Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

December 14th , 2022

(data current to December 6th – December 13th)

Biocomplexity Institute Technical report: TR BI-2022-1891

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End Gun Violence

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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

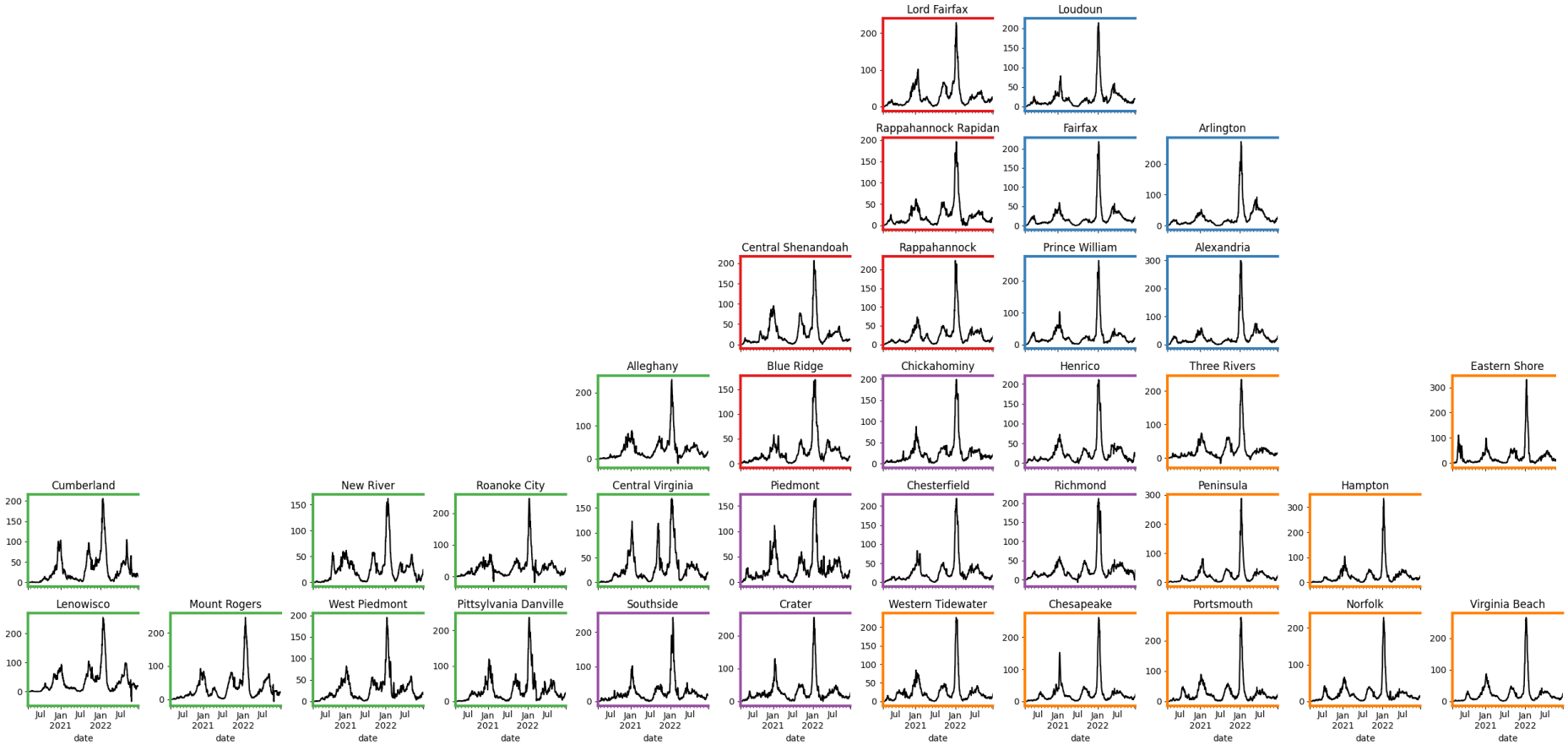
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

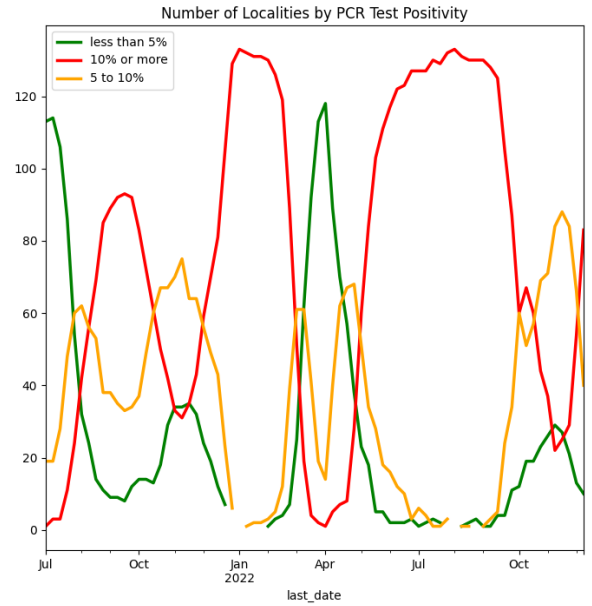
- **Case rates and hospitalizations starting to rise rapidly**
- VA weekly case rate is up to at 95/100K from 81/100K
  - US weekly case rate up sharply to 126 per 100K from 74 per 100K, and hospitalizations continue to quickly rise
- VA hospital occupancy is quickly rising (rolling 7 day mean of 694 from 644 a week ago); highest since early Sept
  - Influenza weekly hospital admissions remain high (~300 a week) but are now declining
- Projections anticipate increases in cases and hospitalizations in coming weeks
  - Combined hospitalizations due to Influenza and COVID-19 are expected to have a steady increase
- Model updates:
  - Model now fitted with Adaptive-Variant X, assumes this as the base case, since current growth can be attributed to rise of swarm of variants with more immune escape, Fall-Winter effects continue to add additional growth

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)

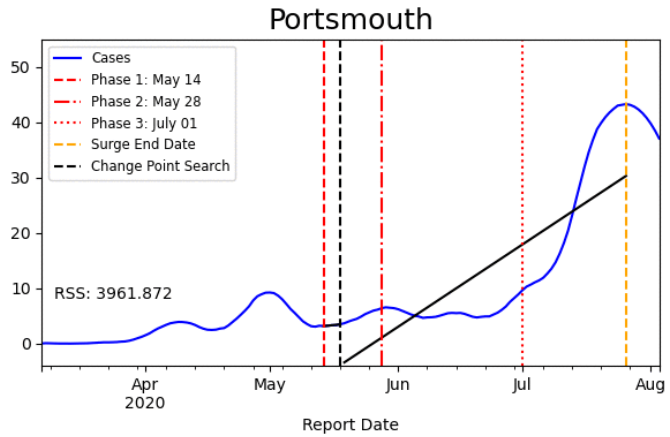
Red: >10.0% (and not "Green" or "Yellow")

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

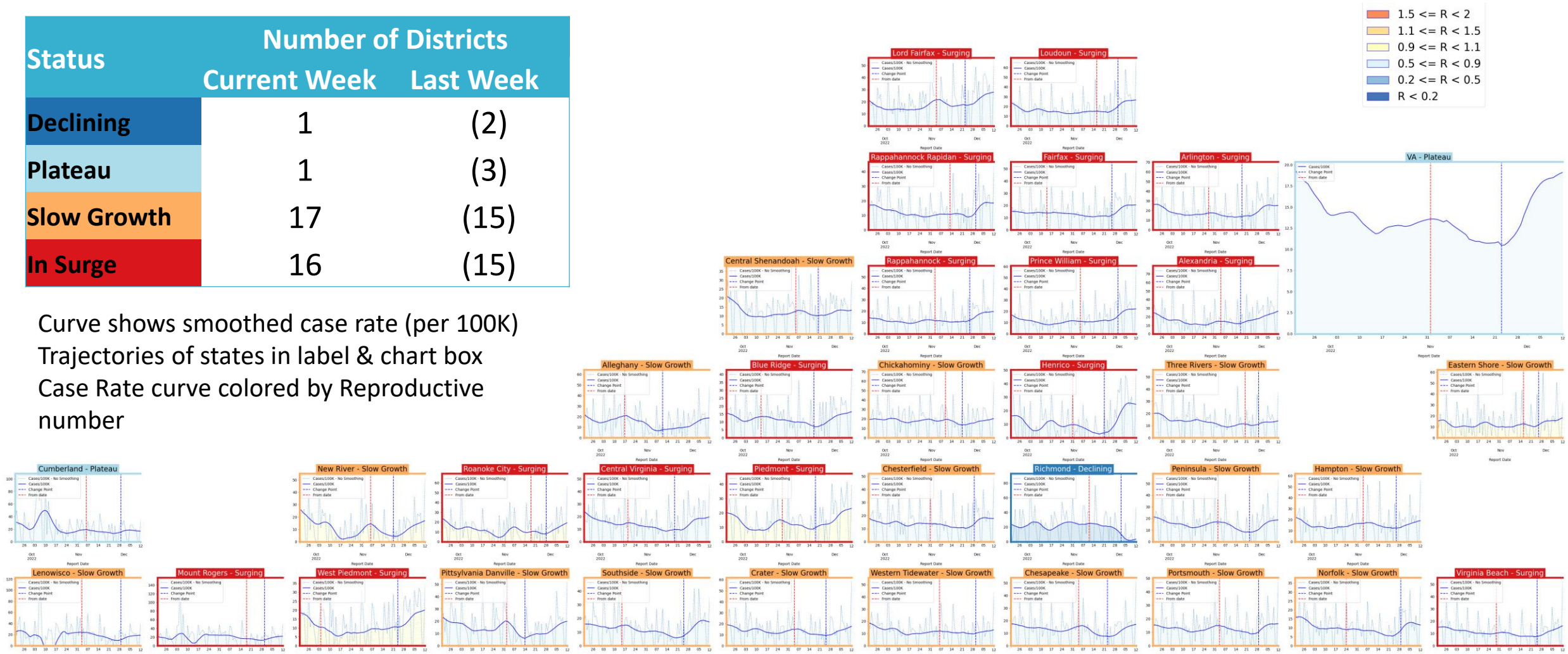


Trajectory	Description	Weekly Case Rate Slope (per 100k)	Weekly Hosp Rate Slope (per 100k)
Declining	Sustained decreases following a recent peak	slope < -0.88/day	slope < -0.07/day
Plateau	Steady level with minimal trend up or down	-0.88/day < slope < 0.42/day	-0.07/day < slope < 0.07/day
Slow Growth	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	1	(2)
Plateau	1	(3)
Slow Growth	17	(15)
In Surge	16	(15)

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

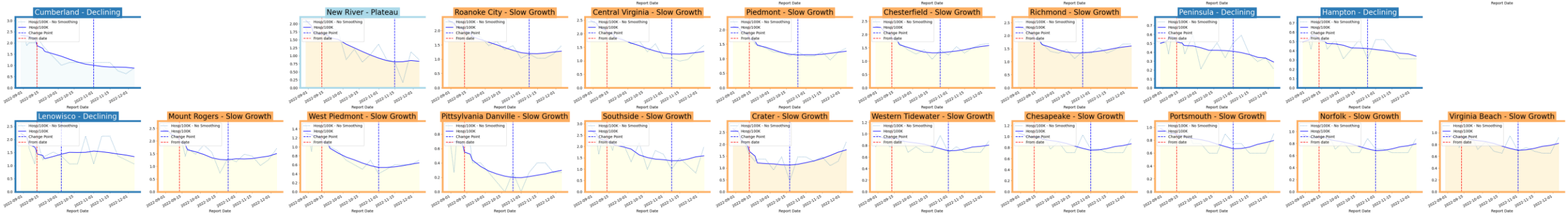


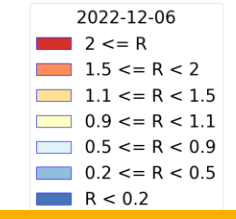
District Hospital Trajectories – last 12 weeks

Status	Number of Districts	
	Current Week	Last Week
Declining	4	(23)
Plateau	1	(5)
Slow Growth	30	(7)
In Surge	0	(0)

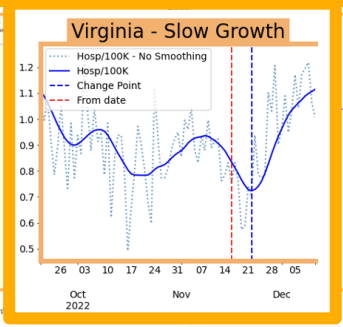
Curve shows smoothed hospitalization rate (per 100K) by district
Hosp rate curve colored by R_e number

Holiday reporting delay
Hospitalization by county is delayed, these data are current as of
December 6th





State level without delay



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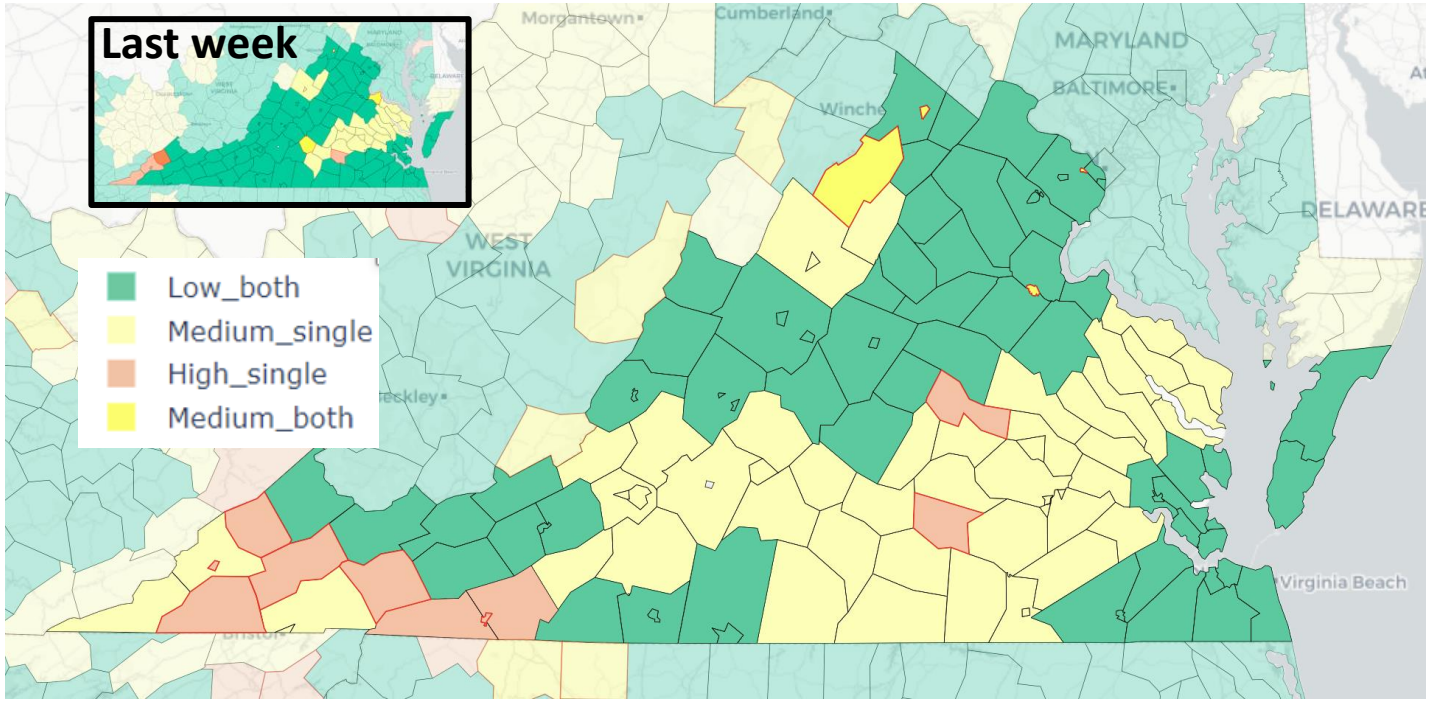
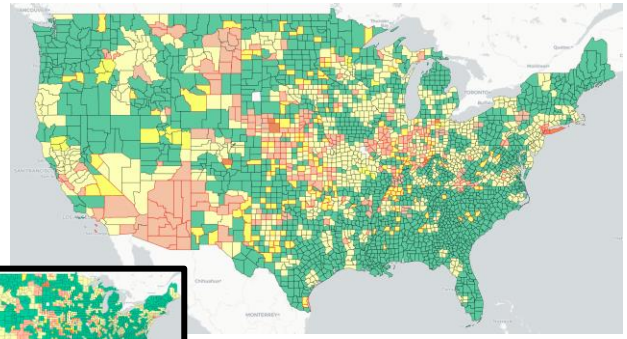
CDC's COVID-19 Community Levels

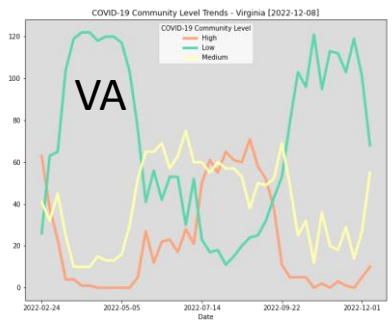


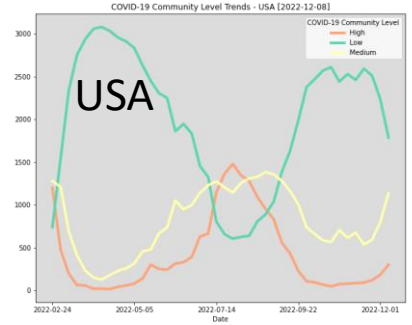
Red outline indicates county had 200 or more cases per 100k in last week

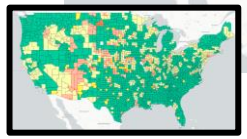
Pale color indicates either beds or occupancy set the level for this county

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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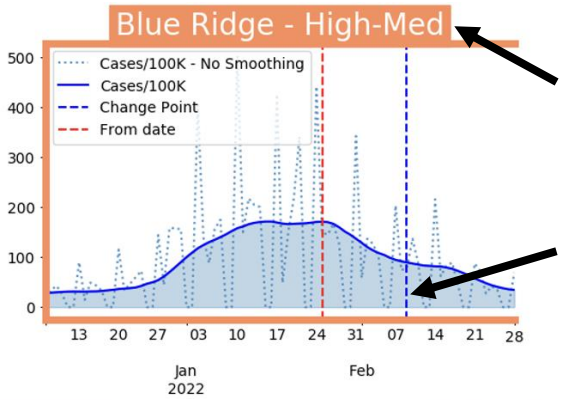
Data from: CDC Data Tracker Portal

District Trajectories with Community Levels

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

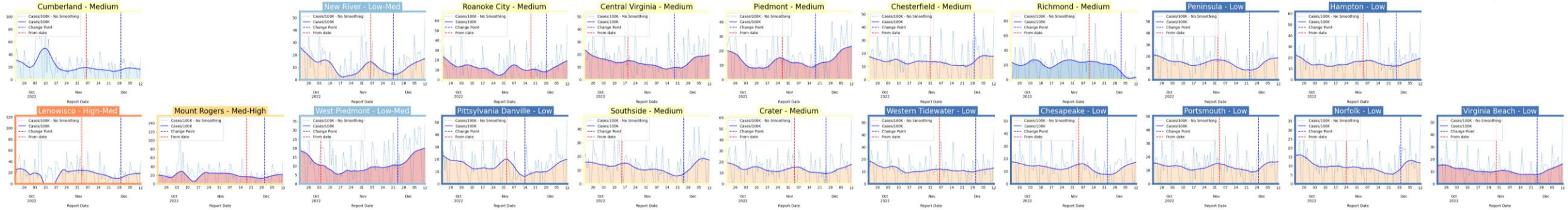
Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory

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

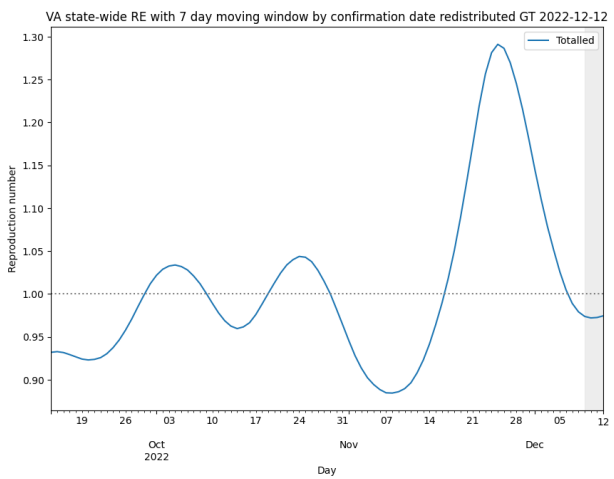
Case rate Trajectory

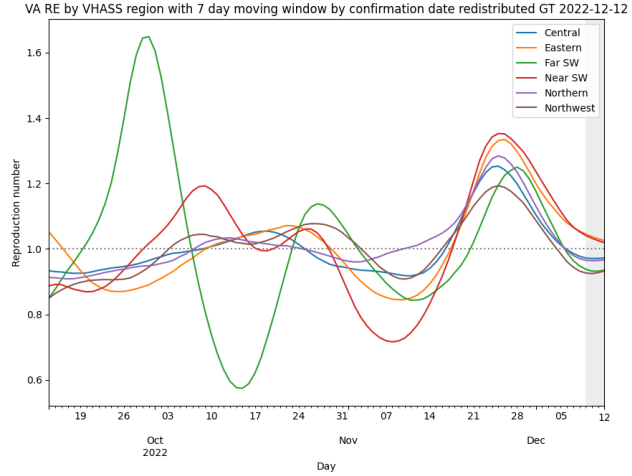


Estimating Daily Reproductive Number –
Redistributed gap

November 28th Estimates

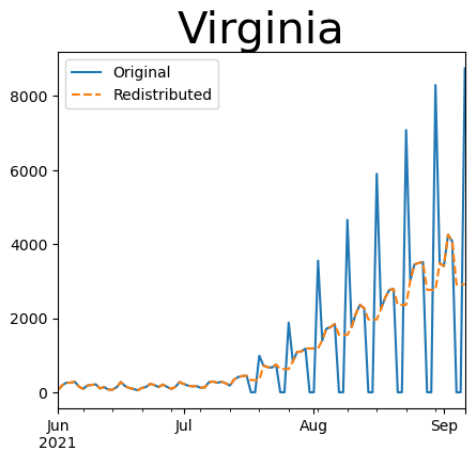
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.973	-0.094
Central	0.970	-0.073
Eastern	1.026	-0.079
Far SW	0.946	-0.142
Near SW	1.019	-0.086
Northern	0.966	-0.119
Northwest	0.938	-0.058





Skipping Weekend Reports & holidays biases estimates

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



Methodology

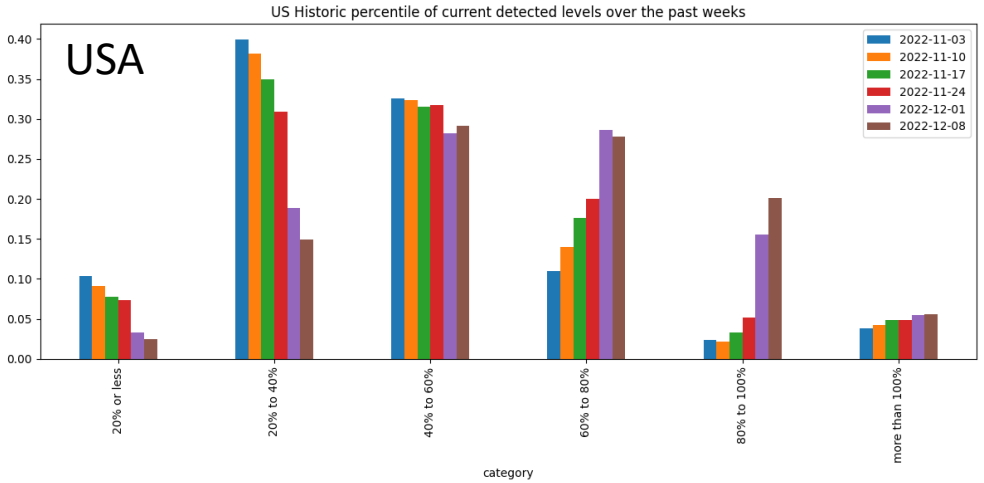
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

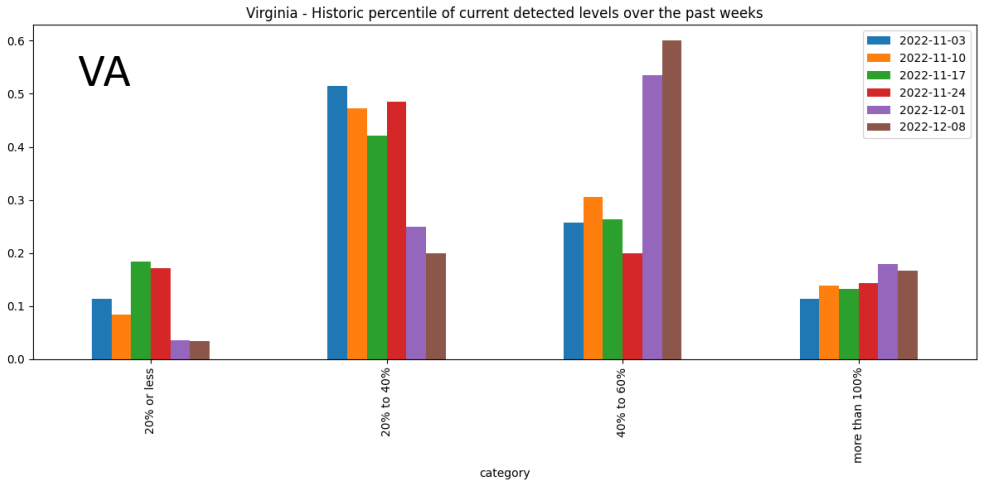
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

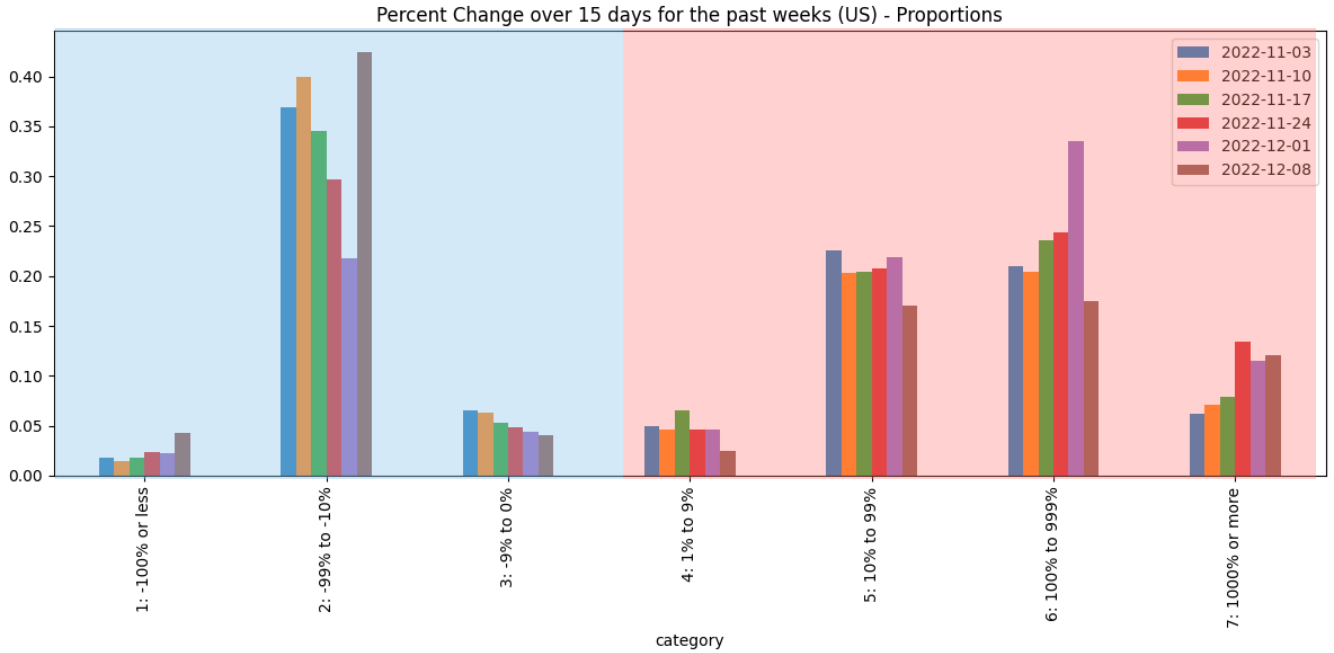
Wastewater Monitoring

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
- Growth seen in the category where current virus levels are at or exceeding max of previous historical levels





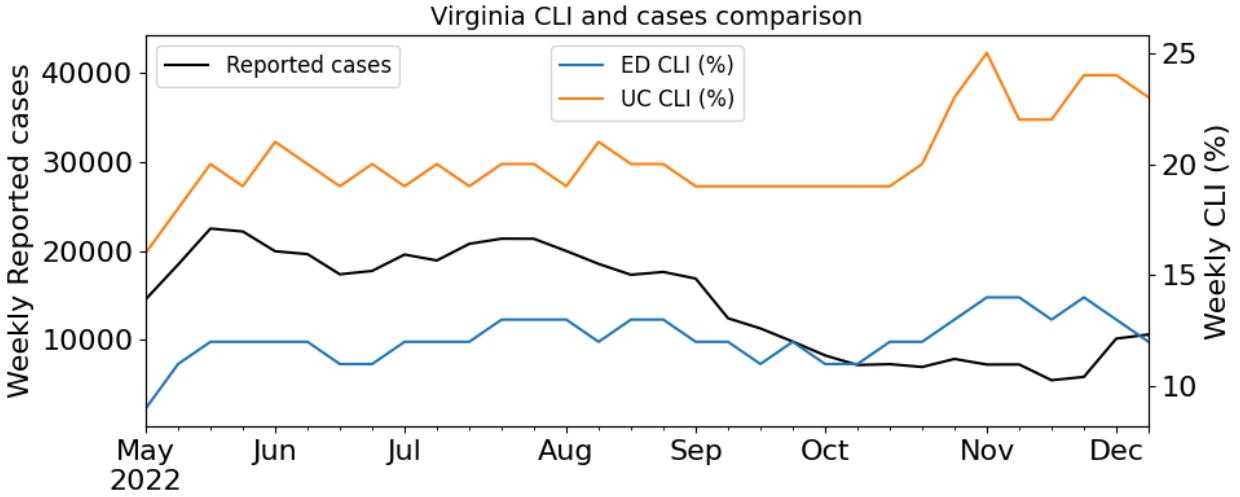


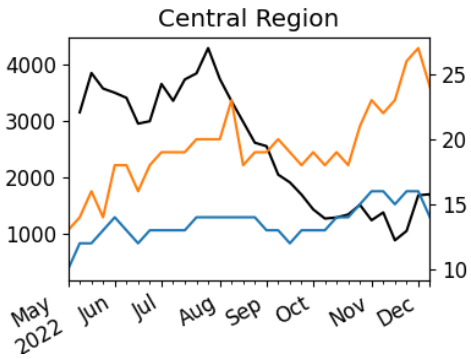
Data Source: [CDC Data Tracker]

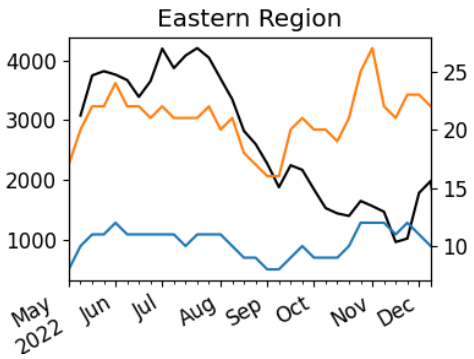
COVID-like Illness Activity

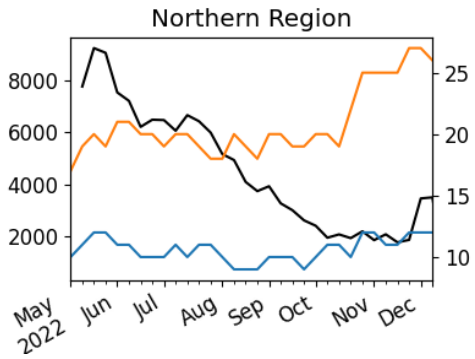
COVID-like Illness (CLI) gives a measure of COVID transmission in the community

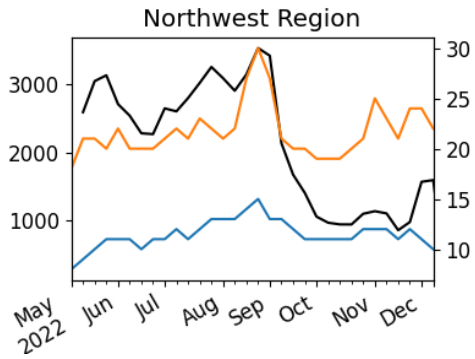
- Emergency Dept (ED) based CLI is more correlated with case reporting
- Urgent Care (UC) is a leading indicator but may be influenced by testing for other URIs
- **After 5 months of plateau, UC CLI remains higher than previous levels statewide**

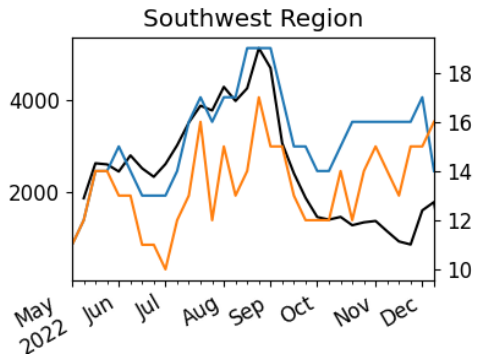










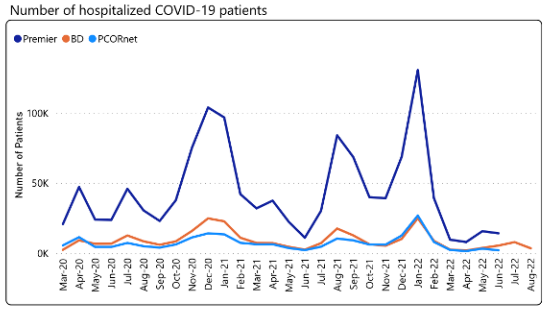


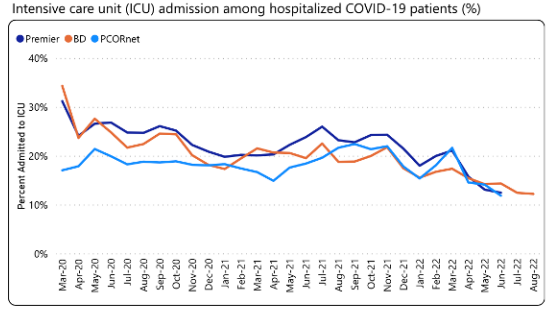
Hospitalizations and Severe Outcomes

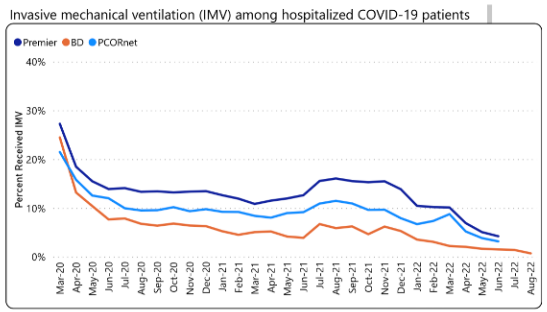
Data Source: [CDC Data Tracker]

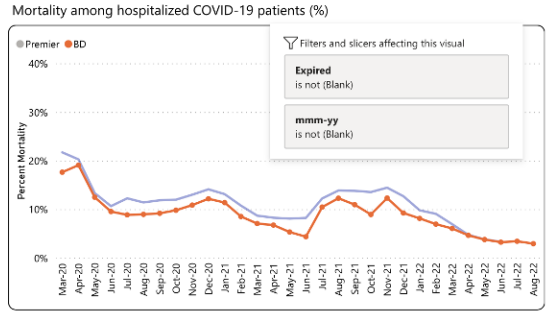
Proportion of most severe outcomes decreasing among those who are hospitalized

- ICU has declined from ~20% of hospitalized to 10-15% since initial Omicron wave
- Seen across all age-groups
- Recent rises in these rates have subsided in the past week

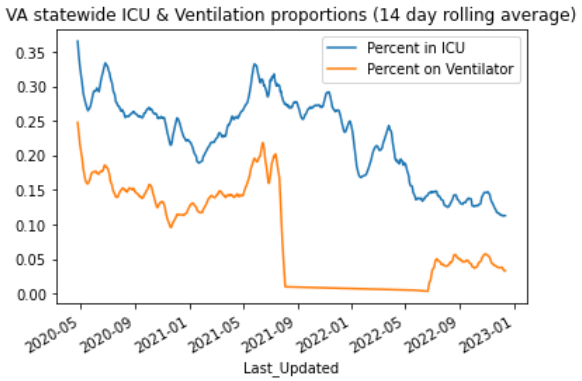




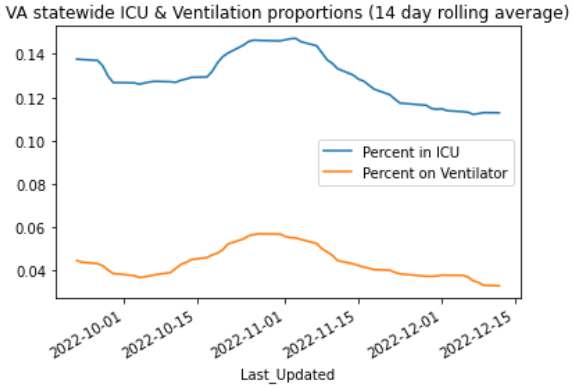




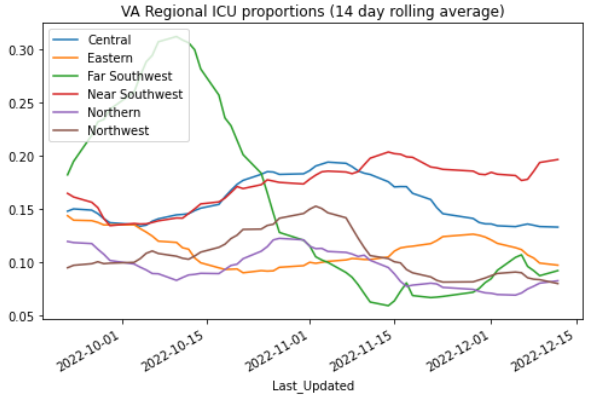
Virginia-wide – full pandemic



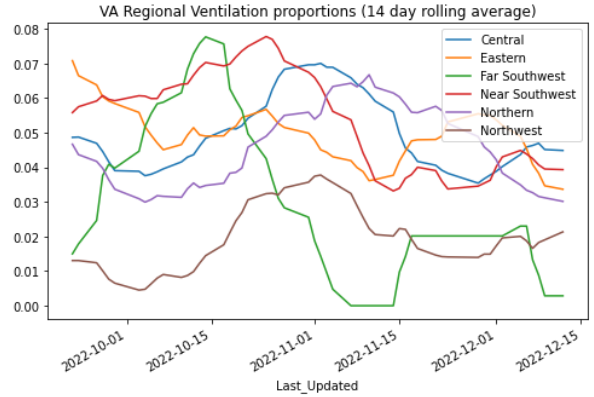
Virginia-wide – recent



Virginia Regional ICU percent



Virginia Regional Ventilation %



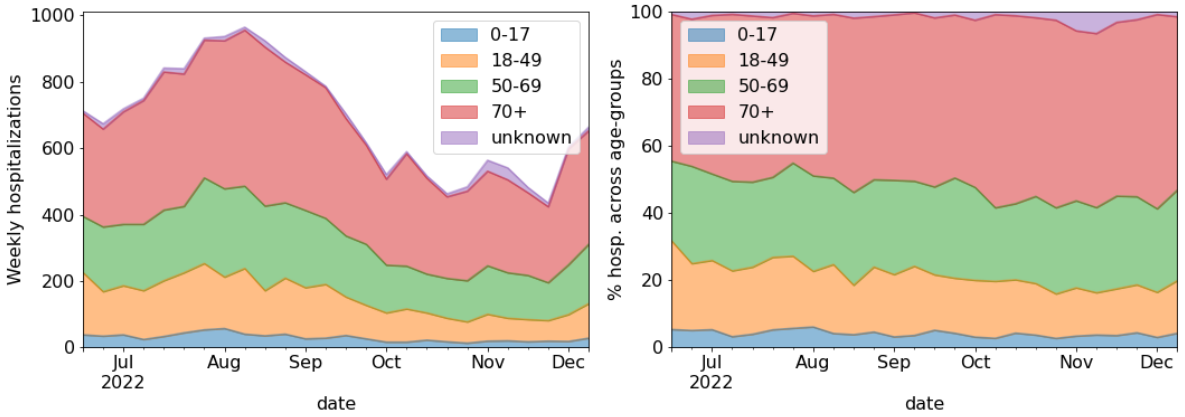
Hospitalizations in VA by Age

Age distribution in hospitals relatively stable

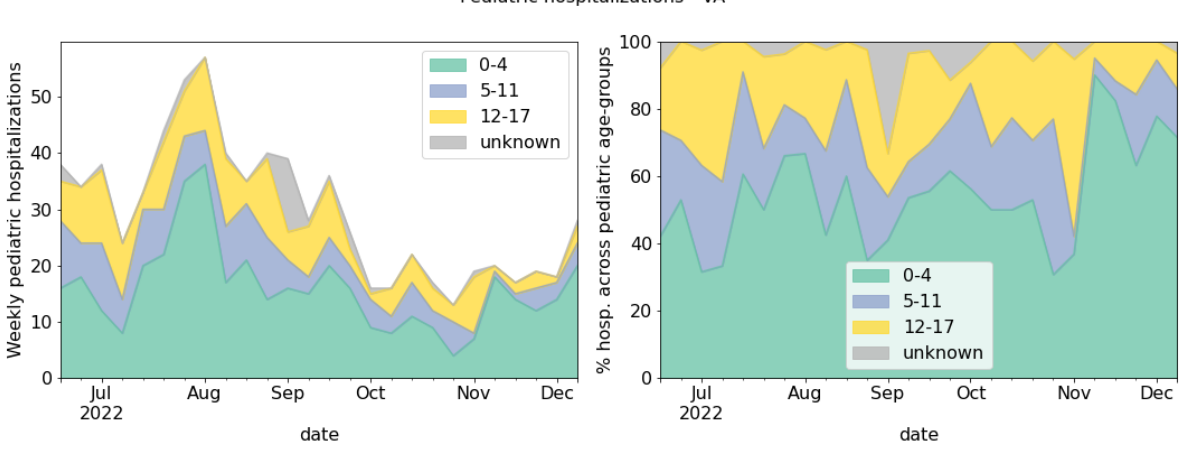
- Uptick in hospitalizations felt across most age-groups, including pediatric
- Majority of pediatric hospitalizations has been in 0-4-yo

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

Virginia Hospitalizations by Age (all ages)



Pediatric Hospitalizations by Age (0-17yo)

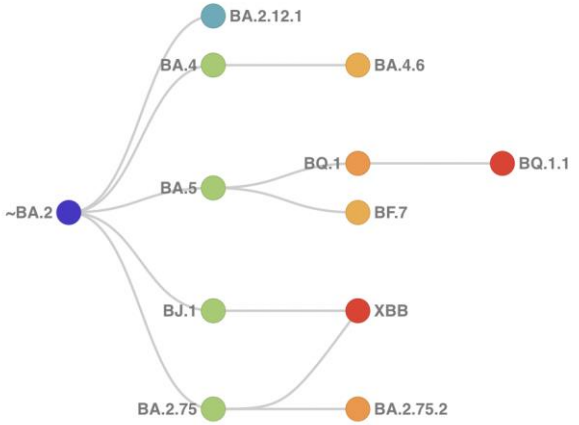


Data Source: Delphi and HHS

SARS-CoV2 Variants of Concern

Emerging variants have potential to continue to alter the future trajectories of pandemic and have implications for future control

- **Variants have been observed to:** increase transmissibility, increase severity (more hospitalizations and/or deaths), and limit immunity provided by prior infection and vaccinations



Omicron Updates

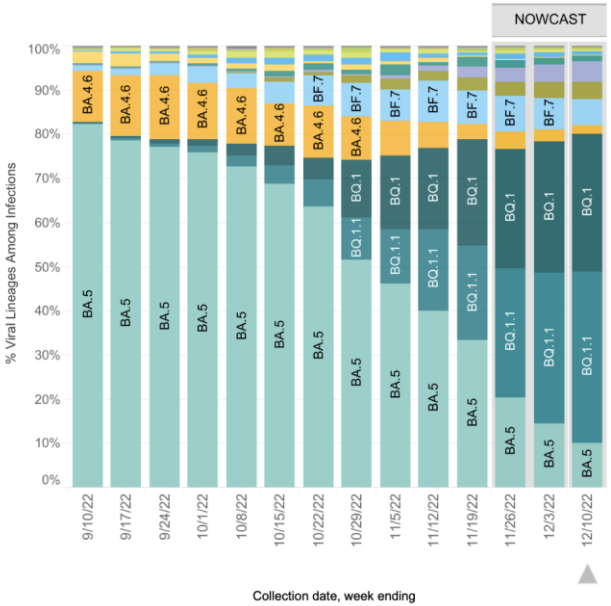
- BQ.1 and BQ.1.1 continue to dominate at 39% and 31% respectively (up from 31% and 34%)
- BA.2.75.* family variants (includes BN.1) remain steady at nearly a 5%
- BF.7 and BA.4.6 have been slowly shrinking to 6% and 2%
- BA.5.2.6 and BF.11 and account for relatively smaller shares (2% and 4% respectively)
- XBB and subvariants remain significant, steady at 5%

HHS Region 3: 12/4/2022 – 12/10/2022 NOWCAST

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

WHO label	Lineage #	US Class	%Total	95%PI
Omicron	BQ.1.1	VOC	38.8%	33.7-44.1%
	BQ.1	VOC	31.2%	28.8-33.8%
	BA.5	VOC	10.1%	8.4-12.1%
	BF.7	VOC	6.0%	4.7-7.6%
	XBB	VOC	4.6%	2.3-8.7%
	BN.1	VOC	3.9%	2.7-5.5%
	BA.4.6	VOC	1.9%	1.6-2.3%
	BA.5.2.6	VOC	1.5%	1.1-2.0%
	BF.11	VOC	0.9%	0.7-1.2%
	BA.2.75	VOC	0.5%	0.3-0.6%
	BA.2	VOC	0.3%	0.2-0.4%
	BA.2.75.2	VOC	0.3%	0.2-0.5%
	BA.4	VOC	0.0%	0.0-0.0%
	B.1.1.529	VOC	0.0%	0.0-0.0%
	BA.1.1	VOC	0.0%	0.0-0.0%
	BA.2.12.1	VOC	0.0%	0.0-0.0%
Delta	B.1.617.2	VBM	0.0%	0.0-0.0%
Other	Other*		0.0%	0.0-0.1%

HHS Region 3: 9/4/2022 – 12/10/2022



* 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
\# BA.1, BA.3 and their sublineages (except BA.1.1 and its sublineages) are aggregated with B.1.1.529. Except BA.2.12.1, BA.2.75, BA.2.75.2, BN.1,XBB and their sublineages, BA.2 sublineages are aggregated with BA.2. Except BA.4.6, sublineages of BA.4 are aggregated to BA.4. Except BF.7, BF.11, BA.5.2.6, BQ.1 and BQ.1.1, sublineages of BA.5 are aggregated to BA.5. For all the lineages listed in the above table, their sublineages are aggregated to the listed parental lineages respectively. Previously, XBB was aggregated with other. Lineages BA.2.75.2, XBB, BN.1, BA.4.6, BF.7, BF.11, BA.5.2.6 and BQ.1.1 contain the spike substitution R346T.

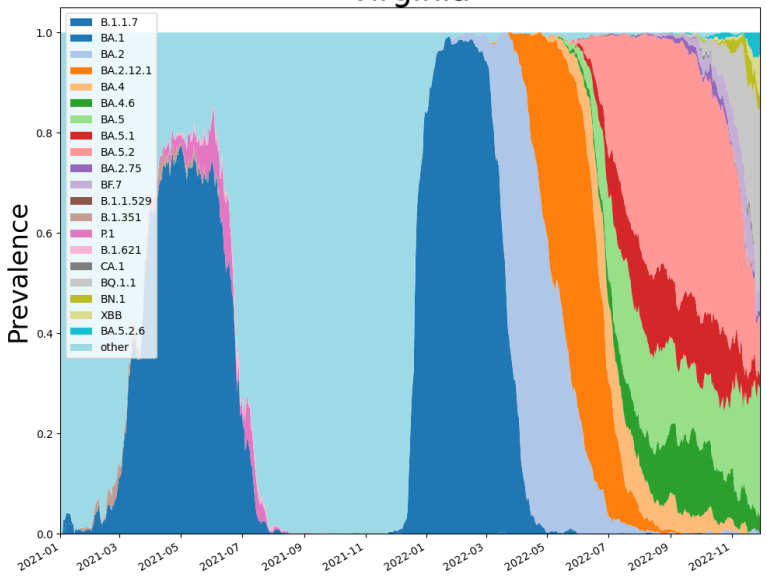
CDC Variant Tracking

SARS-CoV2 Omicron Sub-Variants

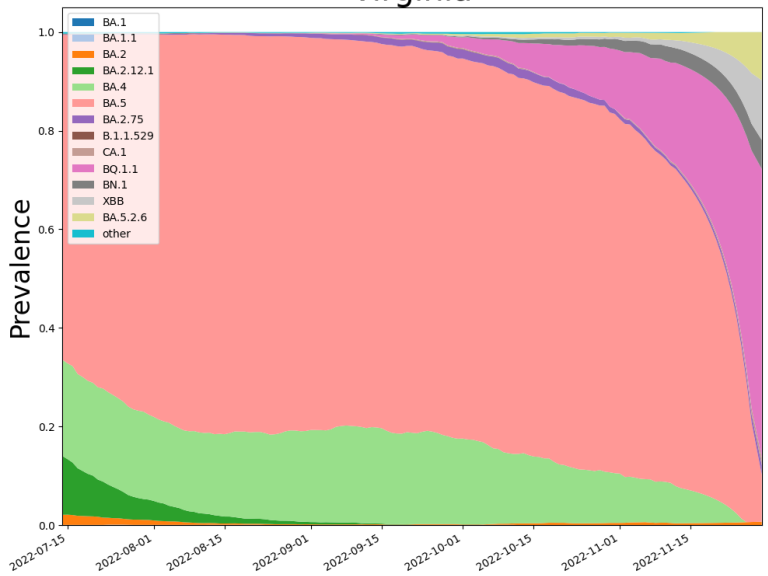
covSPECTRUM
Enabled by data from GISAID

As detected in whole Genomes in public repositories

Virginia

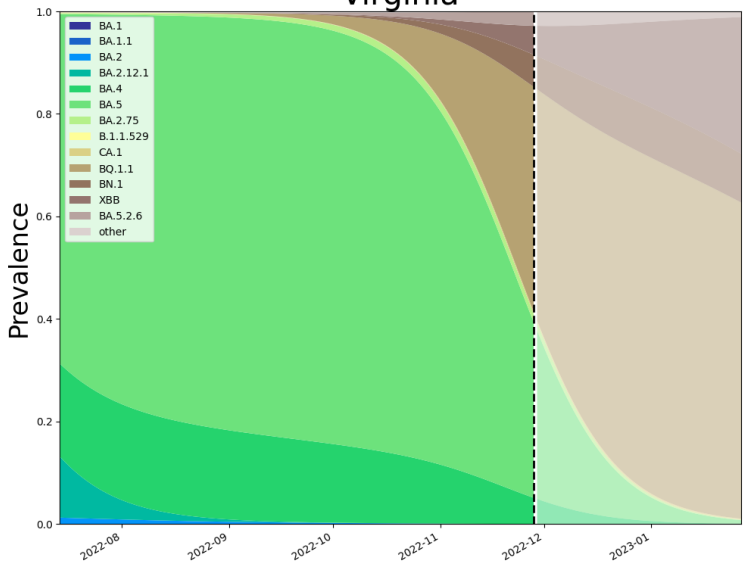


Virginia

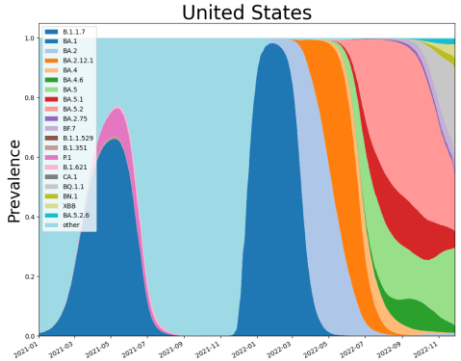


VoC Polynomial Fit Projections

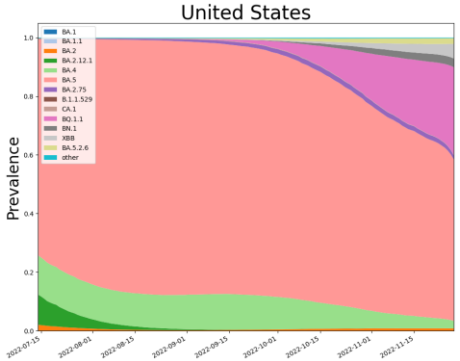
Virginia



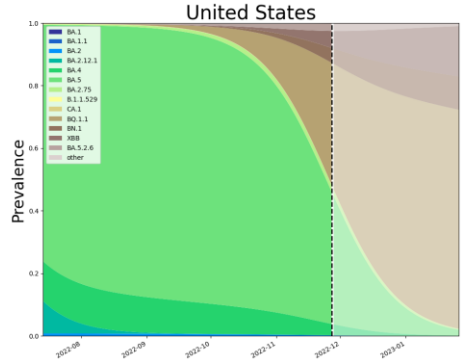
United States



United States



United States



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

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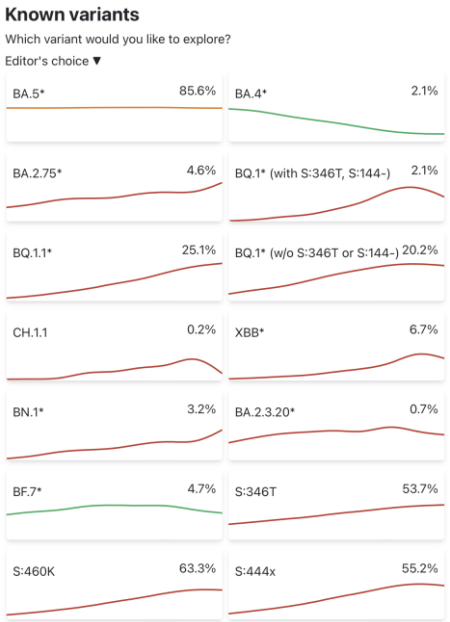
SARS-CoV2 Omicron Sub-Variants

[COV-spectrum](#)

"Editor's choice"

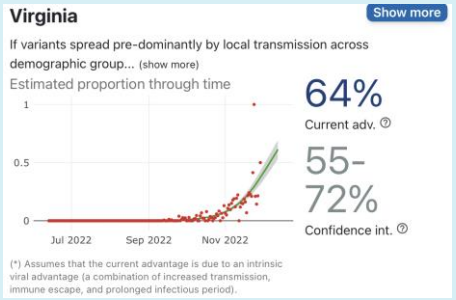
Variants to watch

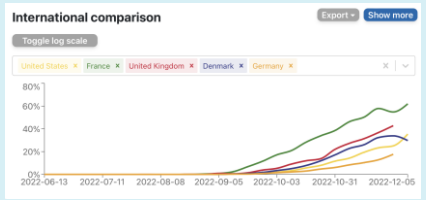


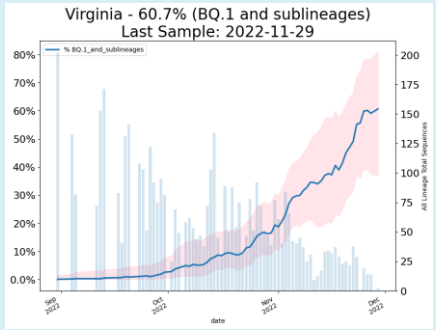
covSPECTRUM

Enabled by data from GISAID

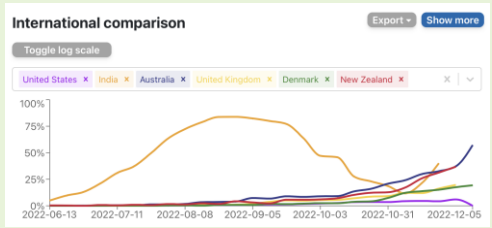
BQ.1.*

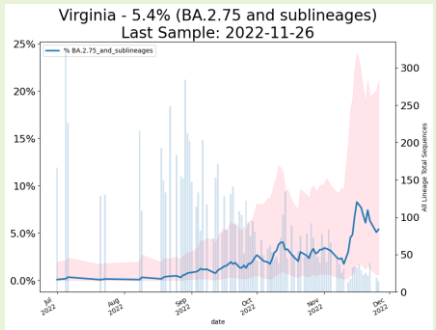




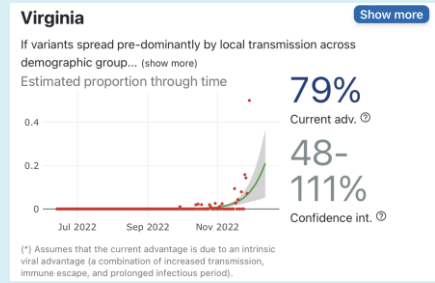


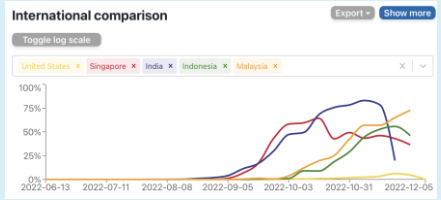
BA.2.75.*

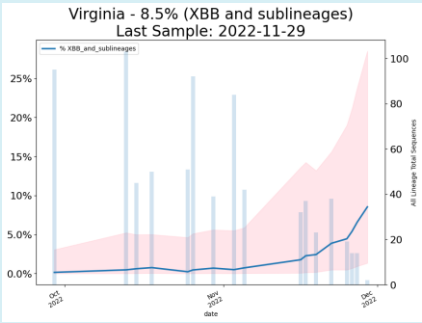




XBB*







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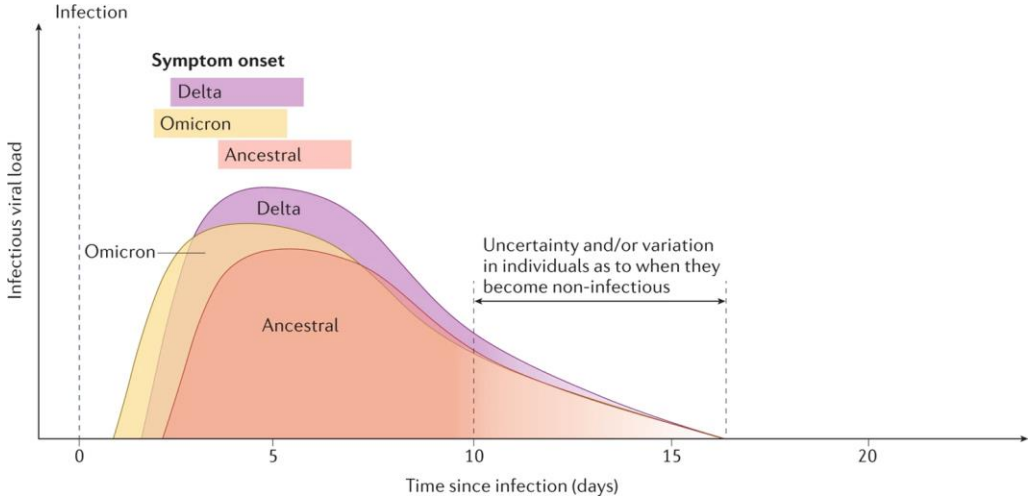
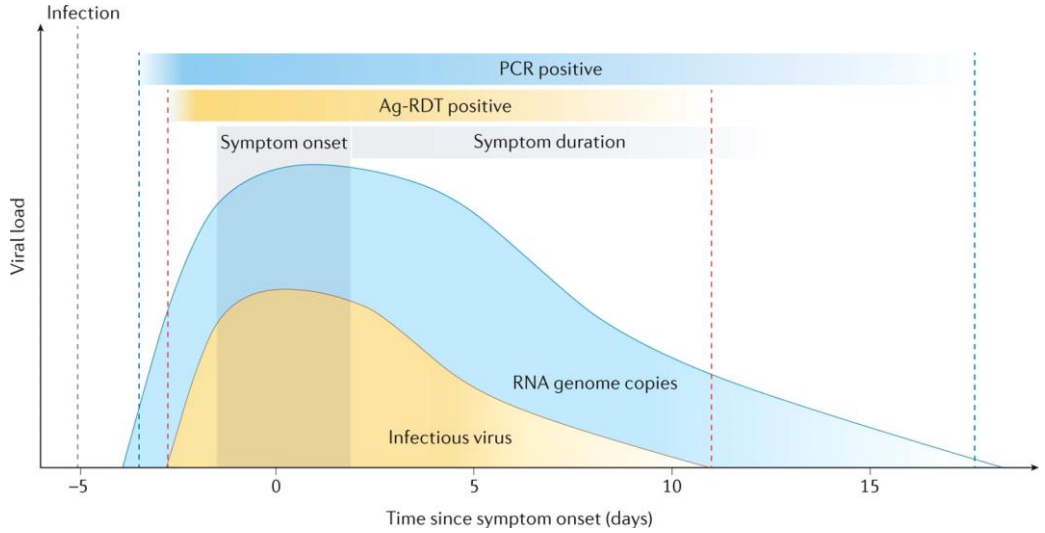
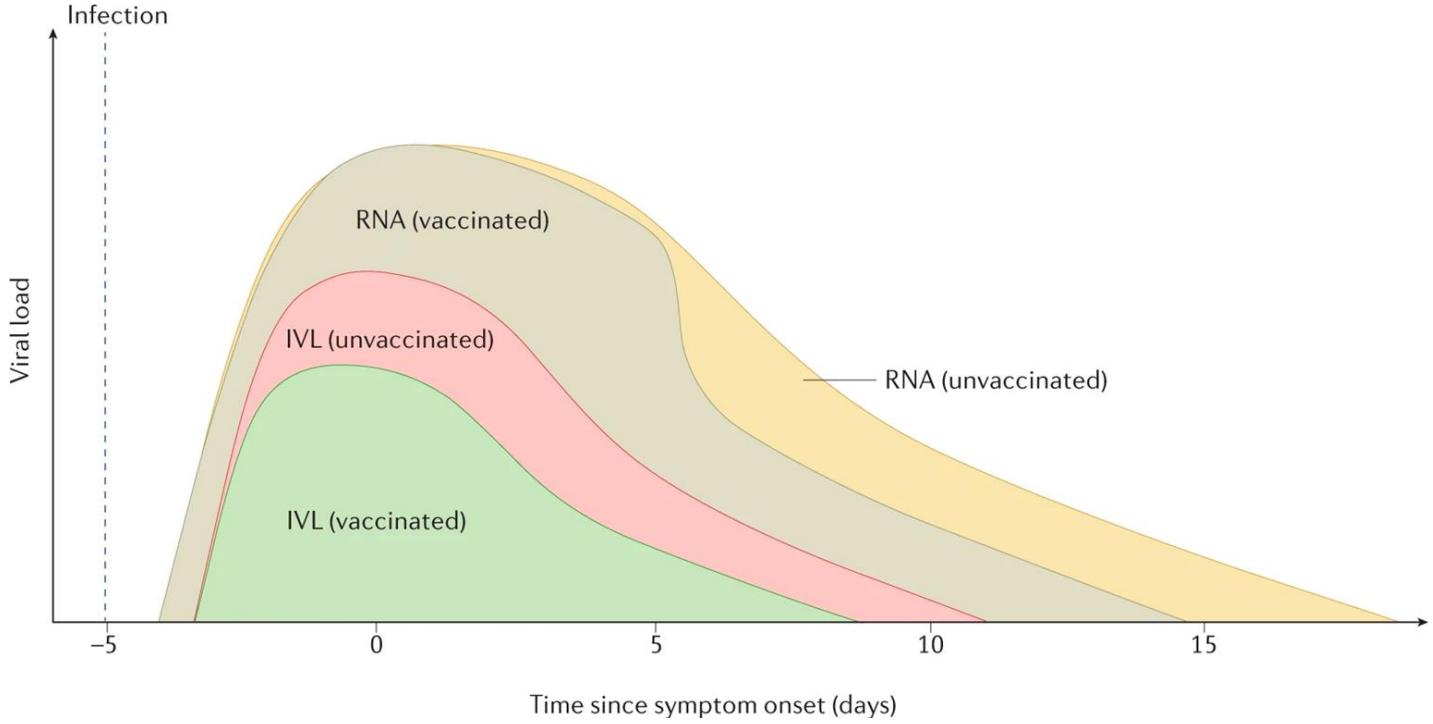
Pandemic Pubs (Dec 13th, 2022)

1. Higher viral load poses a greater risk for onward transmission







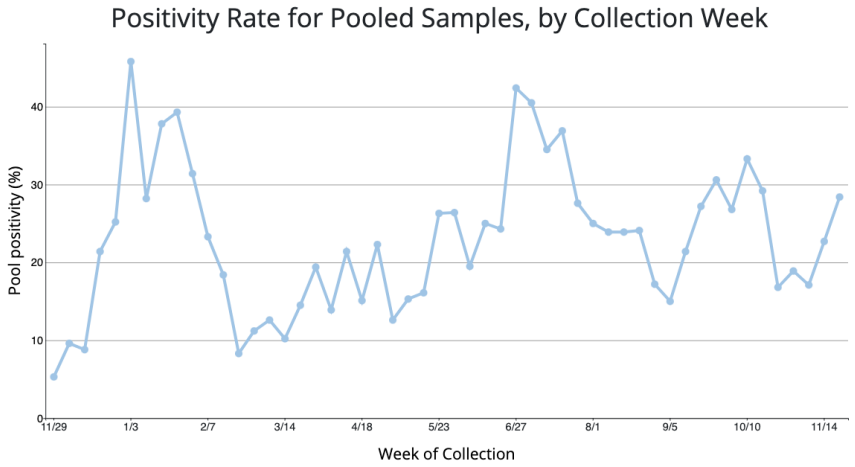
Viral load substantially contributes to human-to-human transmission, with higher viral load posing a greater risk for onward transmission. The findings referenced here suggest that vaccinated individuals are less infectious than unvaccinated individuals.

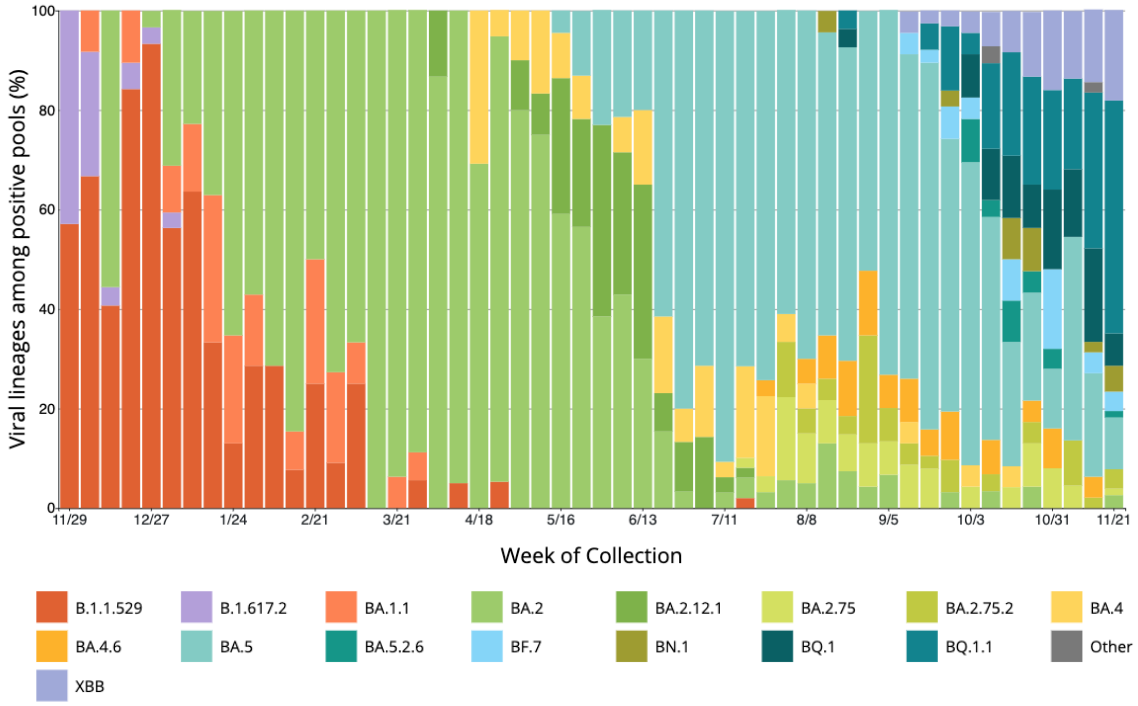
https://www.nature.com/articles/s41579-022-00822-w

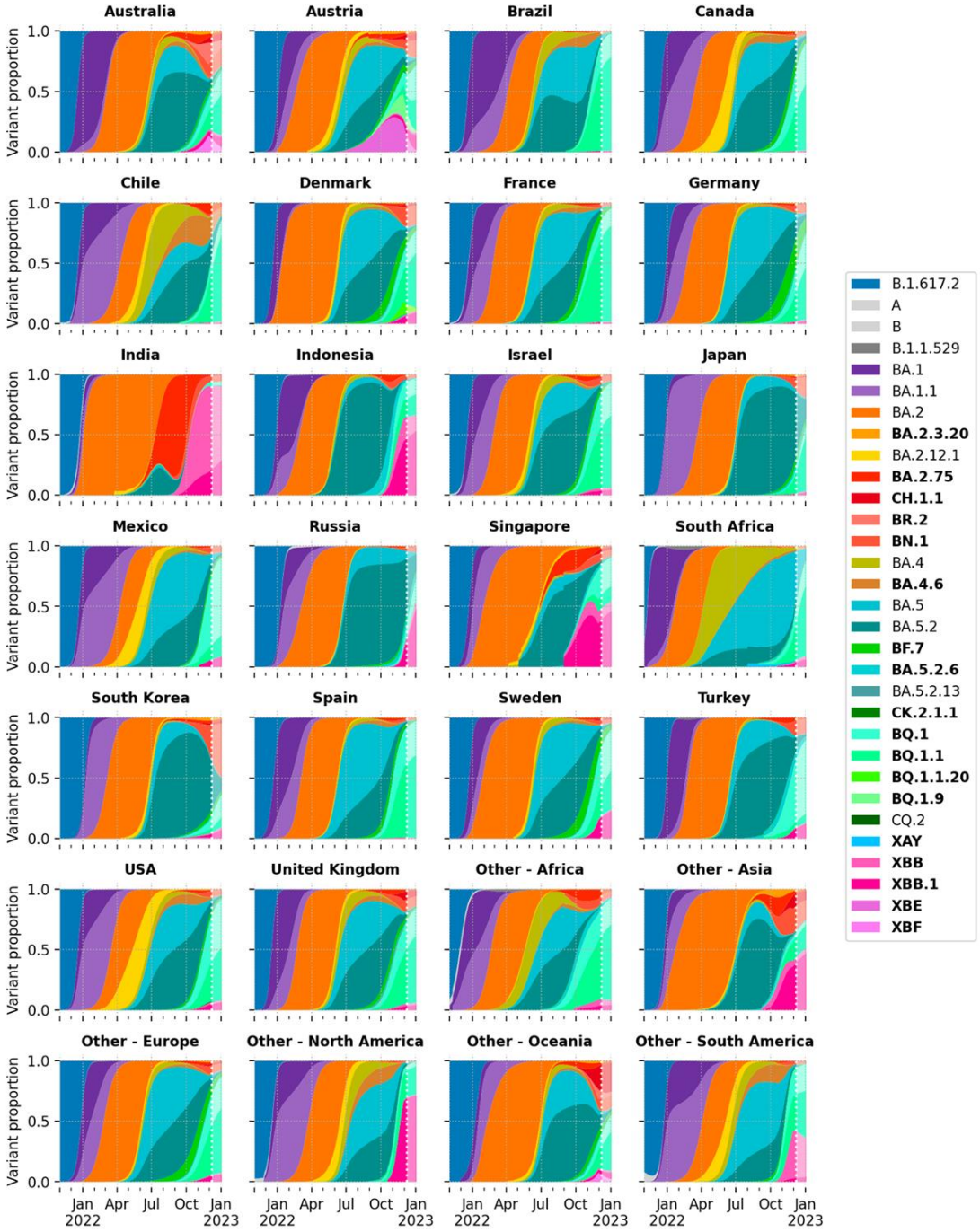
Pandemic Pubs (Dec 13th, 2022)

2. Variants around the world

Traveler-Based Genomic Surveillance for SARS-CoV-2



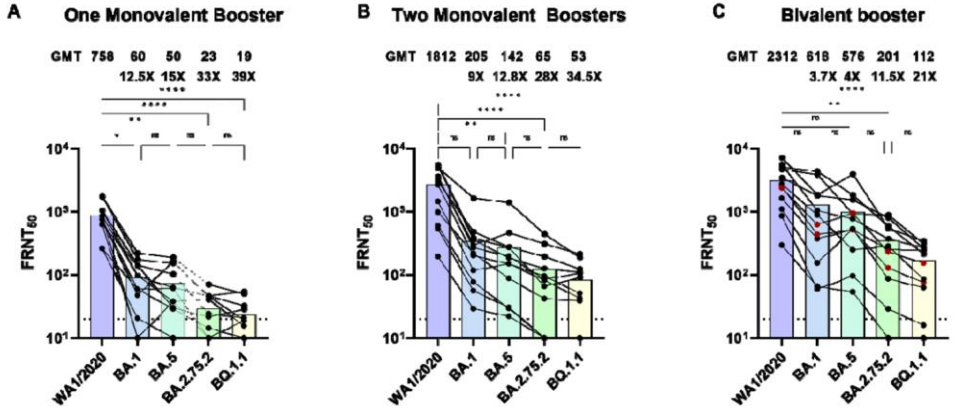




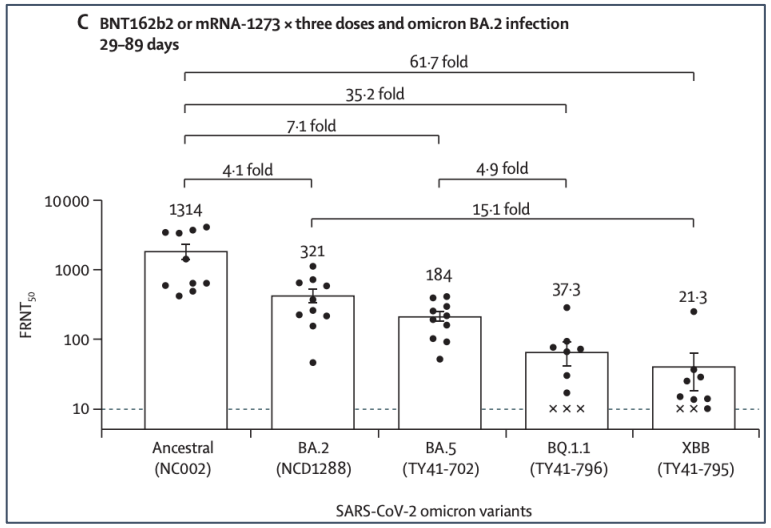
https://covid.cdc.gov/covid-data-tracker/#traveler-genomic-surveillance
https://github.com/gerstung-lab/SARS-CoV-2-International

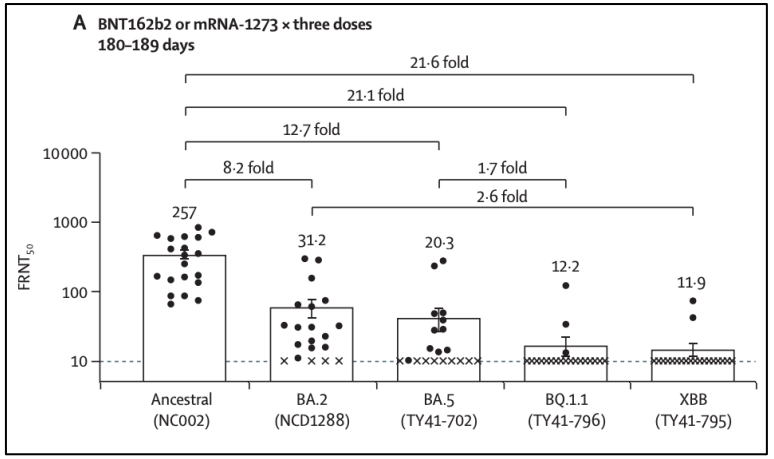
Pandemic Pubs (Dec 13th, 2022)

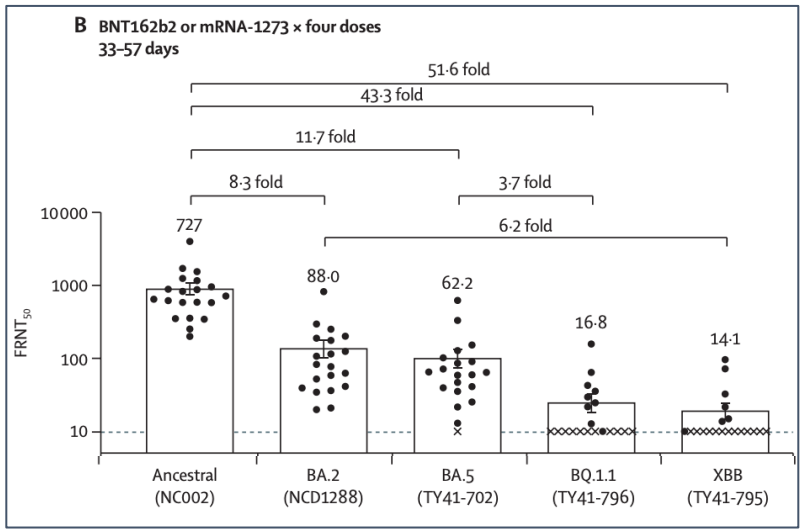
3. Immune escape updates on incoming variants



Previous: Researchers at Emory, Stanford, and NIAID evaluated serum samples from individuals who had received either one or two monovalent boosters or the bivalent booster to determine neutralizing activity against wild-type and Omicron subvariants BA.1, BA.5, BA.2.75.2, and BQ.1.1. Monovalent booster cohort: relative to WA1/2020, observed a reduction in neutralization titers of 9-15-fold against BA.1 and BA.5 and 28-39-fold against BA.2.75.2 and BQ.1.1. In the BA.5-containing bivalent booster cohort, the neutralizing activity improved against all the Omicron subvariants. Relative to wildtype observed a reduction in neutralization titers of 3.7- and 4-fold against BA.1 and BA.5, respectively, and 11.5- and 21-fold against BA.2.75.2 and BQ.1.1, respectively. These data suggest that the bivalent mRNA booster vaccine broadens humoral immunity against the Omicron subvariants.
https://www.biorxiv.org/content/10.1101/2022.10.31.514636v1

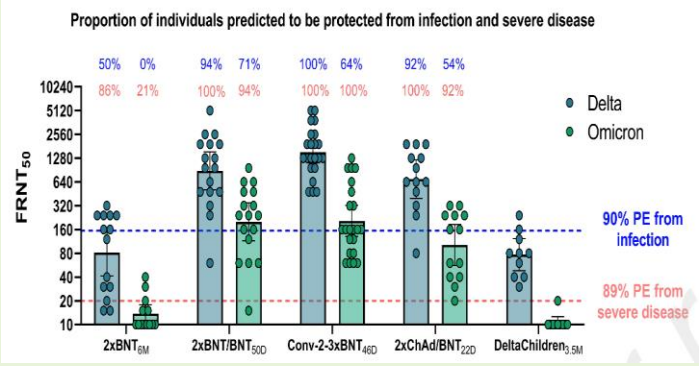






Current: Researchers in Japan and the US recently characterized the immune escape properties of variants BQ.1.1 and XBB, both show higher immune evasion abilities than earlier omicron variants. Groups included individuals (180–189 days after the third dose; n=20) who received three doses of the monovalent mRNA vaccine BNT162b2 (Pfizer–BioNTech) or mRNA-1273 (Moderna), or both; individuals (33–57 days after the fourth dose; n=20) who received four doses of the monovalent mRNA vaccine BNT162b2 or mRNA-1273, or both; and individuals (29–89 days after the infection; n=10) who received three doses of monovalent BNT162b2 or mRNA-1273 before the BA.2 breakthrough infection. Using a live-virus neutralisation assay, to determine the 50% focus reduction neutralisation titre (FRNT50)
https://www.thelancet.com/action/showPdf?pii=S1473-3099%2822%2900816-7

Previous: Italian study provides an analysis of 44 individuals antibody neutralization against omicron and other variants deriving analytic serologic cut-offs that correlate with protection, using a common high-throughput assay targeting anti-SARS-CoV-2 Spike antibodies. Their findings confirm published models for the prediction of protection efficacy. This model provides a useful touchstone for calibrating protection according to immune waning kinetics.
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4016530

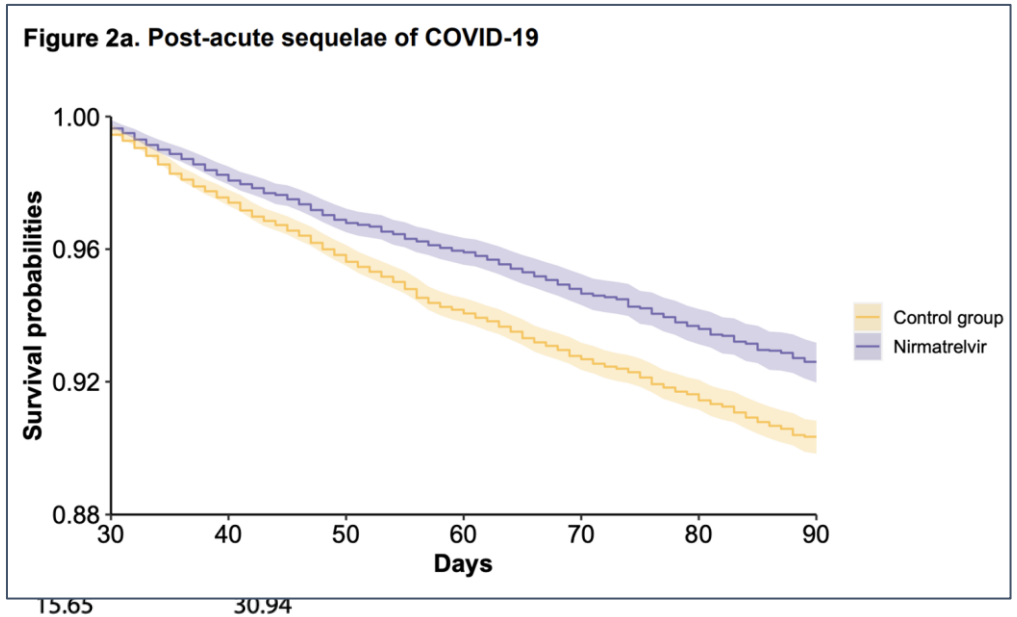


Pandemic Pubs (Dec 7th, 2022)

1. Recent studies highlight the benefit of Paxlovid in reduction of risk associated with hospitalization and long term symptoms

TABLE 2. Adjusted hazard ratios for COVID-19–associated hospitalization based on Paxlovid prescription receipt (exposure) — Cosmos,* United States, April–September 2022

Characteristic	Adjusted HR (95% CI)†	No. of participants	No. hospitalized	Events per 100,000 person-days		
				Overall	Exposed§	Unexposed§
Total	**0.49 (0.46–0.53)**	**693,084**	**5,229**	**25.31**	**15.88**	**29.05**
COVID-19 vaccination status¶						
Vaccinated (≥3 mRNA doses)	**0.50 (0.45–0.55)**	310,196	2,126	**22.98**		
Vaccinated (2 mRNA doses)	**0.50 (0.42–0.58)**	149,498	1,086	**24.37**		
Unvaccinated	**0.50 (0.43–0.59)**	170,789	1,477	**29.05**		
UHC**						
0	**0.89 (0.58–1.36)**	52,592	106	**6.73**		
1	**0.57 (0.45–0.71)**	200,116	503	**8.40**		
≥2	**0.47 (0.44–0.51)**	440,376	4,620	**35.29**		
Previous infection††						
No	**0.48 (0.44–0.51)**	589,147	4,715	**26.86**		
Yes	**0.76 (0.60–0.98)**	103,937	514	**16.56**		
Immunocompromised§§						
No	**0.49 (0.45–0.53)**	628,706	3,770	**20.09**		
Yes	**0.50 (0.44–0.58)**	64,378	1,459	**77.01**		
Month of COVID-19 diagnosis						
Apr 2022	**0.54 (0.40–0.71)**	60,001	450	**25.16**		
May 2022	**0.57 (0.48–0.67)**	139,062	979	**23.61**		
Jun 2022	**0.51 (0.43–0.60)**	143,706	1,006	**23.48**		
Jul 2022	**0.46 (0.40–0.53)**	184,153	1,432	**26.09**	15.65	30.94
Aug 2022	**0.44 (0.38–0.51)**	166,162	1,362	**27.52**	15.60	32.93



Two recent studies:

1) Researchers at the CDC found that **"persons who were prescribed Paxlovid within 5 days of diagnosis had a 51% lower hospitalization rate within 30 days after diagnosis than those who were not prescribed Paxlovid".**

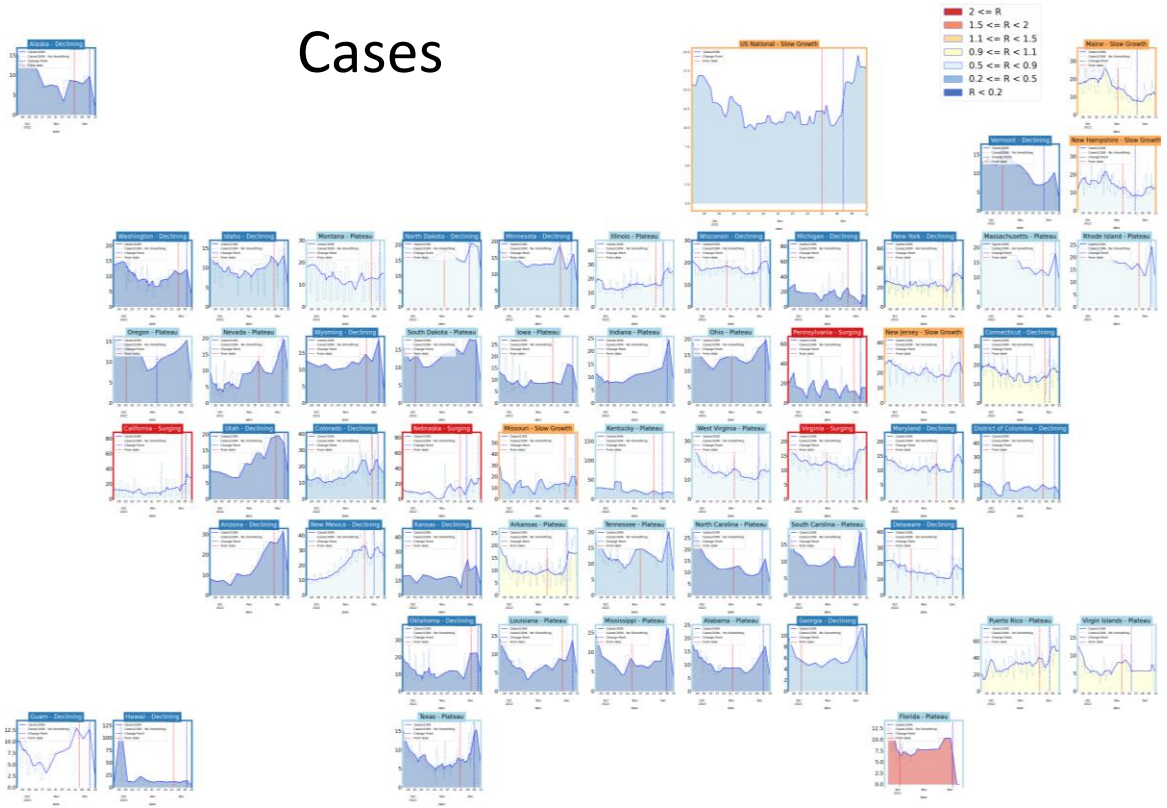
2) Researchers at Veterans Research and Education Foundation used the healthcare databases of the US Department of Veterans Affairs to identify users of the health system who had a SARS-CoV-2 positive test between March 01, 2022 and June 30, 2022, were not hospitalized on the day of the positive test, had at least 1 risk factor for progression to severe COVID-19 illness and survived the first 30 days after SARS-CoV-2 diagnosis. Compared to the control group, **treatment was associated with reduced risk of PASC (HR 0.74 95% CI (0.69, 0.81), including reduced risk of sequelae in the cardiovascular system**

https://www.medrxiv.org/content/10.1101/2022.11.03.22281783v1

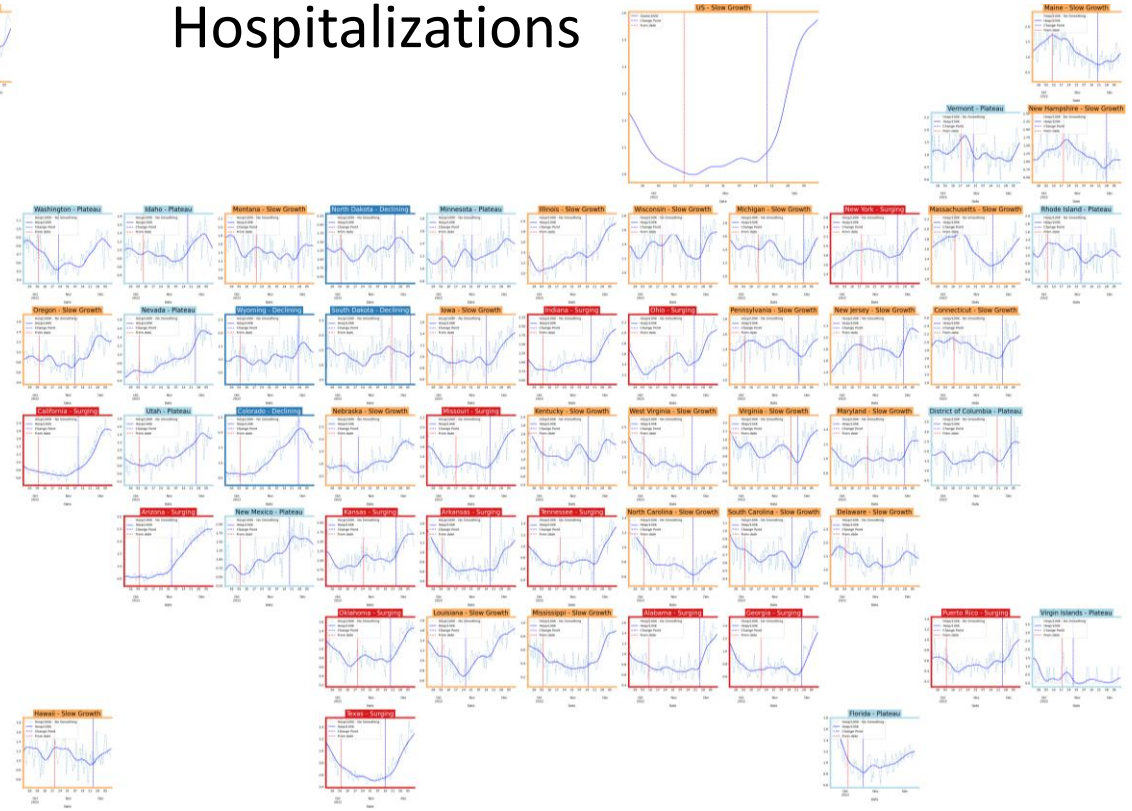
https://www.cdc.gov/mmwr/volumes/71/wr/mm7148e2.htm?s_cid=mm7148e2_w

United States Cases & Hospitalizations

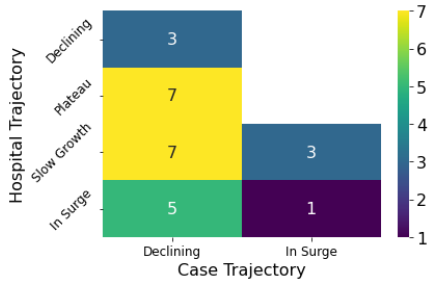
Cases



Hospitalizations



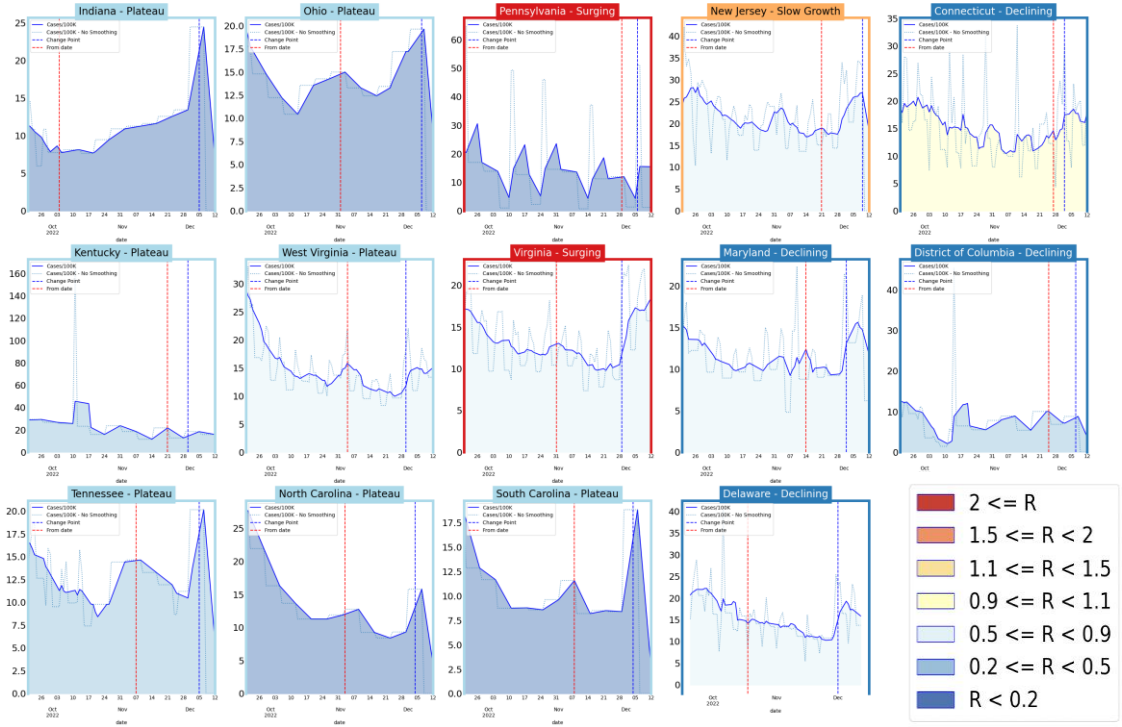
Status	Number of States	
	Current Week	Last Week
Declining	23	(25)
Plateau	23	(19)
Slow Growth	0	(3)
In Surge	4	(7)



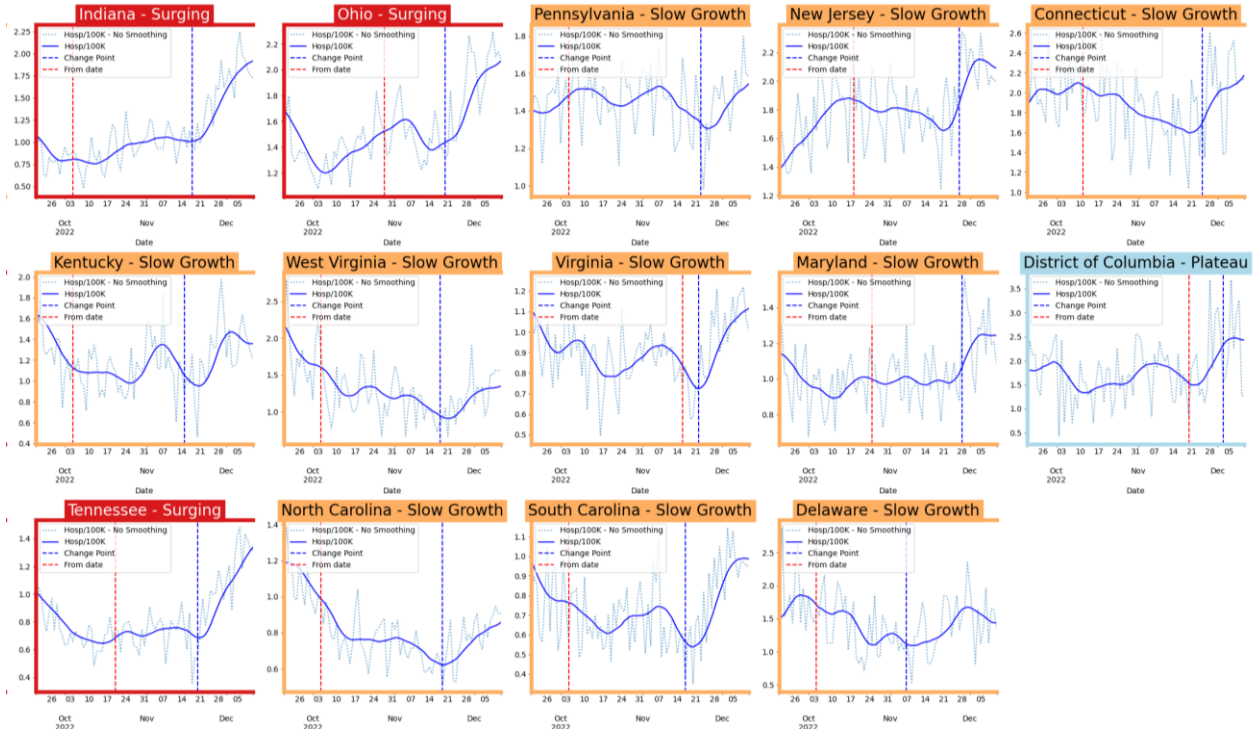
Status	Number of States	
	Current Week	Last Week
Declining	1	(5)
Plateau	11	(29)
Slow Growth	22	(15)
In Surge	19	(4)

Virginia and Her Neighbors

Cases

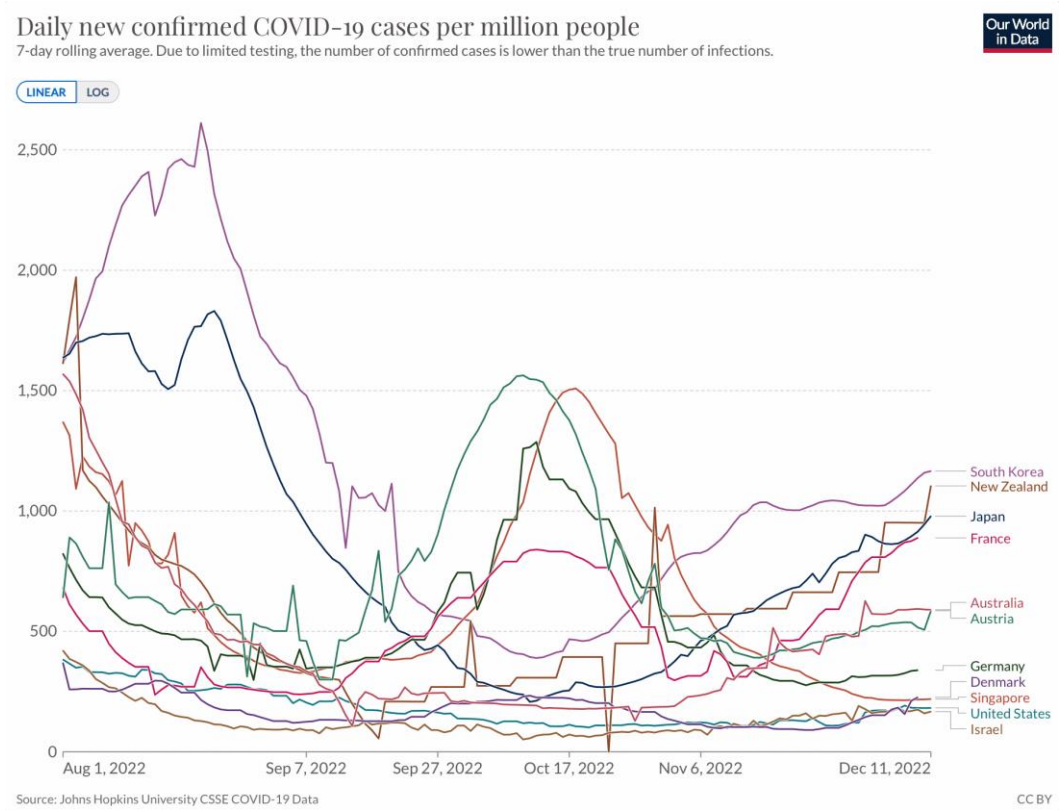


Hospitalizations

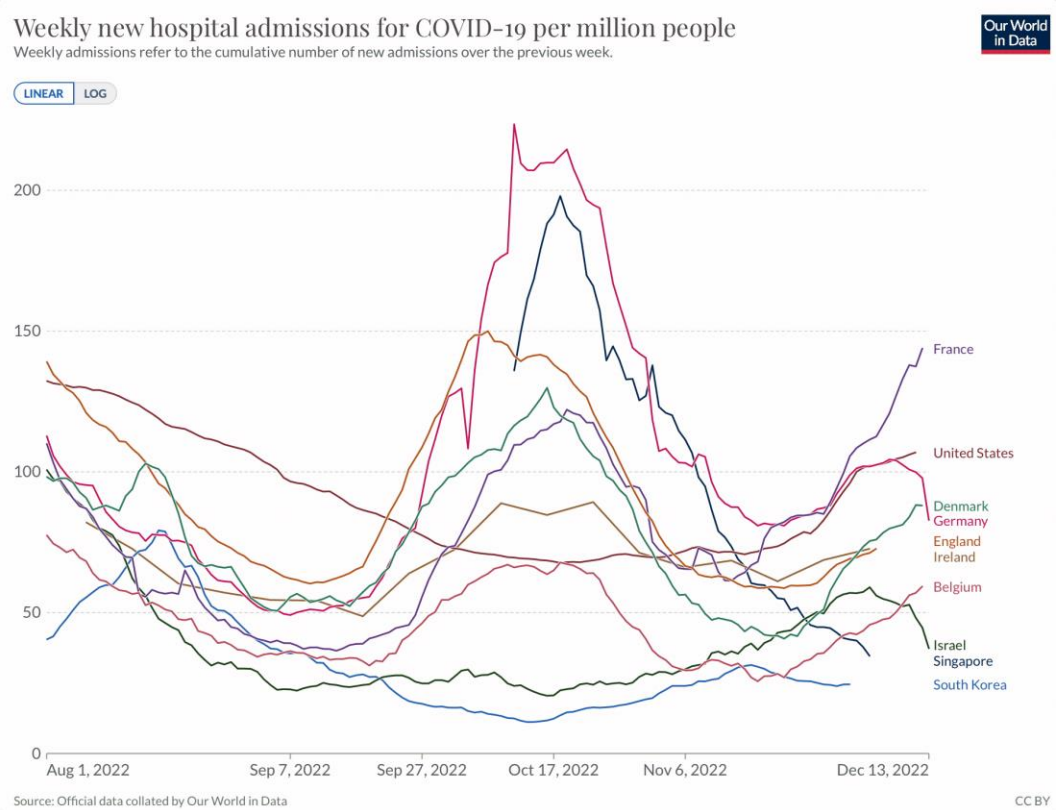


Around the World – Various trajectories

Confirmed cases



Hospitalizations



Our World in Data [Our World in Data]

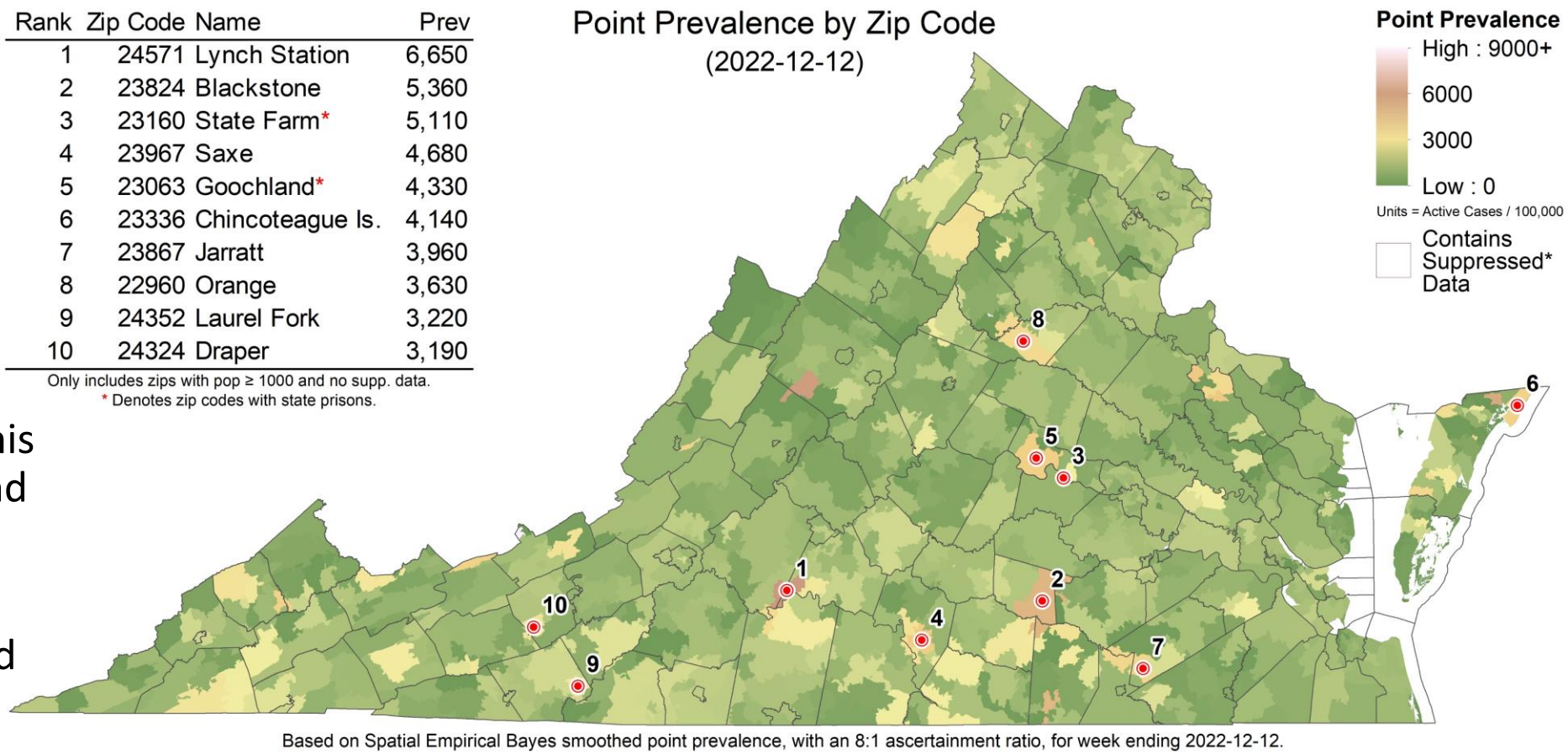
Zip code level weekly Case Rate (per 100K)

Case Rates in the last week by zip code

- Statewide case rates are growing slowly. Map now shows more yellows and even some oranges and reds.
- Chincoteague Island is still in the top five, and reports even higher rates than on Nov 29.
- Two prisons appear in this week's top 10. Goochland appeared in the Nov 29 report also.
- Some counts are low and suppressed to protect anonymity. They are shown with a red outline.

Rank	Zip Code	Name	Prev
1	24571	Lynch Station	6,650
2	23824	Blackstone	5,360
3	23160	State Farm*	5,110
4	23967	Saxe	4,680
5	23063	Goochland*	4,330
6	23336	Chincoteague Is.	4,140
7	23867	Jarratt	3,960
8	22960	Orange	3,630
9	24352	Laurel Fork	3,220
10	24324	Draper	3,190

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 2022-12-12.

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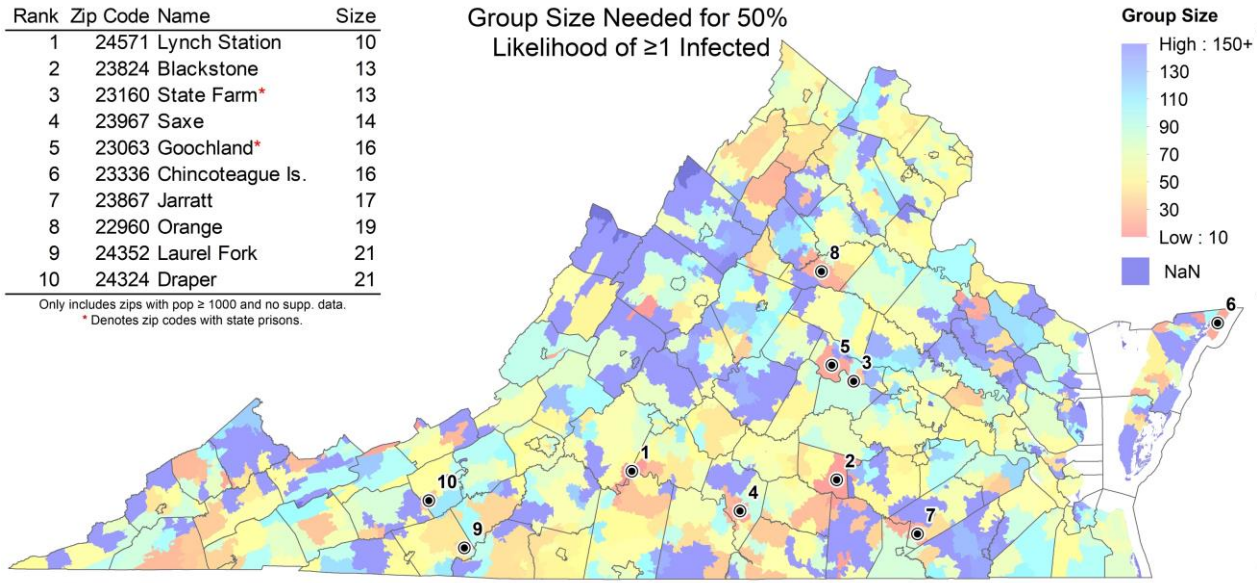
Risk of Exposure by Group Size and HCW prevalence

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 of 10 in Lynch Station, 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 numerator / population's case prevalence. Note areas south of Roanoke/Lynchburg + Bath.

Rank	Zip Code	Name	Size
1	24571	Lynch Station	10
2	23824	Blackstone	13
3	23160	State Farm*	13
4	23967	Saxe	14
5	23063	Goochland*	16
6	23336	Chincoteague Is.	16
7	23867	Jarratt	17
8	22960	Orange	19
9	24352	Laurel Fork	21
10	24324	Draper	21

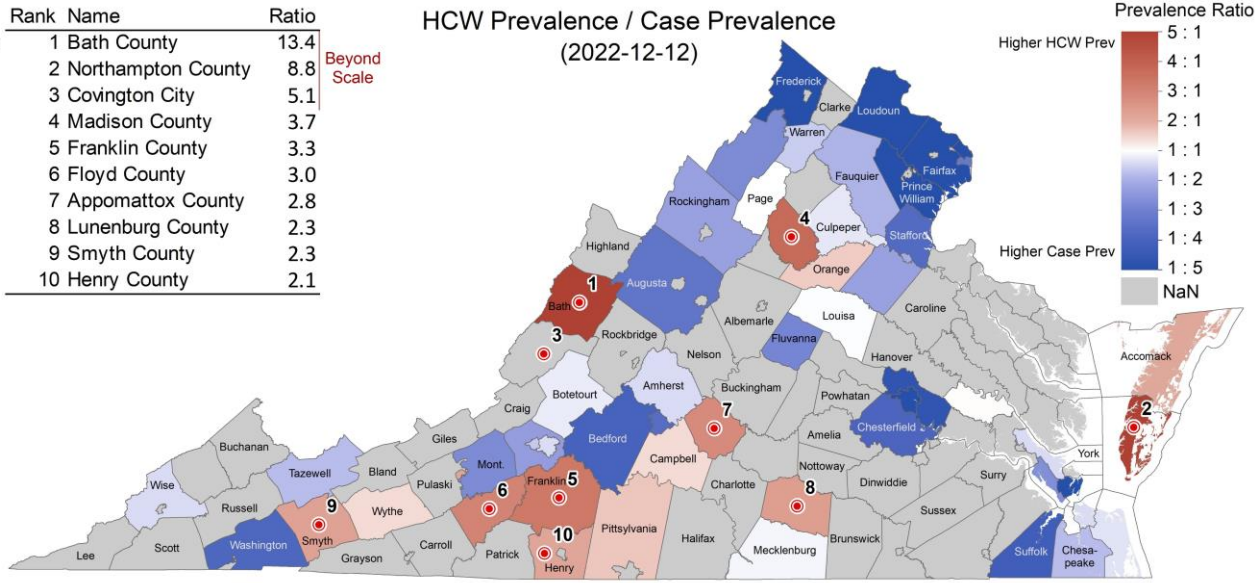
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence, with an 8:1 ascertainment ratio, for week ending 2022-12-12.

Rank	Name	Ratio
1	Bath County	13.4
2	Northampton County	8.8
3	Covington City	5.1
4	Madison County	3.7
5	Franklin County	3.3
6	Floyd County	3.0
7	Appomattox County	2.8
8	Lunenburg County	2.3
9	Smyth County	2.3
10	Henry County	2.1

Beyond Scale



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

Current Hot-Spots

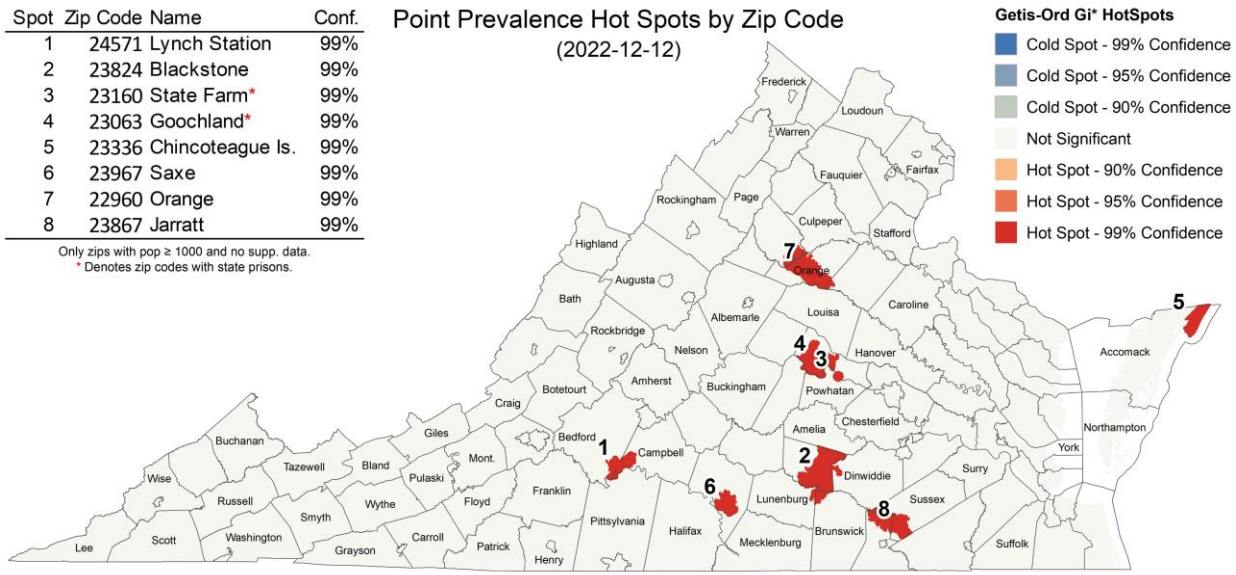
Case rates that are significantly different from neighboring areas or model projections

- **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.
- Spatial hotspots remain sporadic. Temporal hotspots are primarily found in Southwest VA, plus Crater and Rapp./Rapidan, which all saw more cases than models expected. Richmond saw fewer cases than expected.

Spatial Hotspots

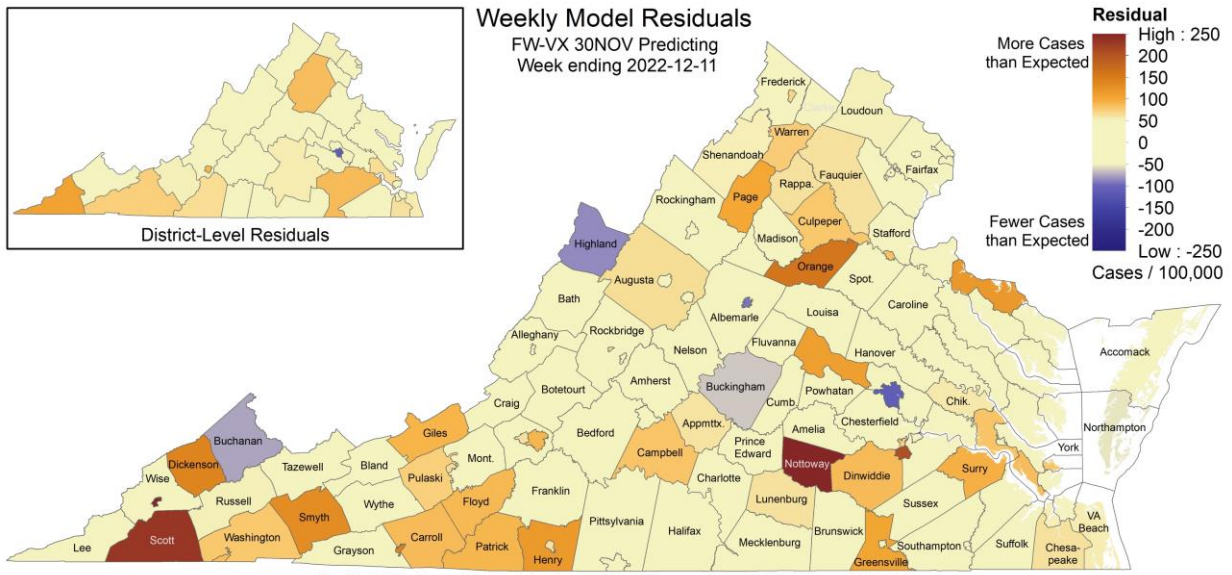
Spot	Zip Code	Name	Conf.
1	24571	Lynch Station	99%
2	23824	Blackstone	99%
3	23160	State Farm*	99%
4	23063	Goochland*	99%
5	23336	Chincoteague Is.	99%
6	23967	Saxe	99%
7	22960	Orange	99%
8	23867	Jarratt	99%

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



Based on Global Empirical Bayes smoothed point prevalence for week ending 2022-12-12.

Clustered Temporal Hotspots



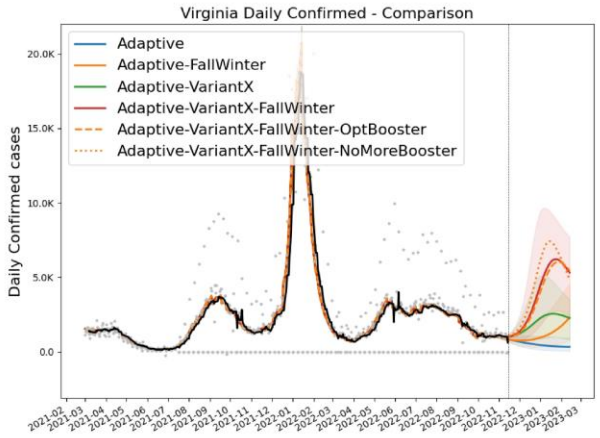
Health District Level Moran's I = 0.070789, Z-Score = 1.78305, P-Value = 0.074578
No Residual Autocorrelation Detected

Scenario Trajectory Tracking

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

Four Weeks Ago

Two Weeks Ago



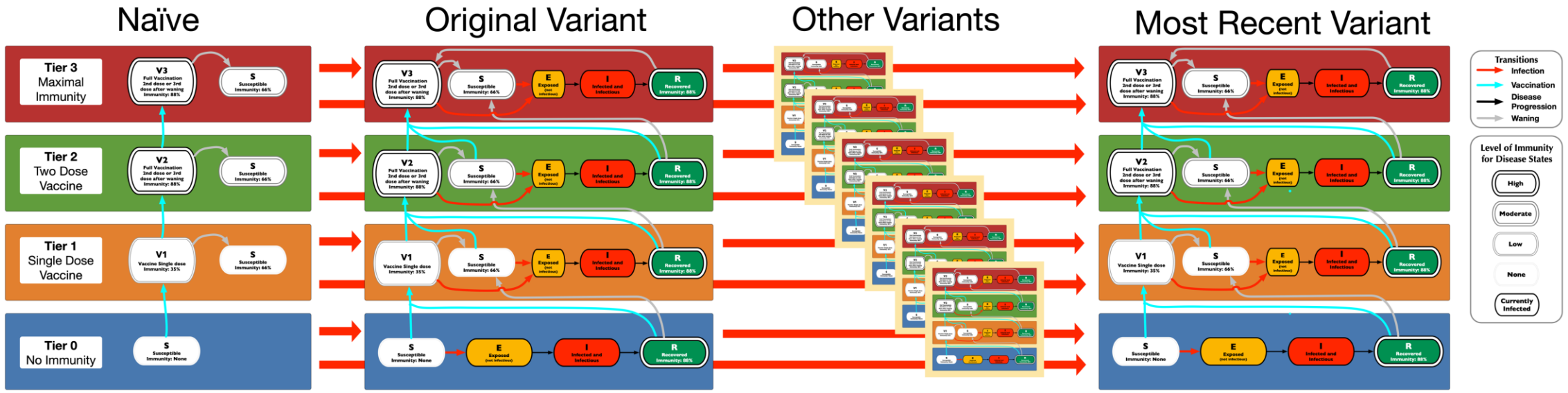
- One-month projections separate the scenarios more clearly and reveals larger overall patterns.
- For the past month Adaptive had been gaining counties and outperforming other scenarios. This week the trend reversed. VariantX-FallWinter was the most accurate statewide as well as in 60 counties.

Model Update – Adaptive Fitting

Model Structure Extended for more sub-variants

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

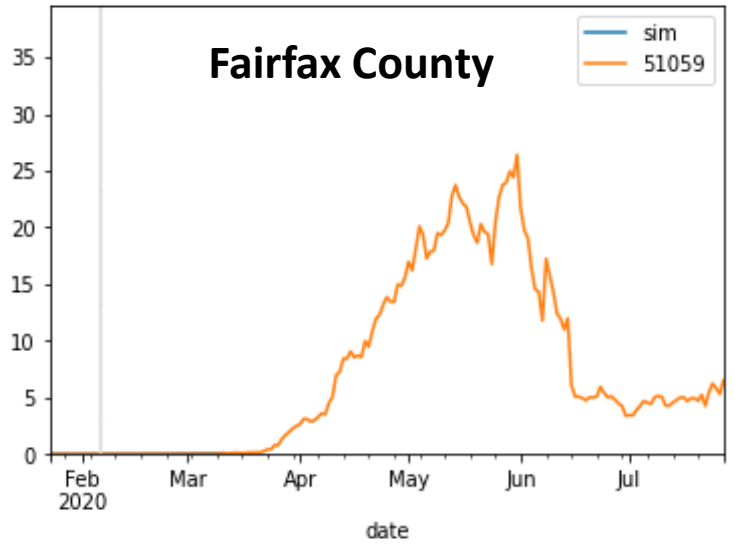
- Multiple strain support allows representation of differential protection based on immunological history (BA.1, BA.2, BA.2.12.1, BA.4/5, and future variants (VariantX))
- Each sub-variant has differing levels of immune escape to previous sub-variants, the prevalences are based on observations for fitting 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

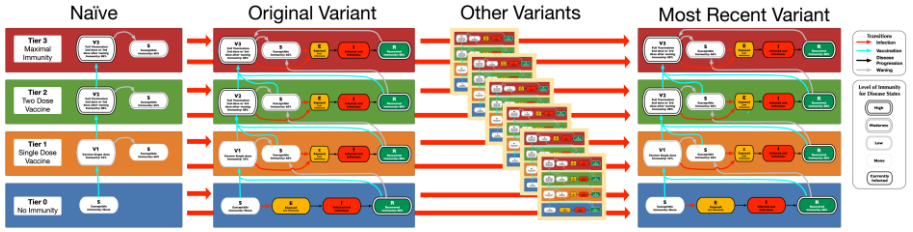
Each county fit precisely, with recent trends used for future projection

- 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

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

Dashboard Updated: 12/14/2022
Data entered by 5:00 PM the prior day.

VDH VIRGINIA DEPARTMENT OF HEALTH

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospital Admissions**	Total Deaths
2,171,414	57,971	22,568
(New Cases: 2,296)^		

Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
1,529,714	641,700	54,382	3,589	18,711	3,857

* 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 September 1st, 2021. Found here: https://ndc.services.cdc.gov/case-definitions/coronavirus-disease-2019-2021/
Source: Cases - Virginia Electronic Disease Surveillance System (VEDSS), data entered by 5:00 PM the prior day.

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
10,351	170,303

* 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**
15,584,461	13.4%

* 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
180	1

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

Accessed 9:30am December 14, 2022
https://www.vdh.virginia.gov/coronavirus/

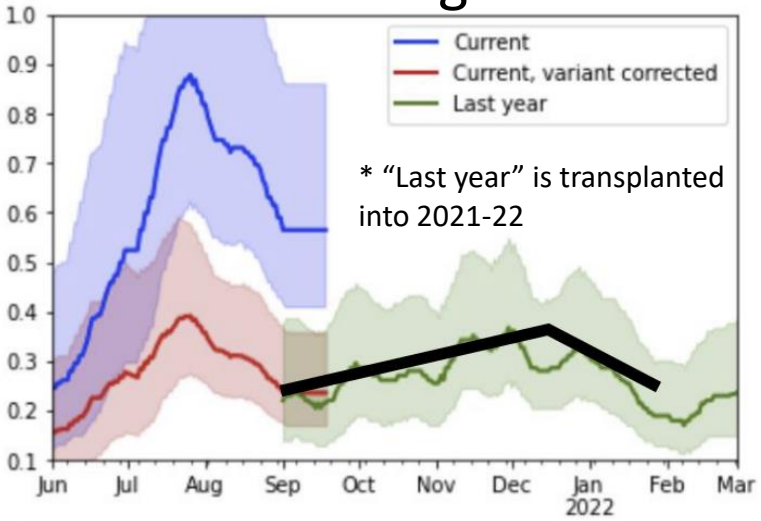
Scenarios – Transmission Conditions

- 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

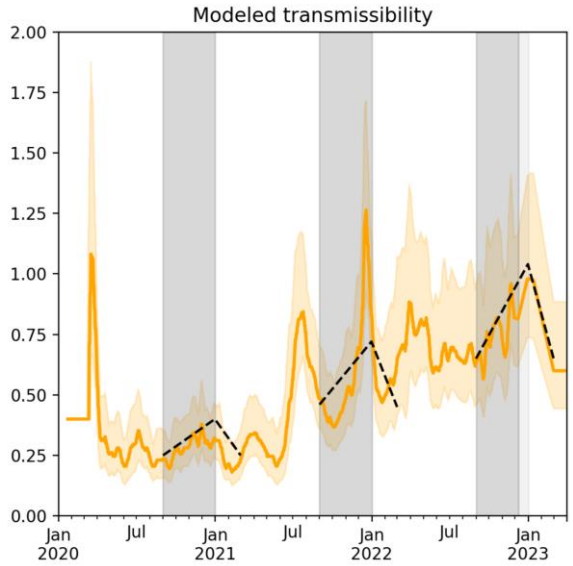
- Based on analyses of the past 2 seasons we generate a “coarse baseline transmission boost”
  - In 2021 the distribution of fitted model transmissibility was nearly identical between these periods when corrected for Delta’s increased transmissibility
- **FallWinter** captures these “transmission drivers”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



Fitting: Black line represents the coarsely fitted base transmissibility

2022 FallWinter has kept pace with observed relative increases:

- 2022’s relative increase in transmission has been roughly the same this year as previous years
- Overall, the transmission rates are higher this year but the increased immunity has kept cases relatively stable



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Scenarios – Optimistic vs. Pessimistic Booster Coverage

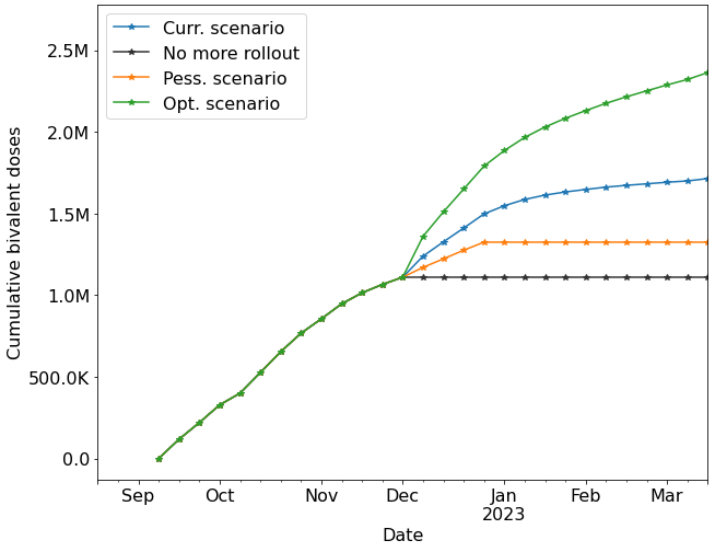
Reformulated Boosters available now

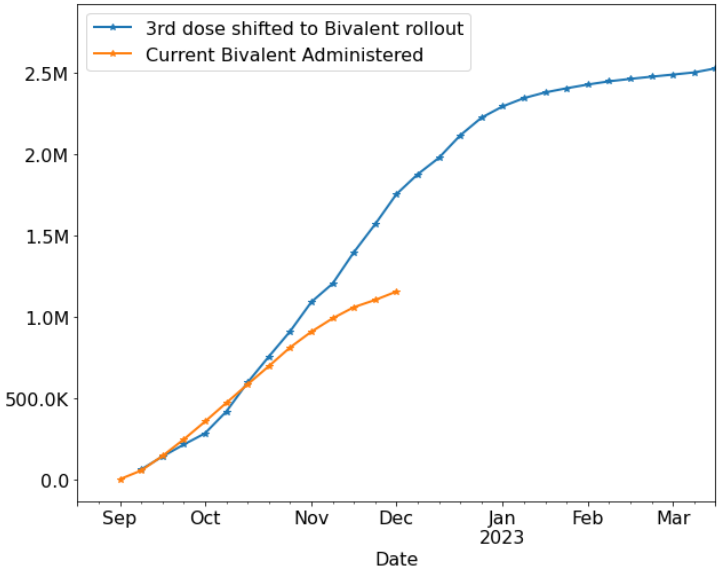
- Assume vax efficacy for BA.4/5 and previous variants is 80% against symptomatic illness
- Campaign follows current ground truth to present
- Variant X has same immune escape to these vaccines as against BA.5 (33%)

Current pace: Follows 3rd dose rollout, but maintains current pace relative to it (eg if slower, same slower rate continues into future)

Optimistic pace: 25% higher than previous 3rd dose schedule

No More: No further Bivalent boosters administered



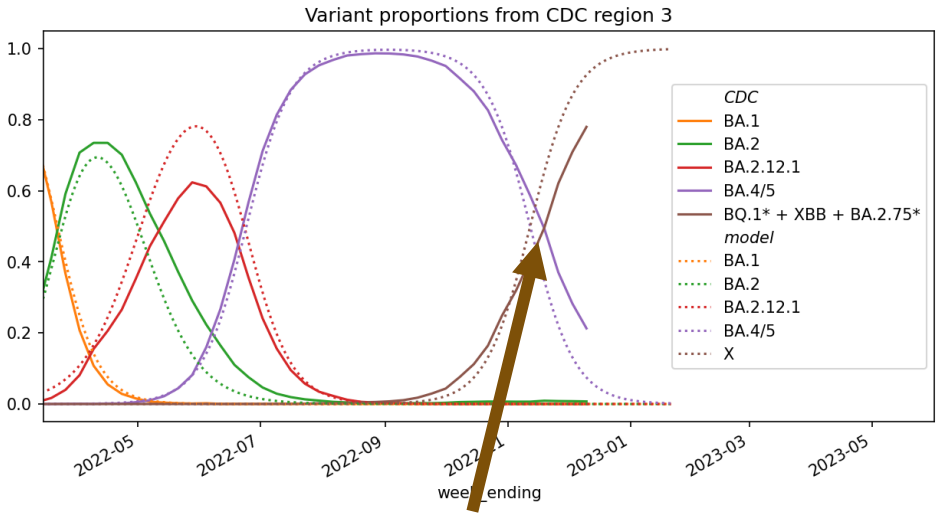


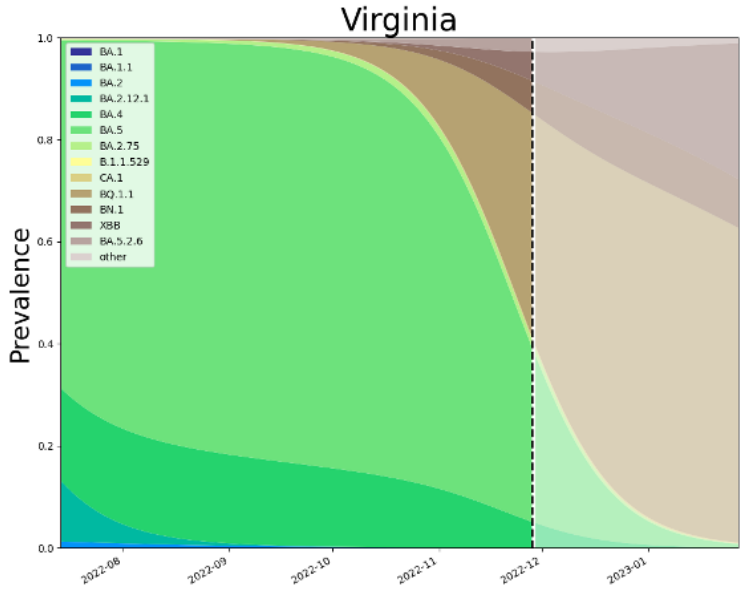
Scenarios – Variant X

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

- An increasingly complex soup of variants with demonstrated growth advantages in other countries and states continues to grow
- BQ.1.1, XBB, and 2.75.* (including BN.1) have shown evidence of significant immune escape, BQ.1.1 currently dominating in US and VA, while others continue to grow slowly
- **VariantX** represents the next variant or the potential swarm of several. We assume similar growth and level of immune escape against previous sub-variants as BA.4/5 (same transmissibility and 30% immune escape against BA.4/5, higher for other sub-variants).

Sub-Variants with Fitted Prevalences and Hypothetical Future waves





Variant X reached 50% on Nov 12th

Projection Scenarios – Combined Conditions

Name	Txm	Variant	Booster	Description
Adaptive	C	SQ	Current	Likely trajectory based on conditions remaining similar to the current experience, includes immune escape due to Omicron
Adaptive-FallWinter	FallWinter	SQ	Current	Like Adaptive, with seasonal forcing of FallWinter added on
Adaptive-VariantX	C	X	Current	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	Current	Like Adaptive-VariantX but with the seasonal force of FallWinter added on
Adaptive-VariantX-FallWinter-OptBooster	FallWinter	X	Optimistic	Like Adaptive-VariantX-Fall Winter but with Optimistic Booster (25% more than 3rd dose rollout)
Adaptive-VariantX-FallWinter-NoMoreBooster	FallWinter	X	No More	Like Adaptive-VariantX-FallWinter but with no additional Booster doses

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 prevalences remain the same (e.g. no significant major driving of transmission anticipated)
X = Novel sub-variant scenario, new variant emerges reaches dominance in near term, 30% immune escape

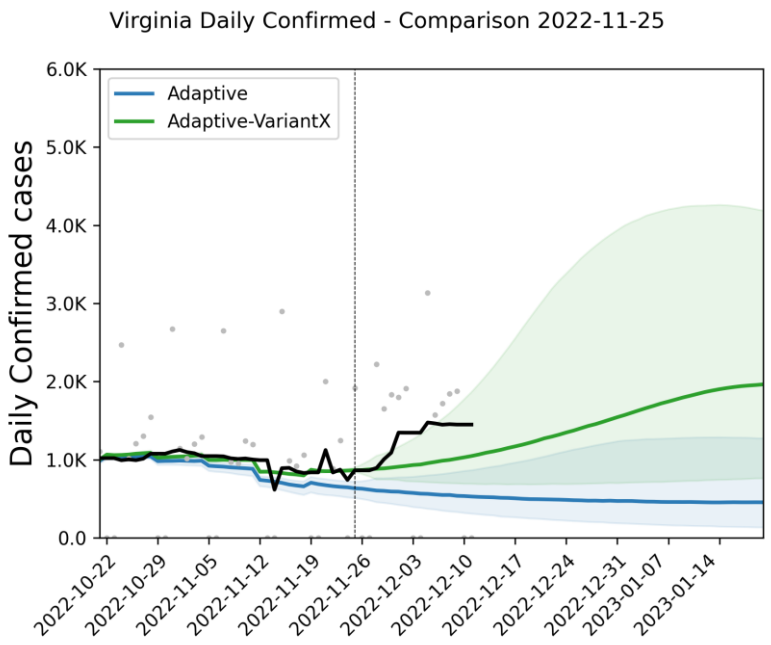
Booster: Current = Current pace relative to 3rd dose rollout is maintained in the future
Optimistic = Starting this week, additional 25% over the 3rd dose rollout is maintained into the future
No More = Starting this week, no additional doses of the booster are administered

Model Results

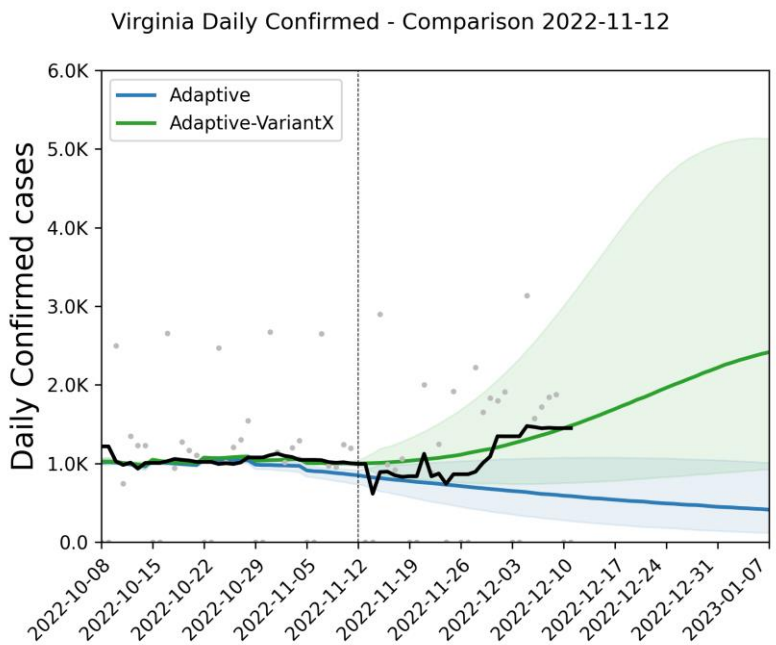
Previous projections comparison - Cases

- Previous projections continue to track observed cases
- Slight decrease 2 weeks ago suppressed growth thus model underpredicted cases
- Flat cases 4 weeks ago allowed Variant X scenario to track observed growth
- July-based long-term projection remains eerily prescient

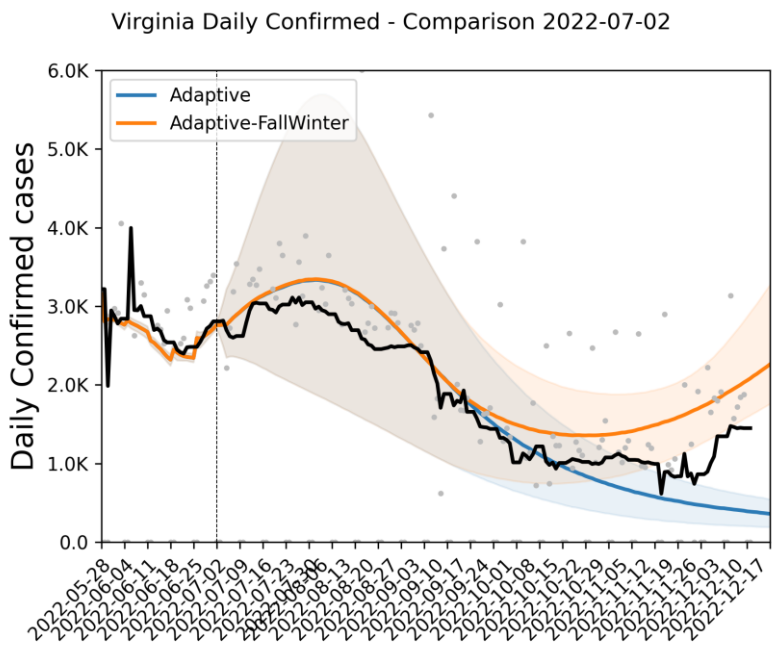
Previous round (2 weeks ago)



Projection from 4 weeks ago



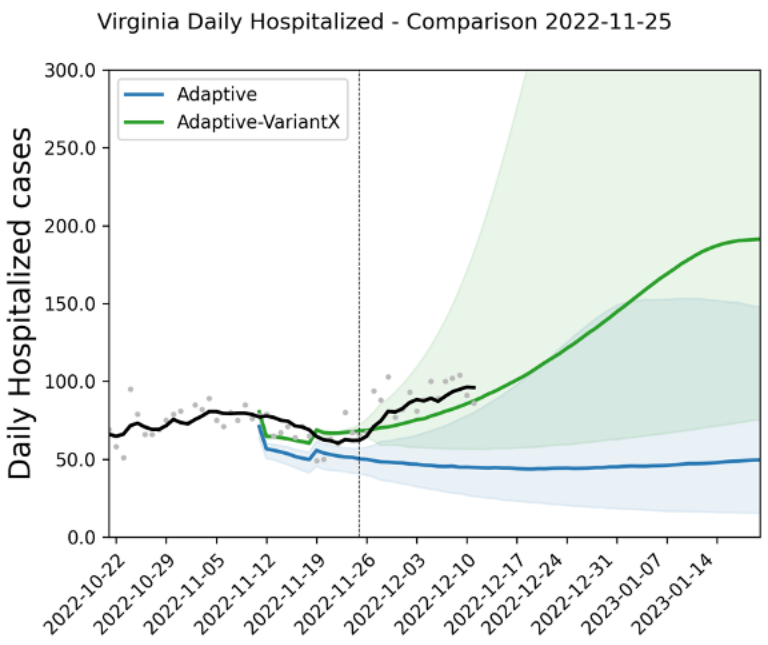
Projection from 5 months ago



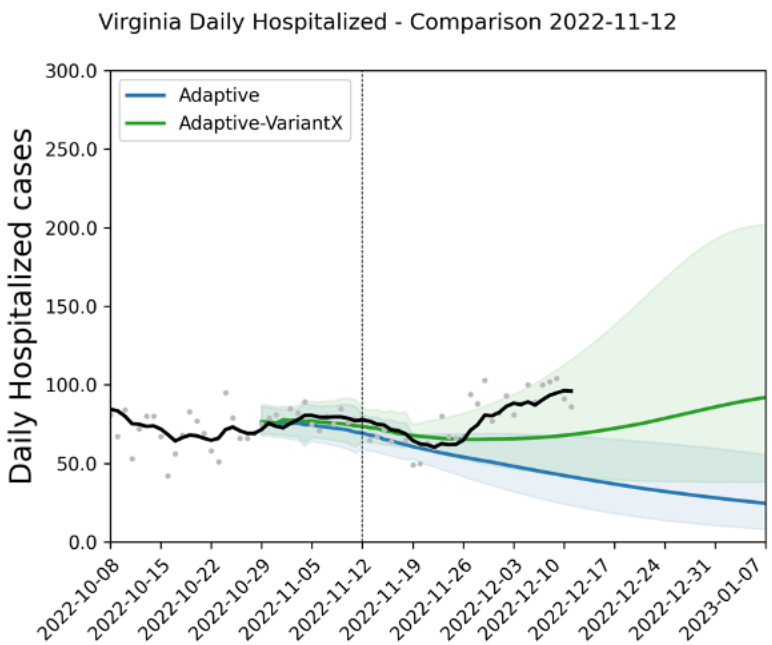
Previous projections comparison - Hospitalizations

- Previous projections have tracked observed hospitalizations well
- Projection from 2 weeks ago had enough growth in hospitalizations to track well
- Projection from 4 weeks ago had declines which delayed the growth
- Projection from early July anticipated a Fall-Winter rise that has tracked well

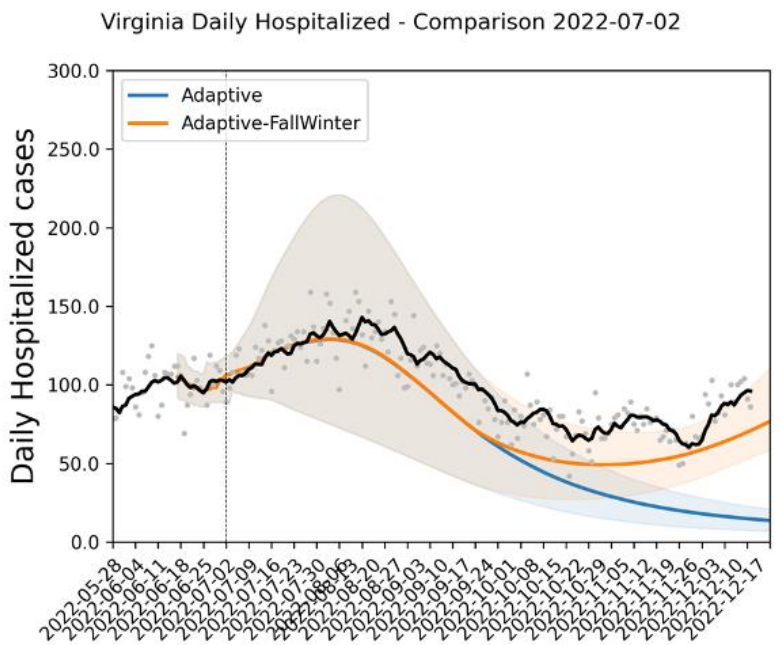
Previous round (2 weeks ago)



Projection from 4 weeks ago

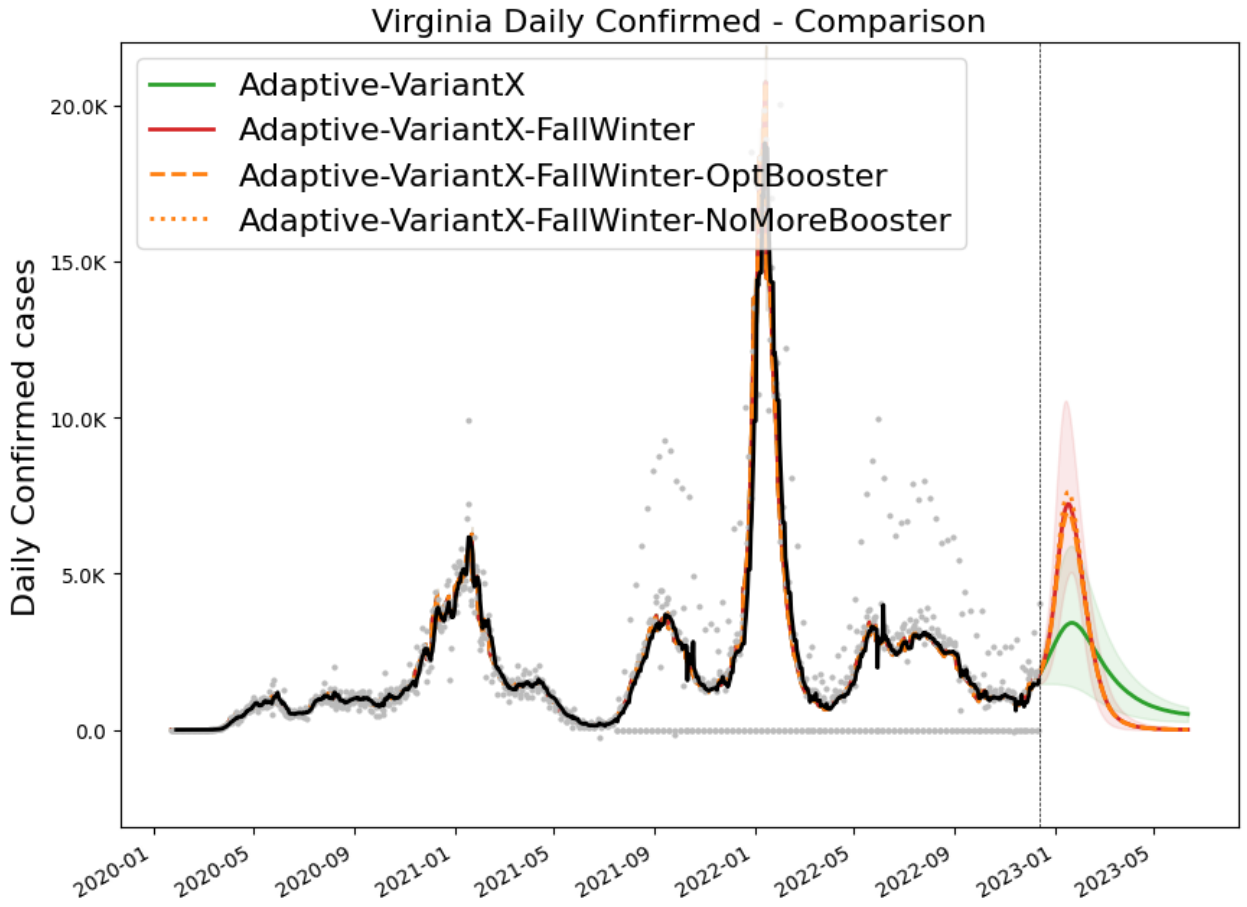


Projection from 5 months ago



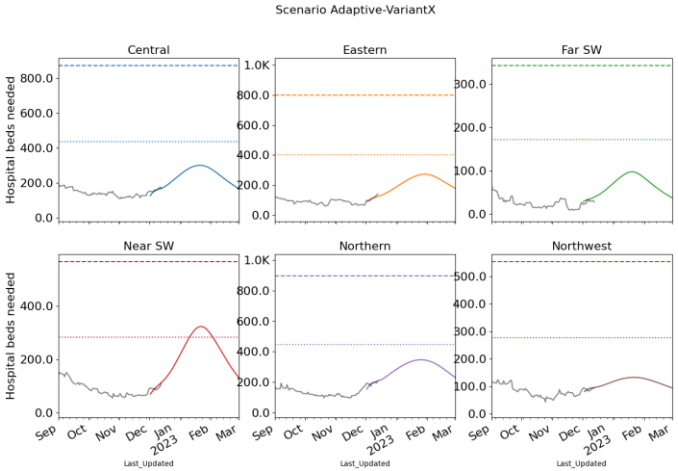
Outcome Projections

Confirmed cases

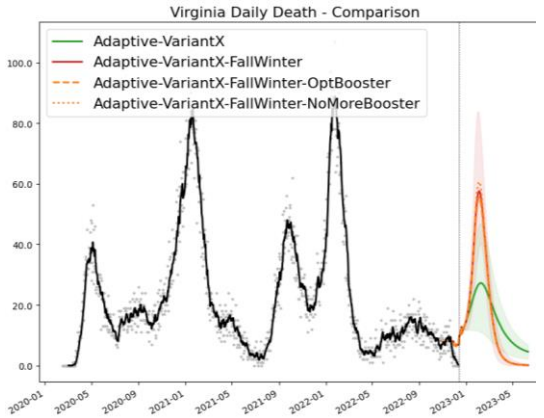


* without surveillance correction VariantBA2 peaked over 10K in July

Estimated Hospital Occupancy

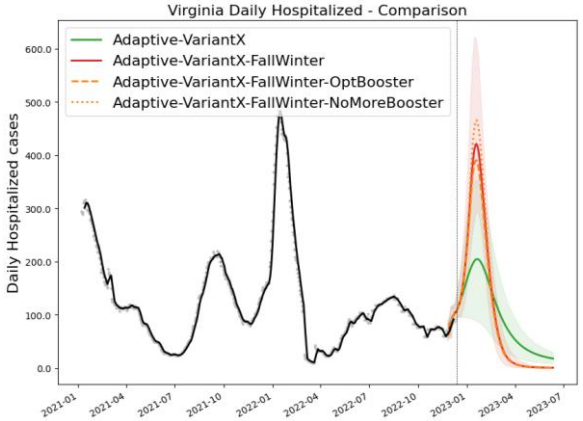


Daily Deaths



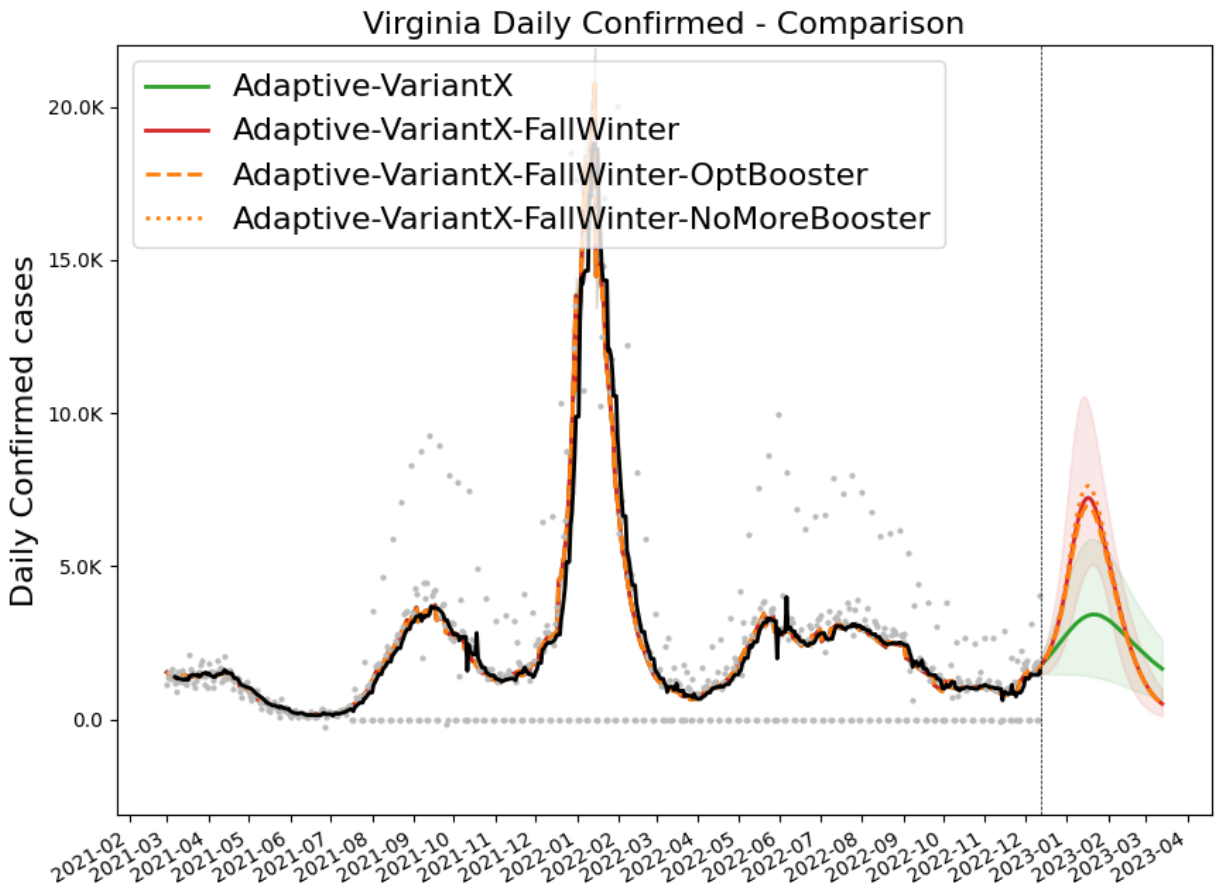
Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized



Outcome Projections – Closer Look

Confirmed cases



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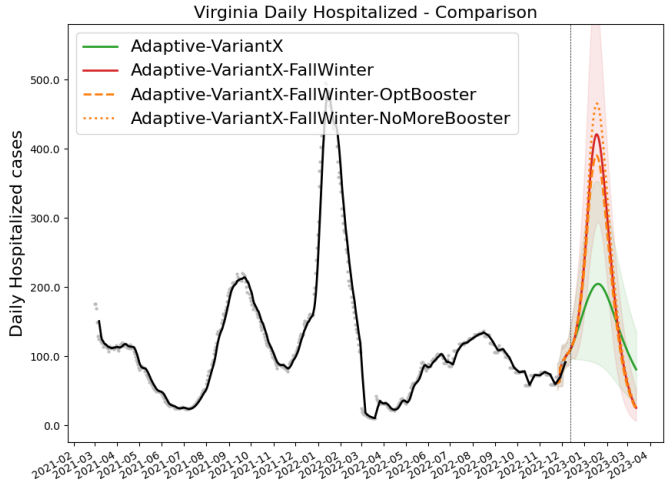
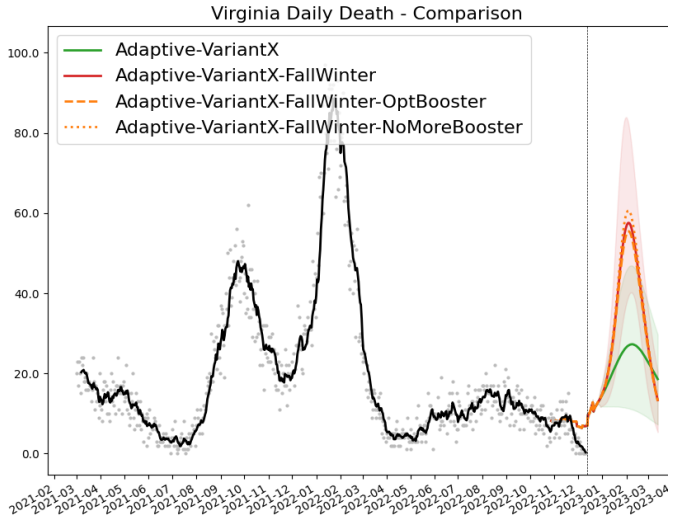
Daily Hospitalized



Daily Deaths



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

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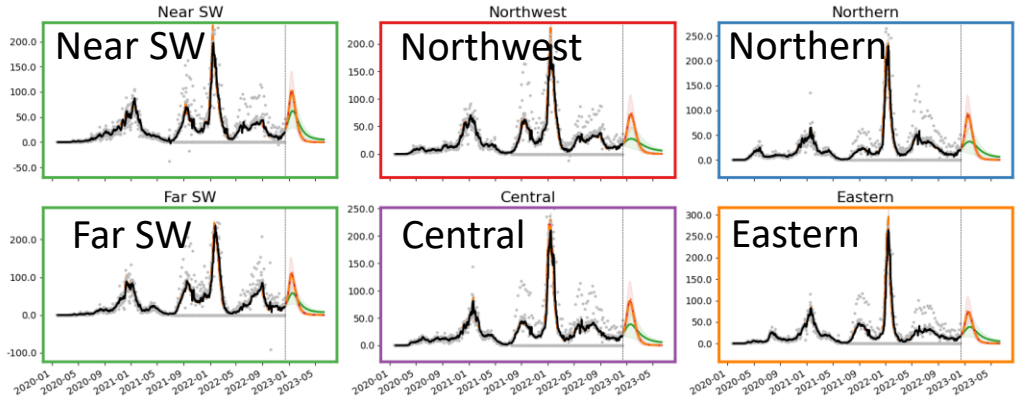
Detailed Projections: Cases for All Scenarios

Projections by Region

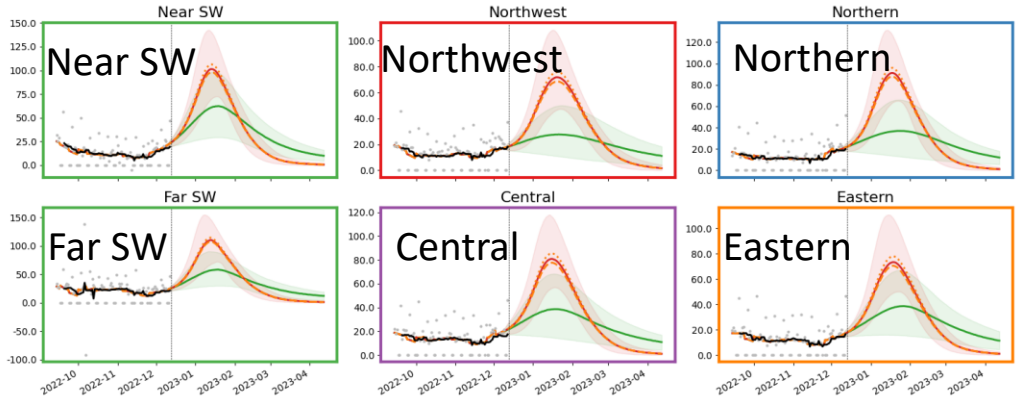


Projections by District

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

Detailed Projections: Cases for All Scenarios - Closer Look

Projections by Region

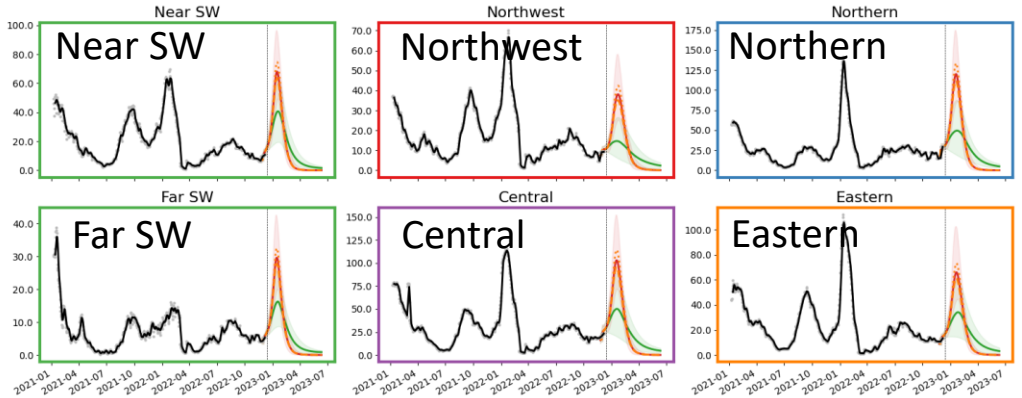


Projections by District

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

Detailed Projections: Hospitalizations for All Scenarios

Projections by Region

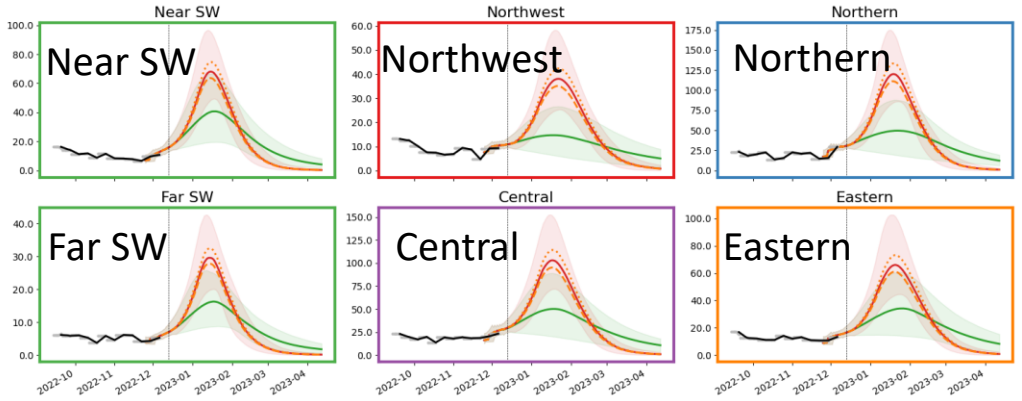


Projections by District

Daily confirmed hospitalizations District (grey with 7-day average in black) with simulation colored by scenario

Detailed Projections: Hosps for All Scenarios - Closer Look

Projections by Region



Projections by District

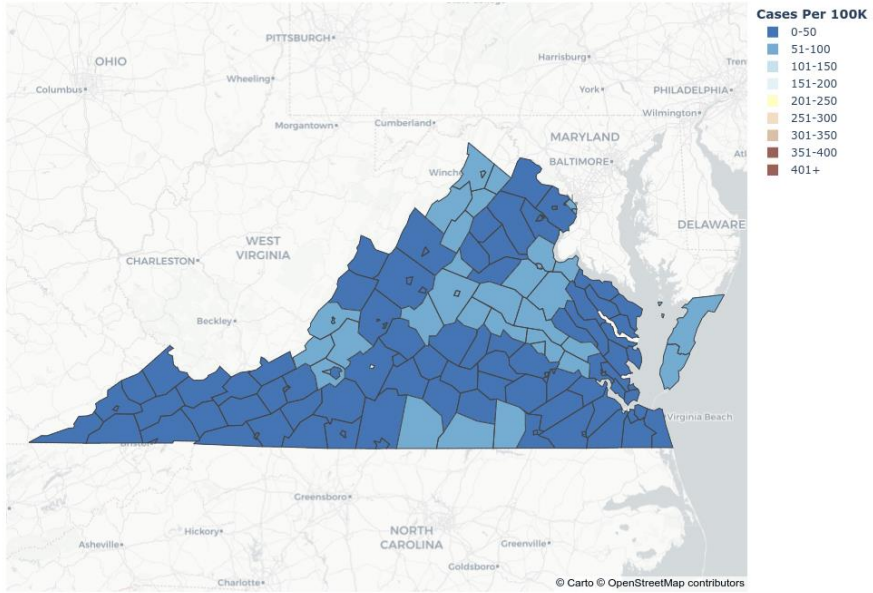
Daily confirmed hospitalizations District (grey with 7-day average in black) with simulation colored by scenario

Adaptive

Adaptive-Fall-Winter

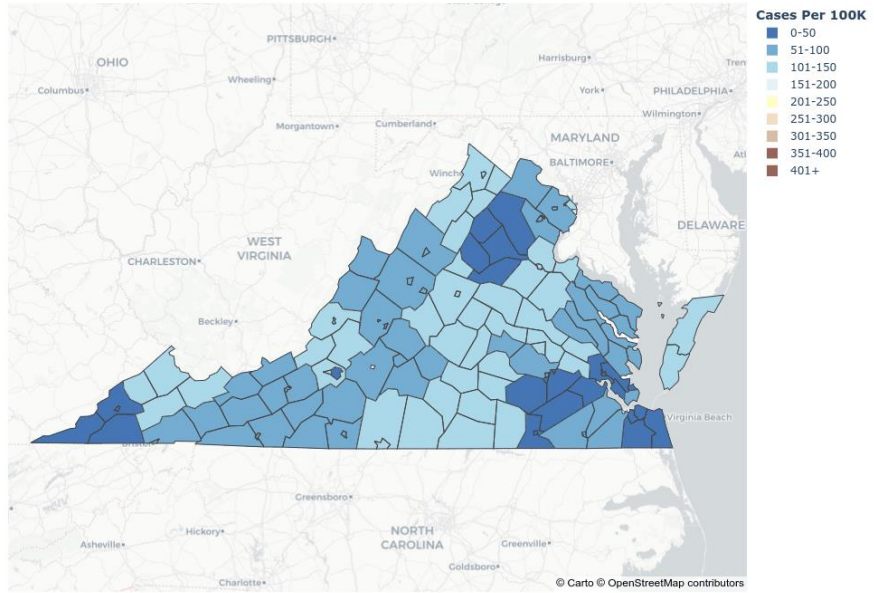
Adaptive

Weekly Projections (Adaptive) 07-Dec-2022

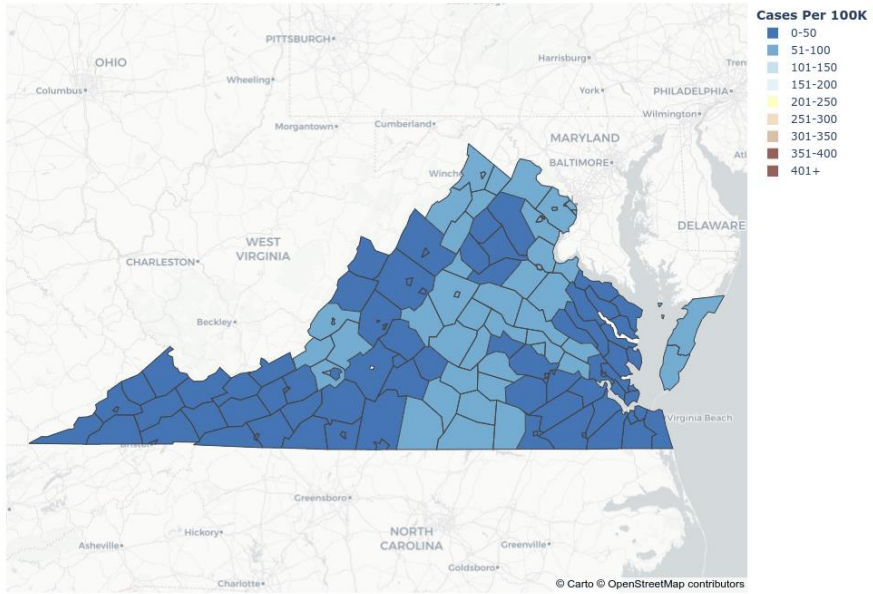


VariantX

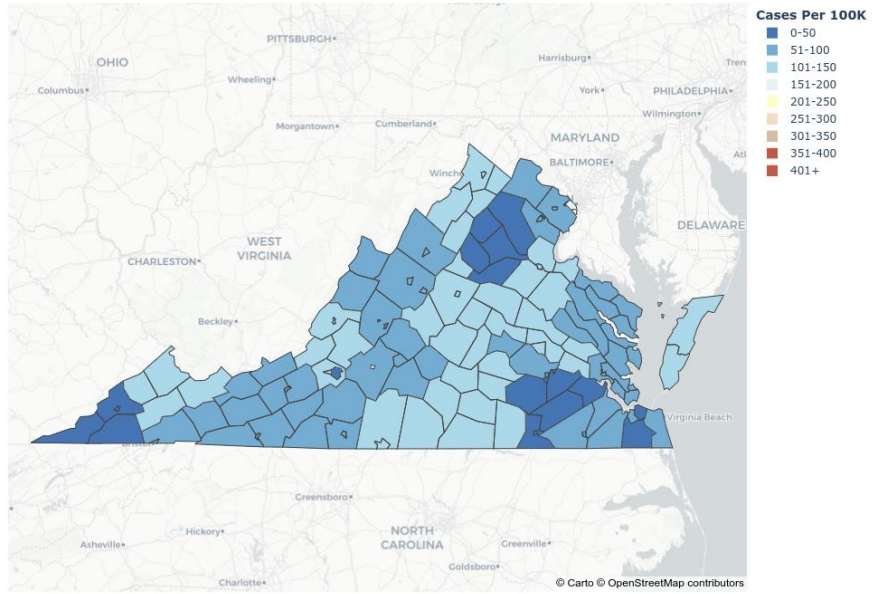
Weekly Projections (Adaptive-VariantX) 07-Dec-2022



Weekly Projections (Adaptive-FallWinter) 07-Dec-2022



Weekly Projections (Adaptive-VariantX-FallWinter) 07-Dec-2022

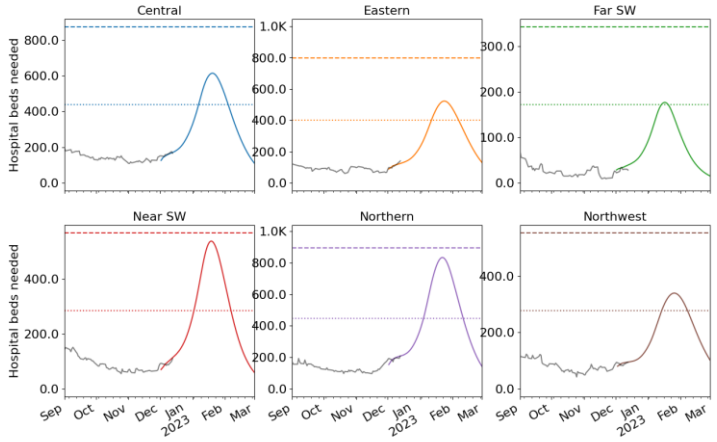


Hospital Demand and Bed Capacity by Region

Capacities by Region

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

Adaptive – VariantX & Fall Winter



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

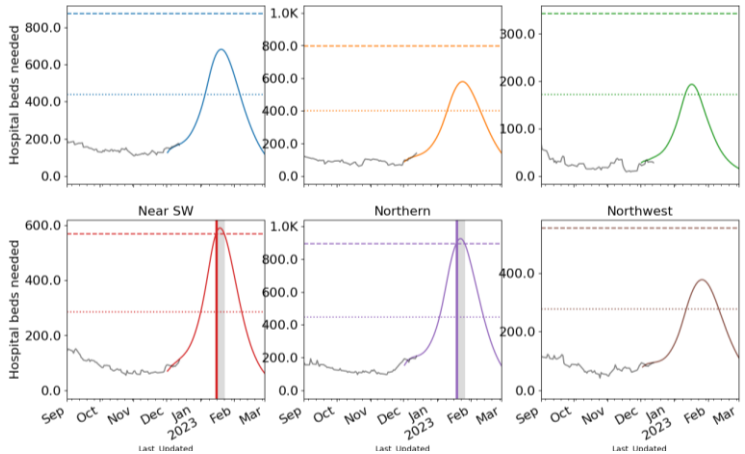
Length of Stay Estimates

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

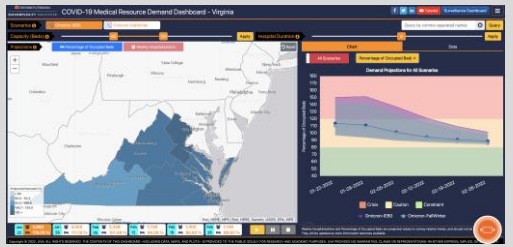
Estimated LOS shortened slightly to better fit observed data

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

Adaptive – VariantX & Fall Winter No More Booster



Interactive Dashboard with regional projections



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

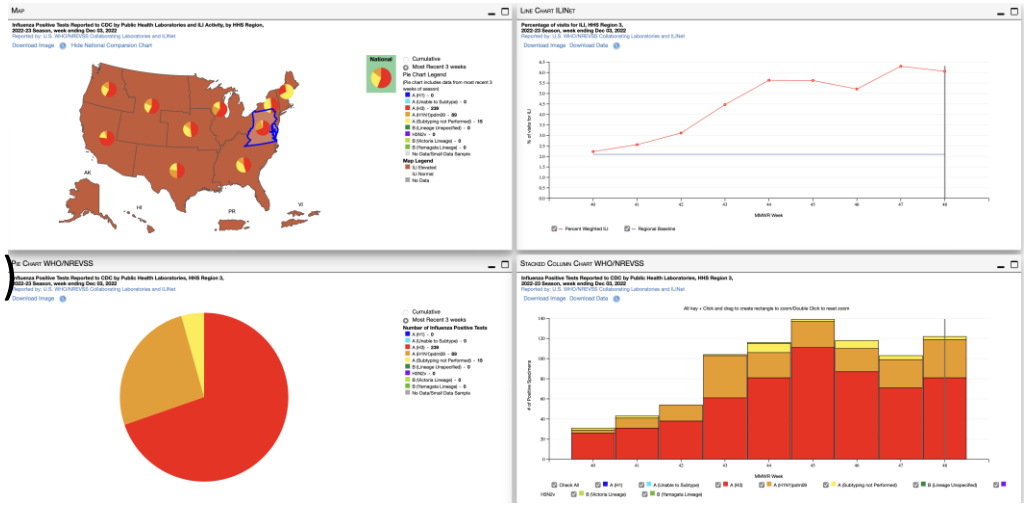
Influenza Update

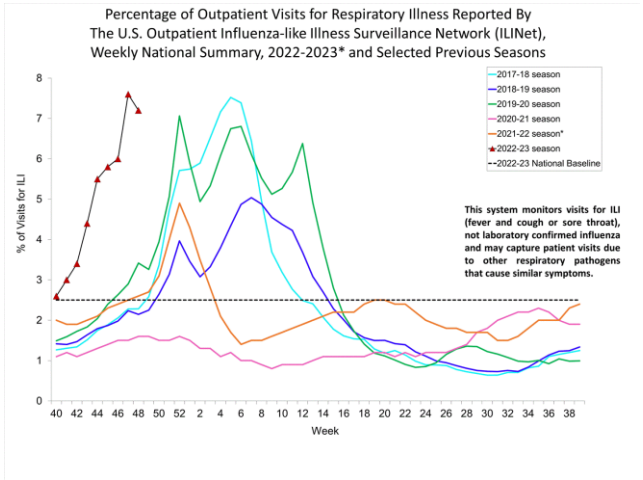
Current Influenza Situation – ILI Activity

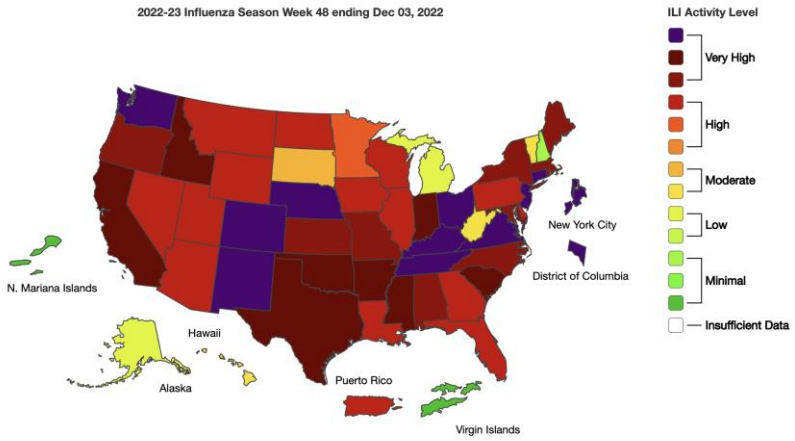
Influenza Activity is Higher than Usual

- Virginia at “Very High” activity along with many states across the US
- In VA ILI Activity remains at the 8-9% for several weeks
- National ILI activity has reached a peak rivaling the previously most intense season in the last decade (2017-18)
- After starting with high proportions of H3N2 typed influenza, H1N1pdm09 now represents ~1/4 of all infections nationally, though remain H3 dominates in VA

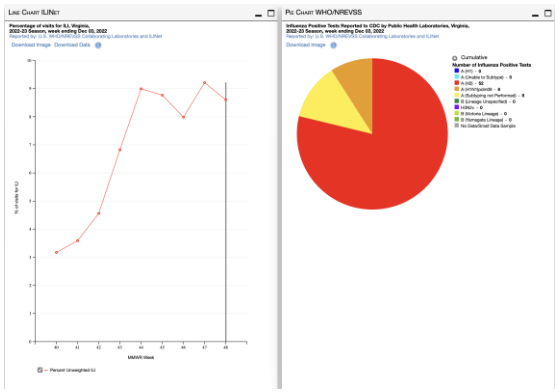
Region 3







Virginia



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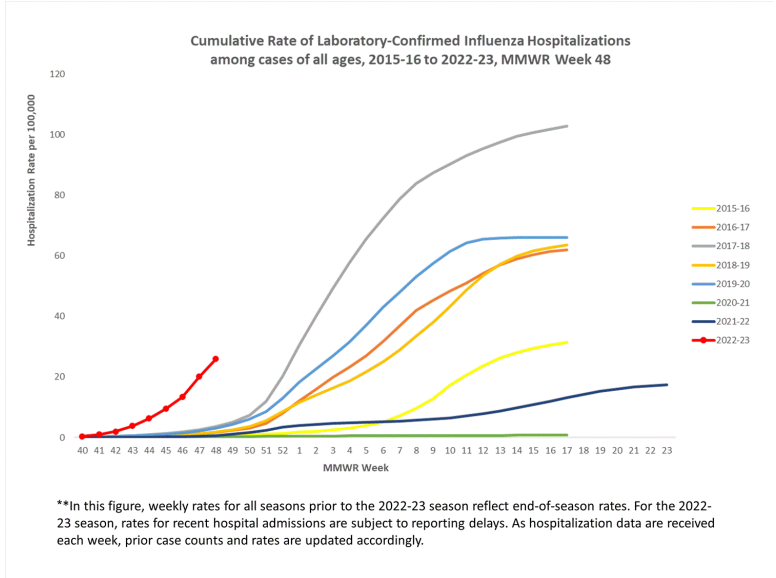
FLUVIEW
A Weekly Influenza Surveillance Report Prepared by the Influenza Division

Current Influenza Situation - Hospitalizations

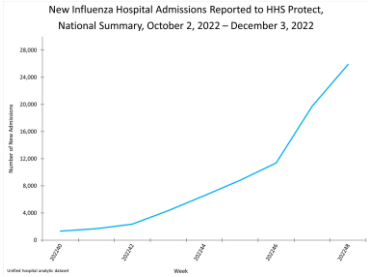
Influenza A hospitalizations continue rapid growth

- National level of influenza hospitalizations
- Nearly all states have doubled their hospitalizations due to influenza in the last couple weeks
- Virginia shows leveling off in the last weeks



**In this figure, weekly rates for all seasons prior to the 2022-23 season reflect end-of-season rates. For the 2022-23 season, rates for recent hospital admissions are subject to reporting delays. As hospitalization data are received each week, prior case counts and rates are updated accordingly.

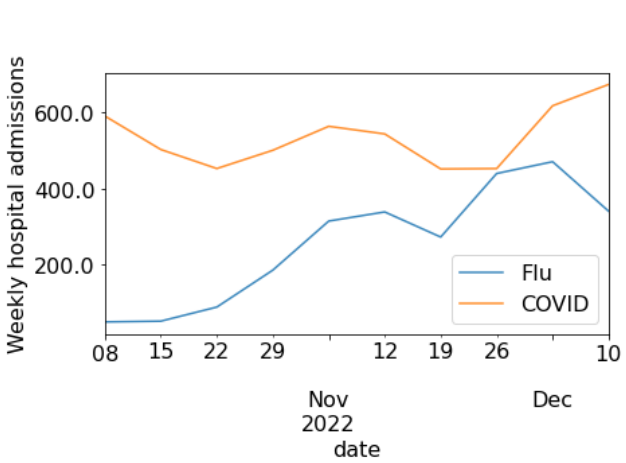
Influenza Hospital Admissions (HHS Protect)

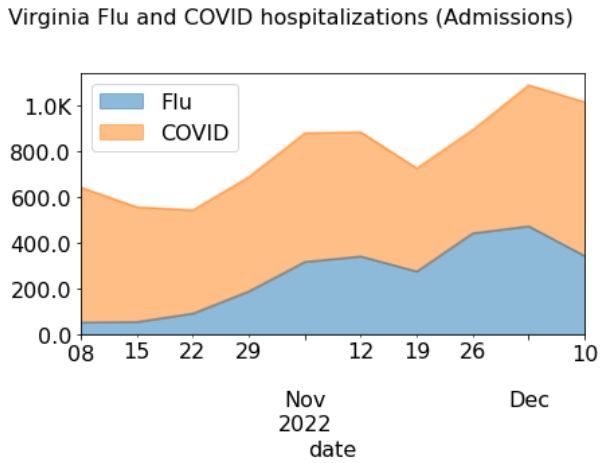


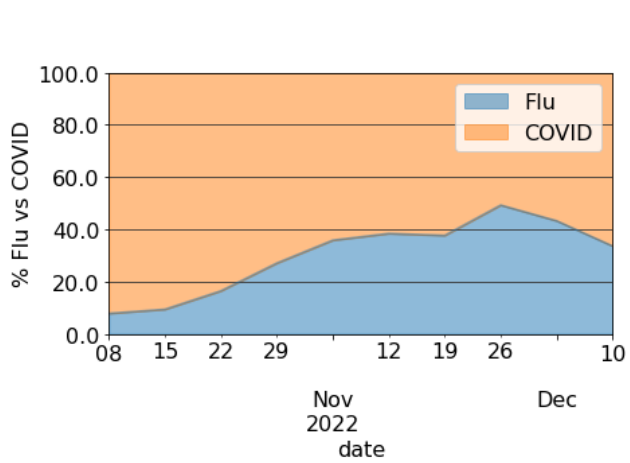
Current Combined Hospitalizations (COVID-19 & Influenza)

COVID-19 and Influenza Weekly Hospitalizations (HHS Protect)

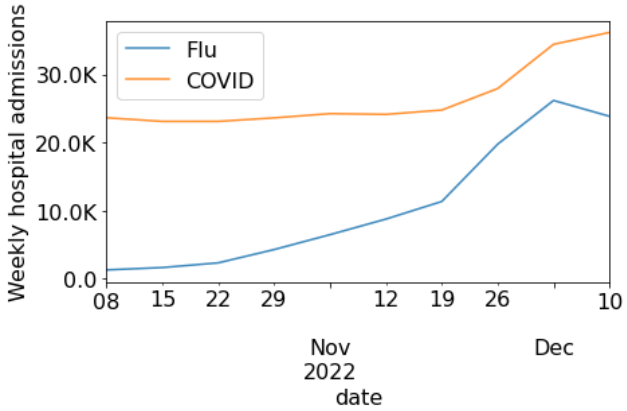
Virginia

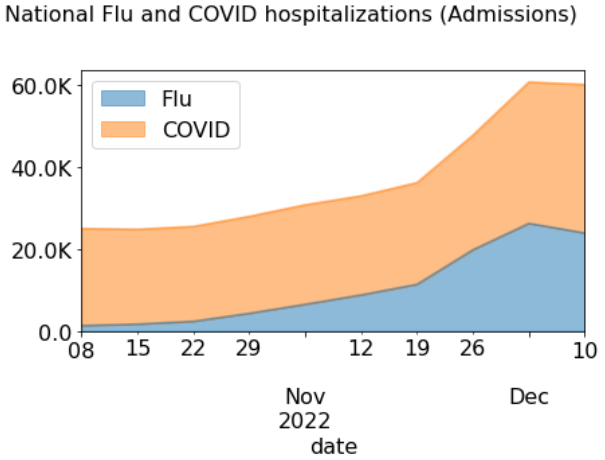


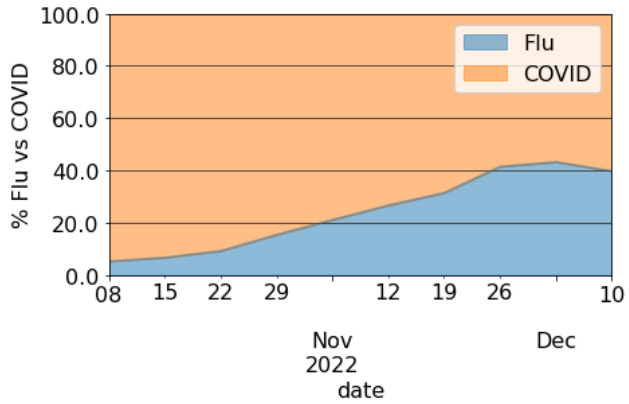




USA







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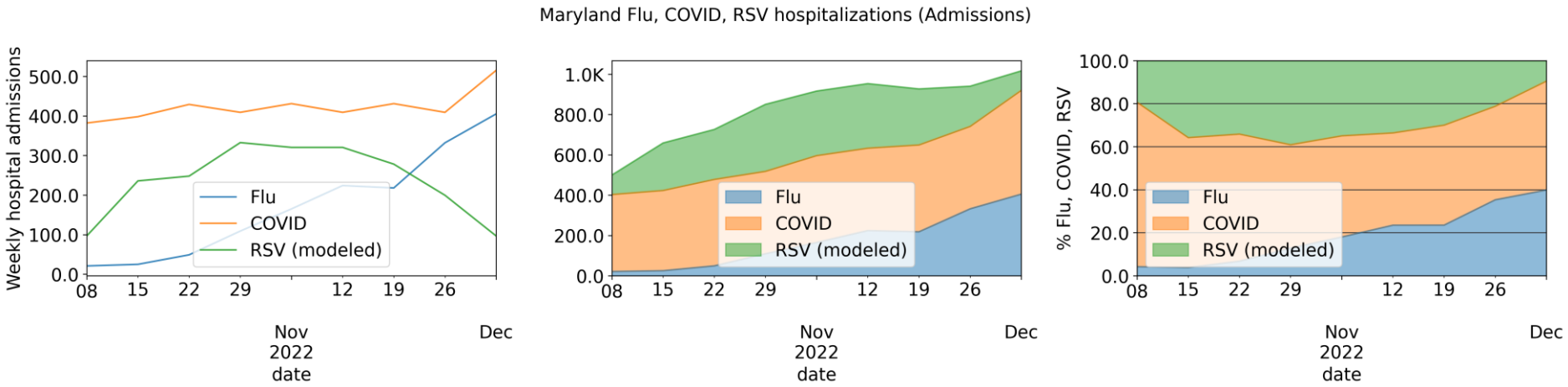
Current Combined Hospitalizations (COVID-19, Flu & RSV)

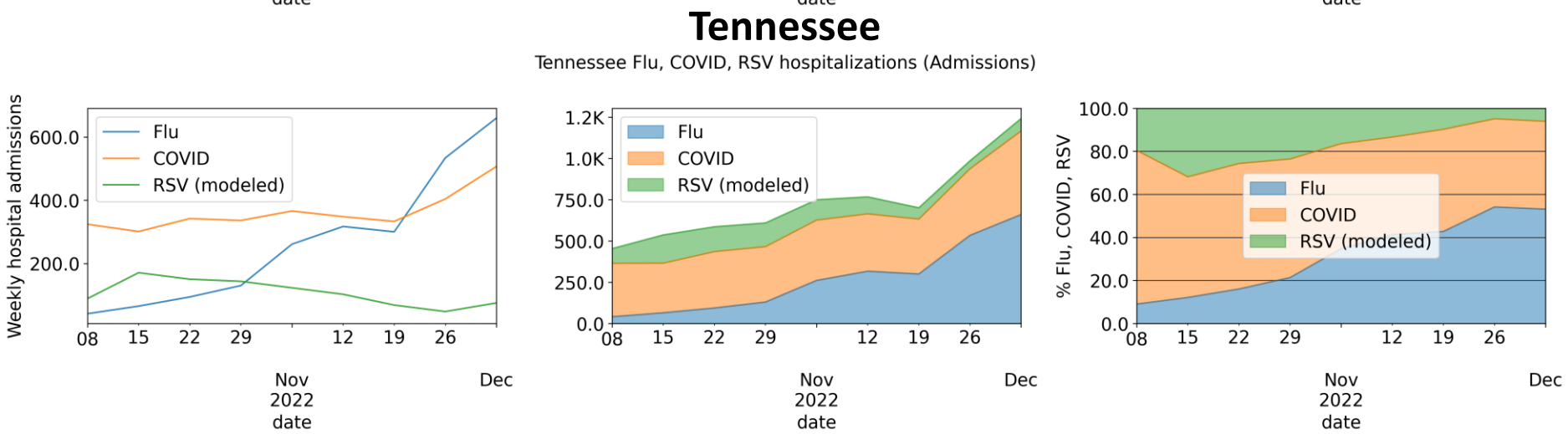
COVID-19, Influenza, and RSV Weekly Hospitalizations

RSV Hospitalizations captured by RSV-Net which has lagged reporting and does not cover Virginia, thus her closest neighbors are shown for comparison

Maryland



Tennessee



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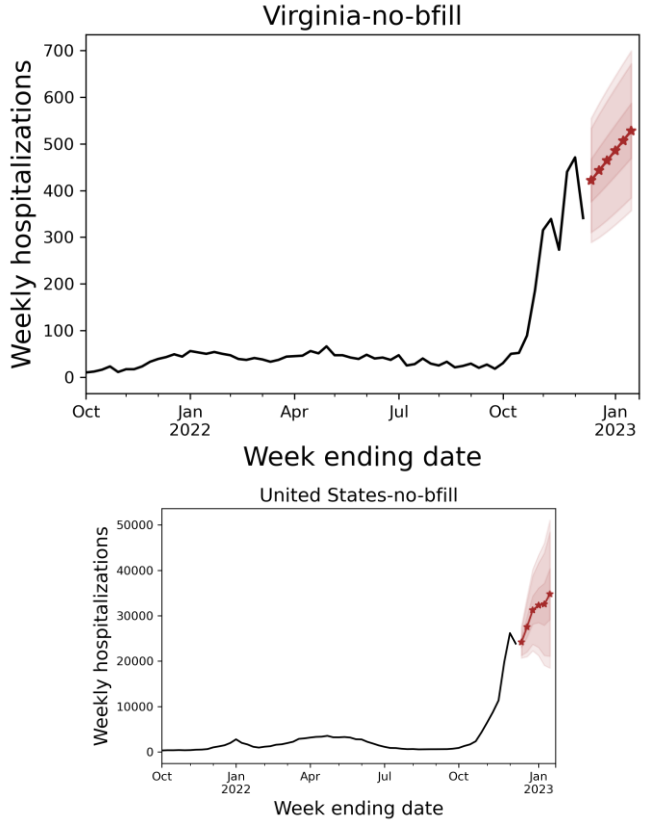
Current Influenza Hospitalization Forecast

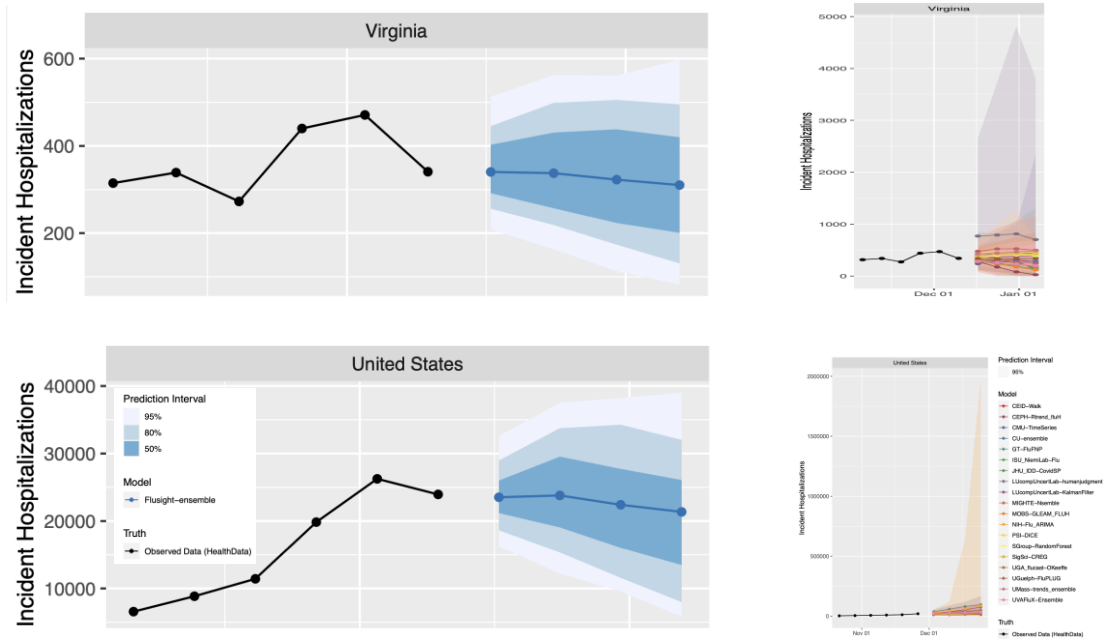
Statistical models for submitting to CDC FluSight forecasting challenge

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

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



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



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CDC FluSight

Combined ILI and COVID-19 Hospitalizations

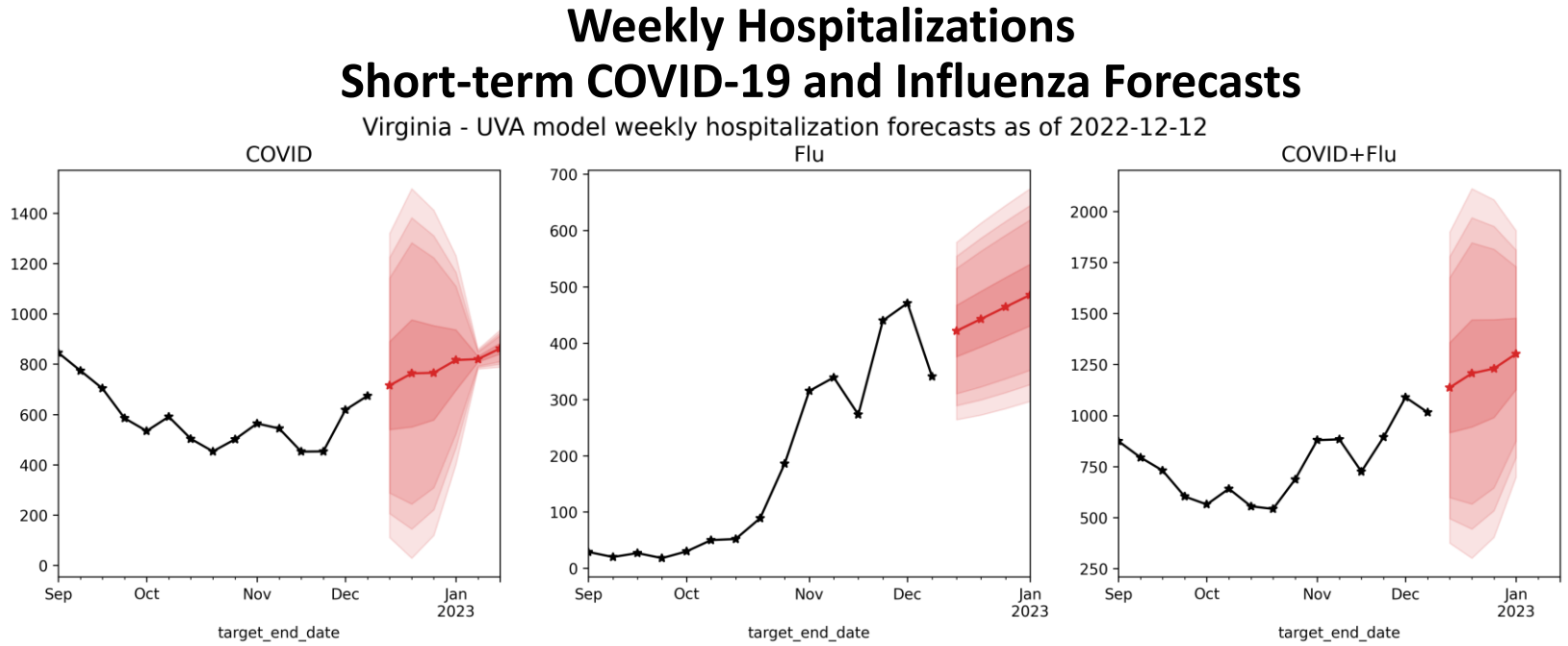
Ensemble methodology that combines the Adaptive with machine learning and statistical models such as:

- Autoregressive (AR, ARIMA) , Neural networks (LSTM), Kalman filtering (EnKF), G-model (phase), Holt-Winters

Weekly forecasts of hospitalizations done at state level.

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

Both are regularly submitted to CDC Forecast Hubs



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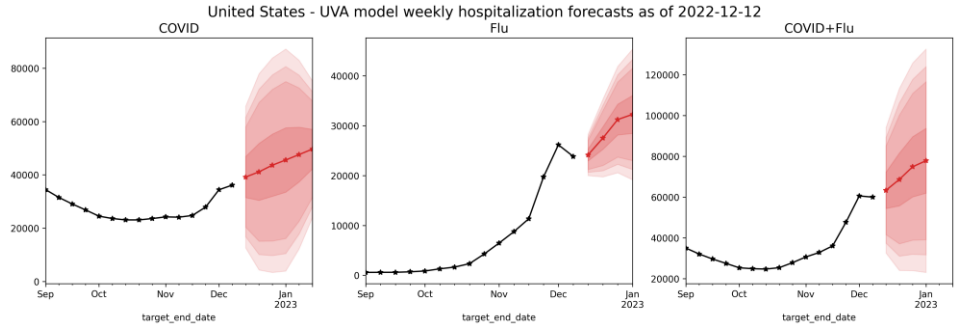
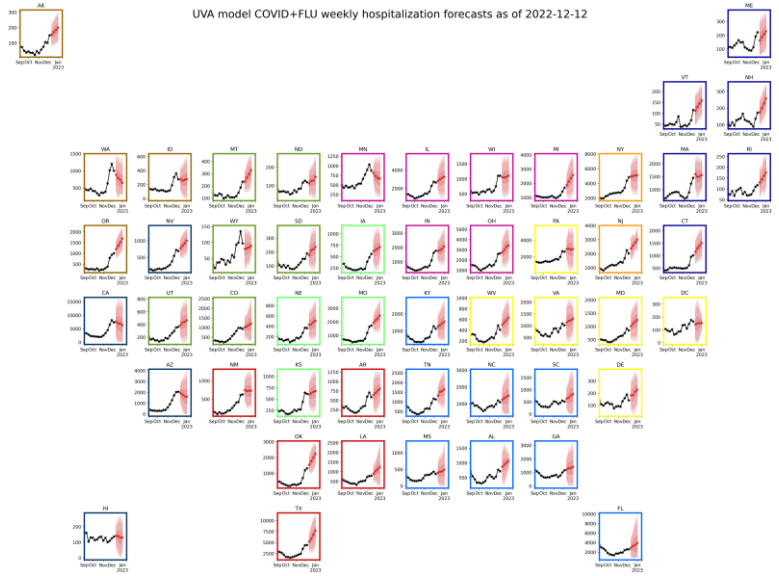
Combined ILI and COVID-19 Hospitalizations

National

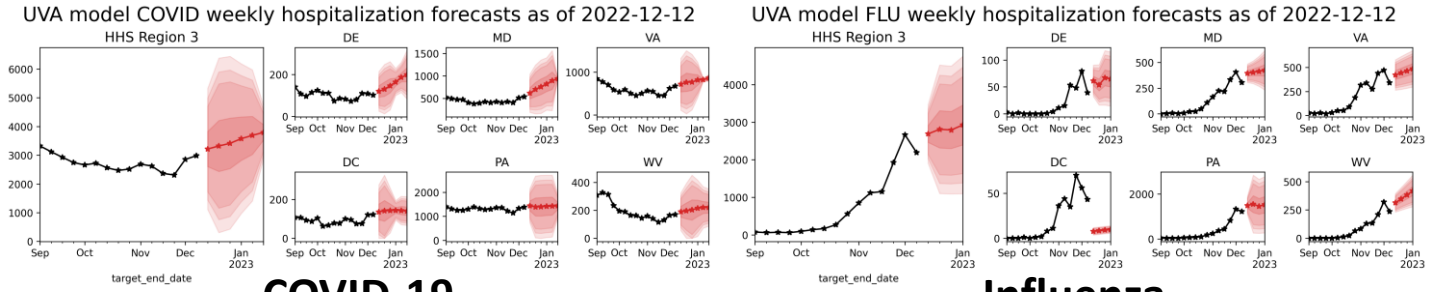
Short-term COVID-19 and Influenza Forecasts



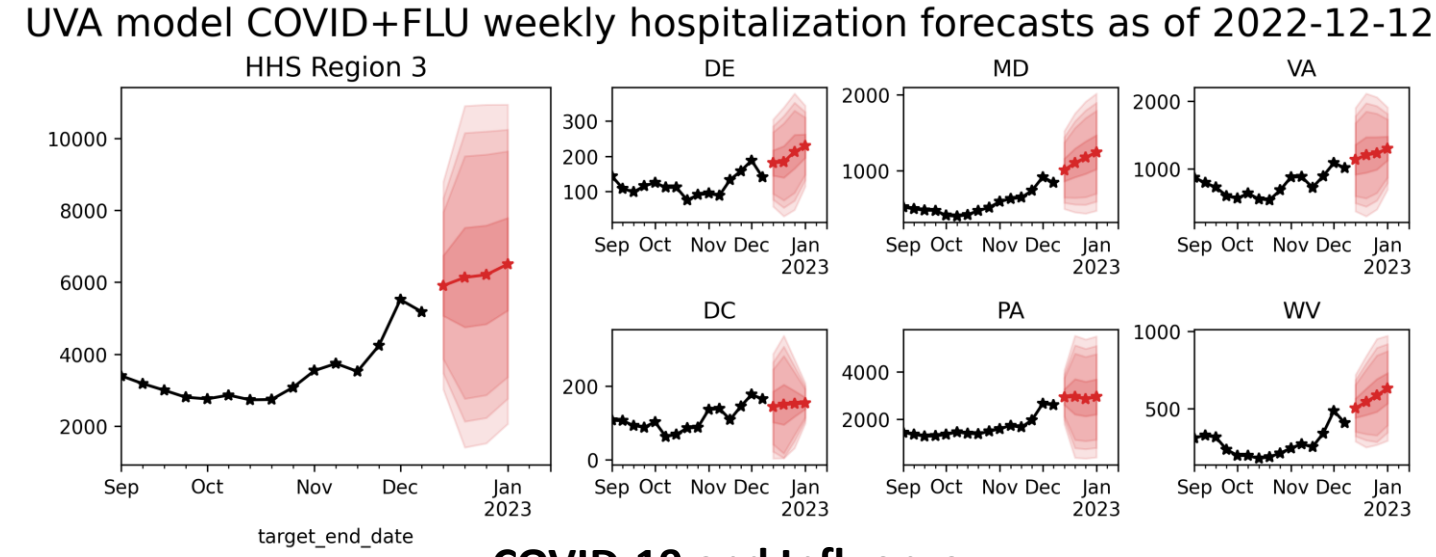


HHS Region 3

Short-term COVID-19 and Influenza Forecasts



COVID-19 **Influenza**



COVID-19 and Influenza

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National Modeling Hub Updates

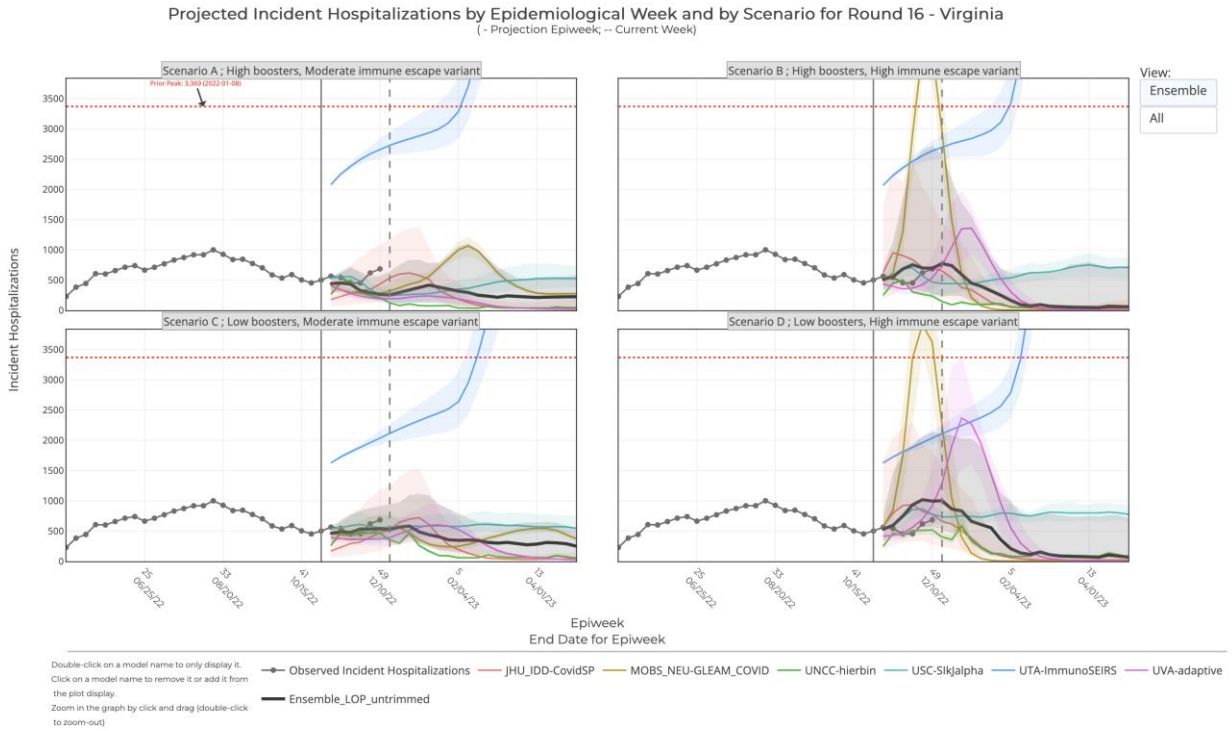
Scenario Modeling Hub – COVID-19 (Round 16)

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

- Round 16 results published
- High escape scenarios tracking best

https://covid19scenariomodelinghub.org/viz.html

	"Level 5" Variants	"Level 6/7" Variants
Accelerating uptake levels of reformulated boosters	"Level 5" Variants **Scenario A** - Variants have a 25% immune escape from BA.5.2 - Seeding based on combined observed prevalence of Level 5 variants at the start of the projection period - No change in severity given symptomatic infection **Accelerating uptake levels of reformulated boosters, with coverage plateauing at 90% of flu vaccination levels by February 1st, 2023** - Teams are free to use available data and information from current and previous rollouts as tehy see fit to define rates - Teams should assume increasing uptake through October and November as necessary to reach the projected February 1st, 2022 plateau	"Level 6/7" Variants **Scenario B** - Variants have a 50% immune escape from BA.5.2 - Seeding based on combined observed prevalence of Level 6 and 7 variants at the start of the projection period - No change in severity given symptomatic infection **Accelerating uptake levels of reformulated boosters, with coverage plateauing at 90% of flu vaccination levels by February 1st, 2023** - Teams are free to use available data and information from current and previous rollouts as tehy see fit to define rates - Teams should assume increasing uptake through October and November as necessary to reach the projected February 1st, 2022 plateau
Current uptake levels of reformulated boosters	"Level 5" Variants **Scenario C** - Variants have a 25% immune escape from BA.5.2 - Seeding based on combined observed prevalence of Level 5 variants at the start of the projection period - No change in severity given symptomatic infection **Current uptake levels of reformulated boosters, with coverage plateauing at booster 1 levels by the end of the simulation** - Teams are free to use available data and information from current and previous rollouts as tehy see fit to define rates - Based on current rates, plateau date is flexible as long as it occurs before the end of the simulation (Teams can adjust rates up if needed to achieve adequate coverage by target date)	"Level 6/7" Variants **Scenario D** - Variants have a 50% immune escape from BA.5.2 - Seeding based on combined observed prevalence of Level 6 and 7 variants at the start of the projection period - No change in severity given symptomatic infection **Current uptake levels of reformulated boosters, with coverage plateauing at booster 1 levels by the end of the simulation** - Teams are free to use available data and information from current and previous rollouts as tehy see fit to define rates - Based on current rates, plateau date is flexible as long as it occurs before the end of the simulation (Teams can adjust rates up if needed to achieve adequate coverage by target date)



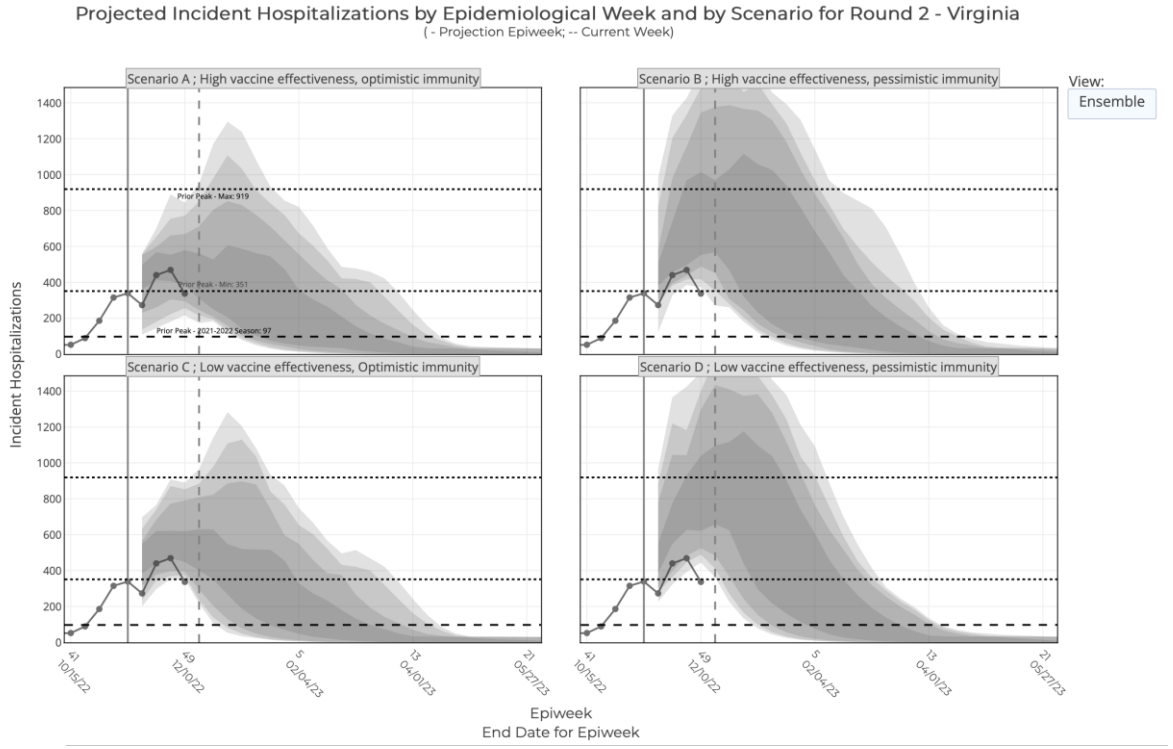
Scenario Modeling Hub – Influenza (Round 2)

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

- Round 2 is more calibrated and similar to Round 1
- Round 3 in progress (prelim results)

	Optimistic flu prior immunity	Pessimistic flu prior immunity
High Vaccine Effectiveness	Scenario A Optimistic flu prior immunity - No impact of missed flu seasons due to the COVID-19 pandemic on prior immunity.* - Same amount of prior immunity as in a typical, pre-COVID19 pandemic prior season. High Vaccine Effectiveness - VE = 50% against medically attended influenza illnesses and hospitalizations (comparable to 2015-16 season).	Scenario B Pessimistic flu prior immunity - Substantial impact of missed flu seasons due to the COVID-19 pandemic on prior immunity.* - 50% lower immunity than a typical, pre-COVID19 pandemic season. High Vaccine Effectiveness - VE = 50% against medically attended influenza illnesses and hospitalizations (comparable to 2015-16 season).
Low Vaccine Effectiveness	Scenario C Optimistic flu prior immunity - No impact of missed flu seasons due to the COVID-19 pandemic on prior immunity.* - Same amount of prior immunity as in a typical, pre-COVID19 pandemic prior season. Low Vaccine Effectiveness - VE = 30% against medically attended influenza illnesses and hospitalizations (comparable to 2018-19 season).	Scenario D Pessimistic flu prior immunity - Substantial impact of missed flu seasons due to the COVID-19 pandemic on prior immunity.* - 50% lower immunity than a typical, pre-COVID19 pandemic season. Low Vaccination Protection - VE = 30% against medically attended influenza illnesses and hospitalizations (comparable to 2018-19 season).

https://fluscenariomodelinghub.org/viz.html



Combined – COVID-19 and Influenza

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

- COVID-19 Scenarios – Round 16

- ☑ **Scenario A**
  High boosters
  Moderate immune escape variant
  (A-2022-10-29)
- ☑ **Scenario B**
  High boosters
  High immune escape variant
  (B-2022-10-29)
- ☑ **Scenario C**
  Low boosters
  Moderate immune escape variant
  (C-2022-10-29)
- ☑ **Scenario D**
  Low boosters
  High immune escape variant
  (D-2022-10-29)

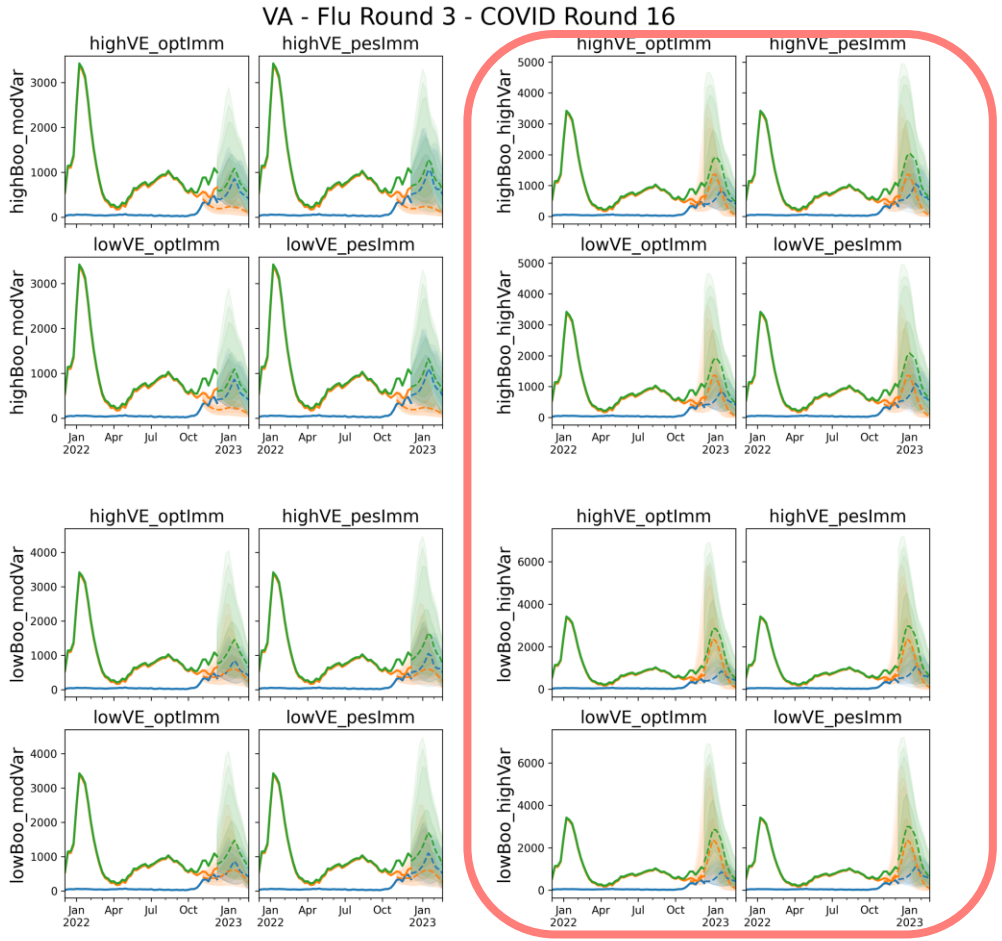
- Influenza Scenarios – Round 3 (prelim)

- ☑ **Scenario A**
  High vaccine effectiveness
  optimistic immunity
  (A-2022-11-13)
- ☑ **Scenario B**
  High vaccine effectiveness
  pessimistic immunity
  (B-2022-11-13)
- ☑ **Scenario C**
  Low vaccine effectiveness
  Optimistic immunity
  (C-2022-11-13)
- ☑ **Scenario D**
  Low vaccine effectiveness
  pessimistic immunity
  (D-2022-11-13)

Round 16 of COVID-19 is published and Round 2 is published, but a quick update Round 3 is now in preliminary results stage

Combined Hospitalizations (VA)

UVA submissions only



COVID scenarios with high immune escape seem to track best

Four COVID-19 scenarios crossed with four Influenza Scenarios

Key Takeaways

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

- **Case rates and hospitalizations starting to rise rapidly**
- VA weekly case rate is up to at 95/100K from 81/100K
  - US weekly case rate up sharply to 126 per 100K from 74 per 100K, and hospitalizations continue to quickly rise
- VA hospital occupancy is quickly rising (rolling 7 day mean of 694 from 644 a week ago); highest since early Sept
  - Influenza weekly hospital admissions remain high (~300 a week) but are now declining
- Projections anticipate increases in cases and hospitalizations in coming weeks
  - Combined hospitalizations due to Influenza and COVID-19 are expected to have a steady increase
- Model updates:
  - Model now fitted with Adaptive-Variant X, assumes this as the base case, since current growth can be attributed to rise of swarm of variants with more immune escape, Fall-Winter effects continue to add additional growth

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

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

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

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

Questions?

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