Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Foresight and Analysis of Infectious Disease Threats to Virginia's Public Health

July 13th, 2023

(data current to July 3rd – July 12th)

Biocomplexity Institute Technical report: TR BI-2023-160

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biocomplexity.virginia.edu

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

Abhijin Adiga, Aniruddha Adiga, Hannah Baek, Chris Barrett, Parantapa Bhattacharya, Chen Chen, Da Qi Chen, Jiangzhuo Chen, Baltazar Espinoza, Galen Harrison, Stefan Hoops, Ben Hurt, Gursharn Kaur, Brian Klahn, Chris Kuhlman, Bryan Lewis, Dustin Machi, Madhav Marathe, Sifat Moon, Henning Mortveit, Mark Orr, Przemyslaw Porebski, SS Ravi, Erin Raymond, Samarth Swarup, Srinivasan Venkatramanan, Anil Vullikanti, Andrew Warren, Amanda Wilson, Dawen Xie

Overview

- **Goal**: Understand impact of current and emerging Infectious Disease threats to the Commonwealth of Virginia using modeling and analytics

- **Approach:**
    - Provide analyses and summaries of current infectious disease threats
    - Survey existing forecasts and trends in these threats
    - Analyze and summarize the current situation and trends of these threats in the broader context of the US and world
    - Provide broad overview of other emerging threats

Key Takeaways

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

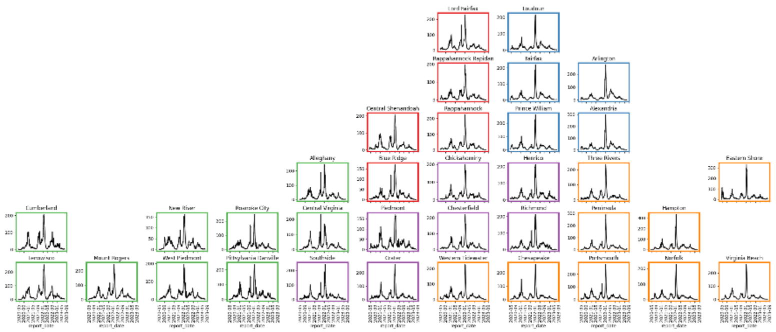
- Case rates are in an undulating plateau, currently in an upswing
- Hospitalization rates remain in plateau, with very slight growth
- Most indicators still point to continued plateaus, though some indicate slow growth
- Scenerio Modeling Hub, round 17 results published, impact of fall booster is high

VDH – UVA Updates

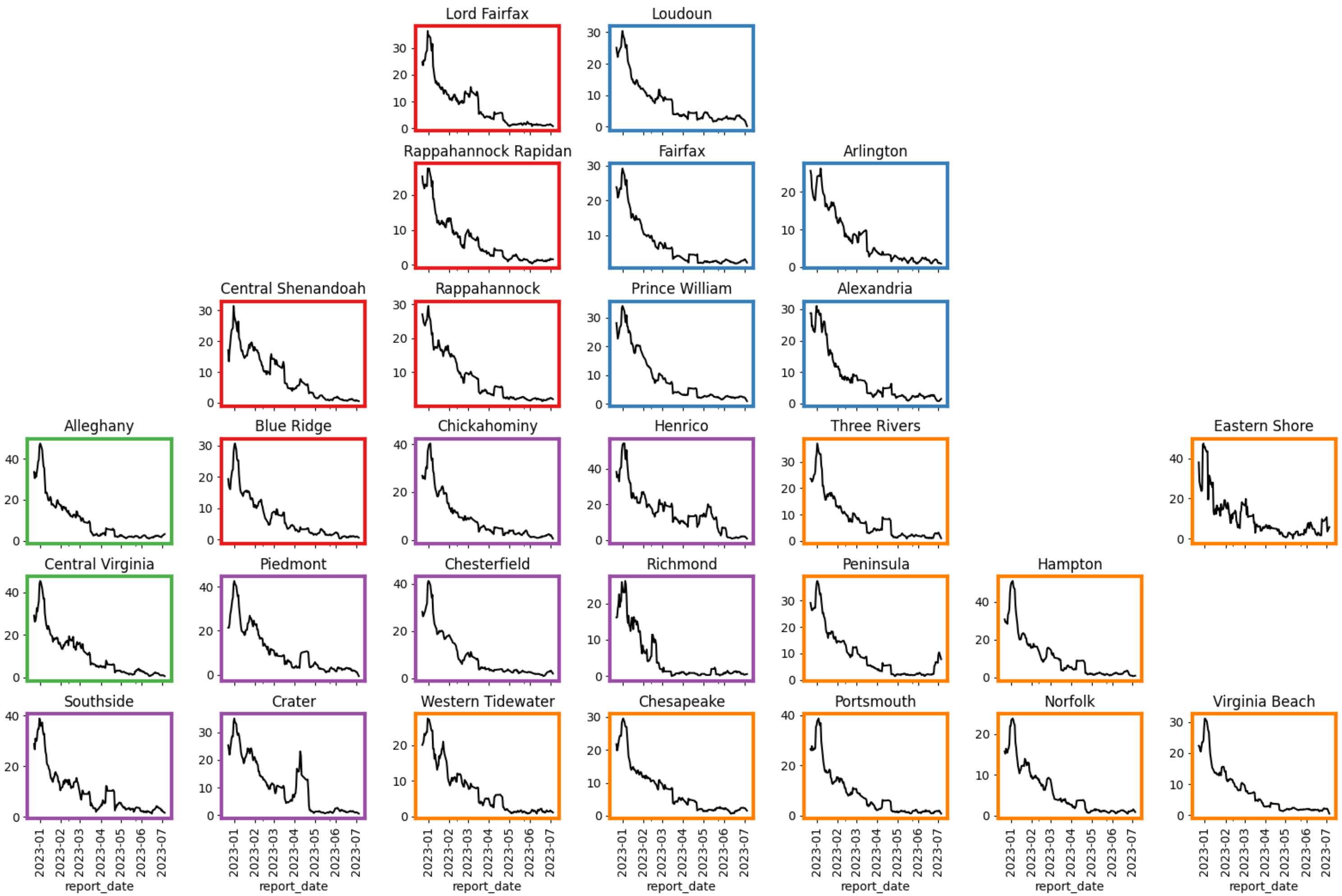
- SPHINX project update – PePITA tool piloted at CSTE conference in Salt Lake City
- Projected Trajectories from previous rounds remain on target, no new projections made this round

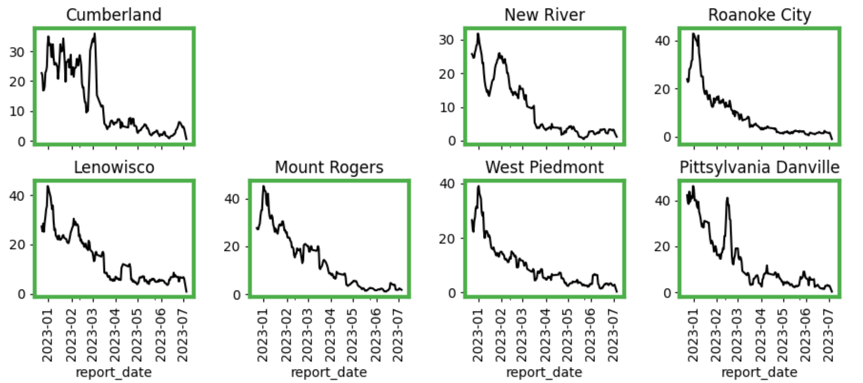
COVID-19 Surveillance

Case Rates (per 100k)



Whole pandemic





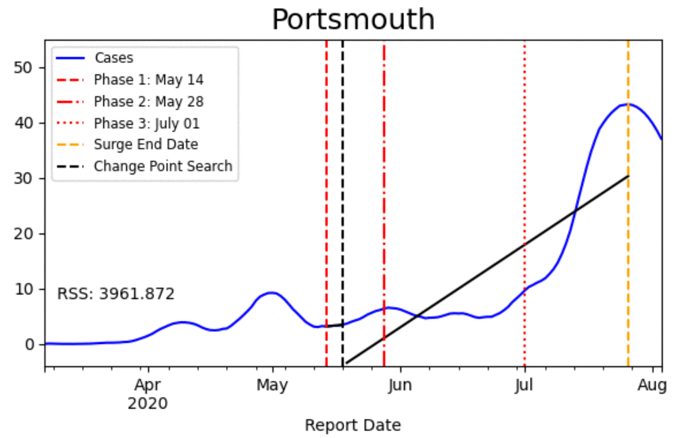
Since December 2021

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

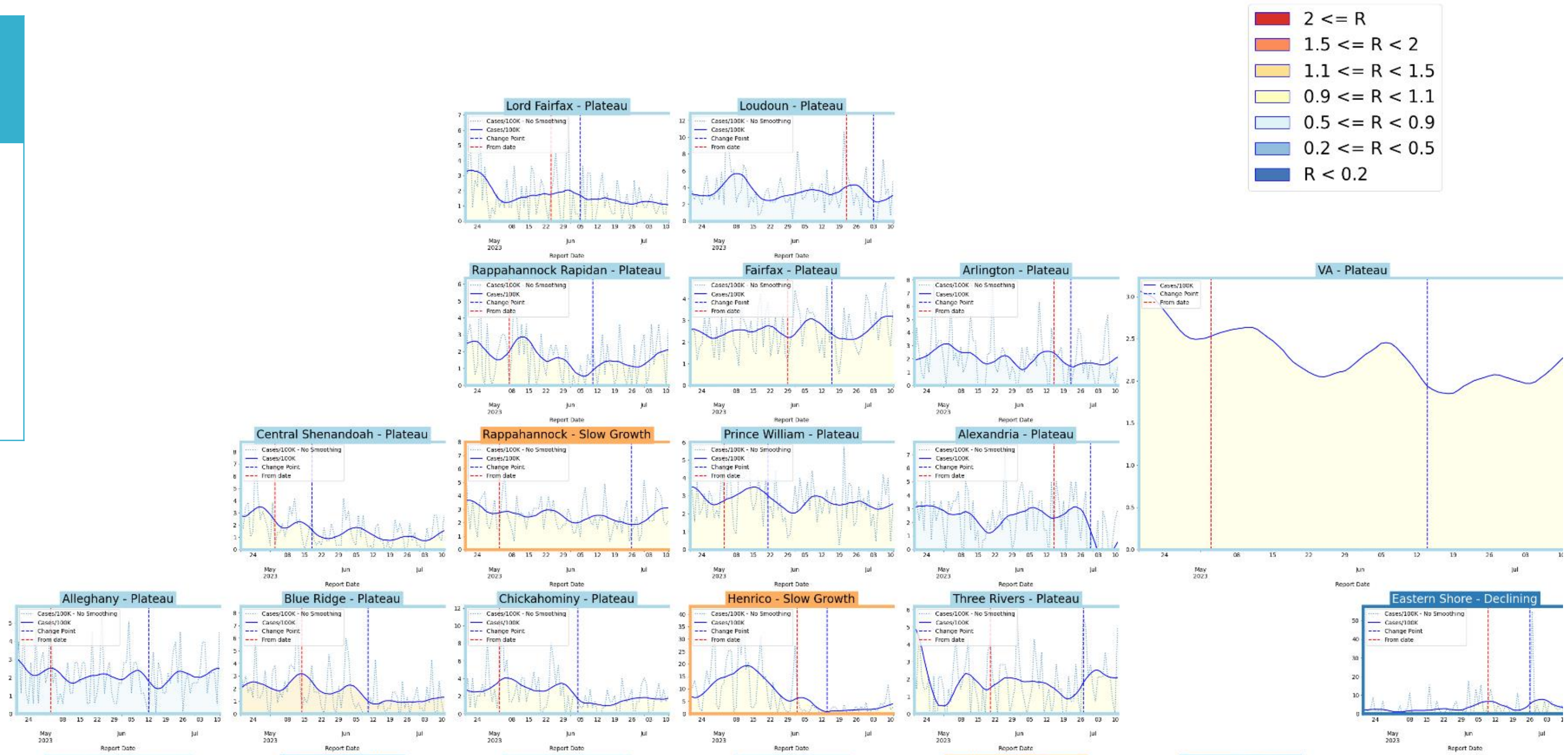


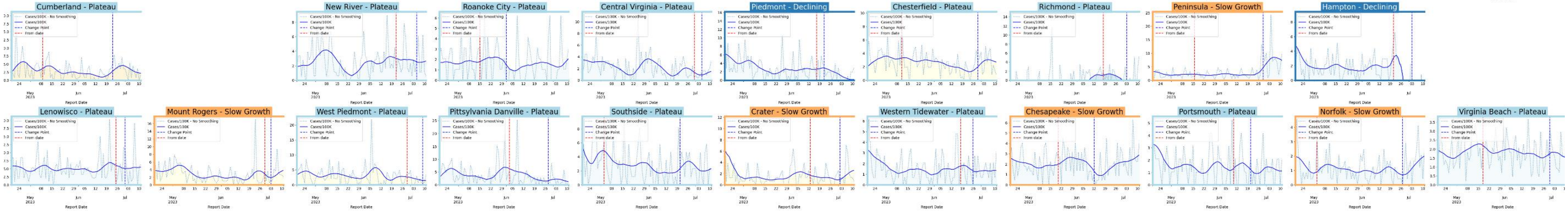
Trajectory	Description	Weekly Case Rate Slope (per 100k)	Weekly Hosp Rate Slope (per 100k)
Declining	Sustained decreases following a recent peak	slope < -0.88/day	slope < -0.07/day
Plateau	Steady level with minimal trend up or down	-0.88/day < slope < 0.42/day	-0.07/day < slope < 0.07/day
Slow Growth	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 Month
Declining	3	(2)
Plateau	25	(25)
Slow Growth	7	(7)
In Surge	0	(1)

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





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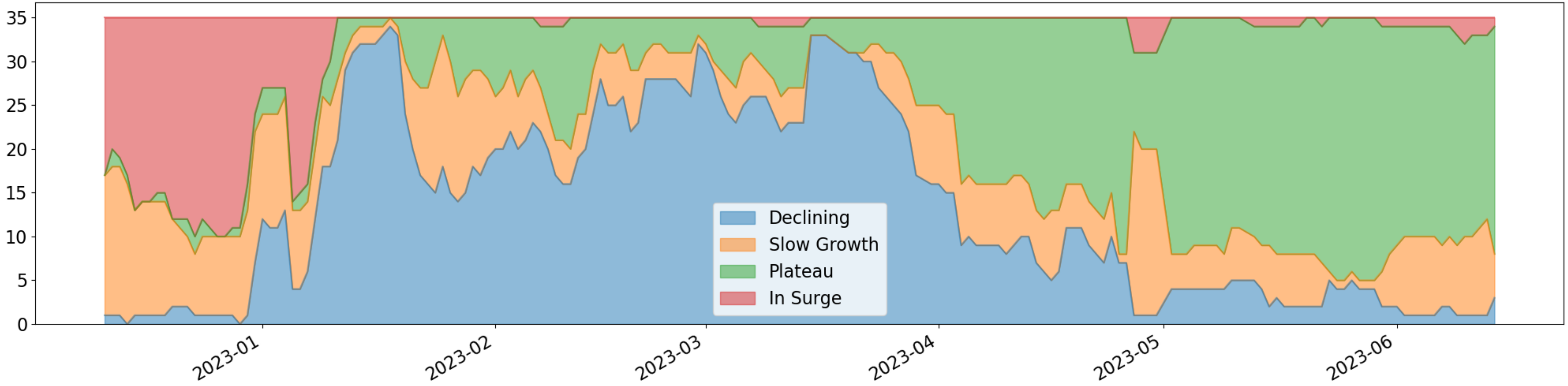
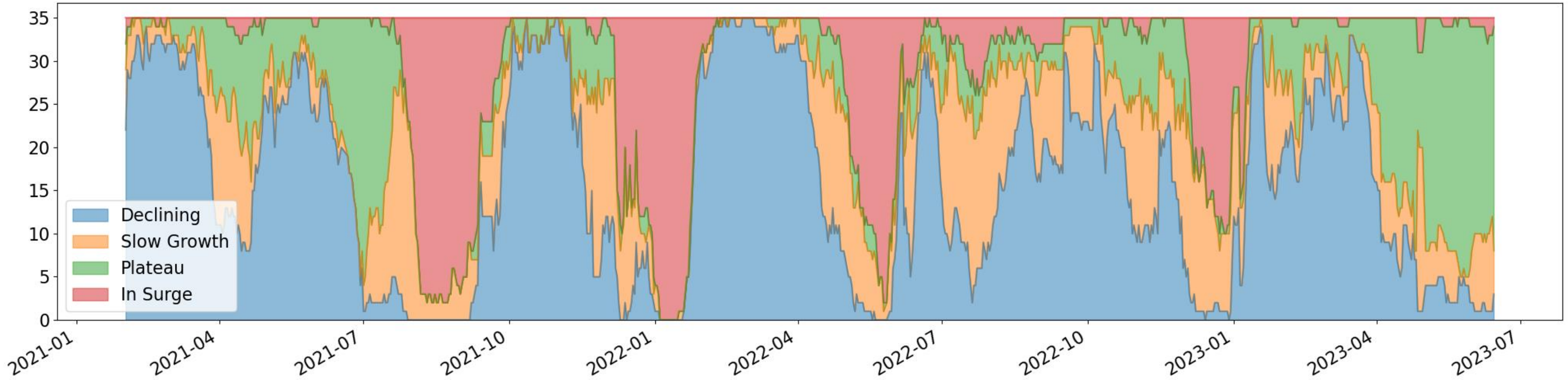
District Case Trajectories – Recent 6 months





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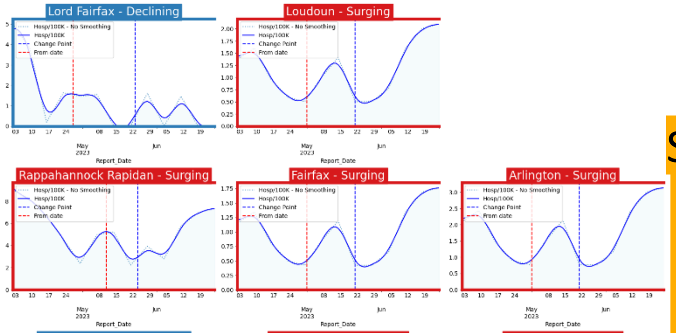
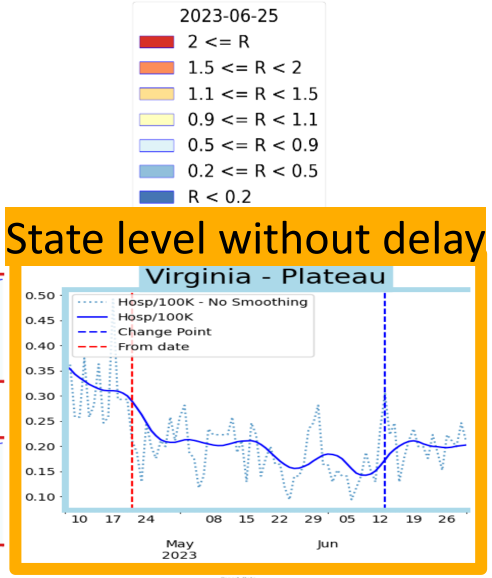
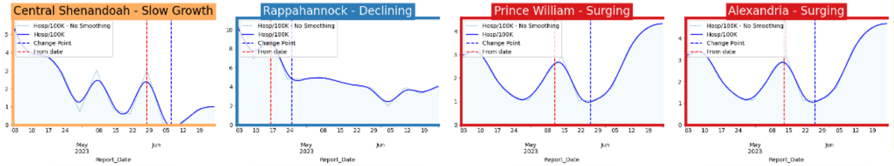
District Hospital Trajectories – last 10 weeks

Status	Number of Districts Current Week	Number of Districts Last Month
Declining	15	(29)
Plateau	5	(6)
Slow Growth	9	(0)
In Surge	6	(0)

Hospitalization by county is delayed, these data are current as week ending of **June 25th**

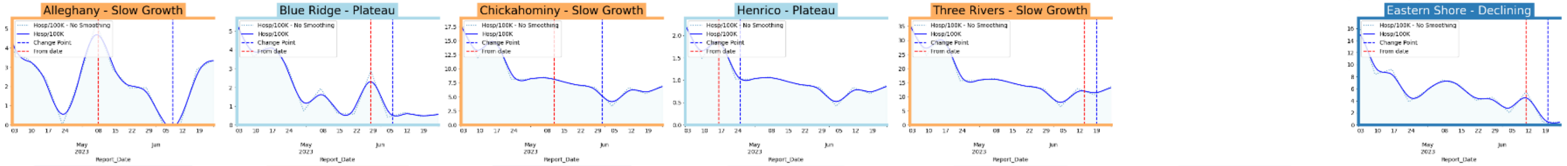


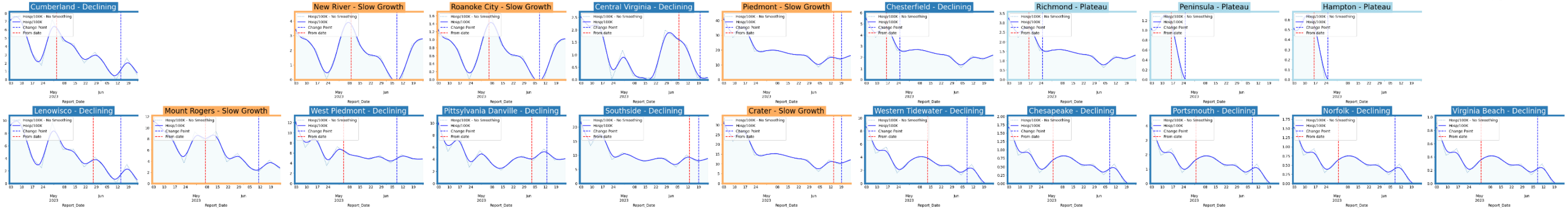




Curve shows smoothed hospitalization rate (per 100K) by district

Hosp rate curve colored by R_e number





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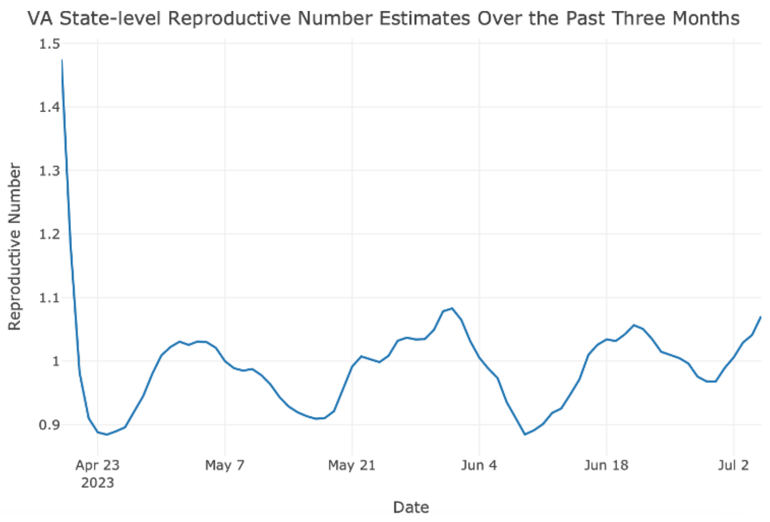
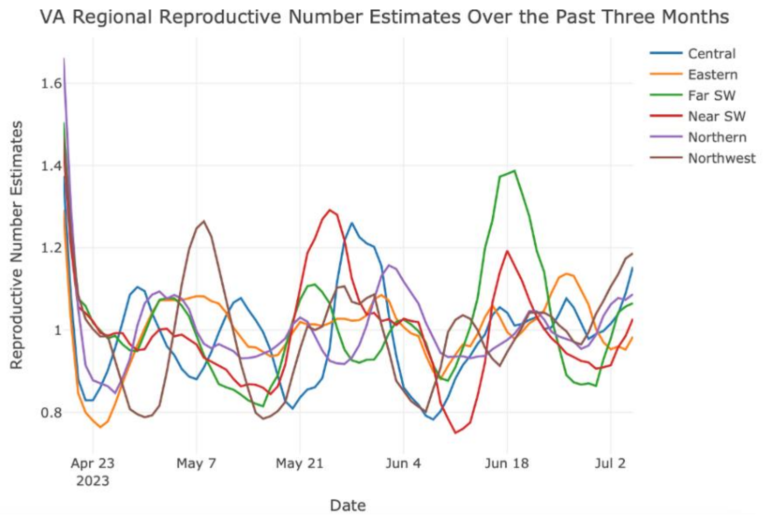
COVID-19 Growth Metrics

Estimating Daily Reproductive Number –
VDH report dates

July 11th Estimates

Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide cases	**1.071**	**0.103**
State-wide hosps	**0.987**	**-0.005**
Central	1.154	0.175
Eastern	0.984	-0.078
Far SW	1.065	0.195
Near SW	1.028	0.106
Northern	1.087	0.125
Northwest	1.187	0.192





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

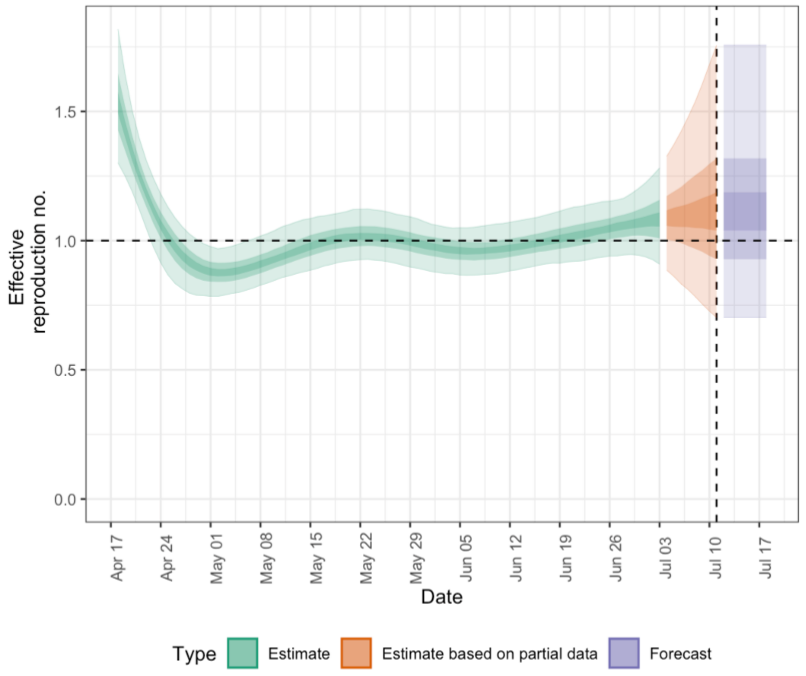
Estimating Daily Reproductive Number – VDH report dates – EpiNow2 estimation

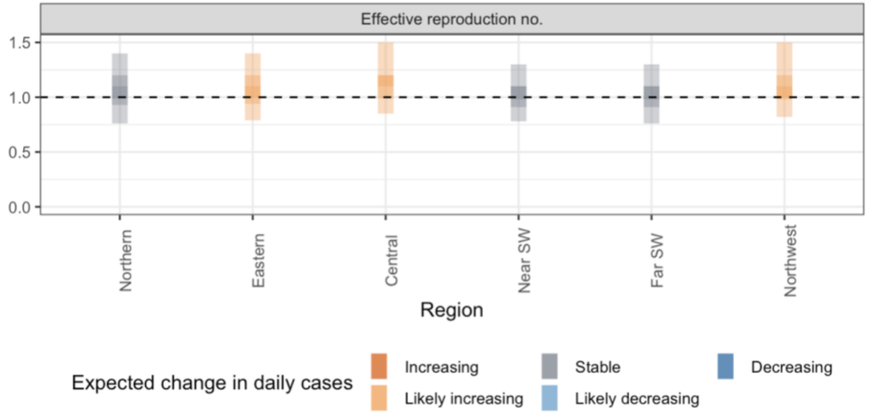
July 11th Estimates

Region	Reproductive number estimate	Confidence interval	Trend forecast
State-wide cases	1.10	0.70 - 1.8	Likely increasing
State-wide hosp	1.00	0.78 - 1.4	Stable
Central	1.10	0.85 - 1.5	Likely increasing
Eastern	1.10	0.79 - 1.4	Likely increasing
Far SW	1.00	0.76 - 1.3	Stable
Near SW	1.00	0.78 - 1.3	Stable
Northern	1.00	0.76 - 1.4	Stable
Northwest	1.10	0.82 - 1.5	Likely increasing

Initial results based on past 3 months of data with updated EpiNow2 method

Re from VDH Cases (last 3 months)





Methodology

- EpiNow2 which is based on similar approach as EpiEstim (currently used on previous slide)
- Serial interval updates with COVID-19 disease model in EpiNow2
- Continue to use confirmation date but report date biases are better accounted for

Sam Abbott, Joel Hellewell, Katharine Sherratt, Katelyn Gostic, Joe Hickson, Hamada S. Badr, Michael DeWitt, Robin Thompson, EpiForecasts, Sebastian Funk (2020). EpiNow2: Estimate Real-Time Case Counts and Time-Varying Epidemiological Parameters. doi:10.5281/zenodo.3957489.

EpiNow2 home: https://epiforecasts.io/EpiNow2/

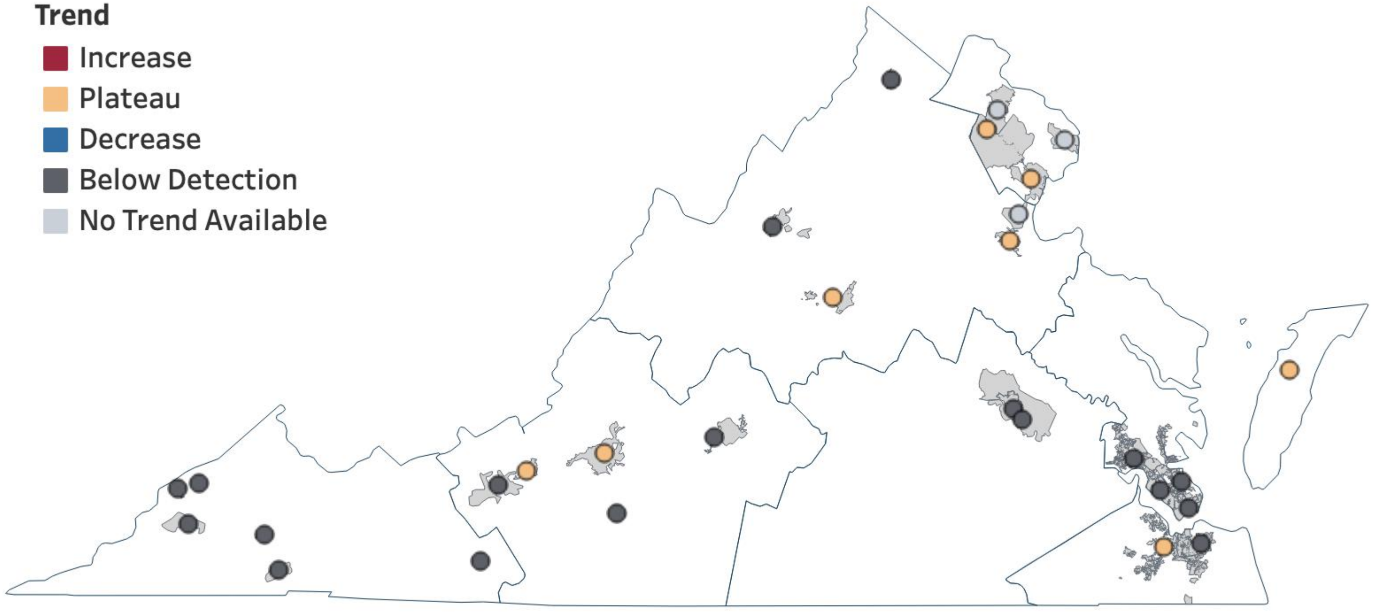
VA Wastewater Data Update

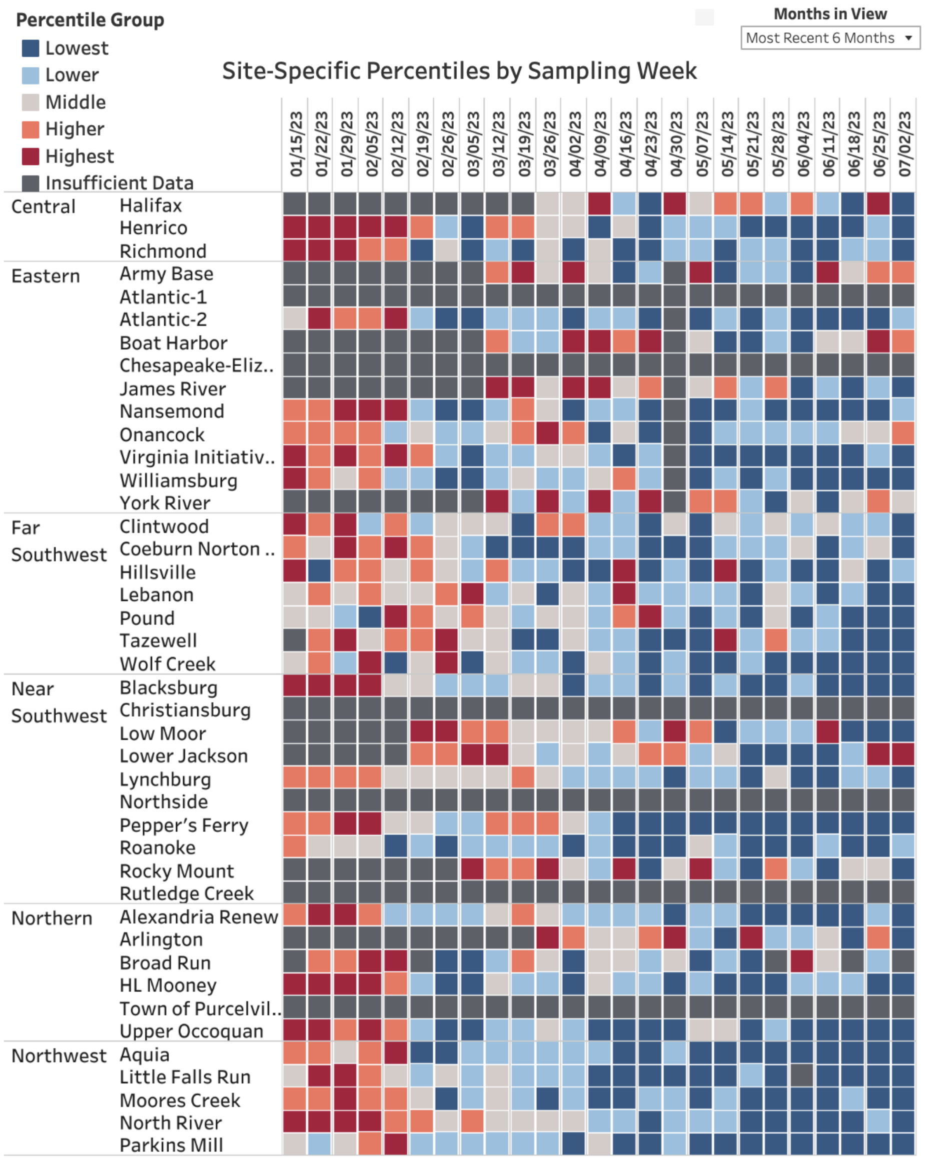
Start of Sample Collection Week

July 2, 2023

Trend

- Increase
- Plateau
- Decrease
- Below Detection
- No Trend Available





[VDH COVID-19 Wastewater Surveillance](#)

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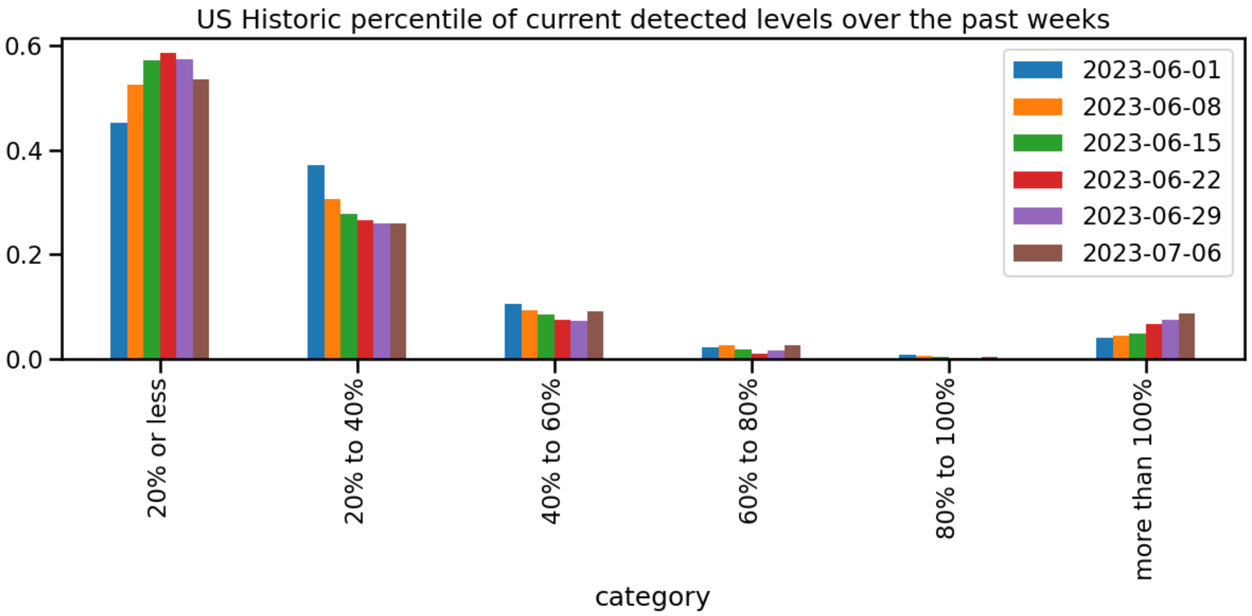
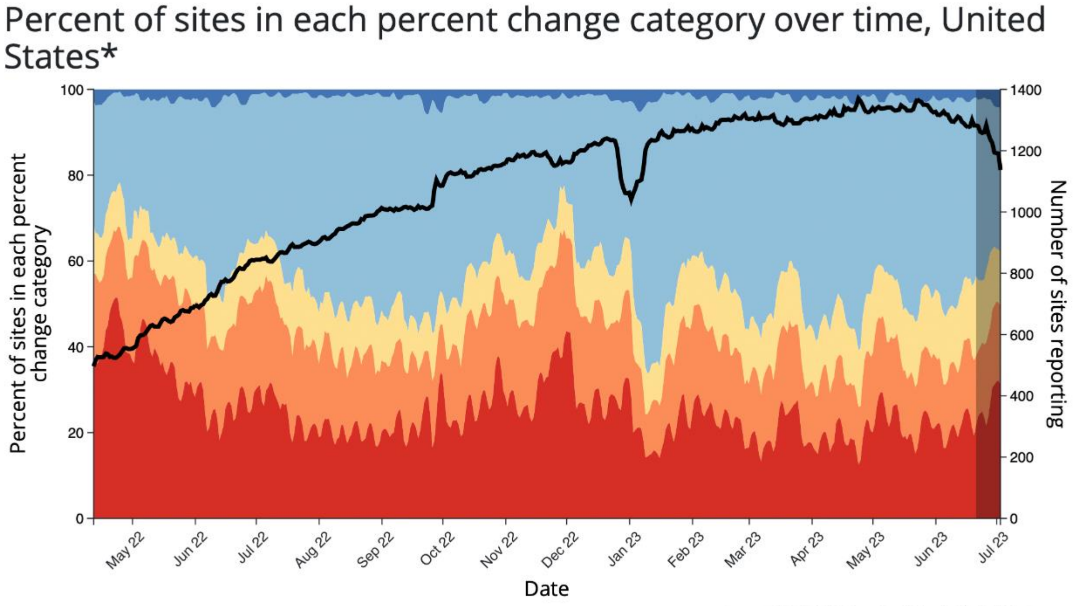
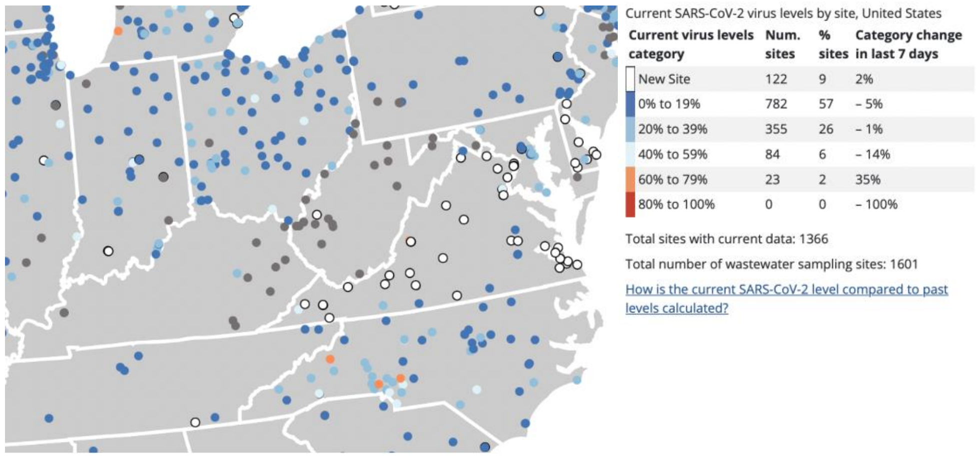
US Wastewater Monitoring

Wastewater provides a coarse estimate of COVID-19 levels in communities and can be a good indicator of activity levels







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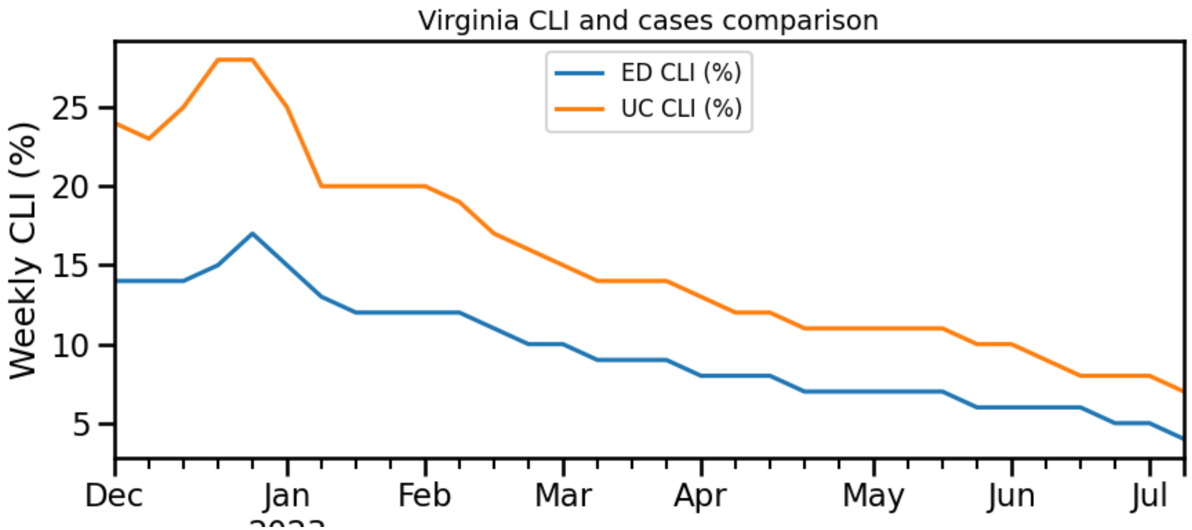
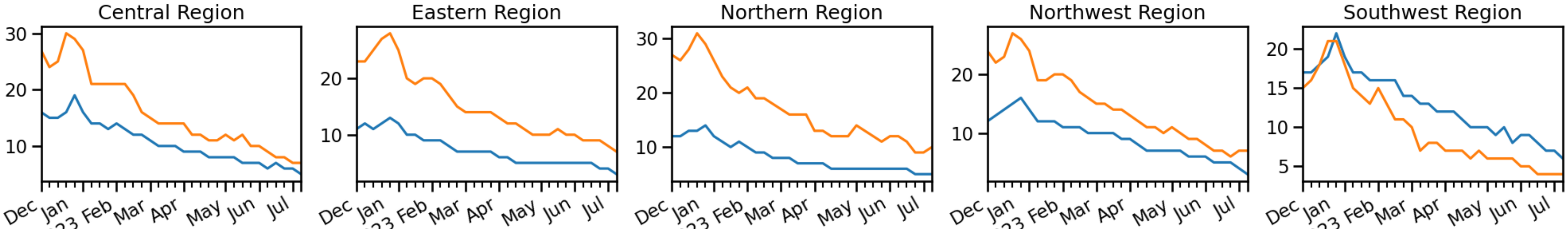
Data Source: CDC Data Tracker

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
- **Levels continue to decline into lowest levels in past 8 months**





COVID-19 Severity Metrics

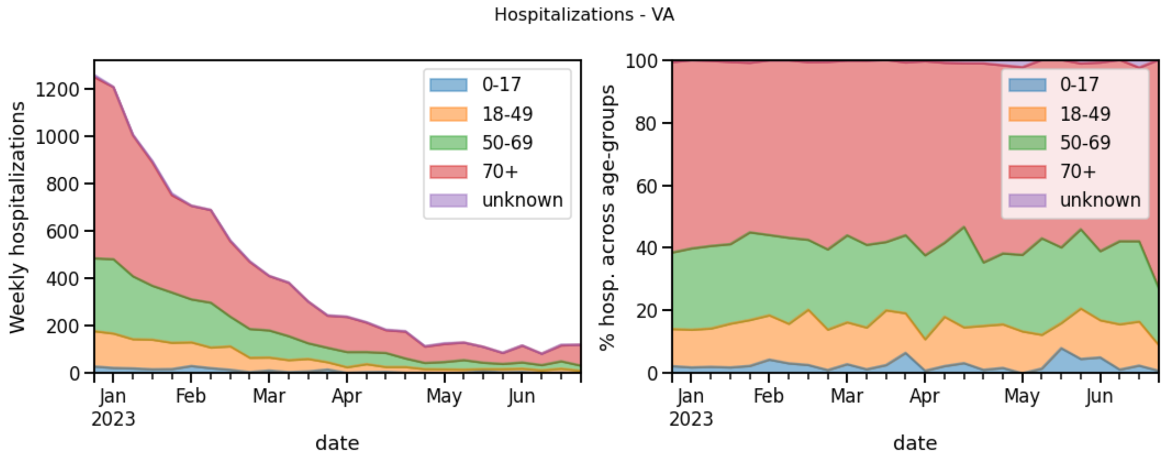
Hospitalizations in VA by Age

Age distribution in hospitals relatively stable

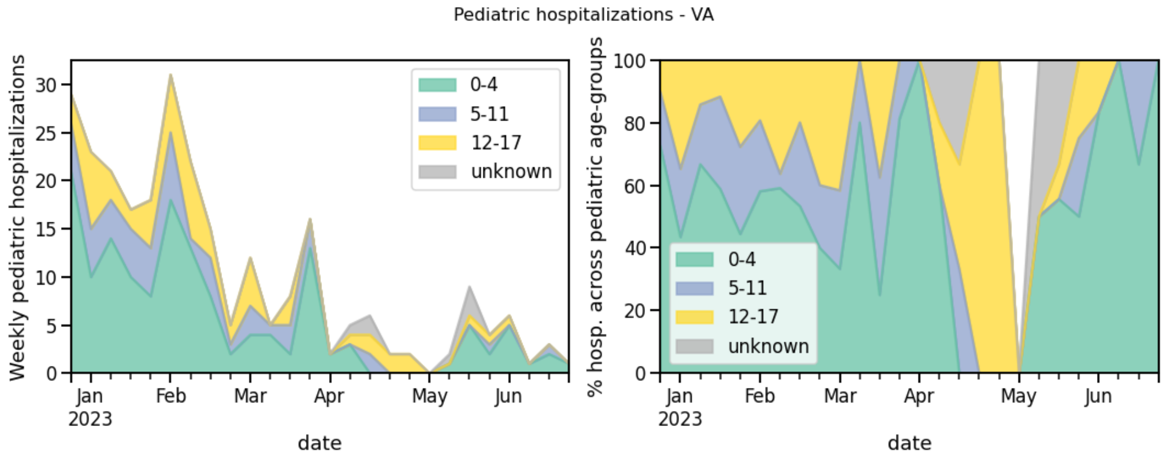
- Uptick in hospitalizations mostly fueled by 70+ age group
- Pediatric hospitalizations level off after uptick last week

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]()

COVID-19 Spatial Epidemiology

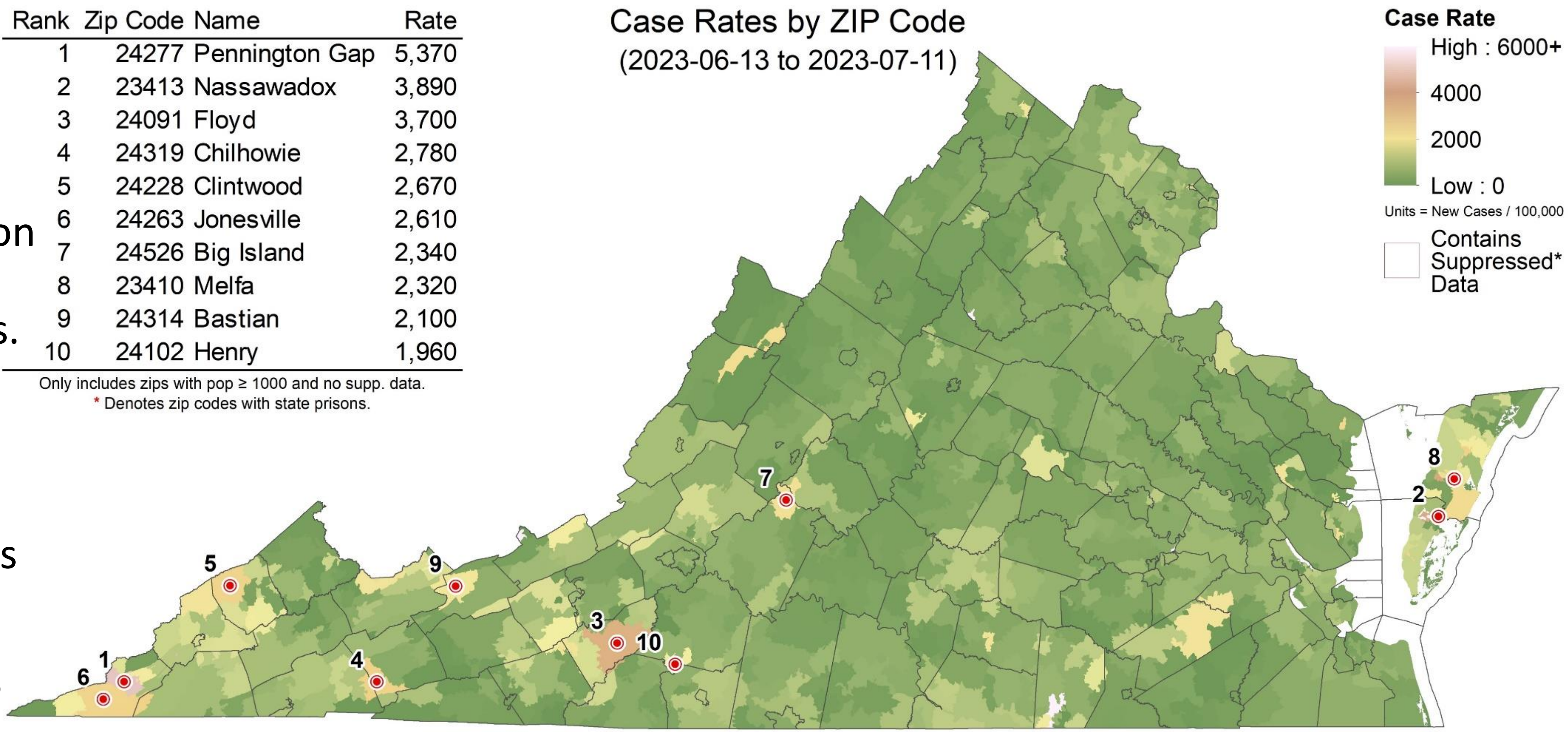
ZIP Code level case rate per 100K over last four weeks

New cases per 100k in the last four weeks by ZIP code

- Statewide COVID19 case rates continue to remain at near historic lows.
- Divide rates by four to calculate average weekly incidence. Even Pennington Gap averaged fewer than 1,350 / 100k weekly cases.
- Nassawadox is yet again reporting an unusually high case rate. It was in the #1 spot in last month's report.
- No ZIP codes with prisons are reported in this month's top 10.

Rank	Zip Code	Name	Rate
1	24277	Pennington Gap	5,370
2	23413	Nassawadox	3,890
3	24091	Floyd	3,700
4	24319	Chilhowie	2,780
5	24228	Clintwood	2,670
6	24263	Jonesville	2,610
7	24526	Big Island	2,340
8	23410	Melfa	2,320
9	24314	Bastian	2,100
10	24102	Henry	1,960

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



Based on Spatial Empirical Bayes smoothed case rates, with an 8:1 ascertainment ratio, for four weeks ending 2023-07-11.

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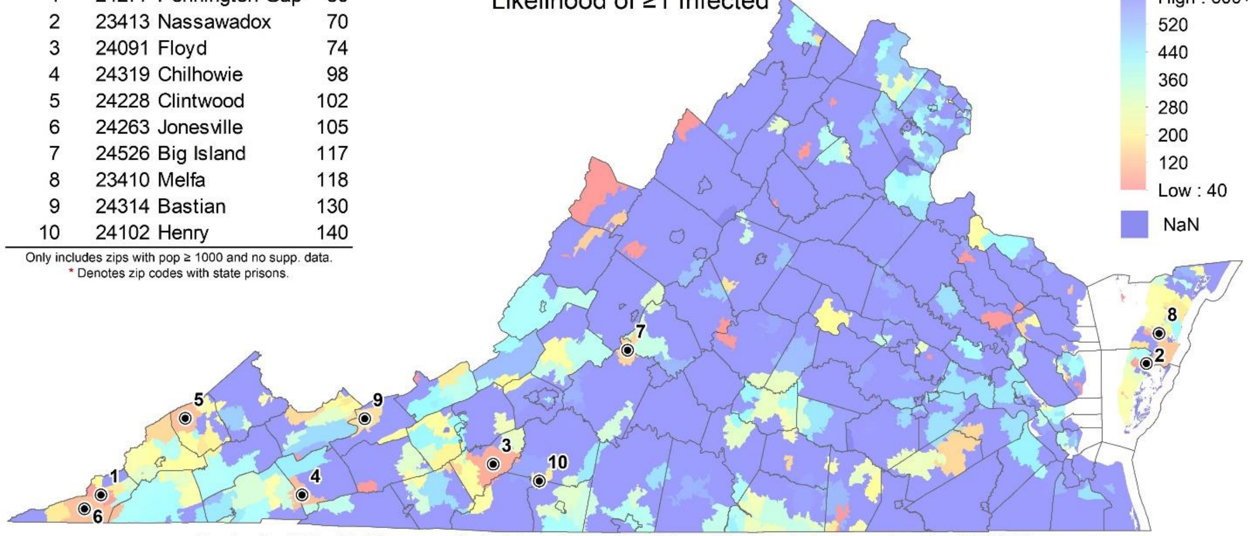
Risk of Exposure by Group Size and HCW prevalence

Case prevalence in the last four weeks 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 50 in Pennington Gap, there is a 50% chance someone will be infected).
- **HCW ratio**: Case rate among health care workers (HCW) in the last four weeks using patient facing health care workers as the numerator / population's case prevalence. High HCW ratios are found in Southwest.

Rank	Zip Code	Name	Size
1	24277	Pennington Gap	50
2	23413	Nassawadox	70
3	24091	Floyd	74
4	24319	Chilhowie	98
5	24228	Clintwood	102
6	24263	Jonesville	105
7	24526	Big Island	117
8	23410	Melfa	118
9	24314	Bastian	130
10	24102	Henry	140

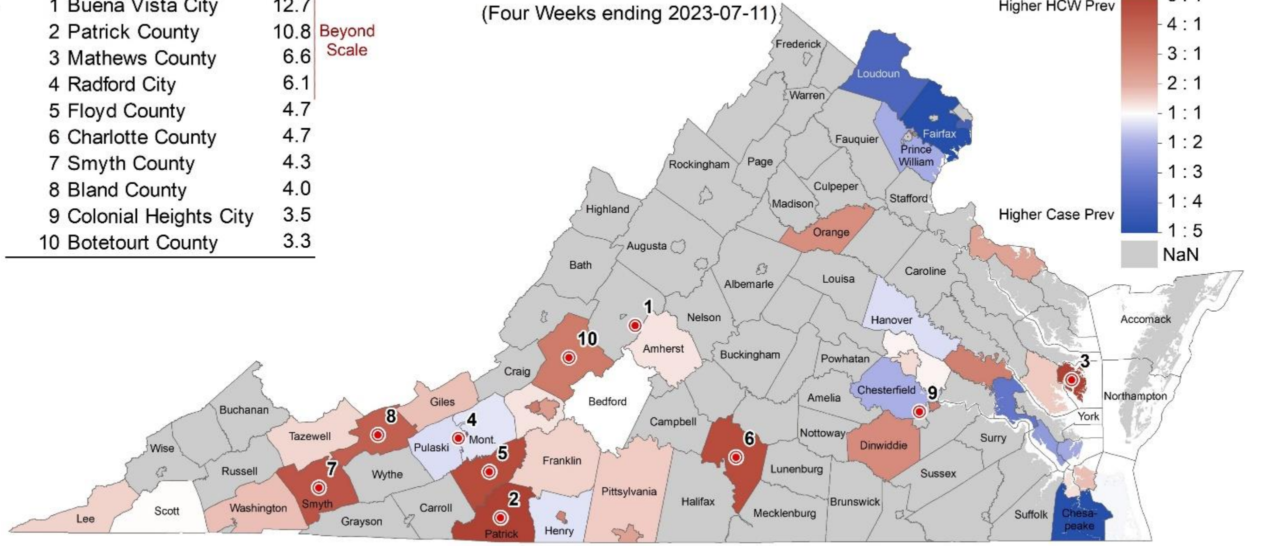
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence, with an 8:1 ascertainment ratio, for four weeks ending 2023-07-11.

Rank	Name	Ratio
1	Buena Vista City	12.7
2	Patrick County	10.8
3	Mathews County	6.6
4	Radford City	6.1
5	Floyd County	4.7
6	Charlotte County	4.7
7	Smyth County	4.3
8	Bland County	4.0
9	Colonial Heights City	3.5
10	Botetourt County	3.3

Beyond Scale



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

Current Hot-Spots

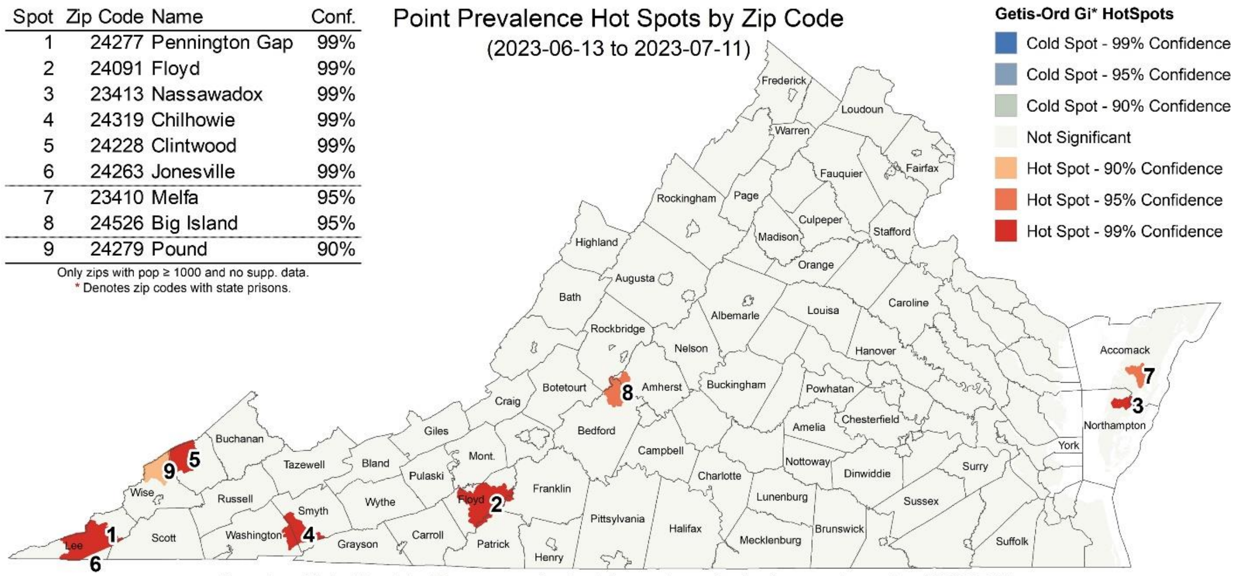
Case rates that are significantly different from neighboring areas or model projections

- **Spatial**: Getis-Ord Gi* based hot spots compare clusters of zip codes with four-week case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations
- **Temporal**: The cumulative case rate (per 100K) projected in March compared to those observed by county, which highlights temporal fluctuations that differ from the model's projections.
- Spatial hotspots were found in the Southwest and Eastern Shore. Model overpredictions seen in Southside, New River and Crater. Lenowisco saw more cases than expected. Overall error was ~4.1% since March.

Spatial Hotspots

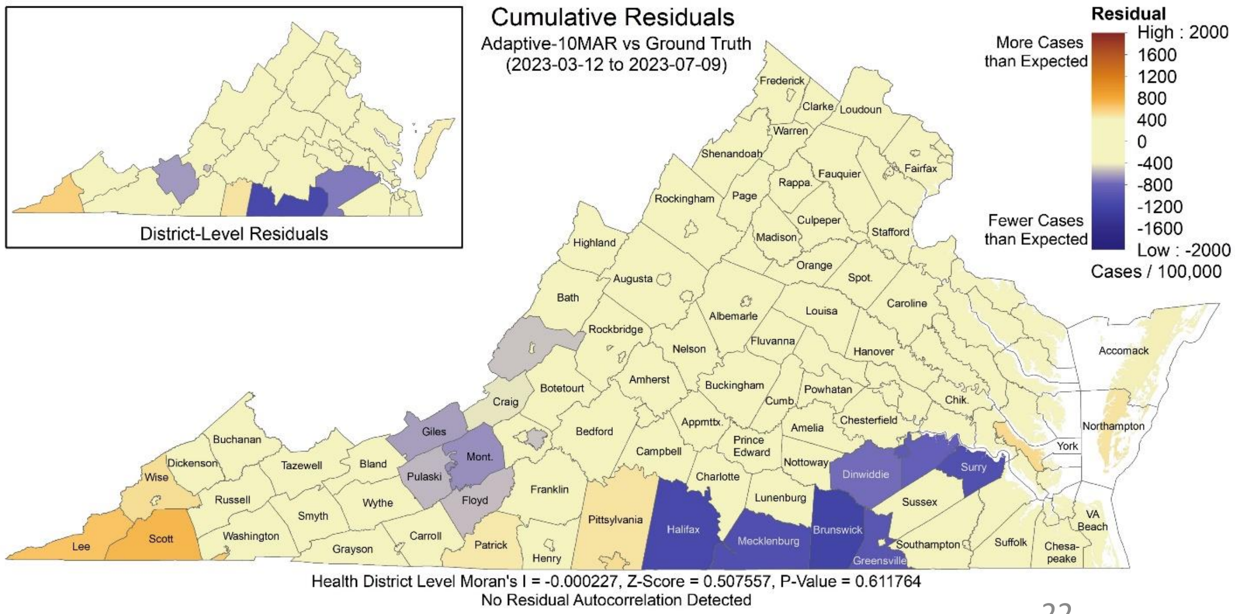
Spot	Zip Code	Name	Conf.
1	24277	Pennington Gap	99%
2	24091	Floyd	99%
3	23413	Nassawadox	99%
4	24319	Chilhowie	99%
5	24228	Clintwood	99%
6	24263	Jonesville	99%
7	23410	Melfa	95%
8	24526	Big Island	95%
9	24279	Pound	90%

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



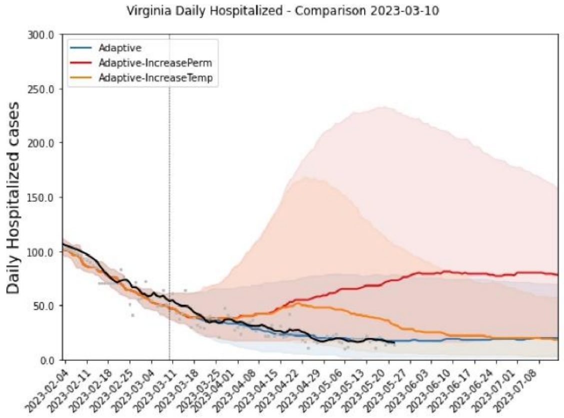
Based on Global Empirical Bayes smoothed point prevalence for the four weeks ending 2023-07-11.

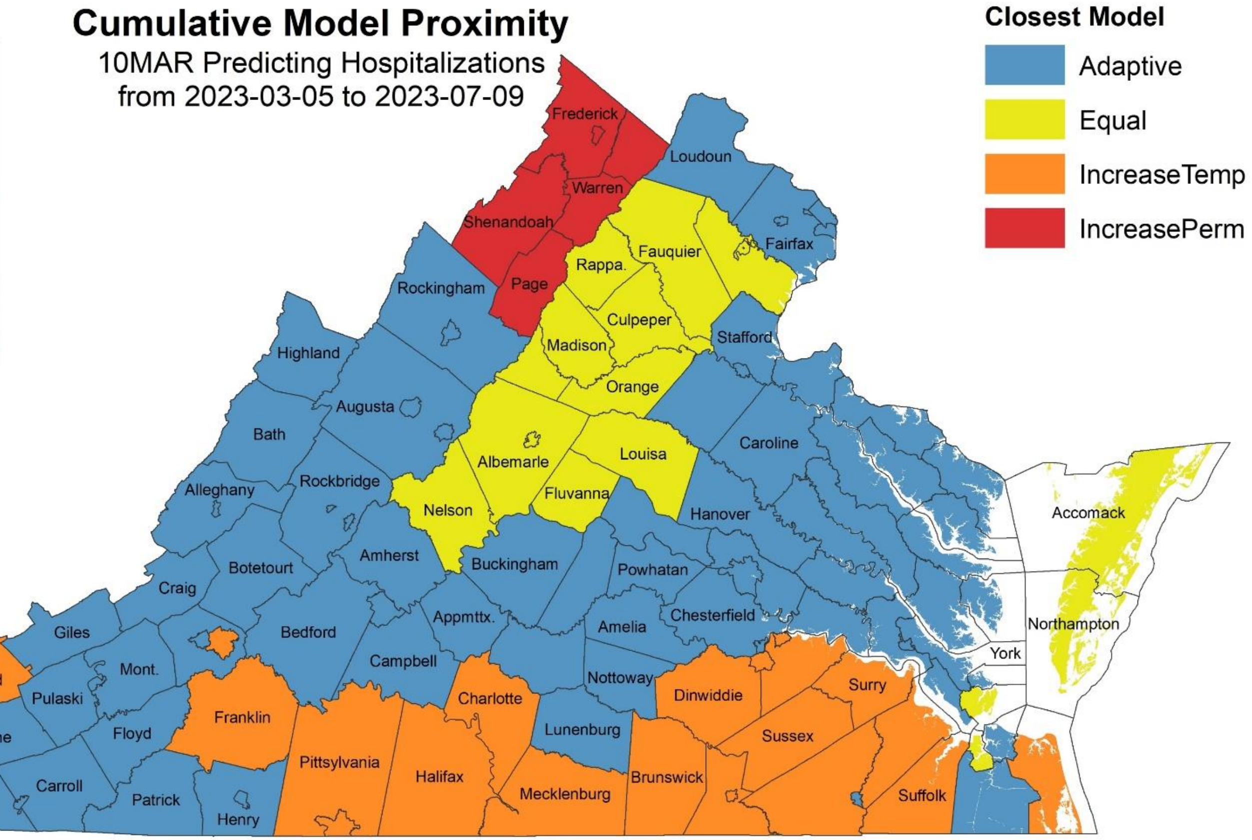
Clustered Temporal Hotspots



Hospitalization Scenario Trajectory Tracking

Which scenario from three months ago did each county track closest?



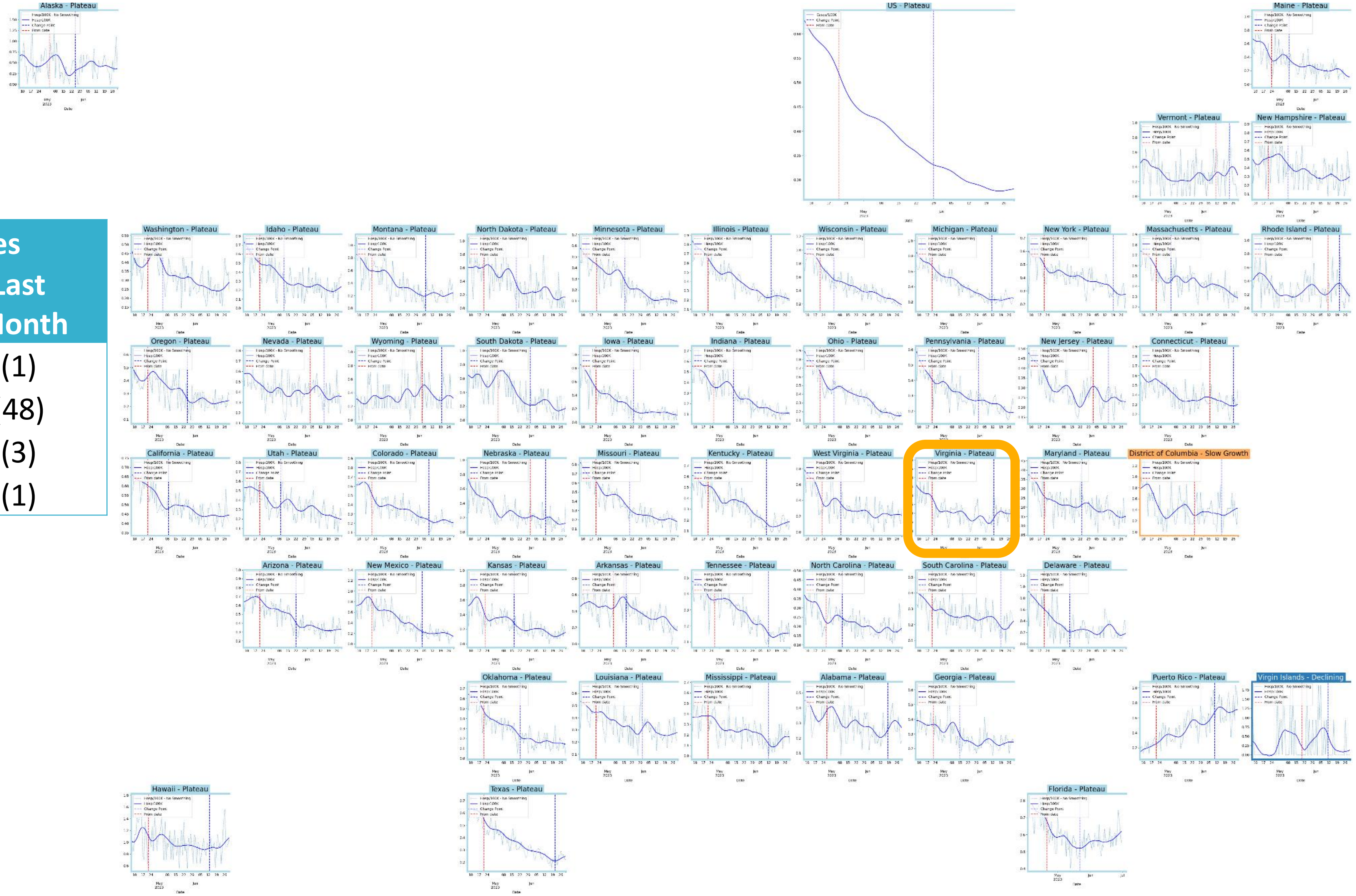


- The counties south of Richmond are now tracking the IncreasedTemp scenario closer than the Adaptive scenario. Last month they tracked both scenarios equally.
- Smyth County is now tracking IncreasedPerm more closely (previously IncreasedTemp).
- Other areas of the Commonwealth are largely the same as last reported, mostly tracking Adaptive.

COVID-19 Broader Context

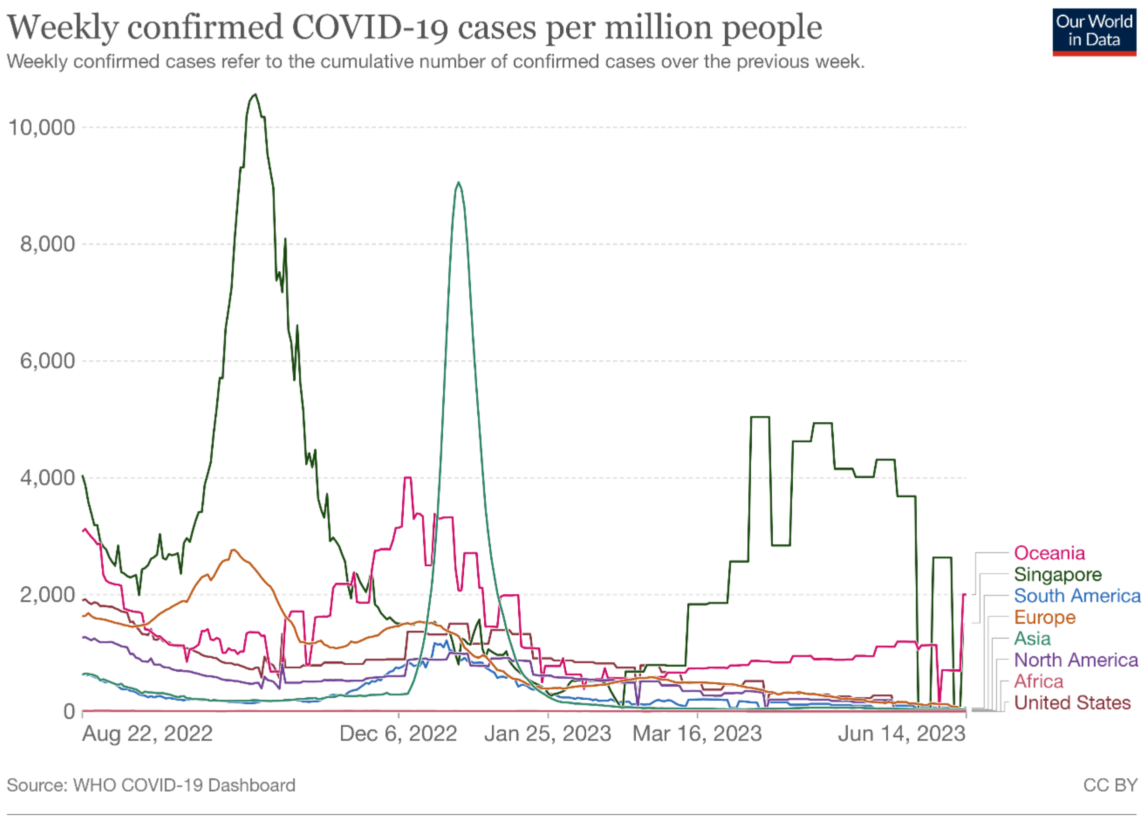
United States Hospitalizations

Status	Number of States Current Week	Number of States Last Month
Declining	1	(1)
Plateau	51	(48)
Slow Growth	1	(3)
In Surge	0	(1)

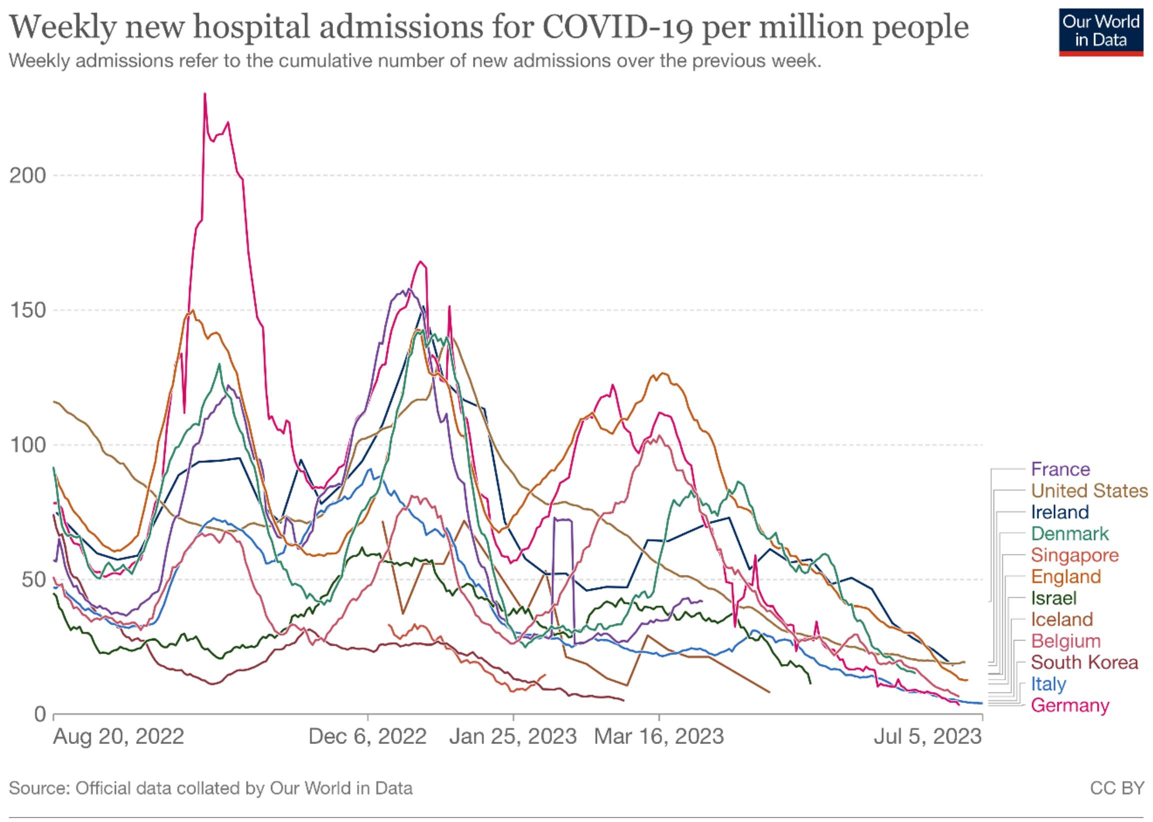


Around the World – Various trajectories

Confirmed cases



Hospitalizations



Our World in Data [Our World in Data](#)

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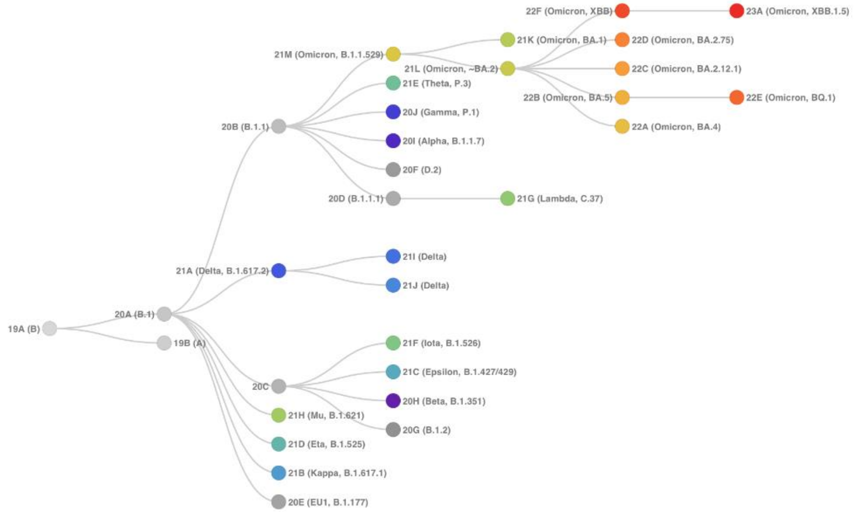
COVID-19 Genomic Update

SARS-CoV2 Variants of Concern



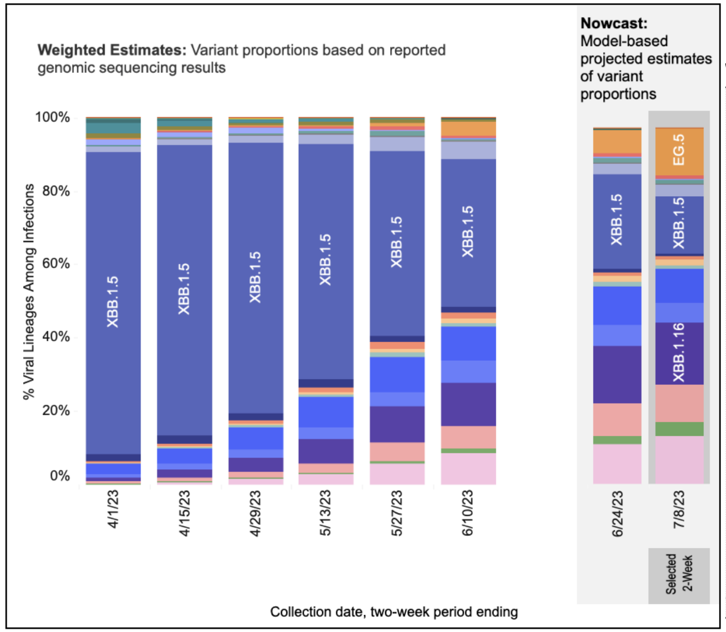
https://clades.nextstrain.org

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

Weighted and Nowcast Estimates in United States for 2-Week Periods in 3/19/2023 – 7/8/2023

Hover over (or tap in mobile) any lineage of interest to see the amount of uncertainty in that lineage's estimate.



Nowcast Estimates in United States for 6/25/2023 – 7/8/2023

USA

WHO label	Lineage #	%Total	95%PI
Omicron	XBB.2.3	13.4%	11.3-15.8%
	XBB.1.9.2	5.6%	4.0-7.7%
	XBB.1.9.1	9.4%	8.1-10.9%
	XBB.1.5.68	1.0%	0.6-1.9%
	XBB.1.5.59	1.6%	1.0-2.6%
	XBB.1.5.10	0.8%	0.4-1.5%
	XBB.1.5.1	0.7%	0.5-1.0%
	XBB.1.5	16.1%	13.8-18.6%
	XBB.1.16.6	4.1%	2.0-7.9%
	XBB.1.16.1	10.4%	8.4-12.8%
	XBB.1.16	17.5%	15.2-20.0%
	XBB	3.6%	2.5-5.1%
	FE.1.1	1.3%	0.6-2.7%
	FD.2	0.1%	0.1-0.3%
	EU.1.1	1.1%	0.6-1.7%
	EG.5	13.0%	7.5-21.1%
	CH.1.1	0.2%	0.1-0.4%
	BQ.1.1	0.0%	0.0-0.0%
	BQ.1	0.0%	0.0-0.0%
	BN.1	0.0%	0.0-0.0%
	BF.7	0.0%	0.0-0.0%
	BA.5	0.0%	0.0-0.0%
	BA.2.75	0.0%	0.0-0.0%
	BA.2	0.0%	0.0-0.0%
Other	Other*	0.0%	0.0-0.1%

Omicron Updates*

- XBB.1.5.* proportions have fallen to 20%
- XBB.1.16.* has grown to 32%
- XBB.1.9.* remains steady at 15%
- XBB.2.3 continues to grow at 13.4%

*percentages are CDC NowCast Estimates

CDC Variant Tracking

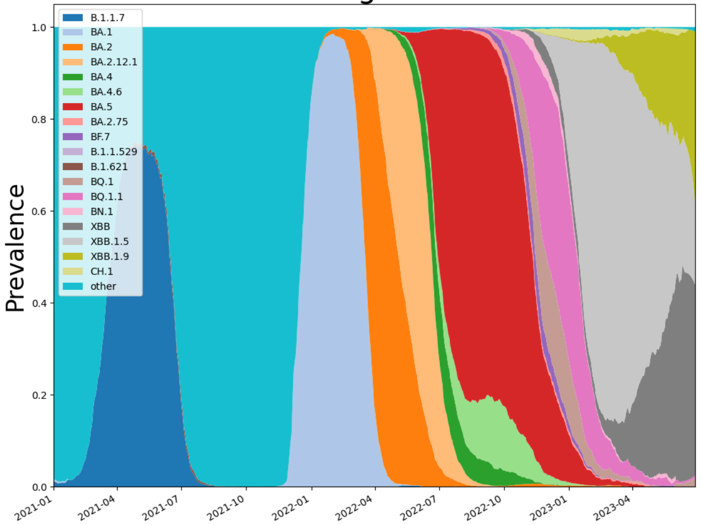
SARS-CoV2 Omicron Sub-Variants

covSPECTRUM
Enabled by data from GISAID

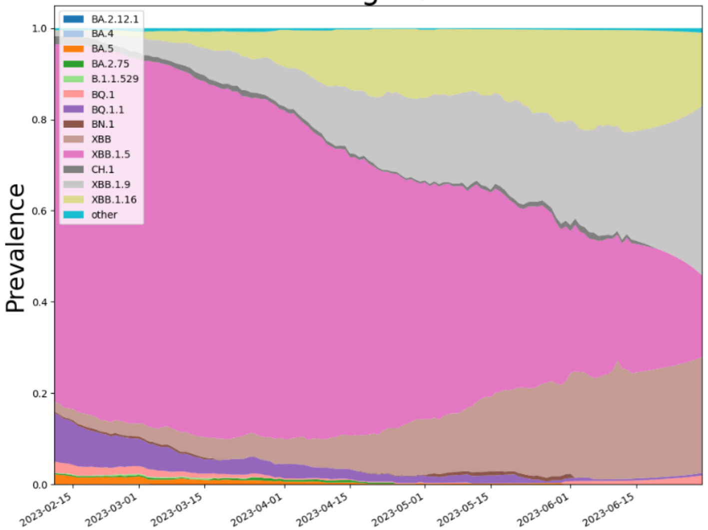
As detected in whole Genomes in public repositories

VoC Polynomial Fit Projections

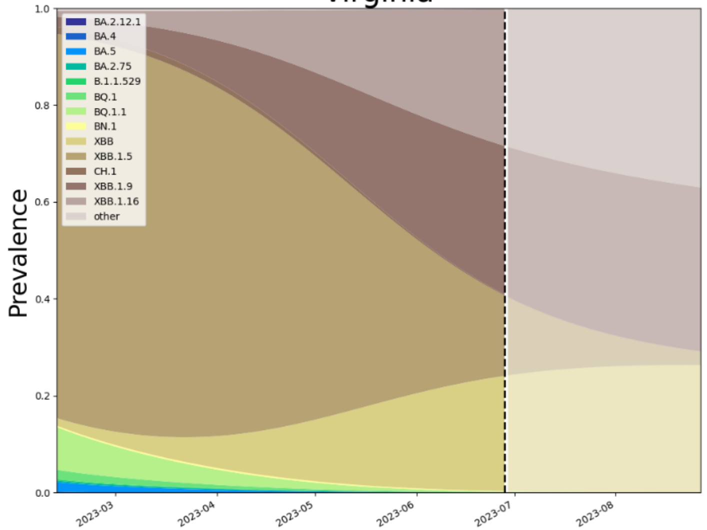
Virginia



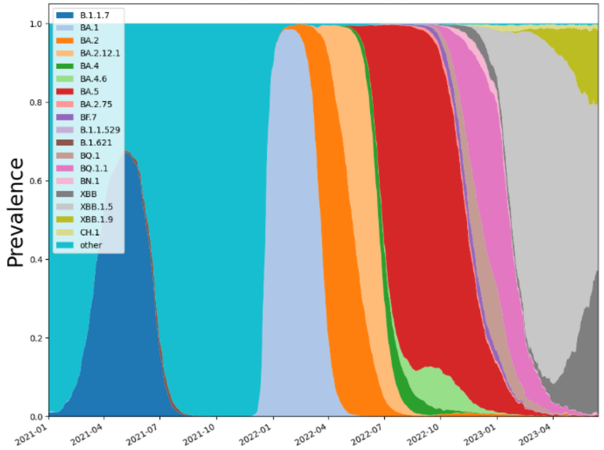
Virginia



Virginia



United States



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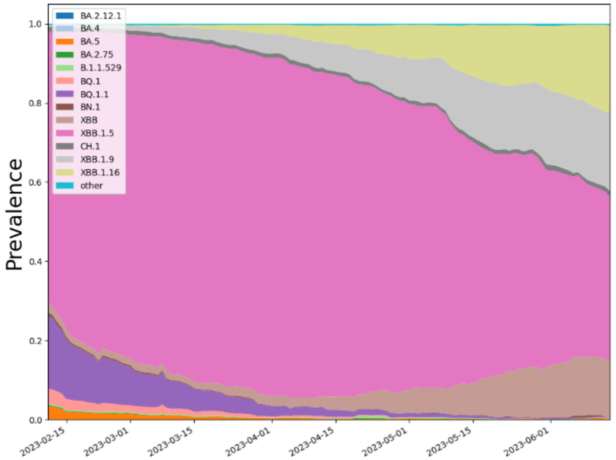
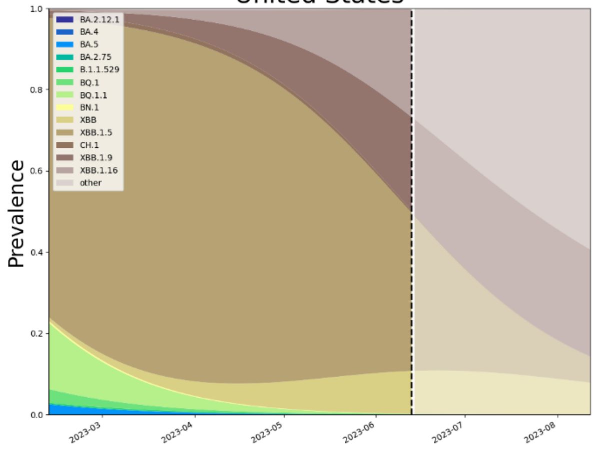


United States



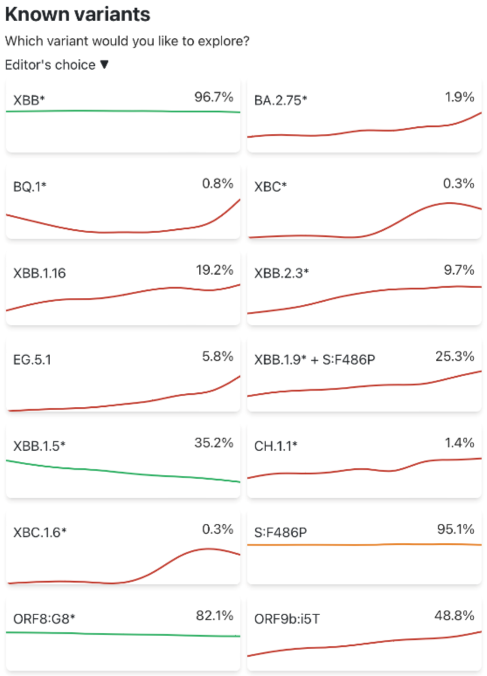
Note: Everything from dotted line forward is a projection.

SARS-CoV2 Omicron Sub-Variants

[COV-spectrum](#)

"Editor's choice"

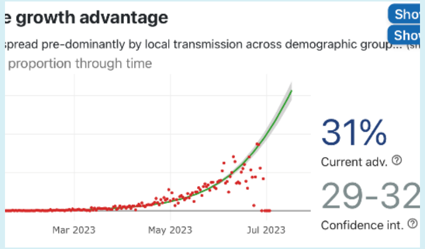
Variants to watch

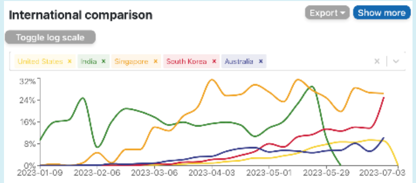


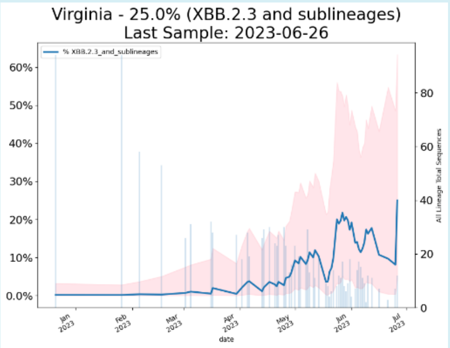
covSPECTRUM

Enabled by data from GISAID

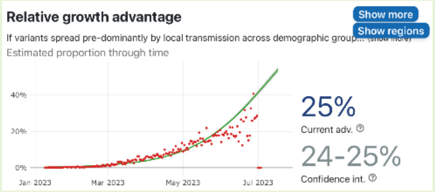
XBB.2.3*

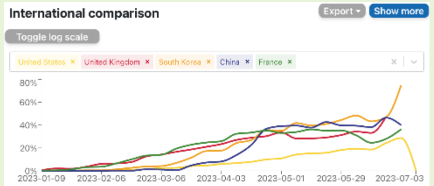


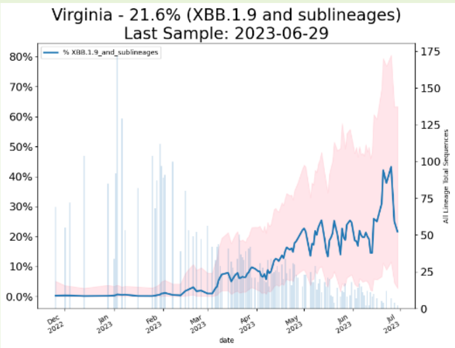




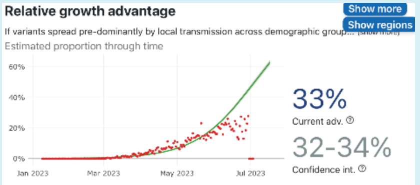
XBB.1.9*

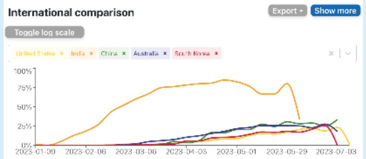


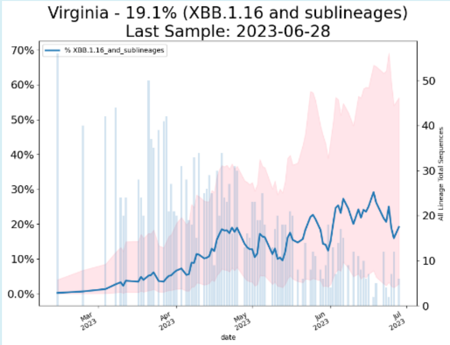




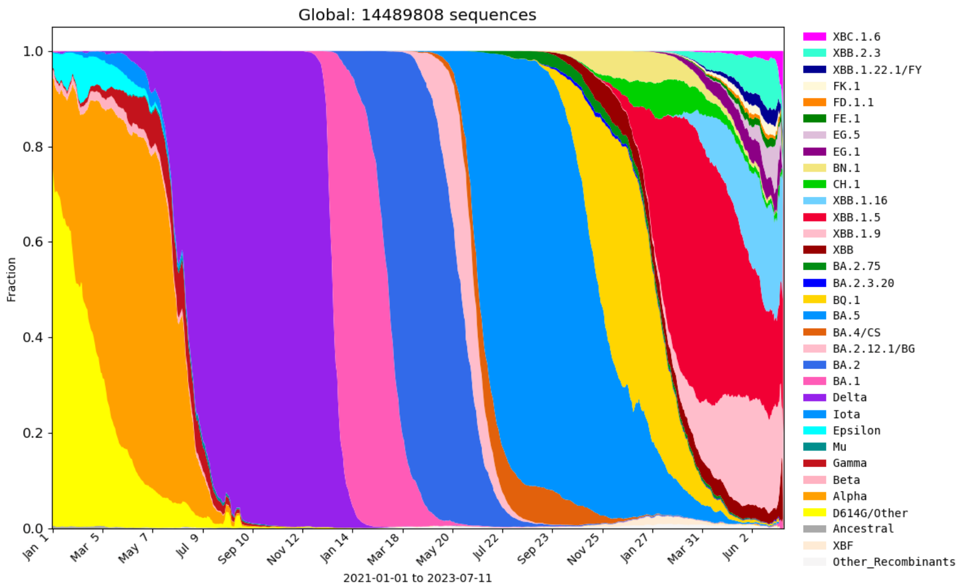
XBB.1.16*

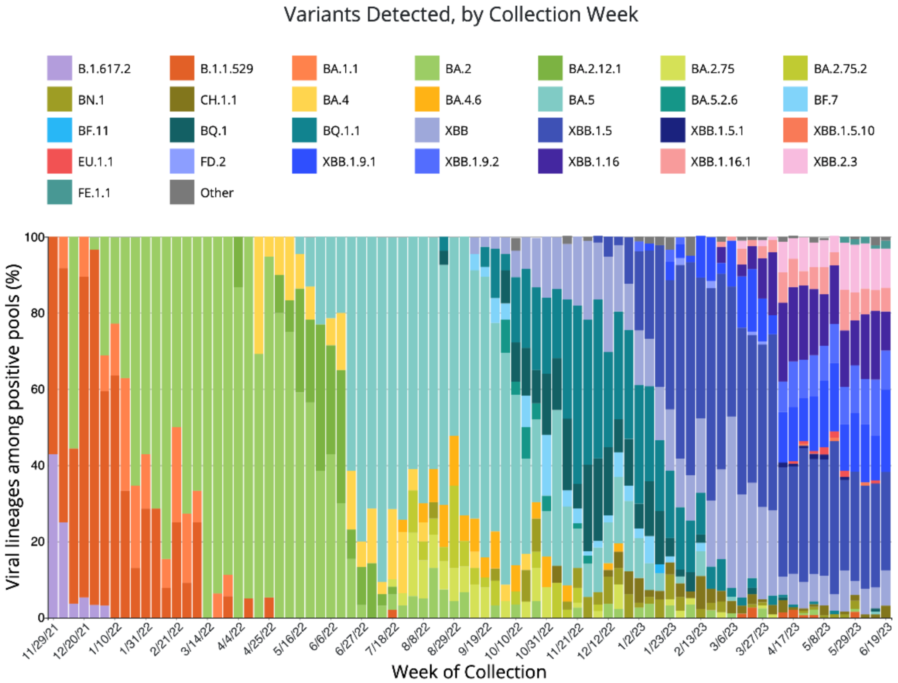


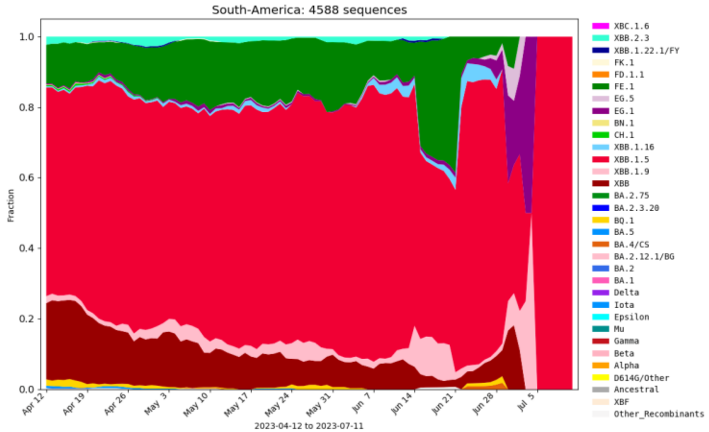


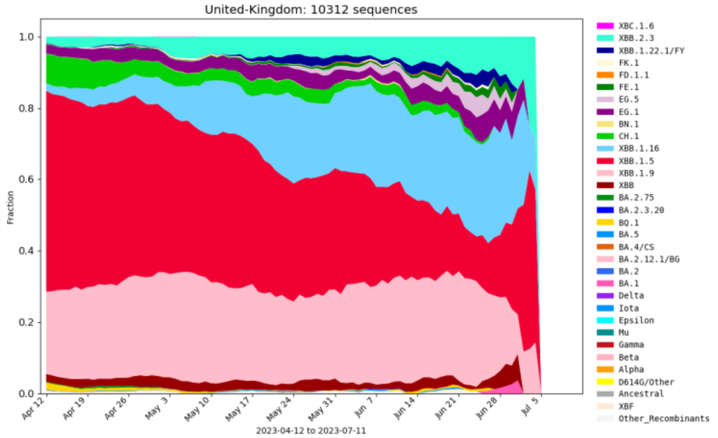


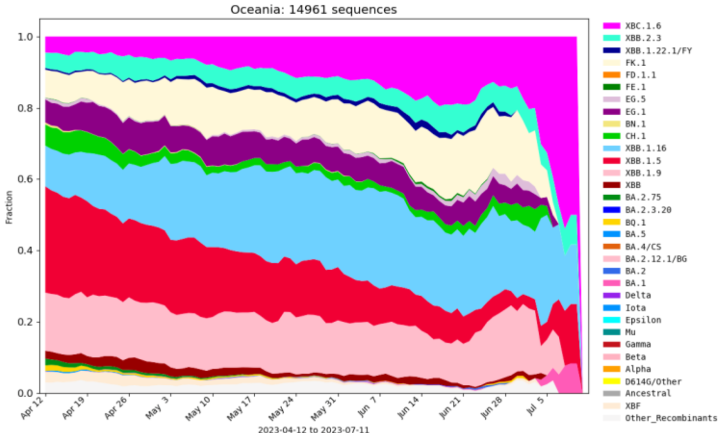
Global SARS-CoV2 Variant Status

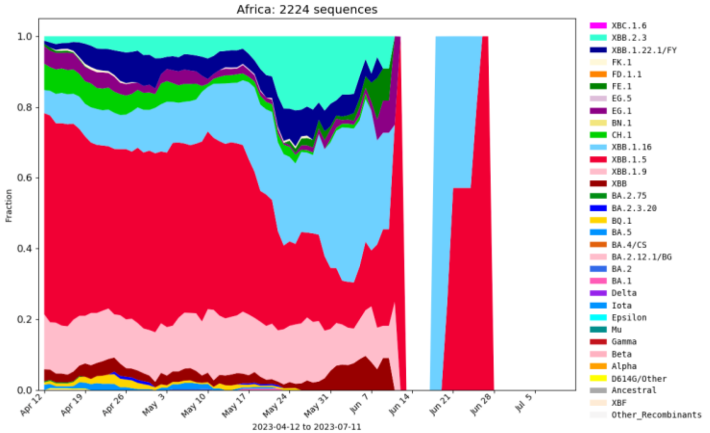


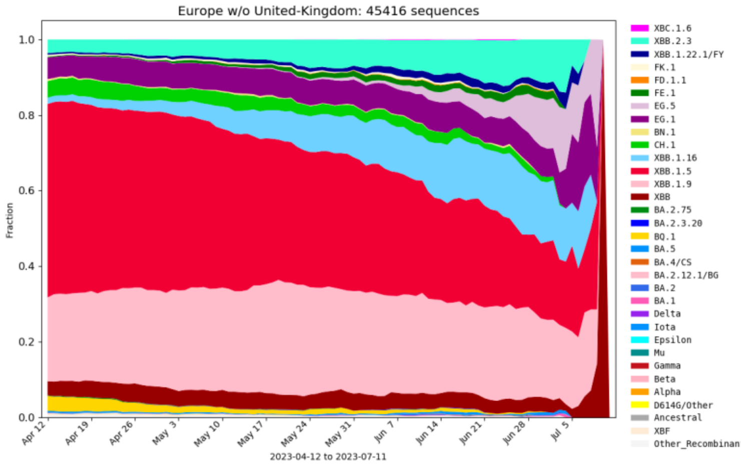


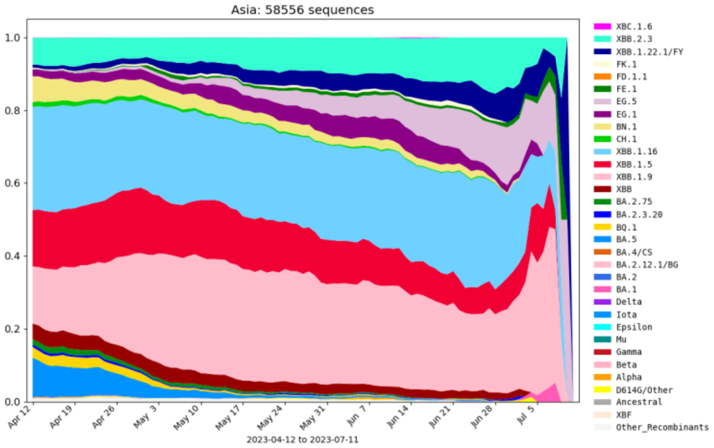








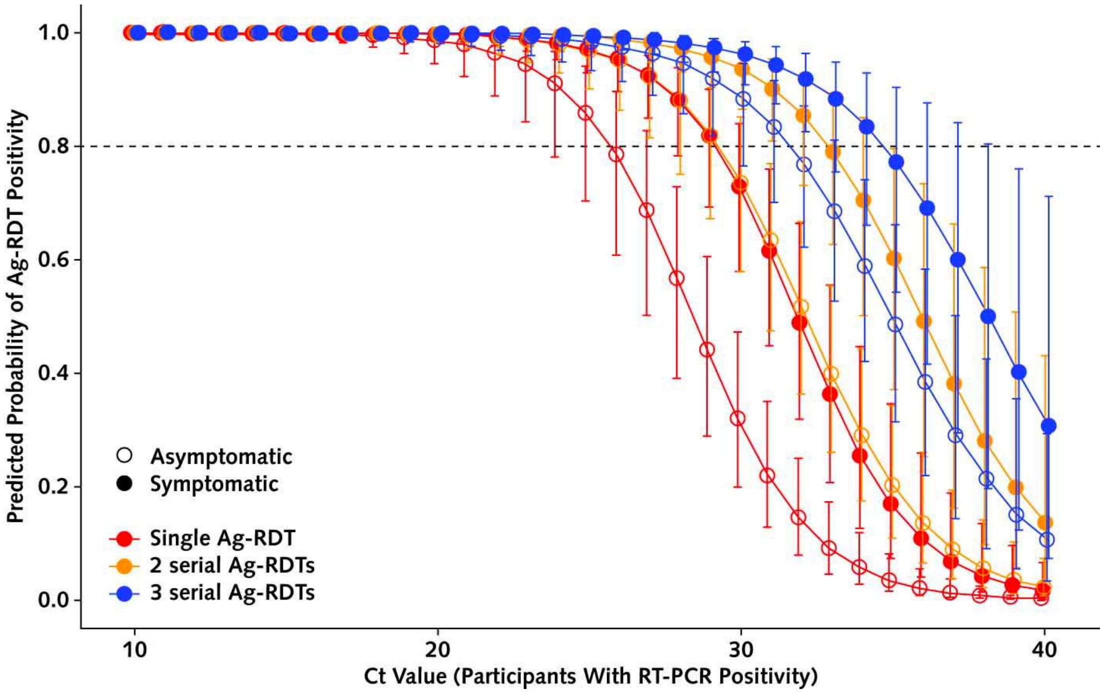


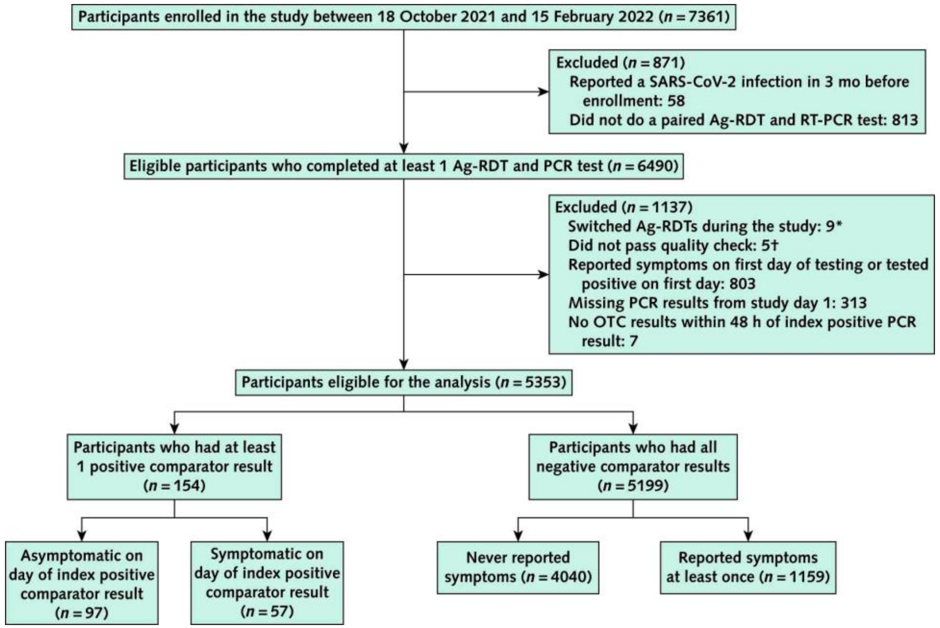


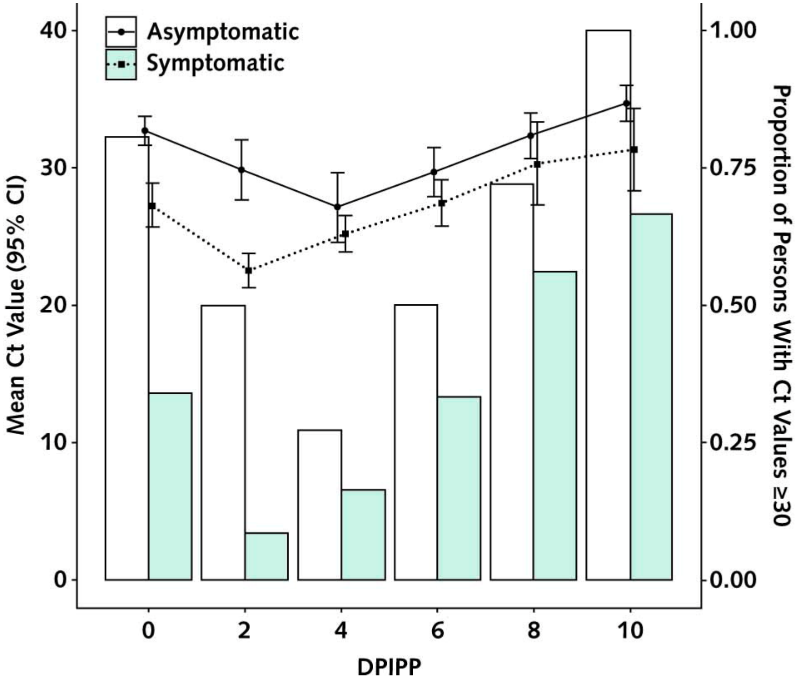
https://cov.lanl.gov/components/sequence/COV/sparks.comp
https://github.com/gerstung-lab/SARS-CoV-2-International (03/29/23)

Pandemic Pubs (July 12th, 2023)

1. Large prospective cohort study suggests use of at home antigen tests should include repeated testing. Antigen test performance was optimized when asymptomatic participants tested 3 times at 48-hour intervals and when symptomatic participants tested 2 times separated by 48 hours.



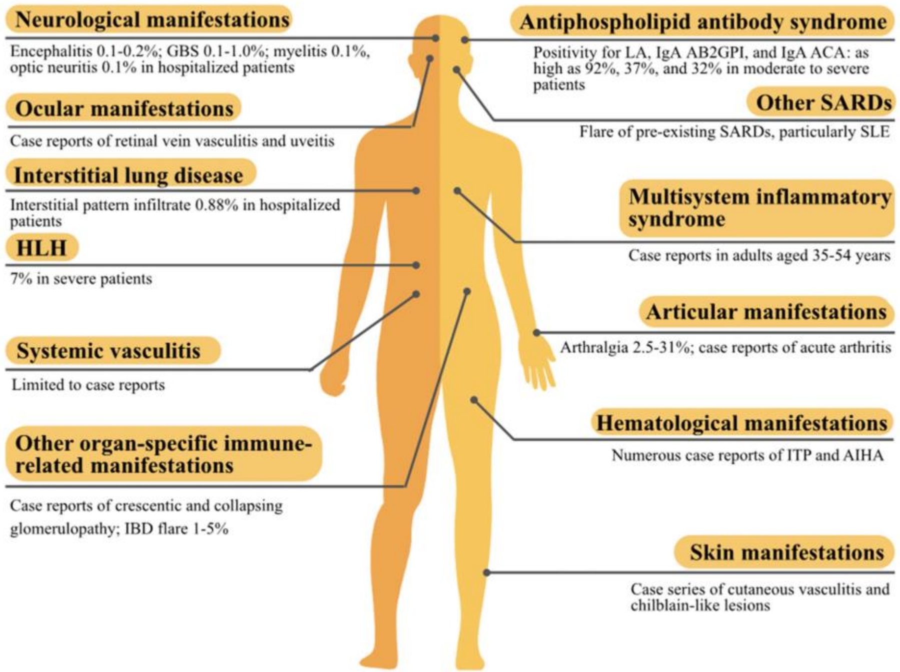




This article describes primary findings from a large study designed in coordination with the National Institutes of Health, FDA, and 3 major Ag-RDT manufacturers to evaluate the performance of serial testing using Ag-RDTs for detection of SARS-CoV-2 among asymptomatic persons within the first week of infection. Of 7361 participants in the study, 5353 who were asymptomatic and negative for SARS-CoV-2 on study day 1 were eligible. In total, 154 participants had at least 1 positive RT-PCR result. The analysis was repeated for different days past index PCR positivity (DPIPPs). Serial testing with Ag-RDTs twice 48 hours apart resulted in an aggregated sensitivity of 93.4% (95% CI, 90.4% to 95.9%) among symptomatic participants on DPIPPs 0 to 6. When singleton positive results were excluded, the aggregated sensitivity on DPIPPs 0 to 6 for 2-time serial testing among asymptomatic participants was lower at 62.7% (CI, 57.0% to 70.5%), but it improved to 79.0% (CI, 70.1% to 87.4%) with testing 3 times at 48-hour intervals.

https://www.acpjournals.org/doi/10.7326/M23-0385
via Eric Topol

Pandemic Pubs (June 8th, 2023)

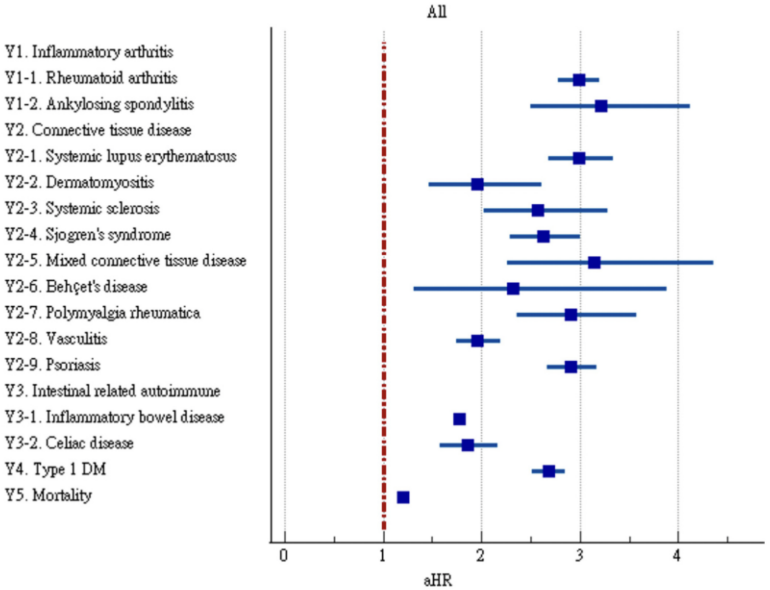


1. Several large cohort studies from three different countries indicate an increased risk (20-30%) for new auto-immune disease following COVID-19 infection. One study shows increased risk based on severity of initial infection.

Study	N with Covid	N Controls No Covid	Increased Risk of New Autoimmune Disease	Citation
US	884,463	2,926,016	19-47%*	Chang R, eClinical Medicine, 9 January 2023
Germany	641,704	1,560,357	43%	Tesch F, MedRxiv, 26 January 2023
UK	458,147	1,818,929	22%	Syed U, MedRxiv 7 October 2022

*range dependent on specific autoimmune condition, adjusted for competing risks, before this adjustment 100-200% increased risk @erictopol

Severe COVID-19 cases have demonstrated a substantial inflammatory response with pro-inflammatory cytokines and chemokines that stimulate pulmonary inflammation. As the burden of COVID-19 cases increases worldwide, so does our understanding of the condition. Owing to worldwide vaccination efforts, mortality due to COVID-19 has been decreasing, but we continue to witness considerable morbidity and increased rates of post-COVID-19 conditions and in particular, new-onset autoimmune and inflammatory diseases in individuals who have had COVID-19. The range and incidence of these post-COVID-19 disorders have now been highlighted in two large retrospective cohort studies.



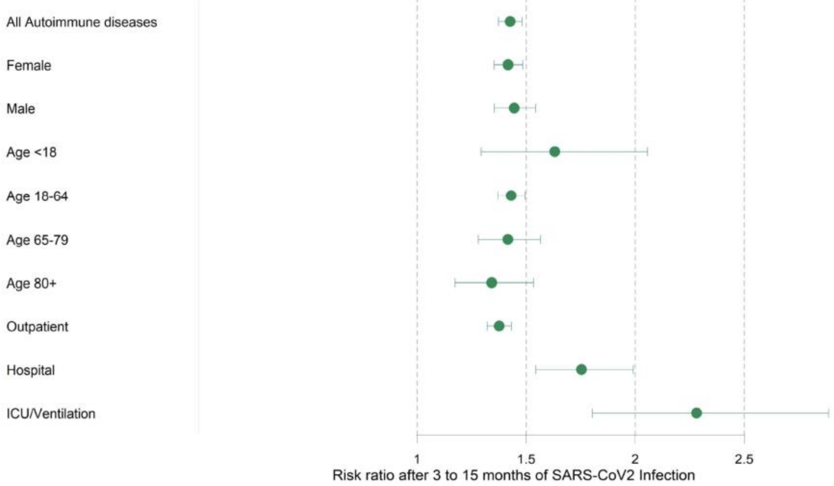
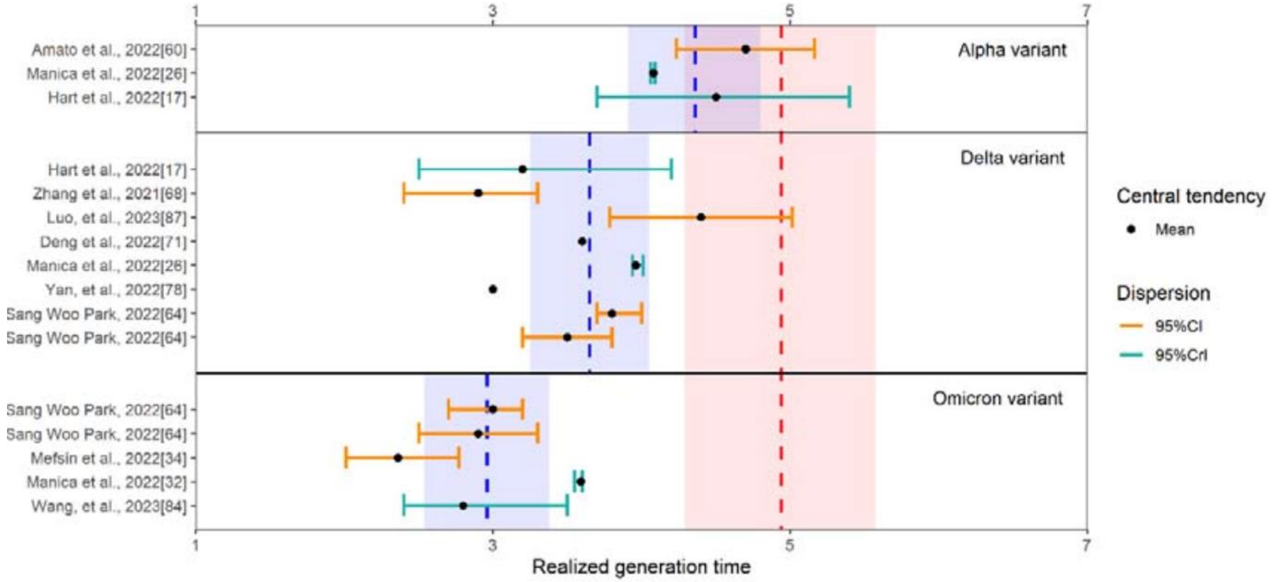


Figure 2 Forest plot comparing incident rate ratios for any first-onset autoimmune disease 3 to 15 months after SARS-CoV-2 infection by subgroup. The severity of COVID-19 was operationalized as only outpatient care, usual hospital care and ICU/ventilation-intensive care unit and mechanical ventilation.

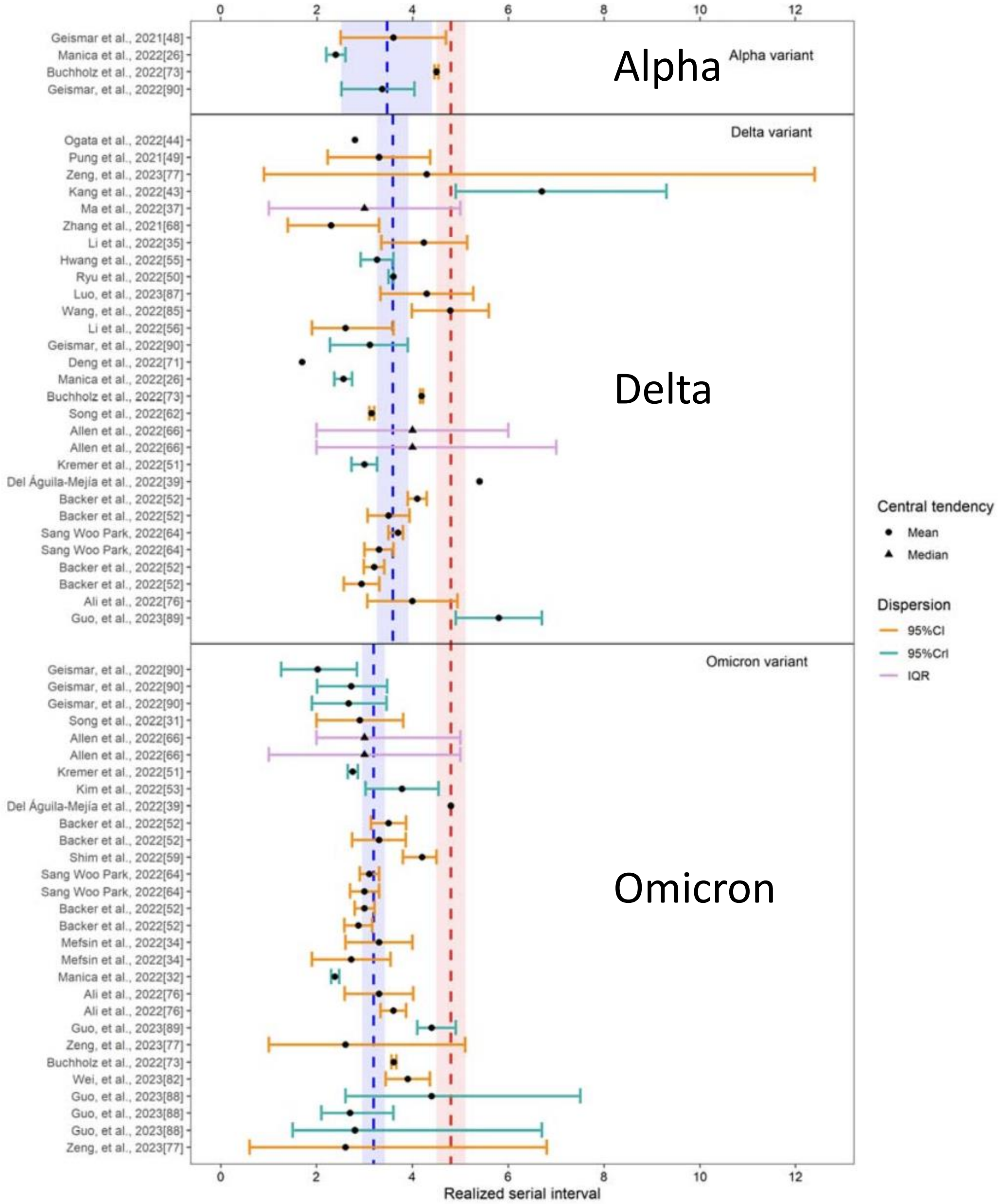
[Nature Reviews Rheumatology](https://www.nature.com/articles/s41584-023-00964-y)
https://www.nature.com/articles/s41584-023-00964-y
via [Eric Topol]()

Pandemic Pubs (May 25th, 2023)

1. Meta-analysis derived pool of many household or contact tracing studies with well observed case series to further quantify the shortening of incubation and serial interval (time between infections) over time during the pandemic and across variants. Omicron's serial interval is shorter than Delta which was similar to Alpha.



Omicron had the shortest pooled estimates for the incubation period (3.63 days, 95%CI: 3.25-4.02 days), serial interval (3.19 days, 95%CI: 2.95-3.43 days), and realized generation time (2.96 days, 95%CI: 2.54-3.38 days) whereas the ancestral lineage had the highest pooled estimates for each of them . We found considerable heterogeneities (I2 > 80%) when pooling the estimates across different virus lineages, indicating potential unmeasured confounding from population factors (e.g., social behavior, deployed interventions).



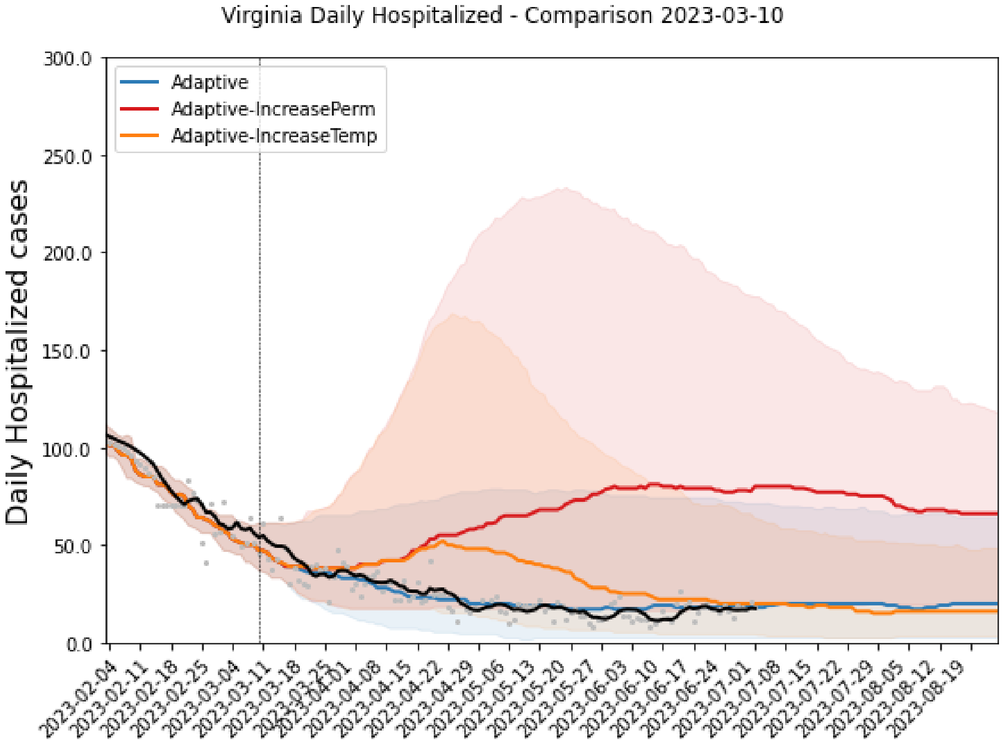
[MedRxiv](https://www.medrxiv.org/content/10.1101/2023.05.19.23290208v1)
https://www.medrxiv.org/content/10.1101/2023.05.19.23290208v1

Model Results

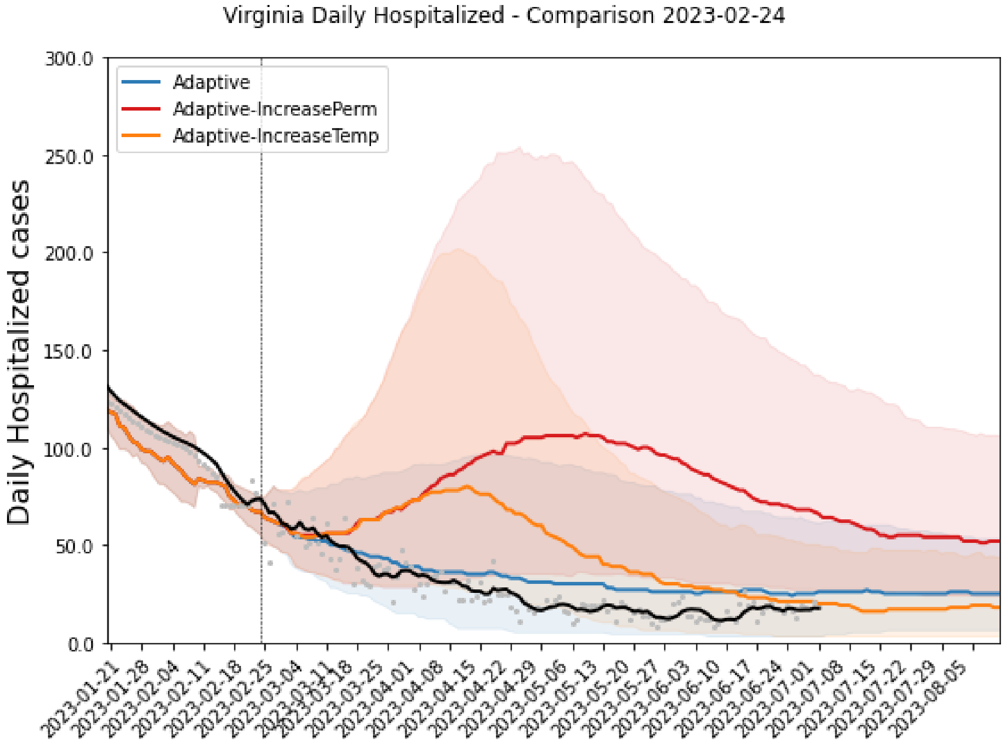
Past projections – Hospitalizations

- Previous projections remain on target with recent observations
- Past 14 weeks have stayed steady and indicate possibility of slight upward trend in coming weeks

Previous round – 14 weeks ago



Previous round – 16 weeks ago



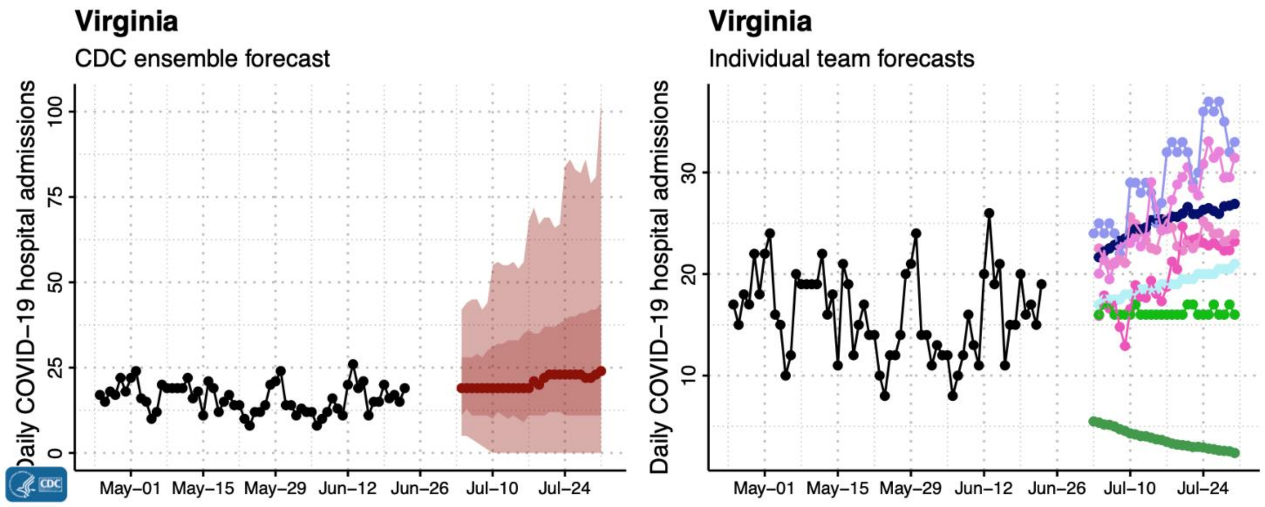
National Modeling Hub Updates

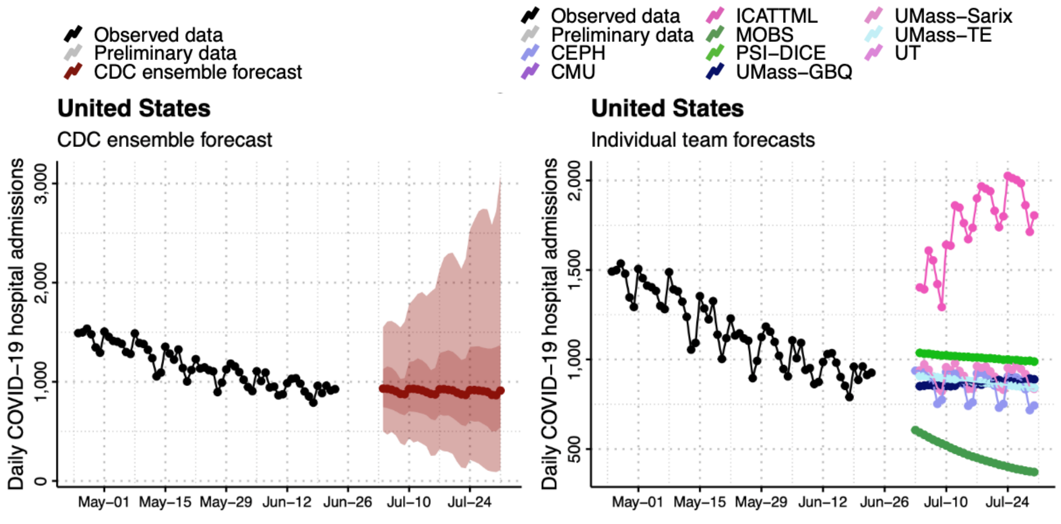
Current COVID-19 Hospitalization Forecast

Statistical models for submitting to CDC COVID Forecasting Hub

- 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 COVID-19 and Forecast for next 4 weeks (CDC COVID Ensemble)





Scenario Modeling Hub – COVID-19 (Round 17)

Collaboration of multiple academic teams to provide national and state-by-state level projections for 6 aligned scenarios

https://covid19scenariomodelinghub.org/viz.html

- Preliminary Results
- Round Designed to explore different seasonal vaccination levels and the impact of Immune Escape

Scenario Dimensions:

Immune Escape (IE):

Slower IE (20%/yr) vs.
Faster IE (50%/yr)

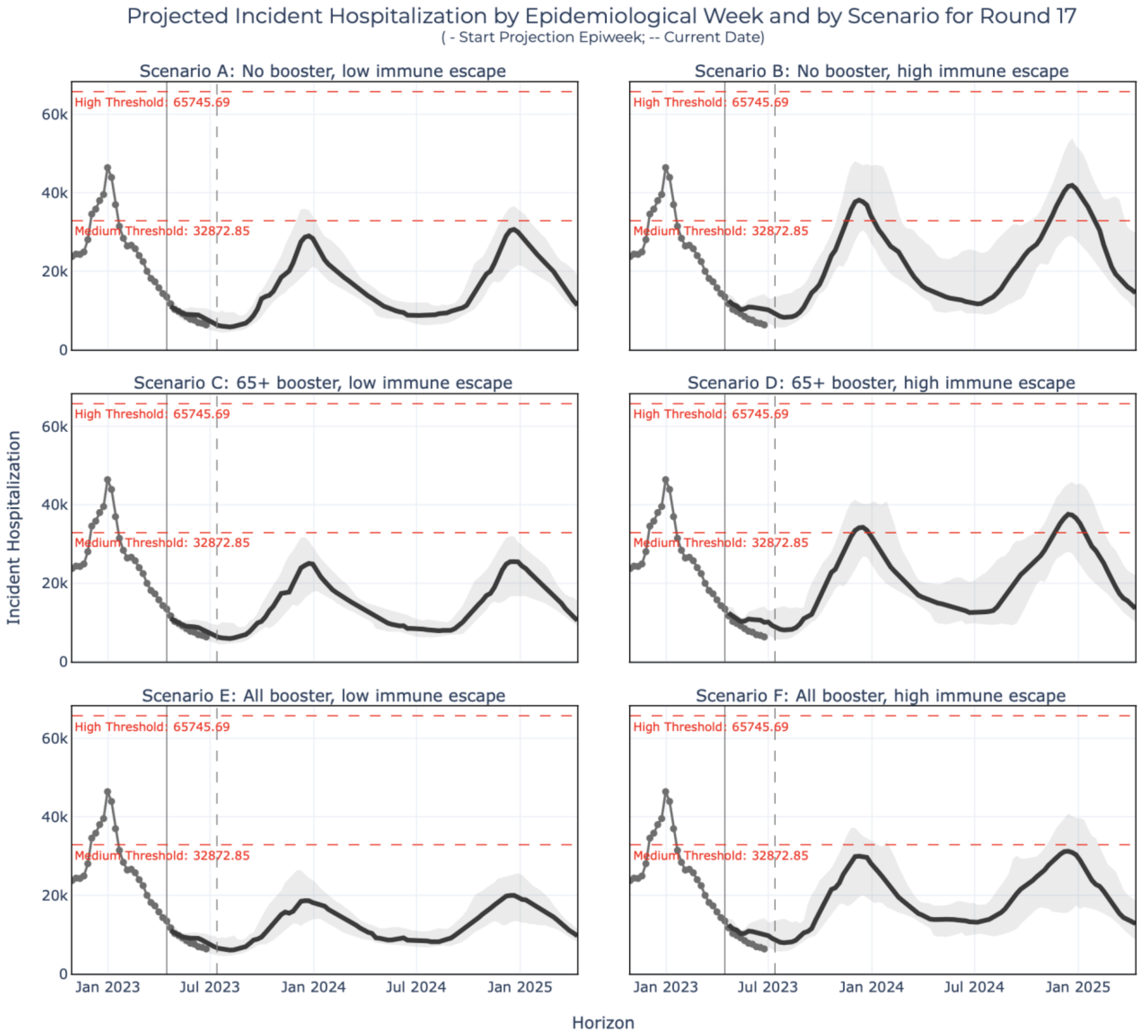
Vaccination levels:

None vs.
Vulnerable and 65 + vs.
Broader population of eligible

	Low immune escape • Immune escape occurs at a constant rate of **20% per year**	**High immune escape** • Immune escape occurs at a constant rate of **50% per year**
No vaccine recommendation • Uptake negligible or continues at very slow levels based on existing 2022 booster trends	Scenario A	Scenario B
Reformulated annual vaccination recommended for 65+ and immunocompromised • Reformulated vaccine has **65% VE against variants circulating on June 15** • Vaccine becomes **available September 1** • Uptake in 65+ same as first booster dose recommended in September 2021 • Uptake in individuals under 65 negligible or continues to trickle based on 2022 booster trends	Scenario C	Scenario D
Reformulated annual vaccination recommended for all currently eligible groups • Reformulated vaccine has **65% VE against variants circulating on June 15** • Vaccine becomes **available September 1** • 65+ uptake same as first booster dose recommended in September 2021 • Coverage in individuals under 65+ saturates at levels of the 2021 booster (approximately 34% nationally)	Scenario E	Scenario F

SMH – COVID-19 (Round 17) - Results

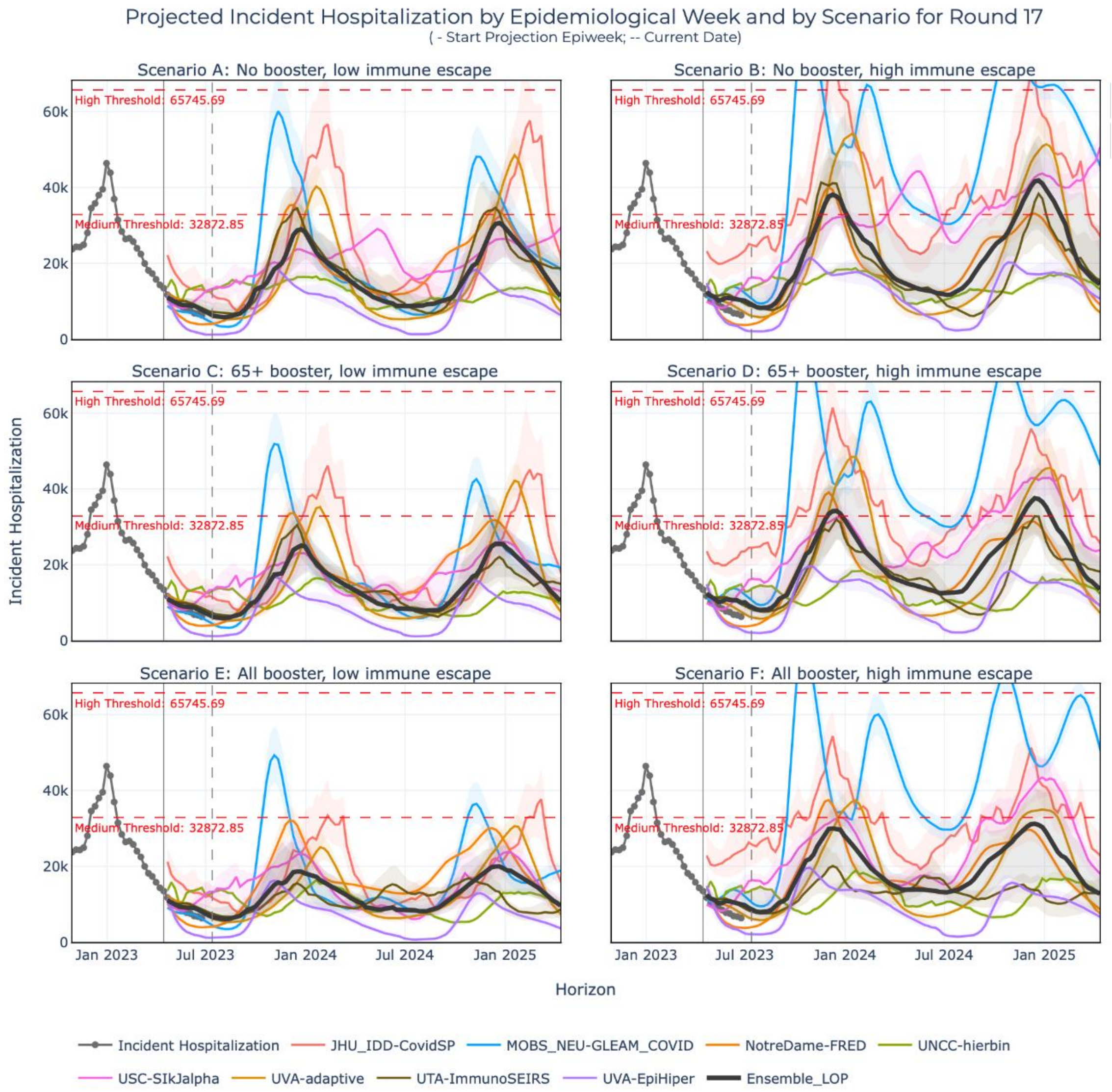
- Peak timing and size can oscillate over the longer term
- These scenarios are very unlikely to remain stable over longer term, nonetheless, some of these patterns may remain
- Scenarios with faster immune escape (dashed) converge more quickly than the slower immune escape



Slower Immune Escape (20%) Faster Immune Escape (20%)

SMH – COVID-19 (Round 17) - Results

- Faster Immune Escape leads to higher estimated seasonal peaks
- Wider booster coverage (all age groups) leads to lower peaks and overall reduction in hospitalizations and deaths
- Peak timing and size can oscillate over the longer term
- These scenarios are very unlikely to remain stable over longer term, nonetheless, some of these patterns may remain
- Not all models follow same trajectory, though the Ensemble has performed well in the past (when scenarios match what eventually happens)

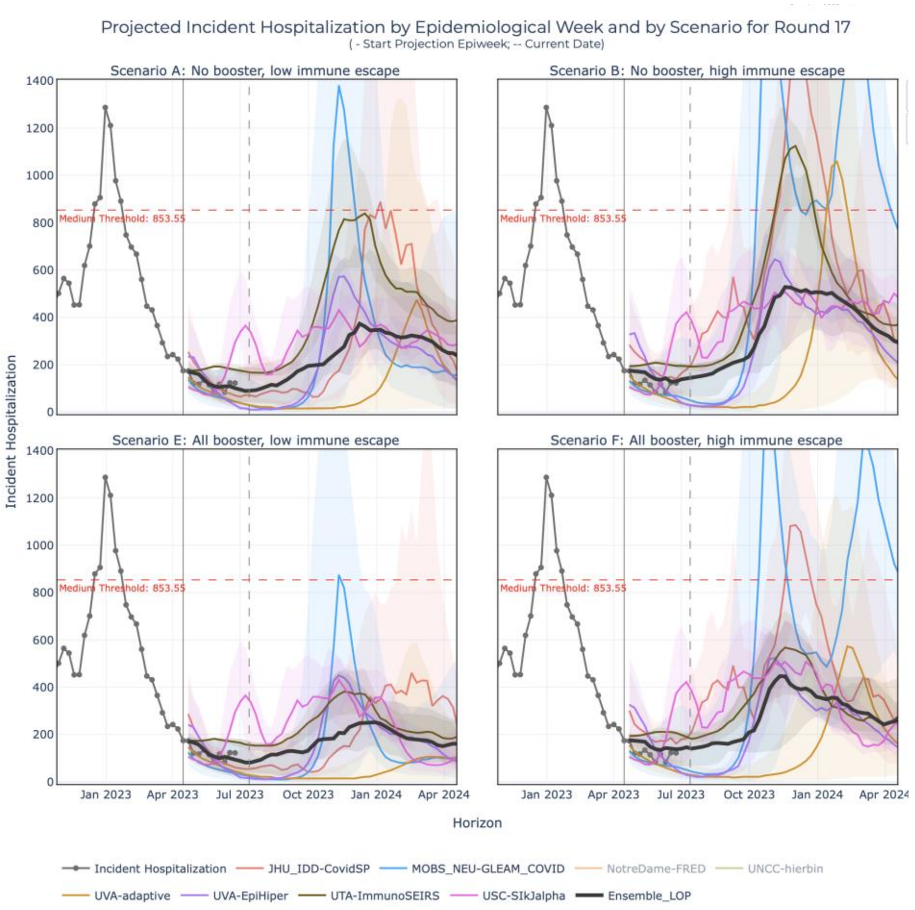


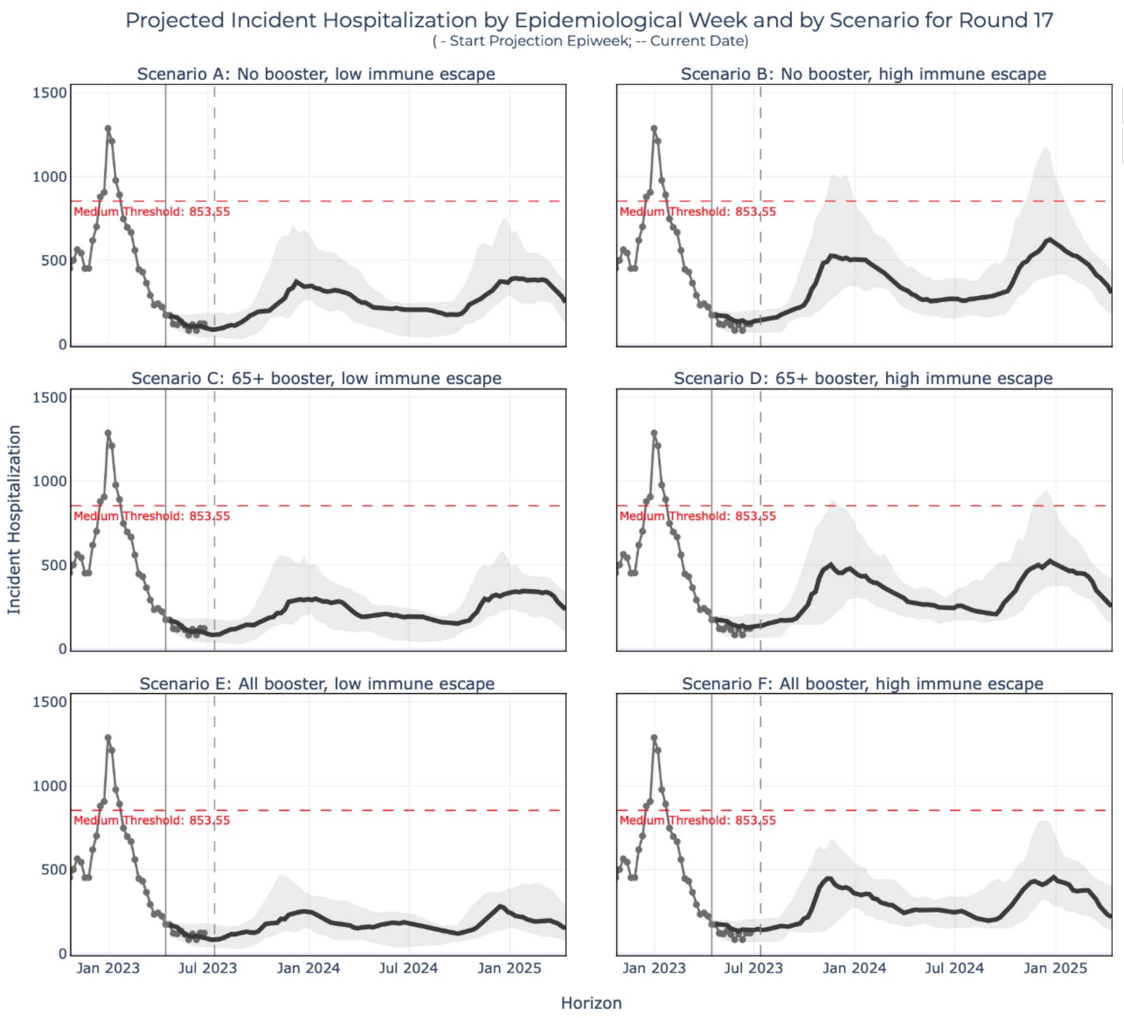
Slower Immune Escape (20%)

Faster Immune Escape (20%)

SMH – COVID-19 (Round 17) – Virginia Results

- To date, immune escape evolution has been slow. Booster campaign size remains unknown



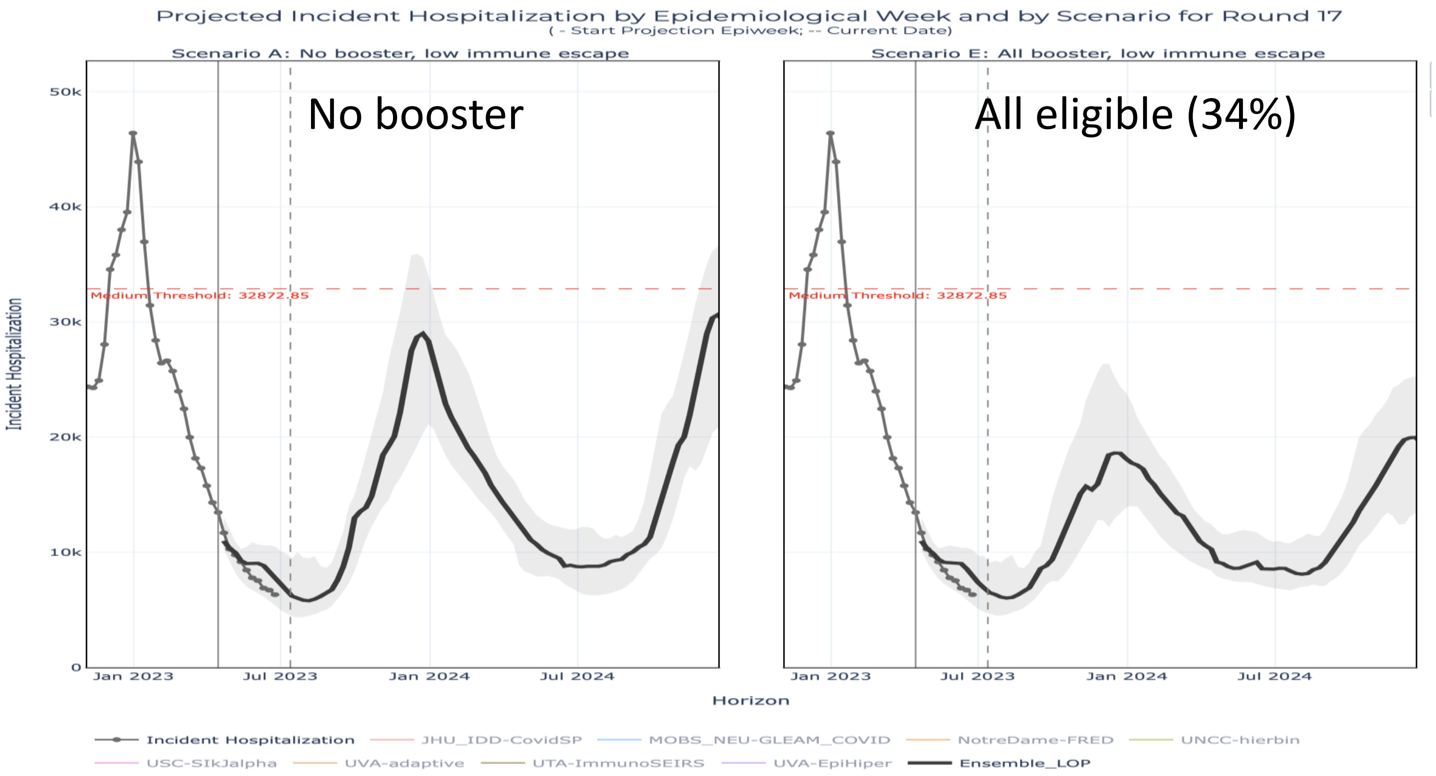


Slower Immune Escape (20%)

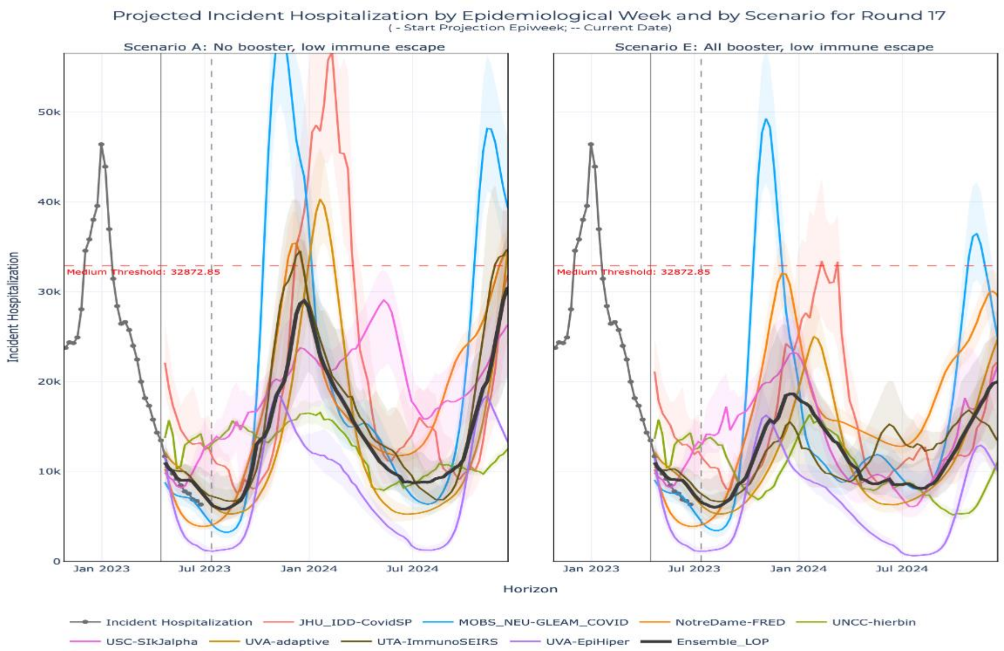
Faster Immune Escape (20%)

SMH – COVID-19 (Round 17) – Results – Booster Impact

- Comparing A and E (low immune escape, no booster vs. all eligible for booster)
  - Total booster coverage similar to last booster campaign (34% national coverage)
- Significant reductions in peak sizes



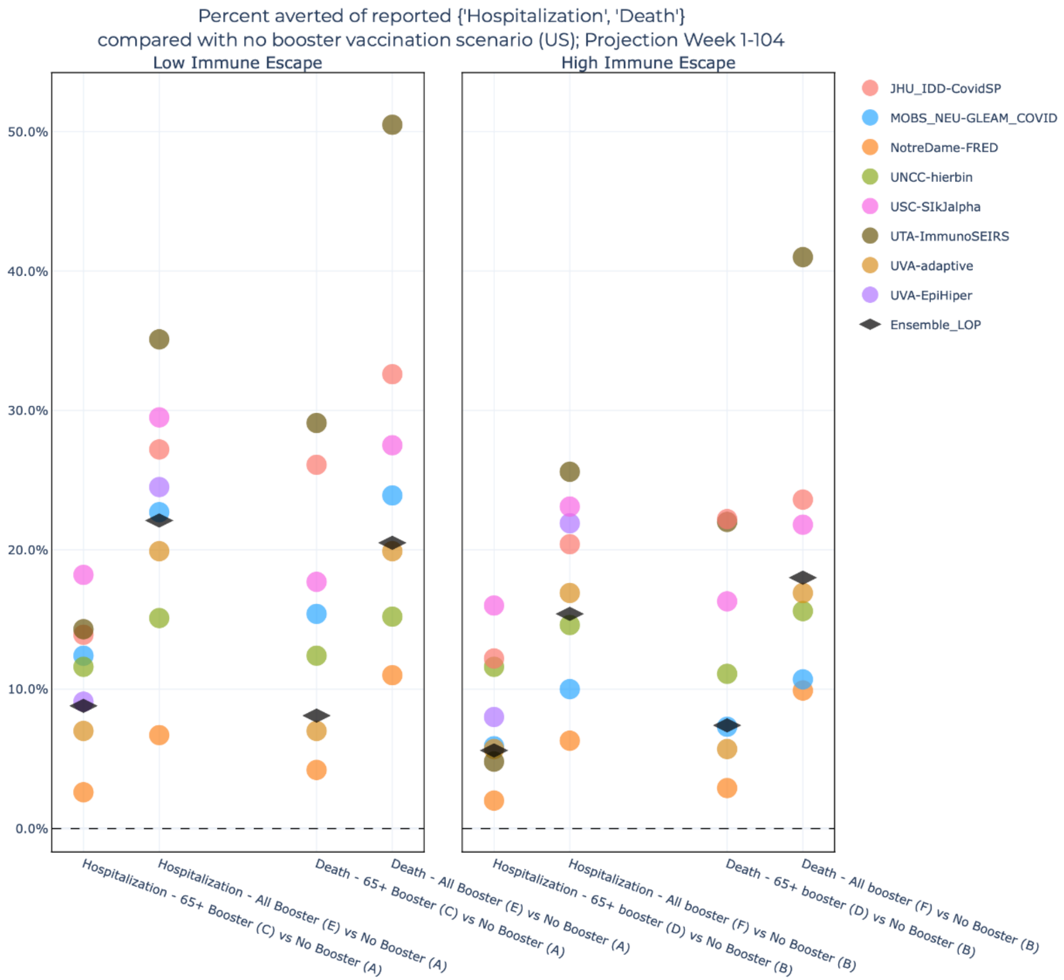
Ensemble Only



All Model Variability

SMH – COVID-19 (Round 17) – Results – Booster Impact

- Models estimate potential reduction in hospitalizations ranging from 35% - 15% for a whole population campaign and 8% - 18% for a 65+ only campaign
- Reductions in deaths are higher with ensemble estimates of 22% reduction for whole population and 18% reduction for 65+
- Reductions are smaller for the high immune escape scenarios



SPHINX Project Update

Strengthening **P**ublic **H**ealth **I**nformatics using **N**e**X**t-generation tools

CSTE OUTBREAK TOOLS PROJECT

- Project started in February 2023
- Objective: Pilot test, evaluate, and deploy analytic tools with identified partners from STLT health departments

CSTE
Council of State and Territorial Epidemiologists

Funding Opportunity Announcement:
Development of forecast, analytic, and visualization tools to improve outbreak response and support public health decision-making

UNIVERSITY of VIRGINIA
BIOCOMPLEXITY INSTITUTE


Ajay Sanjeevan


Aniruddha Adiga


Benjamin Hurt


Bryan Lewis


Gursharn Kaur


Madhav Marathe


Srini Venkatramanan

VDH VIRGINIA DEPARTMENT OF HEALTH

Foresight and Analytics,
Office of Emergency Management

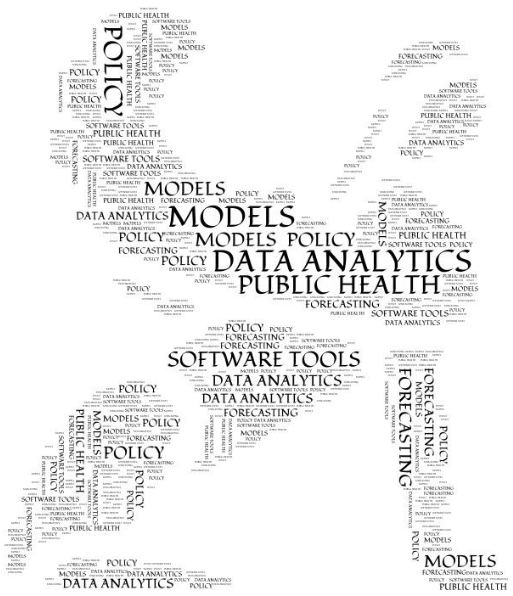
UNIVERSITY of VIRGINIA
BIOCOMPLEXITY INSTITUTE

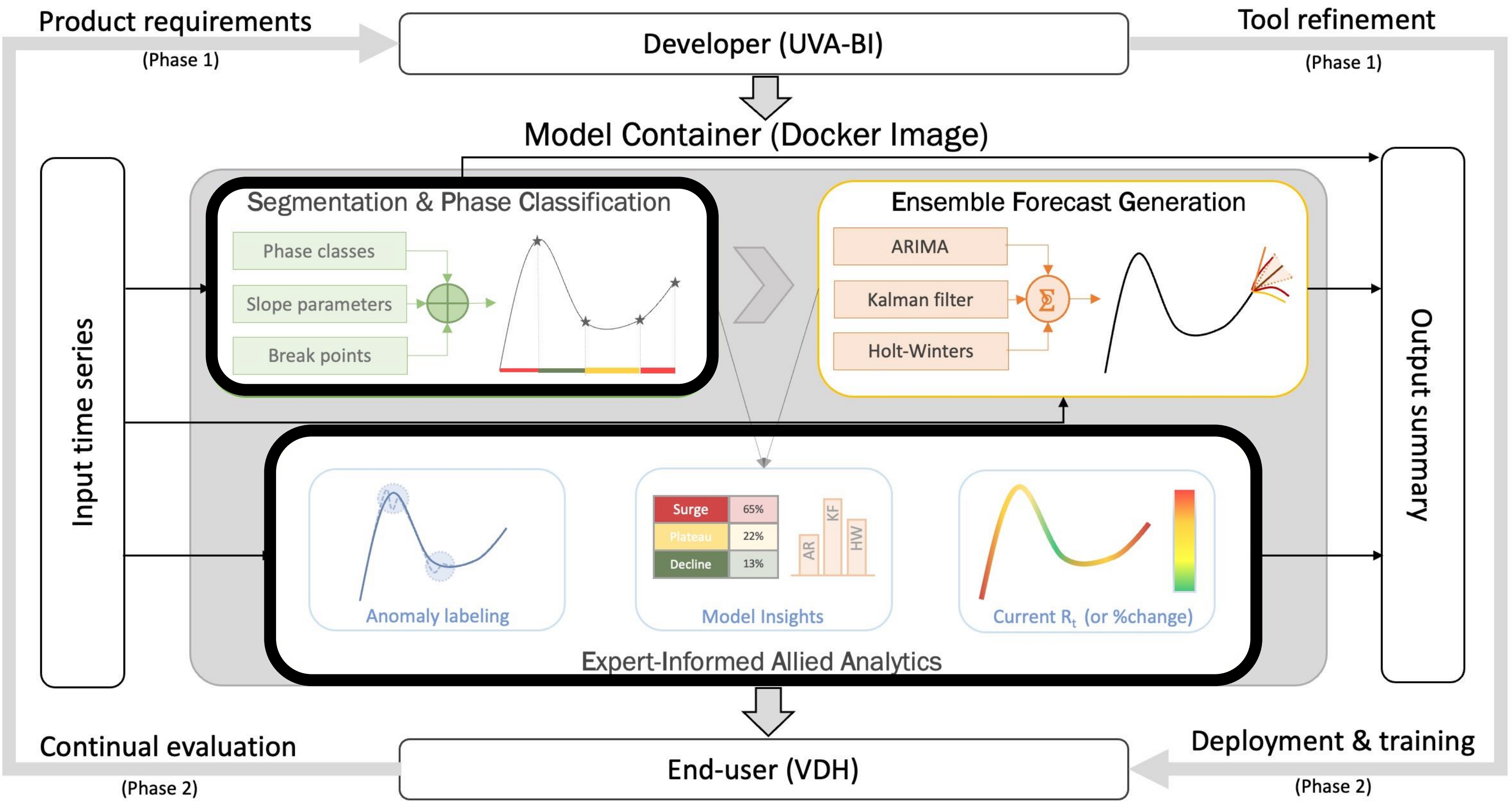

Justin Crow


Alex Telionis

PROPOSED FRAMEWORK

Strengthening **P**ublic **H**ealth **I**nformatics using **N**e**X**t-generation tools





CATEGORICAL INDICATORS

CATEGORICAL INDICATORS FOR EPIDEMICS

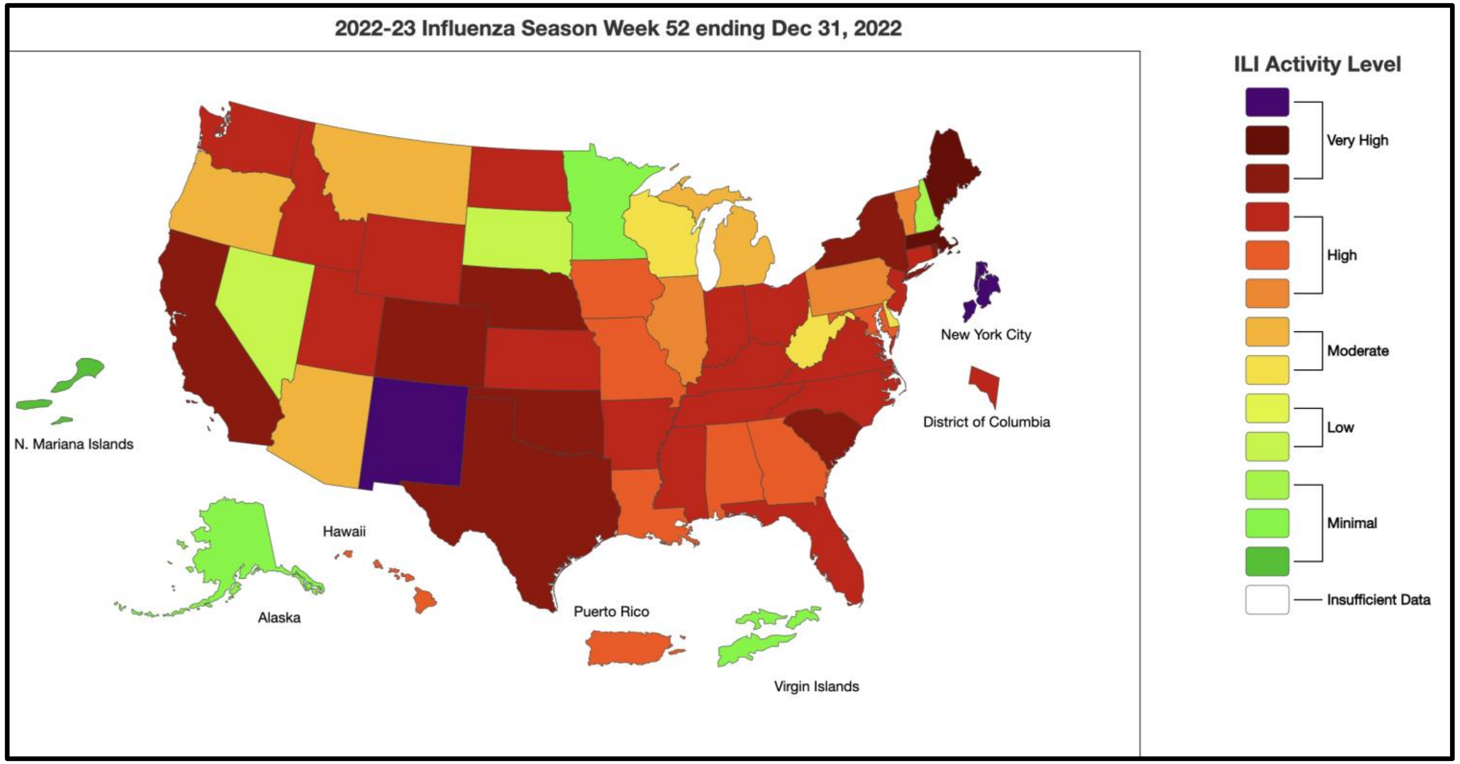
- What do we mean by categorical indicators?
  - Indicators of current level of activity (e.g., High, Medium, Low)
  - Indicators of current trend in the activity (e.g., Surging, Plateau, Declining)
  - Could be based on the raw time series or other derived quantities (e.g., R_t)

- Why categorize?
  - Useful summary of epidemic activity for situation assessment and prognosis
  - Valuable for decision makers as well as public communication

- Challenges
  - Various definitions and lack of standardization
  - Sensitivity to anomalies and dynamic range

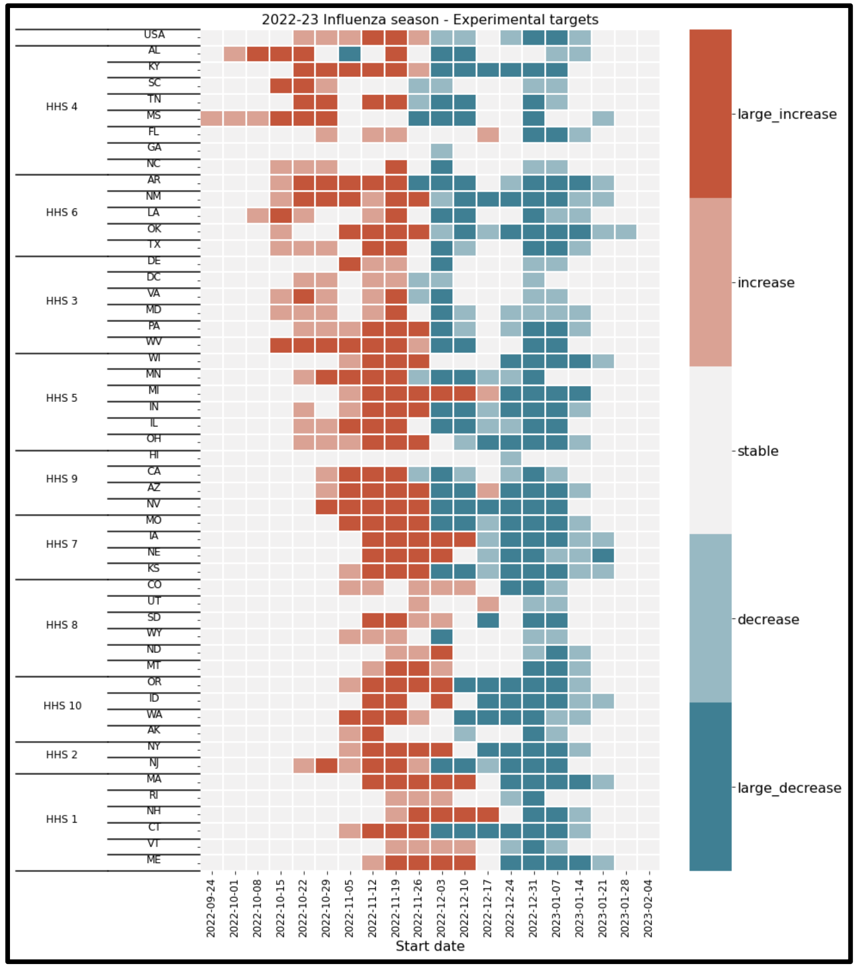
- Opportunities
  - Correlating across multiple signals
  - Aggregating across scales

EXAMPLES FROM INFLUENZA SURVEILLANCE



ILINet State Activity Indicator Map

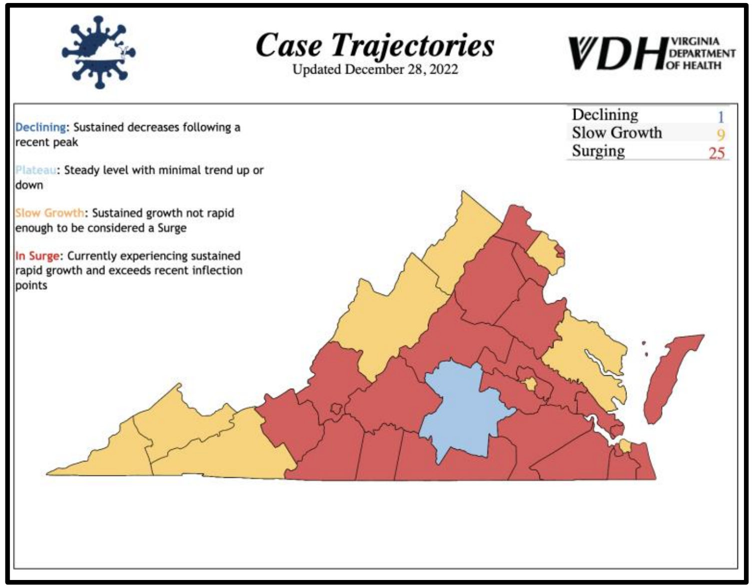
Source: https://gis.cdc.gov/grasp/fluview/main.html



HHS hospitalizations trend indicators (FluSight 2022-23)

https://github.com/cdcepi/Flusight-forecast-data/tree/master/data-experimental

EXAMPLE FROM COVID-19: CASE SURVEILLANCE

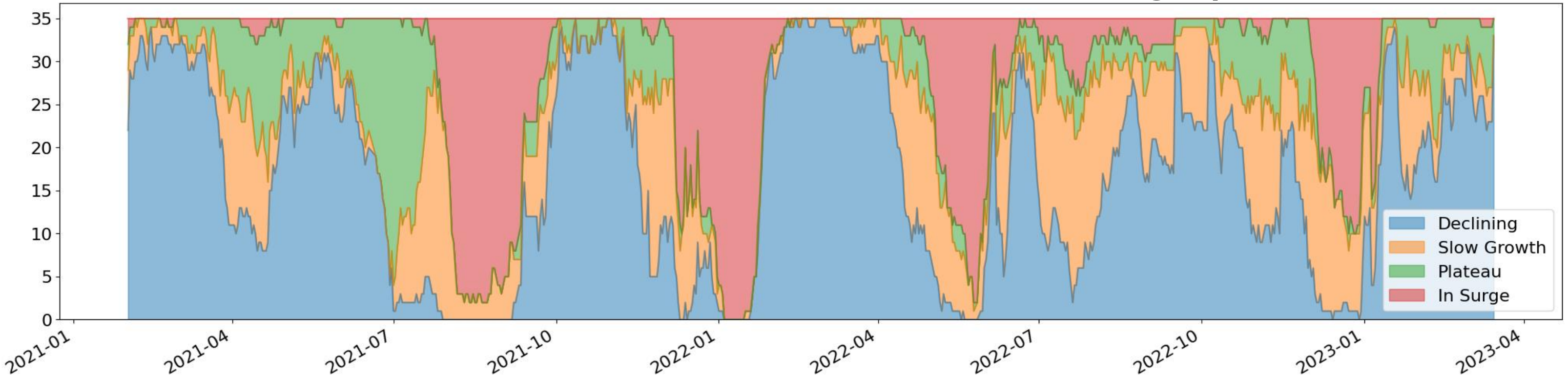


https://www.vdh.virginia.gov/coronavirus/see-the-numbers/covid-19-modeling/district-trajectory-map/

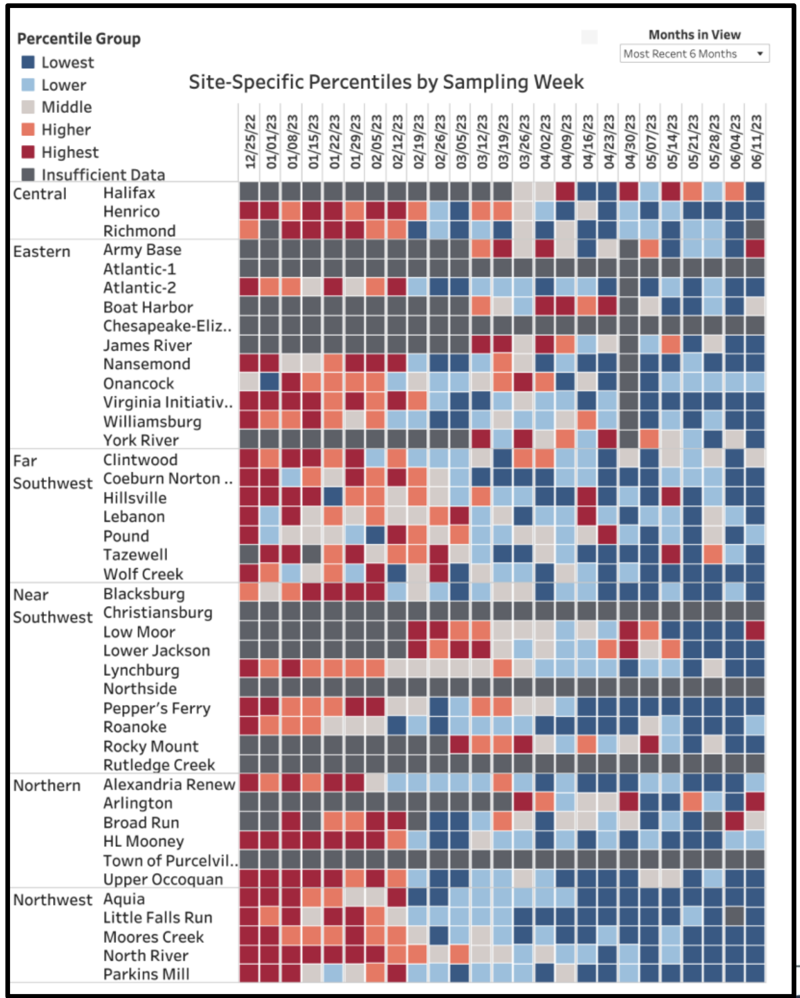
Customized slope thresholds for category definitions

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

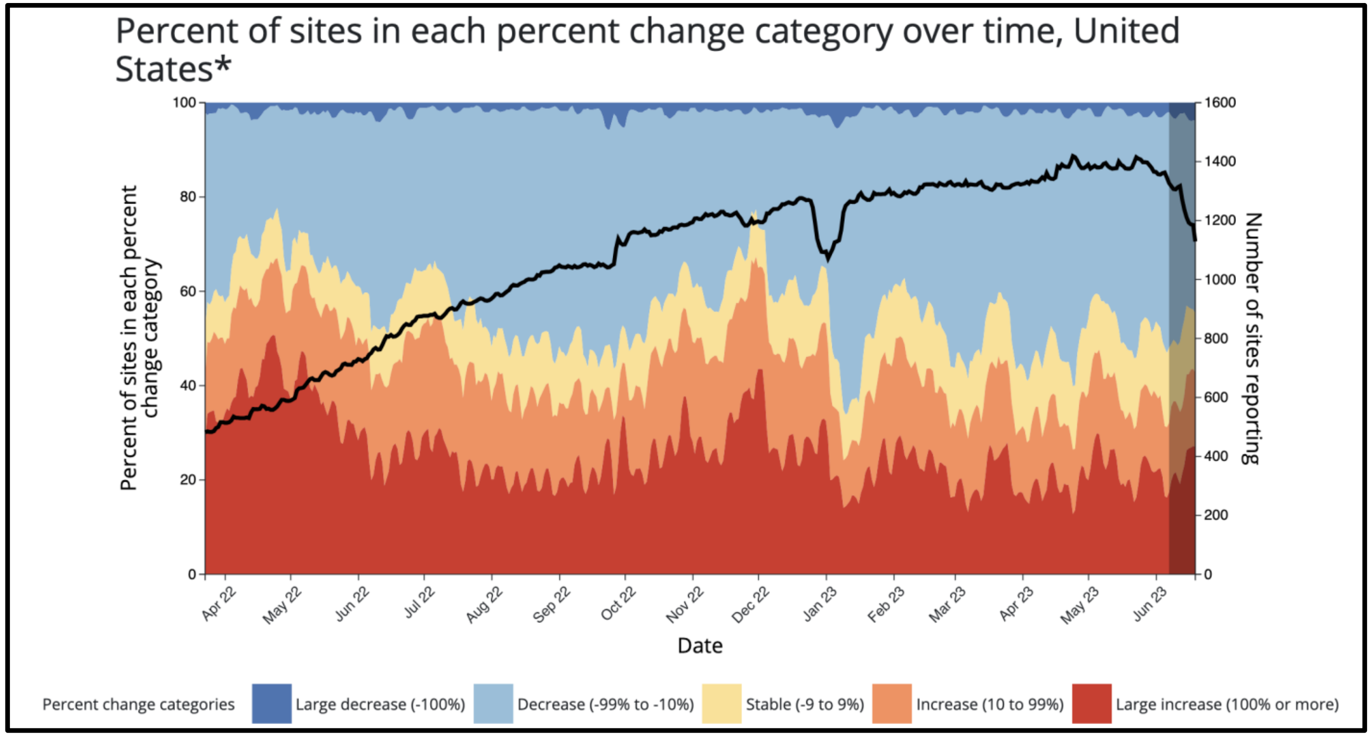
Number of health districts in each category



EXAMPLES FROM COVID-19: WASTEWATER SURVEILLANCE



NATIONAL WASTEWATER SURVEILLANCE SYSTEM



https://covid.cdc.gov/covid-data-tracker/#wastewater-surveillance

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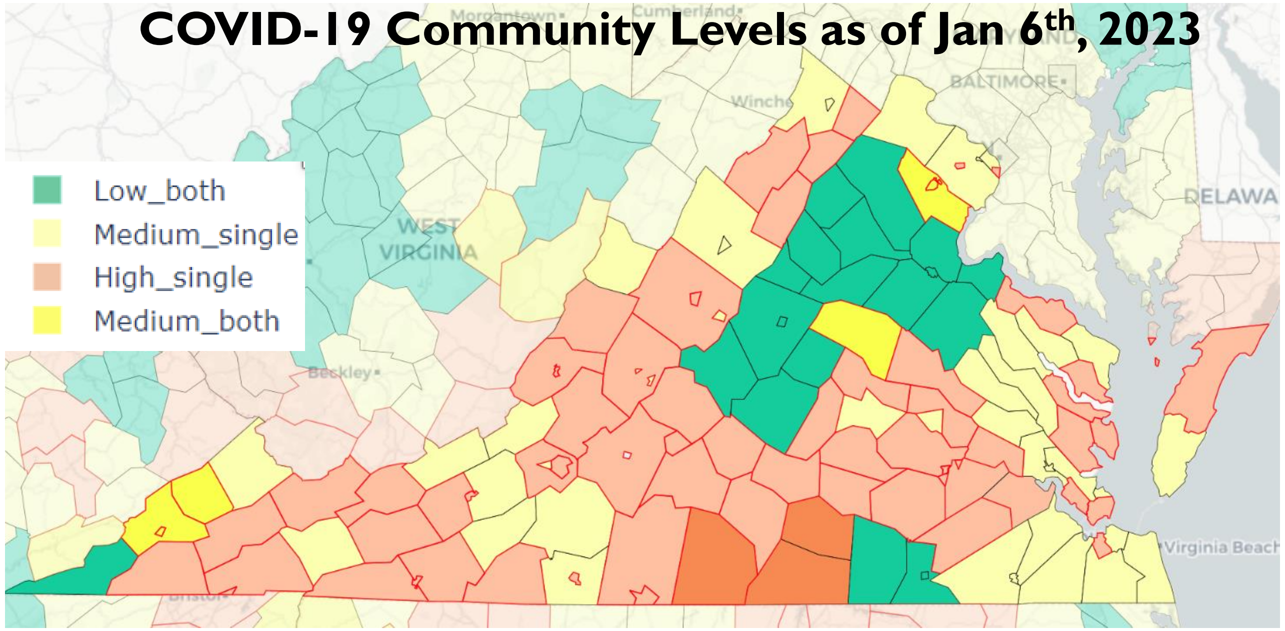
https://www.vdh.virginia.gov/coronavirus/see-the-numbers/covid-19-data-insights/sars-cov-2-in-wastewater/

MULTIVARIATE CATEGORY DEFINITIONS

COVID-19 Community Levels as of Jan 6th, 2023

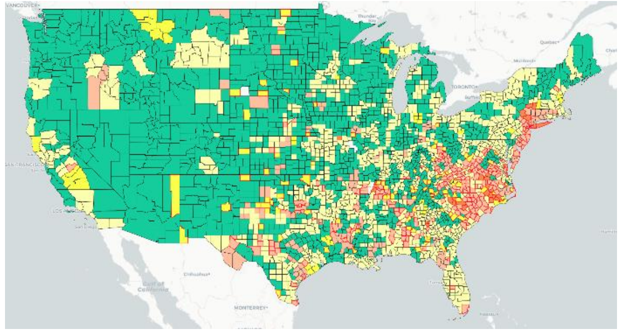


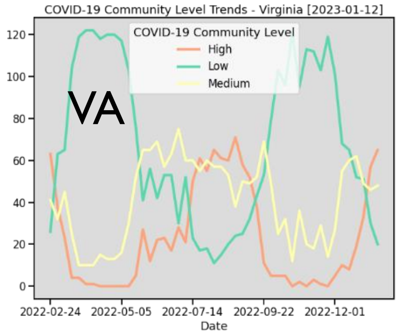
Red outline indicates county had 200 or more cases per 100k in last week

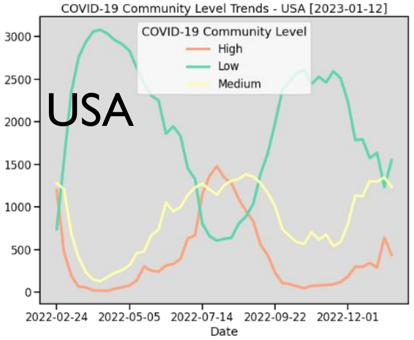
Pale color indicates either beds or occupancy set the level for this county

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

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%





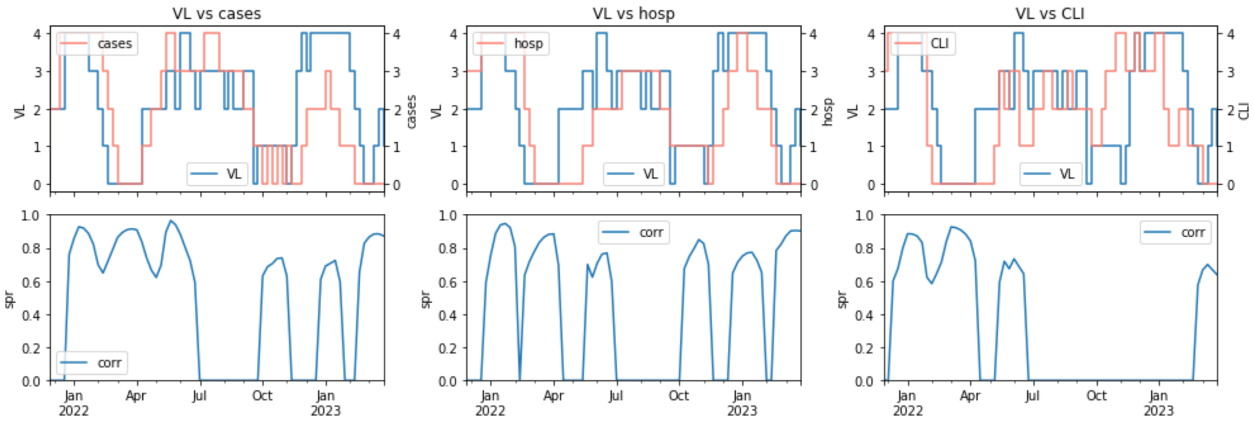


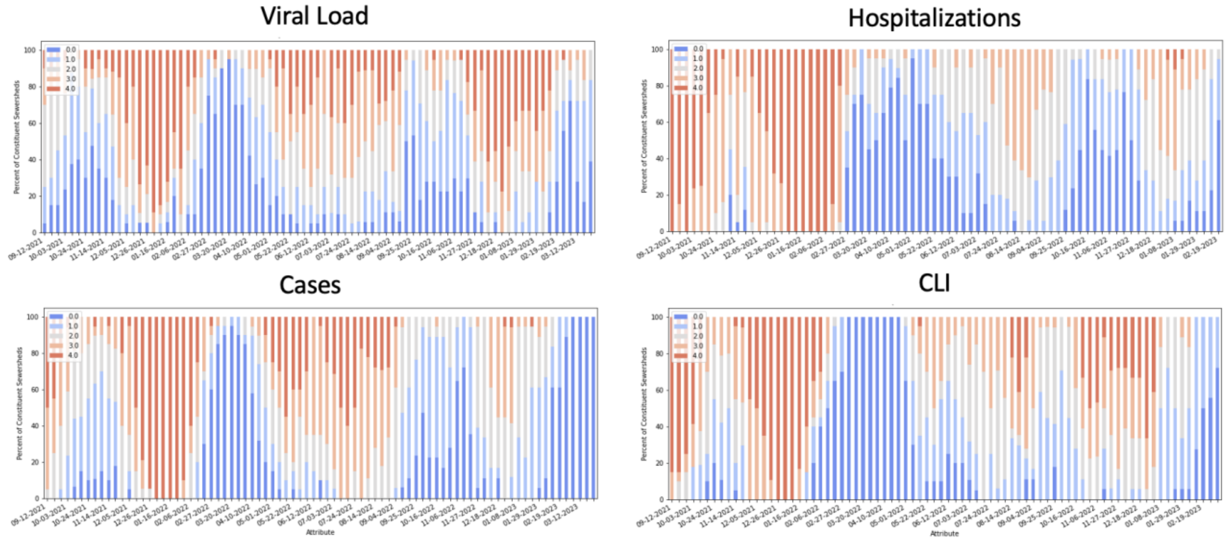
Data from: CDC Data Tracker Portal

MULTI-TIME SERIES ANALYTICS: COVID-19 IN VIRGINIA

- **Source data:**
  - WW viral load by sewershed
  - Cases mapped to sewershed catchment (from line list)
  - CLI% available per health district
  - Hospitalizations by health district (from state level)
- **Categorization:**
  - Obtain quintiles from entire time series (per signal, location)
  - Categorize to level 0 through 4
- **Multi-timeseries analytics:**
  - Pairwise Spearman correlation
  - % locations at various quintiles by signal

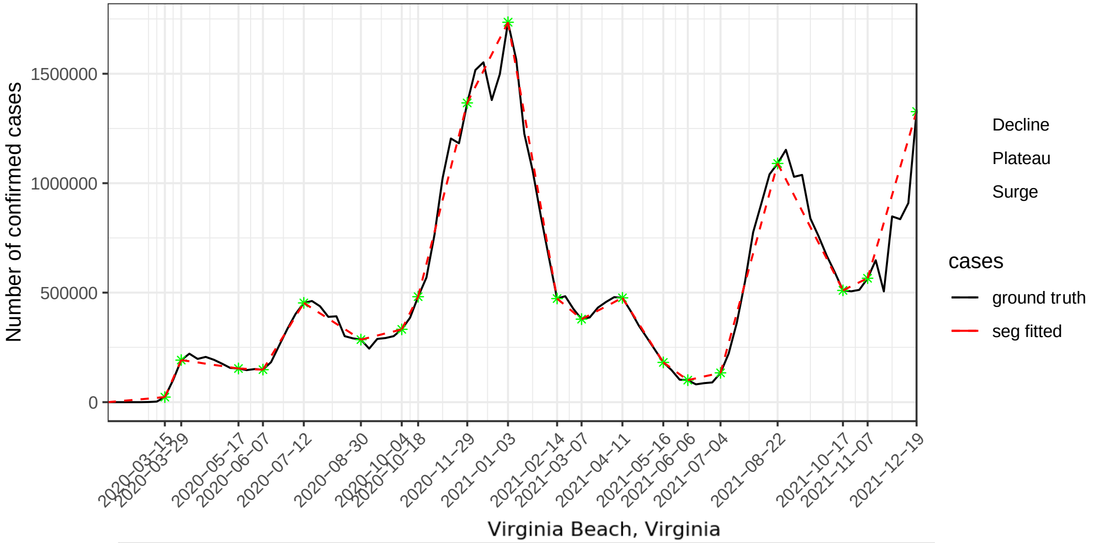
State level categorical correlation

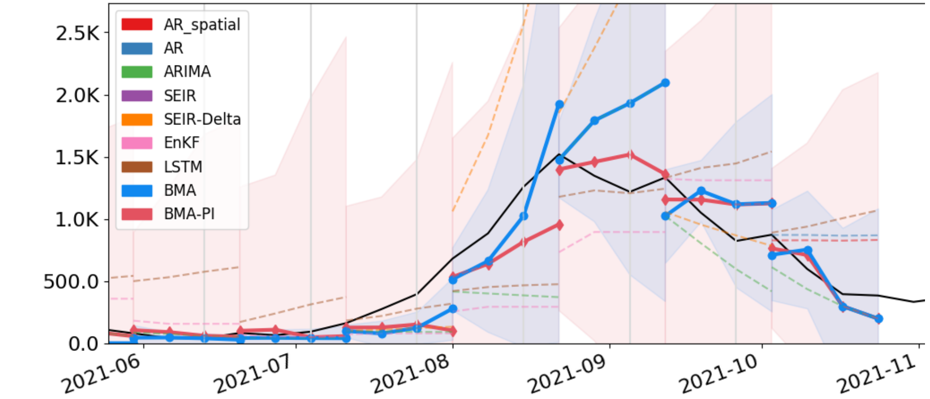




BEYOND ANALYTICS: PHASE-INFORMED FORECASTING

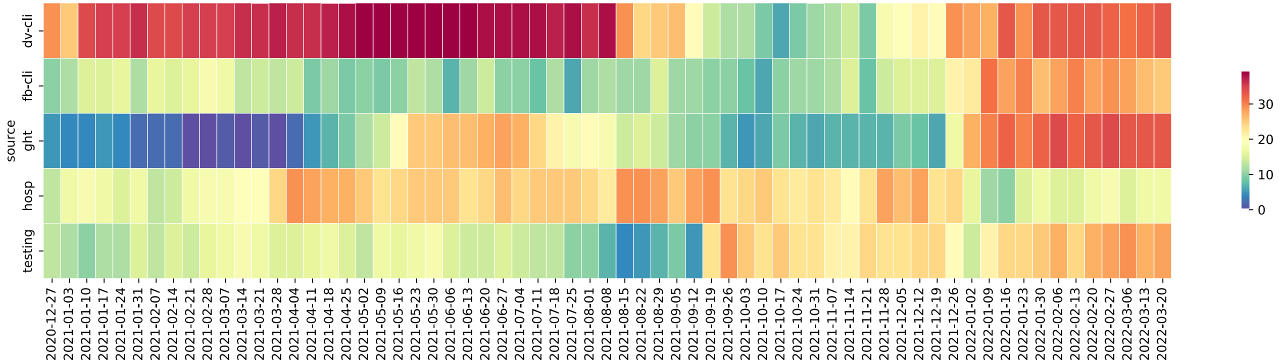
Phase-informed model ensembles



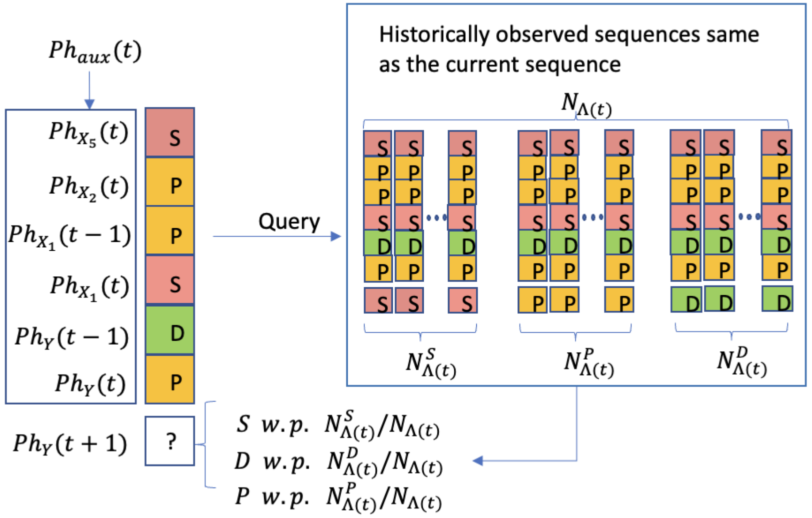


Adiga et al., Phase-Informed Bayesian Ensemble Models Improve Performance of COVID-19 Forecasts, Annual Conference on Innovative Applications of Artificial Intelligence (IAAI), 2023.

Phase prediction using leading indicators



# of states for which an individual signal was identified as a leading indicator



Adiga et al., Enhancing COVID-19 Ensemble Forecasting Model Performance Using Auxiliary Data Sources, IEEE International Conference on Big Data, 2022.

TOOL INTRODUCTION

TAXONOMY OF CATEGORIZATION RULES

- Level-based categories
  - Using equal-width intervals for the data range (e.g., ILINet Activity Indicator)
  - Using quantiles of the data to inform category bins (e.g., VDH COVID-19 wastewater surveillance)
- Trend-based categories
  - Rate change over a fixed length window (HHS hospitalization trends)
  - Rate change over automatically detected segments (VDH case trajectories)
  - Percent change in activity over a fixed length window (CDC NWSS dashboard)
- Combined rules
  - Multi-signal-based categories (e.g., CDC Community Levels)

How to decide on the appropriate categorization for a given signal or region?

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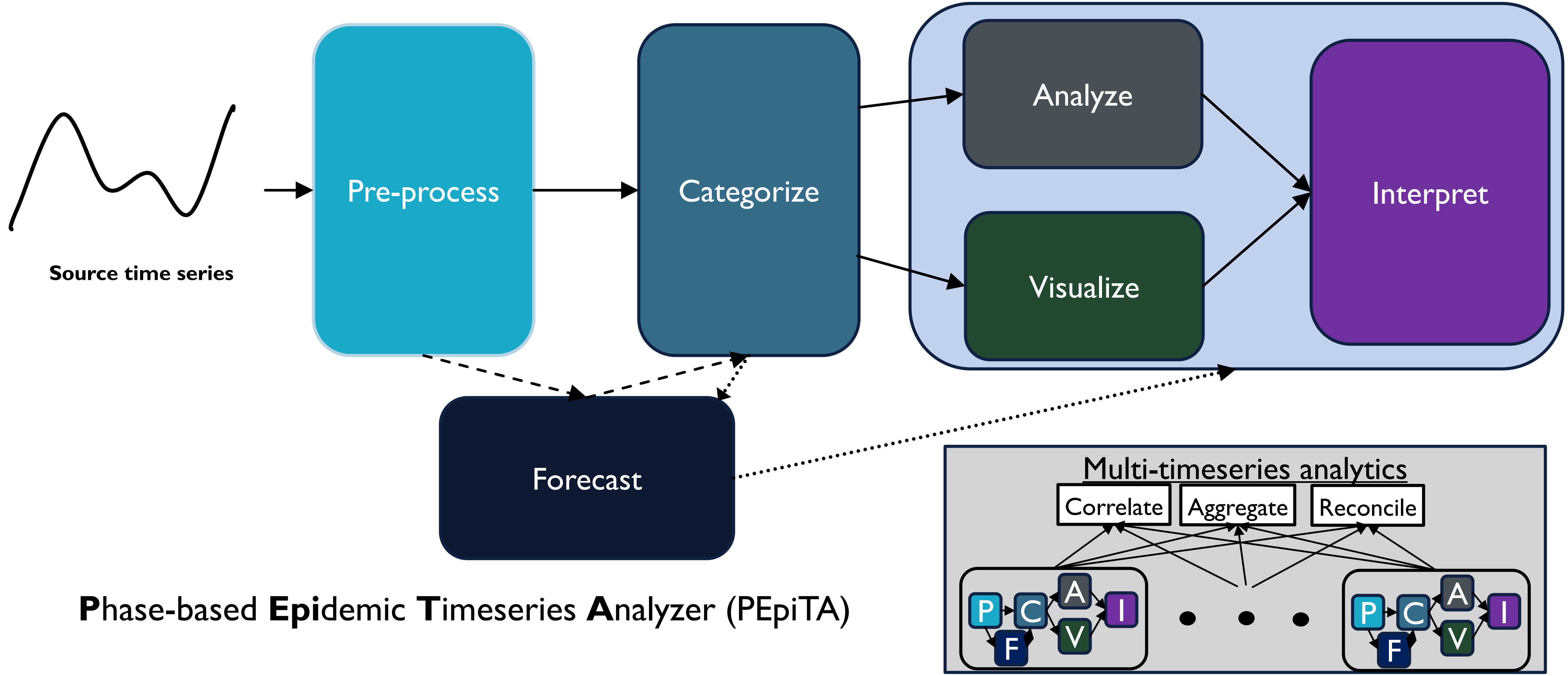
PEpiTA: **P**hase-based **Epi**demic **T**imeseries **A**nalyzer

Phase-based Epidemic Time-series Analyzer (PEpiTA)

- Upload or choose a publicly-available time series for analysis
- Perform standard preprocessing (e.g., interpolation, smoothing)
- Choose among pre-defined rules for category extraction
- Customize analytical parameters such as number of bins, range, trend windows
- Download visualizations and analytical summaries

PEpiTA - WORKFLOW



Phase-based **Epi**demic **T**imeseries **A**nalyzer (PEpiTA)

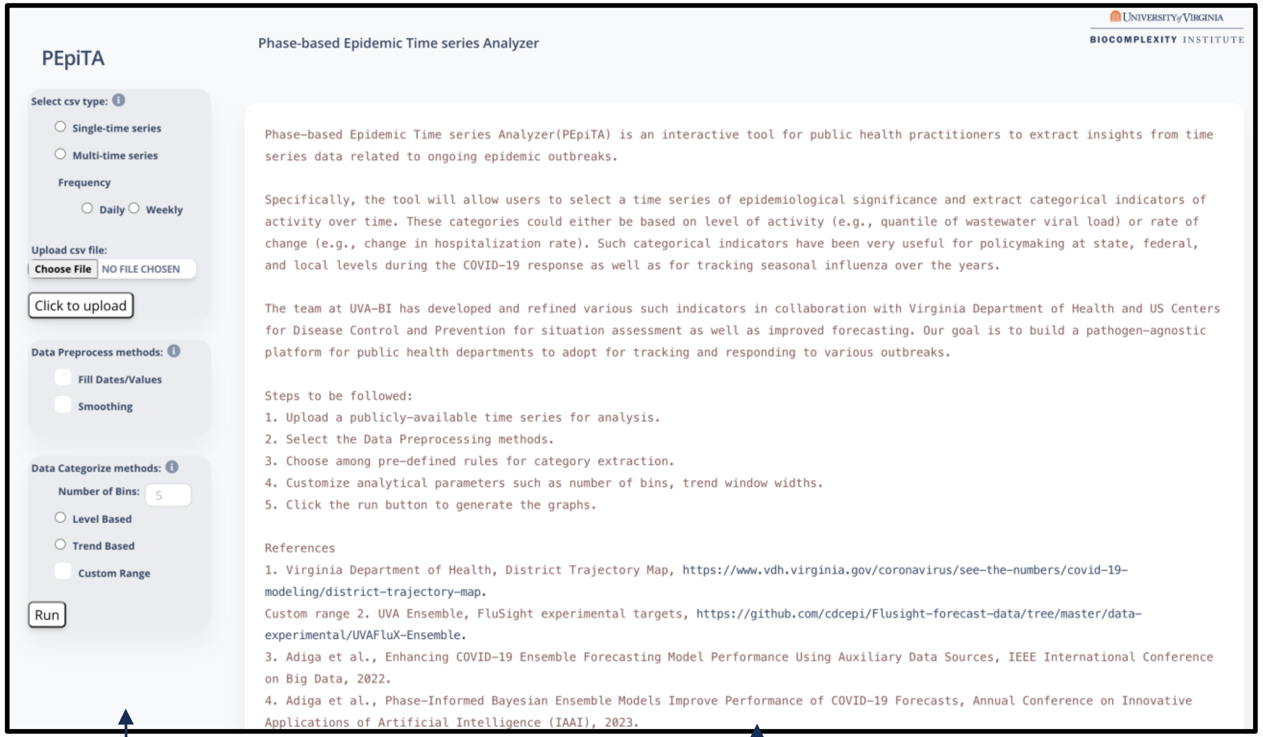
PEpiTA - INTERFACE

- Browser-based interface using Django framework
- Codebase in Python (using pandas, matplotlib)
- Setup for headless mode; Exploring installation options

https://github.com/NSSAC/PEpiTA

```
/Users/vsriniv/Documents/Research/Github/PEpiTA
(base) vsriniv@Srinivasans-MacBook-Pro PEpiTA % cd webdesign
(base) vsriniv@Srinivasans-MacBook-Pro webdesign % python manage.py runserver
Watching for file changes with StatReloader
Performing system checks...

System check identified no issues (0 silenced).
June 23, 2023 - 18:15:37
Django version 4.2.1, using settings 'webdesign.settings'
Starting development server at http://127.0.0.1:8000/
Quit the server with CONTROL-C.
```



Input pane

Landing page

PEpiTA - INTERFACE

CATEGORY	BIN BOUNDARIES	NUMBER OF OCCURRENCES	PERCENT TIME SPENT	AVERAGE DURATION SPENT
C1	(147.13, 895.69)	536	48.59%	107.2
C2	(895.69, 1640.51)	389	35.27%	48.6
C3	(1640.51, 2385.34)	93	8.43%	18.6
C4	(2385.34, 3130.17)	53	4.81%	13.2
C5	(3130.17, 3875.0)	32	2.9%	16.0

Input file properties

Preprocessing method

Categorization method

Visual Summary

Analytical Summary

ONGOING AND FUTURE WORK

- Incorporating stakeholder feedback from VDH and other STLT agencies (like you!)
- Expanding categorization rules and making them *FAIR*

Findable, **A**ccessible, **I**nteroperable, and **R**eusable

- Interoperability with other analytical tools (e.g., epiprocess, EpiNow2)
- Improved analytics and interactive visualizations
- Nowcasting and forecasting capabilities; Advanced multi-time series workflows

If you're interested in testing and providing feedback, please reach out to srini@virginia.edu

Key Takeaways

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

- Case rates are in an undulating plateau, currently in an upswing
- Hospitalization rates remain in plateau, with very slight growth
- Most indicators still point to continued plateaus, though some indicate slow growth
- Scenerio Modeling Hub, round 17 results published, impact of fall booster is high

VDH – UVA Updates

- SPHINX project update – PePITA tool piloted at CSTE conference in Salt Lake City
- Projected Trajectories from previous rounds remain on target, no new projections made this round

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