Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

October 5th, 2022

(data current to Sept 30th – October 4th)

Biocomplexity Institute Technical report: TR BI-2022-1770

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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

Bryan Lewis
brylew@virginia.edu

Srini Venkatramanan
srini@virginia.edu

Madhav Marathe
marathe@virginia.edu

Chris Barrett
ChrisBarrett@virginia.edu

Model Development, Outbreak Analytics, and Delivery Team

Przemyslaw Porebski, Joseph Outten, Brian Klahn, Alex Telionis, Srinivasan Venkatramanan, Bryan Lewis, Aniruddha Adiga, Hannah Baek, Chris Barrett, Jiangzhuo Chen, Patrick Corbett, Stephen Eubank, Galen Harrison, Ben Hurt, Dustin Machi, Achla Marathe, Madhav Marathe, Mark Orr, Akhil Peddireddy, Erin Raymond, James Schlitt, Anil Vullikanti, Lijing Wang, James Walke, Andrew Warren, Amanda Wilson, Dawen Xie

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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

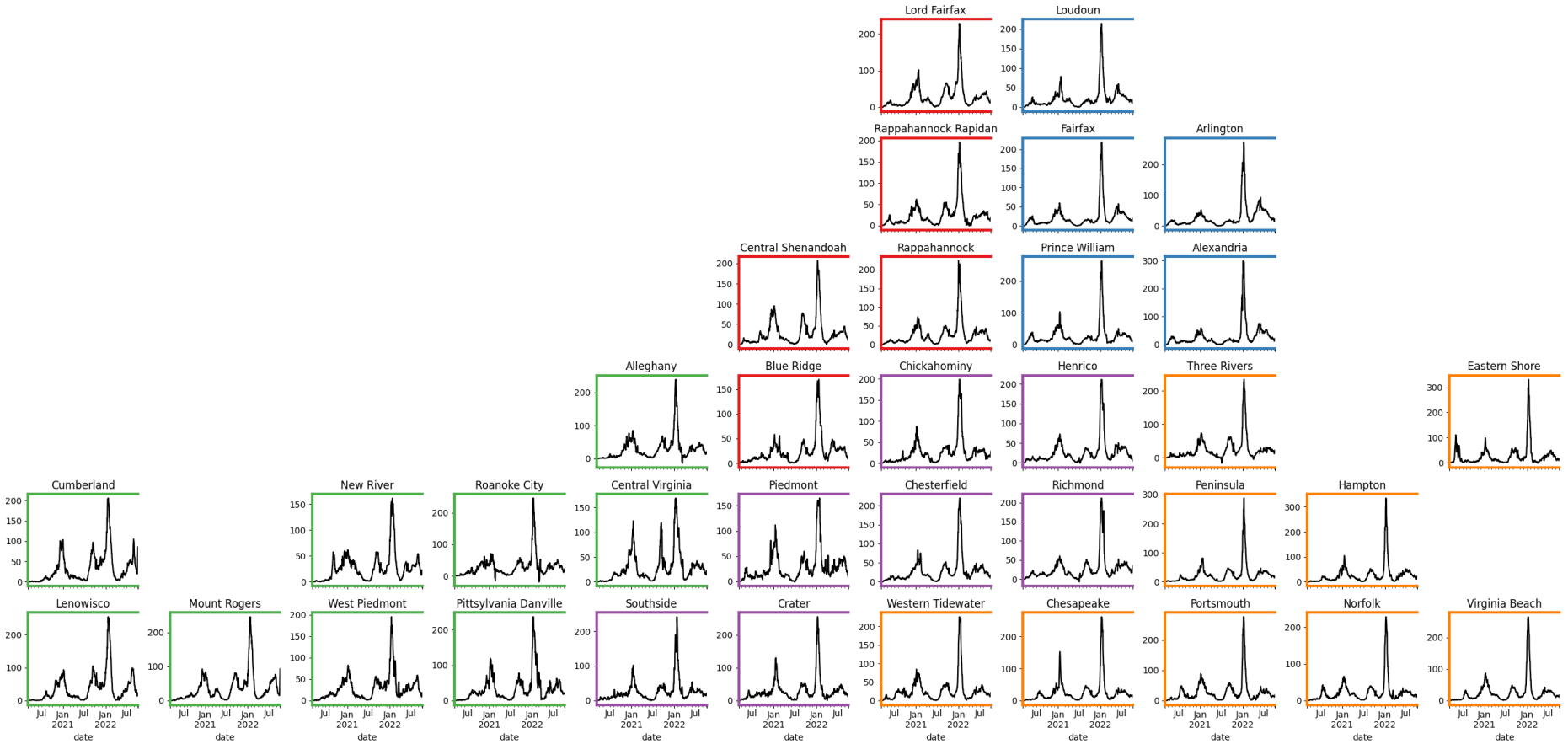
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

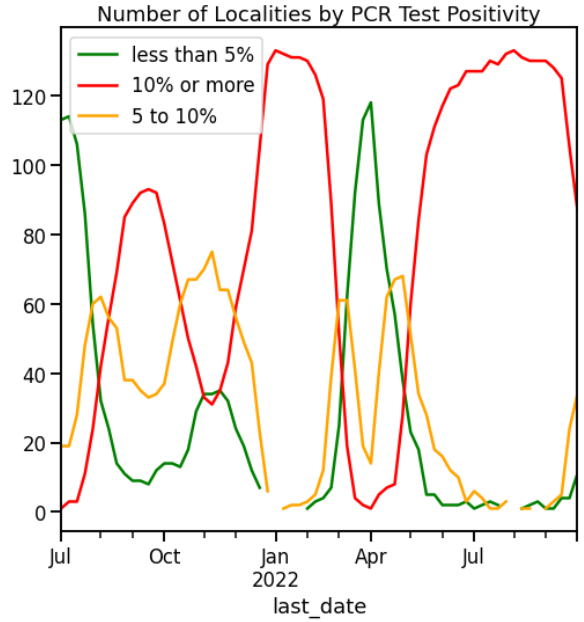
- **Case rates continue their decline, hospitalizations continue steady decline**
- VA weekly case rate continues decline to 99/100K from 109/100K
  - US weekly case rate is down considerably as well at 89/100K from 105/100K
  - VA hospital occupancy (rolling 7 day mean of 545 down from 599 a week ago) has continued to decline
- Projections anticipate continued declines in cases as well as hospitalizations
- Potential for rebounds due to seasonal forces and/or novel sub-variants in the Fall remains
- Model updates:
  - Maintained Booster Scenarios by slowing down the rate of vaccination adopting the rate of 3rd dose rollout
  - Current monitoring still not finding a definite candidate for Variant X, though BQ.1.1 or BA.2.75.2 remain likely, 50% prevalence pushed back to Nov 15th

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)

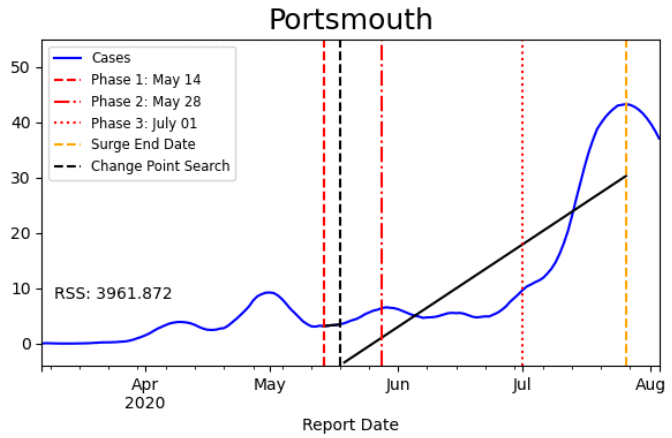
Red: >10.0% (and not "Green" or "Yellow")

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

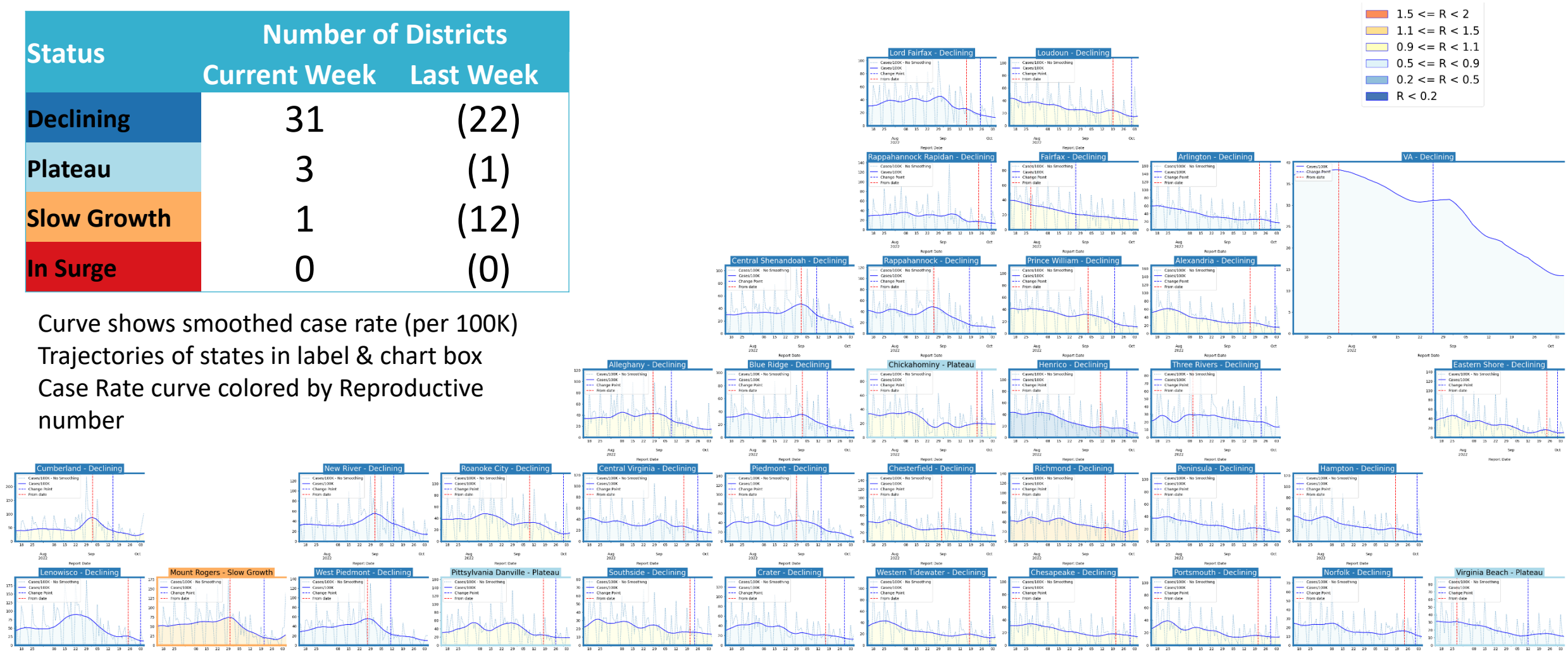


Trajectory	Description	Weekly Case Rate Slope (per 100k)	Weekly Hosp Rate Slope (per 100k)
Declining	Sustained decreases following a recent peak	slope < -0.88/day	slope < -0.07/day
Plateau	Steady level with minimal trend up or down	-0.88/day < slope < 0.42/day	-0.07/day < slope < 0.07/day
Slow Growth	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	31	(22)
Plateau	3	(1)
Slow Growth	1	(12)
In Surge	0	(0)

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



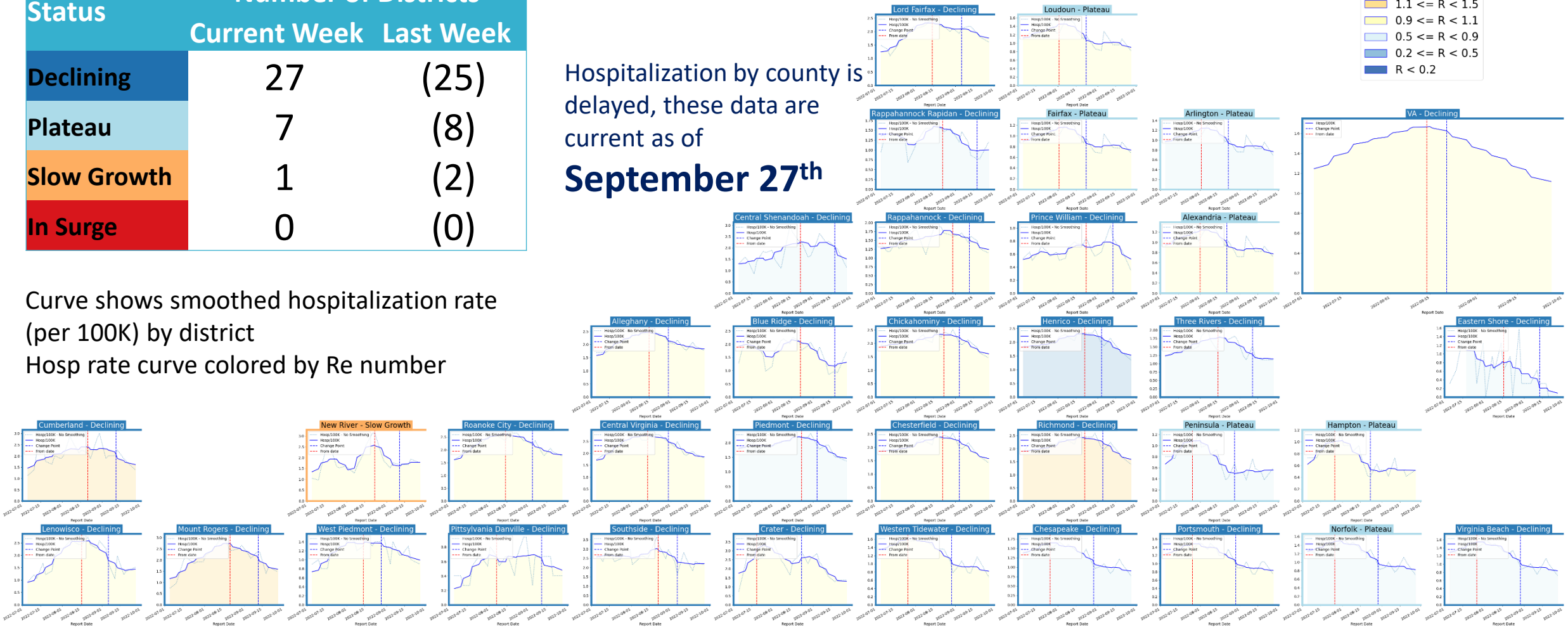
District Hospital Trajectories – last 10 weeks

Status	Number of Districts	
	Current Week	Last Week
Declining	27	(25)
Plateau	7	(8)
Slow Growth	1	(2)
In Surge	0	(0)

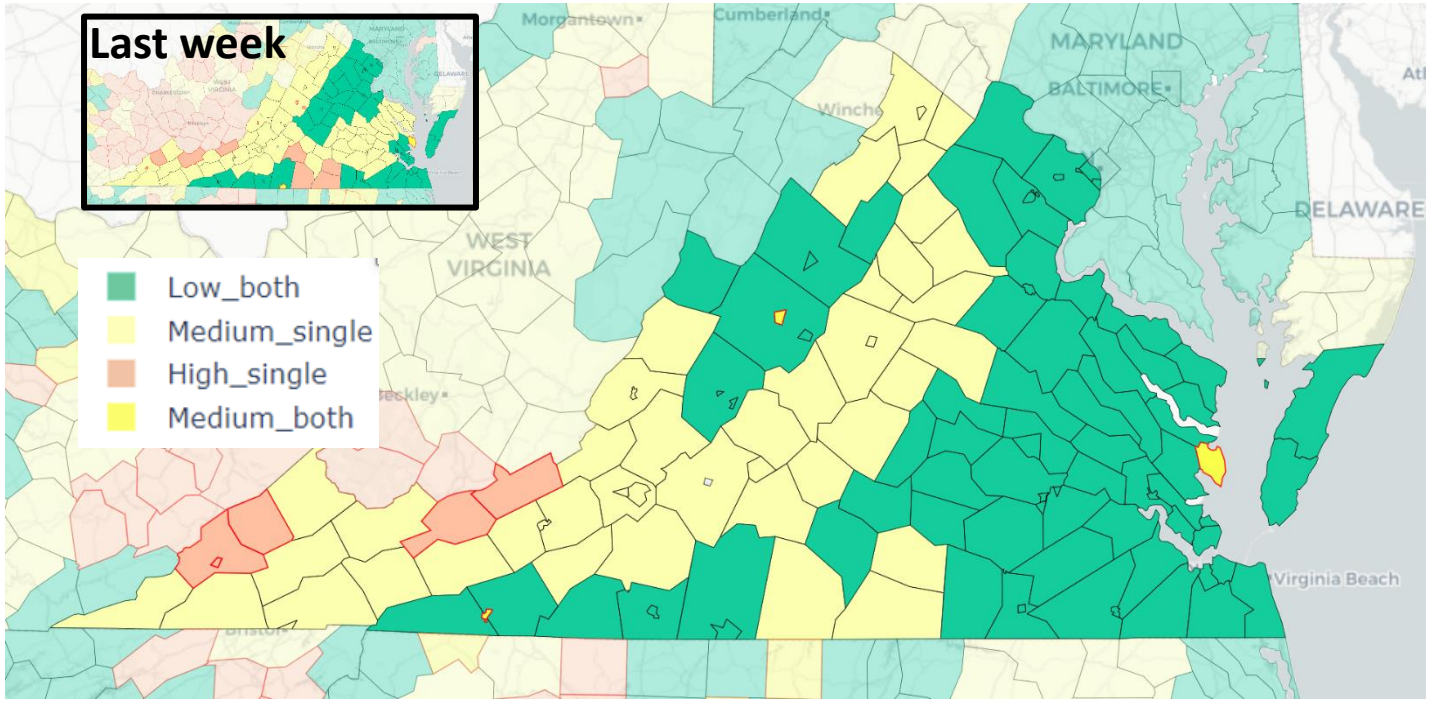
Curve shows smoothed hospitalization rate (per 100K) by district
Hosp rate curve colored by Re number

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

September 27th



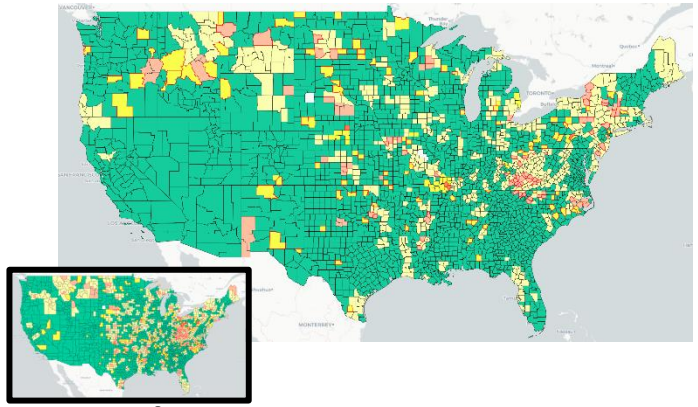
CDC's COVID-19 Community Levels

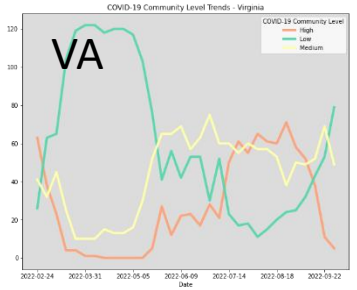


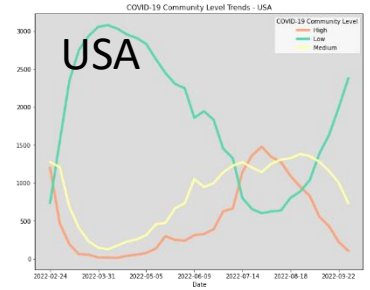
Red outline indicates county had 200 or more cases per 100k in last week

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







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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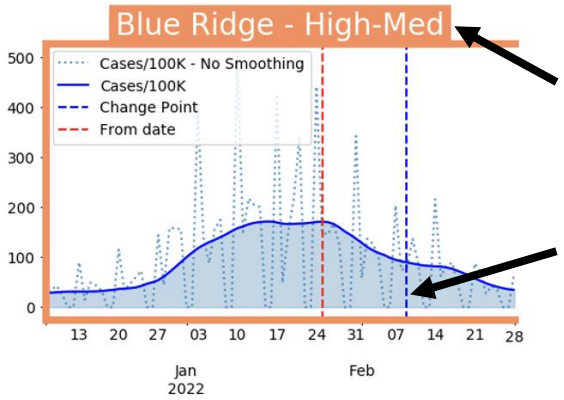
Data from: CDC Data Tracker Portal

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

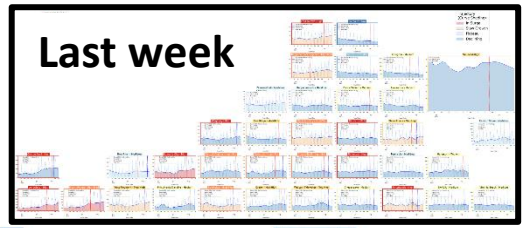
Trajectory (Curve Shading)
- In Surge
- Slow Growth
- Plateau
- Declining



District's Aggregate Community Level

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

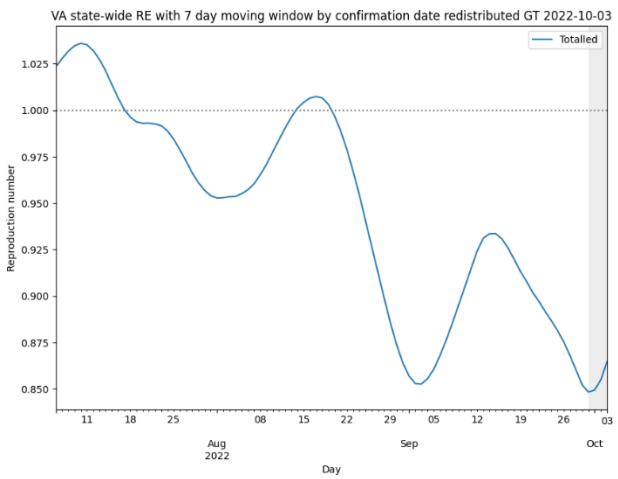
Case rate Trajectory

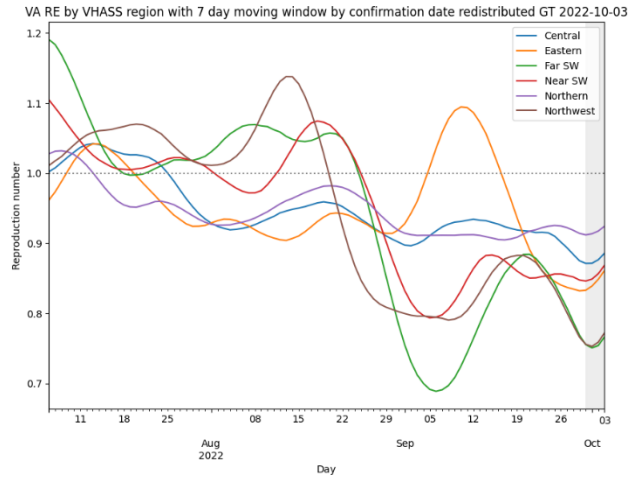


Estimating Daily Reproductive Number –
Redistributed gap

October 3rd Estimates

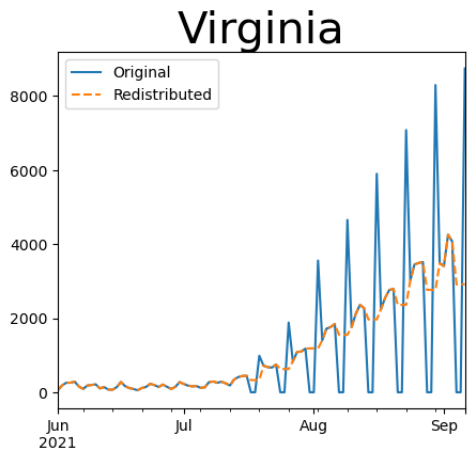
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.865	0.006
Central	0.886	0.014
Eastern	0.861	-0.027
Far SW	0.766	-0.121
Near SW	0.868	0.093
Northern	0.924	0.035
Northwest	0.772	-0.025





Skipping Weekend Reports & holidays biases estimates

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



Methodology

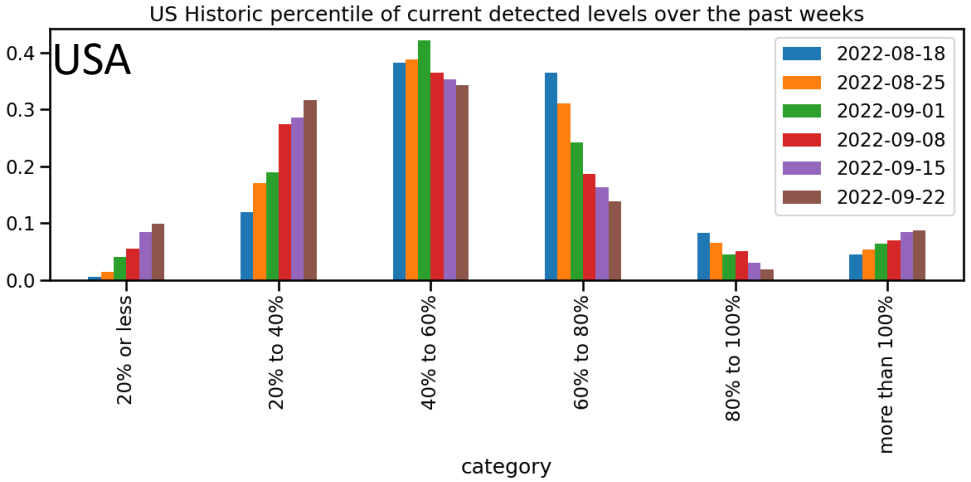
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

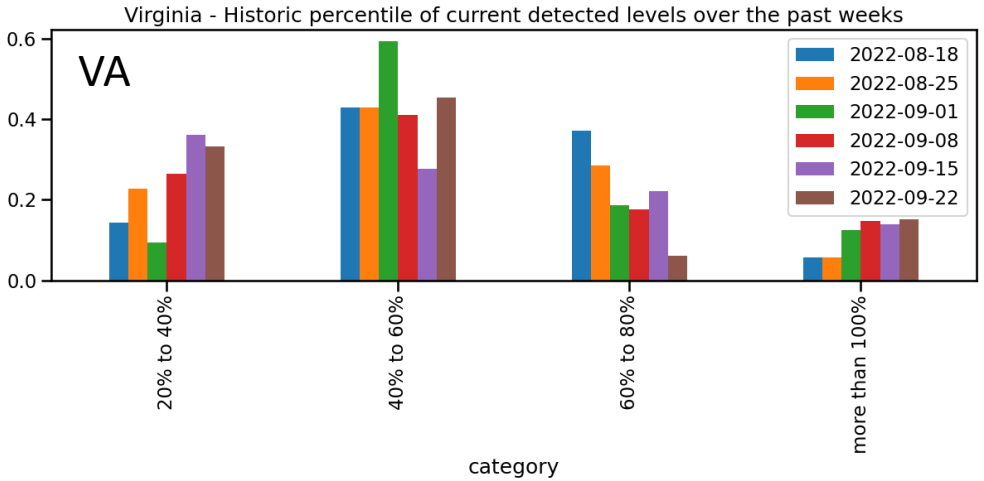
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

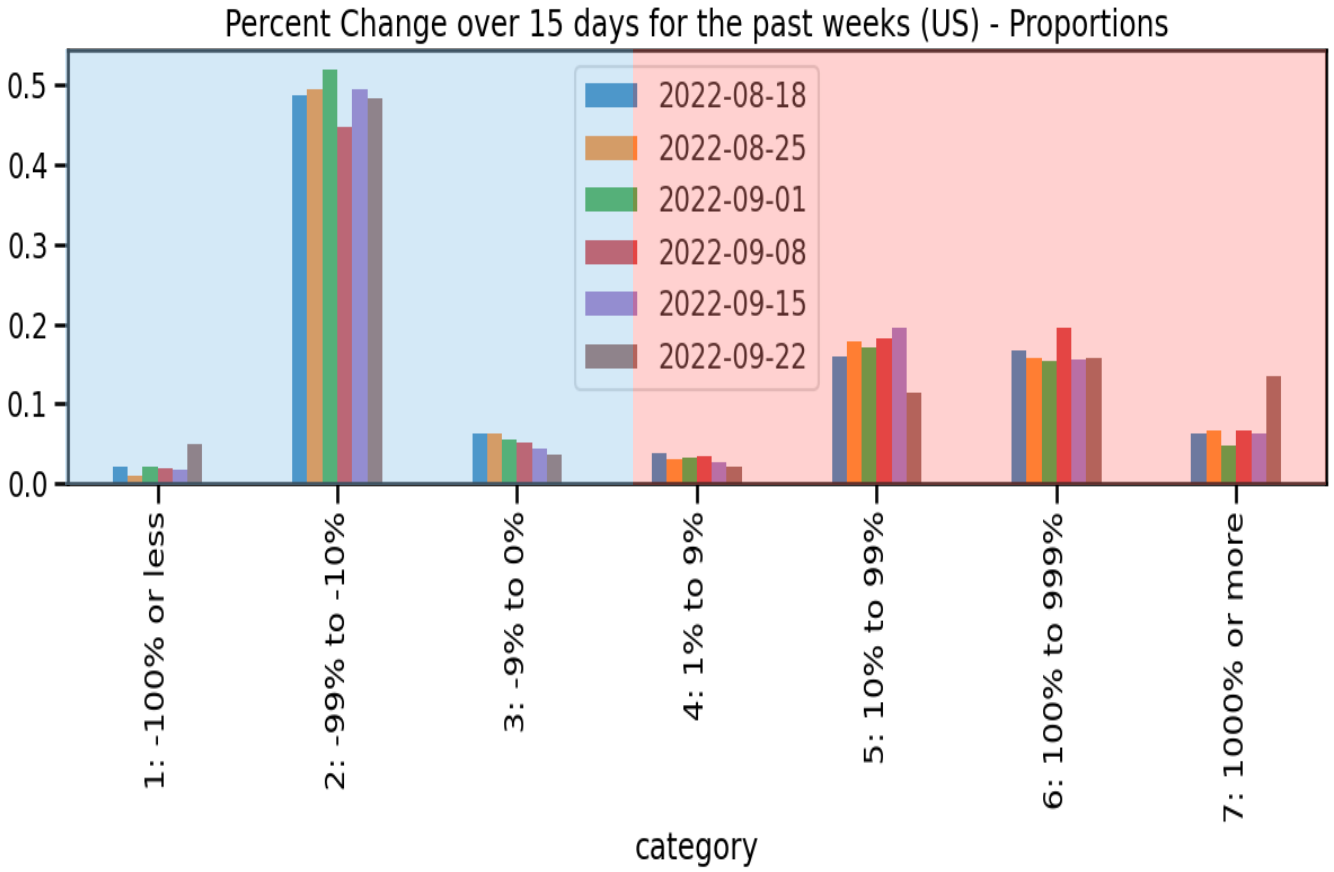
Wastewater Monitoring

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





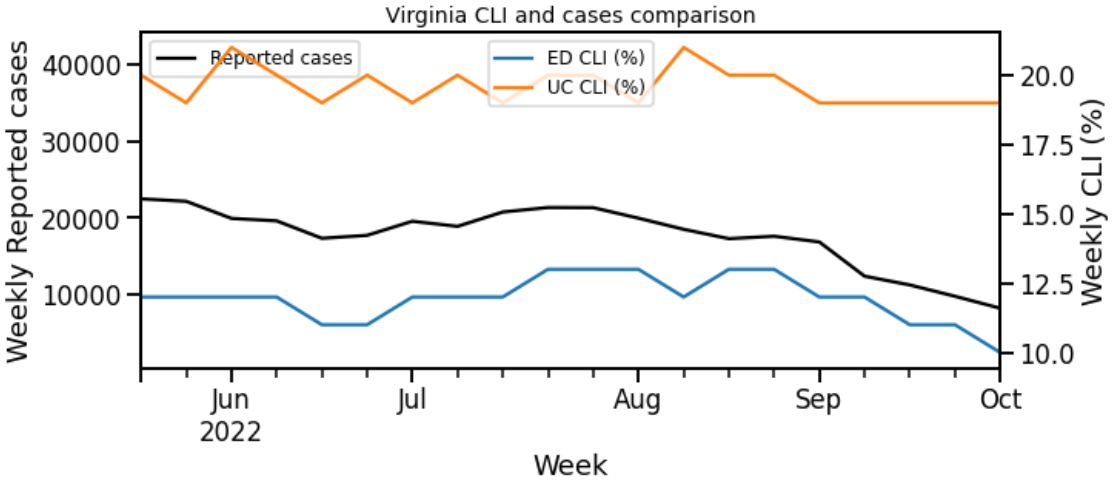


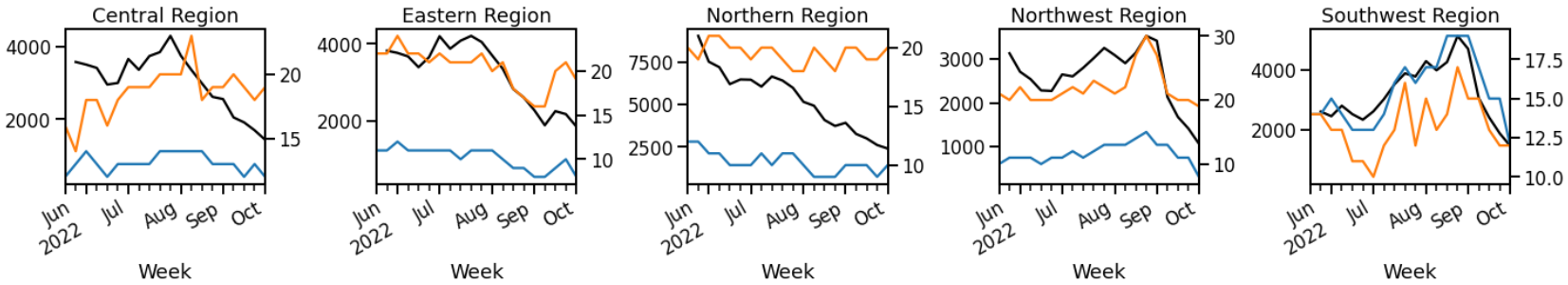
Data Source: [CDC Data Tracker]

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 been in a plateau since mid-May state-wide, with some regional fluctuations**



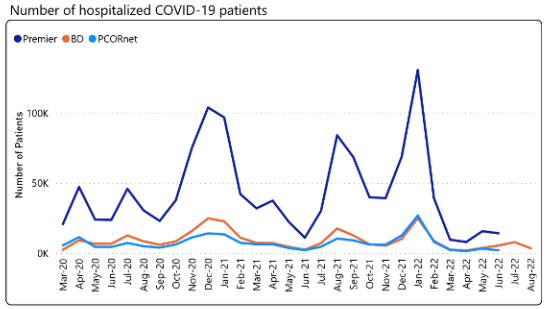


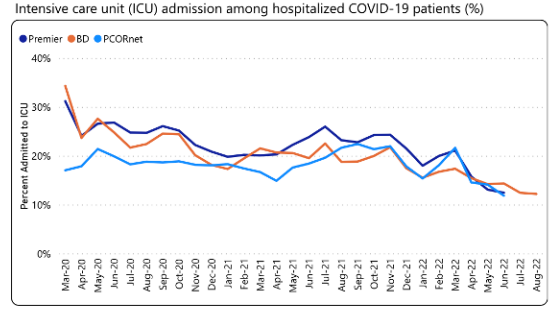
Hospitalizations and Severe Outcomes

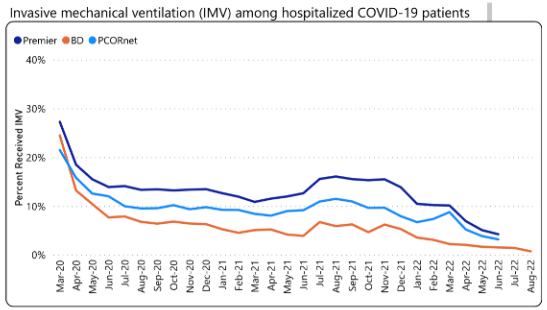
Data Source: [CDC Data Tracker]

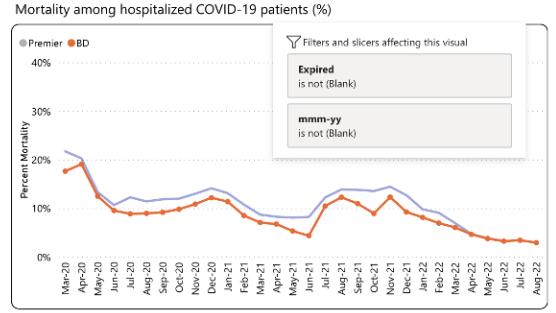
Proportion of most severe outcomes decreasing among those who are hospitalized

- 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

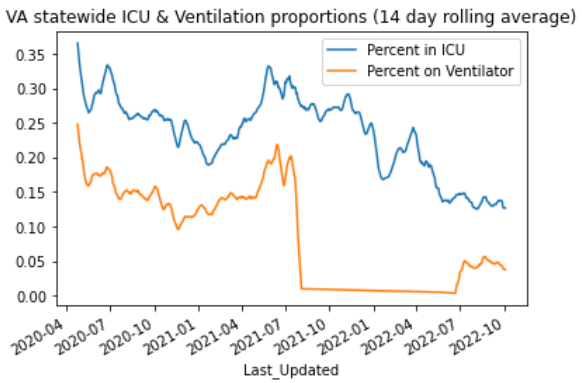




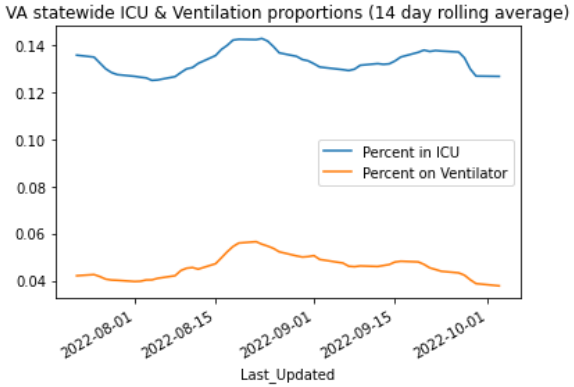




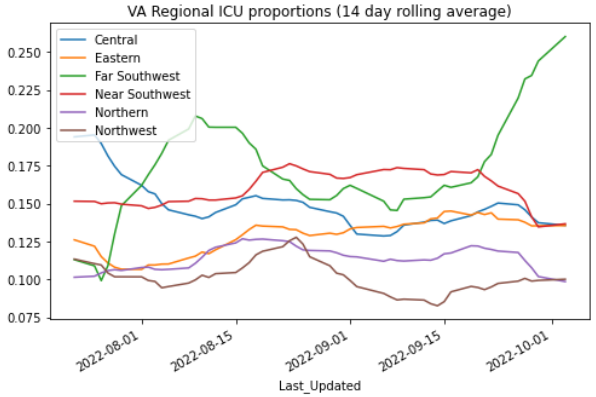
Virginia wide – full pandemic



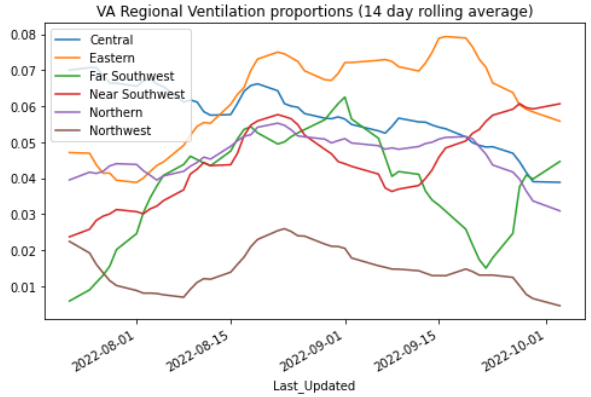
Virginia wide – recent



Virginia Regional ICU percent



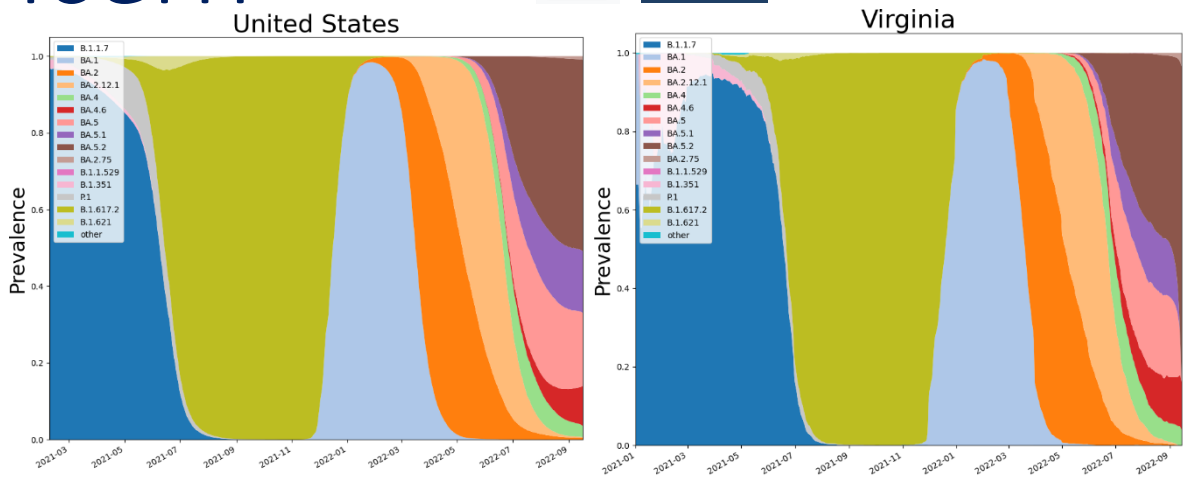
Virginia Regional Ventilation %



SARS-CoV2 Variants of Concern

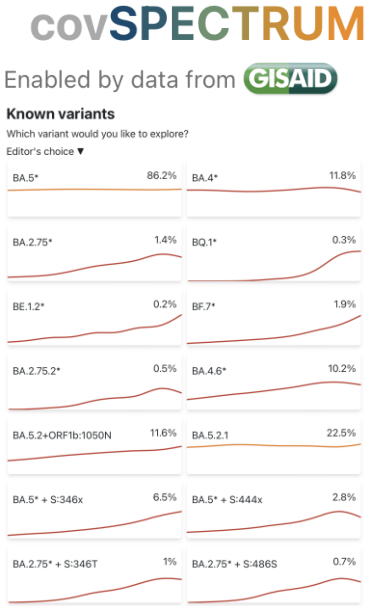
Emerging new variants will alter the future trajectories of pandemic and have implications for future control

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



Omicron Updates

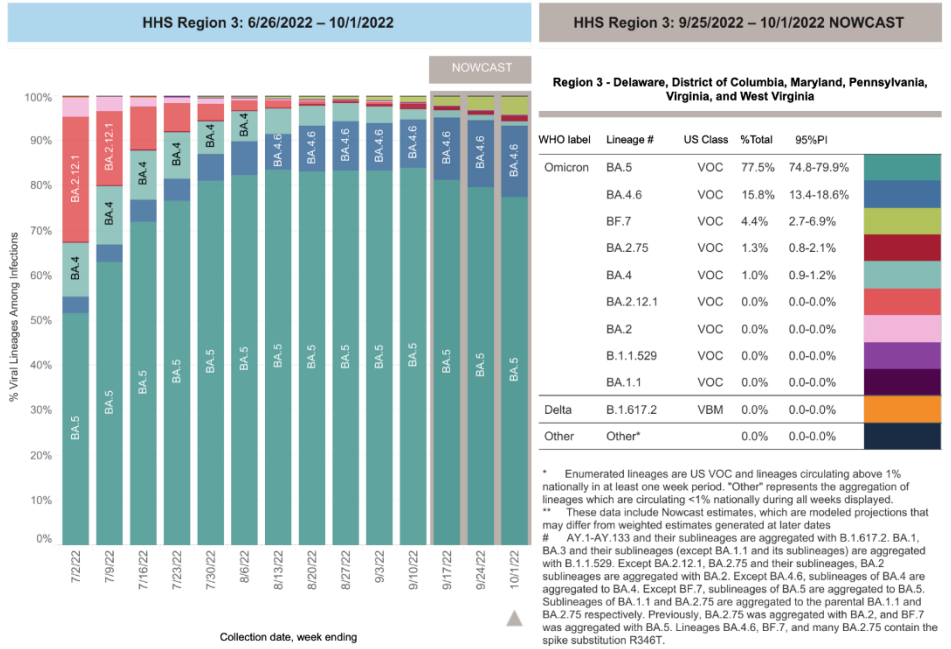
- BA.4.6 remains slow growing to about 16% from 15% last week
- BA.5 continues to slowly yield share to other variants, now down to 78% from 80% last week
- BF.7 showing strong growth up to 4.4 from 1.2% last week
- BQ.1.1 recently seeing growth in England and other countries that mimics past variants of concern that have gone on to dominate
- BA.2.72.2 also shows signs as being a potential candidate as a future variant of concern, has recently [been shown to have significant immune escape]



[COV-spectrum]

"Editor's choice"

Variants to watch

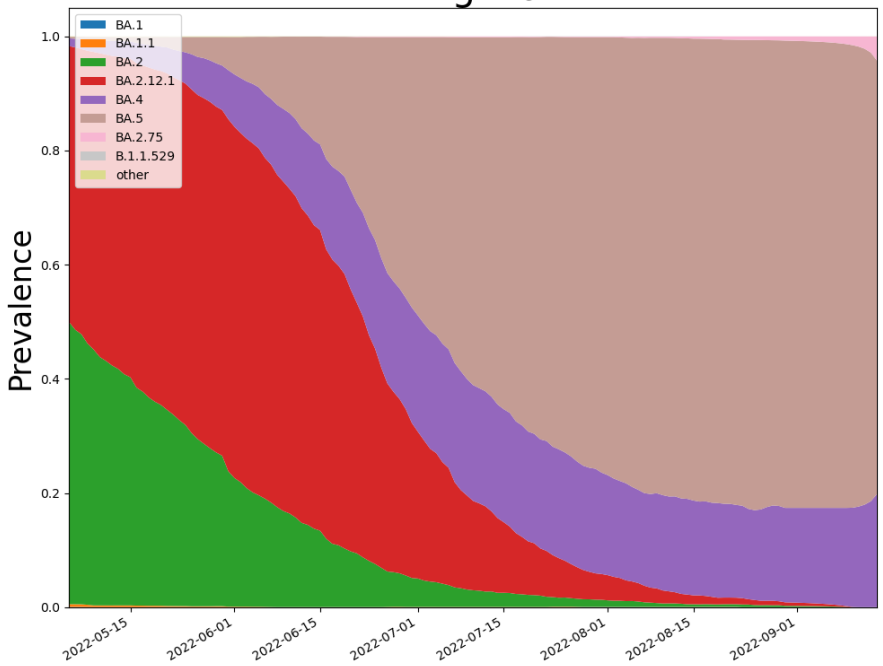


[CDC Variant Tracking]

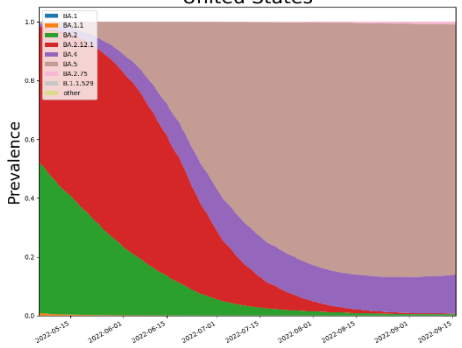
SARS-CoV2 Omicron and Sub-Variants

As detected in whole Genomes in public repositories

Virginia

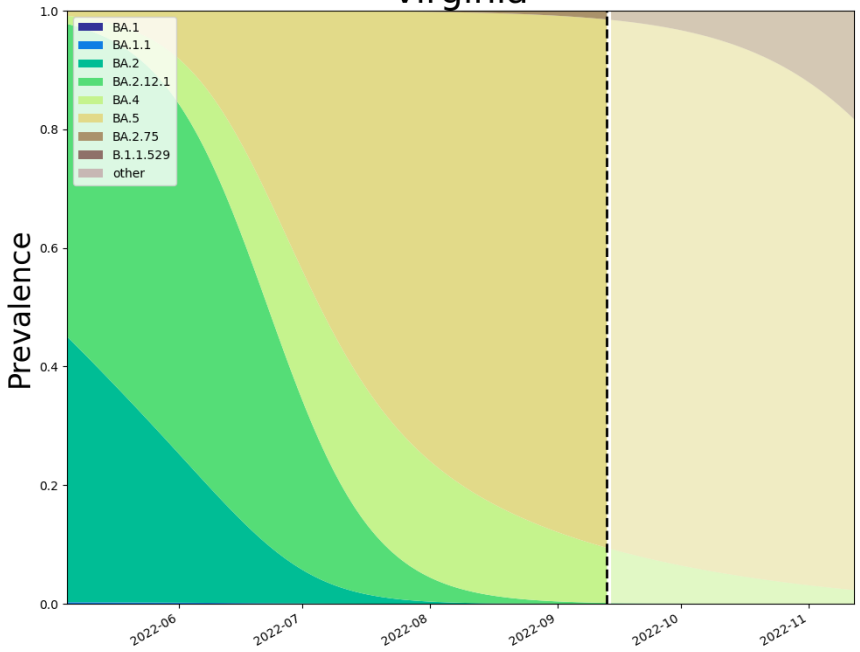


United States

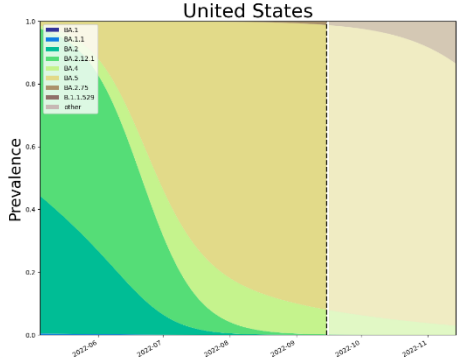


VoC Polynomial Fit Projections

Virginia

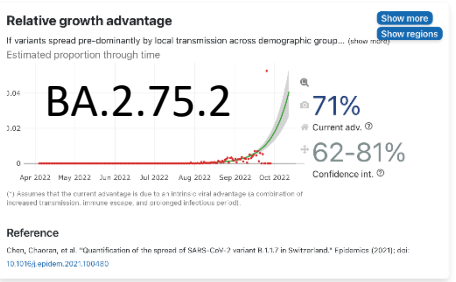


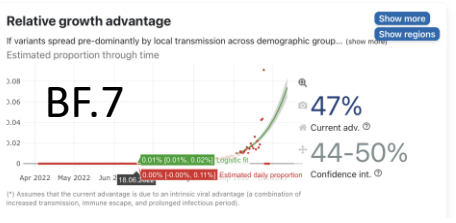
United States

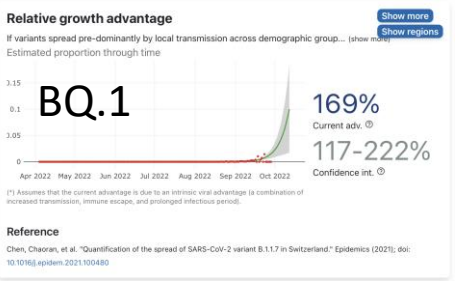


Note: Data lags force projections to start in past. Everything from dotted line forward is a projection.

Relative Growth Advantages



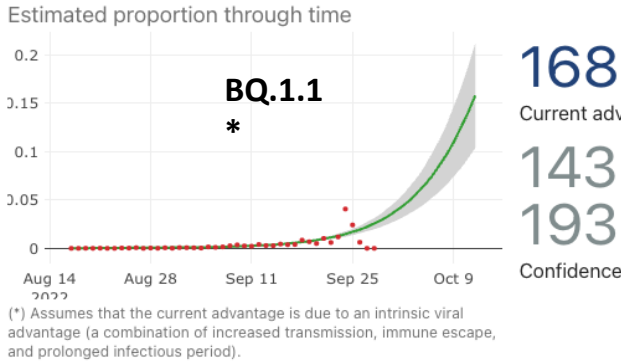


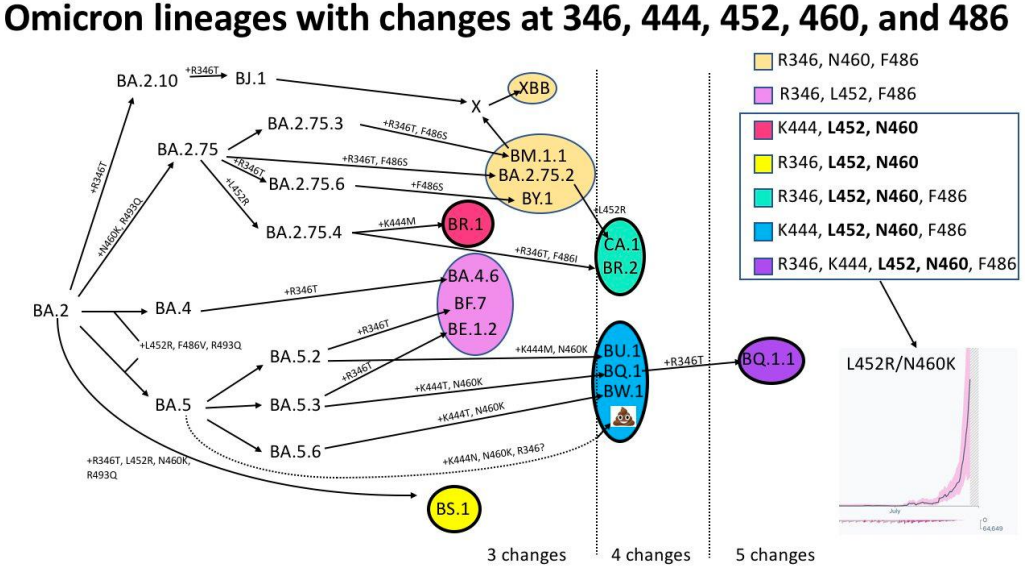


[COV-spectrum]

Pandemic Pubs

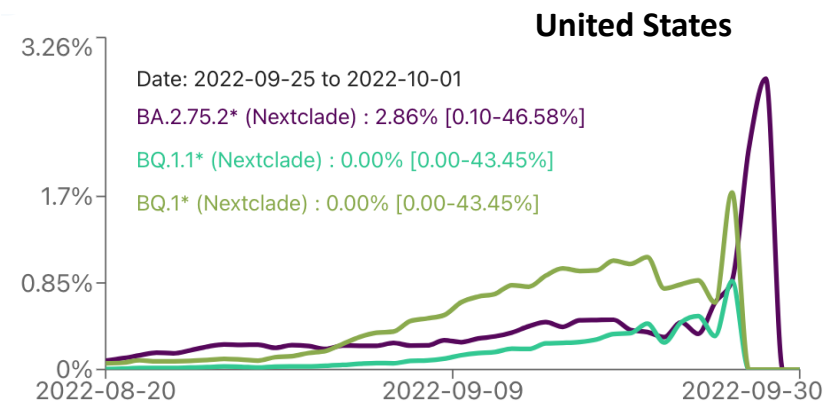
1. BQ.1.1, a descendant of BA.5, shows strong growth advantage in recent sequence surveillance.
Current Bivalent booster doses target BA.5 making it a well-timed and a worthwhile intervention.

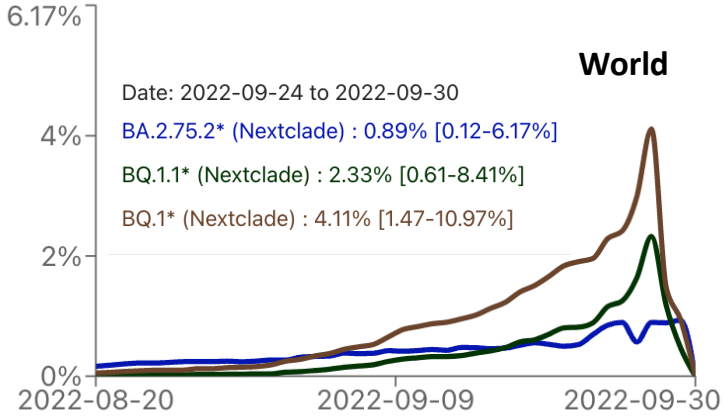




https://twitter.com/dfocosi/status/1574319177602670592?s=12&t=myre59DuQ1H31TI_-yd7DQ

World





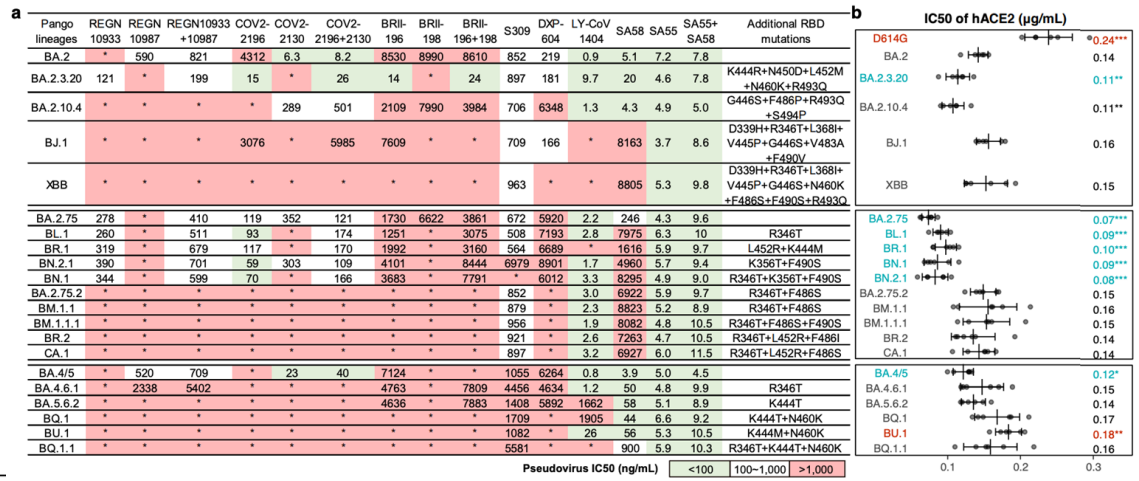
description	number_sequences	submitted_past_10_days	relative_growth_advantage	relative_growth_advantage_low	relative_growth_advantage_high
BA.4.6, BF.7, any BA.4/5+S:346T/S:444 etc.	67699	11538	31.64%	31.39%	31.89%
BA.2.75.2, BQ.1, BM.1.1, BY.1, BA.2.3.20, ...	3853	1465	73.37%	70.96%	75.78%
BQ.1.1, BN.1, BM.1.1.1, CA.1, ...	714	345	101.44%	93.21%	109.68%
XBB	66	40	157.47%	111.26%	203.67%

Estimates from surveillance using mutational profiles approximating BQ.1, BQ.1.1, and BA.2.75.2
https://cov-spectrum.org/explore/World/AllSamples/from=2022-08-17&to=2022-10-04/variants?nextcladePangoLineage=BA.2.75.2*&nextcladePangoLineage1=bq.1.1*&nextcladePangoLineage2=bq.1&analysisMode=CompareEquals&

https://cov-spectrum.org/collections/54

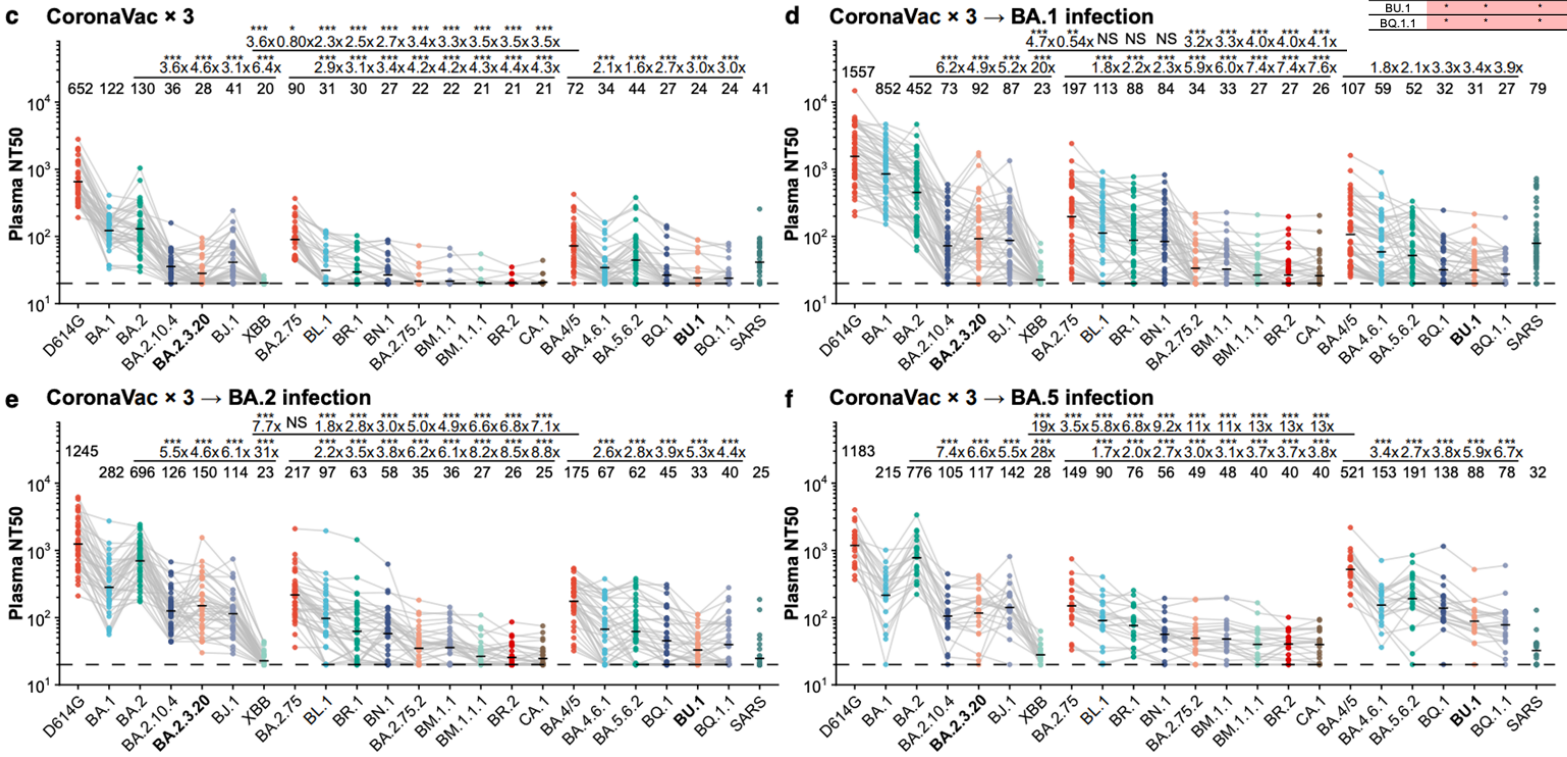
Pandemic Pubs

2. 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.

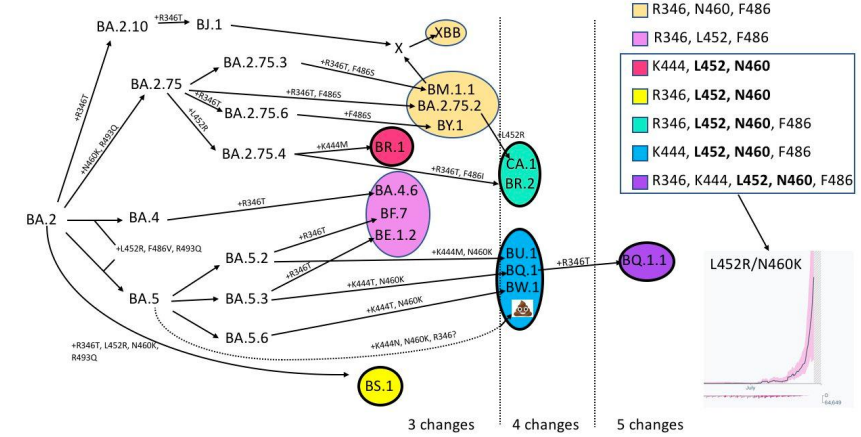


Pango lineages	REGN 10933	REGN 10987	REGN10933 +10987	COV2-2196	COV2-2130	COV2-2196+2130	BRII-196	BRII-198	BRII-196+198	S309	DXP-604	LY-CoV 1404	SA58	SA55	SA55+ SA58	Additional RBD mutations
BA.2	*	590	821	4312	6.3	8.2	8530	8990	8610	852	219	0.9	5.1	7.2	7.8	
BA.2.3.20	121	*	199	15	*	26	14	*	24	897	181	9.7	20	4.6	7.8	K444R+N450D+L452M +N460K+R493Q
BA.2.10.4	*	*	*	*	289	501	2109	7990	3984	706	6348	1.3	4.3	4.9	5.0	G446S+F486P+R493Q +S494P
BJ.1	*	*	*	3076	*	5985	7609	*	*	709	166	*	8163	3.7	8.6	D339H+R346T+L368I+ V445P+G446S+V483A +F490V
XBB	*	*	*	*	*	*	*	*	*	963	*	*	8805	5.3	9.8	D339H+R346T+L368I+ V445P+G446S+N460K +F486S+F490S+R493Q
BA.2.75	278	*	410	119	352	121	1730	6622	3861	672	5920	2.2	246	4.3	9.6	
BL.1	260	*	511	93	*	174	1251	*	3075	508	7193	2.8	7975	6.3	10	R346T
BR.1	319	*	679	117	*	170	1992	*	3160	564	6689	*	1616	5.9	9.7	L452R+K444M
BN.2.1	390	*	701	59	303	109	4101	*	8444	6979	8901	1.7	4960	5.7	9.4	K356T+F490S
BN.1	344	*	599	70	*	166	3683	*	7791	*	6012	3.3	8295	4.9	9.0	R346T+K356T+F490S
BA.2.75.2	*	*	*	*	*	*	*	*	*	852	*	3.0	6922	5.9	9.7	R346T+F486S
BM.1.1	*	*	*	*	*	*	*	*	*	879	*	2.3	8823	5.2	8.9	R346T+F486S
BM.1.1.1	*	*	*	*	*	*	*	*	*	956	*	1.9	8082	4.8	10.5	R346T+F486S+F490S
BR.2	*	*	*	*	*	*	*	*	*	921	*	2.6	7263	4.7	10.5	R346T+L452R+F486I
CA.1	*	*	*	*	*	*	*	*	*	897	*	3.2	6927	6.0	11.5	R346T+L452R+F486S
BA.4/5	*	520	709	*	23	40	7124	*	*	1055	6264	0.8	3.9	5.0	4.5	
BA.4.6.1	*	2338	5402	*	*	*	4763	*	7809	4456	4634	1.2	50	4.8	9.9	R346T
BA.5.6.2	*	*	*	*	*	*	4636	*	7883	1408	5892	1662	58	5.1	8.9	K444T
BQ.1	*	*	*	*	*	*	*	*	*	1709	*	1905	44	6.6	9.2	K444T+N460K
BU.1	*	*	*	*	*	*	*	*	*	1082	*	26	56	5.3	10.5	K444M+N460K
BQ.1.1	*	*	*	*	*	*	*	*	*	5581	*	*	900	5.9	10.3	R346T+K444T+N460K

Pseudovirus IC50 (ng/mL): <100 | 100~1,000 | >1,000



Omicron lineages with changes at 346, 444, 452, 460, and 486



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 capability 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

https://twitter.com/dfocosi/status/1574319177602670592?s=12&t=myre59DuQ1H31TI_-yd7DQ

Pandemic Pubs (last week)

1. Representative survey estimates 7.3% of the US adult population (~18.5 million) reported having long COVID by July
2. A propensity matched cohort from the UK found that 2+ doses of vaccine decreased adjusted long COVID risk by 41% (95% CI 31%-50%)
3. BA.2.75.2 neutralised, on average, at titers ~6.5-times lower than BA.5, making BA.2.75.2 the most neutralisation-resistant variant evaluated to date
4. Retrospective cohort study of 6,245,282 older adults (age ≥65 years) who had medical encounters between 2/2020–5/2021, indicates that people with COVID-19 were at significantly increased risk for a new diagnosis of Alzheimer's disease within 360 days after the initial COVID-19 diagnosis

1

Prevalence of Long COVID Among All Respondent (with or without COVID)

	Total	Long COVID	Crude Prevalence of Long COVID % (95% CI)	Age and sex direct-standardized prevalence of long COVID* % (95% CI)	Crude prevalence ratio (PR) PR (95% CI)	Adjusted prevalence ratio (aPR)** aPR (95% CI)	Estimated Number with Long COVID
	Weighted N (%)	Weighted N (%)					
Total	3,042 (100.0)	222 (100.0)	7.3 (6.1, 8.5)				18,533,864
Age							
18-24	365 (12.0)	17 (7.8)	4.8 (0.9, 8.6)	4.4 (1.8 - 10.0)	**0.45 (0.27, 0.76)**	**0.50 (0.30, 0.84)**	1,445,641
25-34	547 (18.0)	58 (26.1)	10.6 (6.6, 14.6)	10.0 (6.8 - 14.6)	Ref	Ref	4,837,339
35-44	495 (16.3)	43 (19.1)	8.6 (5.3, 11.9)	9.0 (6.1 - 13.1)	0.81 (0.56, 1.18)	0.87 (0.60, 1.26)	3,539,968
45-54	498 (16.4)	37 (16.5)	7.4 (4.6, 10.2)	7.4 (5.1 - 10.7)	0.70 (0.47, 1.03)	0.72 (0.49, 1.07)	3,058,088
55-64	508 (16.7)	41 (18.2)	8.0 (5.5, 10.5)	8.3 (6.0 - 11.2)	0.75 (0.51, 1.10)	0.80 (0.55, 1.18)	3,373,163
65+	629 (20.7)	27 (12.2)	4.3 (3.0, 5.6)	4.2 (3.0 - 5.8)	**0.41 (0.26, 0.63)**	**0.43 (0.27, 0.66)**	2,261,131
Gender							
Male	1,443 (47.4)	72 (32.4)	5.0 (3.6, 6.3)	5.0 (3.8 - 6.5)	Ref	Ref	6,004,972
Female	1,516 (49.8)	144 (64.8)	9.5 (7.5, 11.5)	9.4 (7.7 - 11.6)	**1.90 (1.45, 2.50)**	**1.84 (1.40, 2.42)**	12,009,944

NY researchers conducted a population-representative survey, June 30-July 2, 2022, of a random sample of 3,042 United States adults. Using questions developed by the United Kingdom's Office of National Statistics, we estimated the prevalence by sociodemographics, adjusting for gender and age. An estimated 7.3% (95% CI: 6.1-8.5%) of all respondents reported long COVID, approximately 18,533,864 adults. One-quarter (25.3% [18.2-32.4%]) of respondents with long COVID reported their day-to-day activities were impacted 'a lot' and 28.9% had SARS-CoV-2 infection >12 months ago.
https://www.medrxiv.org/content/10.1101/2022.09.12.22279862v1

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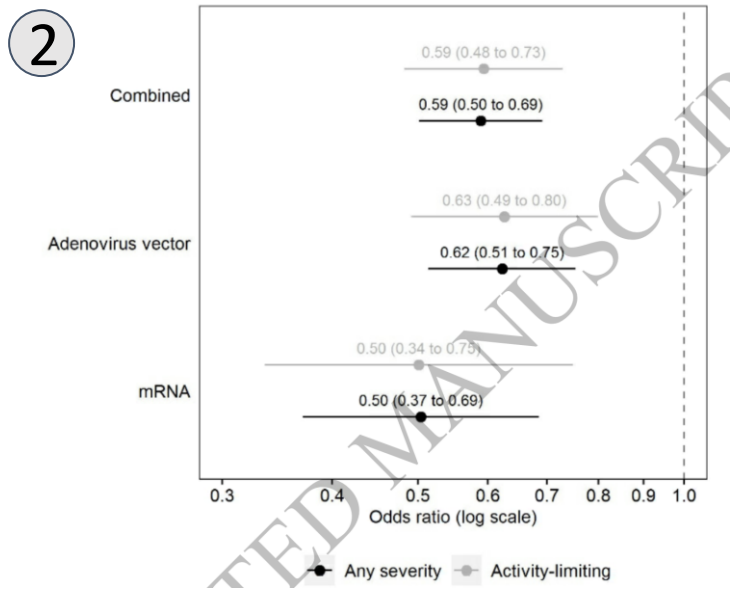

Oxford researchers investigated Long Covid incidence by vaccination status in a random sample of UK adults from April 2020 to November 2021. Persistent symptoms were reported by 9.5% of 3,090 breakthrough SARS-CoV-2 infections and 14.6% of unvaccinated controls (adjusted odds ratio 0.59, 95% CI: 0.50-0.69), emphasising the need for public health initiatives to increase population-level vaccine uptake. Matched study participants who were double-vaccinated at time of infection to control participants who were unvaccinated when infected and remained so at their first follow-up visit ≥12 weeks later. Most double-vaccinated participants (3,057, 98.9%) were infected after 17 May 2021, when the Delta variant dominated in the UK, while nearly all unvaccinated participants (3,082, 14 99.7%) were infected before this date.
https://academic.oup.com/ofid/advance-article/doi/10.1093/ofid/ofac464/6696170?login=false
https://twitter.com/DFisman/status/1570901408211402752

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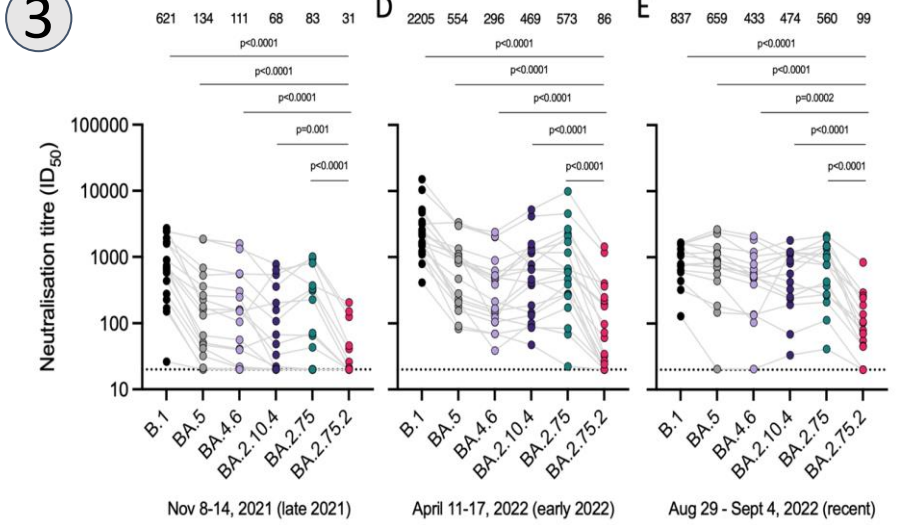

In 18 random blood donor samples in Stockholm, sampled recently BA.2.75.2 was neutralised, on average, five-fold less potently than BA.5. These are recent samples in a city that has good vaccine coverage and likely relatively high prior infection rates. Researchers also report the sensitivity of emerging omicron sublineages BA.2.75.2, BA.4.6, and BA.2.10.4 to neutralisation by a panel of clinically relevant and pre-clinical monoclonal antibodies, as well as by serum from blood donated in Stockholm, Sweden.
https://www.biorxiv.org/content/10.1101/2022.09.16.508299v2
https://twitter.com/benjmurrell/status/1570862185819303937?s=12&t=sL45iDMQ7GGmC2KakXPNZg

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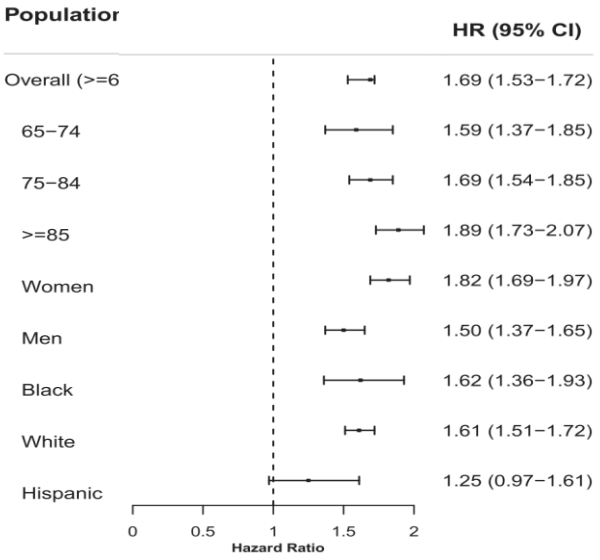
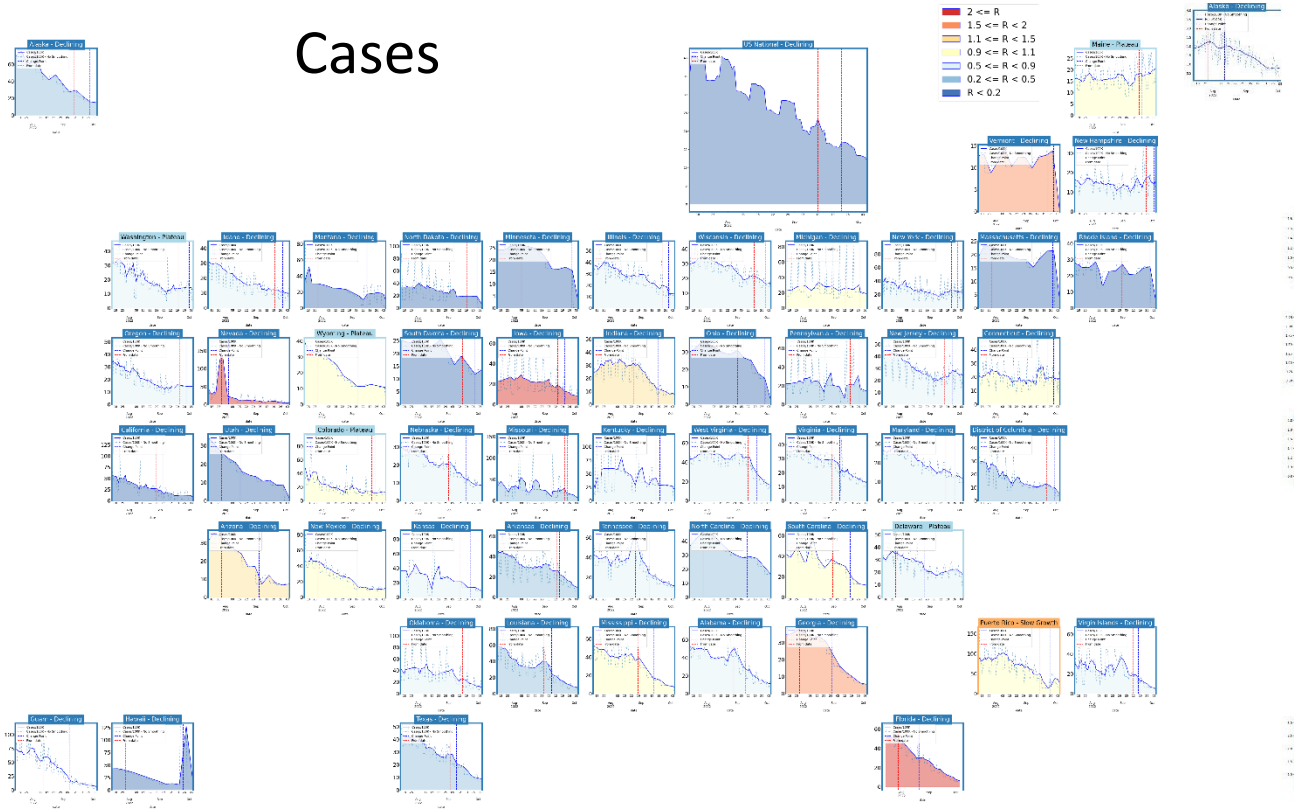


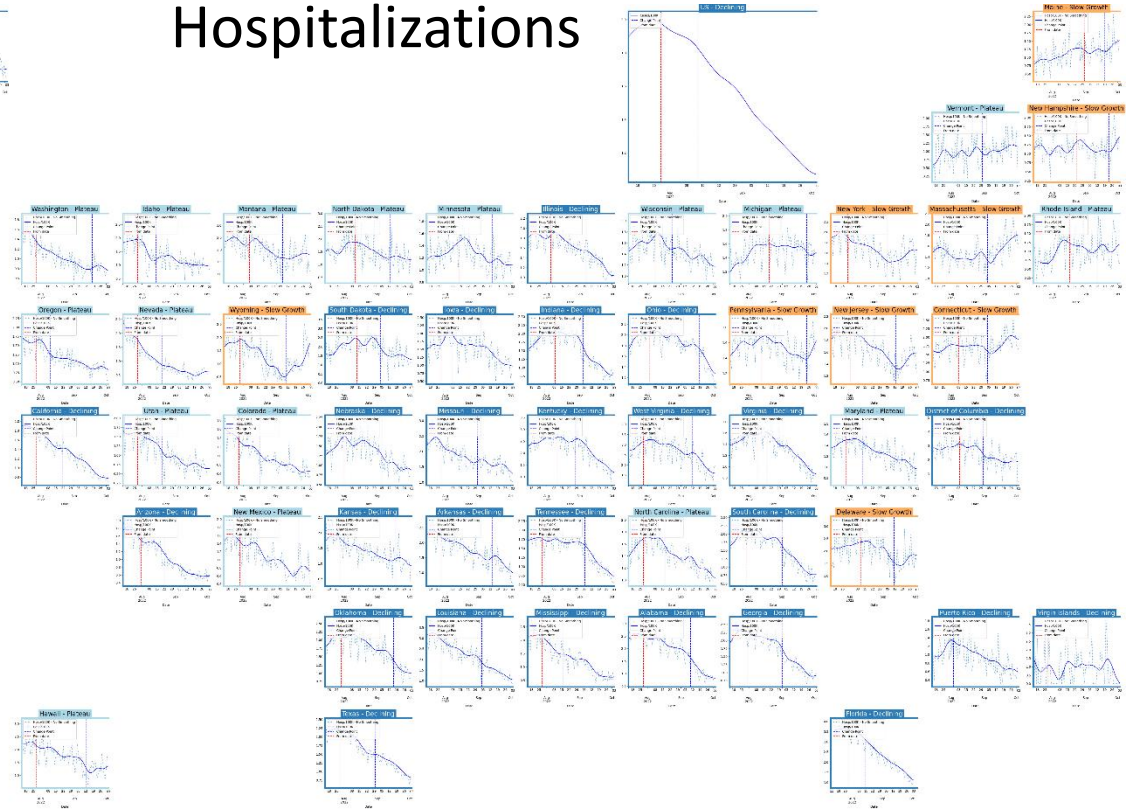
https://content.iospress.com/articles/journal-of-alzheimers-disease/jad220717

United States Case & Hospitalizations

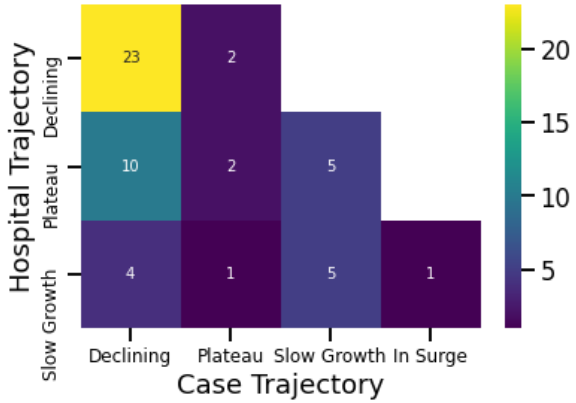
Cases



Hospitalizations



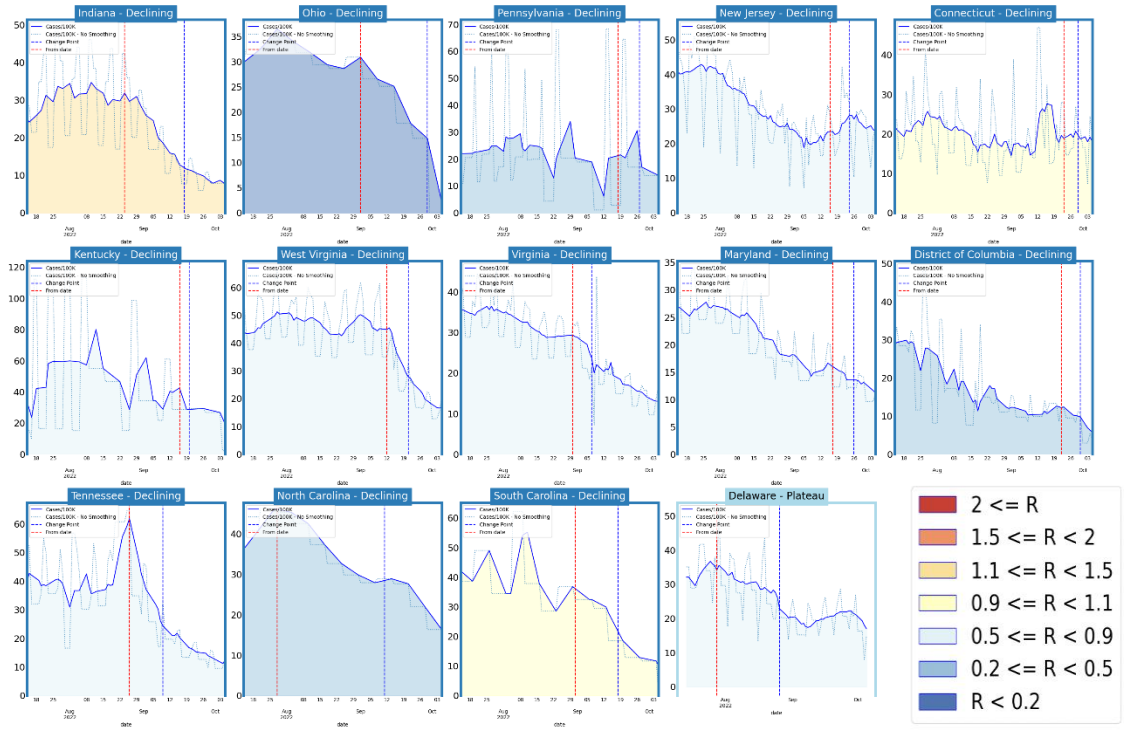
Status	Number of States	
	Current Week	Last Week
Declining	48	(37)
Plateau	5	(5)
Slow Growth	1	(11)
In Surge	0	(1)



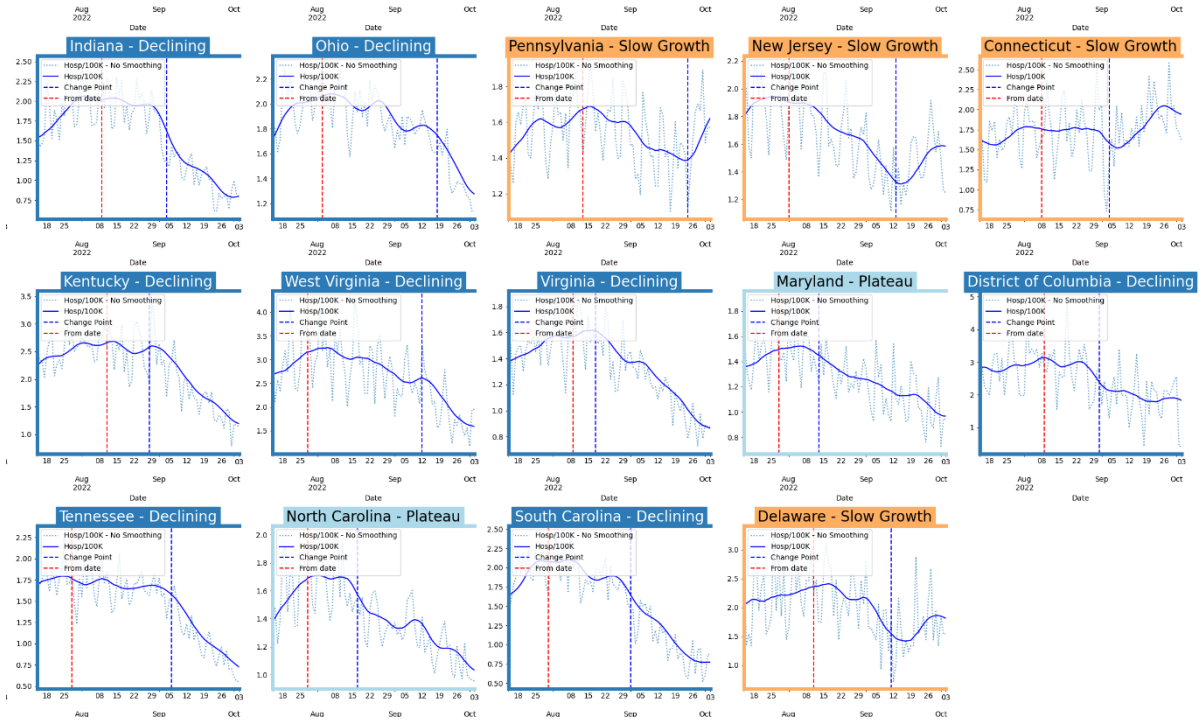
Status	Number of States	
	Current Week	Last Week
Declining	27	(26)
Plateau	17	(21)
Slow Growth	9	(6)
In Surge	0	(1)

Virginia and Her Neighbors

Cases

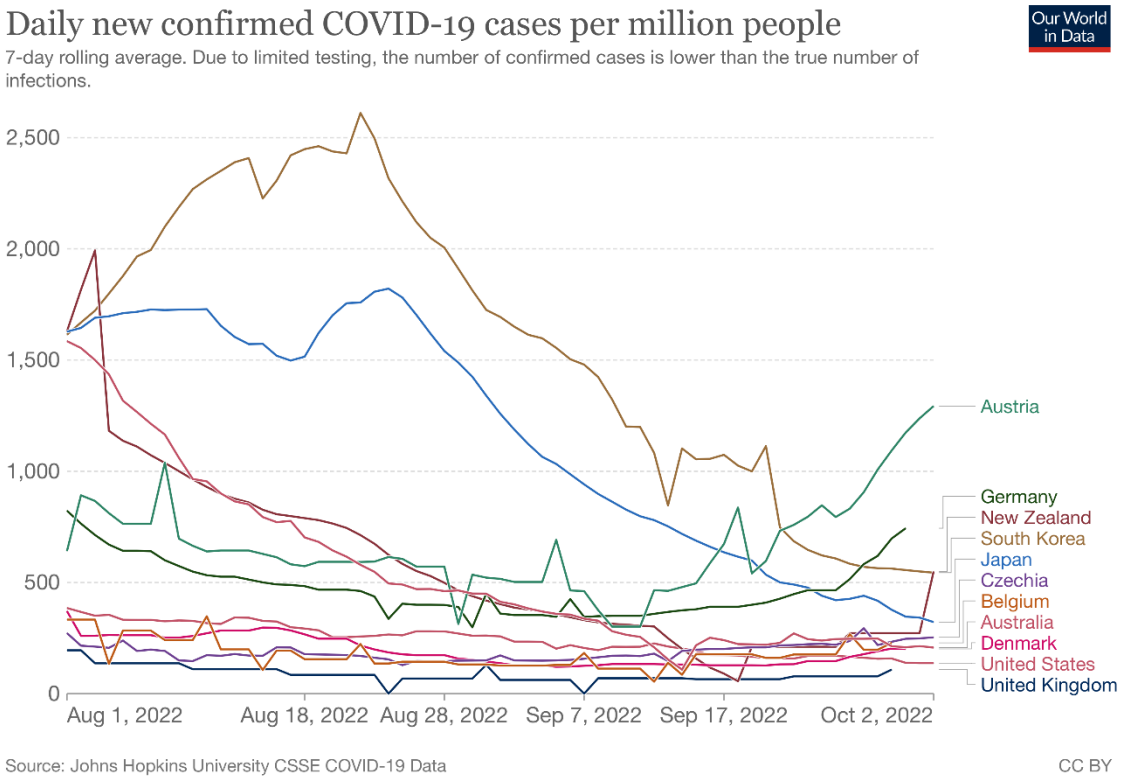


Hospitalizations

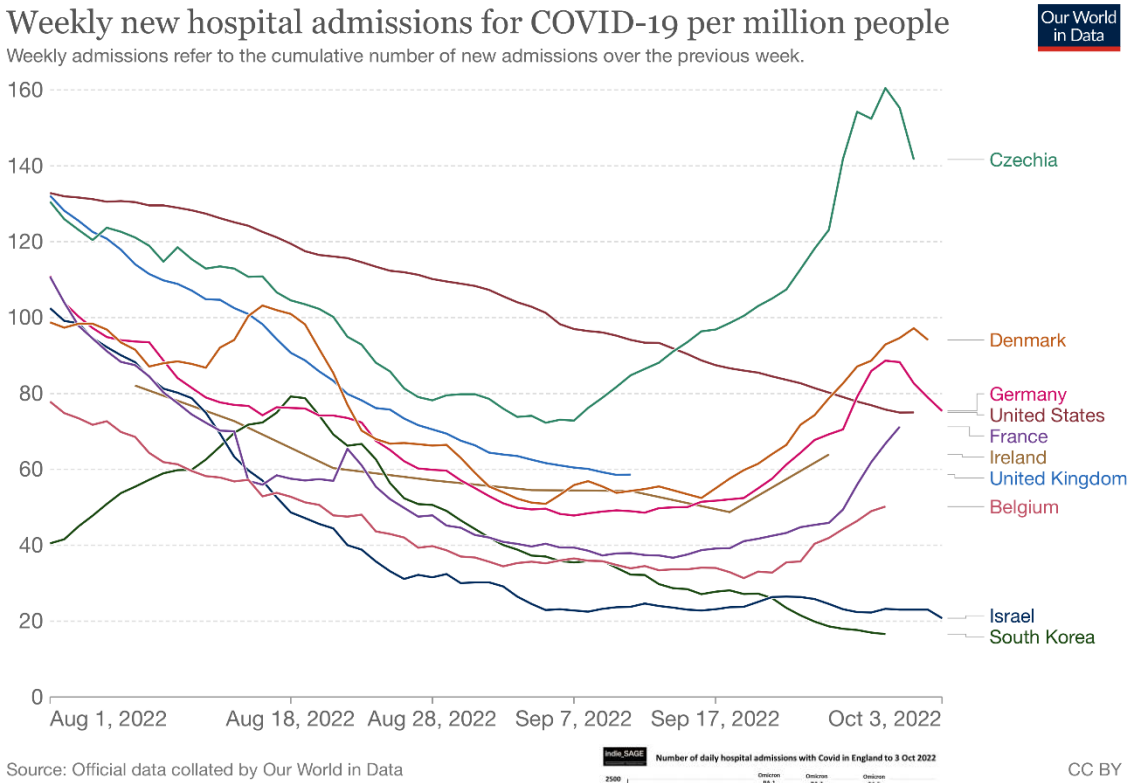


Around the World – Various trajectories

Confirmed cases



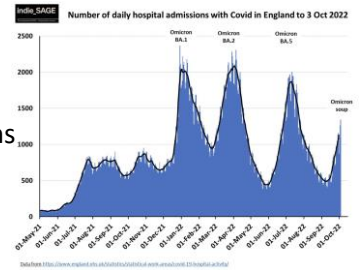
Hospitalizations



[Our World in Data]

[National Health England]

Rapid rise in hospitalizations



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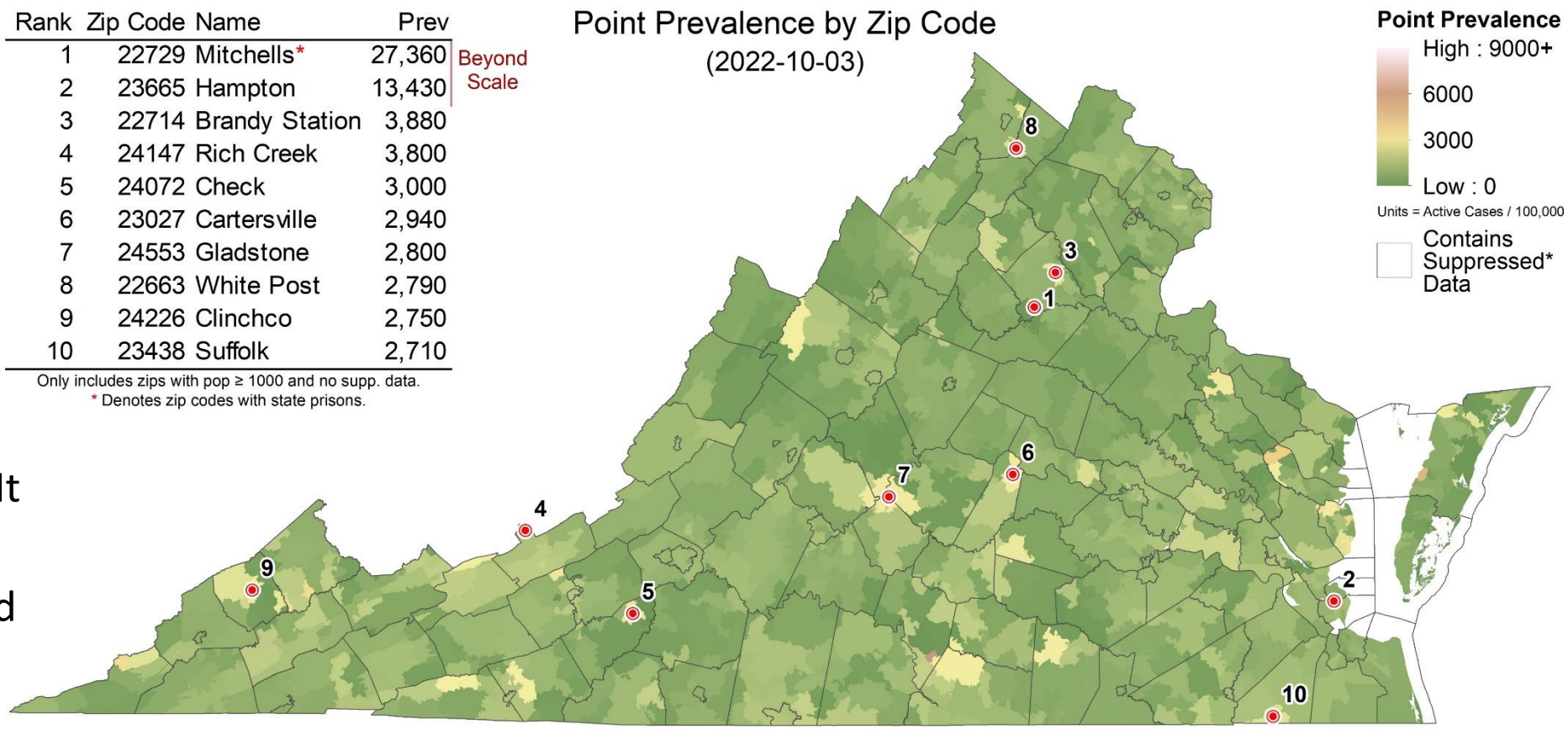
Zip code level weekly Case Rate (per 100K)

Case Rates in the last week by zip code

- Statewide rates have fallen significantly. We will adjust the color ramp if trends continue.
- High prevalence areas are spread randomly across Virginia (no spatial autocorrelation).
- Mitchells, VA has by far the highest prevalence. It is home to a prison.
- Some counts are low and suppressed to protect anonymity. Those are shown with a dark red outline.

Rank	Zip Code	Name	Prev	
1	22729	Mitchells*	27,360	Beyond Scale
2	23665	Hampton	13,430	
3	22714	Brandy Station	3,880	
4	24147	Rich Creek	3,800	
5	24072	Check	3,000	
6	23027	Cartersville	2,940	
7	24553	Gladstone	2,800	
8	22663	White Post	2,790	
9	24226	Clinchco	2,750	
10	23438	Suffolk	2,710	

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence, with an 8:1 ascertainment ratio, for week ending 2022-10-03.

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Risk of Exposure by Group Size and HCW prevalence

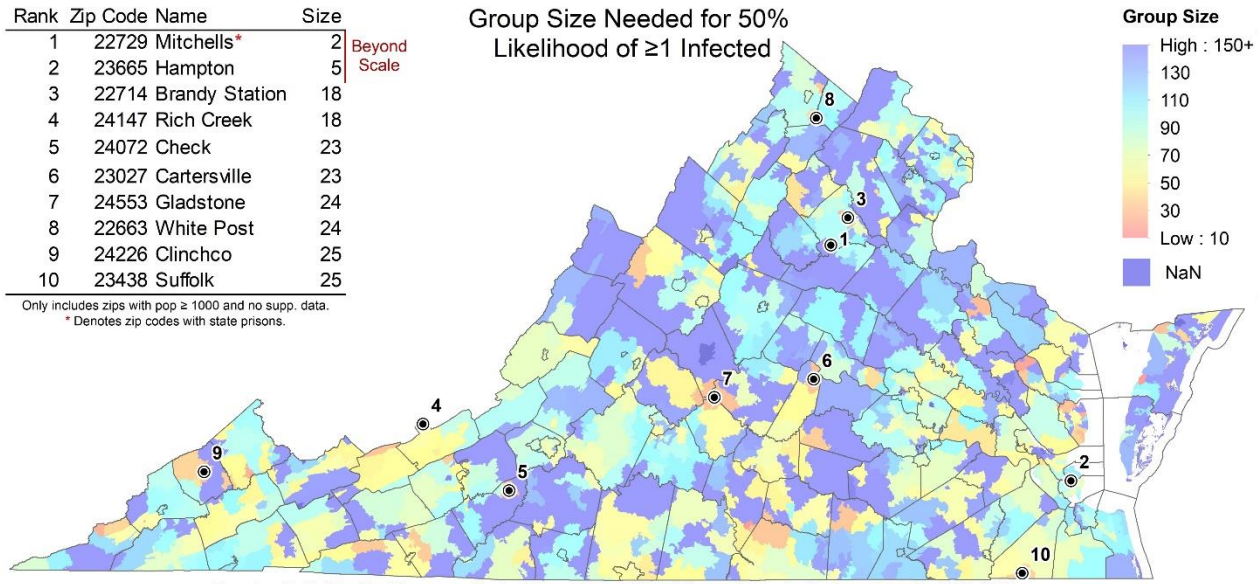
Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people

- **Group Size**: Assumes **8 undetected infections** per confirmed case (ascertainment rate from recent seroprevalence survey) and shows minimum size of a group with a 50% chance an individual is infected by zip code (e.g., in a group 2 in Mitchells, there is a 50% chance someone will be infected).
- **HCW ratio**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator / general population's case prevalence. Note Williamsburg City.

Rank	Zip Code	Name	Size
1	22729	Mitchells*	2
2	23665	Hampton	5
3	22714	Brandy Station	18
4	24147	Rich Creek	18
5	24072	Check	23
6	23027	Cartersville	23
7	24553	Gladstone	24
8	22663	White Post	24
9	24226	Clinchco	25
10	23438	Suffolk	25

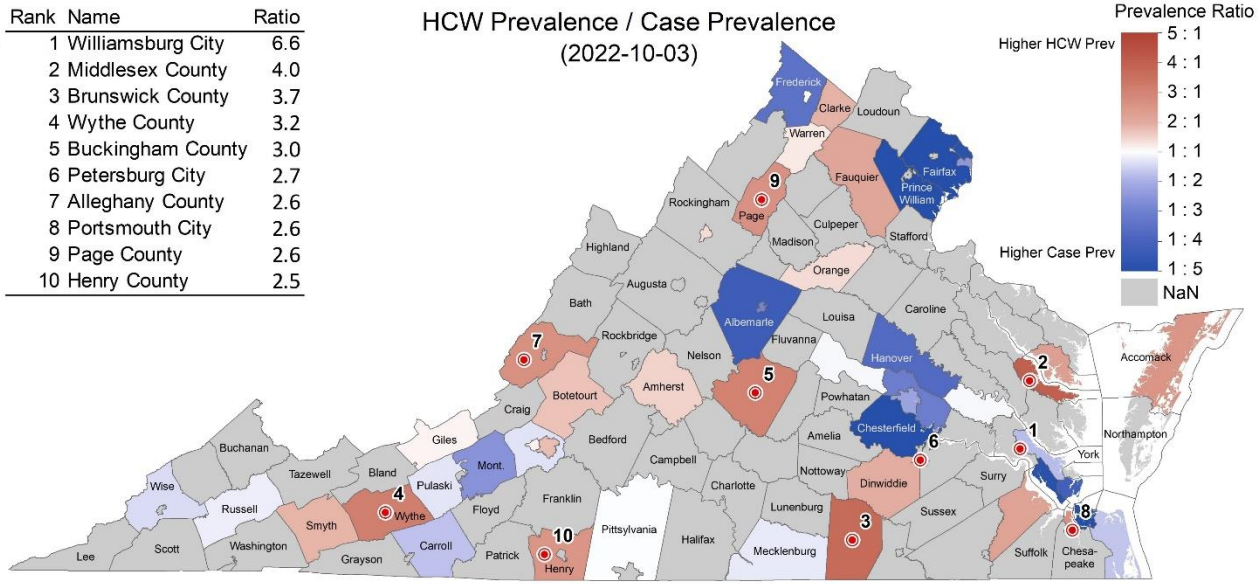
Beyond Scale

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence, with an 8:1 ascertainment ratio, for week ending 2022-10-03.

Rank	Name	Ratio
1	Williamsburg City	6.6
2	Middlesex County	4.0
3	Brunswick County	3.7
4	Wythe County	3.2
5	Buckingham County	3.0
6	Petersburg City	2.7
7	Alleghany County	2.6
8	Portsmouth City	2.6
9	Page County	2.6
10	Henry County	2.5



Note: This assumes that the ascertainment rate of healthcare workers is double that of the public.

Current Hot-Spots

Case rates that are significantly different from neighboring areas or model projections

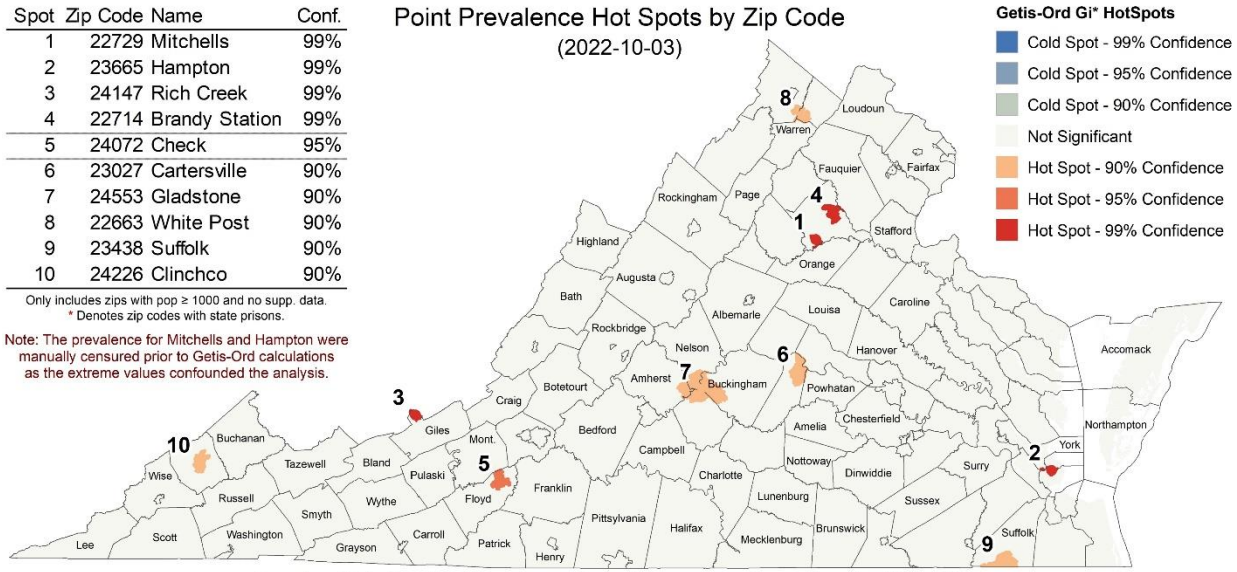
- **Spatial**: Getis-Ord Gi* based hot spots compare clusters of zip codes with weekly case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations
- **Temporal**: The weekly case rate (per 100K) projected last week compared to observed by county, which highlights temporal fluctuations that differ from the model's projections. Note new color ramp (down 75%).
- Spatial hot spots are appearing sporadically across the Commonwealth. Models slightly underpredicted the Far Southwest, and slightly overpredicted Central Virginia, Northern Virginia, and the Tidewater.

Spatial Hotspots

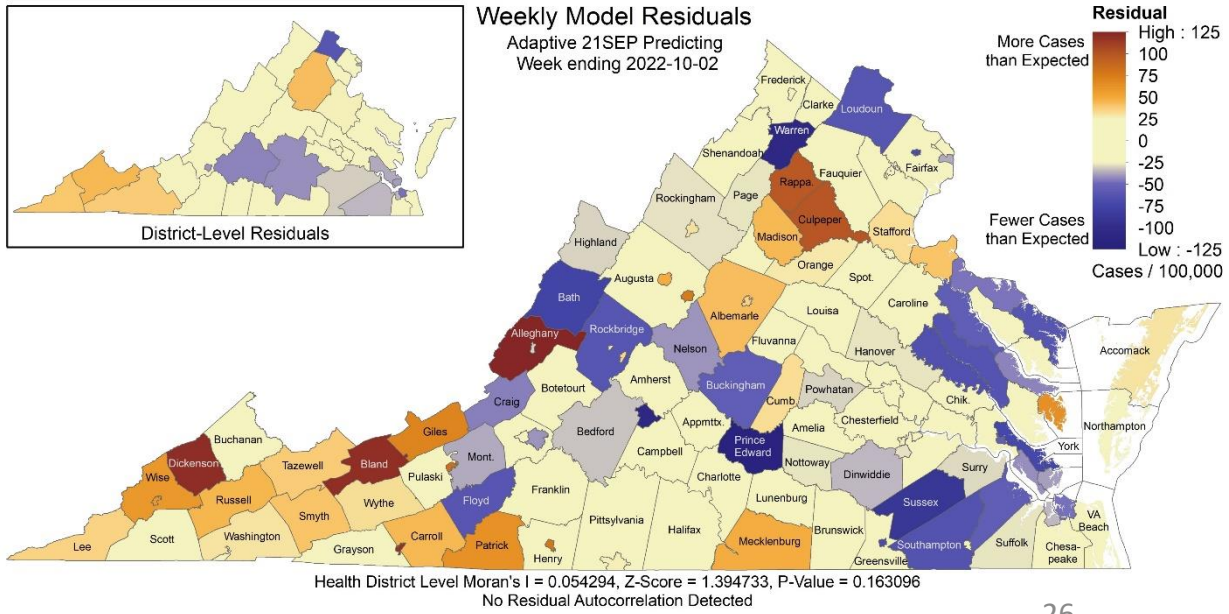
Spot	Zip Code	Name	Conf.
1	22729	Mitchells	99%
2	23665	Hampton	99%
3	24147	Rich Creek	99%
4	22714	Brandy Station	99%
5	24072	Check	95%
6	23027	Cartersville	90%
7	24553	Gladstone	90%
8	22663	White Post	90%
9	23438	Suffolk	90%
10	24226	Clinchco	90%

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.

Note: The prevalence for Mitchells and Hampton were manually censured prior to Getis-Ord calculations as the extreme values confounded the analysis.



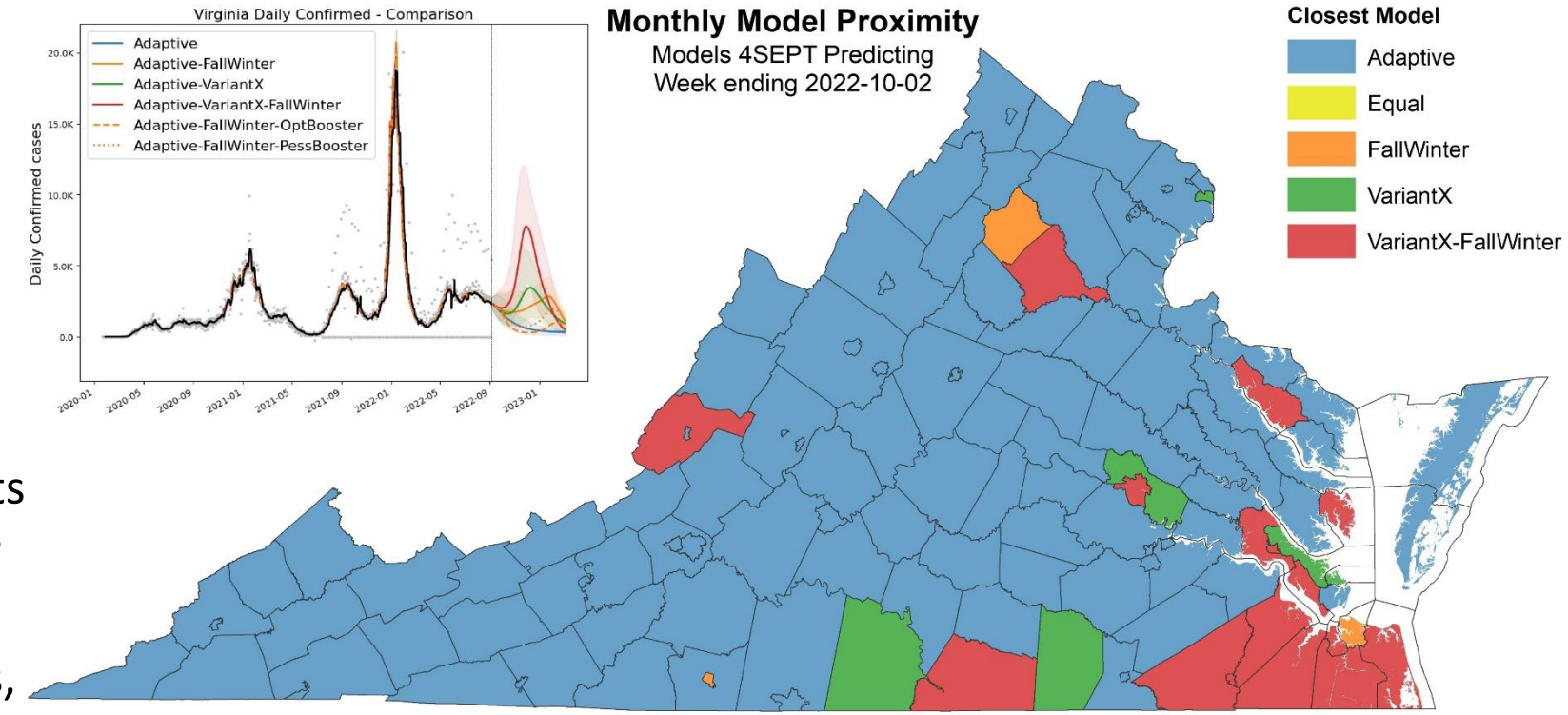
Clustered Temporal Hotspots



Scenario Trajectory Tracking

Which scenario from a month ago did the projection for each county track closest?

- One month out separates the projections more and reveals larger overall patterns.
- Booster scenarios not included as vaccination efforts have only recently begun.
- Overall state level models were on track, largely tracking the Adaptive scenario over Variant X This is expected, as no novel variants supplanted BA.4/5 in the time since the modeling run.
- Currently only a handful of counties, mostly in the Southeast, are tracking FallWinter scenarios more closely than the Adaptive scenario.



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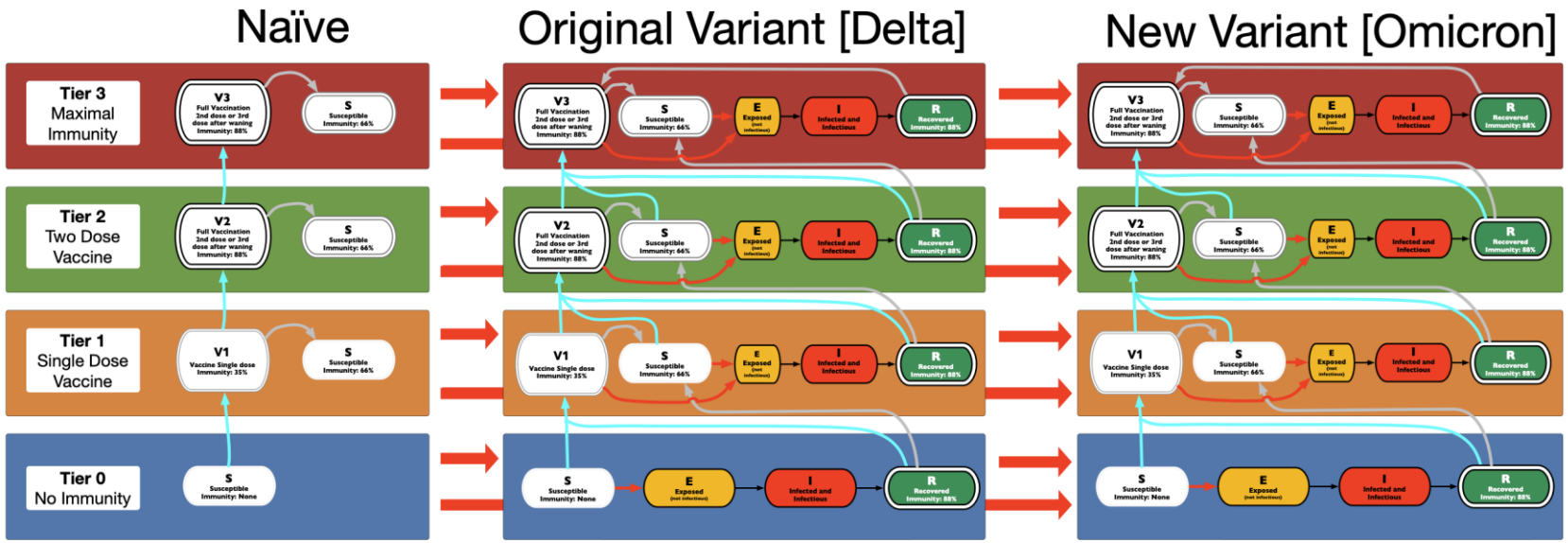
Model Update – Adaptive Fitting

Model Structure Extended for more sub-variants

Omicron sub-variants escape immunity induced by previous sub-variants

- Multiple strain support allows representation of differential protection based on immunological history (BA.1, BA.2, BA.2.12.1, BA.4/5, and future variants (VariantX))
- Each sub-variant has differing levels of immune escape to previous sub-variants, the prevalences are based on observations for fitting purposes, and projections use estimated future prevalences
- Adaptive fitting approach continues to use simulation to generate the full distribution of immune states across the population



Adaptive Fitting Approach

Each county fit precisely, with recent trends used for future projection

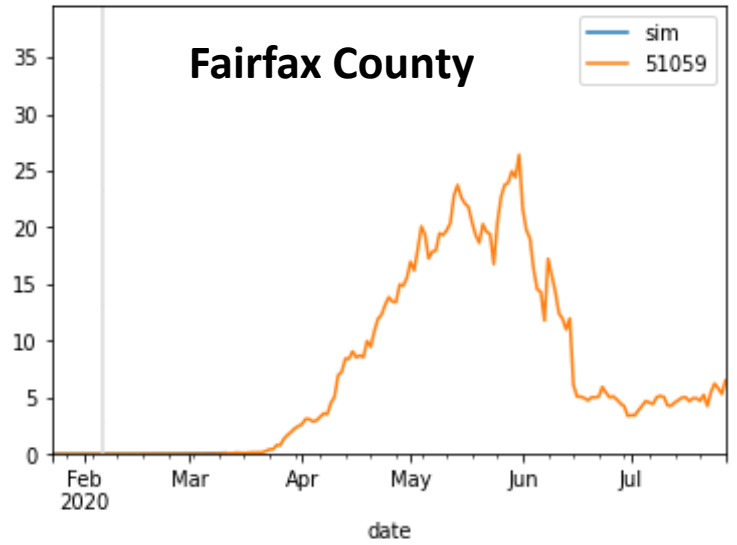
- Allows history to be precisely captured, and used to guide bounds on projections

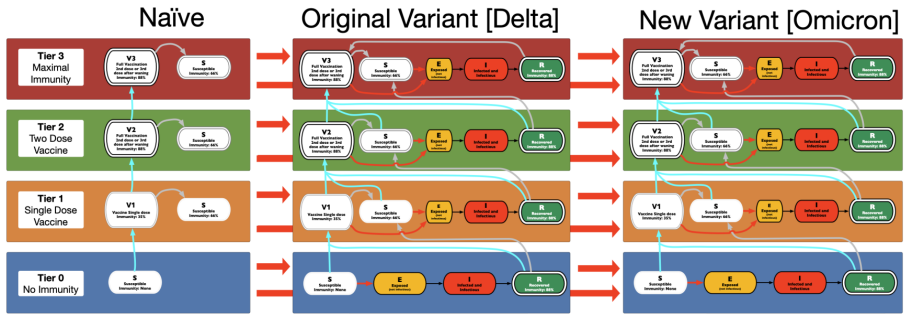
Model: An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- Allows for future "what-if" Scenarios to be layered on top of calibrated model
- Allows for waning of immunity and for partial immunity against different outcomes (eg lower protection for infection than death)

External Seeding: Steady low-level importation

- Widespread pandemic eliminates sensitivity to initial conditions, we use steady 1 case per 10M population per day external seeding





Using Ensemble Model to Guide Projections

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

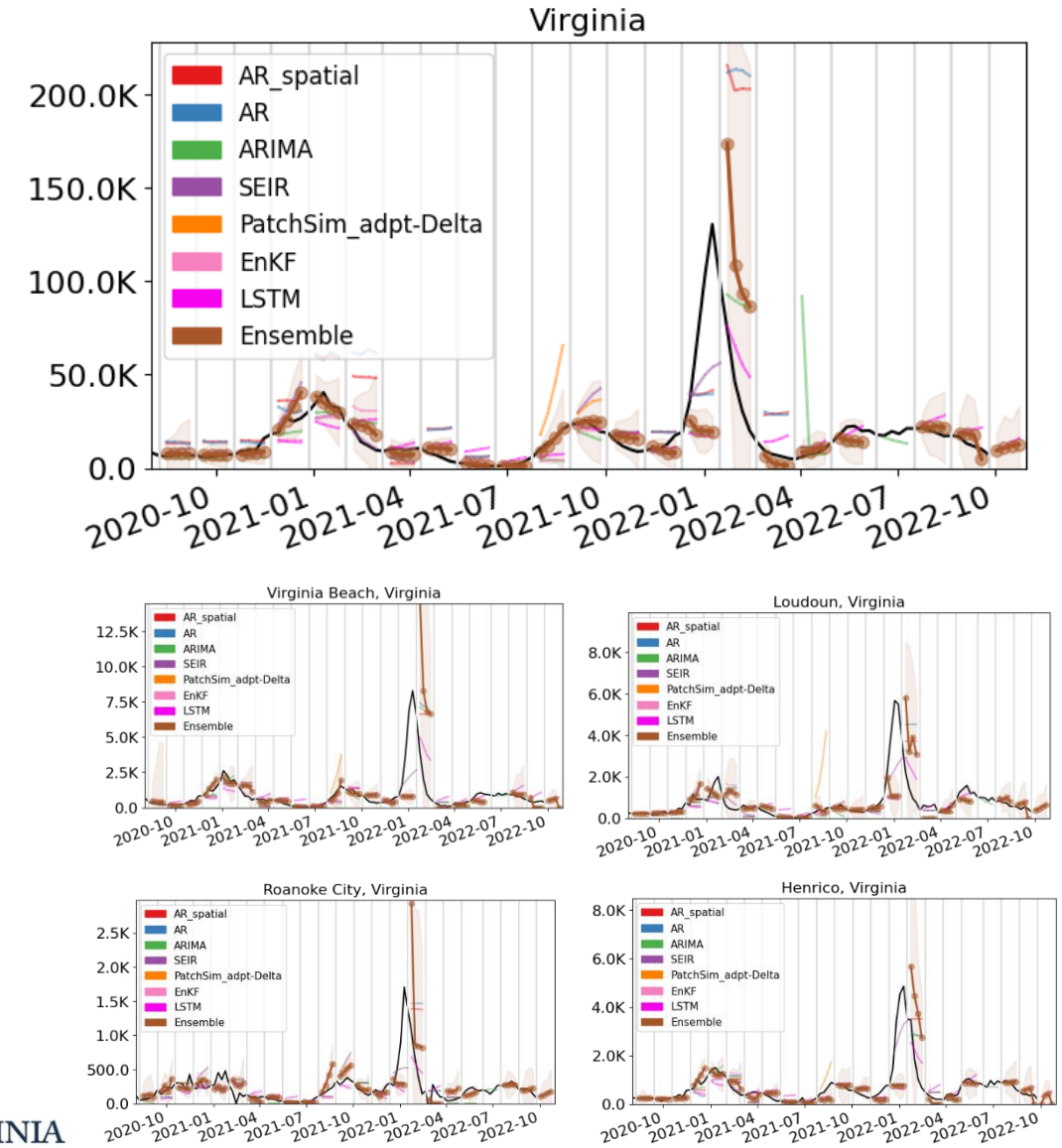
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

<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.



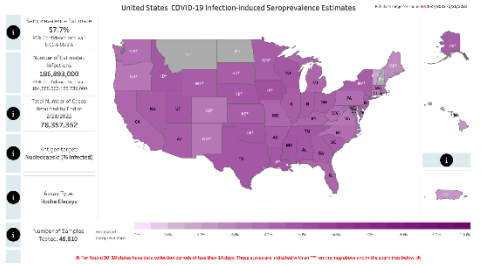
Seroprevalence updates to model design

Several seroprevalence studies have stopped

- CDC Nationwide Commercial Laboratory Seroprevalence Survey is no longer reporting updates; pre-Omicron this data estimated ascertainment ratio of ~4-6x

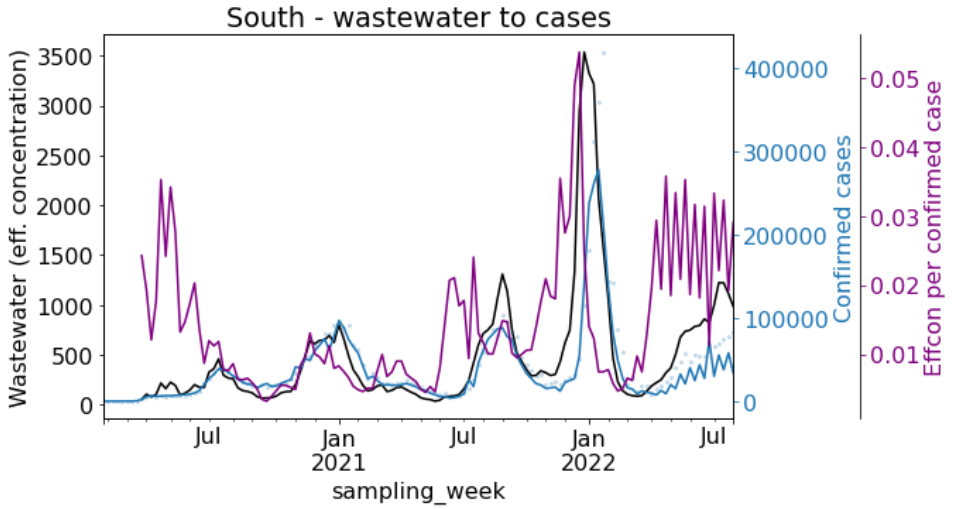
Testing Behavior has changed, fewer cases are reported

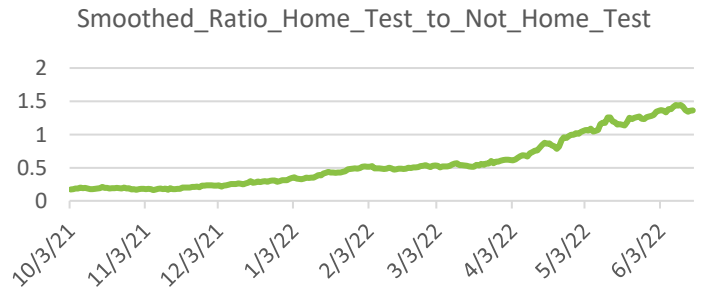
- Home testing, reduced symptoms due to breakthrough / reinfection, and elimination of public health leave
- Outbreaks Near Me from Boston Children's Hospital and Momentive collects reports of home testing
- Wastewater data is consistent with case ascertainment being significantly lower than during the Omicron BA.1 wave
- Accounting for home testing, changes case ascertainment to be 2 times more than pre-Omicron resulting in a current rate of 16 infections to one case



Virginia
Feb 22nd: 45% [42% - 48%];
Jan 22nd: 34% [31%-39%]

https://covid.cdc.gov/covid-data-tracker/#national-lab





OutbreaksNearMe

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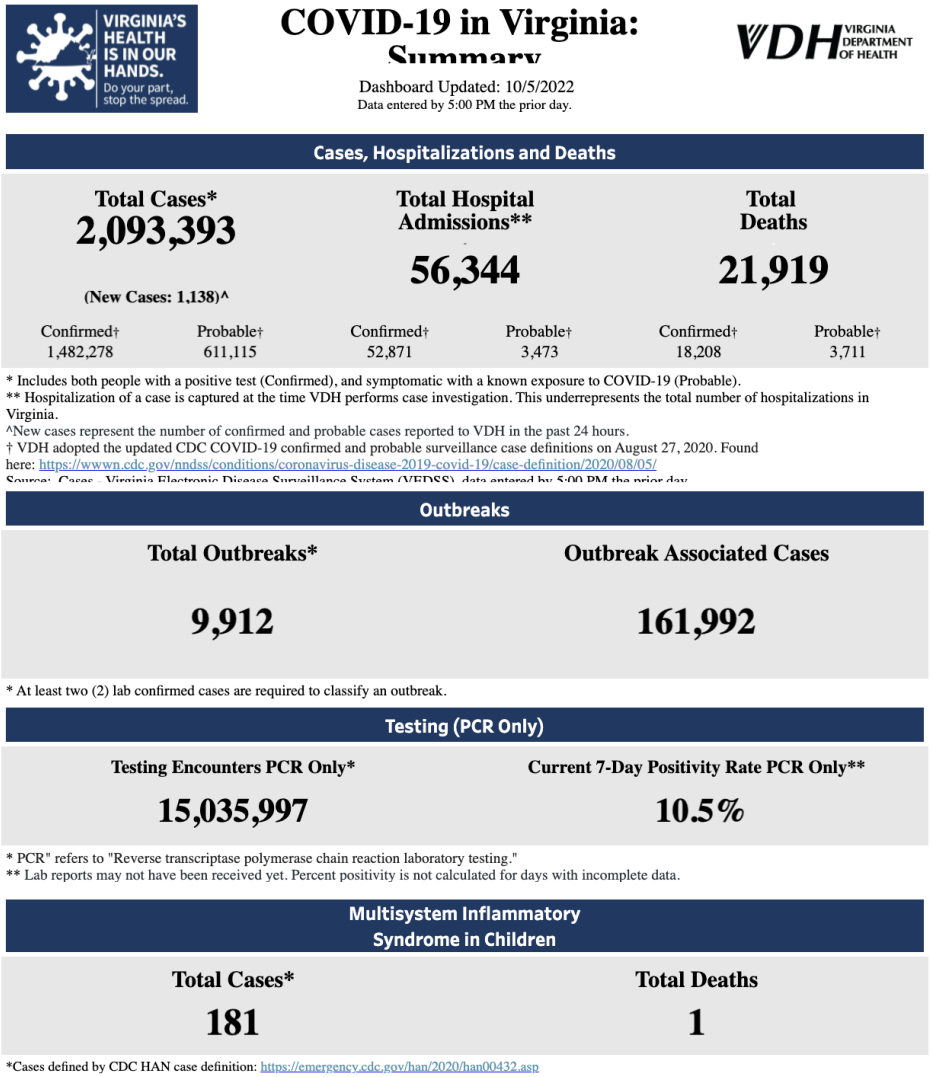
Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data and ensemble's forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak
- **Project:** future cases and outcomes generated using the collection of fit models run into the future
  - **Mean trend from last 7 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories
- **Outcomes**: Data driven by shift and ratio that has least error in last month of observations
  - Hospitalizations: 3 days from confirmation, 6.8% of cases hospitalized
  - Deaths: 11 days from confirmation, 1.45% of cases die



VIRGINIA'S HEALTH IS IN OUR HANDS. Do your part, stop the spread.

COVID-19 in Virginia: Summary

VDH VIRGINIA DEPARTMENT OF HEALTH

Dashboard Updated: 10/5/2022
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospital Admissions**	Total Deaths
2,093,393	56,344	21,919
(New Cases: 1,138)^		

Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
1,482,278	611,115	52,871	3,473	18,208	3,711

* Includes both people with a positive test (Confirmed), and symptomatic with a known exposure to COVID-19 (Probable).
** Hospitalization of a case is captured at the time VDH performs case investigation. This underrepresents the total number of hospitalizations in Virginia.
^New cases represent the number of confirmed and probable cases reported to VDH in the past 24 hours.
† VDH adopted the updated CDC COVID-19 confirmed and probable surveillance case definitions on August 27, 2020. Found here: https://wwwn.cdc.gov/nndss/conditions/coronavirus-disease-2019-covid-19/case-definition/2020/08/05/

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
9,912	161,992

* At least two (2) lab confirmed cases are required to classify an outbreak.

Testing (PCR Only)

Testing Encounters PCR Only*	Current 7-Day Positivity Rate PCR Only**
15,035,997	10.5%

* PCR" refers to "Reverse transcriptase polymerase chain reaction laboratory testing."
** Lab reports may not have been received yet. Percent positivity is not calculated for days with incomplete data.

Multisystem Inflammatory Syndrome in Children

Total Cases*	Total Deaths
181	1

*Cases defined by CDC HAN case definition: https://emergency.cdc.gov/han/2020/han00432.asp

Accessed 9:00am October 5, 2022
https://www.vdh.virginia.gov/coronavirus/

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Scenarios – Transmission Conditions

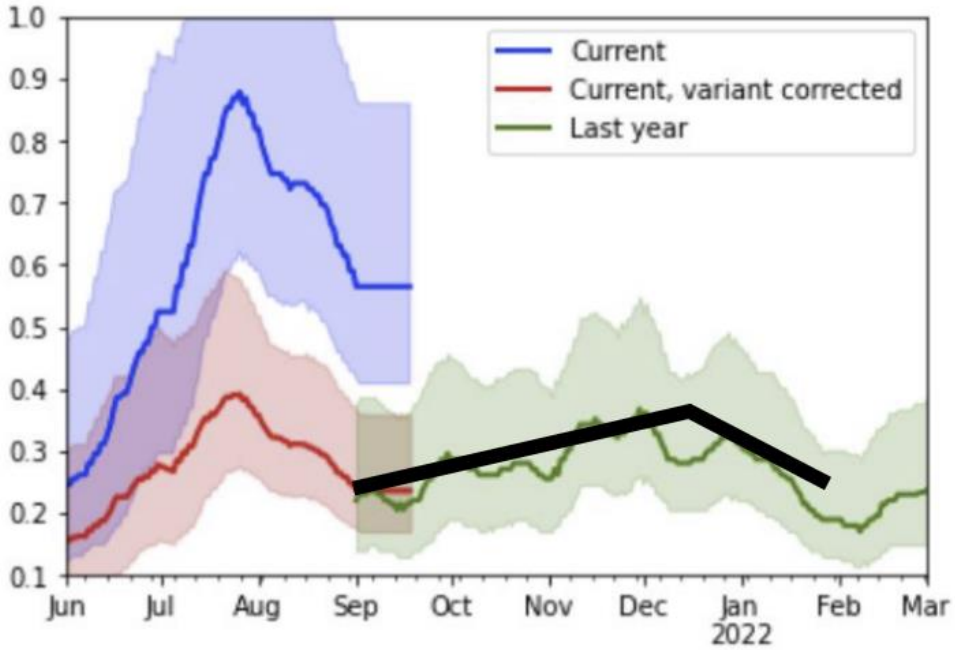
- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity**: Omicron waning with a mean of 4 months
- **Projection Condition Ingredients**:
  - **Adaptive:** Controls remain as currently experienced into the future with NO influence from other conditions (eg seasonal, variants, etc.)
  - **Seasonal (Fall-Winter boosting):** Controls remain the same, however, seasonal forcing similar to past Fall-Winter waves is added from Sept-Feb
  - **Vaccine Booster Campaign (Booster):** Reformulated booster available this fall provides improved immunity against Omicron sub-variants
  - **New Variants (VariantX)**: As of yet unidentified novel sub-variant with similar immune escape but no transmission advantage emerges 4 months after the last significant sub-variant and grows at a similar rate

Scenarios – FallWinter

September – February saw strong waves of transmission for both years

- Based on analyses of the past 2 seasons we generate a “coarse baseline transmission boost”
  - In 2021 the distribution of fitted model transmissibility was nearly identical between these periods when corrected for Delta’s increased transmissibility
- **FallWinter** captures these “transmission drivers” from the past and uses them as if they were to occur again this season

Fitting:
Black line represents the coarsely fitted base transmissibility



* “Last year” is transplanted into 2021-22

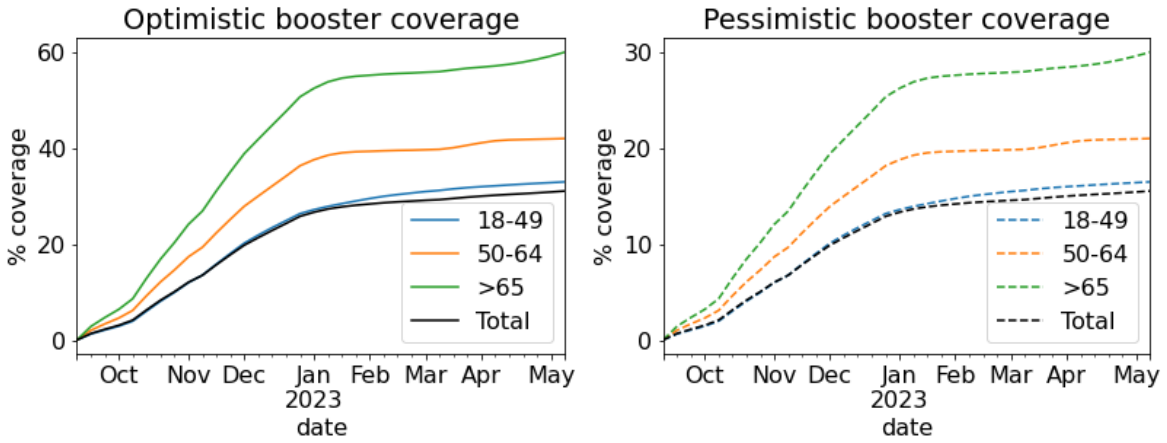
Scenarios – Optimistic vs. Pessimistic Booster Coverage

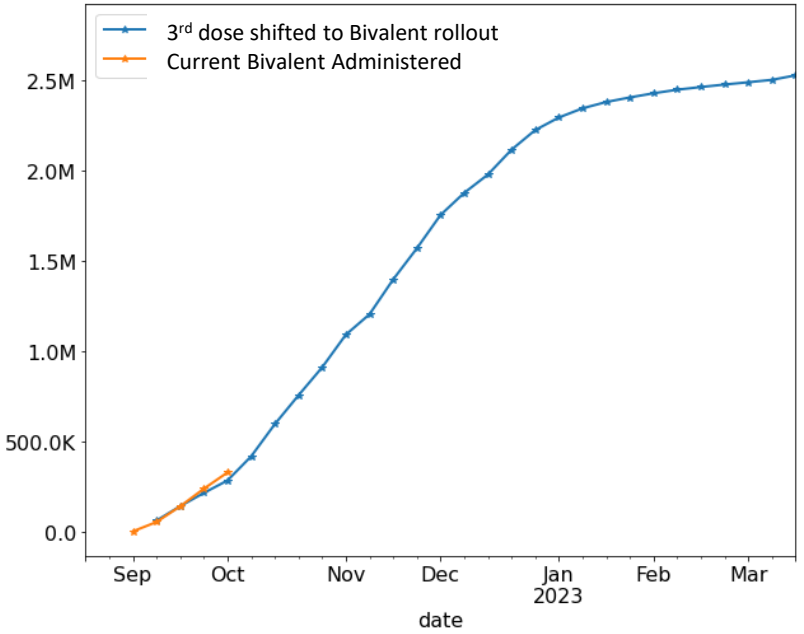
Reformulated Boosters available now

- Assuming Vax efficacy for BA.4/5 and previous variants is 80% against symptomatic illness
- Campaign starts in mid-September following the ongoing rollout
- Pace of vaccination follows that of 3rd booster (adjusted after initial uptake did not keep pace with seasonal influenza vax uptake)
- Variant X has same immune escape to these vaccines as against BA.5 (40%)

Optimistic coverage: 33% of pop (same as 3rd dose)

Pessimistic coverage: 16% of pop (half of 3rd dose)



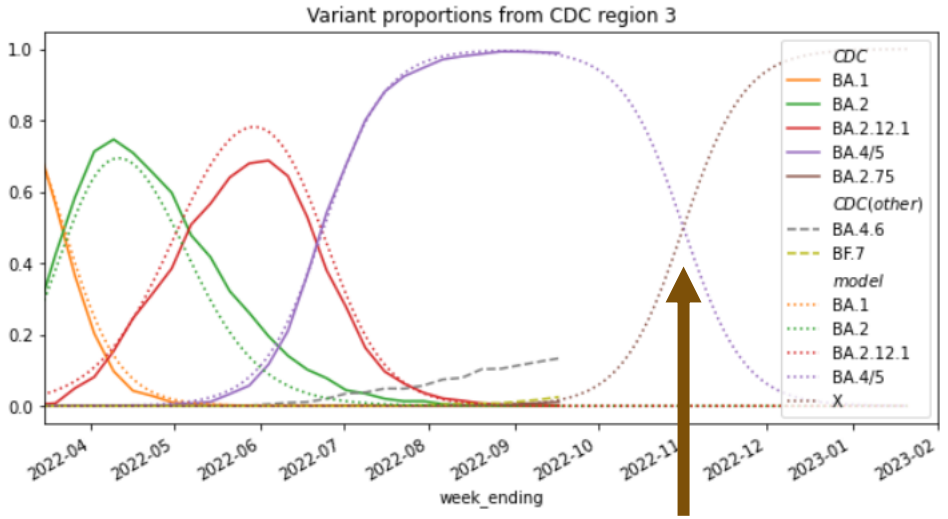


Scenarios – Variant X

Omicron sub-variants seem to be emerging and then dominating with some regularity

- ECDC currently monitoring BA.2 + L452X and BA.2.75 as VOI and XAK as well as other BA.4 and BA.5 strains as Variants under Monitoring
- BA.2.75.2 remains main sub-variant characterized enough to suggest future dominance, but has yet to demonstrate rapid growth in US
- Hypothetical future sub-variant, **VariantX**, may continue the pattern. Assumes similar growth and level of immune escape against previous sub-variants as BA.4/5 (same transmissibility and 40% immune escape against BA.4/5, higher for other sub-variants).

Sub-Variants with Fitted Prevalences and Hypothetical Future waves



Variant X reaches 50% on Nov 15th

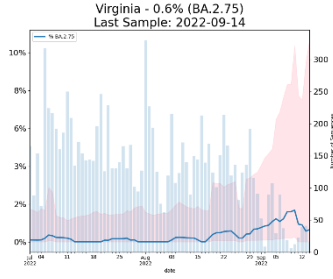
Variants of Interest

WHO label	Lineage + additional mutations	Country first detected (community)	Spike mutations of interest	Year and month first detected	Impact on transmissibility	Impact on immunity	Impact on severity	Transmission in EU/EEA
Omicron	BA.2 + L452X (x)	n/a	L452X	n/a	No evidence	Increased (7)	No evidence	Detected (a)
Omicron	BA.2.75	India	(y)	May 2022	No evidence	Increased (9, 10)	No evidence	Detected (a)

Variants under Monitoring

WHO label	Lineage + additional mutations	Country first detected (community)	Spike mutations of interest	Year and month first detected	Impact on transmissibility	Impact on immunity	Impact on severity	Transmission in EU/EEA
Omicron	XAK	Germany	(y)	June 2022	No evidence	No evidence	No evidence	Detected (a)
Omicron	BA.4 + R346X (x)	n/a	R346X	n/a	No evidence	No evidence	No evidence	Detected (a)
Omicron	BA.5 + R346X (x)	n/a	R346X	n/a	No evidence	No evidence	No evidence	Detected (a)

BA.2.75 detected in VA (very limited samples)



Projection Scenarios – Combined Conditions

Name	Txm	Variant	Description
Adaptive	C	SQ	Likely trajectory based on conditions remaining similar to the current experience, includes immune escape due to Omicron
Adaptive-FallWinter	FallWinter	SQ	Like Adaptive, with seasonal forcing of FallWinter added on
Adaptive-FallWinter-OptBooster	FallWinter	SQ	Like Adaptive-Fall Winter but with Optimistic Booster (90% of seasonal influenza coverage)
Adaptive-FallWinter-PessBooster	FallWinter	SQ	Like Adaptive-Fall Winter but with Pessimistic Booster (45% of seasonal influenza coverage)
Adaptive-VariantX	C	X	Like Adaptive, with emergence of a speculative unknown variant 4 months after BA.4/5 with similar level of immune escape and equal transmissibility
Adaptive-VariantX-FallWinter	FallWinter	X	Like Adaptive-VariantX but with the seasonal force of FallWinter added on

Transmission: C = Current levels persist into the future
FallWinter = Transmission rates learned from Sept through February of past seasons are estimated and added as a seasonal boosting to baseline transmission rates

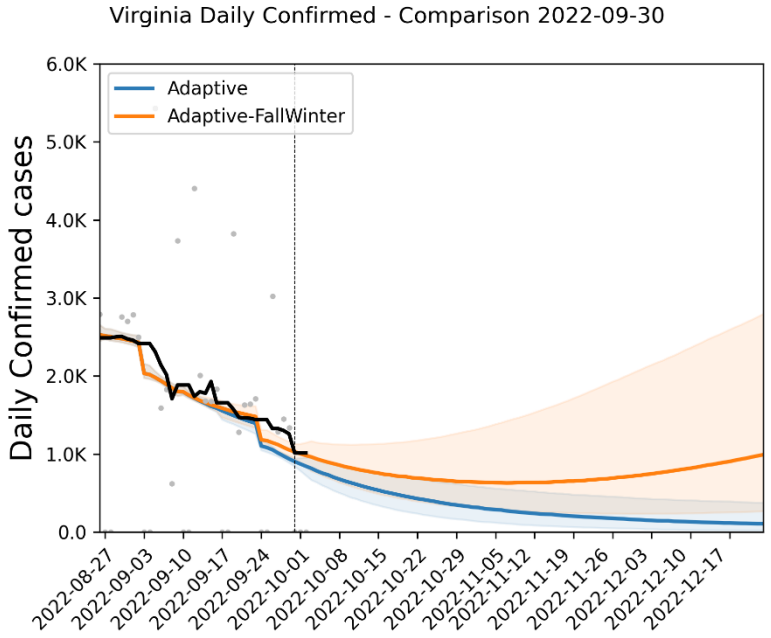
Variant: SQ = Status quo of current transmission driver from BA.5 remains the same (eg already significantly past dominance, thus no significant major driving of transmission anticipated)
X = Speculative novel sub-variant scenario, emerges 4 months after current variant, similar levels of escape

Model Results

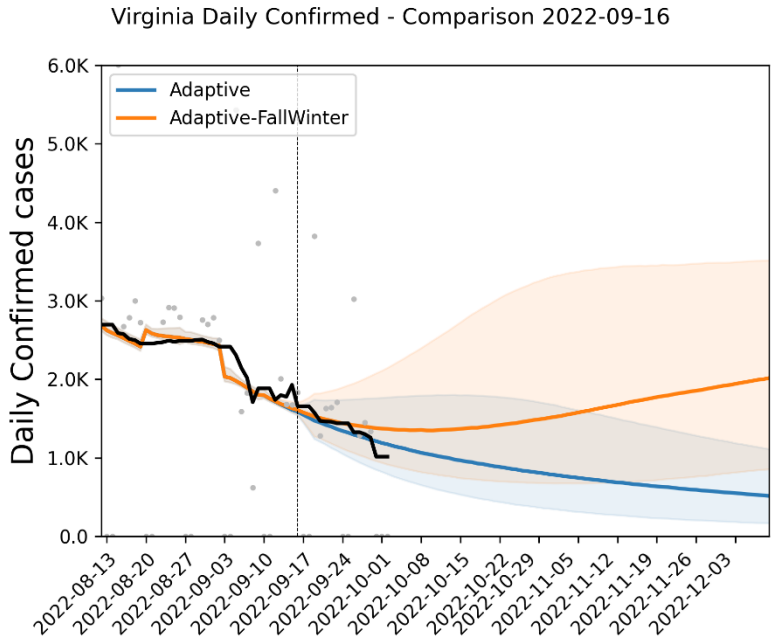
Previous projections comparison - Cases

- 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

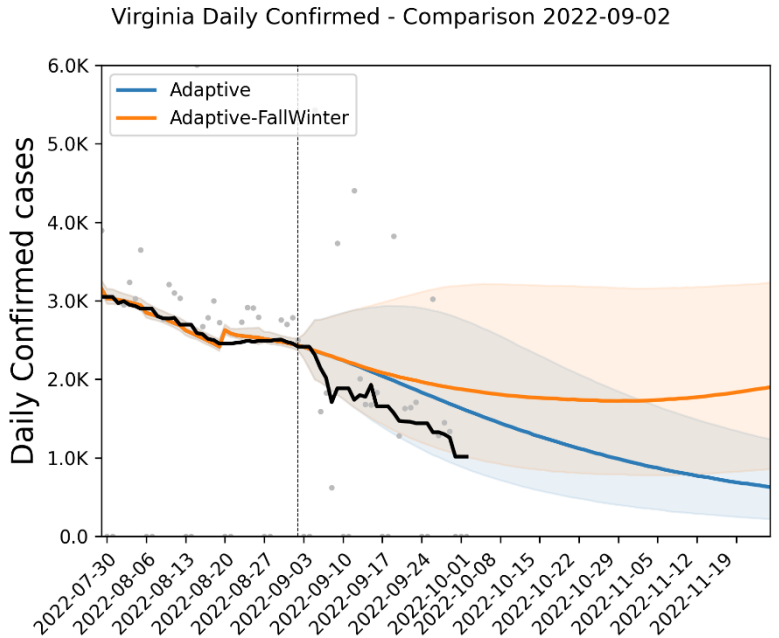
This week's projection



Projection from 2 weeks ago



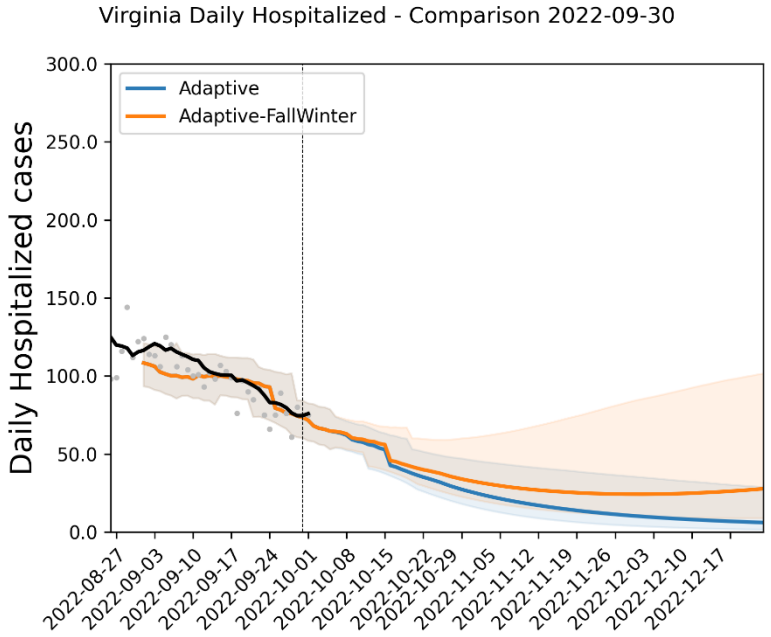
Projection from 4 weeks ago



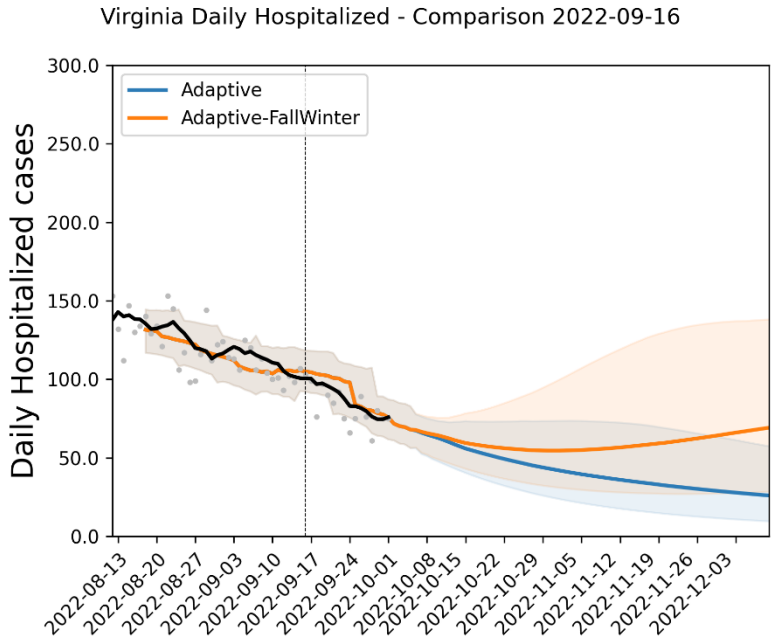
Previous projections comparison - Hospitalizations

- Previous projections have tracked observed hospitalizations well
- Projection from 2 weeks ago projected continued decline
- Projection from late July anticipated a plateau giving way to gentle decline

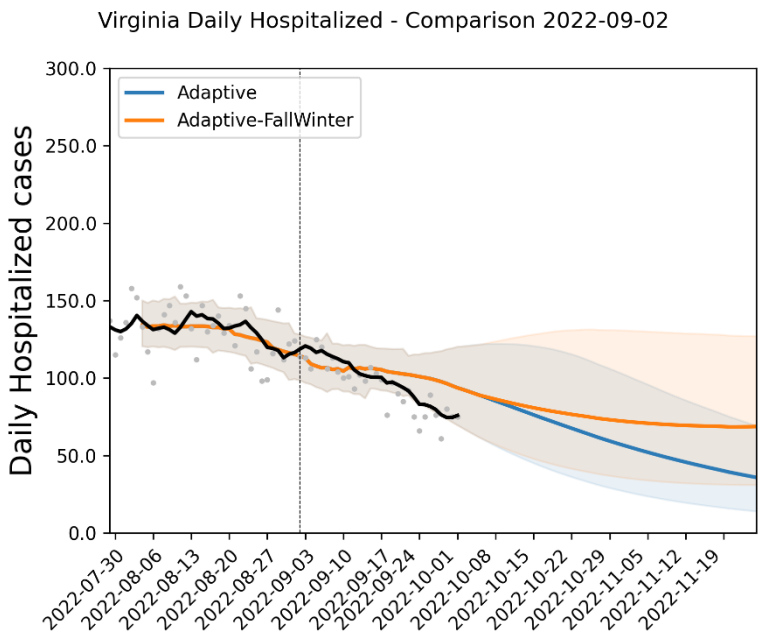
This week's projection



Projection from 2 weeks ago

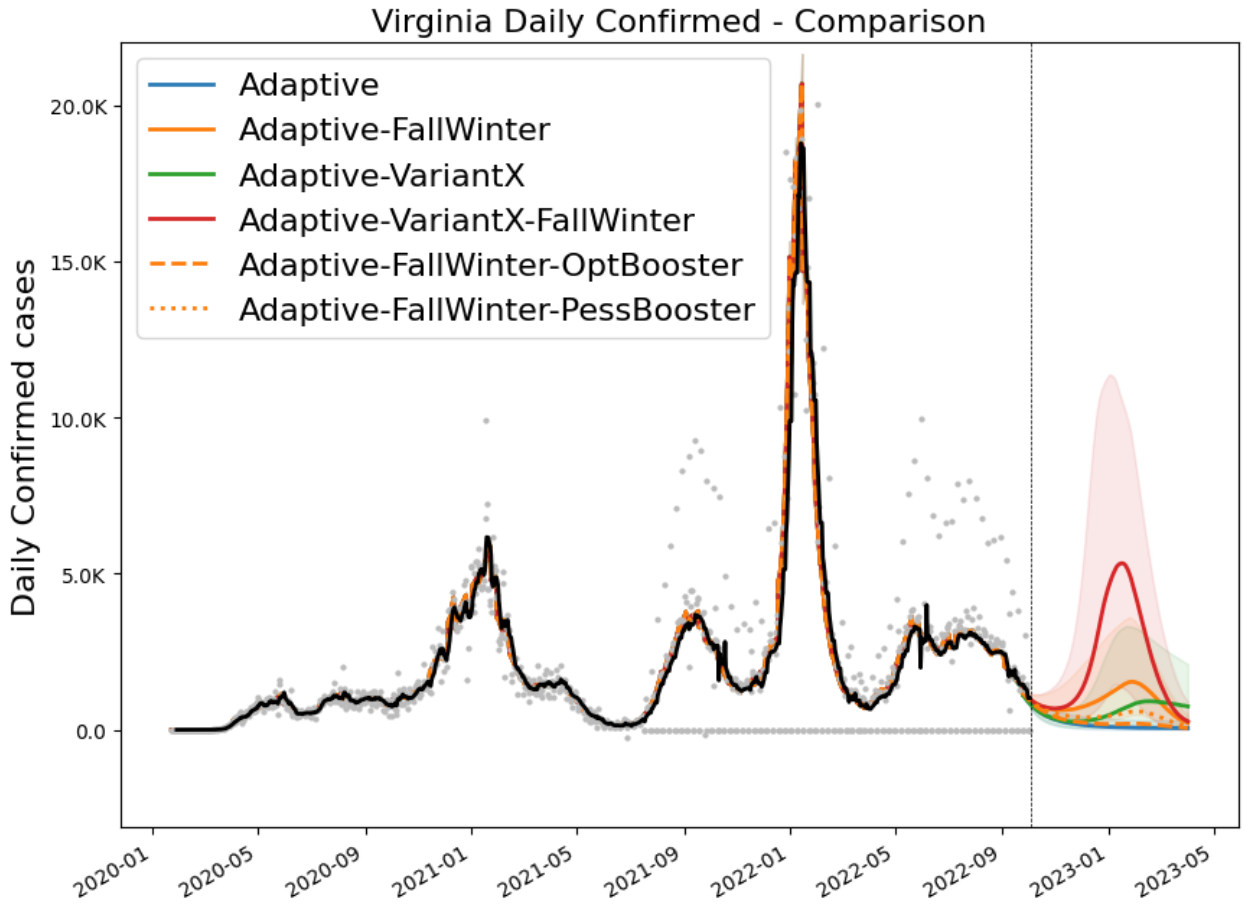


Projection from 4 weeks ago



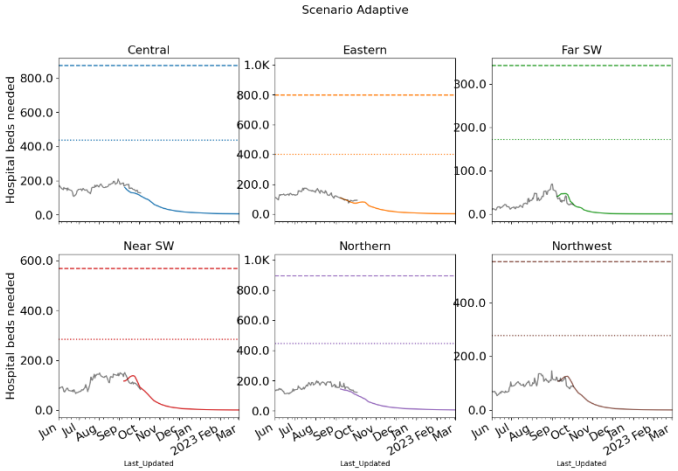
Outcome Projections

Confirmed cases

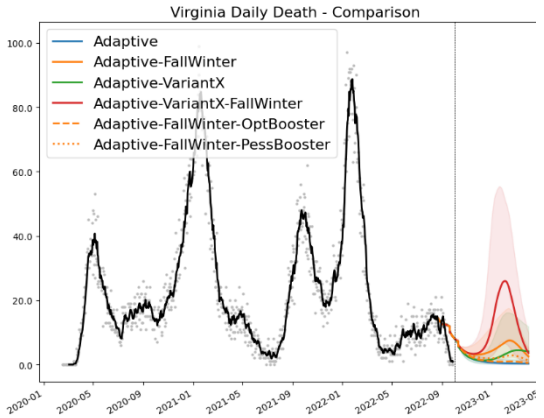


* without surveillance correction VariantBA2 peaked over 10K in July

Estimated Hospital Occupancy

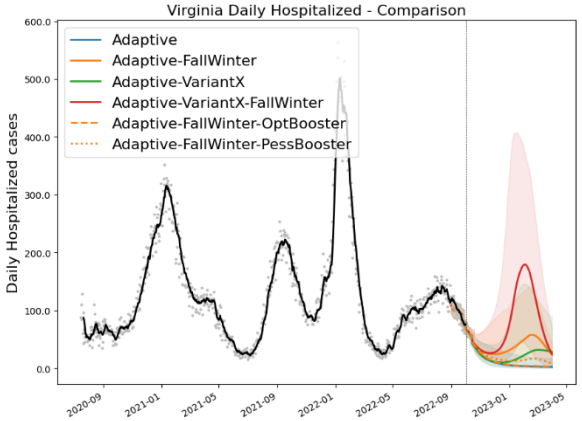


Daily Deaths



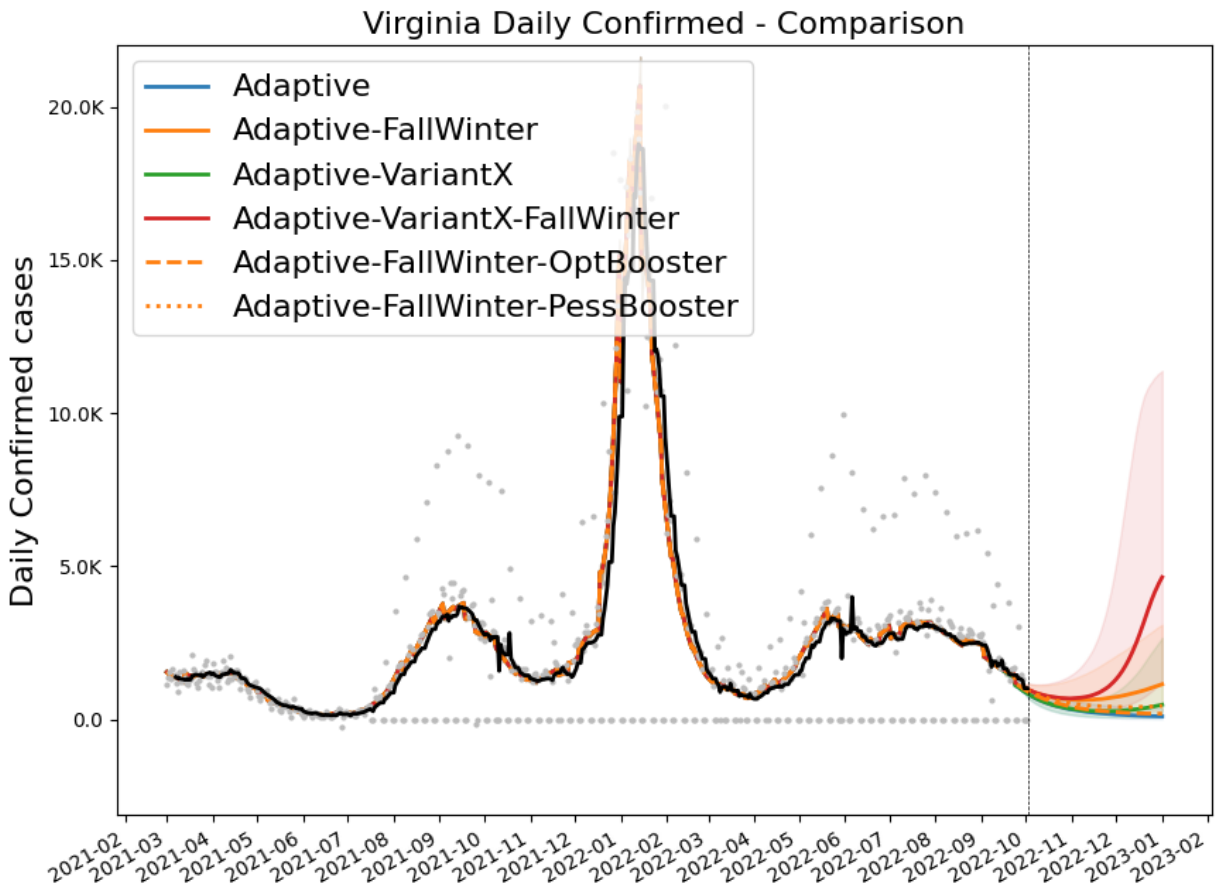
Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized



Outcome Projections – Closer Look

Confirmed cases



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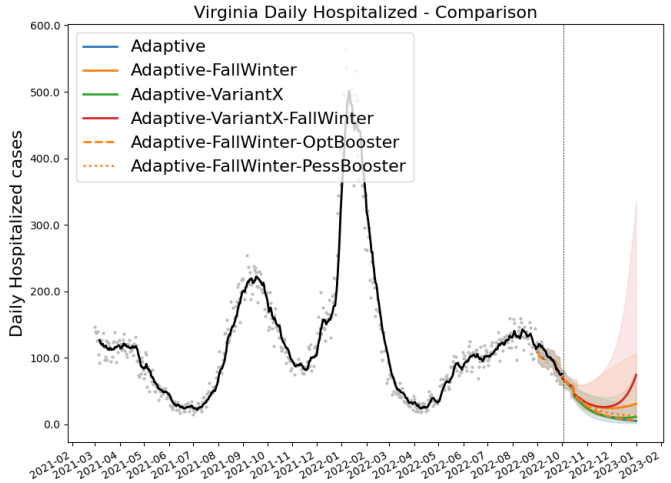
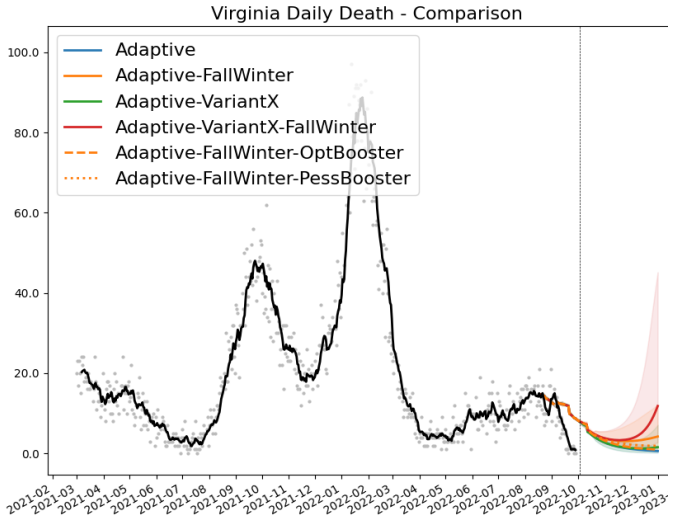
Daily Hospitalized



Daily Deaths



Death ground truth from VDH "Event Date" data, most recent dates are not complete

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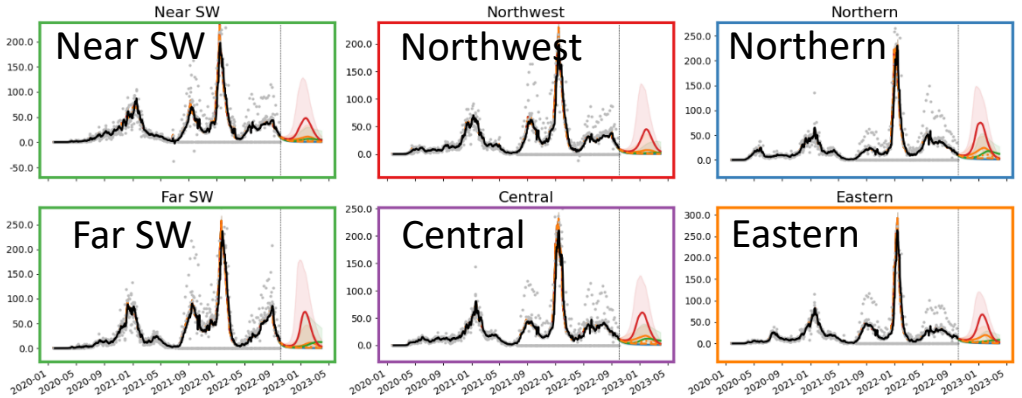
Detailed Projections: All Scenarios

Projections by Region

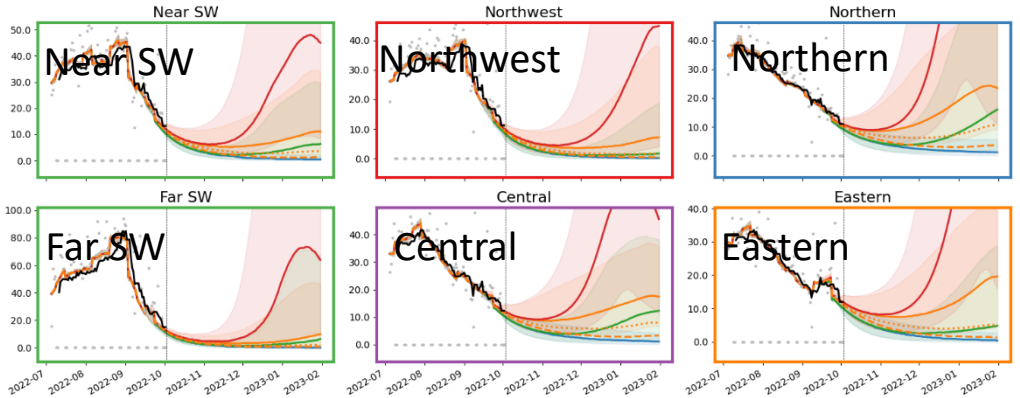


Projections by District

Daily confirmed cases) by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

Detailed Projections: All Scenarios - Closer Look

Projections by Region



Projections by District

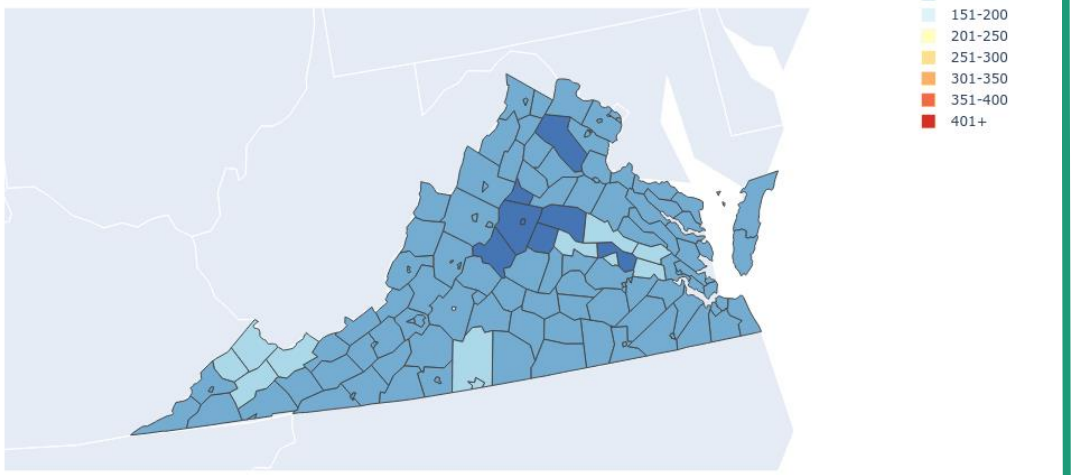
Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

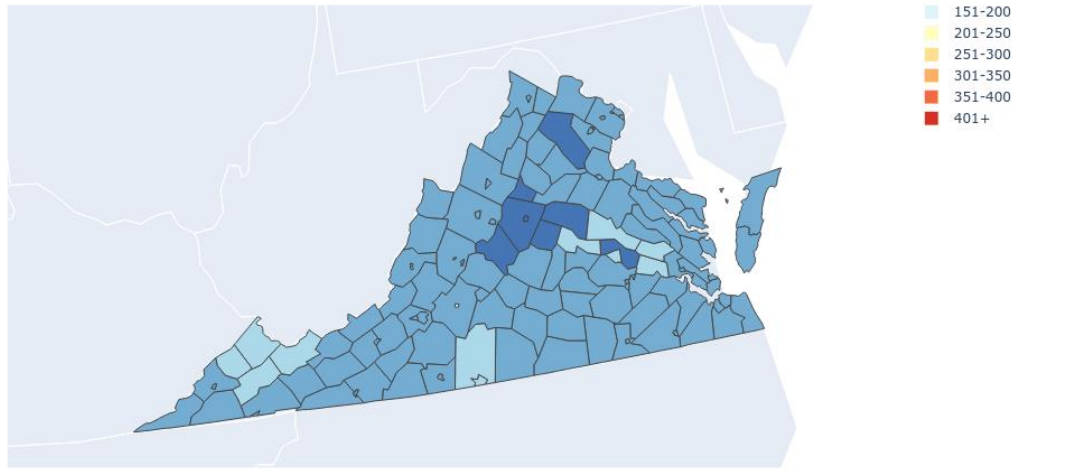
Adaptive

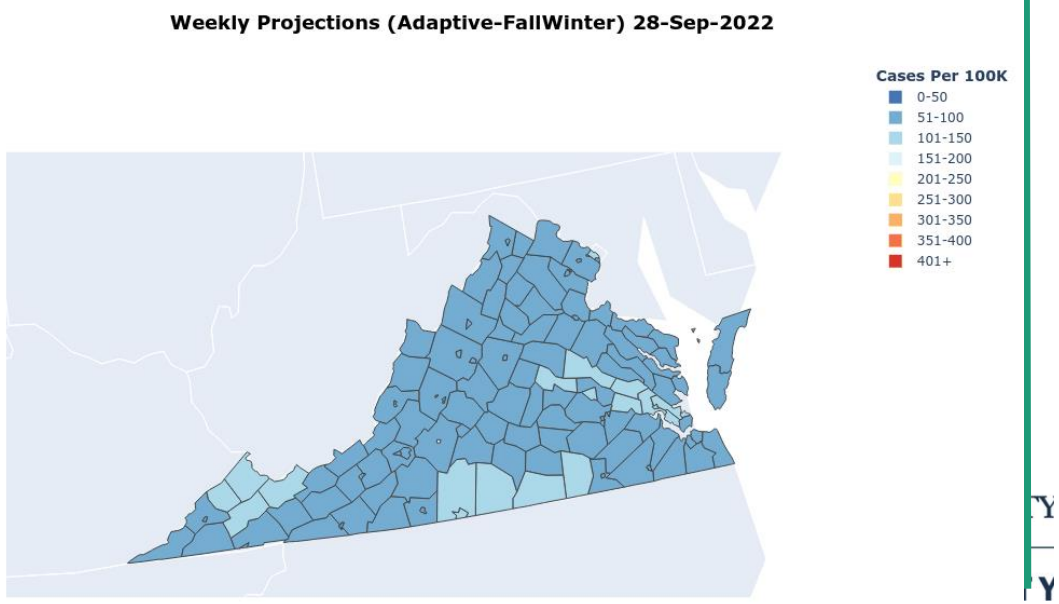
VariantX

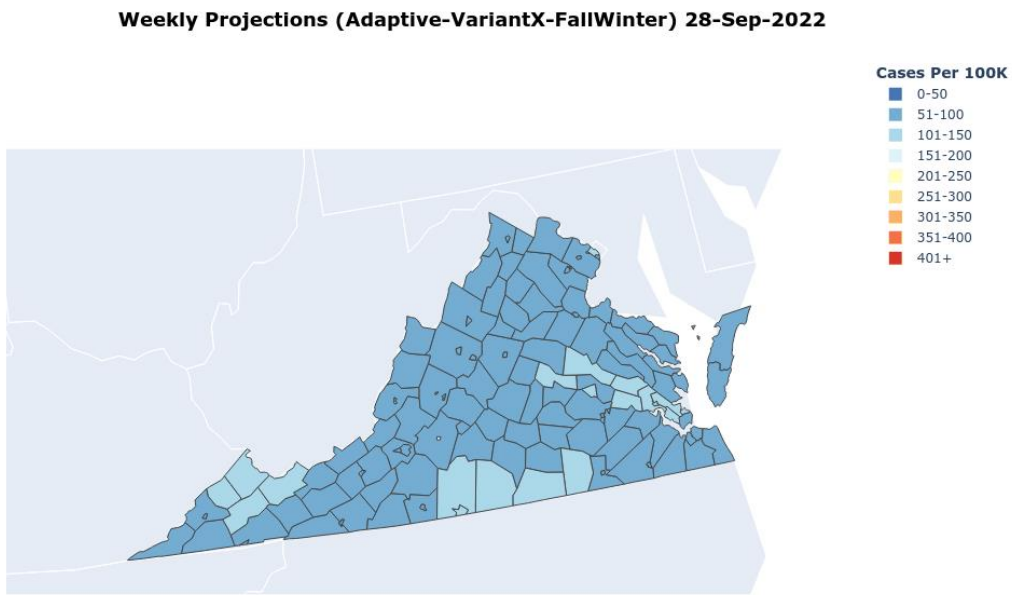
Adaptive

Adaptive-Fall-Winter

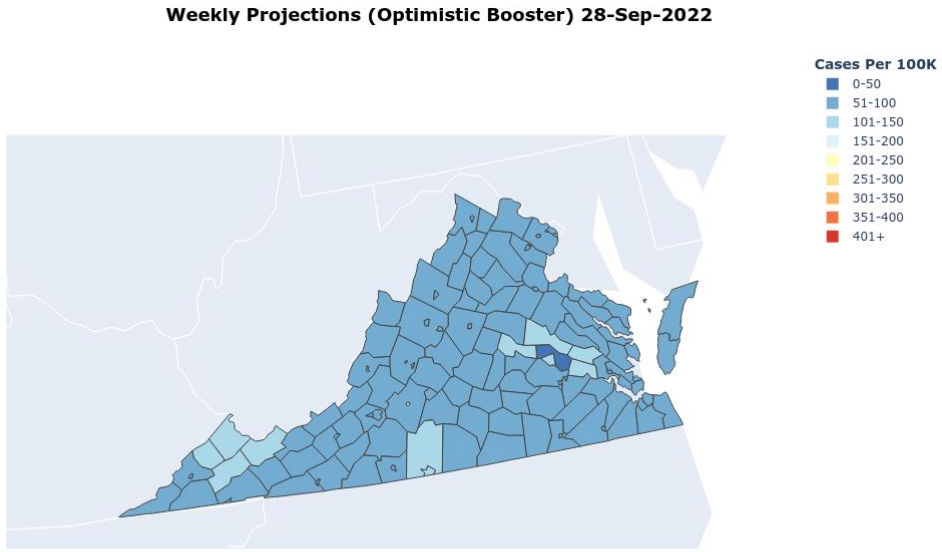


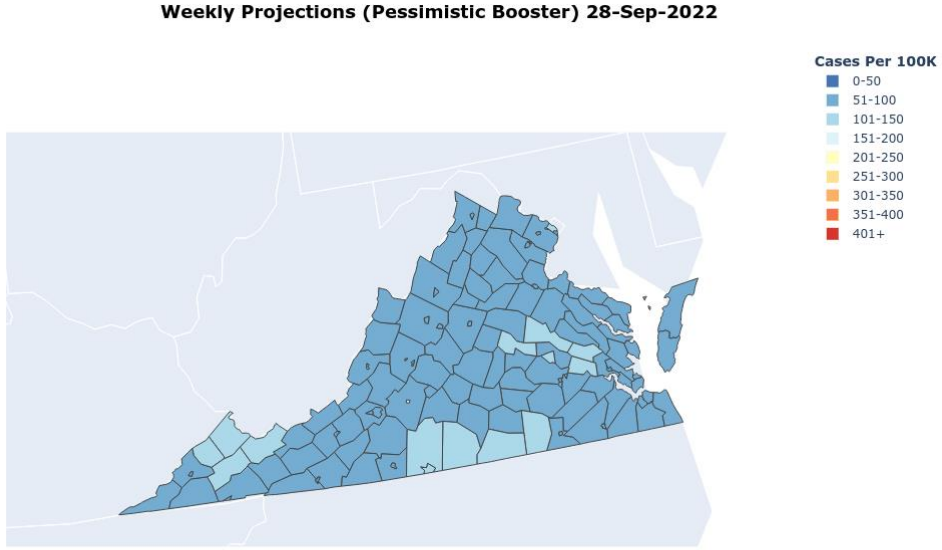


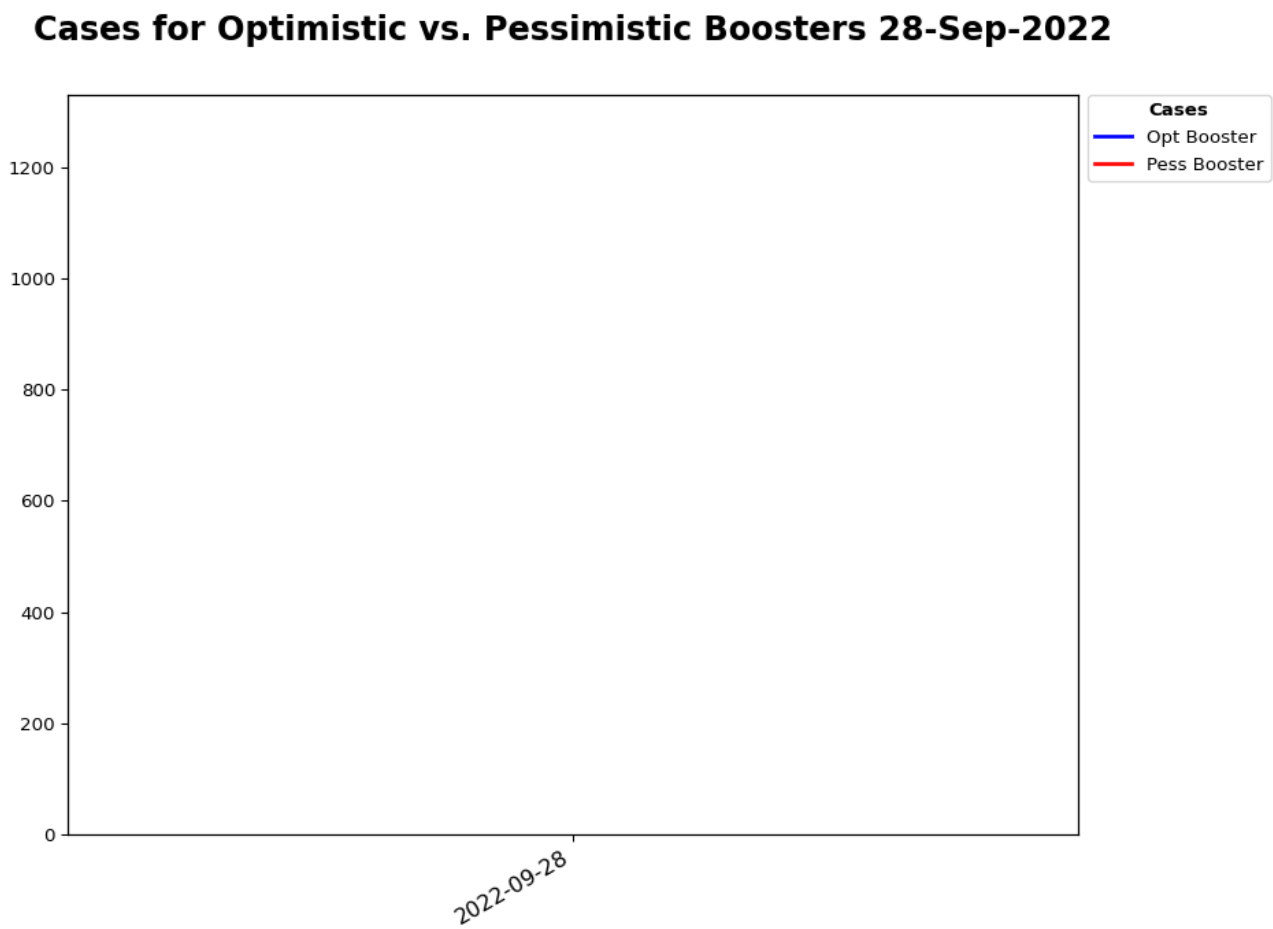




Impact of Optimistic vs. Pessimistic Booster Distribution



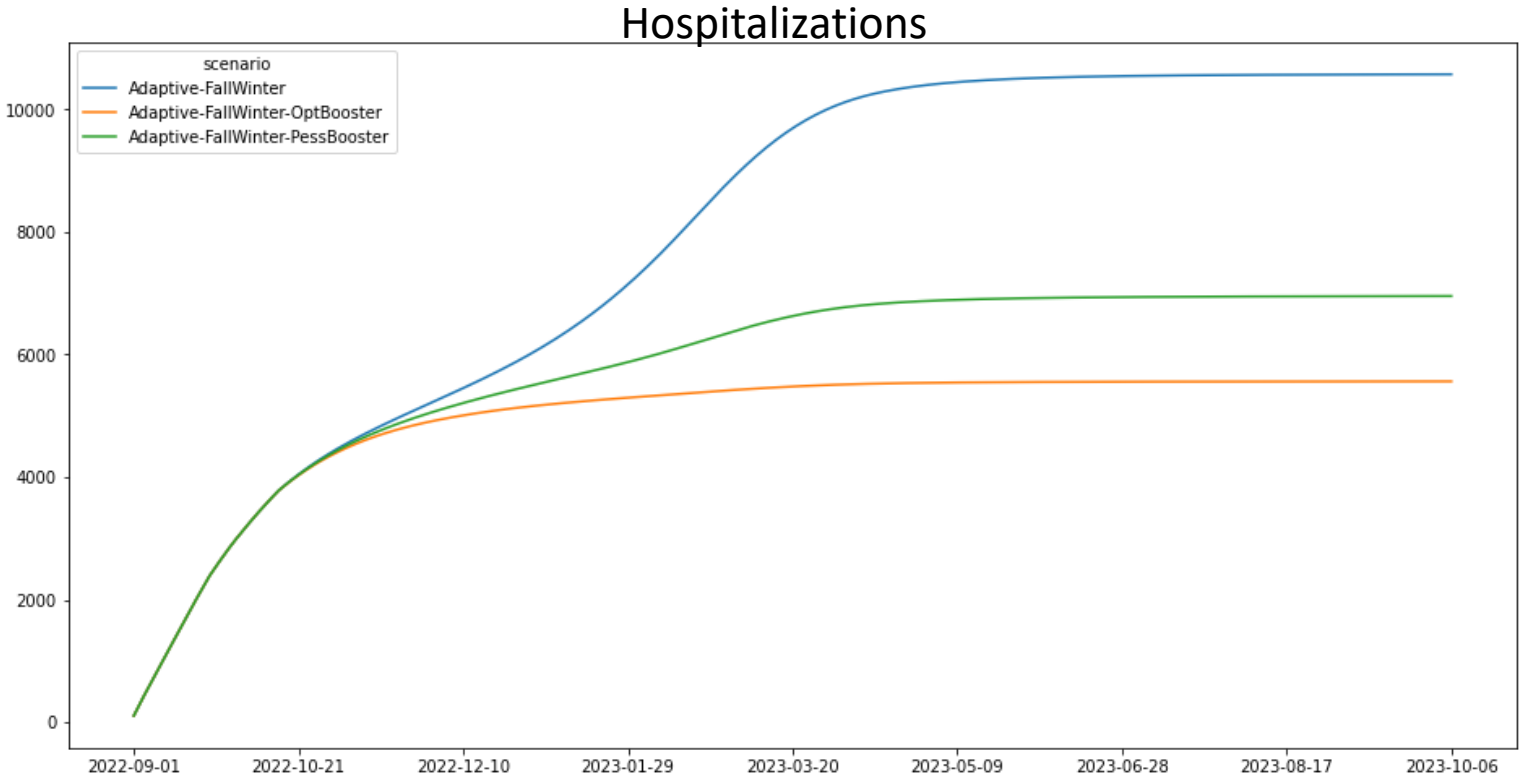




Booster Campaign Coverage has impact on future hospitalizations

Booster Campaign can significantly limit future hospitalizations and severe outcomes

- Reduction in future hospitalizations (3600 to 5K) through Spring 2023

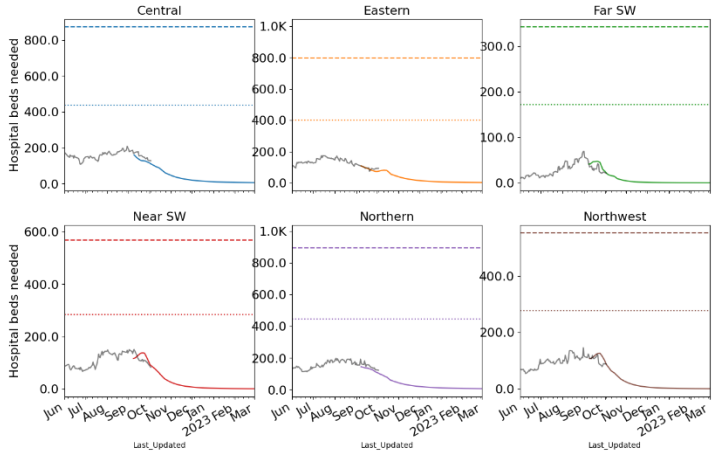


Hospital Demand and Bed Capacity by Region

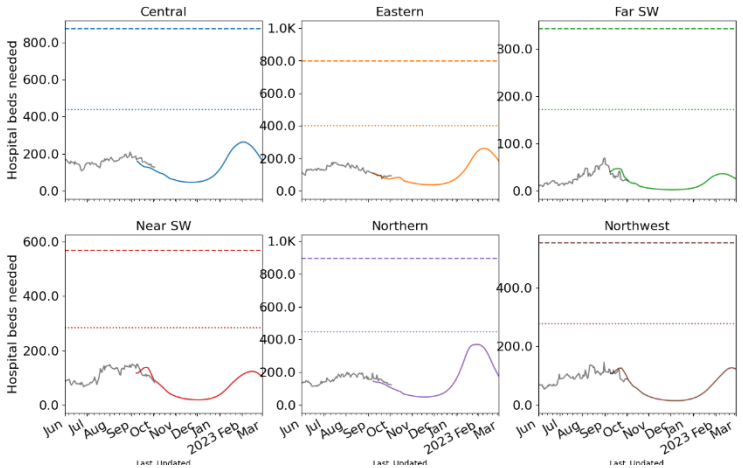
Capacities by Region

COVID-19 capacity ranges from 80% (dots) to 120% (dash) of total beds

Adaptive



Adaptive – VariantX & Fall Winter



Length of Stay more variable with Omicron, occupancy projections may vary as a result, ad-hoc estimation performed per region

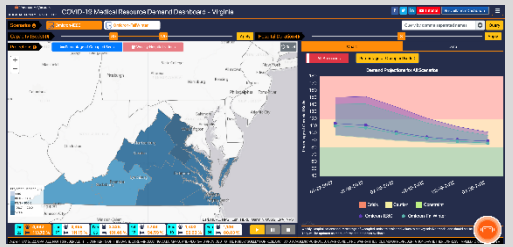
Estimated LOS shortened slightly to better fit observed data

Projections show continued declines and with expanded capacities and adjusted length of stay, no capacities exceeded

Length of Stay Estimates

Central	8
Eastern	6
Far SW	4
Near SW	9
Northern	5
Northwestern	9

Interactive Dashboard with regional projections



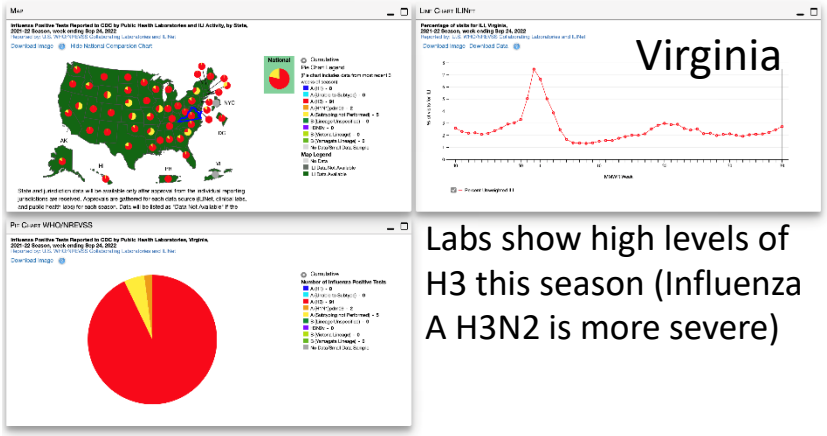
https://nssac.bii.virginia.edu/covid-19/vmrddash/

Current Influenza Hospitalization Forecast

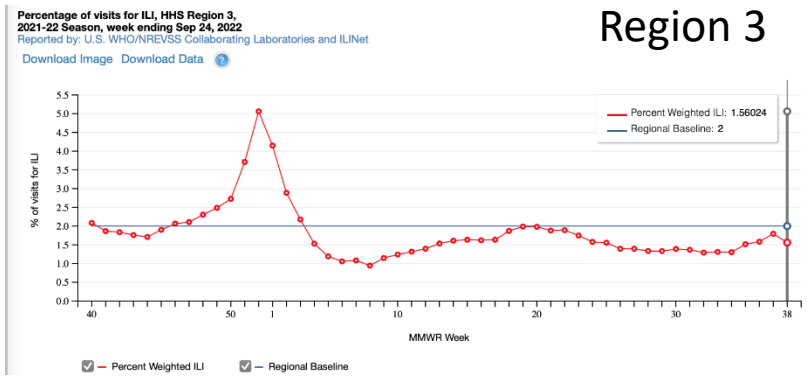
Statistical models for submitting to CDC FluSight forecasting challenge

- 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

Influenza-like Illness Activity

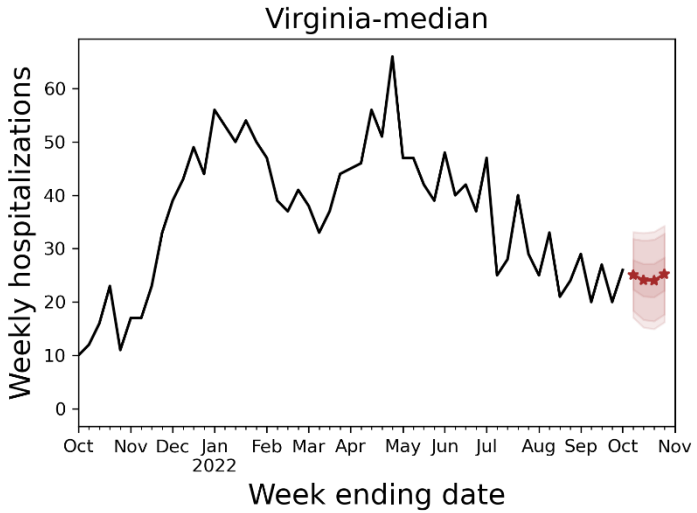


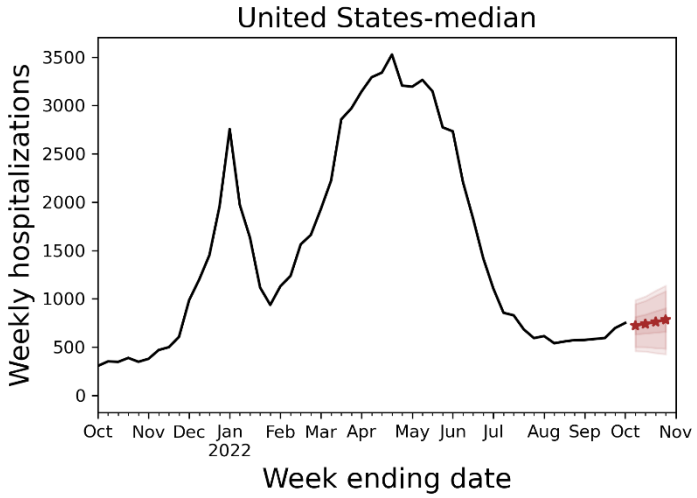
Labs show high levels of H3 this season (Influenza A H3N2 is more severe)



Region 3

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

UNIVERSITY of VIRGINIA
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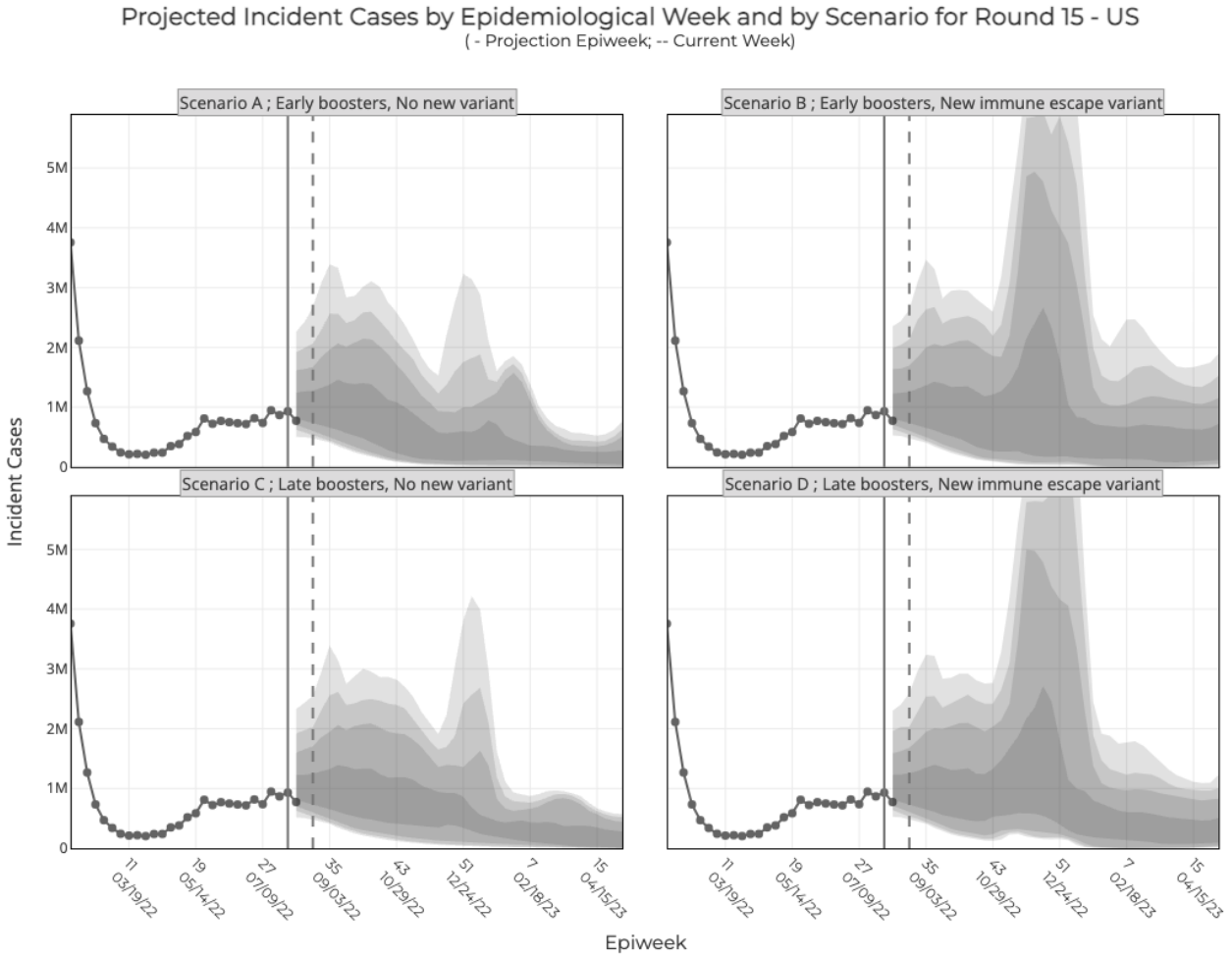
Scenario Modeling Hub – COVID-19 (Round 15)

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

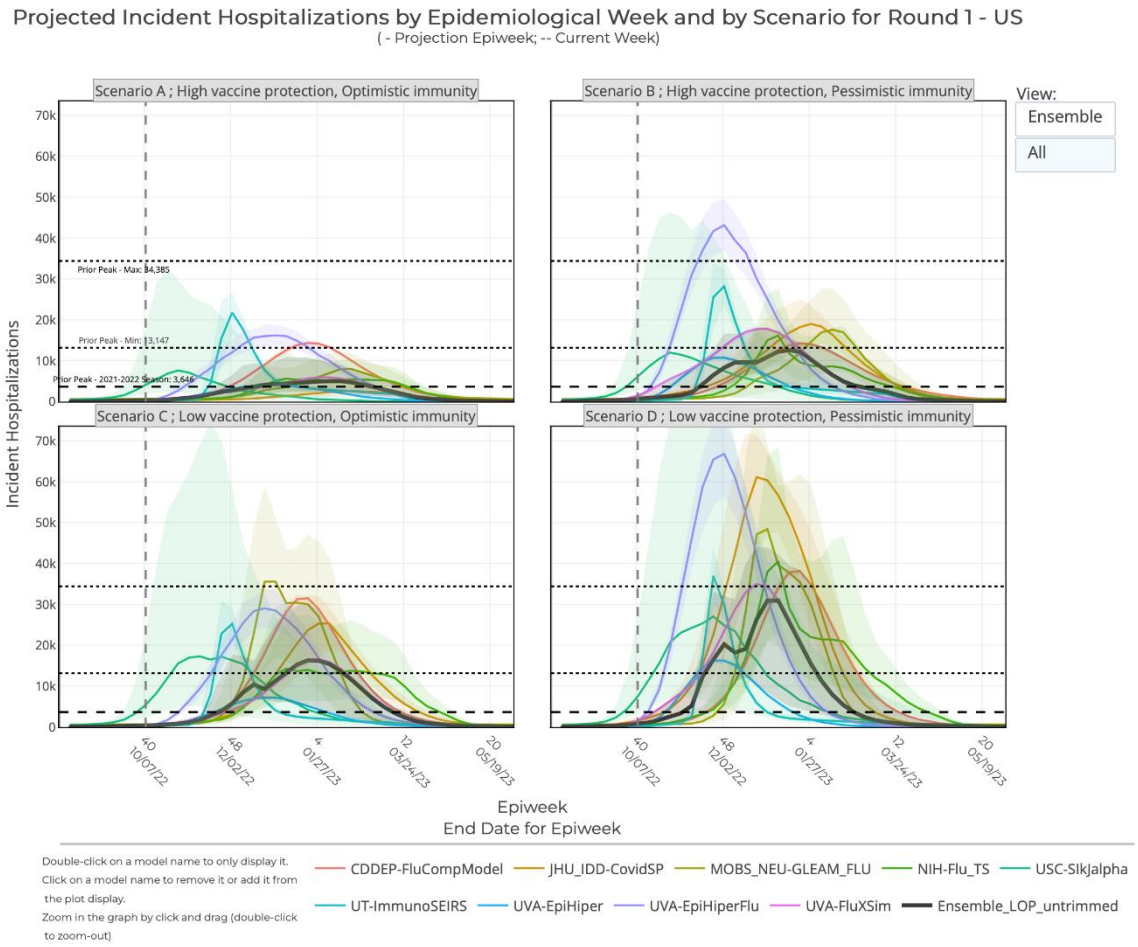


Scenario Modeling Hub – Influenza (Round 1)

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 continue their decline, hospitalizations continue steady decline**
- VA weekly case rate continues decline to 99/100K from 109/100K
  - US weekly case rate is down considerably as well at 89/100K from 105/100K
  - VA hospital occupancy (rolling 7 day mean of 545 down from 599 a week ago) has continued to decline
- Projections anticipate continued declines in cases as well as hospitalizations
- Potential for rebounds due to seasonal forces and/or novel sub-variants in the Fall remains
- Model updates:
  - Maintained Booster Scenarios by slowing down the rate of vaccination adopting the rate of 3rd dose rollout
  - Current monitoring still not finding a definite candidate for Variant X, though BQ.1.1 or BA.2.75.2 remain likely, 50% prevalence pushed back to Nov 15th

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

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

Questions?

Points of Contact

Bryan Lewis
brylew@virginia.edu

Srini Venkatramanan
srini@virginia.edu

Madhav Marathe
marathe@virginia.edu

Chris Barrett
ChrisBarrett@virginia.edu

Biocomplexity COVID-19 Response Team

Aniruddha Adiga, Abhijin Adiga, Hannah Baek, Chris Barrett, Golda Barrow, Richard Beckman, Parantapa Bhattacharya, Jiangzhuo Chen, Clark Cucinell, Patrick Corbett, Allan Dickerman, Stephen Eubank, Stefan Hoops, Ben Hurt, Ron Kenyon, Brian Klahn, Bryan Lewis, Dustin Machi, Chunhong Mao, Achla Marathe, Madhav Marathe, Henning Mortveit, Mark Orr, Joseph Outten, Akhil Peddireddy, Przemyslaw Porebski, Erin Raymond, Jose Bayoan Santiago Calderon, James Schlitt, Samarth Swarup, Alex Telionis, Srinivasan Venkatramanan, Anil Vullikanti, James Walke, Andrew Warren, Amanda Wilson, Dawen Xie