Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

August 17th, 2022

(data current to August 13th – August 16th)

Biocomplexity Institute Technical report: TR BI-2022-1681

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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

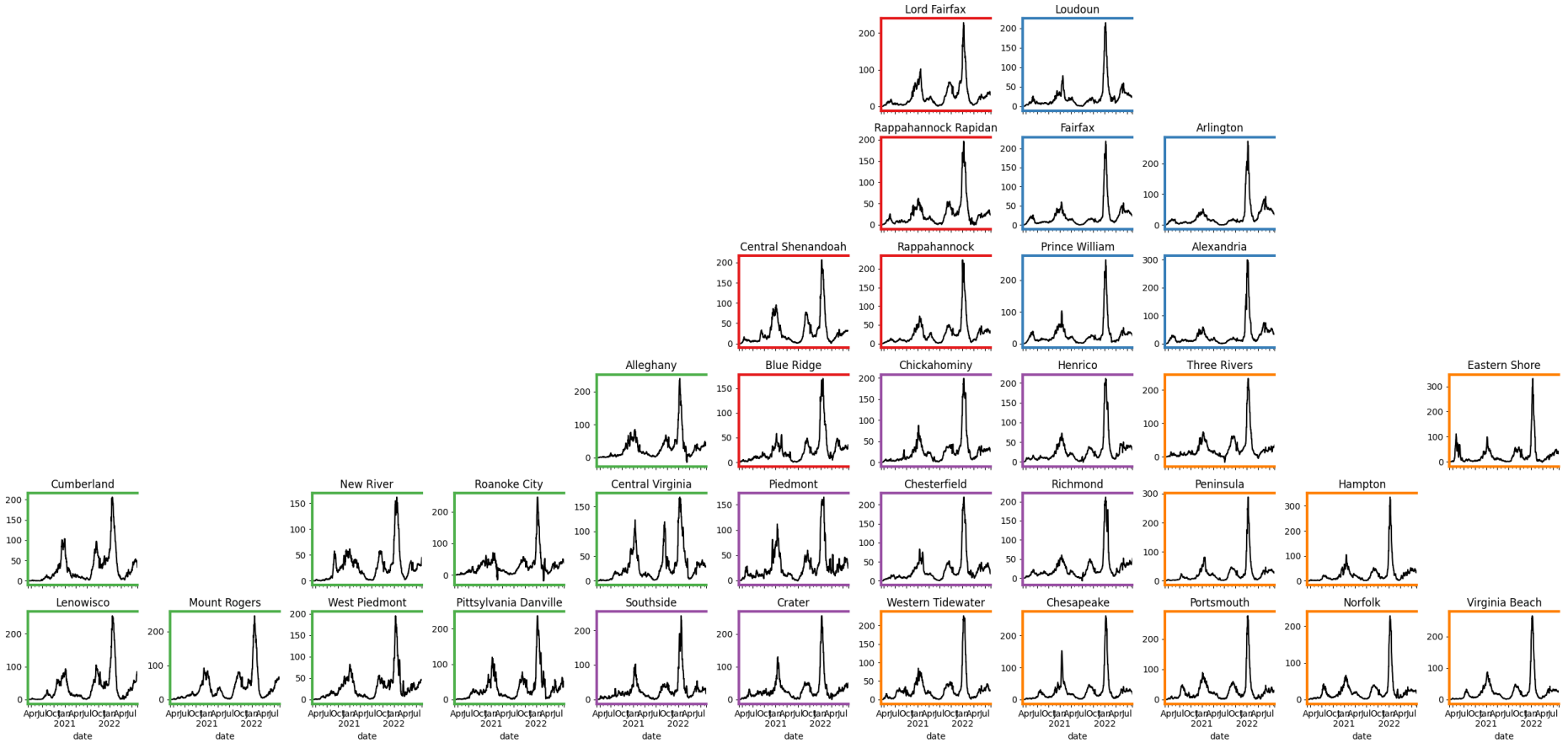
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

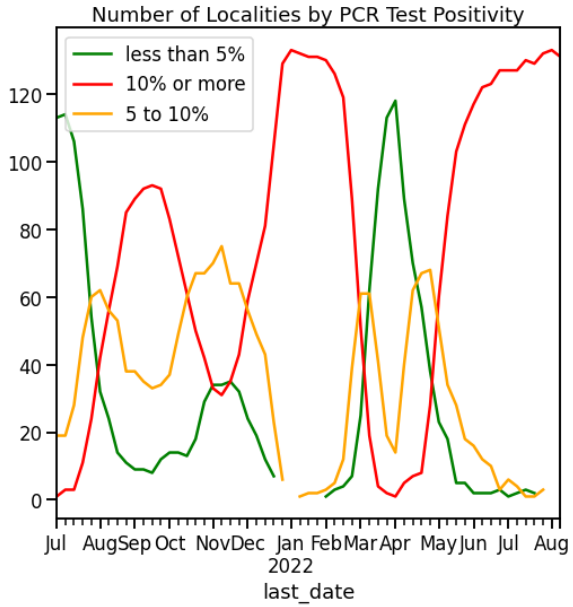
- **Case rates have begun declining following a plateau period**
- VA weekly case rate down to 211/100K from 228/100K
  - US weekly case rate is down to 207/100K from 227/100K
  - VA hospital occupancy (rolling 7 day mean of 786 up from 776 a week ago) currently on plateau
- Trends in Severity of those hospitalized continue to decline
- Sub-variant prevalence evolution as expected
- 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)

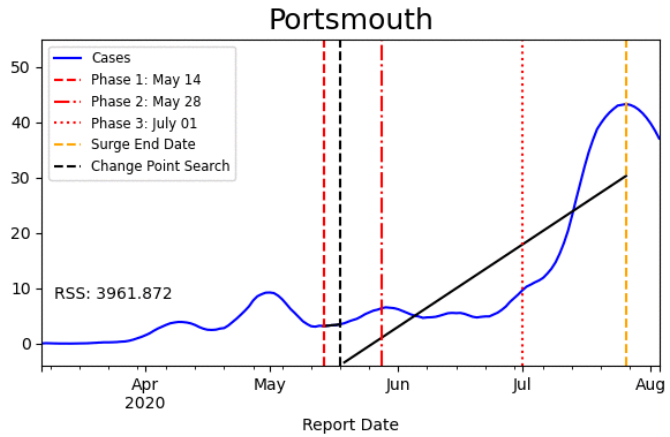
Red: >10.0% (and not "Green" or "Yellow")

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

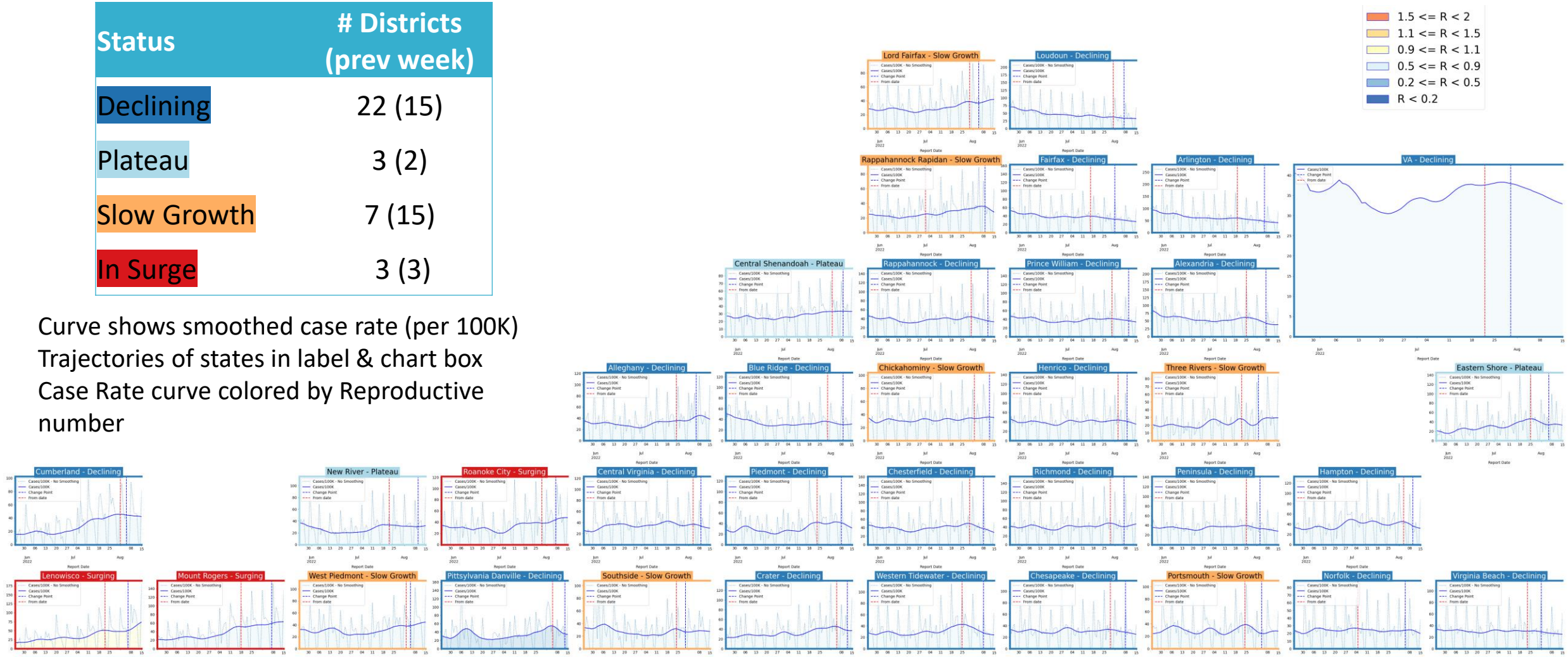


Trajectory	Description	Weekly Case Rate Slope (per 100k)	Weekly Hosp Rate Slope (per 100k)
Declining	Sustained decreases following a recent peak	slope < -0.88/day	slope < -0.07/day
Plateau	Steady level with minimal trend up or down	-0.88/day < slope < 0.42/day	-0.07/day < slope < 0.07/day
Slow Growth	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	# Districts (prev week)
Declining	22 (15)
Plateau	3 (2)
Slow Growth	7 (15)
In Surge	3 (3)

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

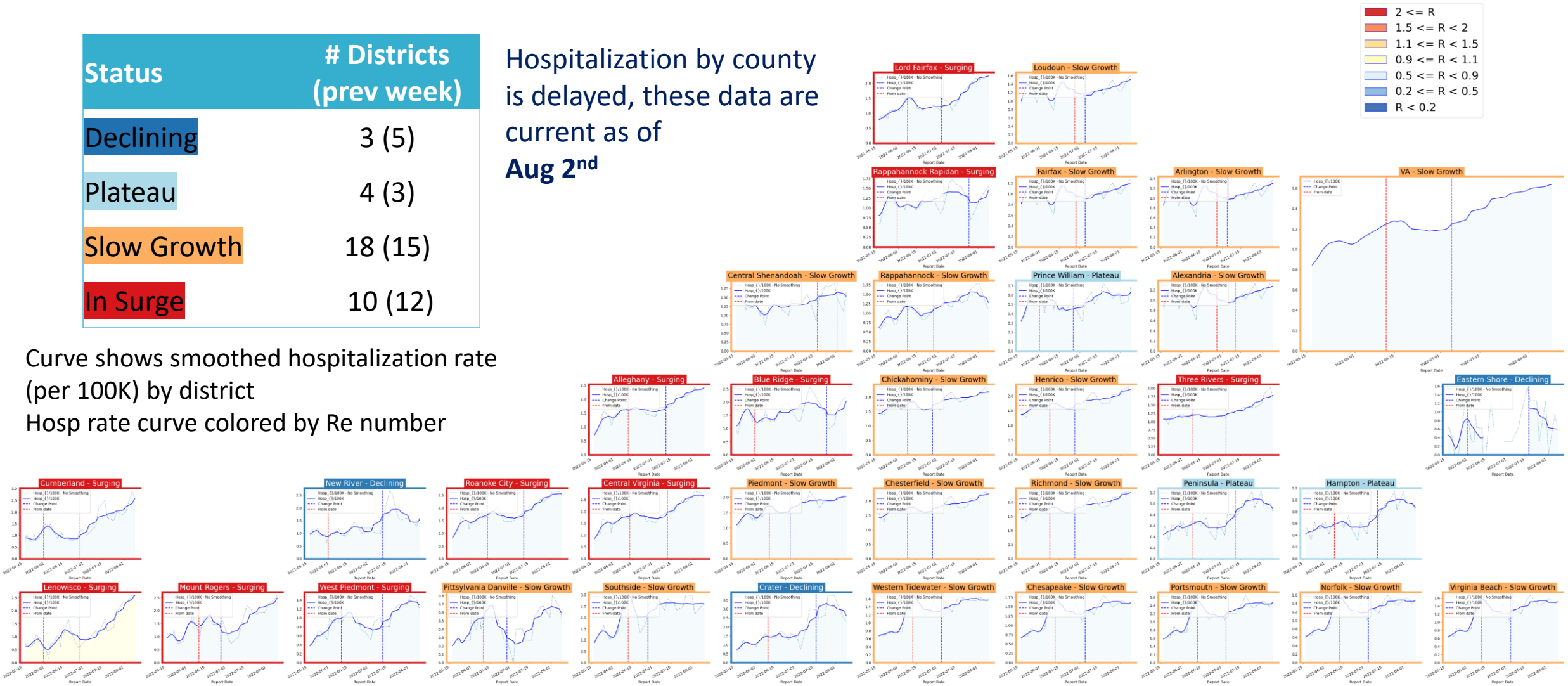


District Hospital Trajectories – last 10 weeks

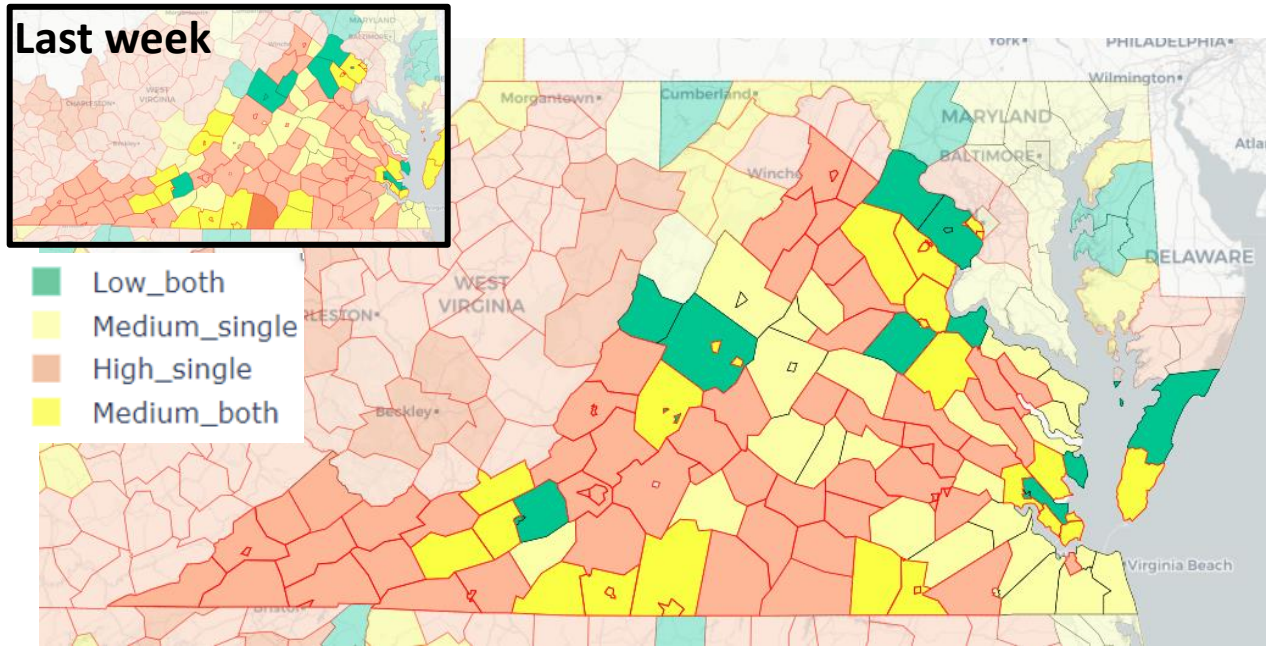
Status	# Districts (prev week)
Declining	3 (5)
Plateau	4 (3)
Slow Growth	18 (15)
In Surge	10 (12)

Hospitalization by county is delayed, these data are current as of **Aug 2nd**

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



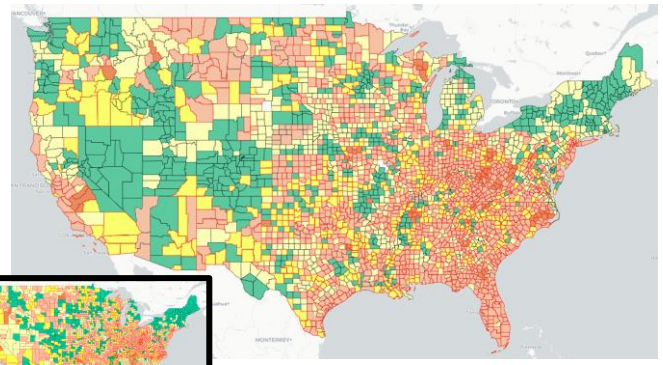
CDC's COVID-19 Community Levels



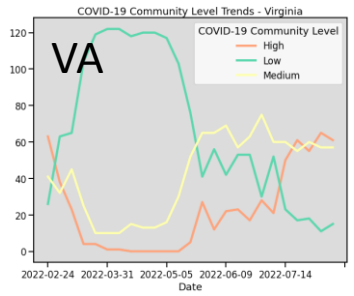
Red outline indicates county had 200 or more cases per 100k in last week

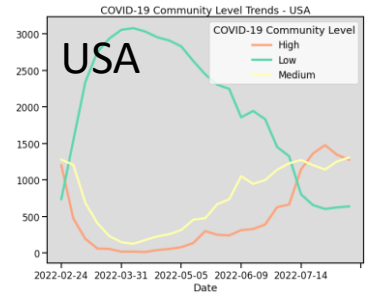
Pale color indicates either beds or occupancy set the level for this county

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

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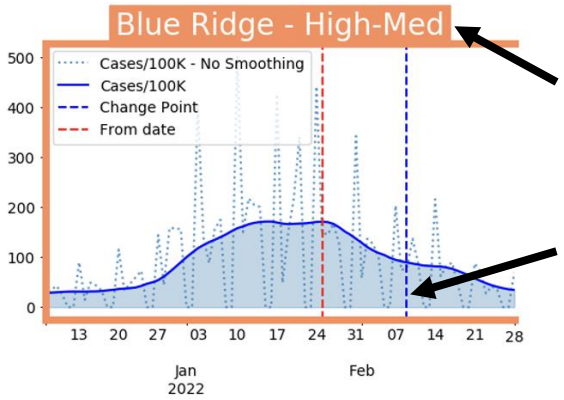
Data from: CDC Data Tracker Portal

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

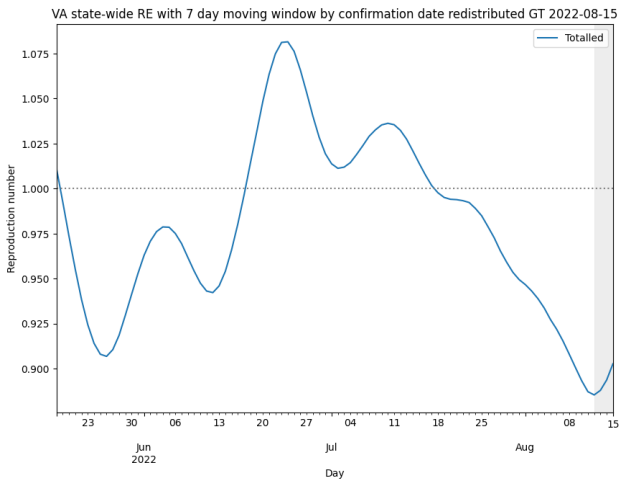
Aggregate level a simple mean of all levels for counties in district

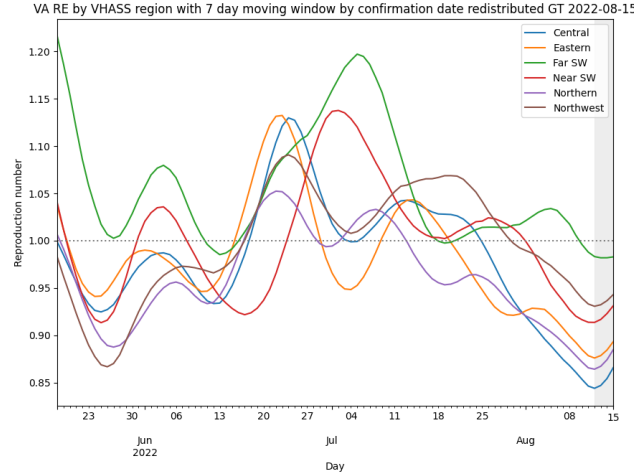
Case rate Trajectory

Estimating Daily Reproductive Number – Redistributed gap

August 15th Estimates

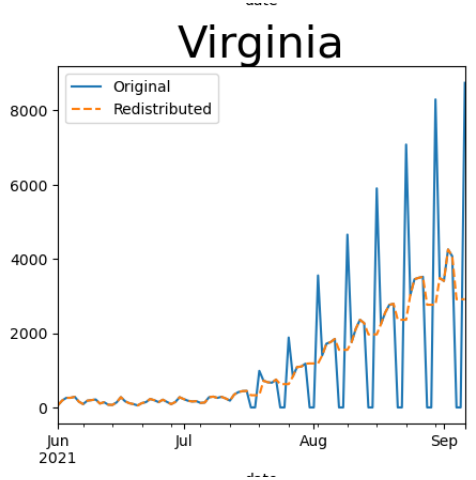
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.903	-0.016
Central	0.866	-0.049
Eastern	0.893	-0.045
Far SW	0.983	0.026
Near SW	0.931	-0.030
Northern	0.885	-0.003
Northwest	0.943	0.009





Skipping Weekend Reports & holidays biases estimates

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



Methodology

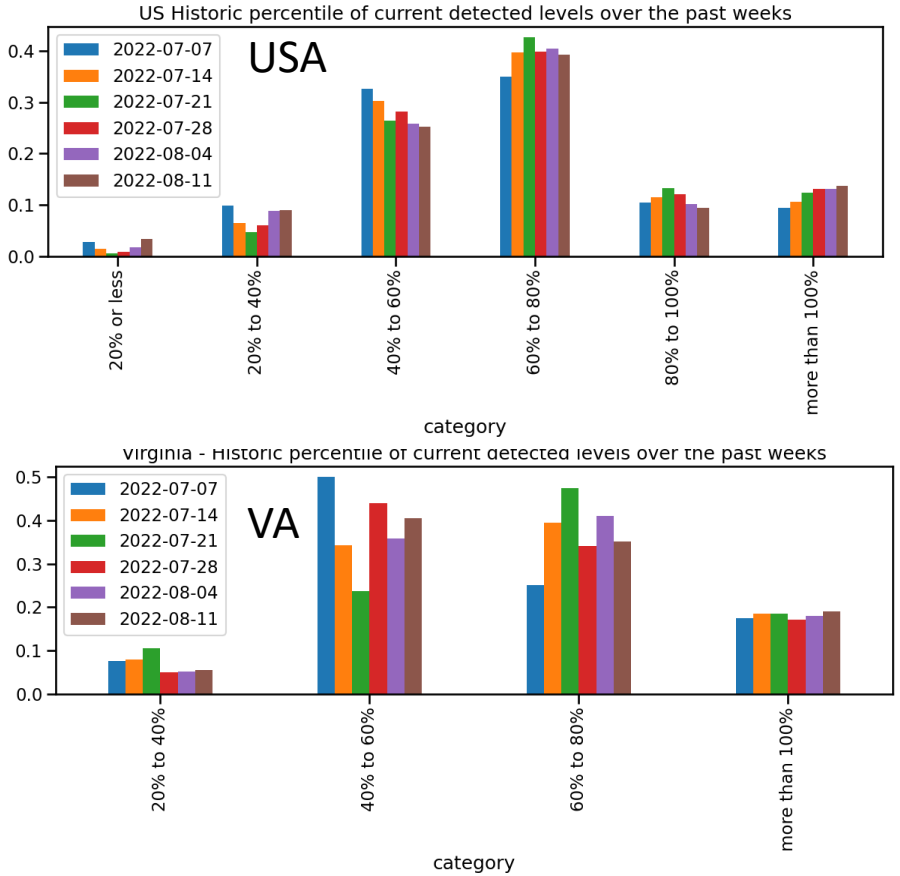
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

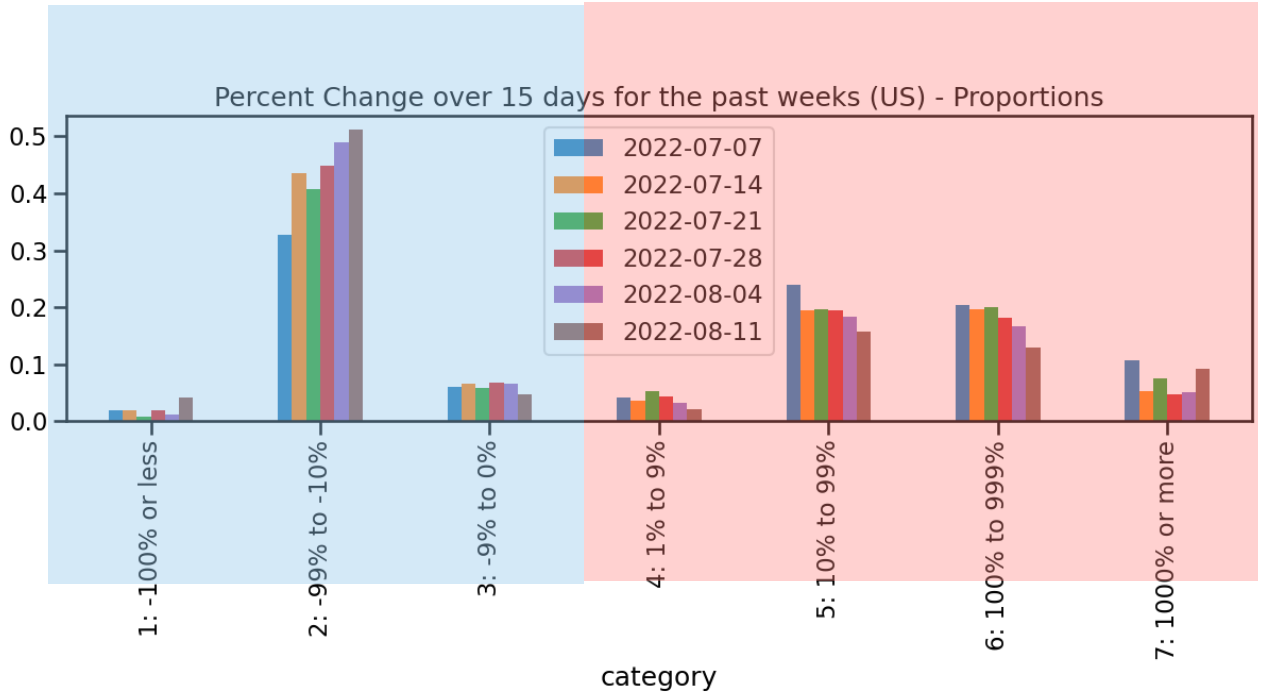
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

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

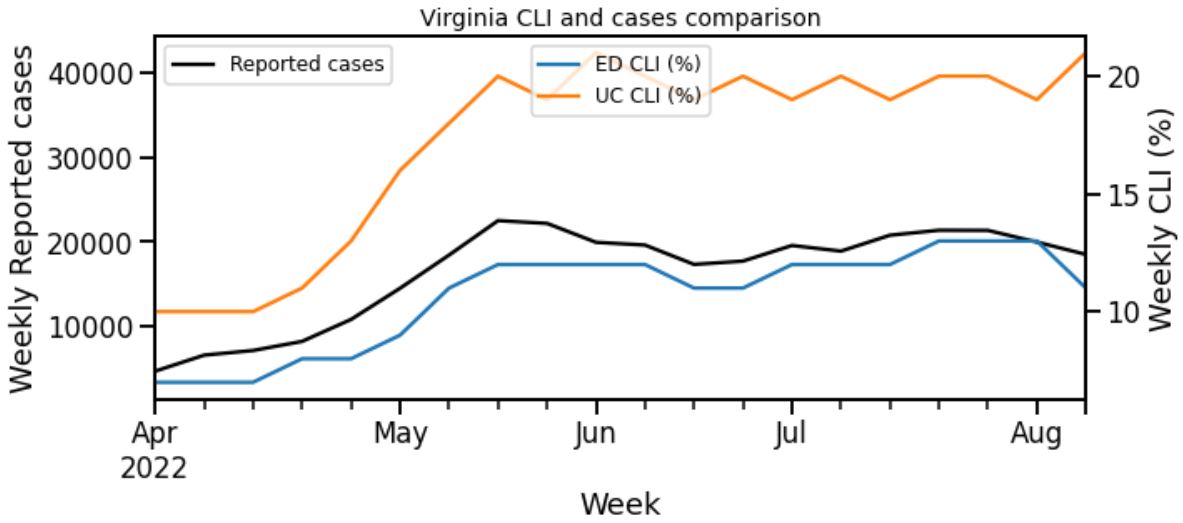


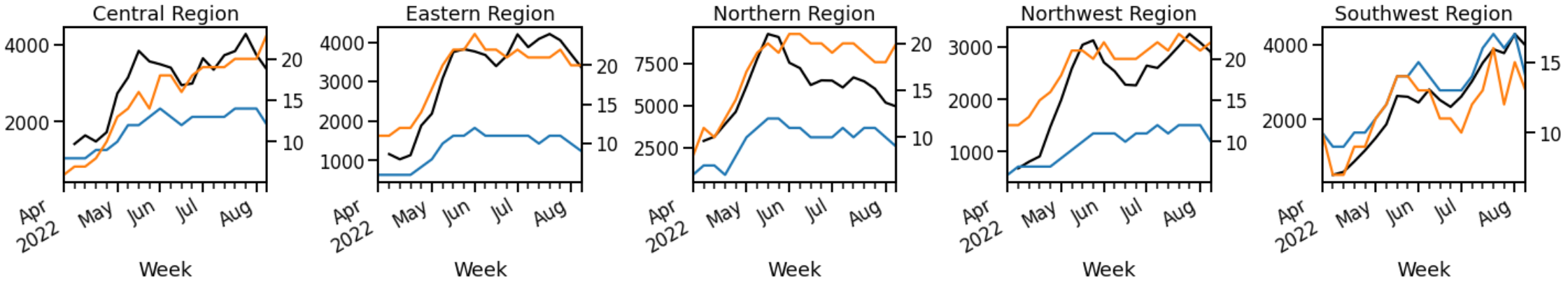


COVID-like Illness Activity

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 statewide, mixed by region**

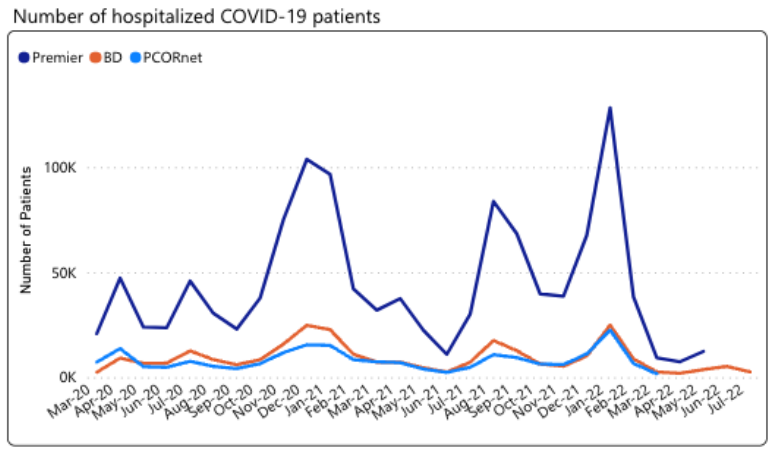


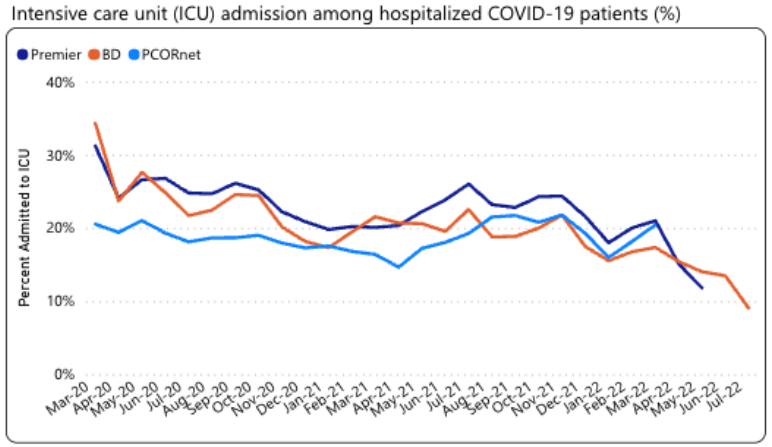


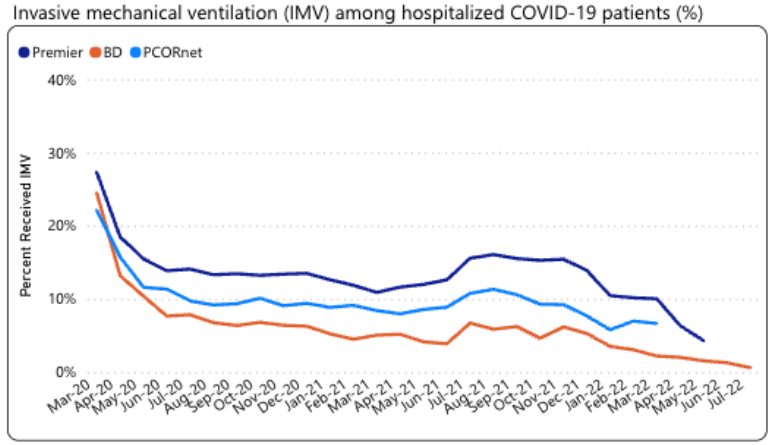
Hospitalizations and Severe Outcomes

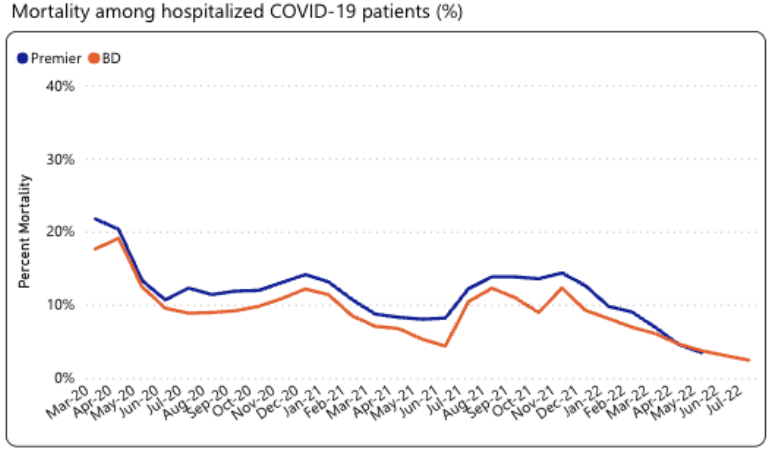
Proportion of most severe outcomes decreasing among those who are hospitalized

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









SARS-CoV2 Variants of Concern

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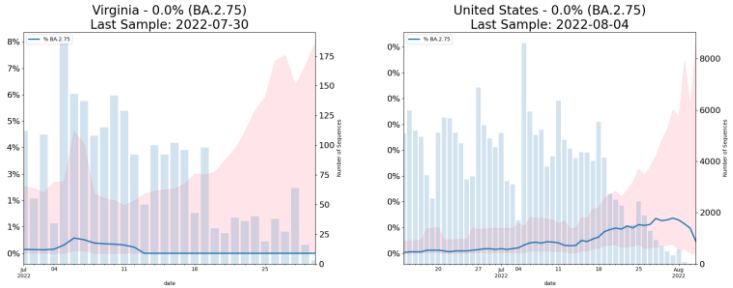
Emerging new variants will alter the future trajectories of pandemic and have implications for future control

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

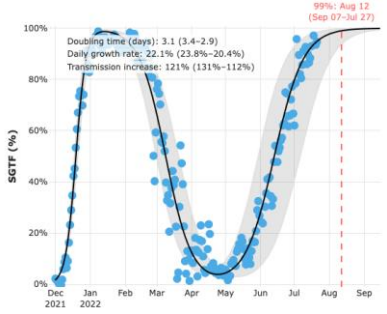
Omicron Updates (Region 3)

- 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

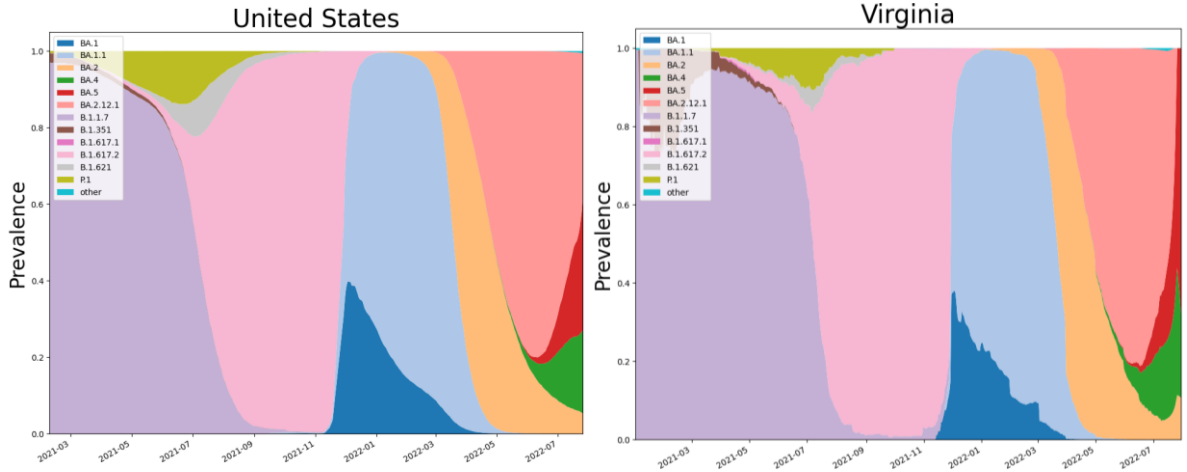


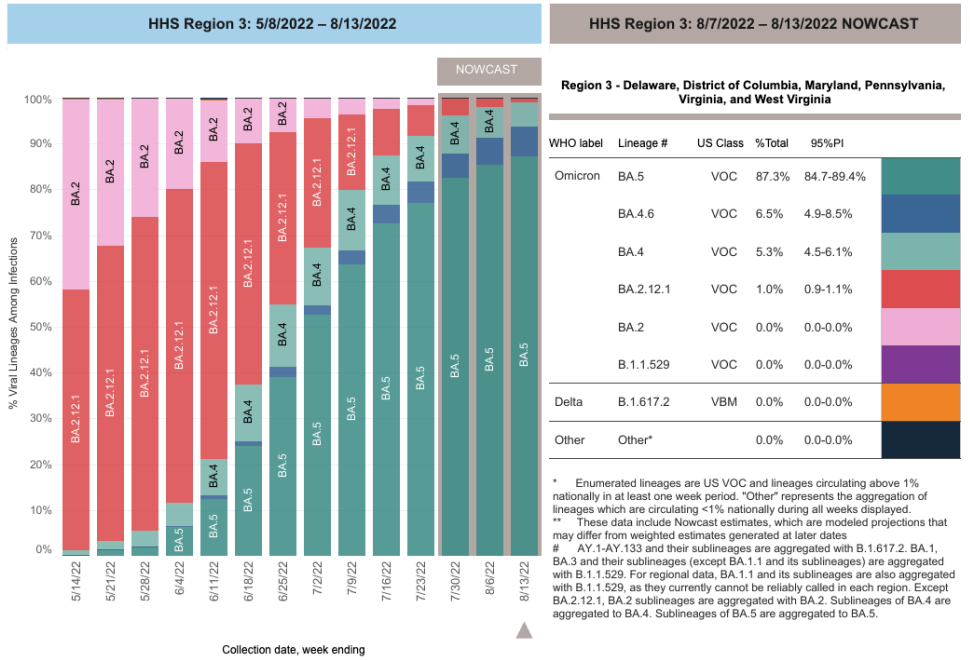
BA.2.75 detected in US (very limited samples)

SGTF in San Diego



Currently estimated to be nearly 100%% in San Diego





Region 3 - Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia

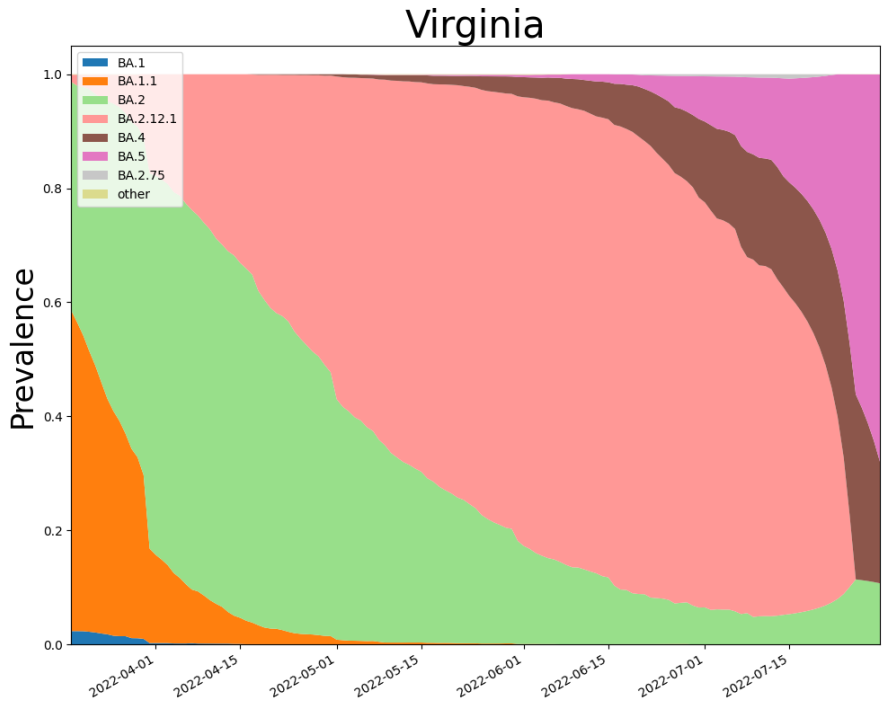
WHO label	Lineage #	US Class	%Total	95%PI
Omicron	BA.5	VOC	87.3%	84.7-89.4%
	BA.4.6	VOC	6.5%	4.9-8.5%
	BA.4	VOC	5.3%	4.5-6.1%
	BA.2.12.1	VOC	1.0%	0.9-1.1%
	BA.2	VOC	0.0%	0.0-0.0%
	B.1.1.529	VOC	0.0%	0.0-0.0%
Delta	B.1.617.2	VBM	0.0%	0.0-0.0%
Other	Other*		0.0%	0.0-0.0%

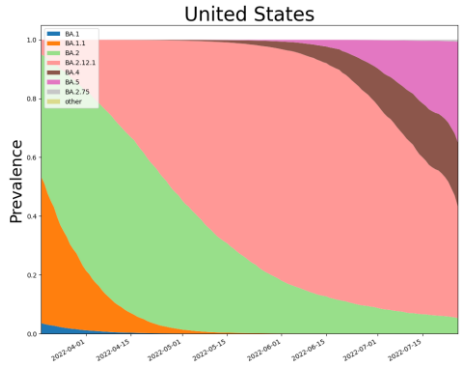
* Enumerated lineages are US VOC and lineages circulating above 1% nationally in at least one week period. "Other" represents the aggregation of lineages which are circulating <1% nationally during all weeks displayed.
** These data include Nowcast estimates, which are modeled projections that may differ from weighted estimates generated at later dates
# AY.1-AY.133 and their sublineages are aggregated with B.1.617.2. BA.1, BA.3 and their sublineages (except BA.1.1 and its sublineages) are aggregated with B.1.1.529. For regional data, BA.1.1 and its sublineages are also aggregated with B.1.1.529, as they currently cannot be reliably called in each region. Except BA.2.12.1, BA.2 sublineages are aggregated with BA.2. Sublineages of BA.4 are aggregated to BA.4. Sublineages of BA.5 are aggregated to BA.5.

CDC Variant Tracking

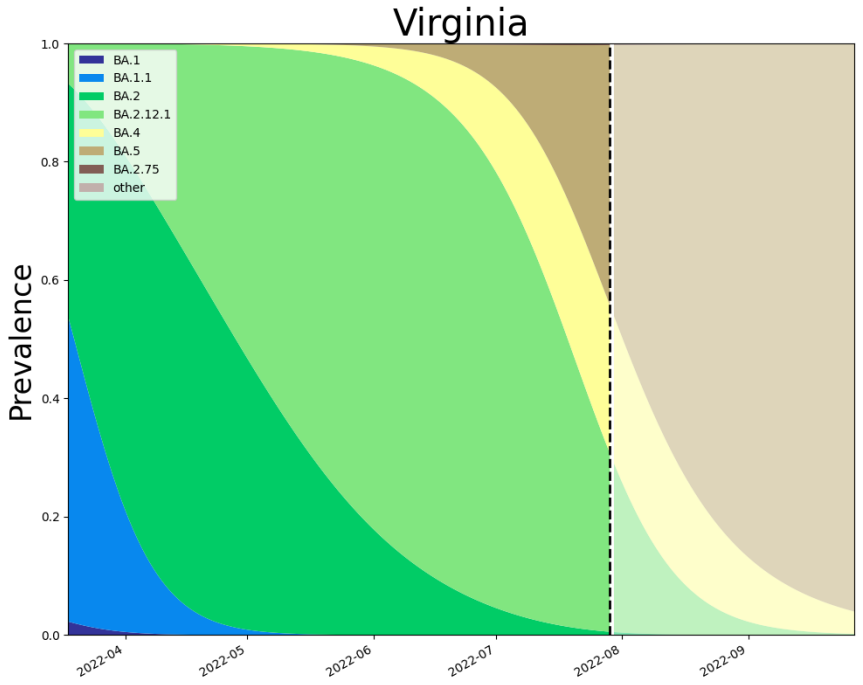
SARS-CoV2 Omicron and Sub-Variants

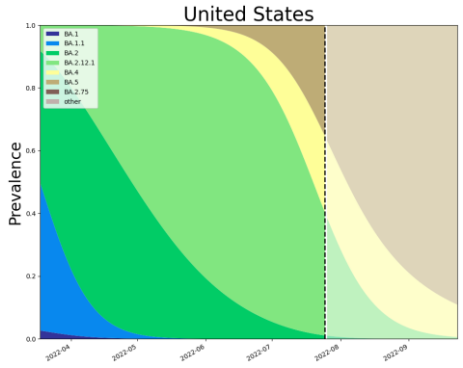
As detected in whole Genomes in public repositories





VoC Polynomial Fit Projections





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

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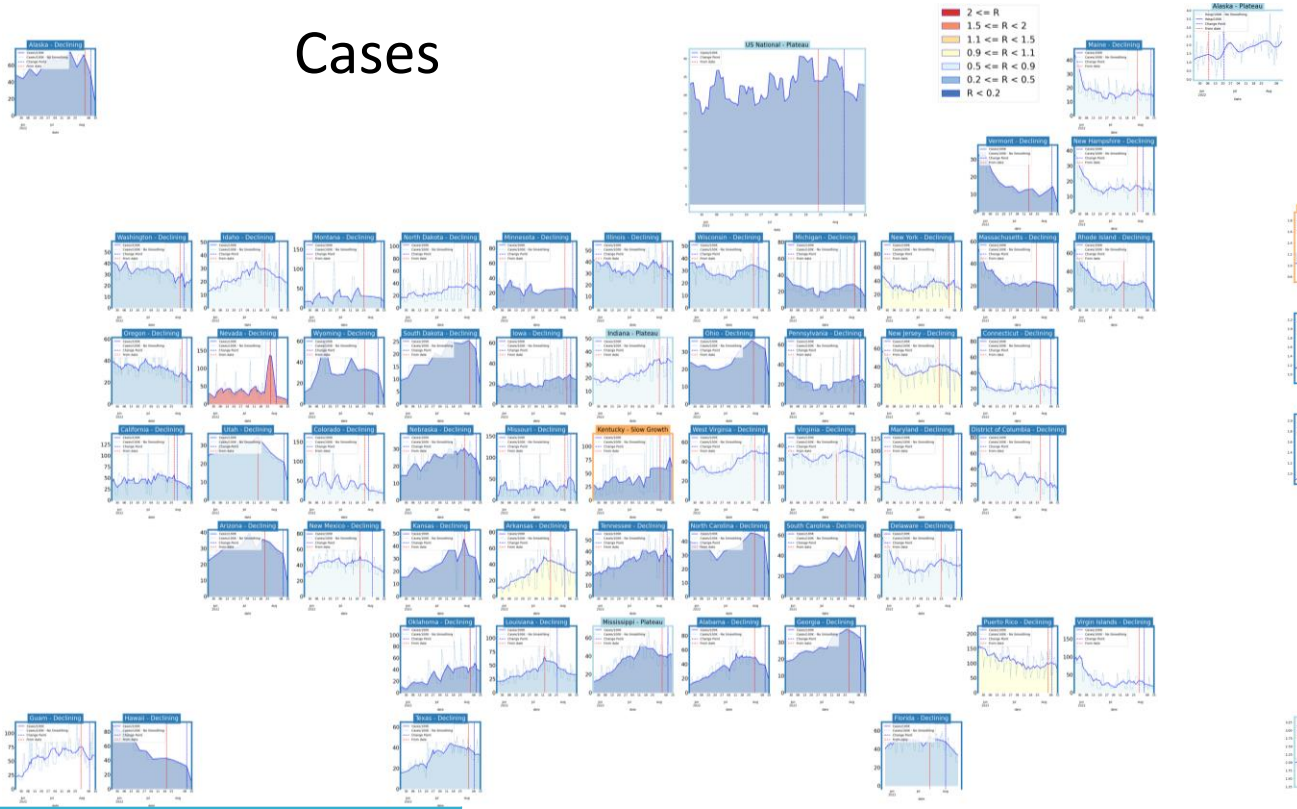
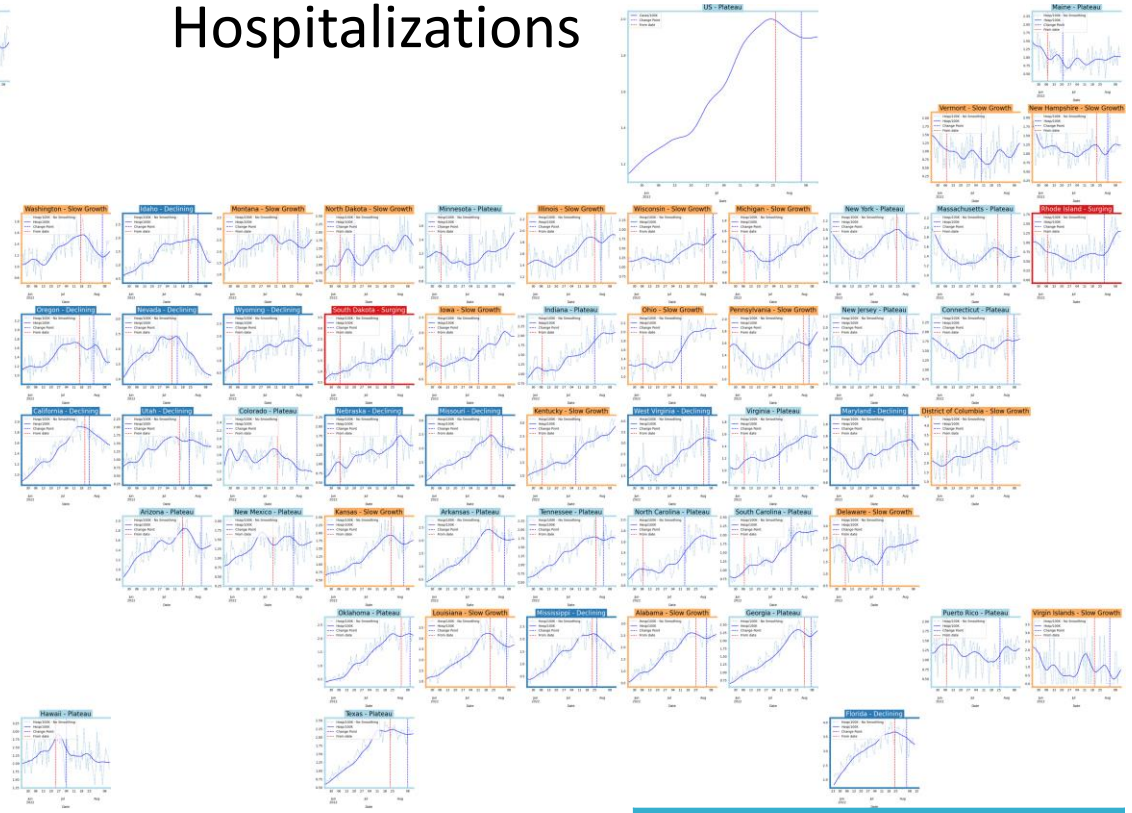
United States Case & Hospitalizations

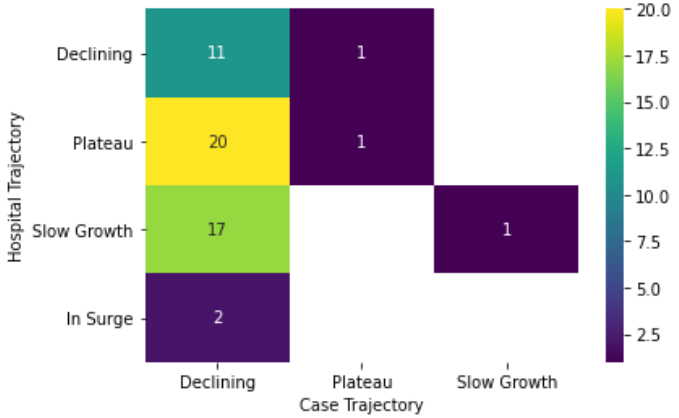
Cases



Hospitalizations



Status	# States
Declining	51 (46)
Plateau	2 (5)
Slow Growth	1 (3)
In Surge	0 (0)

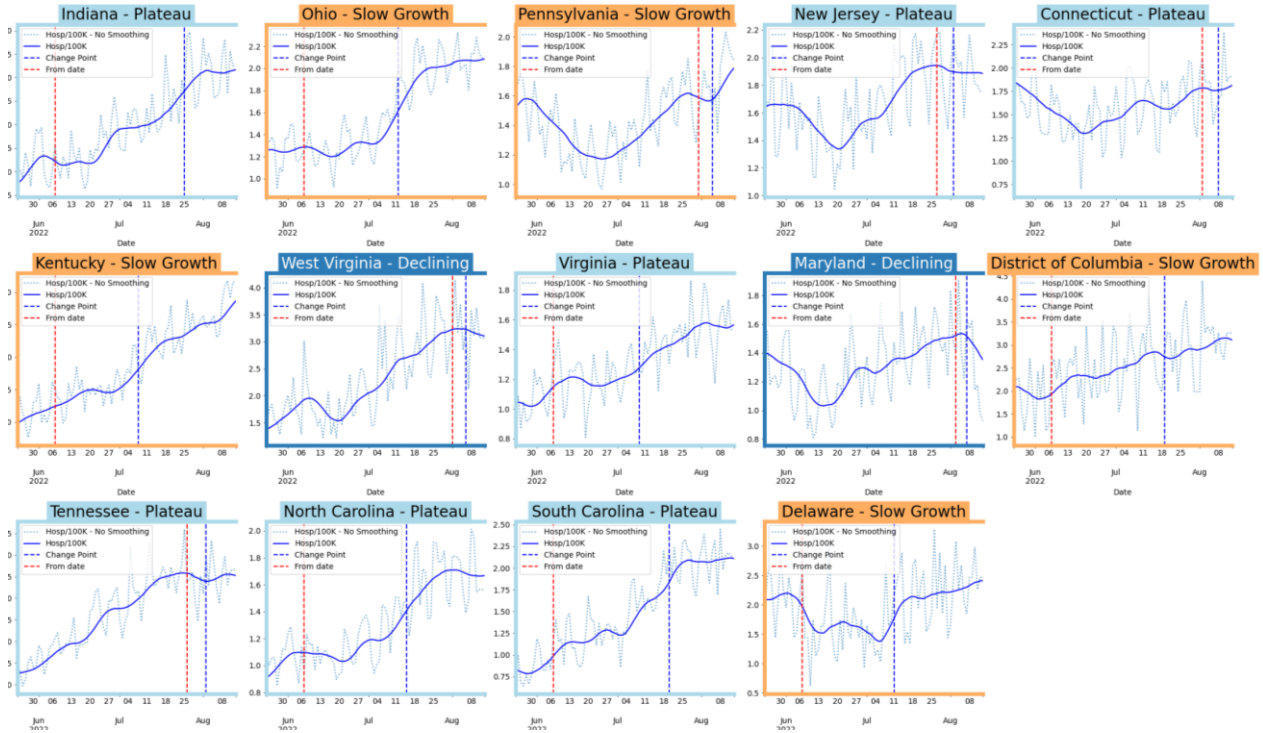


Status	# States
Declining	12 (14)
Plateau	21 (18)
Slow Growth	18 (19)
In Surge	2 (2)

Virginia and Her Neighbors

Cases

Hospitalizations



Using Ensemble Model to Guide Projections

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

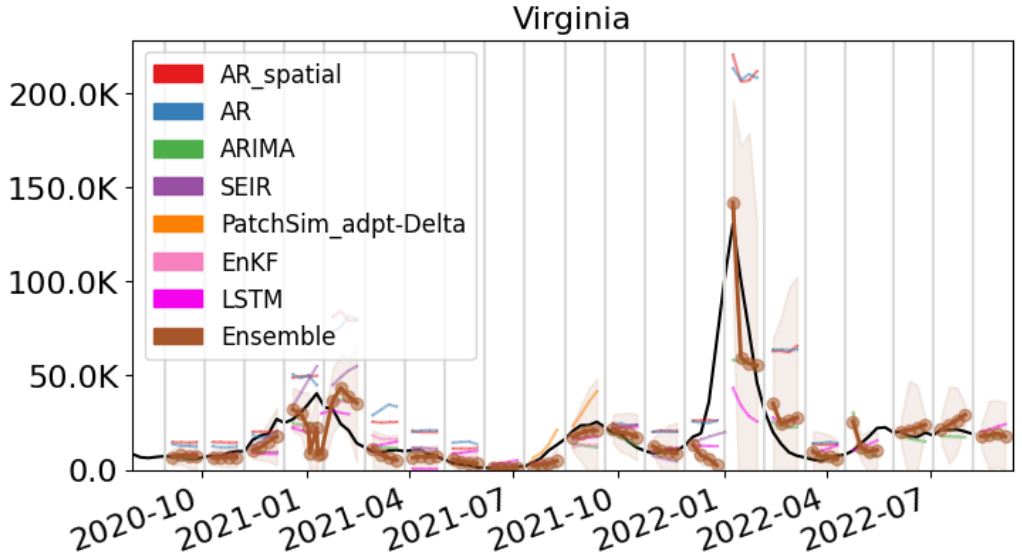
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

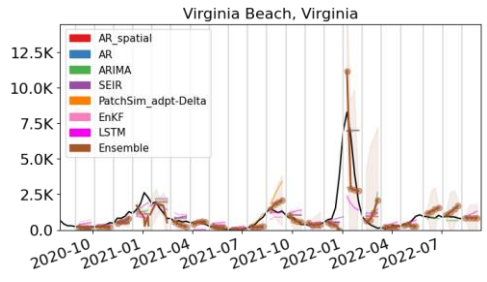
<u>Weekly forecasts</u> done at county level.

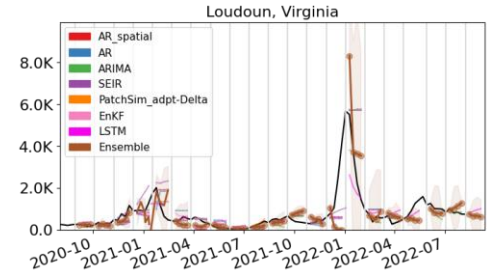
Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

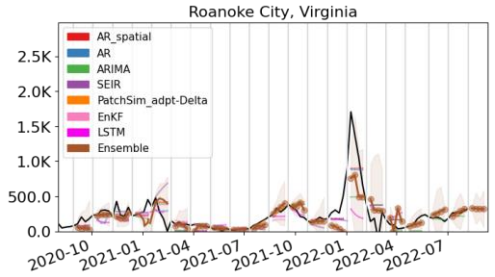
Ensemble forecast provides additional ‘surveillance’ for making scenario-based projections.

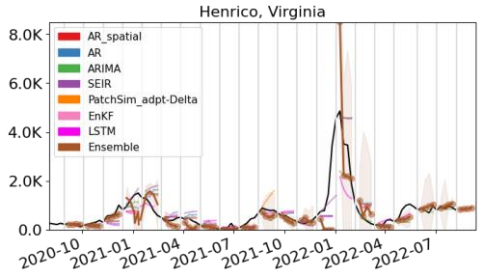
Also submitted to CDC Forecast Hub.



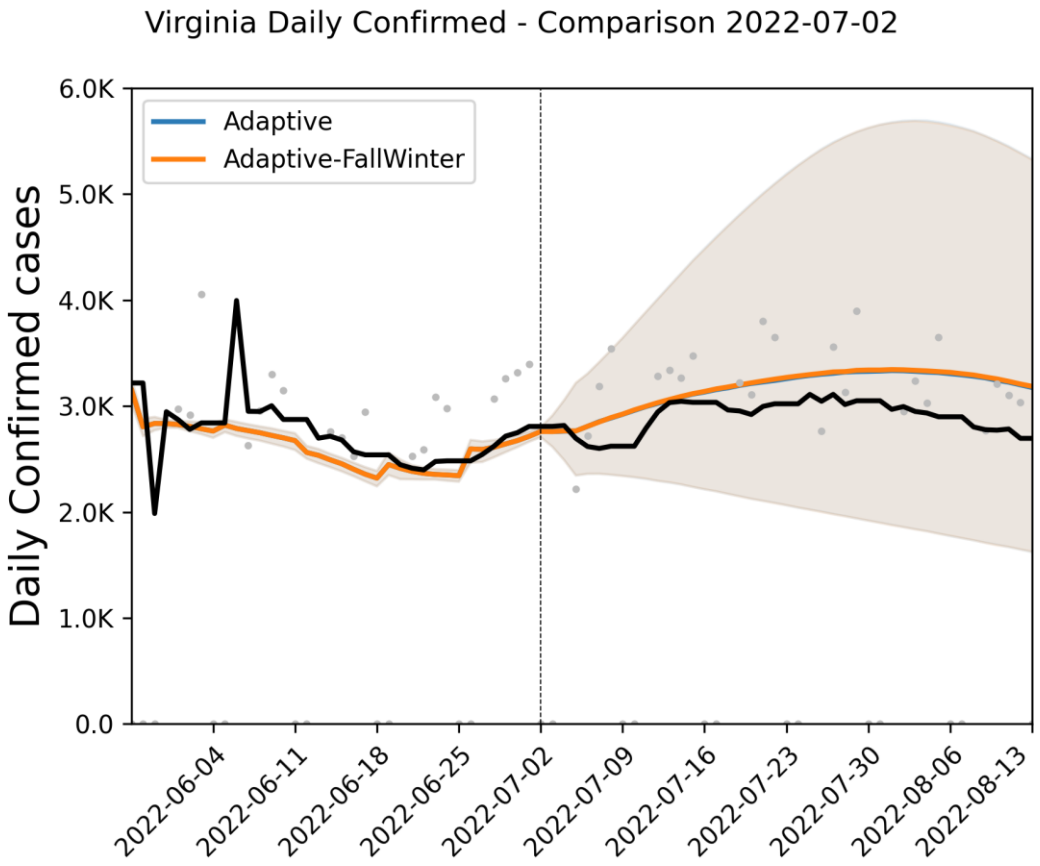


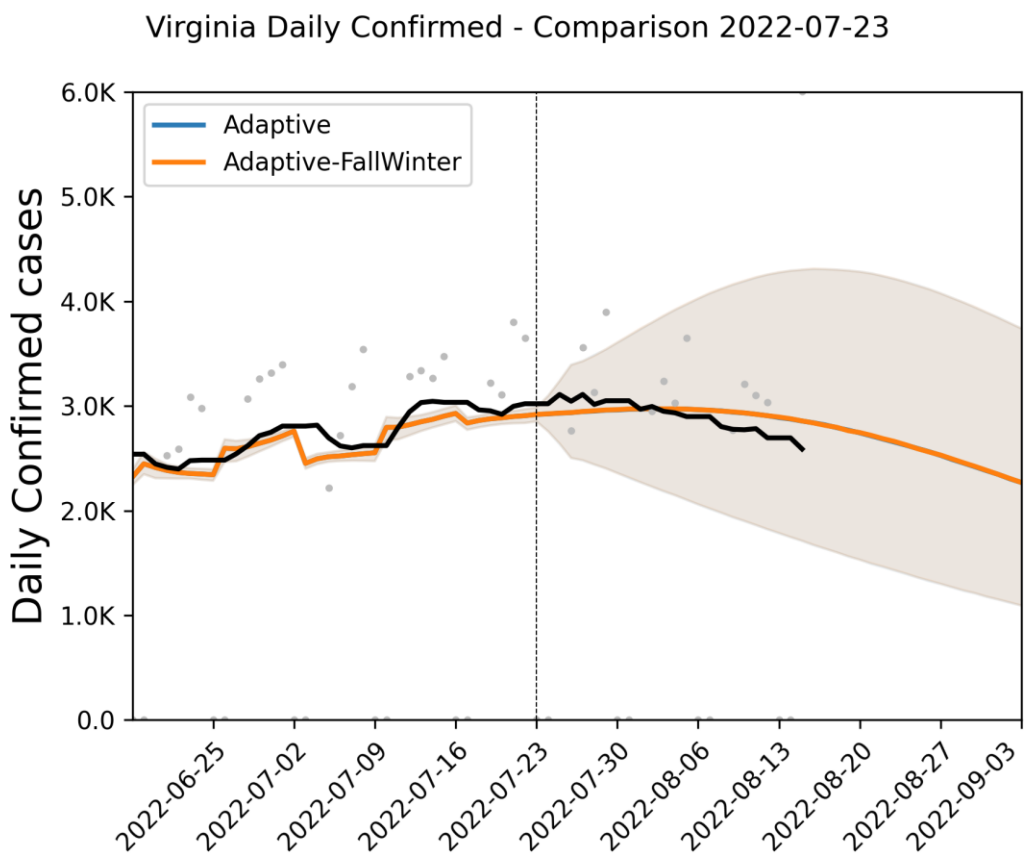




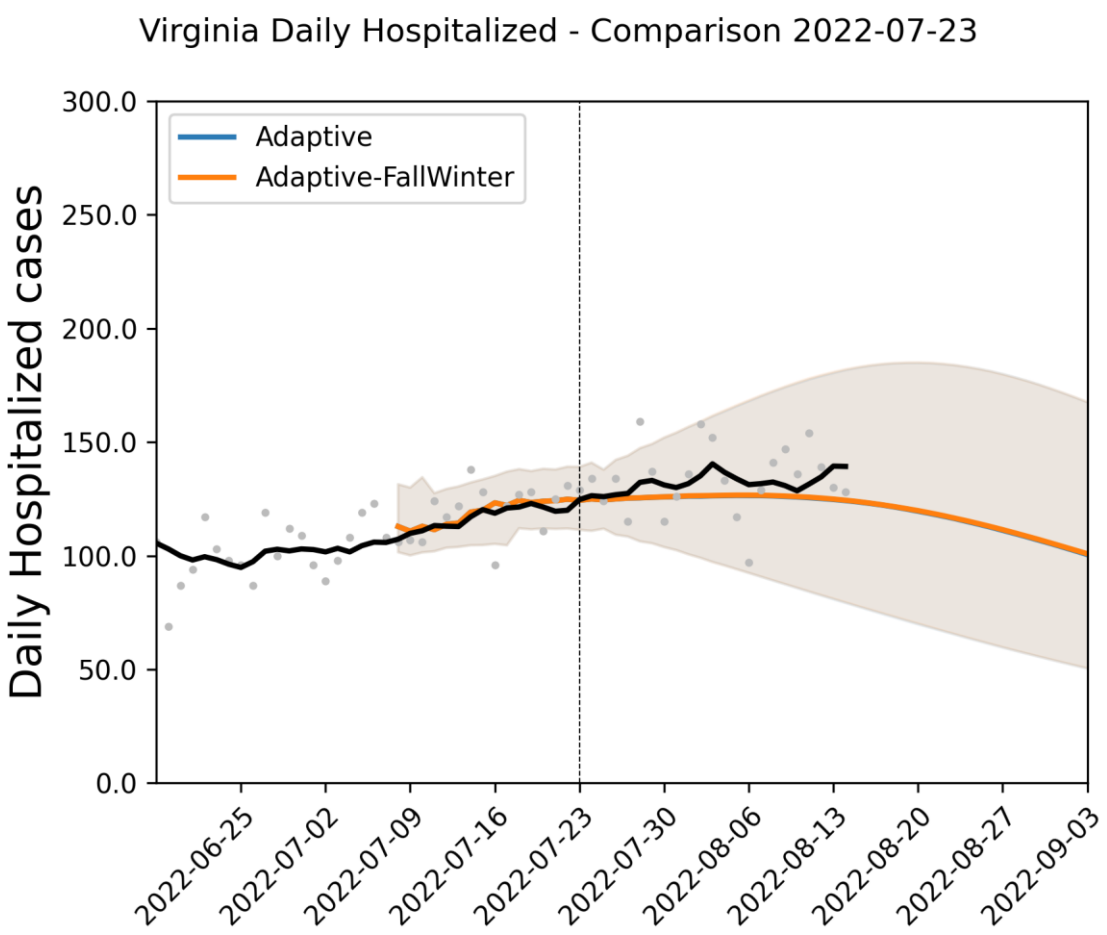


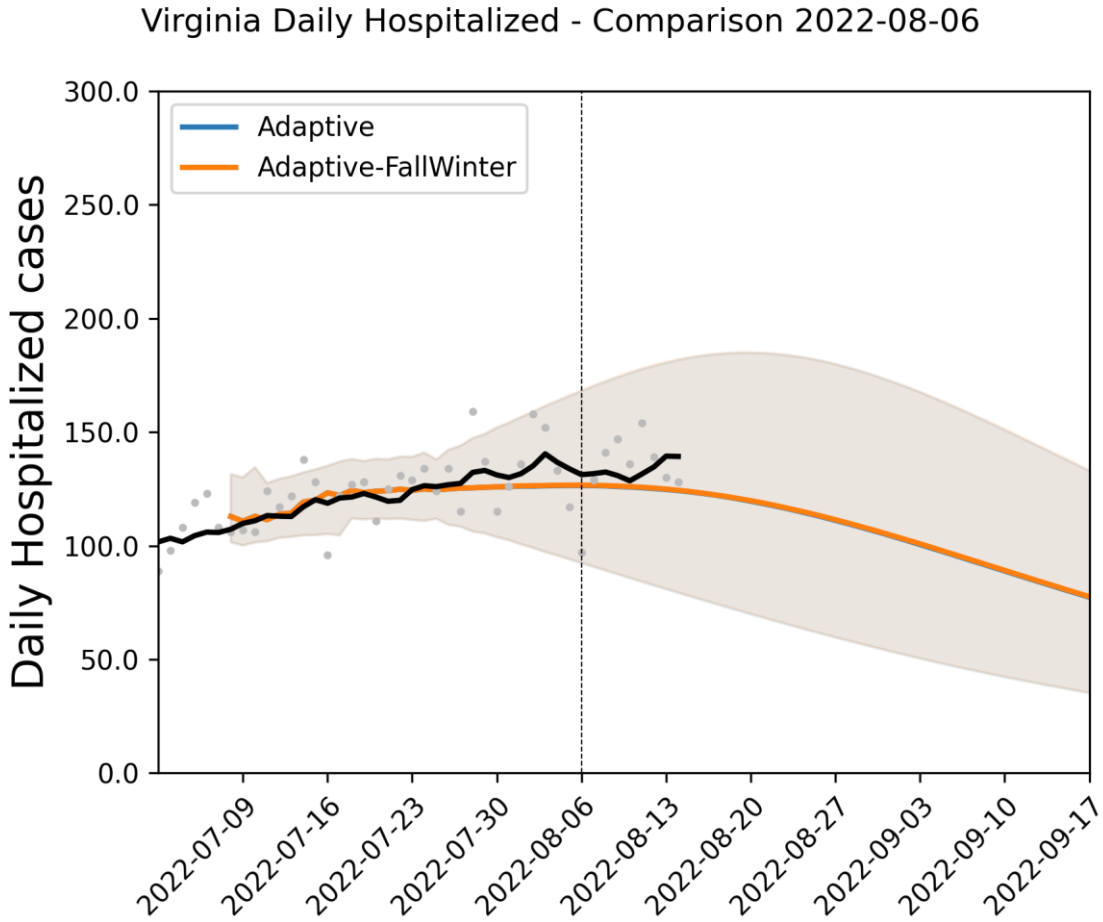
Case projection comparison





Hospitalization projection comparison



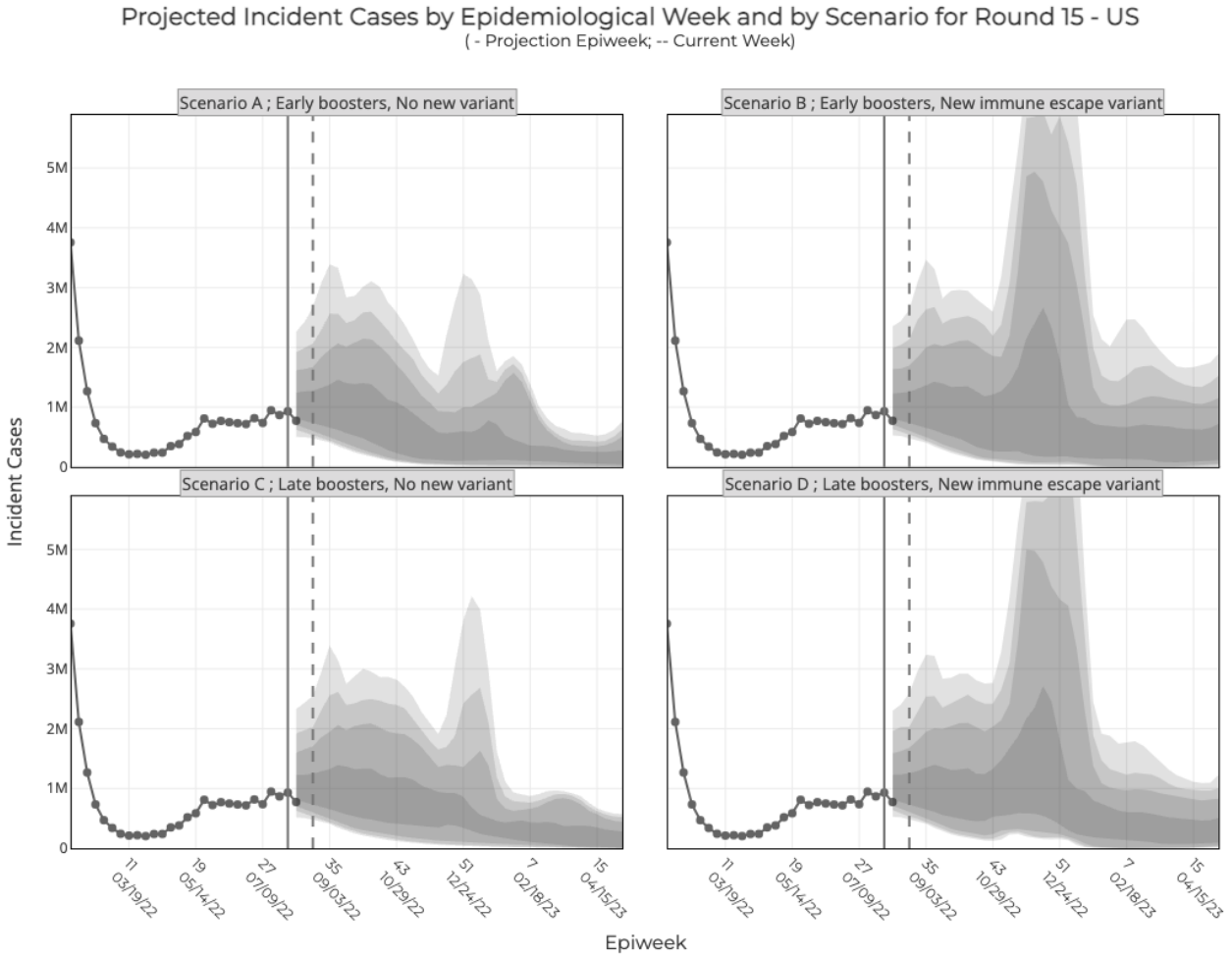


Scenario Modeling Hub – COVID-19 (Rd15), Flu (Rd1)

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
- Flu scenarios currently being generated
  - Impact of missed flu seasons on pre-season immunity
  - Testing different seasonal vaccine coverage and efficacy

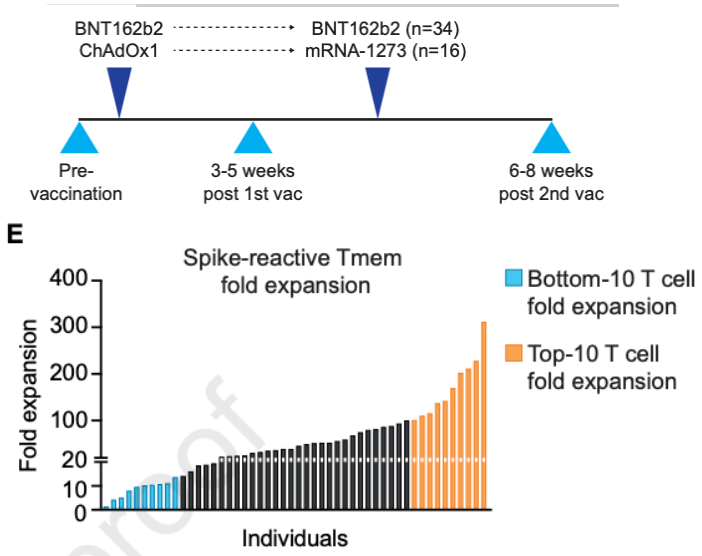
https://covid19scenariomodelinghub.org/viz.html



Pandemic Pubs

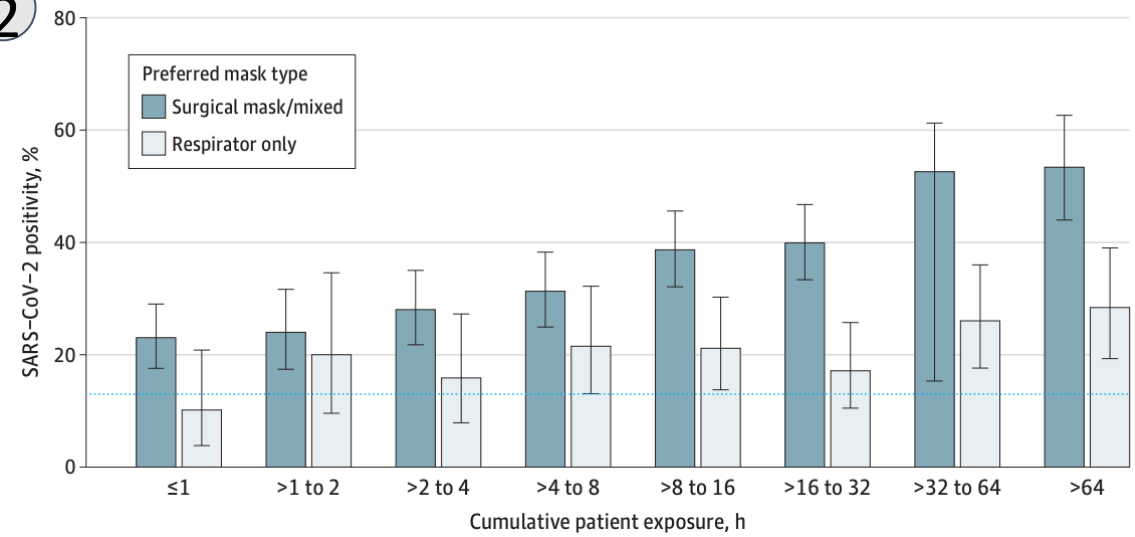
1. Elderly defect in CD4+ T cell repertoire causes age-dependent decline of immune response quality against SARS-CoV-2
2. Swiss study indicates high quality respirators significantly reduce work-related risk for HCW due to COVID-19
3. SARS-CoV-2 spike antigen in a majority of PASC patients up to 12 months post-diagnosis, suggesting the presence of an active persistent SARSCoV-2 viral reservoir

1



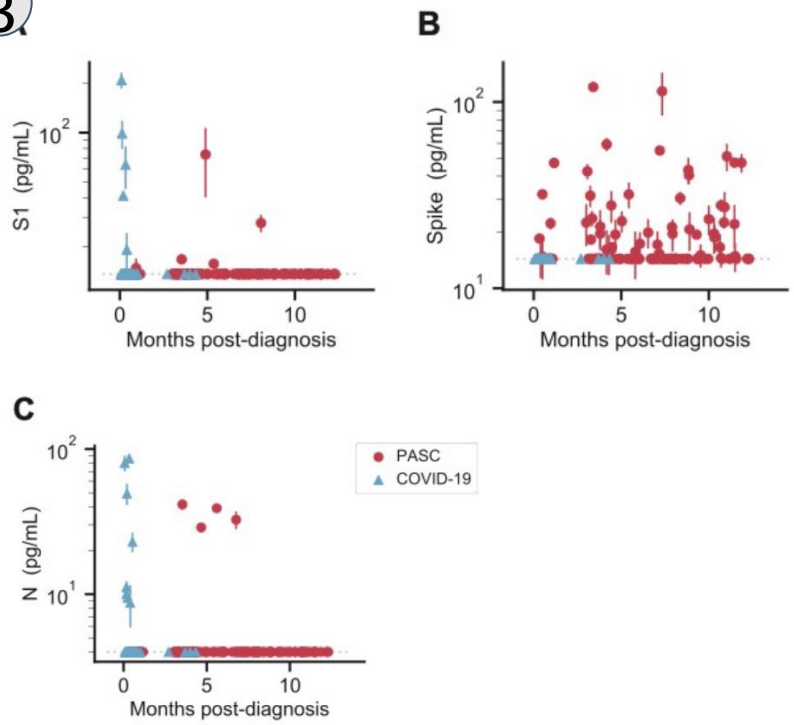
New study from researchers in Germany highlight the need for alternative strategies to induce high-quality T cell responses against newly arising pathogens in the elderly. Analyzed the SARS-CoV-2 spike protein specific CD4+ T cell response before and after vaccination in 50 SARS-CoV-2-naive individuals, confirmed by being negative for SARS-CoV-2 IgG pre-vaccination
https://www.cell.com/immunity/fulltext/S1074-7613(22)00396-X#relatedArticles

2



2919 HCWs (median age, 43 years (range, 18-73 years); 749 participants (26%) were infected with SARS-CoV-2. SARS-CoV-2 positivity was 13% in HCWs without patient exposure. For those exposed to patients, positivity was 21% for HCWs using respirator masks and 35% for those using surgical/mixed masks (OR, 0.49; 95% CI, 0.39-0.61), showing an increase for surgical/mixed mask users (OR, 1.21; 95% CI, 1.15-1.28) and respirator mask users (OR, 1.15; 95% CI, 1.05-1.27) across categories of patient exposure
https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2795150

3



Harvard researchers analyzed plasma samples collected from a cohort of PASC and COVID-19 patients (n = 63) to quantify circulating viral antigens and inflammatory markers. Strikingly, we detect SARS-CoV-2 spike antigen in a majority of PASC patients up to 12 months post-diagnosis, suggesting the presence of an active persistent SARSCoV-2 viral reservoir. Furthermore, temporal antigen profiles for many patients show the presence of spike at multiple time points over several months, highlighting the potential utility of the SARS-CoV-2 full spike protein as a biomarker for PASC.
https://www.medrxiv.org/content/10.1101/2022.06.14.22276401v1

Key Takeaways

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

- **Case rates have begun declining following a plateau period**
- VA weekly case rate down to 211/100K from 228/100K
  - US weekly case rate is down to 207/100K from 227/100K
  - VA hospital occupancy (rolling 7 day mean of 786 up from 776 a week ago) currently on plateau
- Trends in Severity of those hospitalized continue to decline
- Sub-variant prevalence evolution as expected
- Projections from last week remain largely on target

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

Additional Analyses

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/

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

Questions?

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