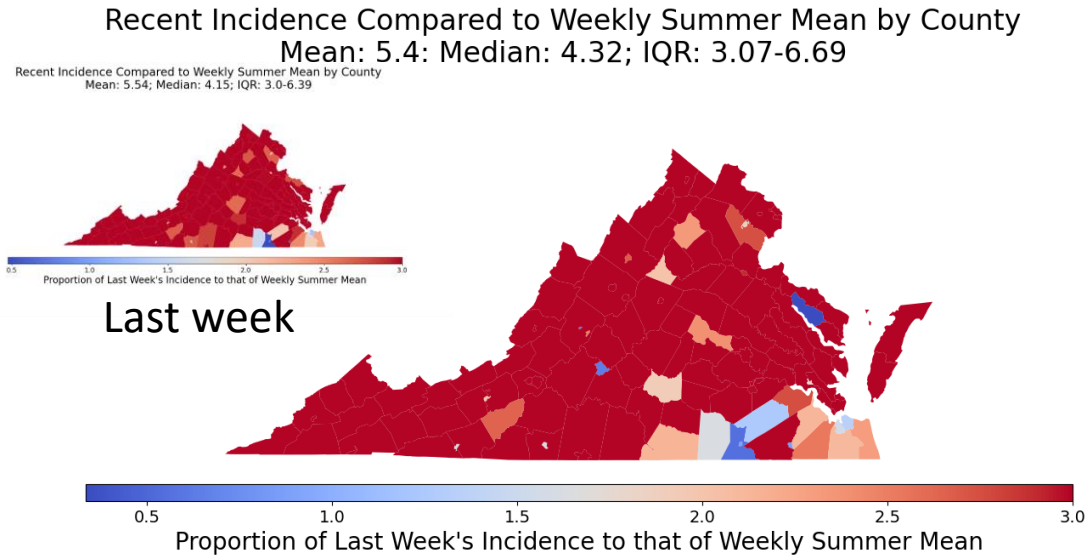


Hospitalizations



County-level comparison to last Summer





Using Ensemble Model to Guide Projections

Ensemble methodology that combines the Adaptive with machine learning and statistical models such as:

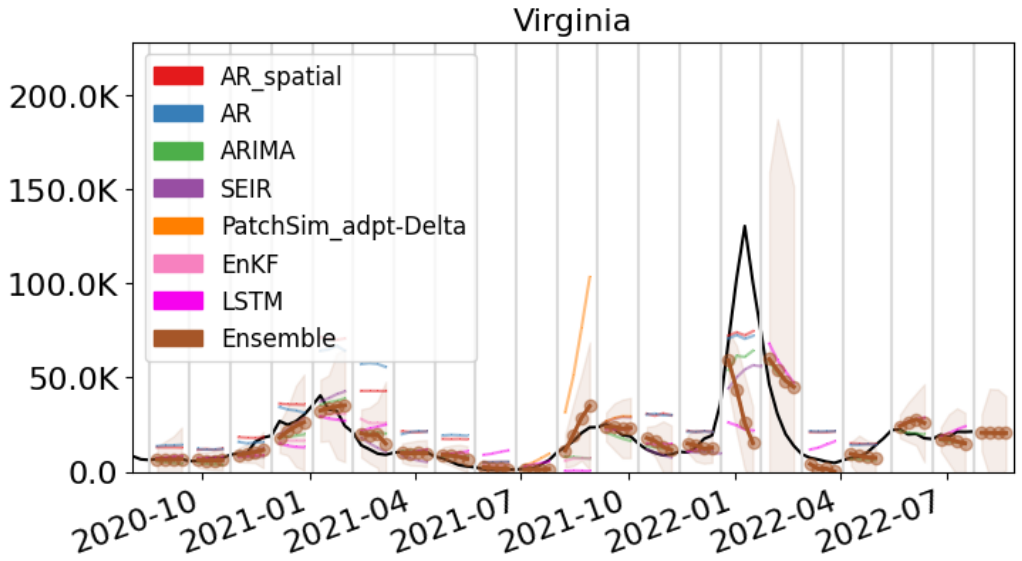
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

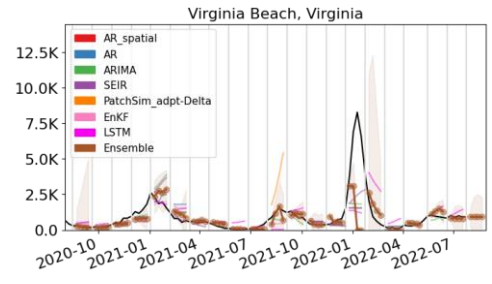
<u>Weekly forecasts</u> done at county level.

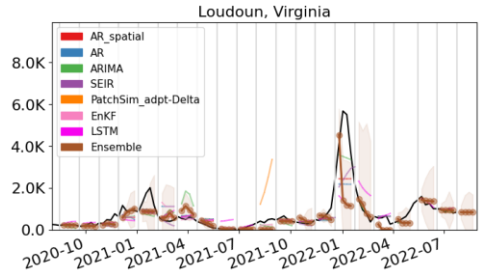
Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

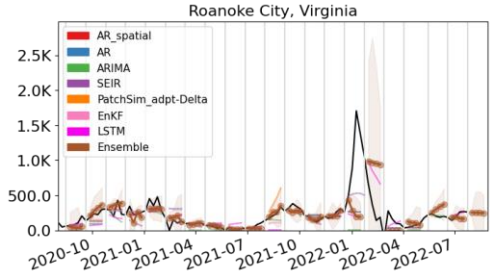
Ensemble forecast provides additional ‘surveillance’ for making scenario-based projections.

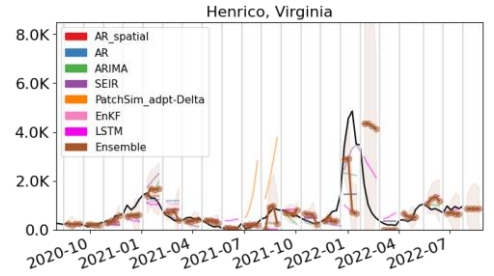
Also submitted to CDC Forecast Hub.









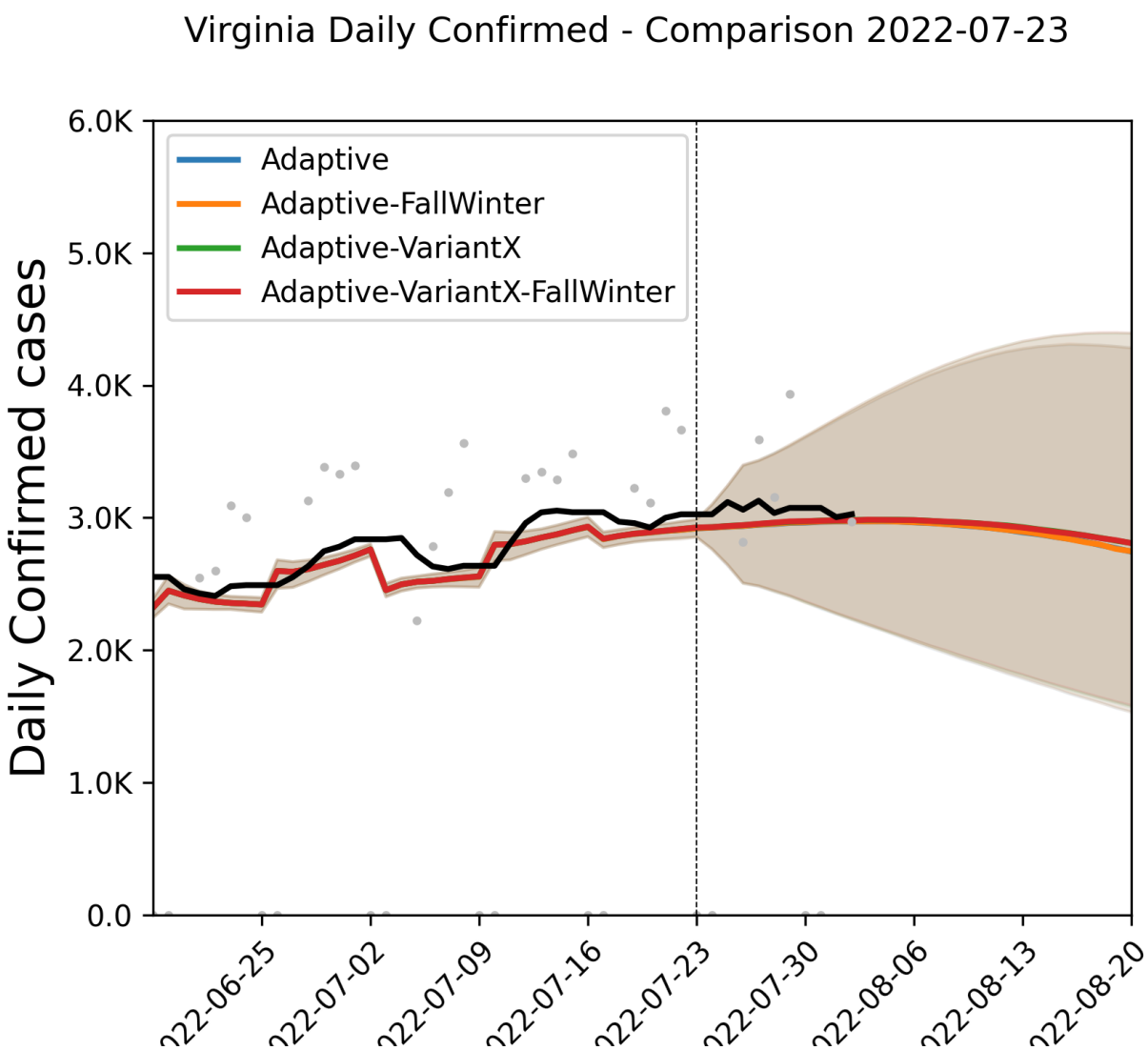


UNIVERSITY of VIRGINIA

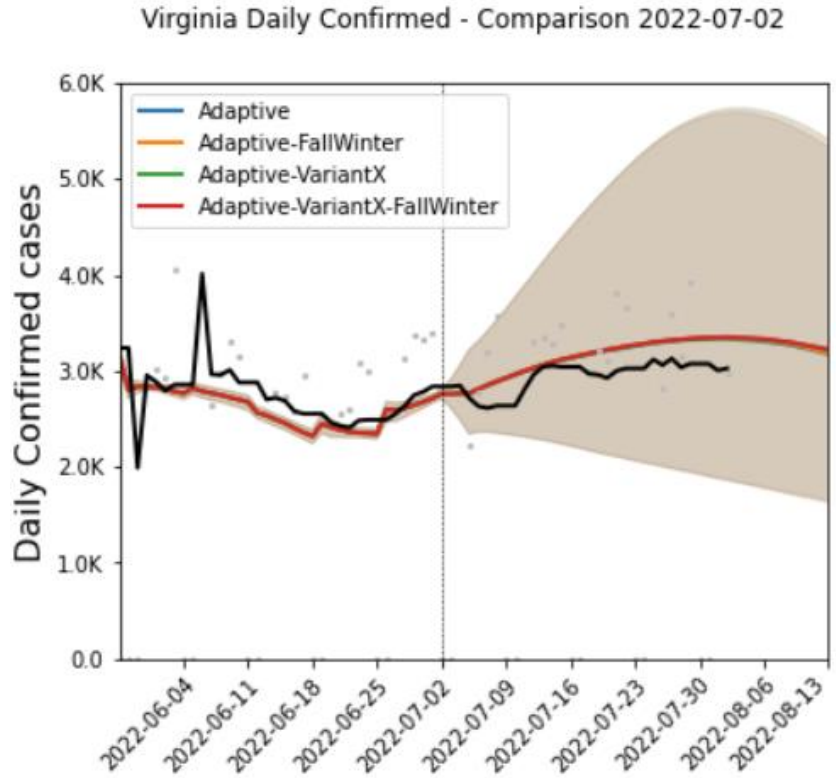
BIOCOMPLEXITY INSTITUTE

Last case projection comparison – 1 week and 1 month ago

Projection from July 27th update (based on surveillance up July 23rd)

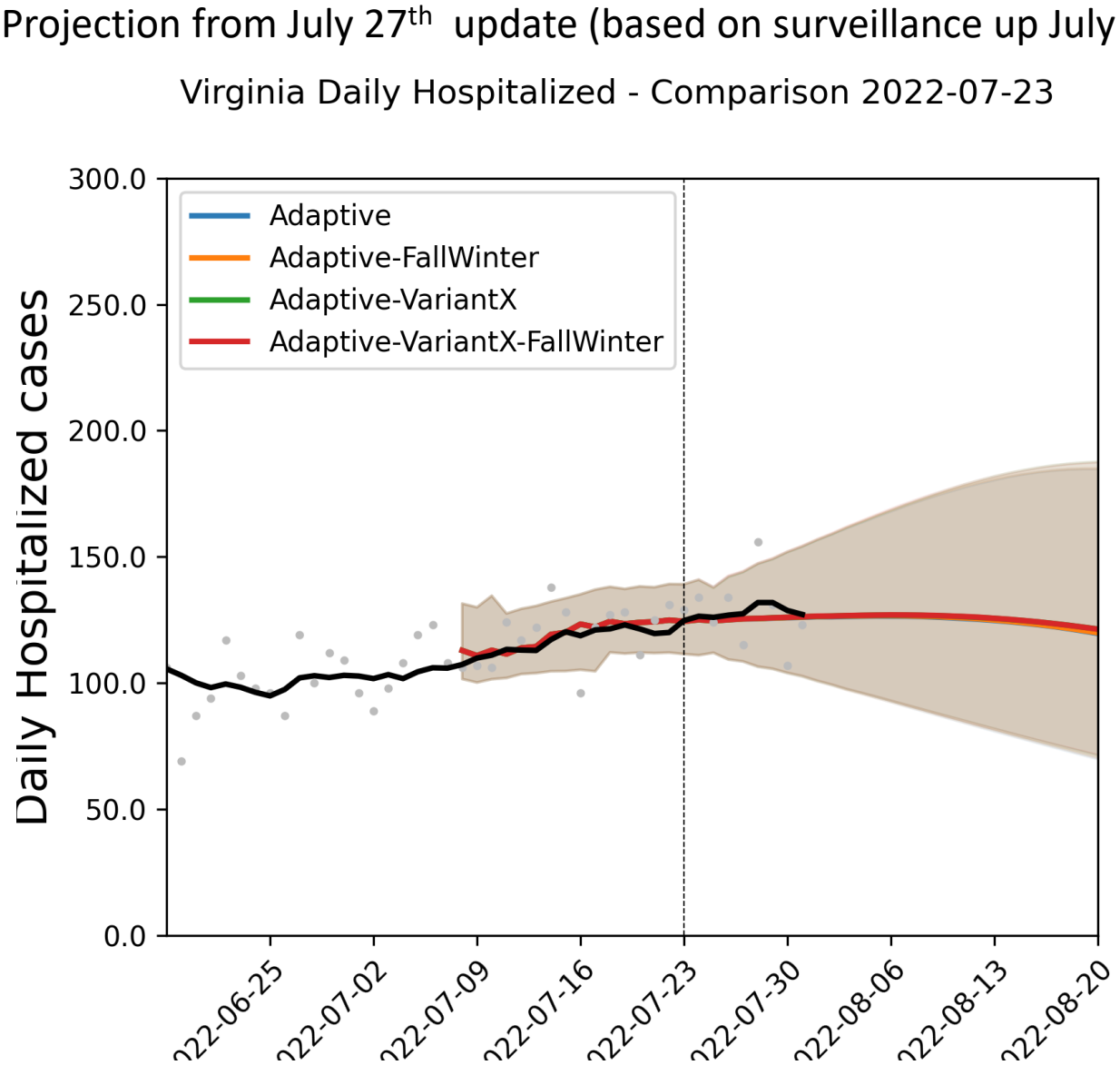


Projection based on surveillance up July 2nd



Last hospitalization projection comparison – 1 week ago

Projection from July 27th update (based on surveillance up July 23rd)



Key Takeaways

Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

- **Case rates remain high though stable, hospitalizations rise though the pace of growth has slackened**
- VA weekly case rate is flat, remaining at 250/100K from 250/100K
  - US weekly case rate is down to 240/100K from 263/100K
  - VA hospital occupancy (rolling 7 day mean of 776 up from 754 a week ago) continues to rise, but now at a slower pace
- Trends in Severity of those hospitalized continue to decline
- Sub-variant prevalence evolves as expected, BA.4.6 now highlighted on CDC variant tracker
- Projections from last week remain largely on target

The situation continues to change. Models continue to be updated regularly.

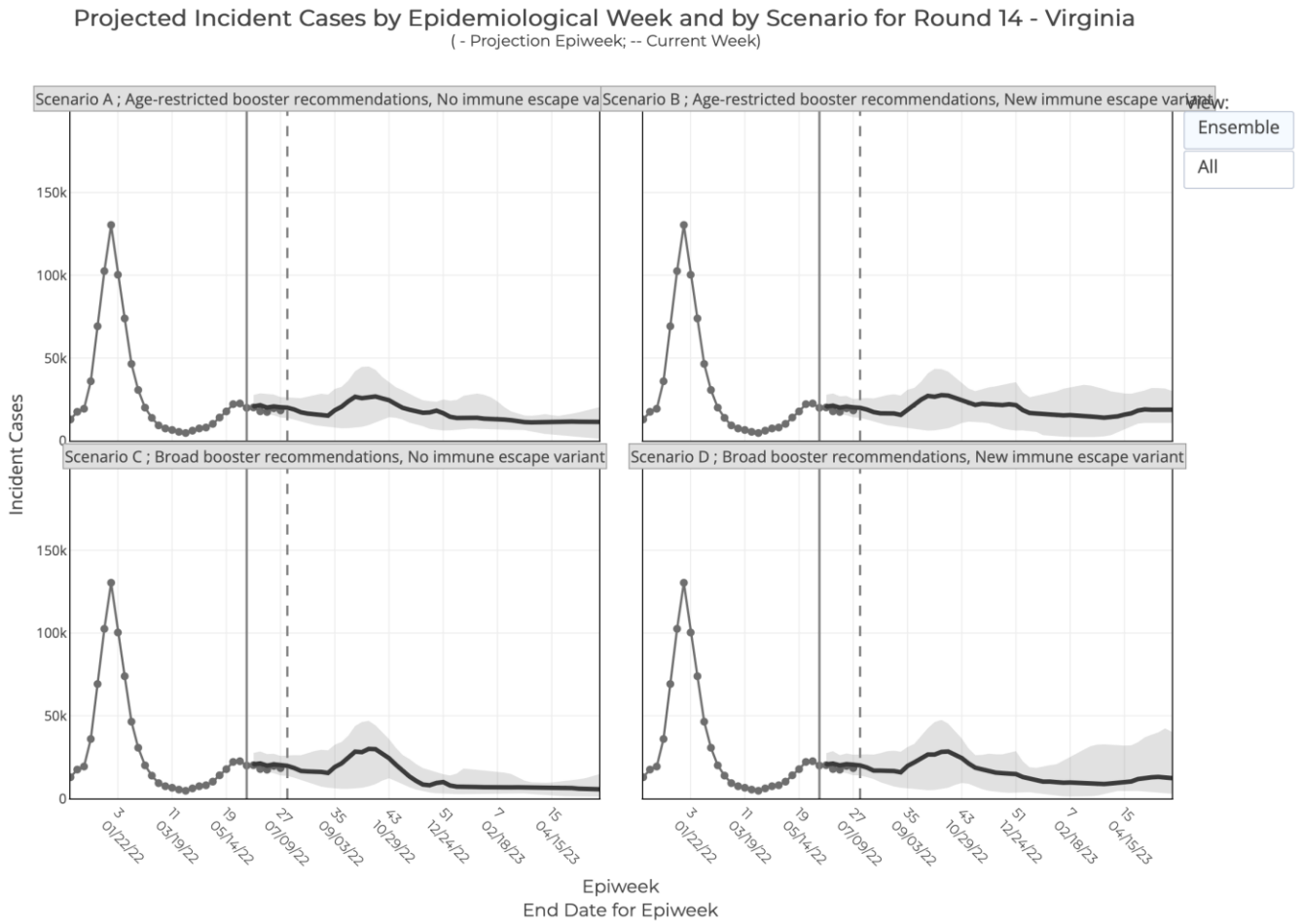
Additional Analyses

COVID-19 Scenario Modeling Hub – Round 14

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios

- Round 14 results getting finalized
  - Scenarios: Test benefits of reformulated fall boosters w/ and w/out a new variant
- Round 15 update being discussed

https://covid19scenariomodelinghub.org/viz.html



Round 14

Scenario defined as of 2022-05-17
Model Projecting from Epiweek 23 to Epiweek 23

- ☑ **Scenario A**
  Age-restricted booster recommendations
  No immune escape variant
  (A-2022-05-09)
- ☑ **Scenario B**
  Age-restricted booster recommendations
  New immune escape variant
  (B-2022-05-09)
- ☑ **Scenario C**
  Broad booster recommendations
  No immune escape variant
  (C-2022-05-09)
- ☑ **Scenario D**
  Broad booster recommendations
  New immune escape variant
  (D-2022-05-09)

References

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NSSAC. PatchSim: Code for simulating the metapopulation SEIR model. https://github.com/NSSAC/PatchSim

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Biocomplexity Institute. COVID-19 Surveillance Dashboard. https://nssac.bii.virginia.edu/covid-19/dashboard/

Google. COVID-19 community mobility reports. https://www.google.com/covid19/mobility/

Biocomplexity page for data and other resources related to COVID-19: https://covid19.biocomplexity.virginia.edu/

Questions?

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