Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

October 26th, 2022

(data current to October 22nd – October 25th)

Biocomplexity Institute Technical report: TR BI-2022-1775

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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

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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

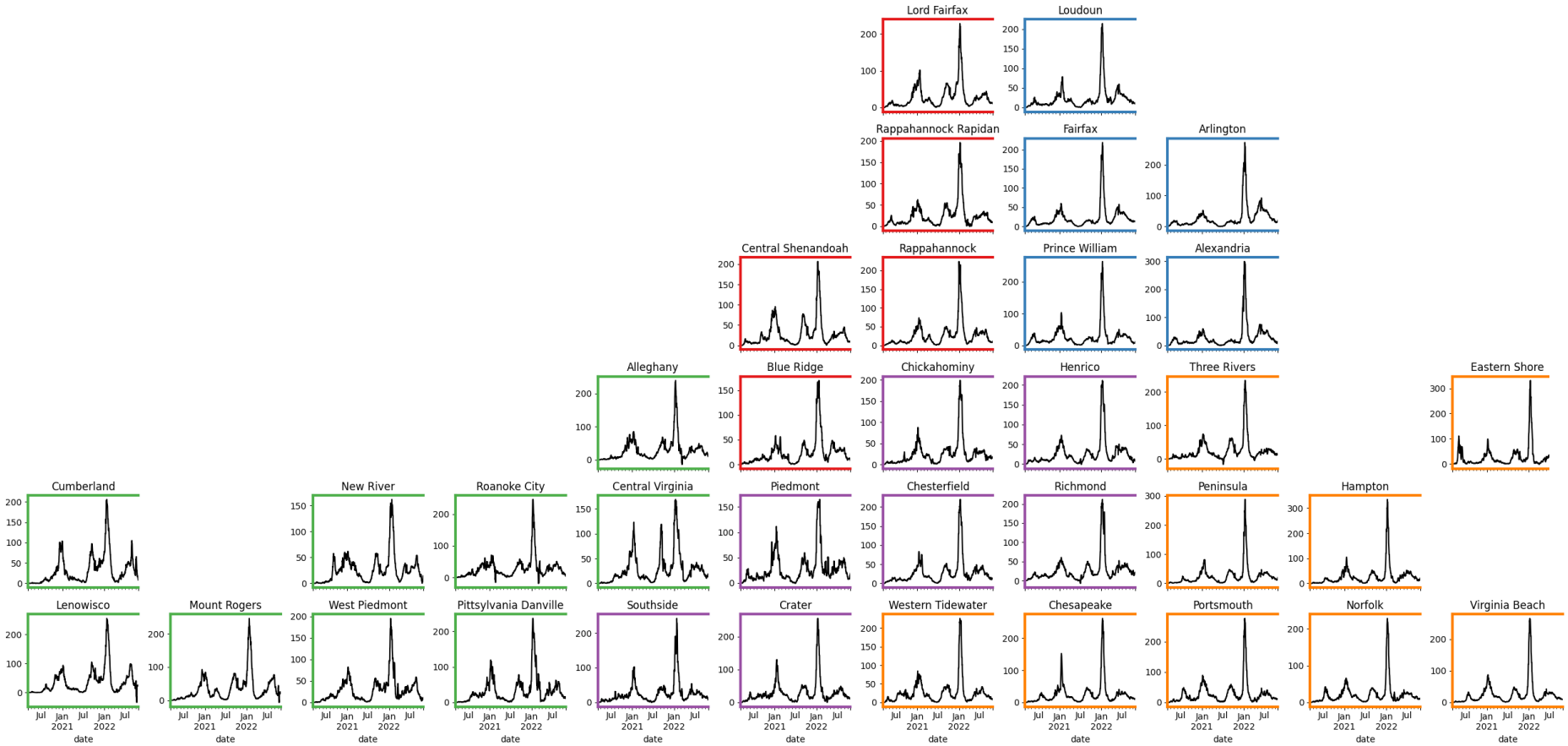
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

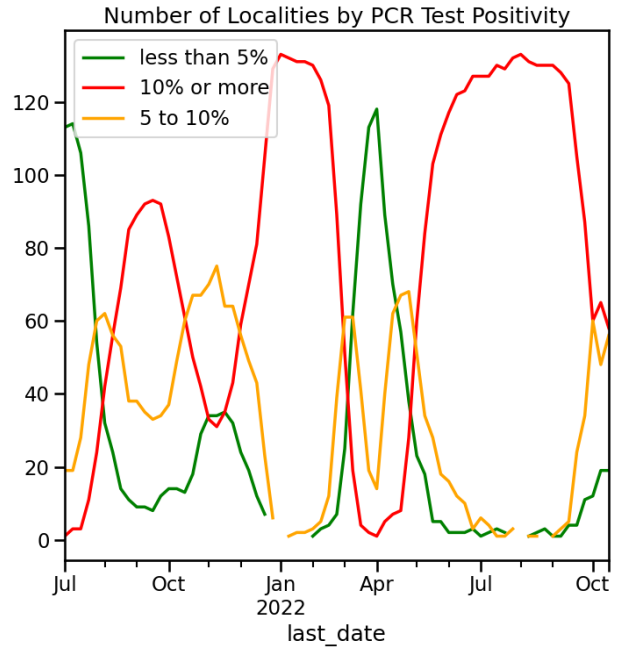
- **Case rates have continued to decline though hospitalizations have shown some recent growth**
- VA weekly case rate is slightly down at 81 per 100K from 84 per 100K
  - US weekly case rate is flat remaining at 74 per 100K from 74 per 100K
  - VA hospital occupancy (rolling 7 day mean of 455 slightly down from 482 a week ago) down but experiencing recent activity
- Sub-variant prevalence has started to grow rapidly, BA.5 subvariants seem to be accelerating
- Projections from last week remain largely on target with limited impact of Fall Winter scenario, however hospitalization trajectories

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)

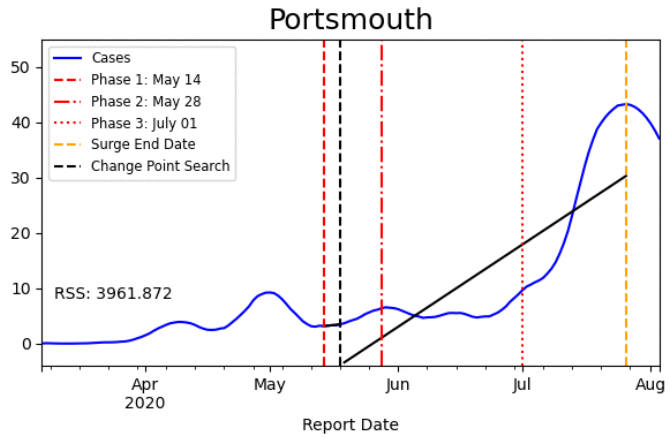
Red: >10.0% (and not "Green" or "Yellow")

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

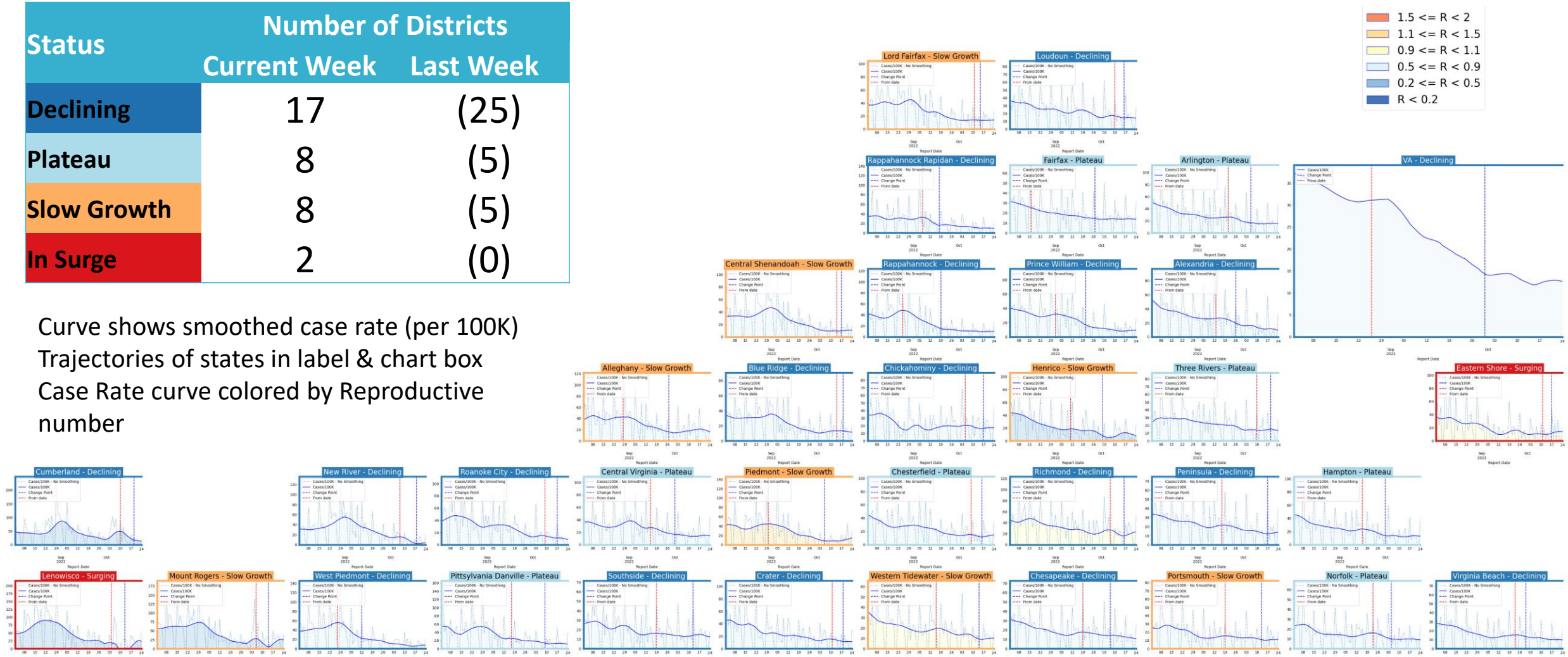


Trajectory	Description	Weekly Case Rate Slope (per 100k)	Weekly Hosp Rate Slope (per 100k)
Declining	Sustained decreases following a recent peak	slope < -0.88/day	slope < -0.07/day
Plateau	Steady level with minimal trend up or down	-0.88/day < slope < 0.42/day	-0.07/day < slope < 0.07/day
Slow Growth	Sustained growth not rapid enough to be considered a Surge	0.42/day < slope < 2.45/day	0.07/day < slope < 0.21/day
In Surge	Currently experiencing sustained rapid and significant growth	2.45/day < slope	0.21/day < slope

District Case Trajectories – last 10 weeks

Status	Number of Districts	
	Current Week	Last Week
Declining	17	(25)
Plateau	8	(5)
Slow Growth	8	(5)
In Surge	2	(0)

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



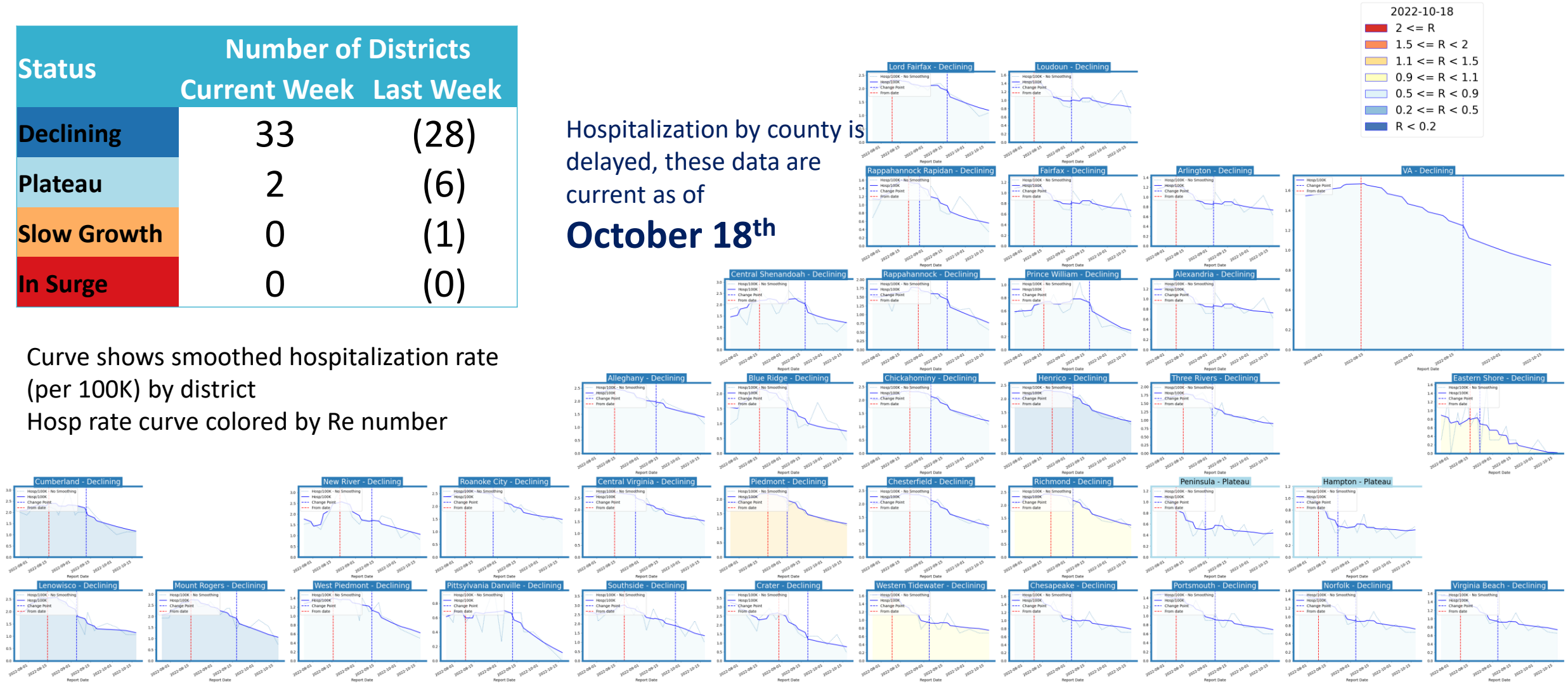
District Hospital Trajectories – last 10 weeks

Status	Number of Districts	
	Current Week	Last Week
Declining	33	(28)
Plateau	2	(6)
Slow Growth	0	(1)
In Surge	0	(0)

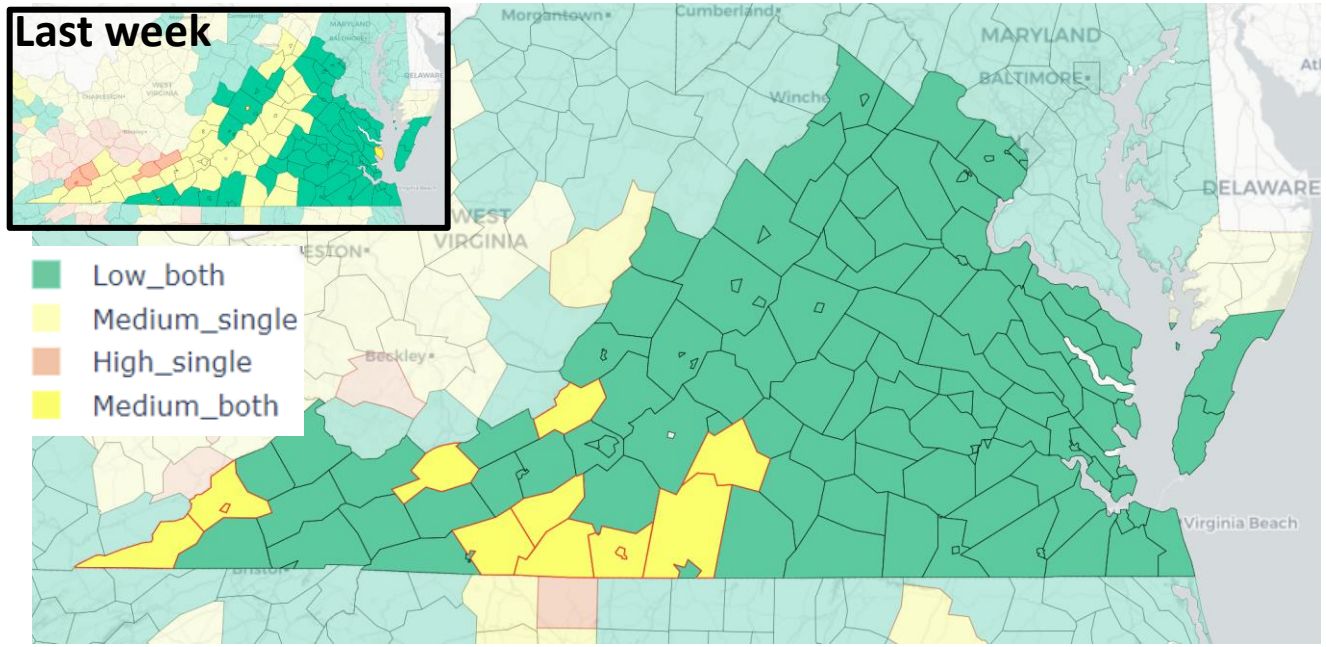
Curve shows smoothed hospitalization rate (per 100K) by district
Hosp rate curve colored by Re number

Hospitalization by county is delayed, these data are current as of

October 18th



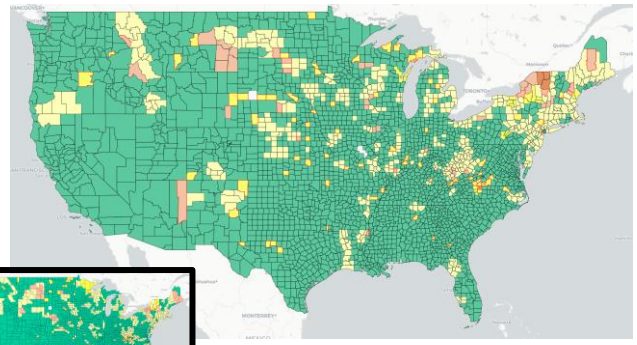
CDC's COVID-19 Community Levels

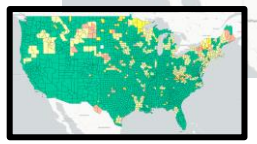


Red outline indicates county had 200 or more cases per 100k in last week

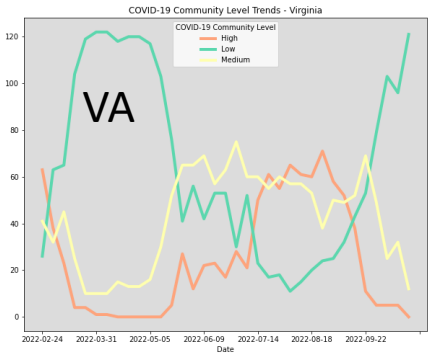
Pale color indicates either beds or occupancy set the level for this county

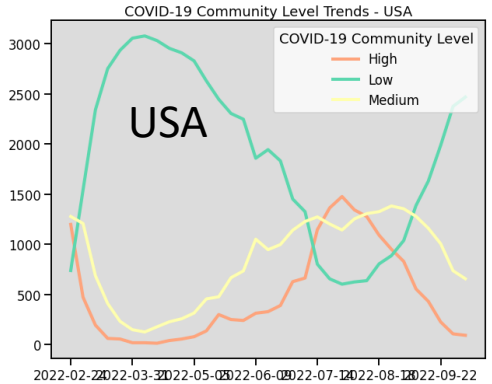
Dark color indicates both beds and occupancy set the level for this county





Last week





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%

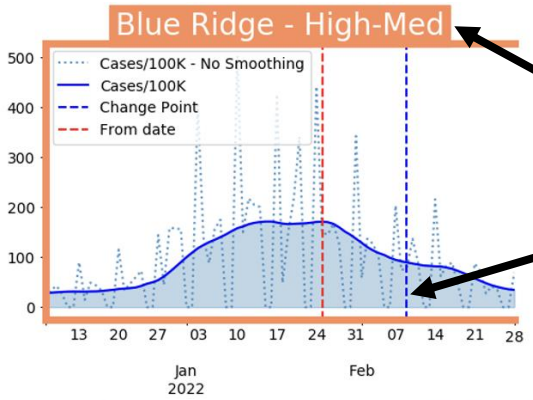
The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

District Trajectories with Community Levels

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

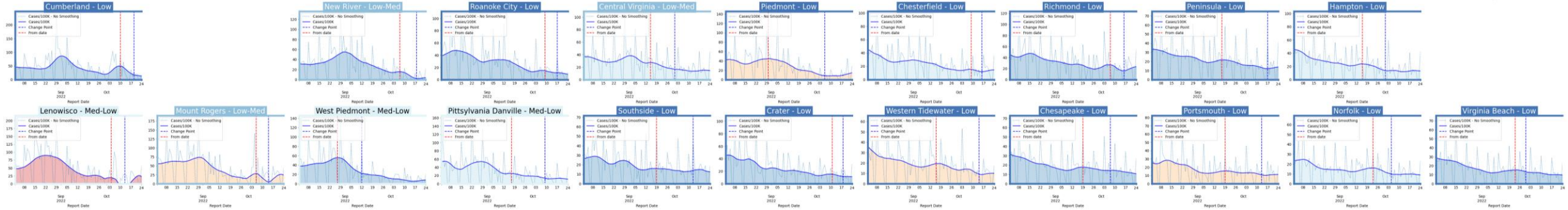
Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory

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



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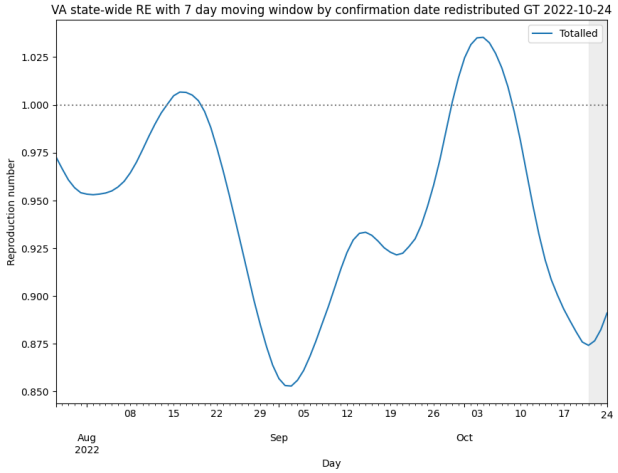
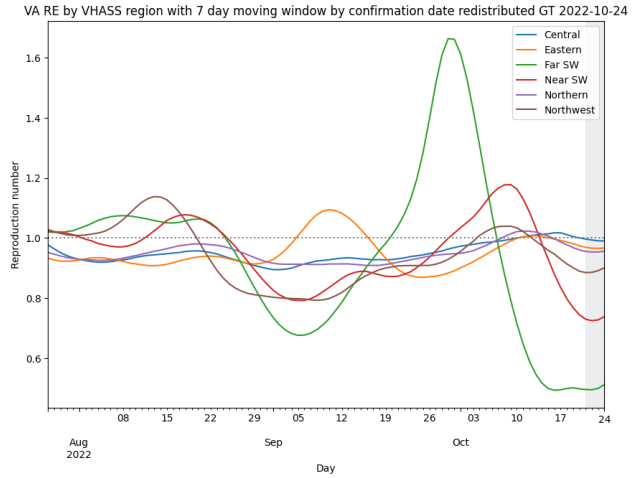
Estimating Daily Reproductive Number – Redistributed gap

October 24th Estimates

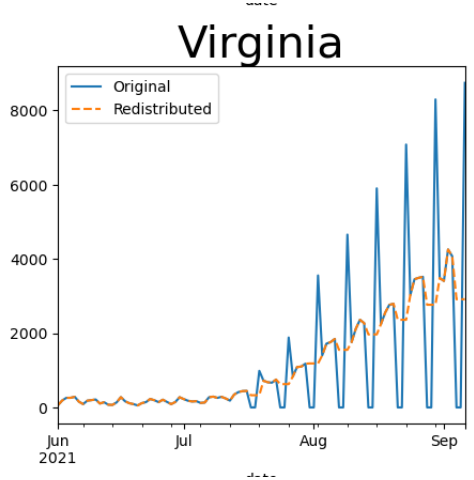
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.890	-0.033
Central	0.989	0.059
Eastern	0.958	-0.028
Far SW	0.502	-0.021
Near SW	0.741	-0.329
Northern	0.955	-0.062
Northwest	0.901	-0.016





Skipping Weekend Reports & holidays biases estimates

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



Methodology

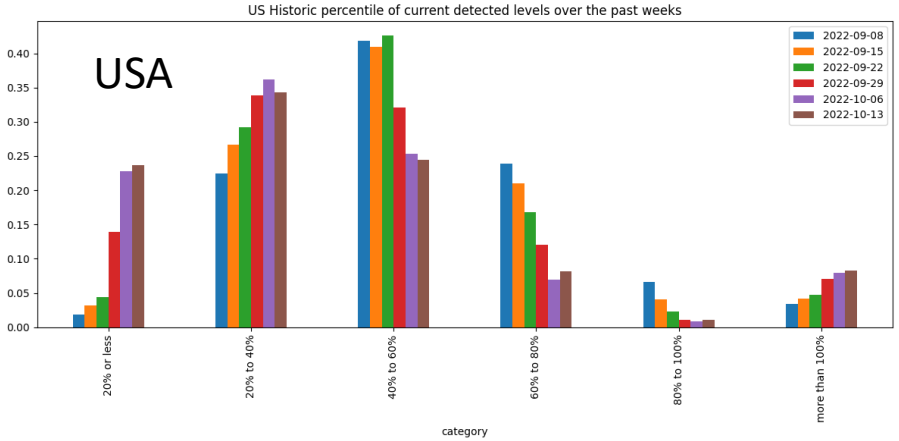
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

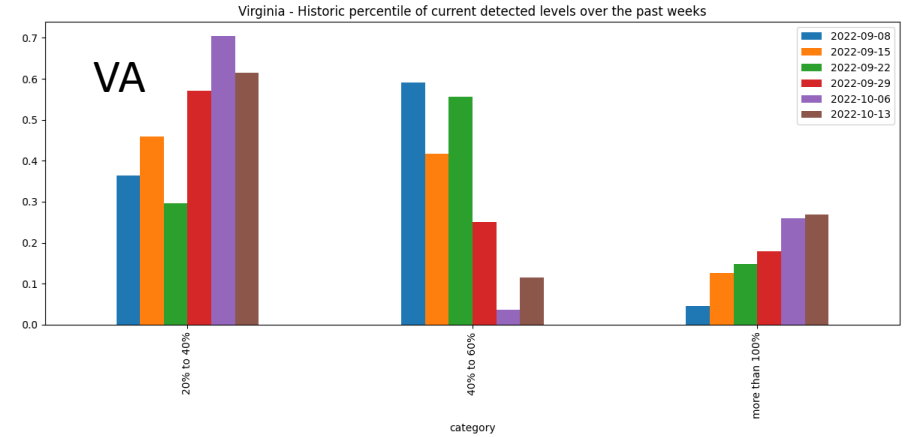
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

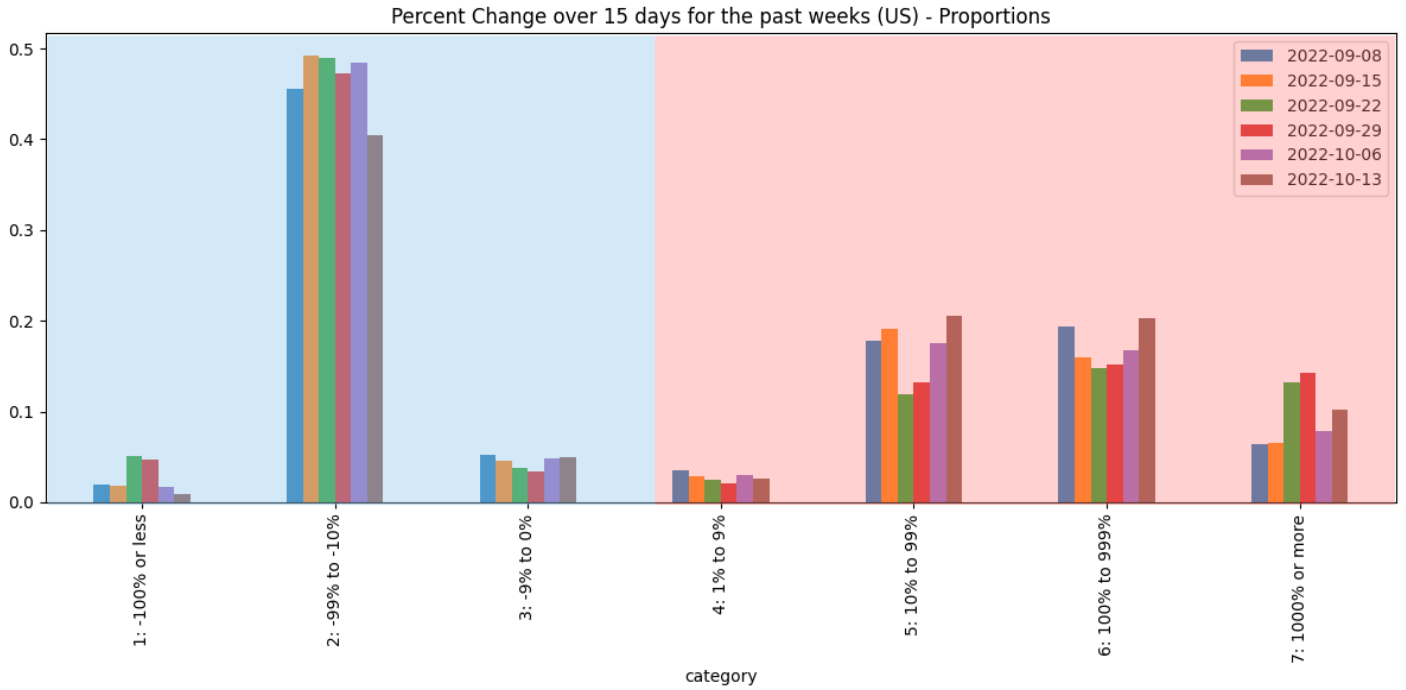
Wastewater Monitoring

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





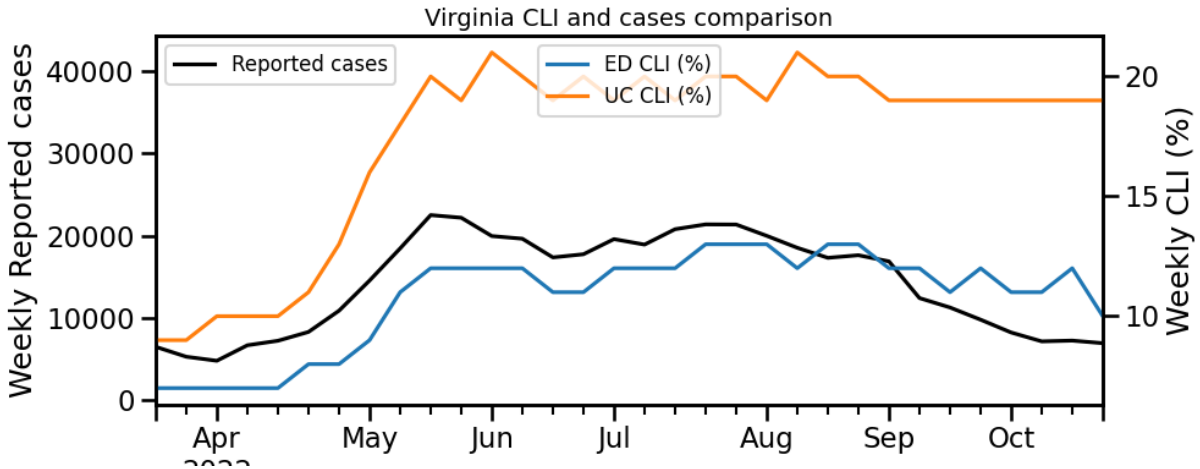


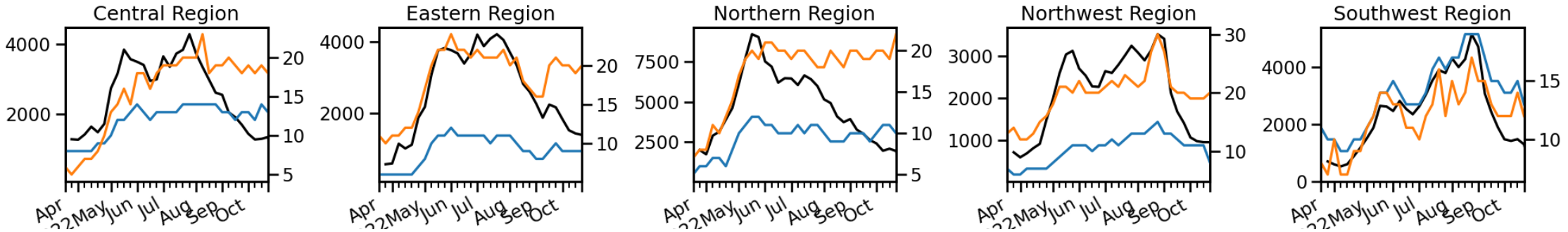
Data Source: [CDC Data Tracker]

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 since May 2022, mixed by region**



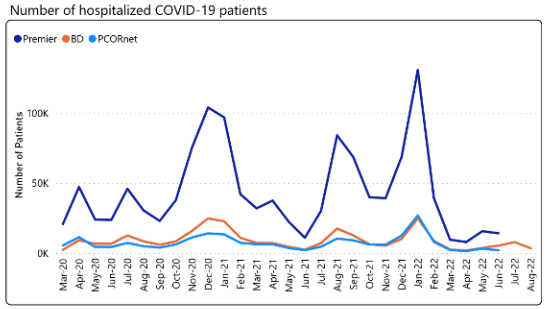


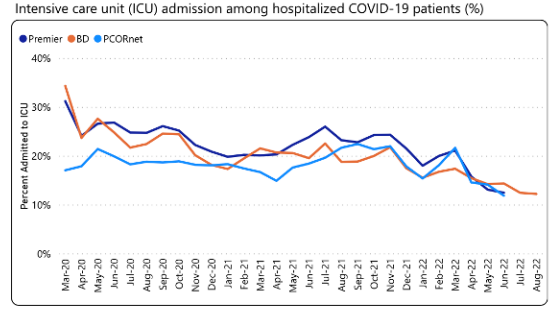
Hospitalizations and Severe Outcomes

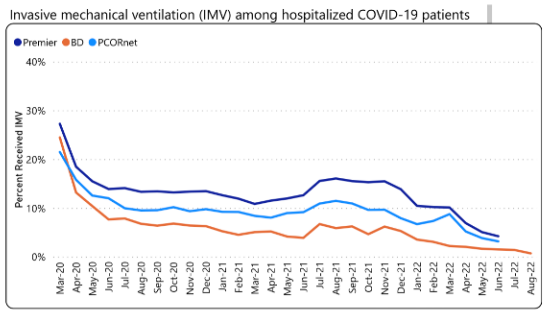
Data Source: [CDC Data Tracker]

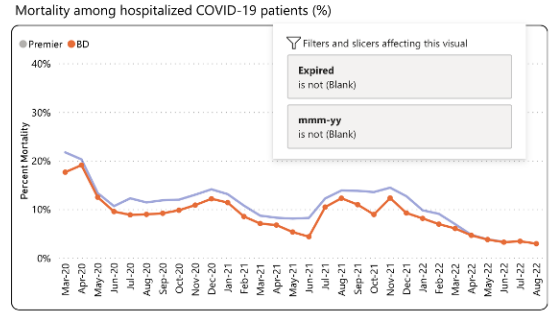
Proportion of most severe outcomes decreasing among those who are hospitalized

- ICU has declined from ~20% of hospitalized to nearly 10% since initial Omicron wave
- Also seen across all age-groups
- Similar levels of decline seen in VA
- Regionally more variation

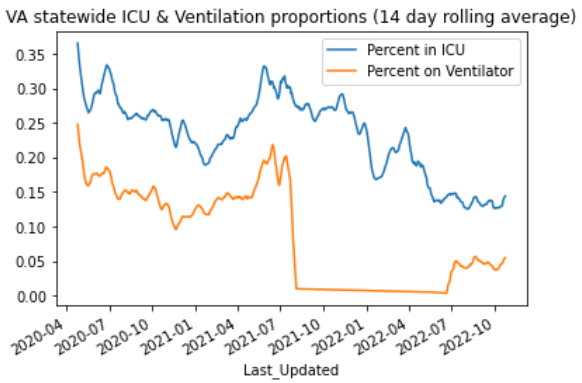




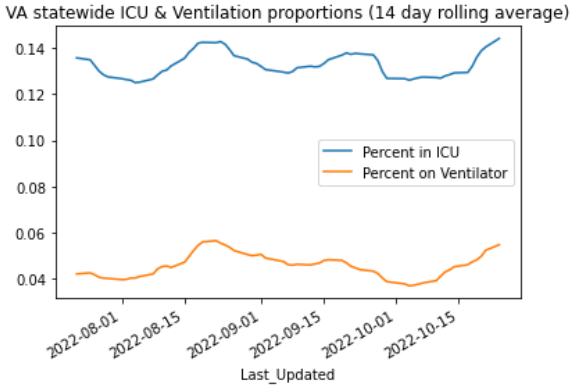




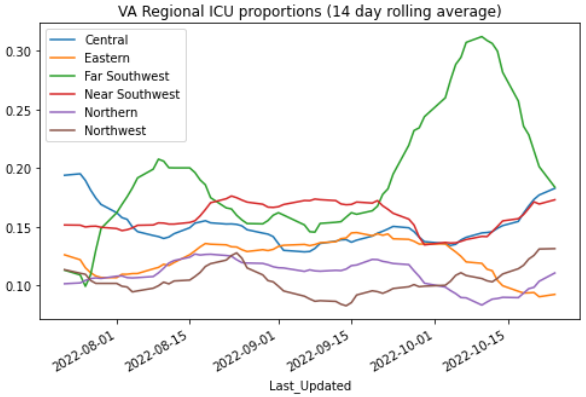
Virginia wide – full pandemic



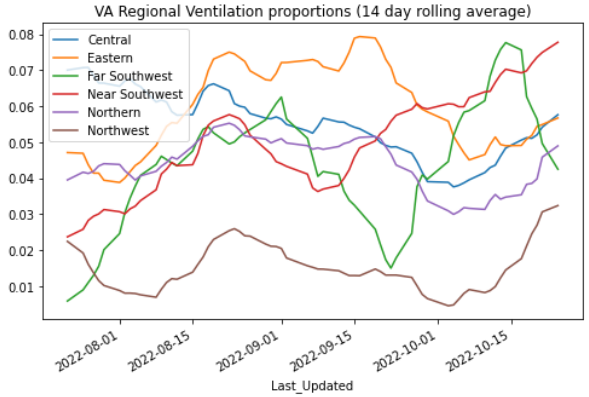
Virginia wide – recent



Virginia Regional ICU percent



Virginia Regional Ventilation %



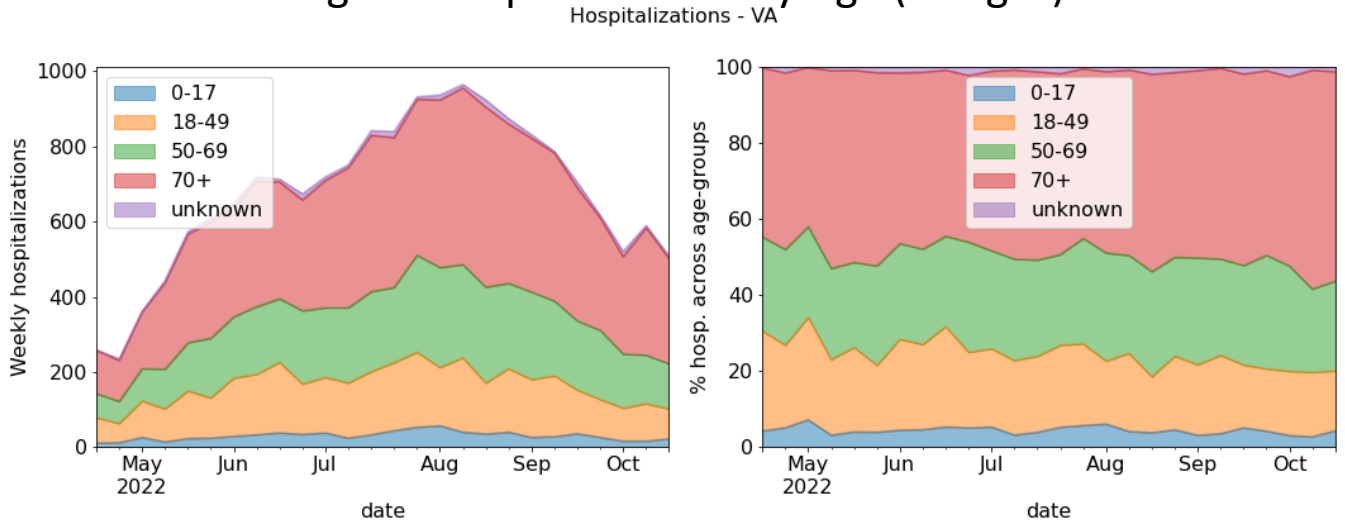
Hospitalizations in VA by Age

Age distribution in hospitals relatively stable

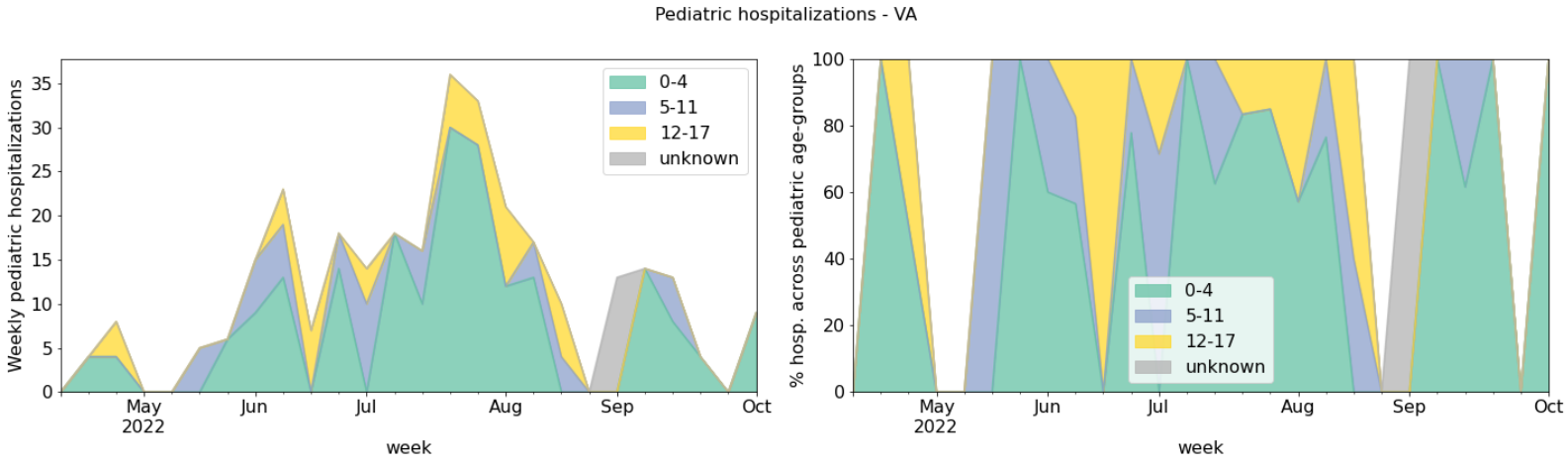
- Recent change in pediatric hospitalizations, though not higher yet than in previous months

Note: These data are lagged and based on hospital reporting HHS

Virginia Hospitalizations by Age (all ages)



Pediatric Hospitalizations by Age (0-17yo)



Data Source: Delphi and HHS

SARS-CoV2 Variants of Concern

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

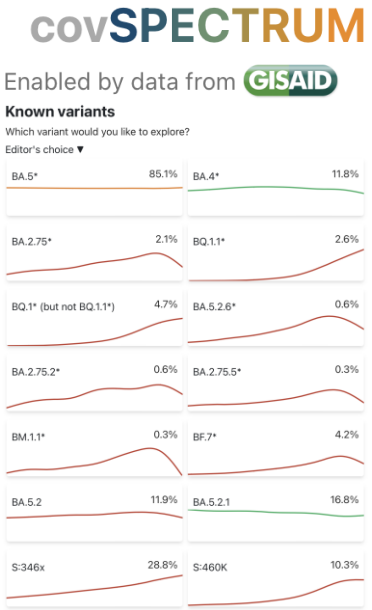
- **Emerging variants can:** Increase transmissibility, increase severity (more hospitalizations and/or deaths), and limit immunity provided by prior infection and vaccinations

Omicron Updates

- Soup of variants has grown to 41% of variants from 36% last week
- BQ.1.1 continues to show quick growth up to 10.5% from 7%, with BQ.1.* accounting for another 7%
- BF.7 continues steady slow growth at 7.3%
- BA.4.6 remains steady at 11-13% for last 4 weeks
- BQ.1.1 recently seeing growth in England and other countries that mimics past variants of concern that have gone on to dominate
- BA.2.75.2 also shows signs as being a potential candidate as a future variant of concern, has recently been shown to have significant immune escape

Relative Growth Advantages

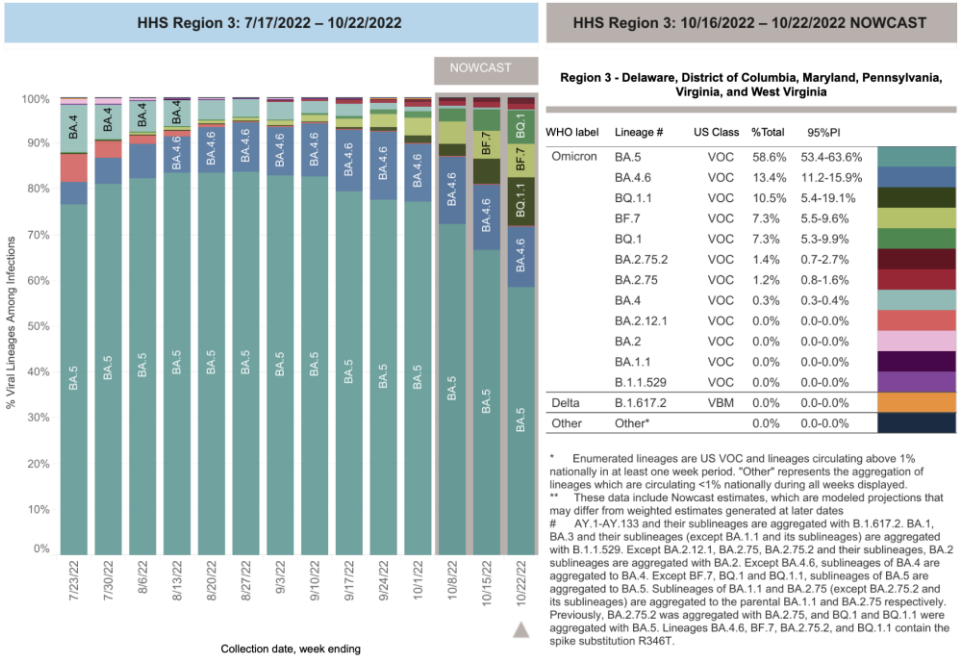
COV-spectrum



COV-spectrum

“Editor’s choice”

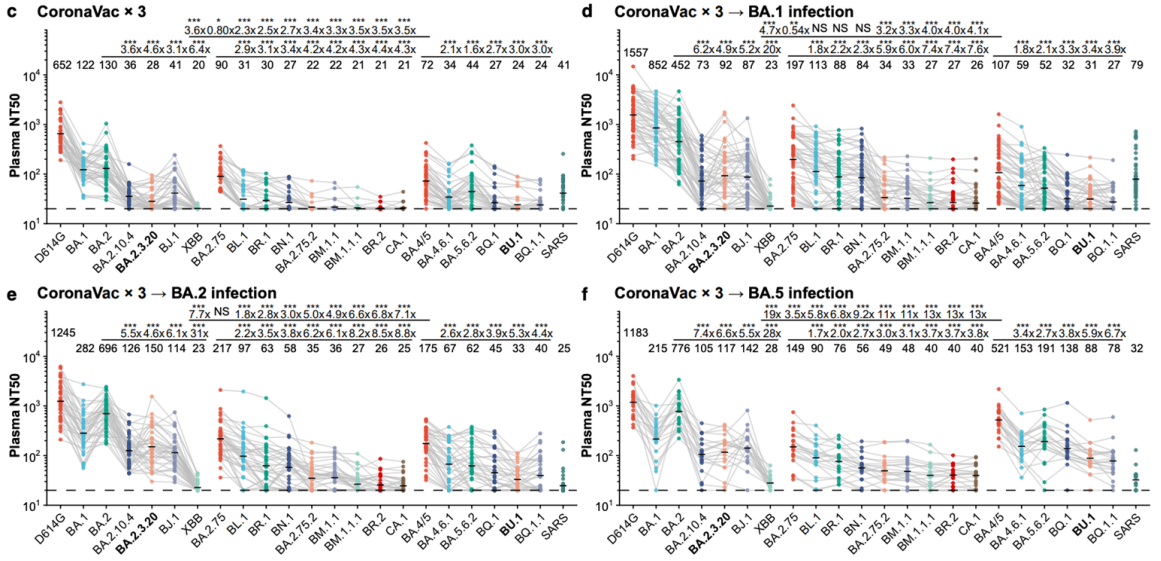
Variants to watch

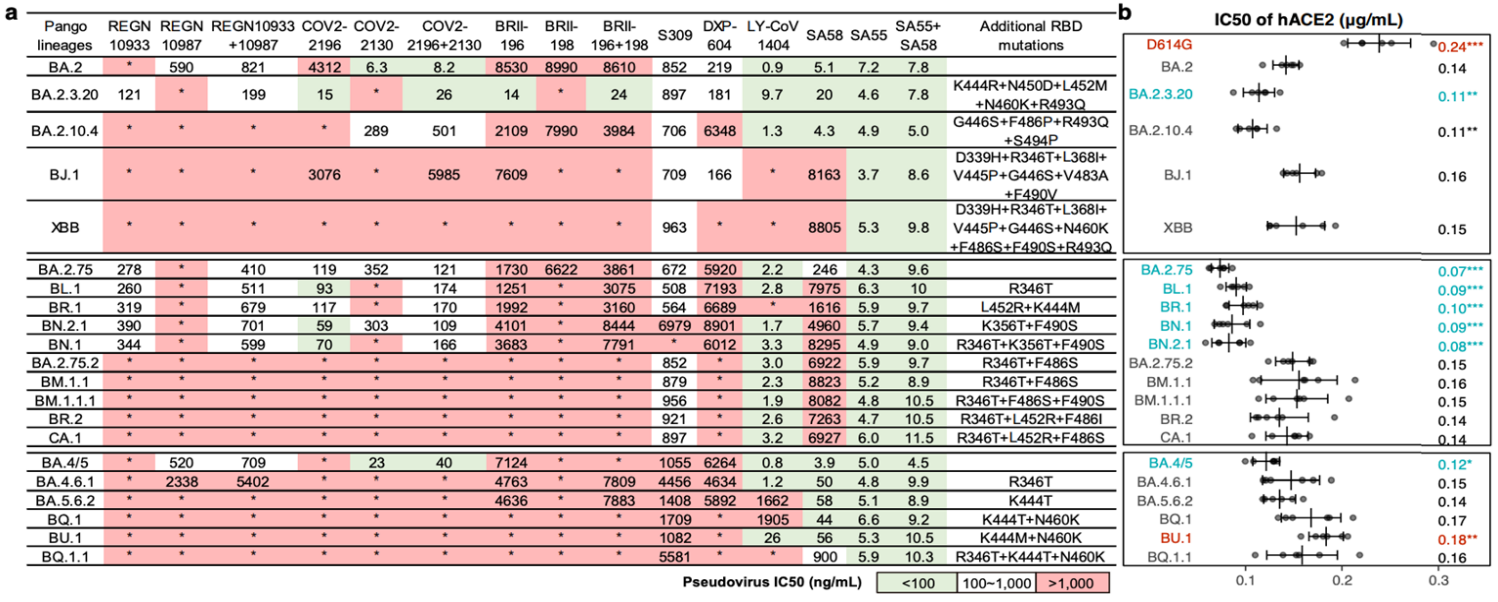


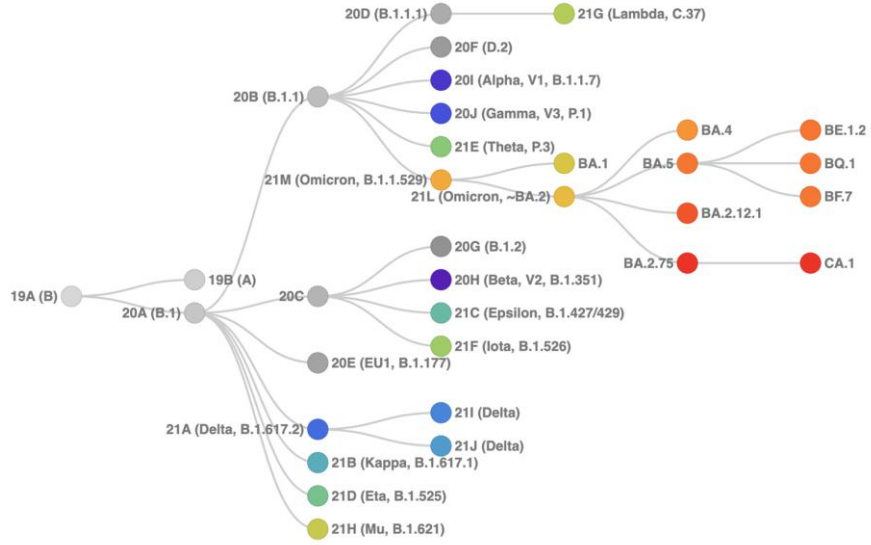
CDC Variant Tracking

Pandemic Pubs

Both BQ.1.1 and XBB show substantial immune escape and significant negation of many pharmaceutical interventions. XBB is significantly more immune evasive than BA.2.75.2 and BQ.1.1 against plasma from all breakthrough infections, comparable to or even exceeding the level of escape displayed by SARS-CoV-1 against SARS-CoV-2 convalescent plasma.





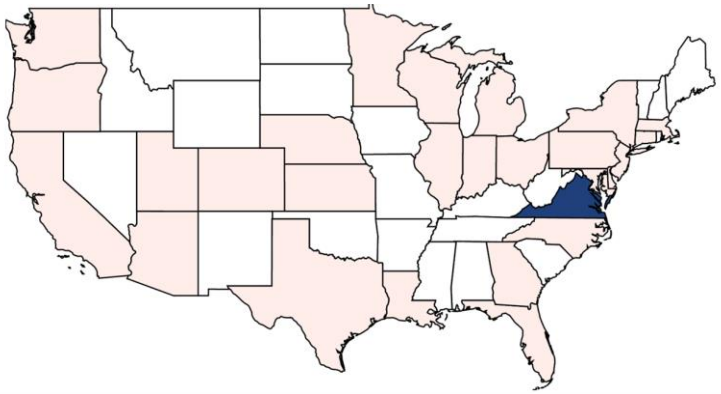


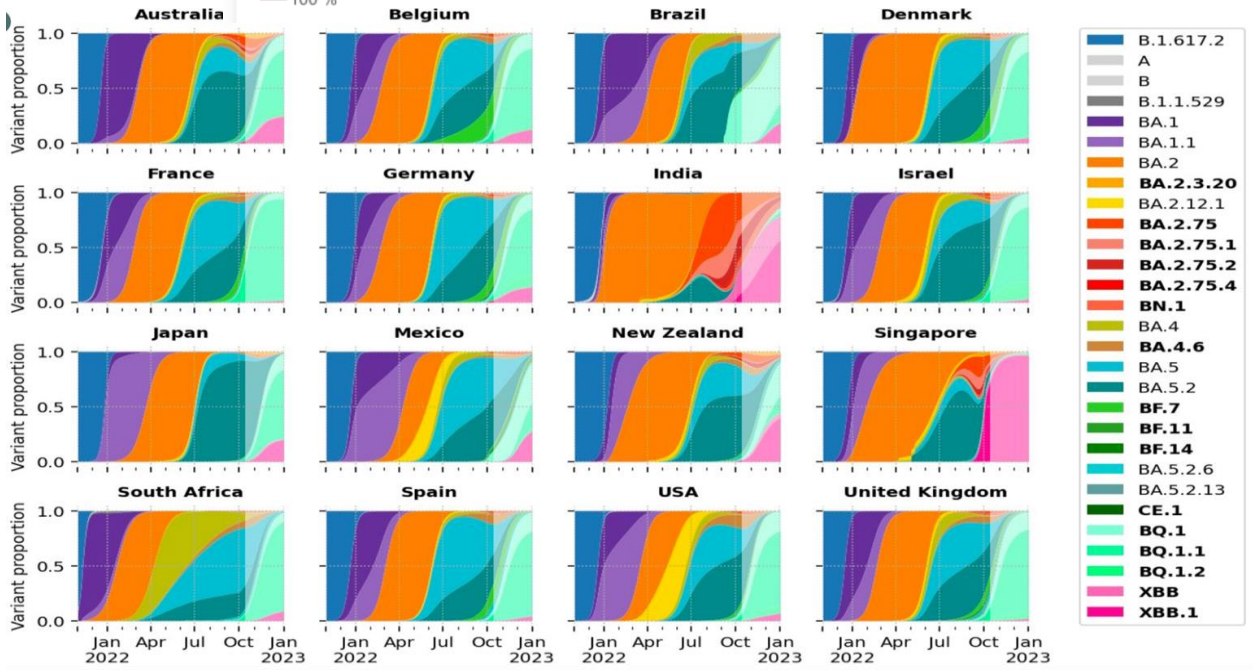
https://github.com/aswarren/ncov-clades-schema

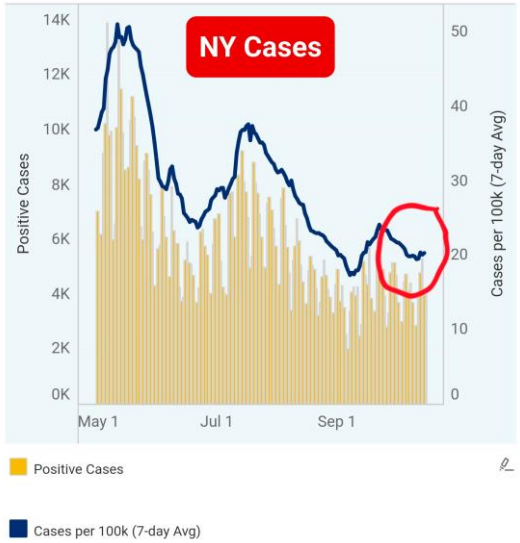
Researchers in Beijing characterize multiple concerning immune escape variants using plasma from breakthrough infections in those vaccinated with three doses of CoronaVac. **Similar to BQ.1.1, XBB also escapes Evusheld and Bebtelovimab**. BU.1, BR.2, BM.1.1.1, CA.1, and XBB all displayed moderate hACE2 binding relative to previously widely circulating variants of BA.2 and BA.5.
https://www.biorxiv.org/content/10.1101/2022.09.15.507787v3
https://twitter.com/yunlong_cao/status/1577343549120872448

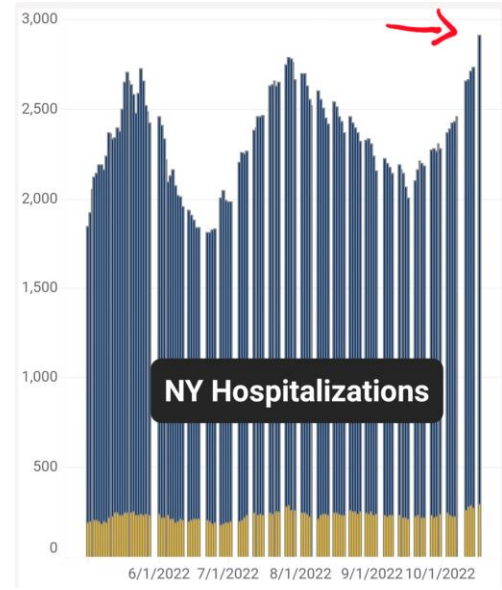
Pandemic Pubs

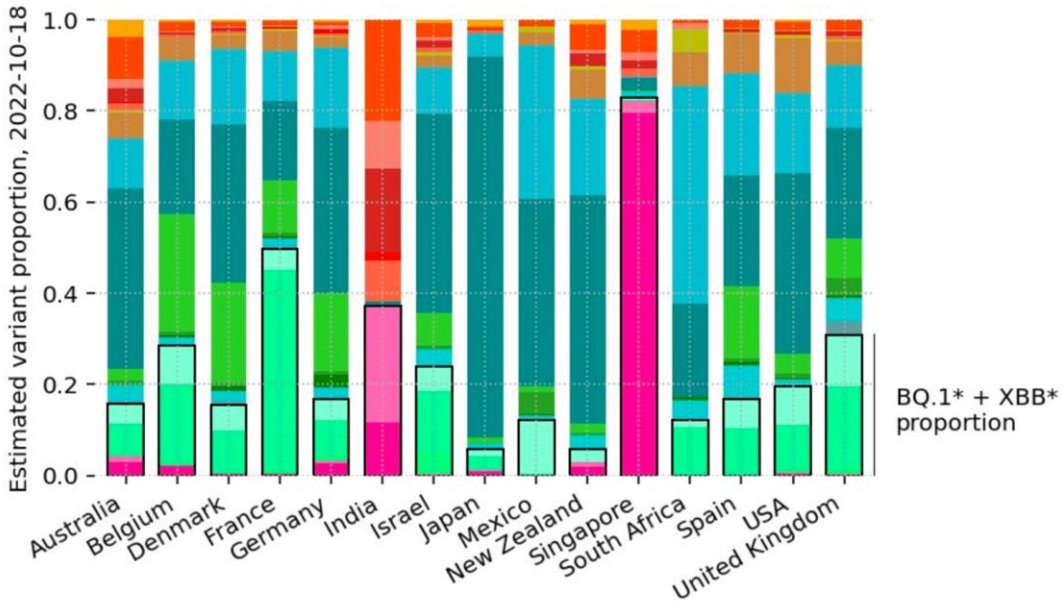
Both BQ.1.1 and XBB show substantial immune escape and significant negation of many pharmaceutical interventions. XBB is significantly more immune evasive than BA.2.75.2 and BQ.1.1 against plasma from all breakthrough infections. BQ.1.1 shows strong growth in NY and has been detected at increasing levels throughout the country.











https://twitter.com/MoritzGerstung/status/1582266906777526274
https://twitter.com/JPWeiland/status/1581735046704074752
https://cov-spectrum.org/explore/United%20States/AllSamples/Past6M/variants?nextcladePangoLineage=BQ.1.1*&

Pandemic Pubs

XBB, a SARSCoV2 recombinant, shows strong growth in Singapore. Reportedly 17% of recent infections are reinfections. Increase in hospitalized cases remains proportional to the increase in local cases, likely as a result of strong vaccine uptake in the country.

MINISTRY OF HEALTH
SINGAPORE

Over the last 28 days,

Infected
143,627

99.8%
Had No or Mild Symptoms

0.2%
Required Oxygen Supplementation

0.03%
ICU

0.02%
Died

MINISTRY OF HEALTH
SINGAPORE

As of 18 Oct 2022, 12:00pm

New Cases

8,243
7-day Moving Average of Local Cases

716
Local PCR

10,837
Local ART

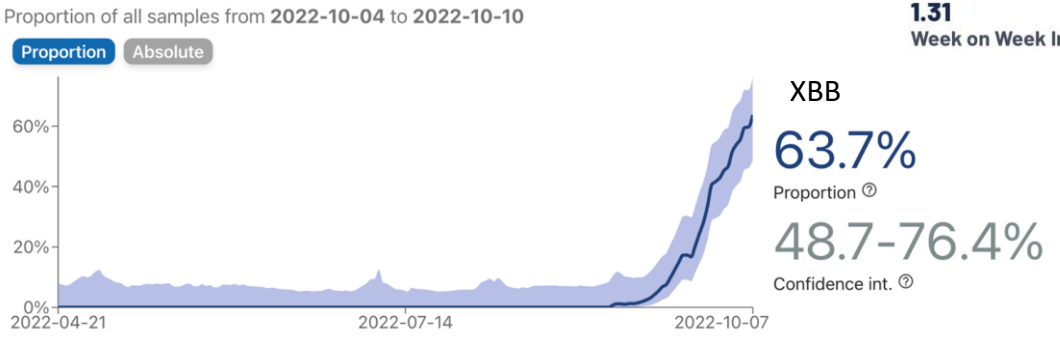
15
Imported PCR

366
Imported ART

8,097
Discharged

5
Died

1.31
Week on Week Infection Ratio



XBB
63.7%
Proportion
48.7-76.4%
Confidence int.

MINISTRY OF HEALTH
SINGAPORE

As of 17 Oct 2022 (COVID-19 vaccines under National Vaccination Programme only)

92% of total population
Received at least one dose

95% of eligible population
92% of total population
Completed full regimen

79% of total population
Received booster shots

MINISTRY OF HEALTH
SINGAPORE

COVID-19

COVID-19 Situation at a Glance →

As of 18 Oct 2022, 12:00pm

Hospitalised
661

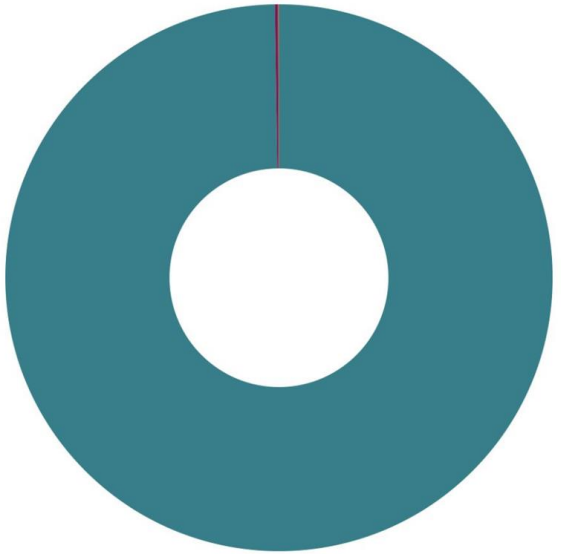
58
Required Oxygen Supplementation

14
ICU

MINISTRY OF HEALTH
SINGAPORE

As of 18 October 2022, 12pm

Local Cases in the Last 28 Days by Severity of Condition

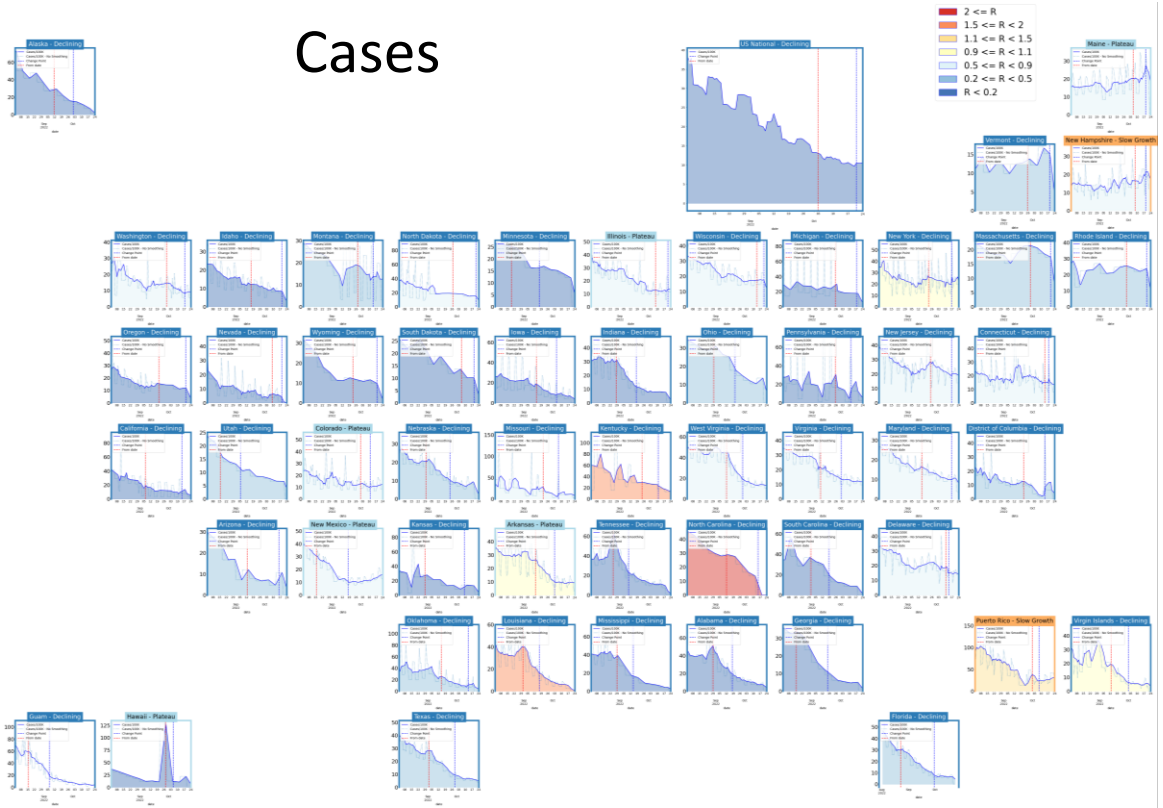


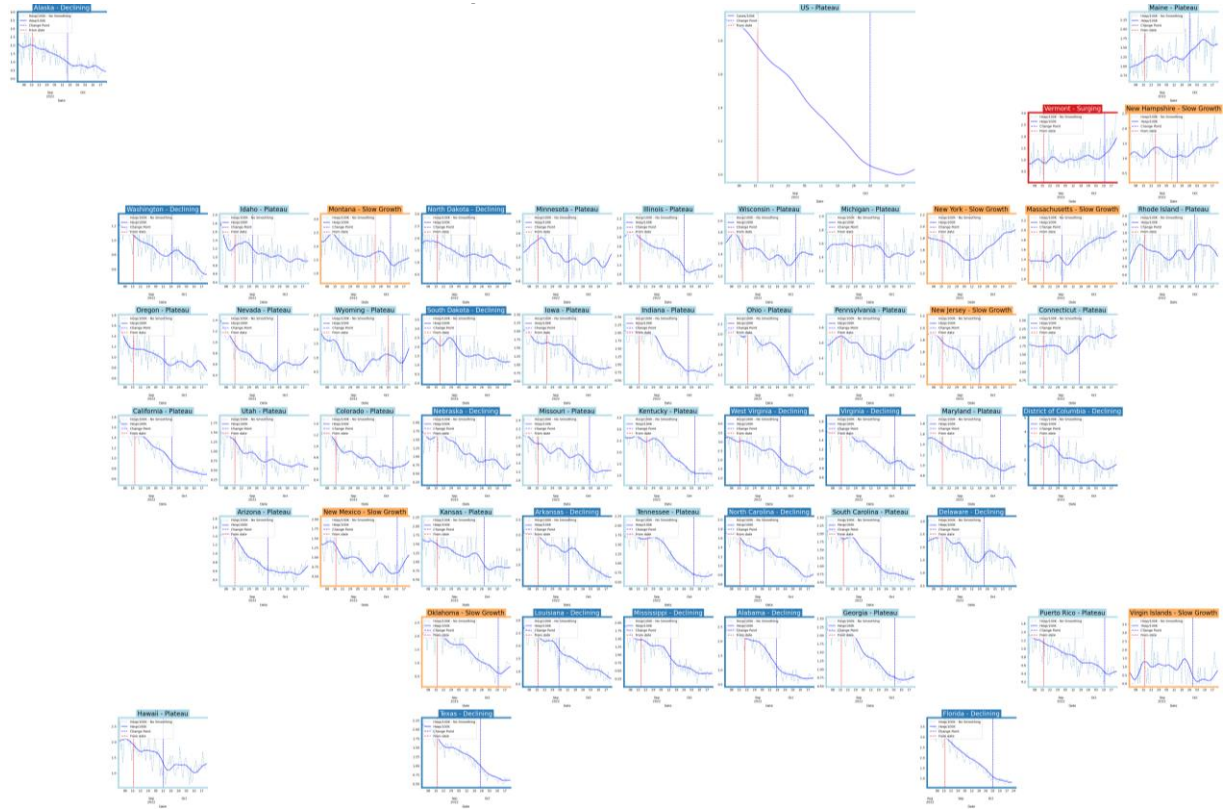
Asymptomatic/Mild Symptoms	143,289 (99.8%)
Ever Required Oxygen Supplementation in General Ward	263 (0.2%)
Ever in ICU	42 (0.03%)
Deceased	33 (0.02%)

https://twitter.com/sailorrooscout/status/1582388135434268673
https://cov-spectrum.org/explore/Singapore/AllSamples/Past6M/variants?nextcladePangoLineage=XBB*&
https://www.moh.gov.sg/news-highlights/details/opening-remarks-by-minister-for-health-mr-ong-ye-kung-at-the-moh-press-conference-to-update-on-the-covid-19-situation-on-15-october-2022

United States Case & Hospitalizations

Cases



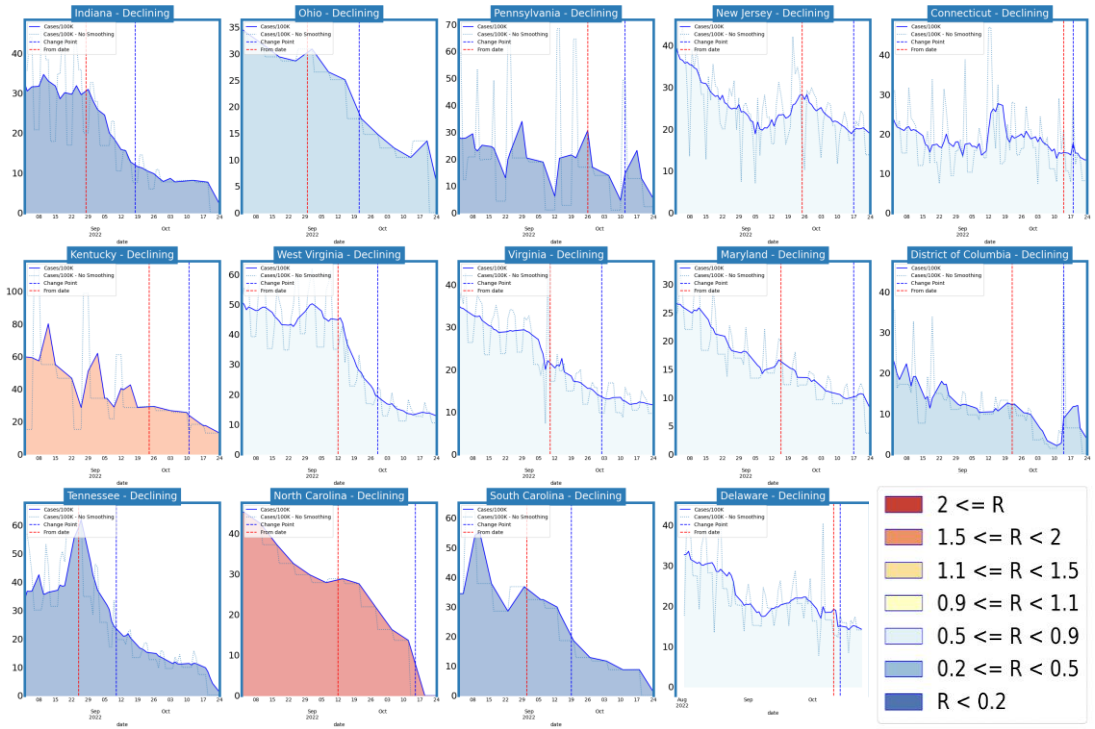


Status	Number of States	
	Current Week	Last Week
Declining	46	(48)
Plateau	6	(5)
Slow Growth	2	(1)
In Surge	0	(0)

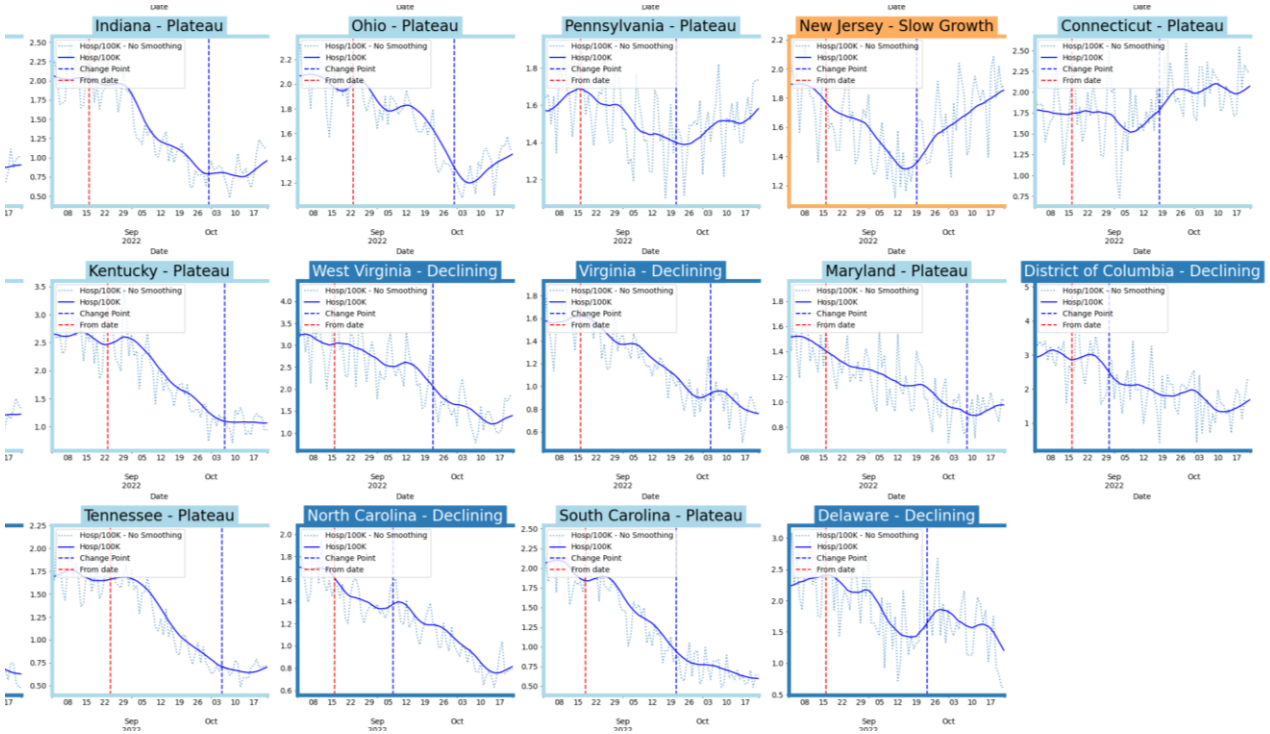
Status	Number of States	
	Current Week	Last Week
Declining	16	(22)
Plateau	28	(21)
Slow Growth	8	(9)
In Surge	1	(1)

Virginia and Her Neighbors

Cases

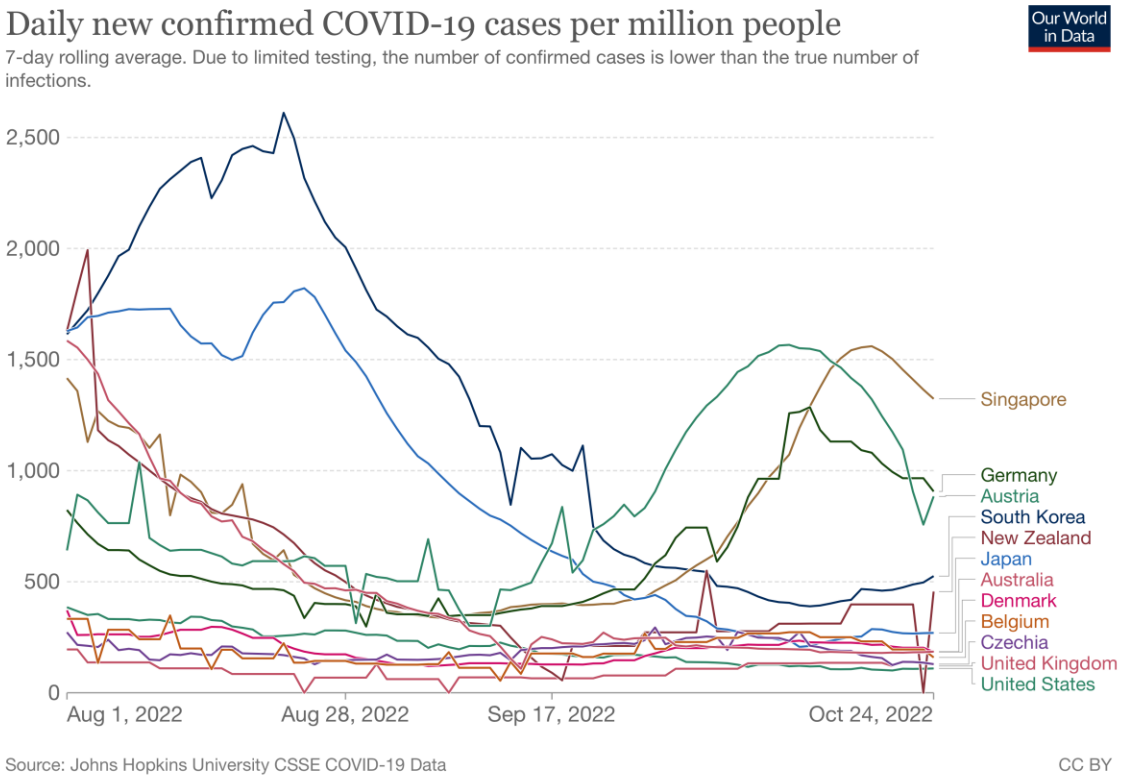


Hospitalizations

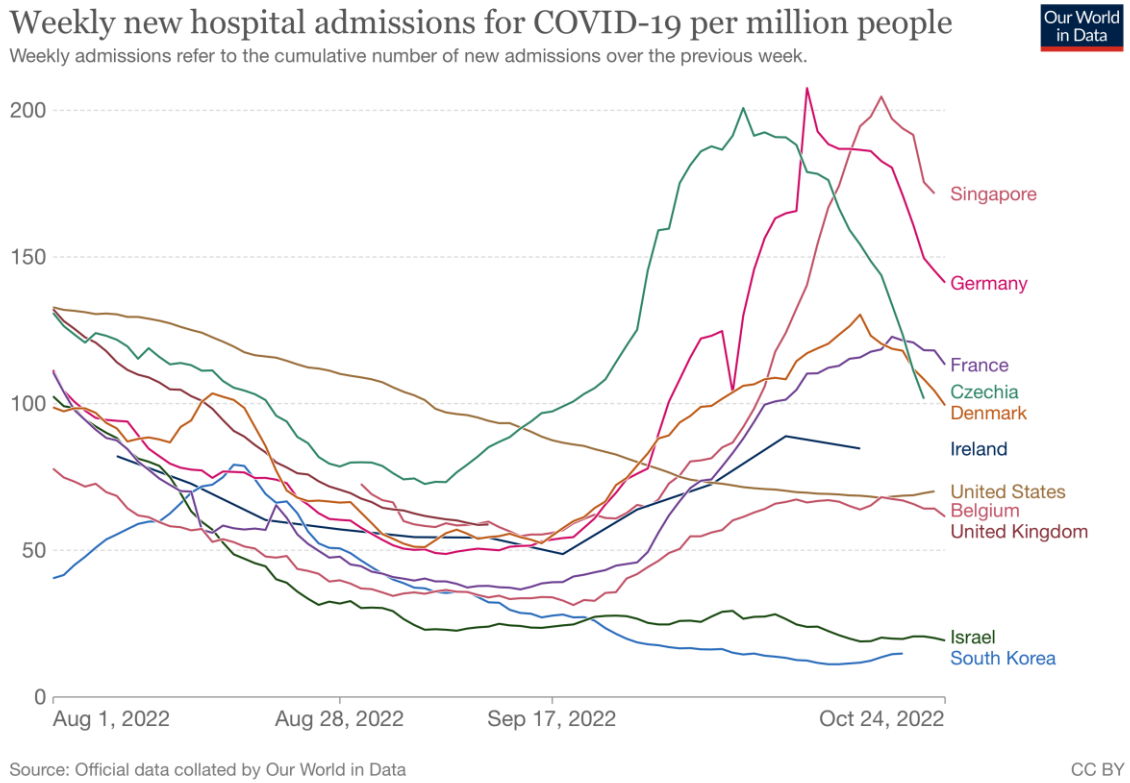


Around the World – Various trajectories

Confirmed cases



Hospitalizations



[Our World in Data]

Statistical Ensemble Models - Hospitalizations

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

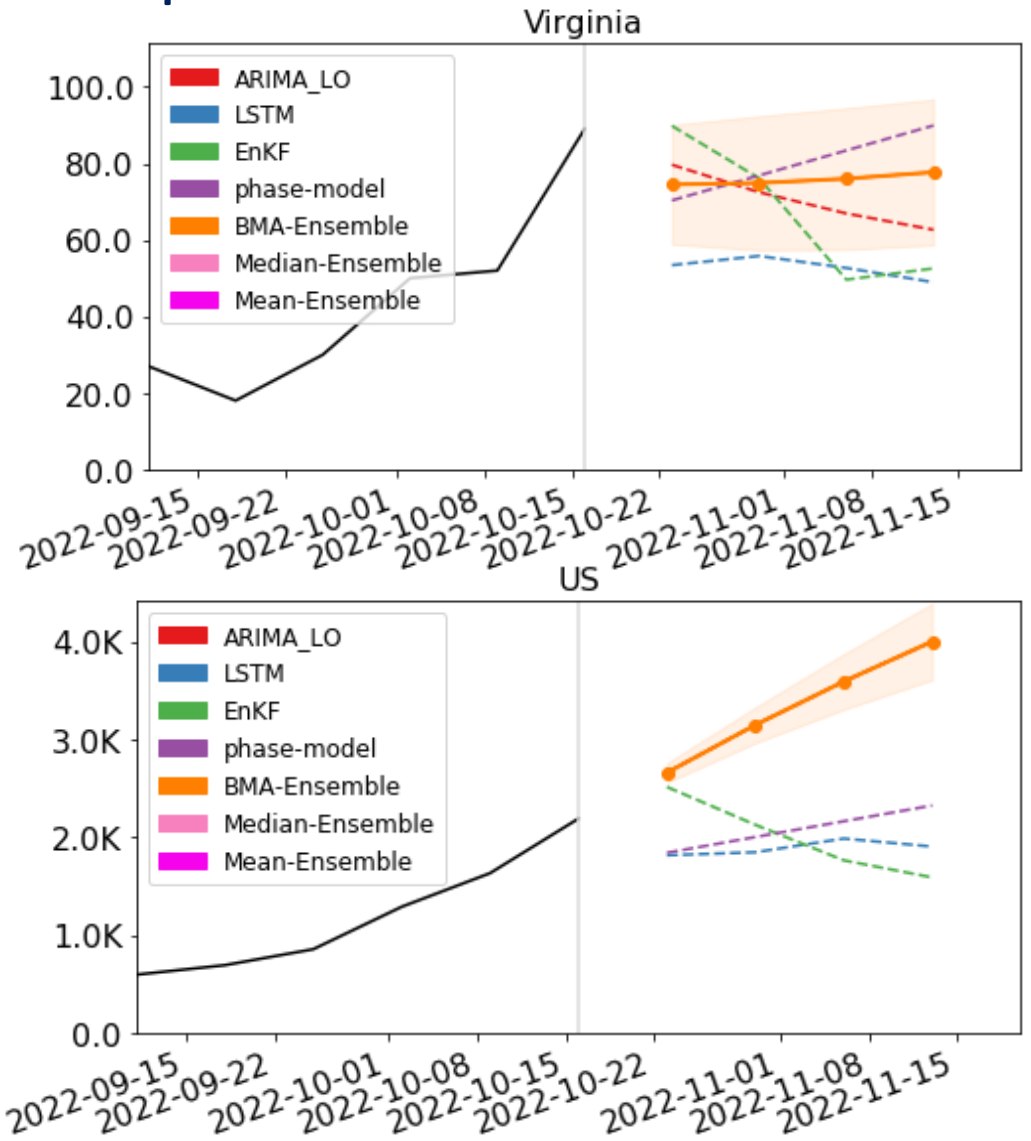
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)
- Phase-based ensembling (phase)

<u>Weekly forecasts of hospitalizations</u> done at state 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.

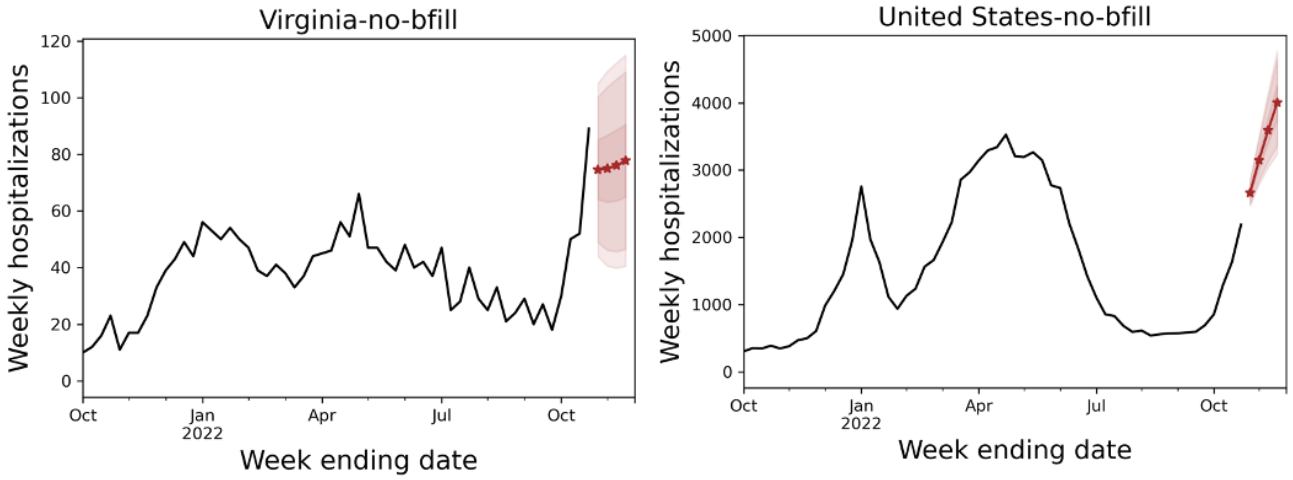


Current Influenza Hospitalization Forecast

Statistical models for submitting to CDC FluSight forecasting challenge

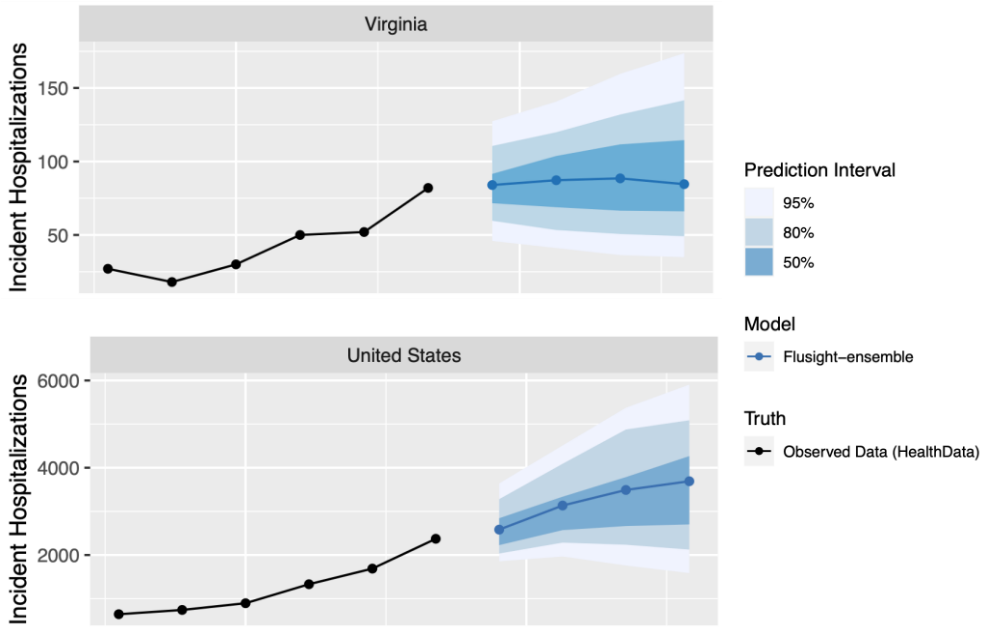
- Similar to COVID-19 case forecasts, uses a variety of statistical and ML approaches to forecast weekly hospital admissions for the next 4 weeks for all states in the US

Hospital Admissions for Influenza and Forecast for next 4 weeks (UVA ensemble)



Initial forecasts have wide uncertainty due to noisiness in data due to low numbers of hospitalizations

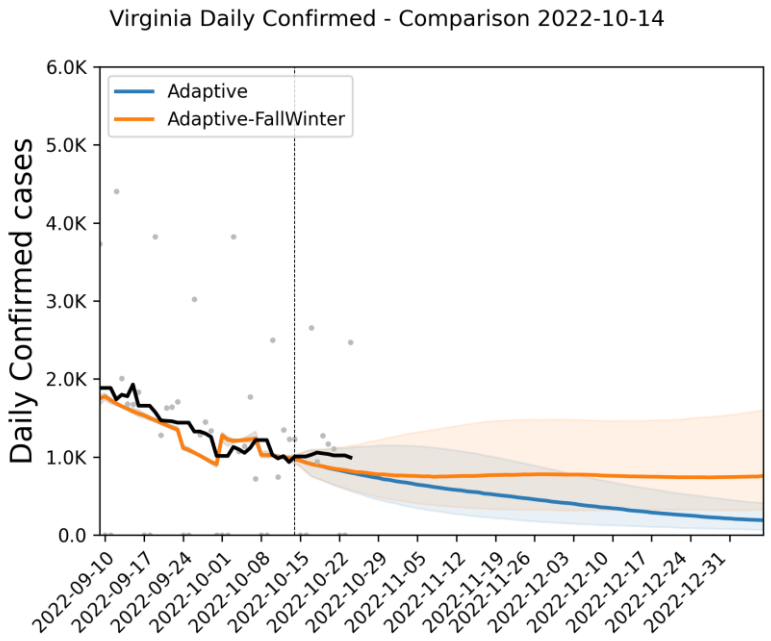
Hospital Admissions for Influenza and Forecast for next 4 weeks (CDC FluSight Ensemble)



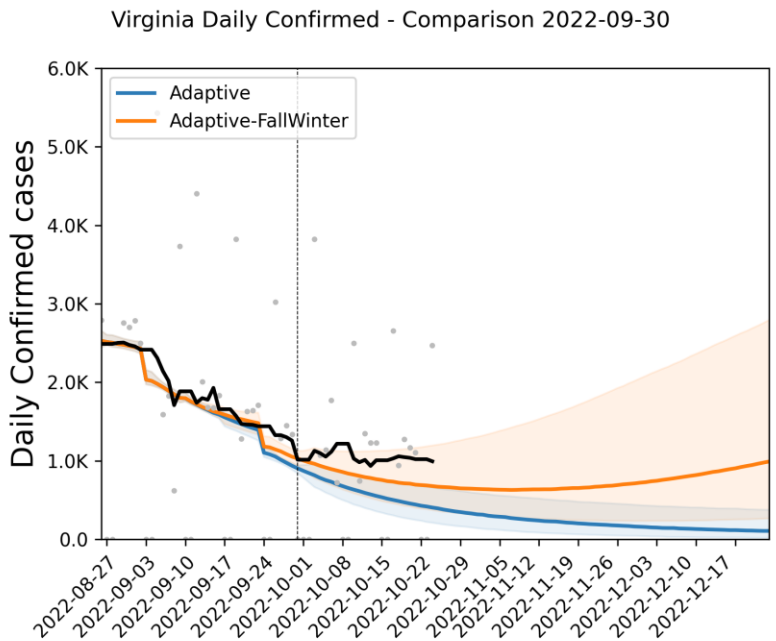
Previous projections comparison - Cases

- Previous projections continue to track observed cases
- Projection from 2 weeks ago projected continued decline but cases plateaued
- Projection from 4 weeks ago projected slower decline better capturing recent plateau

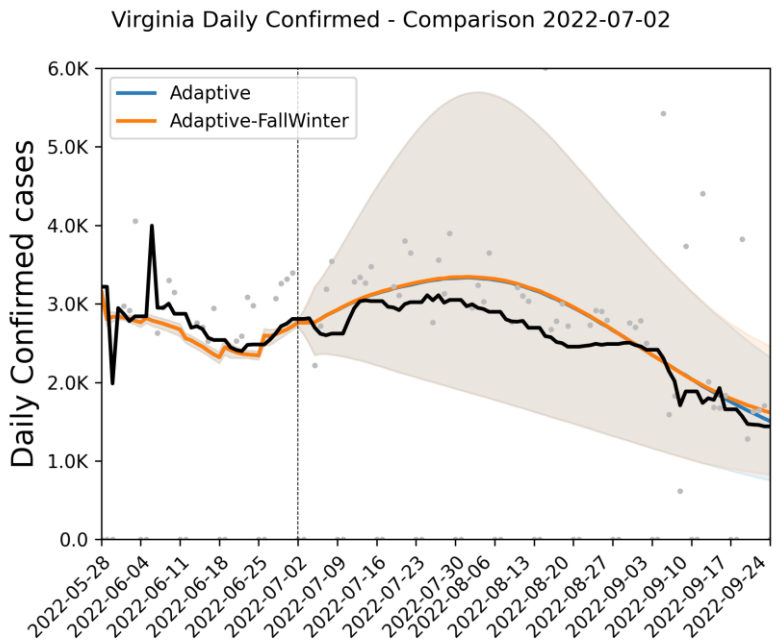
Projection from 1 week ago



Projection from 3 weeks ago



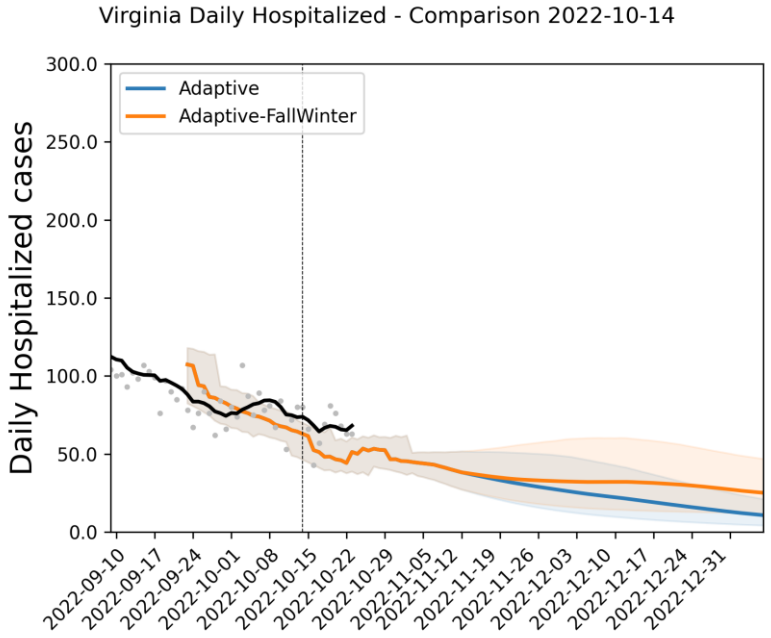
Projection from 3 months ago



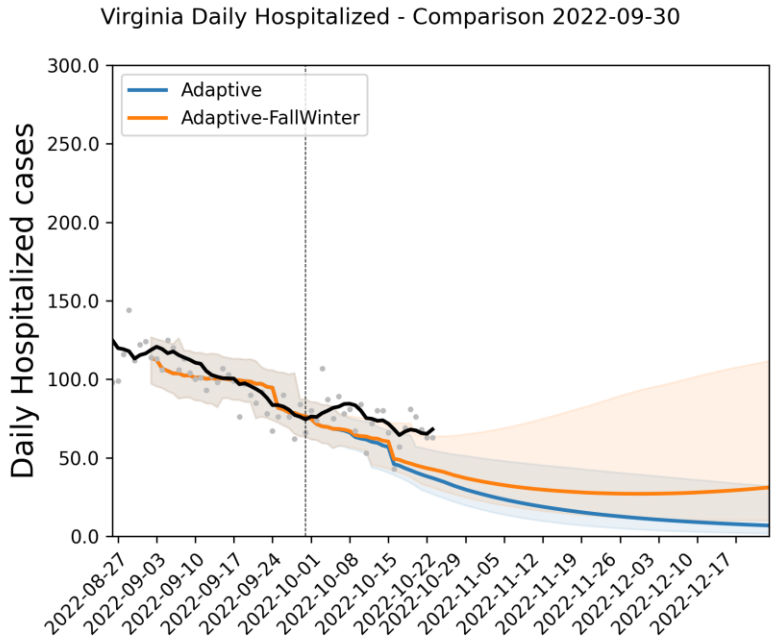
Previous projections comparison - Hospitalizations

- Previous projections have tracked observed hospitalizations reasonably well, though the case to hospitalization ratios may be shifting as model is under predicting

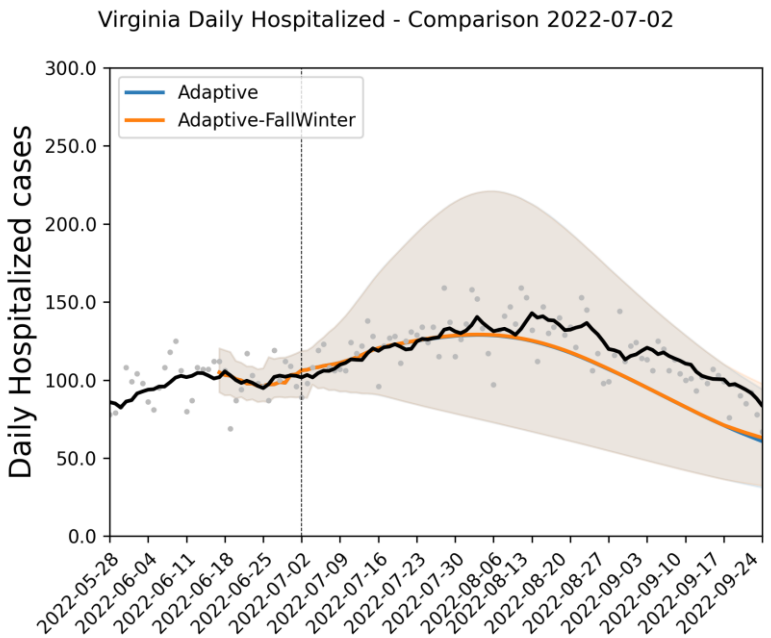
Projection from 1 week ago



Projection from 3 weeks ago



Projection from 3 months ago

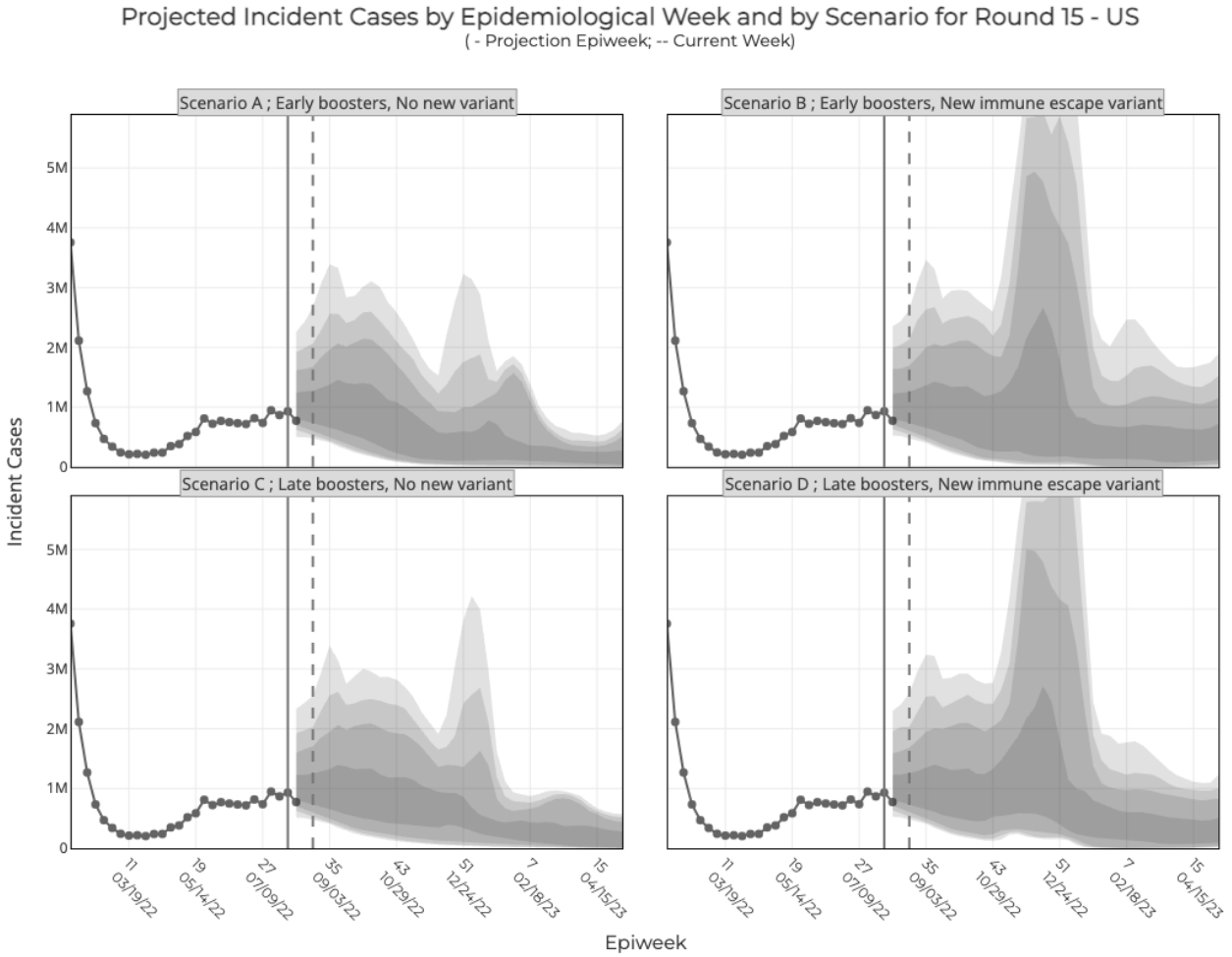


Scenario Modeling Hub – COVID-19 (Round 15)

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

- Round 15 results published
  - Scenarios: Test benefits of reformulated fall boosters w/ and w/out a new variant
  - Timing of reformulated boosters is one of the axes

https://covid19scenariomodelinghub.org/viz.html

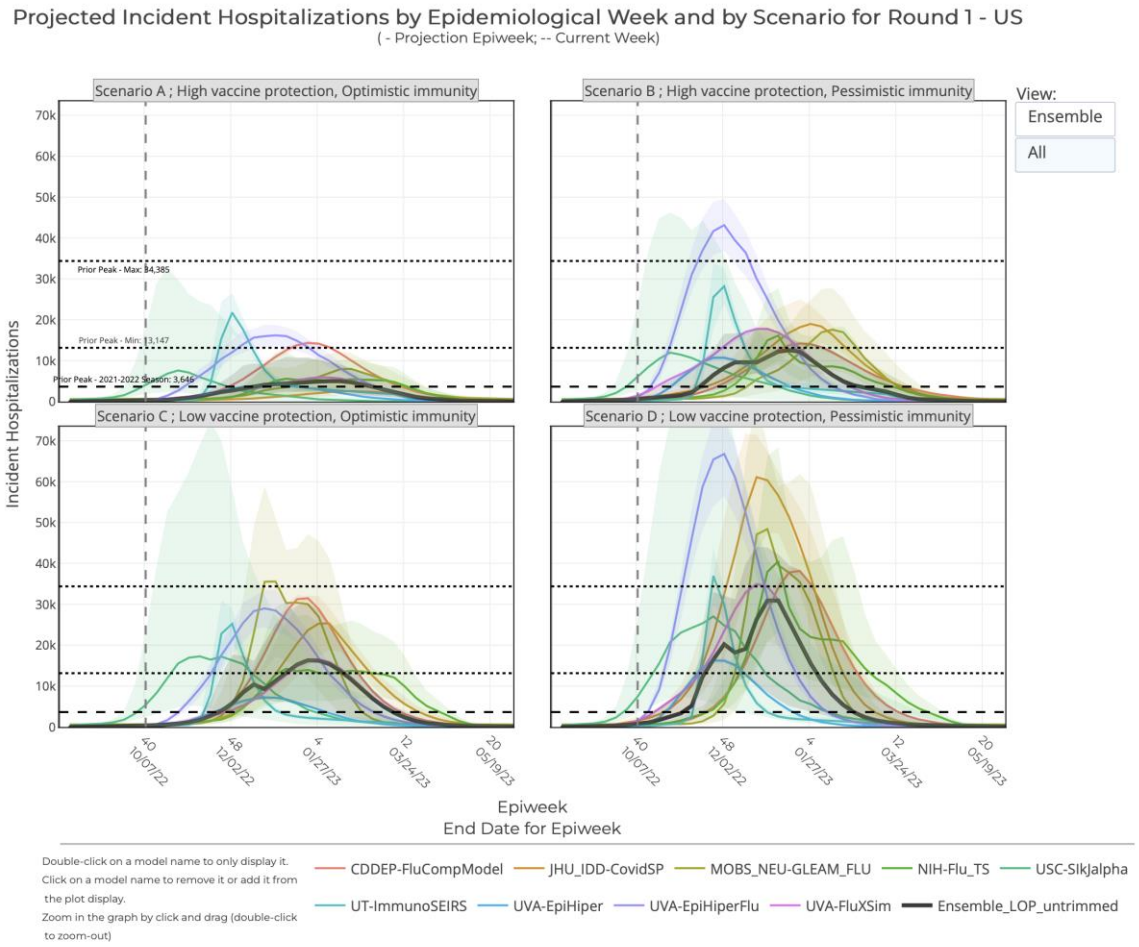


Scenario Modeling Hub – Influenza (Round 1)

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

- Round 1 results recently published
  - Impact of missed flu seasons on pre-season immunity
  - Testing different seasonal vaccine coverage and efficacy
  - Projected from Aug 14th 2022
- High degree of uncertainty as previous 2 seasons have been irregular and there is still limited data for this season available
- Demonstrates importance of good vaccine coverage especially if previous immunity is weak

https://fluscenariomodelinghub.org/viz.html



Key Takeaways

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

- **Case rates have continued to decline though hospitalizations have shown some recent growth**
- VA weekly case rate is slightly down at 81 per 100K from 84 per 100K
  - US weekly case rate is flat remaining at 74 per 100K from 74 per 100K
  - VA hospital occupancy (rolling 7 day mean of 455 slightly down from 482 a week ago) down but experiencing recent activity
- Sub-variant prevalence has started to grow rapidly, BA.5 subvariants seem to be accelerating
- Projections from last week remain largely on target with limited impact of Fall Winter scenario, however hospitalization trajectories

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

Additional Analyses

References

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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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