Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

November 9th, 2022

data current to November 5th – November 8th

Biocomplexity Institute Technical report: TR BI-2022-1779

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About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others

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Overview

- **Goal**: Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

Key Takeaways

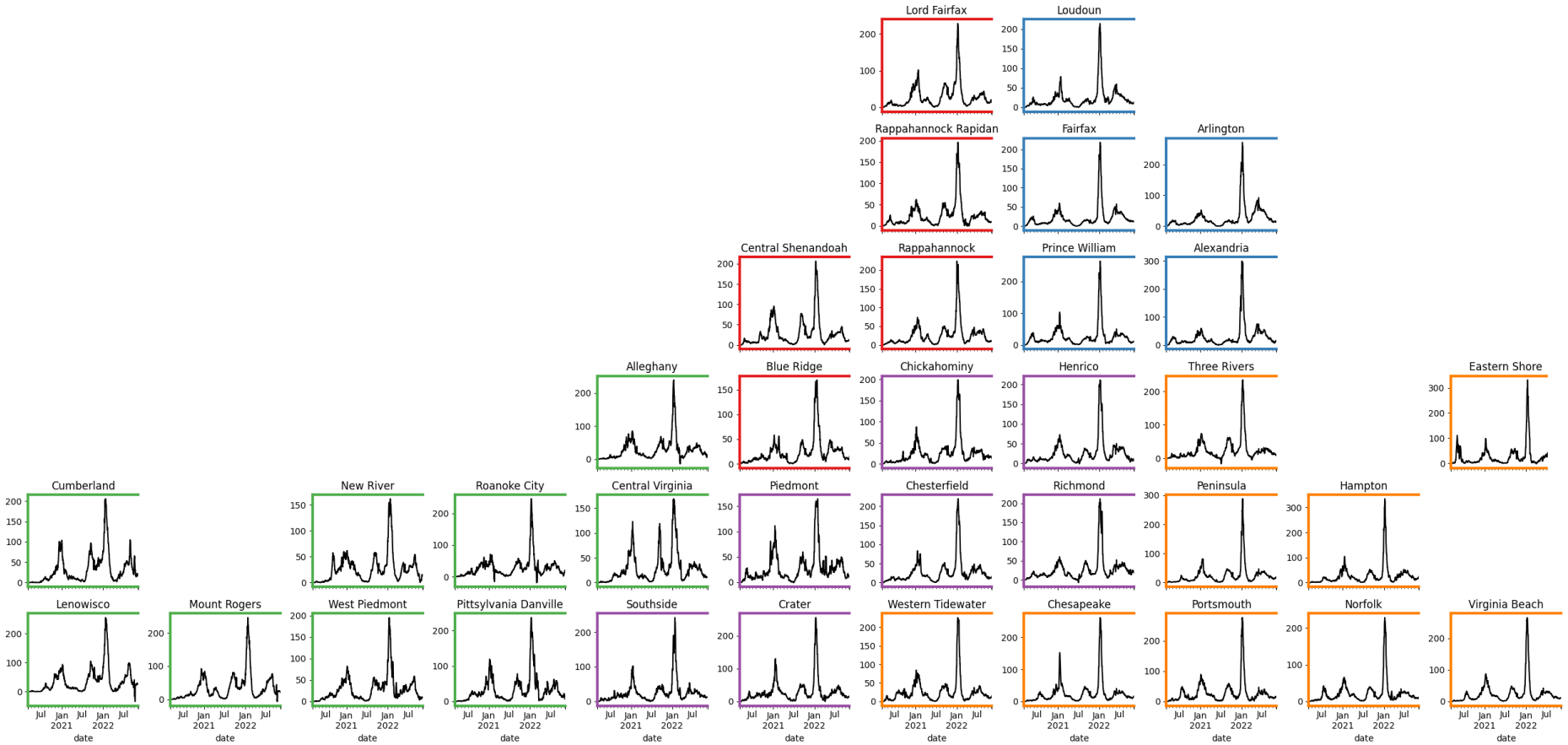
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

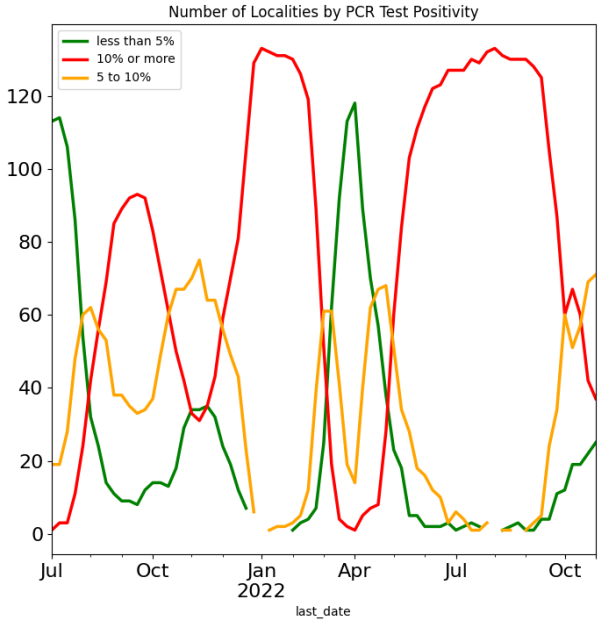
- **Case rates have continued to decline though hospitalizations have shown some recent growth**
- VA weekly case rate is slightly down at 81 per 100K from 84 per 100K
  - US weekly case rate is flat remaining at 74 per 100K from 74 per 100K
  - VA hospital occupancy (rolling 7 day mean of 455 slightly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

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

Situation Assessment

Case Rates (per 100k) and Test Positivity





County level RT-PCR test positivity

Green: <5.0% (or <20 tests in past 14 days)

Orange: 5.0%-10.0% (or <500 tests and <2000 tests/100k and >10% positivity over 14 days)

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

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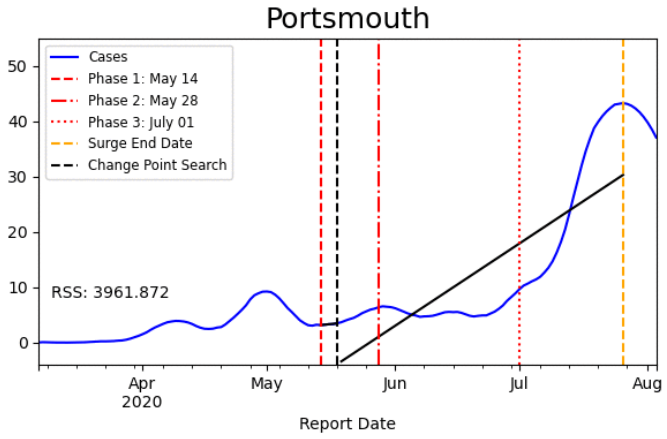
District Trajectories

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

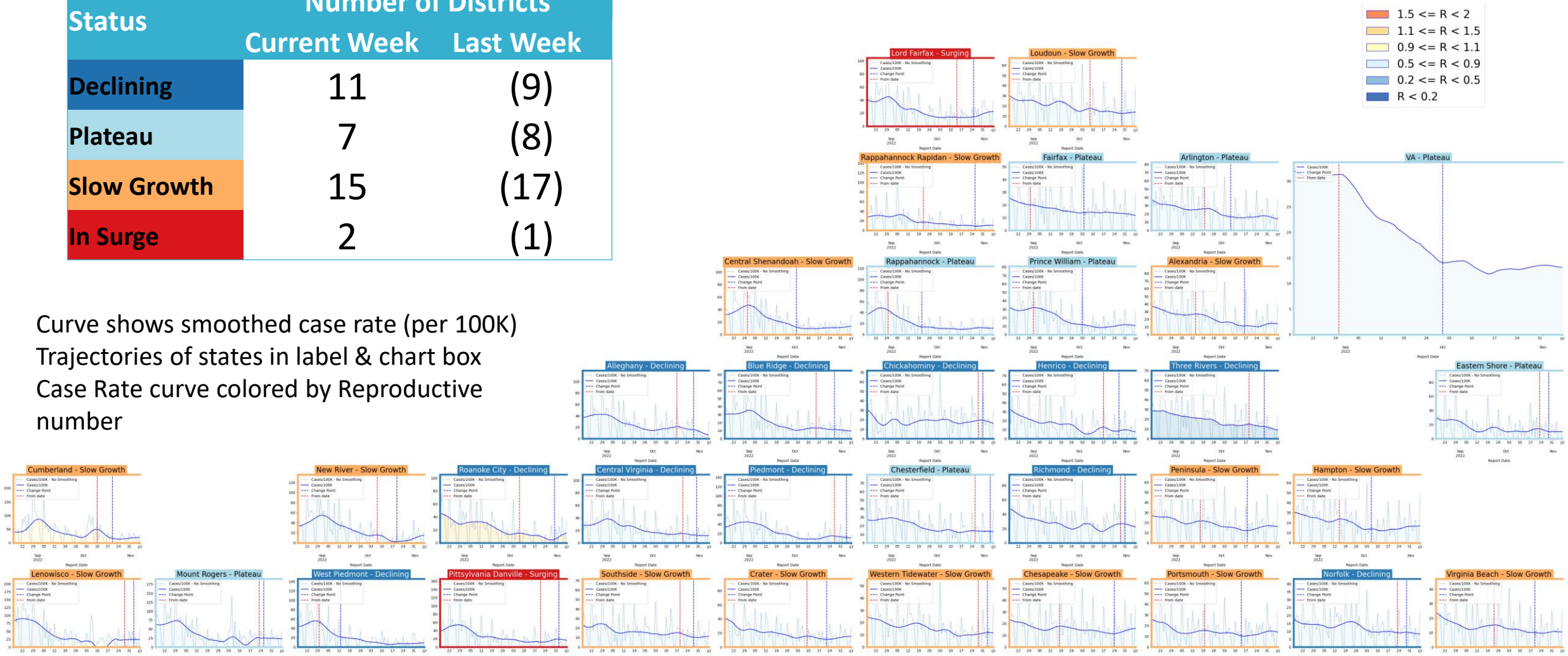


Trajectory	Description	Weekly Case Rate Slope (per 100k)	Weekly Hosp Rate Slope (per 100k)
Declining	Sustained decreases following a recent peak	slope < -0.88/day	slope < -0.07/day
Plateau	Steady level with minimal trend up or down	-0.88/day < slope < 0.42/day	-0.07/day < slope < 0.07/day
Slow Growth	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	11	(9)
Plateau	7	(8)
Slow Growth	15	(17)
In Surge	2	(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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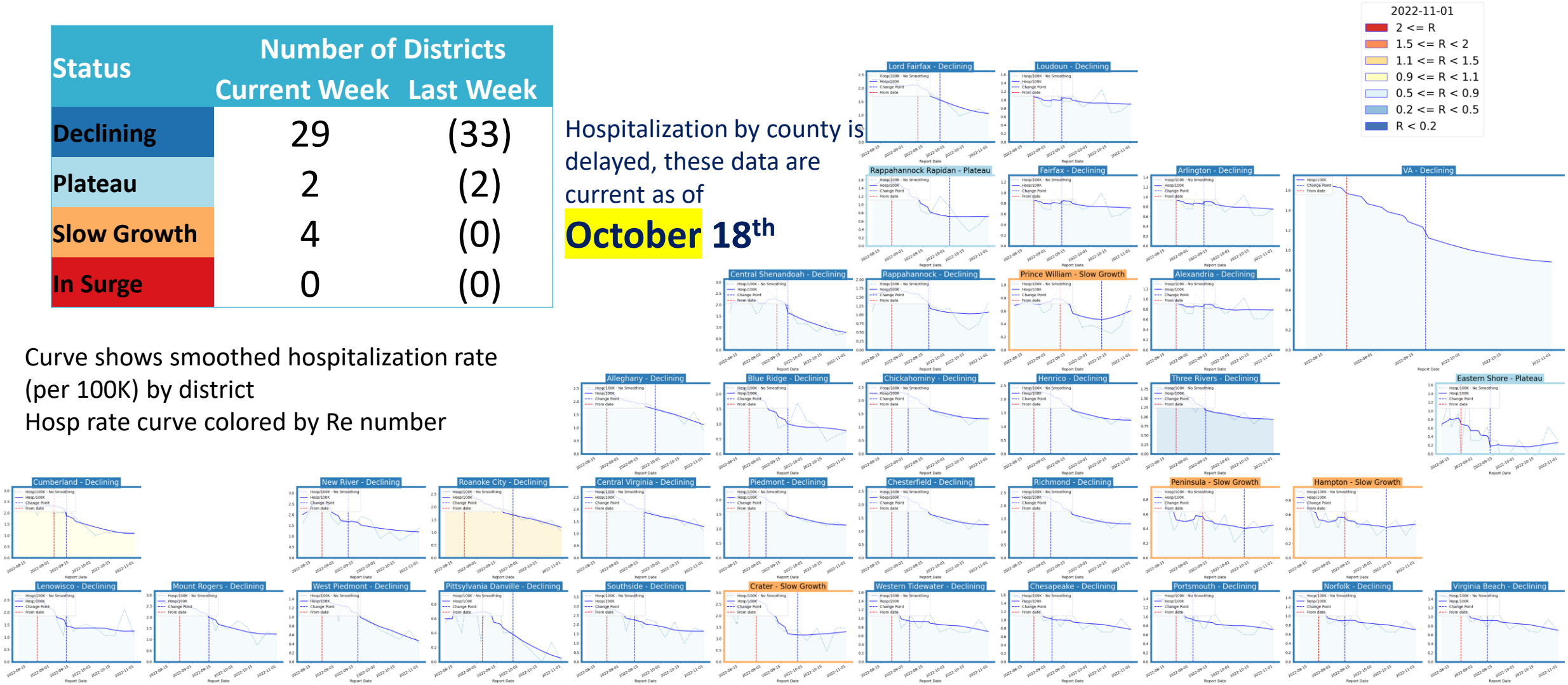
District Hospital Trajectories – last 10 weeks

Status	Number of Districts Current Week	Last Week
Declining	29	(33)
Plateau	2	(2)
Slow Growth	4	(0)
In Surge	0	(0)

Hospitalization by county is delayed, these data are current as of **October 18th**

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



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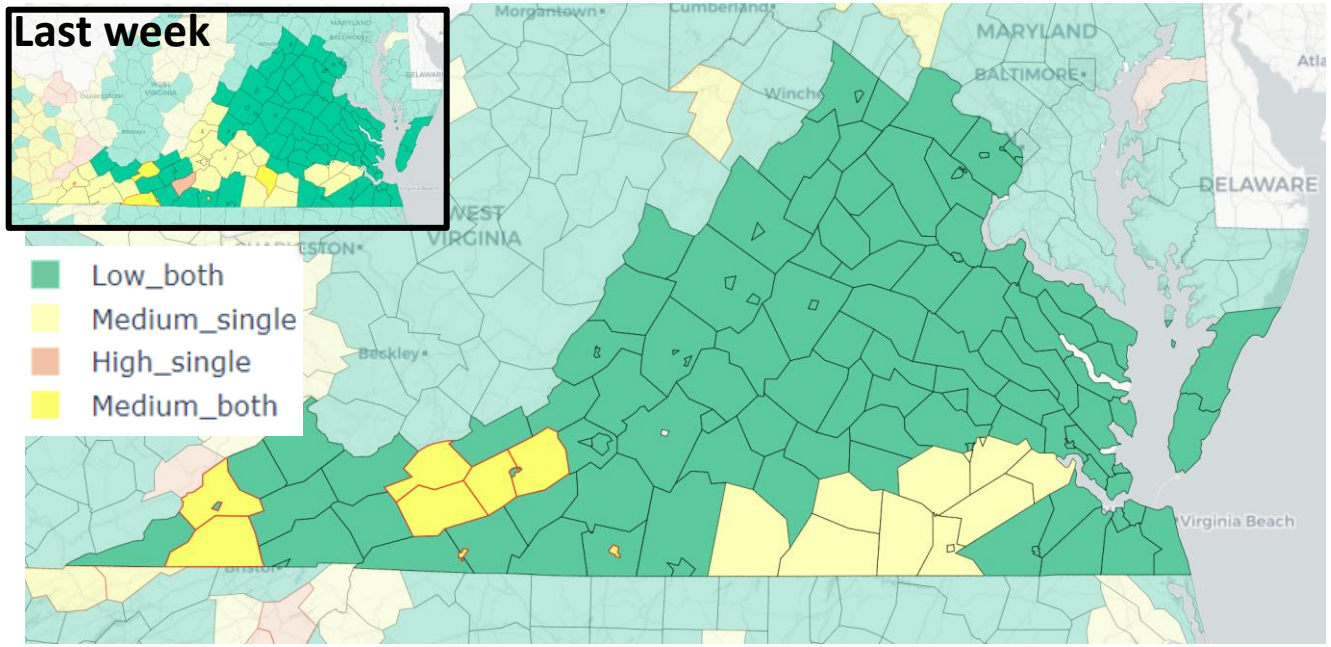
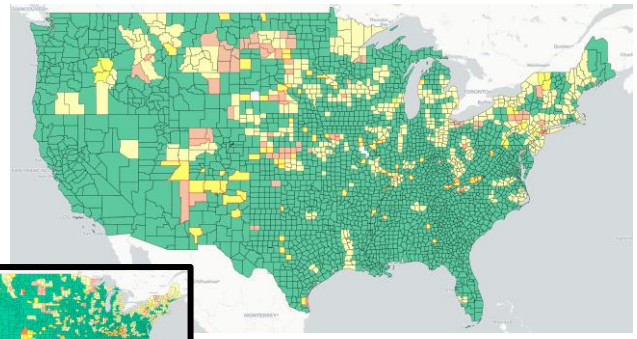
CDC's COVID-19 Community Levels

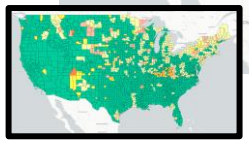


Red outline indicates county had 200 or more cases per 100k in last week

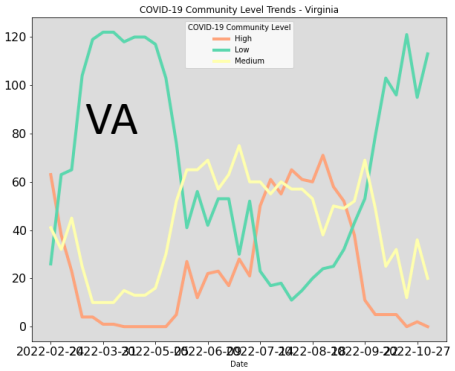
Pale color indicates either beds or occupancy set the level for this county

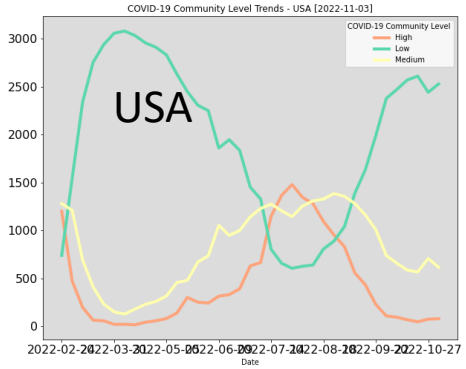
Dark color indicates both beds and occupancy set the level for this county





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

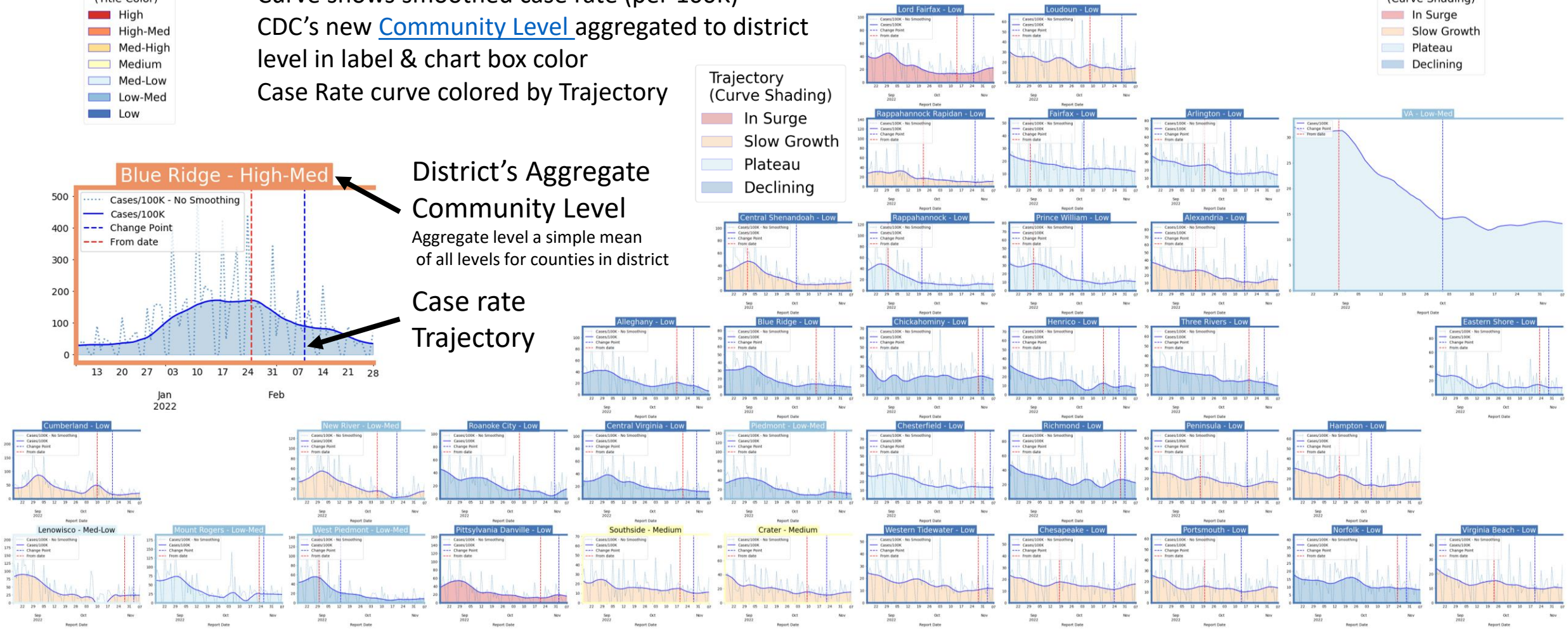
Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory

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



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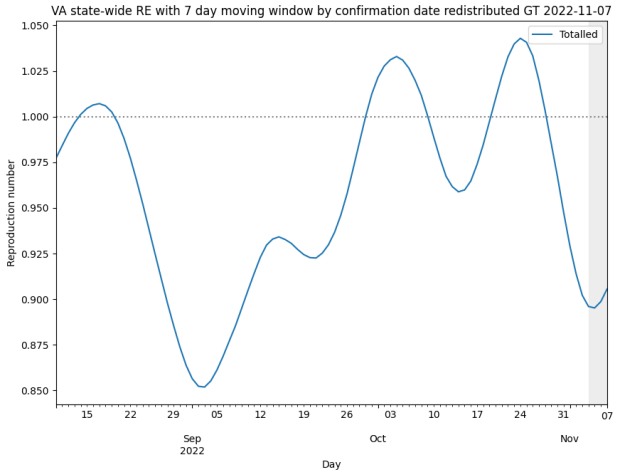
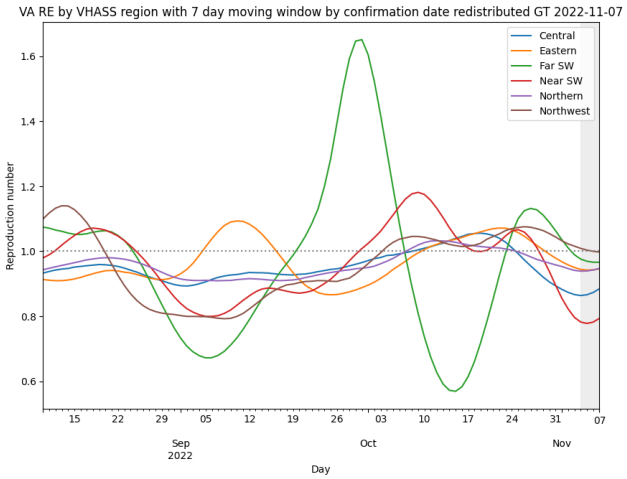
Estimating Daily Reproductive Number –
Redistributed gap

November 7th Estimates

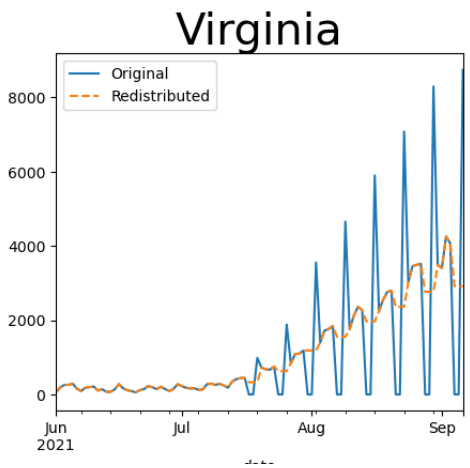
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.905	-0.099
Central	0.884	-0.106
Eastern	0.946	-0.091
Far SW	0.966	-0.052
Near SW	0.793	-0.204
Northern	0.947	-0.049
Northwest	0.997	0.018





Skipping Weekend Reports & holidays biases estimates

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



Methodology

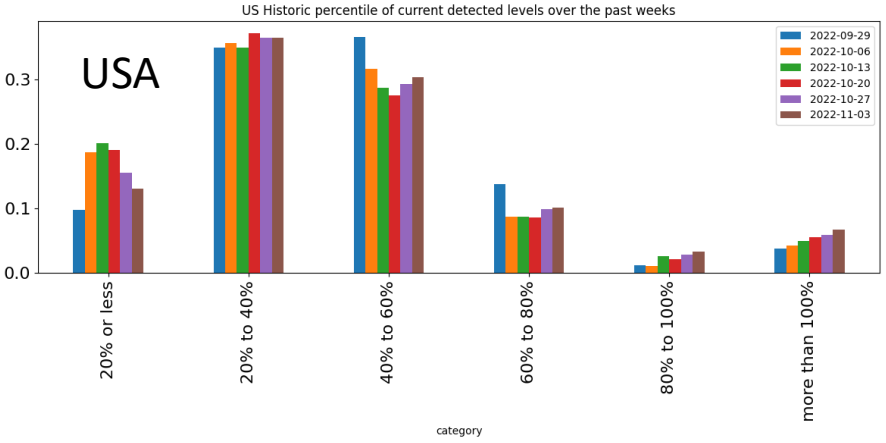
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

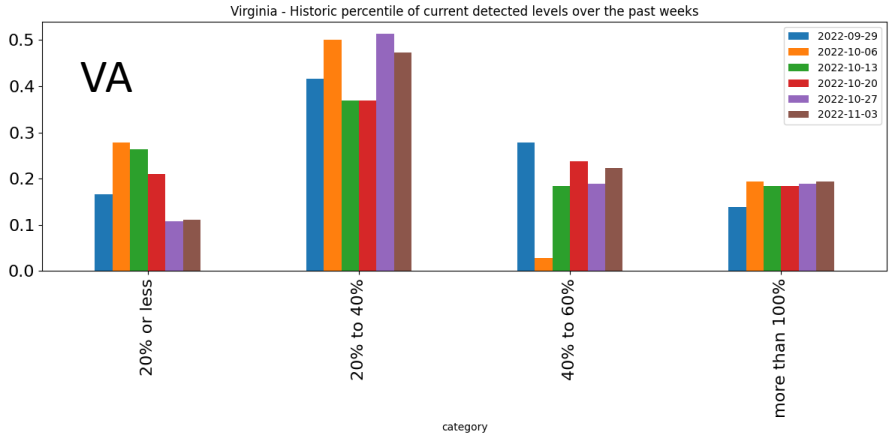
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

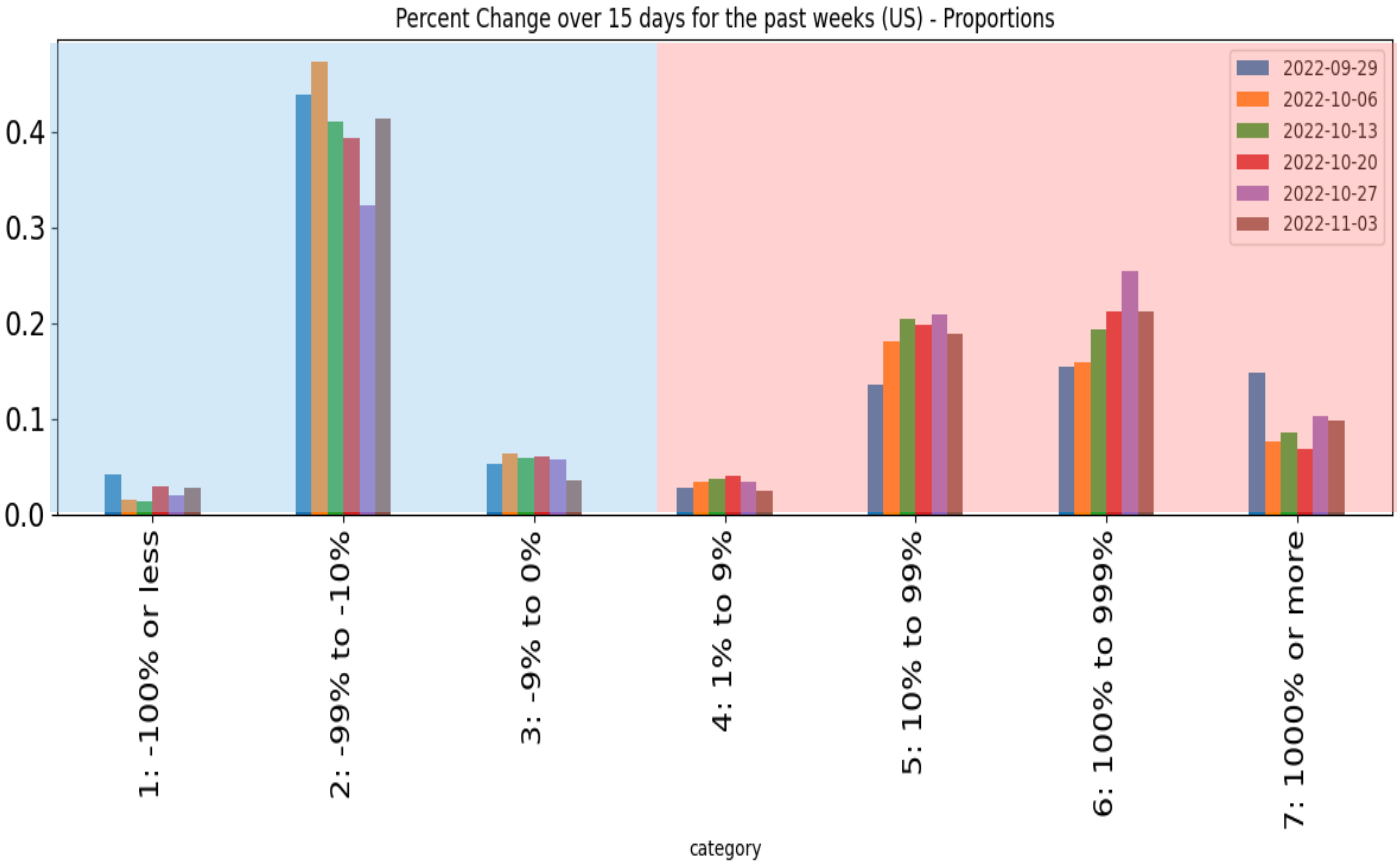
Wastewater Monitoring

Wastewater provides a coarse early warning of COVID-19 levels in communities

- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago
- Current virus levels are at or exceeding max of previous historical levels, has slowed, though more sites are entering upper quintiles





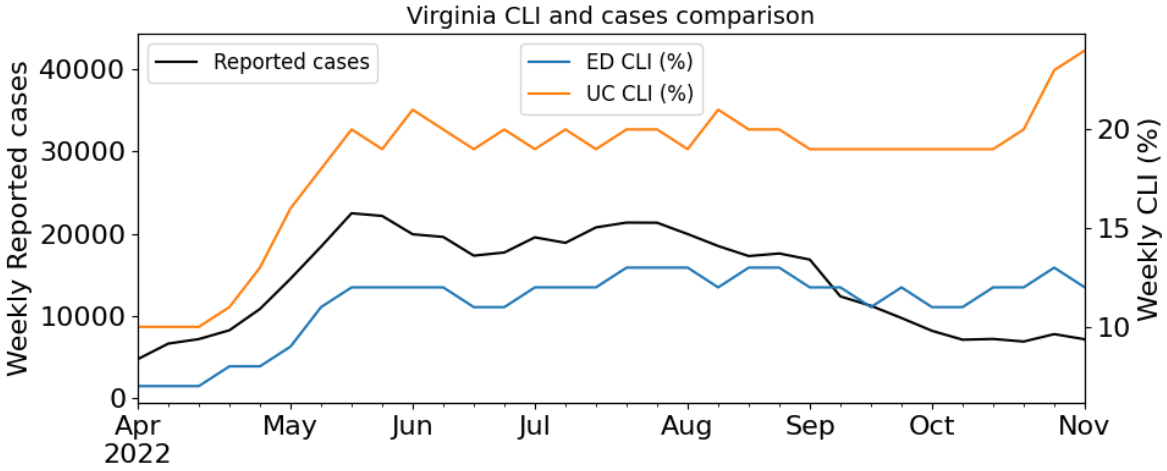


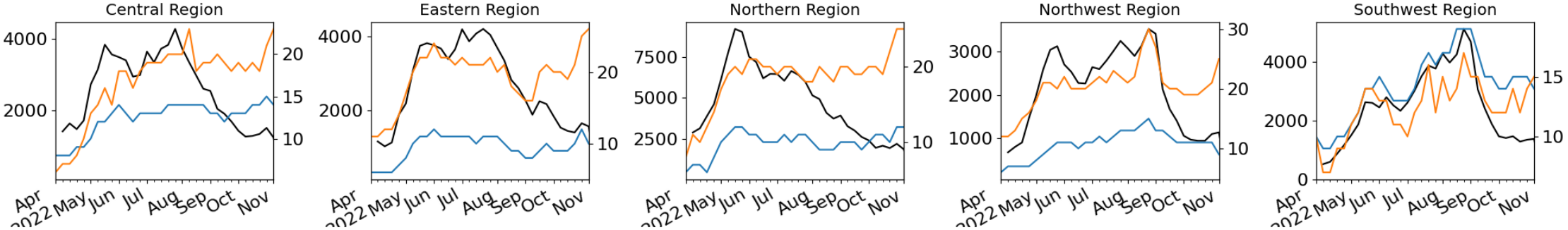
Data Source: [CDC Data Tracker]

COVID-like Illness Activity

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

- Emergency Dept (ED)-based CLI is more correlated with case reporting
- Urgent Care (UC) is a leading indicator but prone to some false positives
- **Current trends in UC CLI are higher statewide and most regions than seen in previous 6 months**



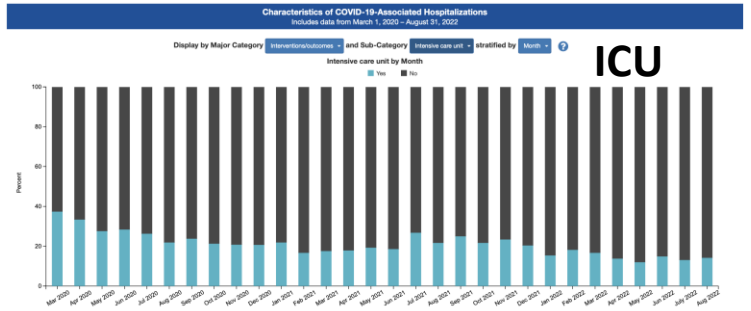


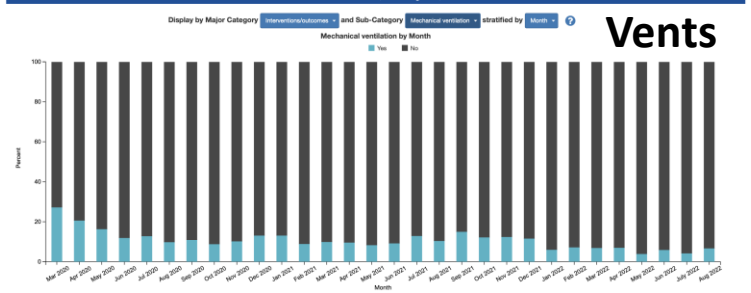
Hospitalizations and Severe Outcomes

Data Source: [CDC Data Tracker]

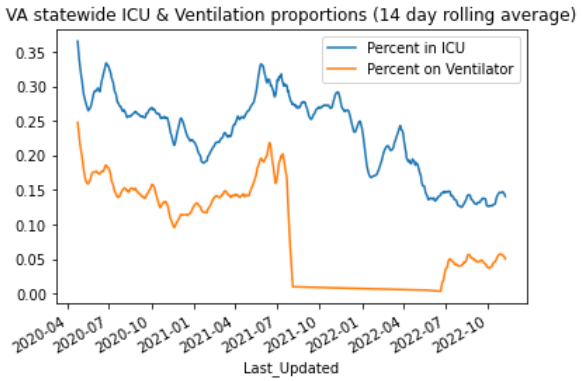
Proportion of most severe outcomes decreasing among those who are hospitalized

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

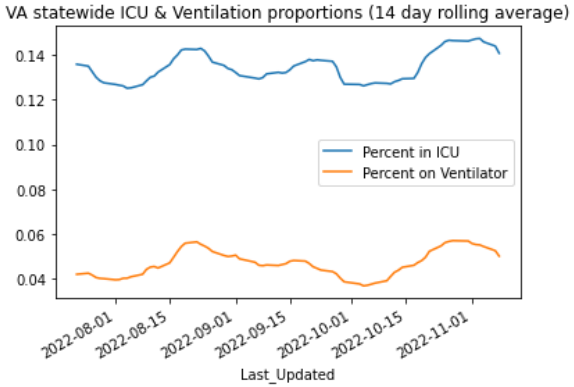




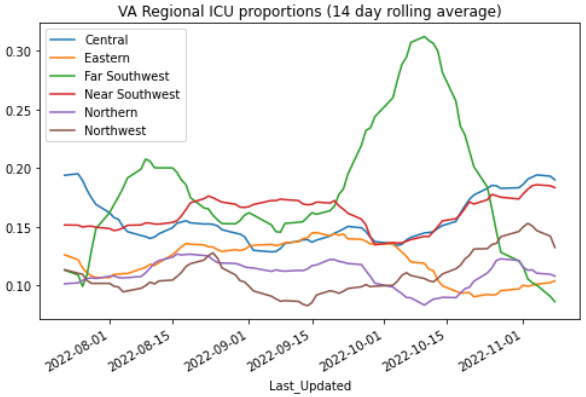
Virginia wide – full pandemic



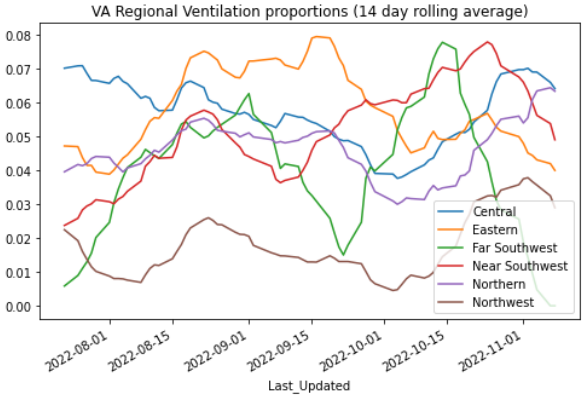
Virginia wide – recent



Virginia Regional ICU percent



Virginia Regional Ventilation %



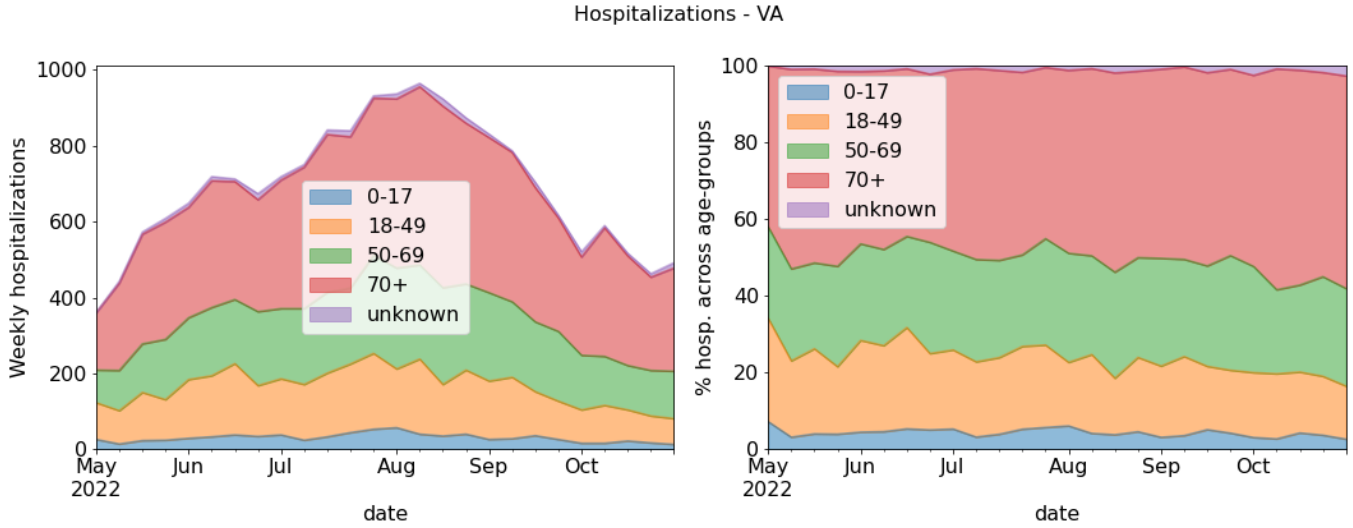
Hospitalizations in VA by Age

Age distribution in hospitals relatively stable

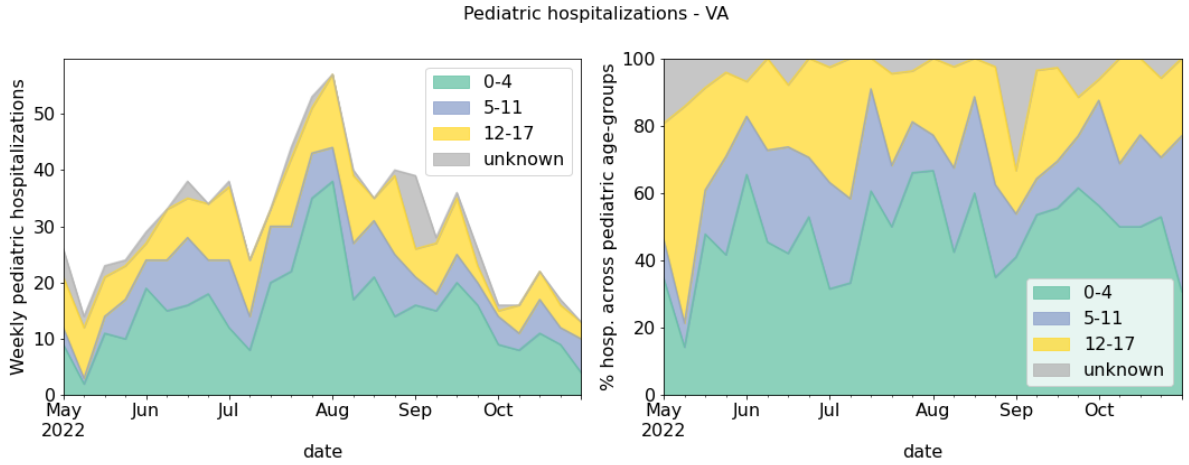
- Recent change in pediatric hospitalizations, though not higher yet than in previous months

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

Virginia Hospitalizations by Age (all ages)



Pediatric Hospitalizations by Age (0-17yo)

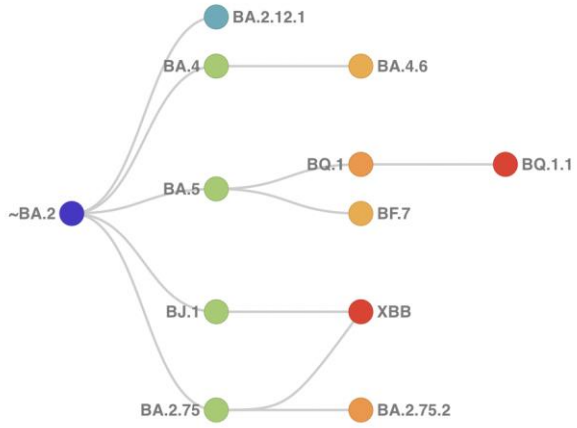


Data Source: Delphi and HHS

SARS-CoV2 Variants of Concern

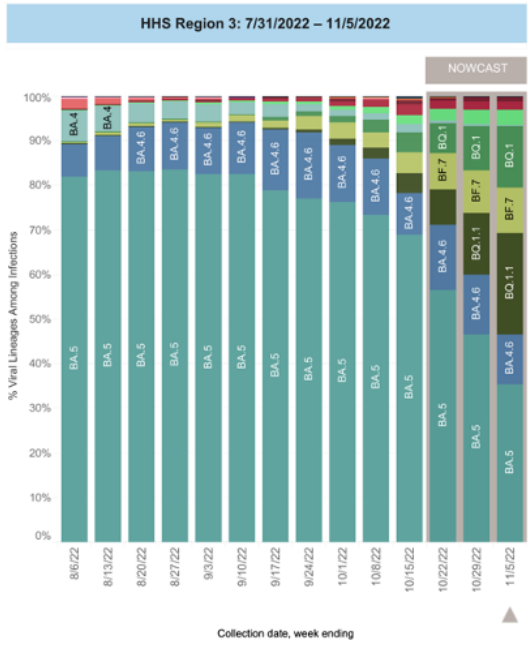
Emerging variants have potential to continue to alter the future trajectories of pandemic and have implications for future control

- **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

- Soup of tracked variants has grown to 65% from 53% last week
- BQ.1.1 continues to show quick growth up to 23% from 17%, with BQ.1.* accounting for another 14%
- BF.7 continues steady slow growth at 10%
- BA.4.6 remains steady at 11-13% for last 6 weeks
- BQ.1.1 seen to cause surge in Europe, though it seems to have been a short-lived growth period
- XBB and subvariants remain a concern



HHS Region 3: 10/30/2022 – 11/5/2022 NOWCAST

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

WHO label	Lineage #	US Class	%Total	95%PI
Omicron	BA.5	VOC	35.3%	31.4-39.3%
	BQ.1.1	VOC	22.8%	16.8-30.0%
	BQ.1	VOC	13.8%	11.7-16.2%
	BA.4.6	VOC	11.2%	9.1-13.7%
	BF.7	VOC	10.2%	7.7-13.3%
	BA.5.2.6	VOC	3.4%	2.7-4.3%
	BA.2.75	VOC	1.8%	1.3-2.5%
	BA.2.75.2	VOC	1.2%	0.7-2.3%
	BA.4	VOC	0.2%	0.2-0.3%
	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%
	BA.2	VOC	0.0%	0.0-0.0%
Delta	B.1.617.2	VBM	0.0%	0.0-0.0%
Other	Other*		0.1%	0.0-0.1%

* 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 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, 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, BA.5.2.6 were aggregated with BA.5. Lineages BA.2.75.2, BA.4.6, BF.7, BA.5.2.6 and BQ.1.1 contain the spike substitution R346T.

CDC Variant Tracking

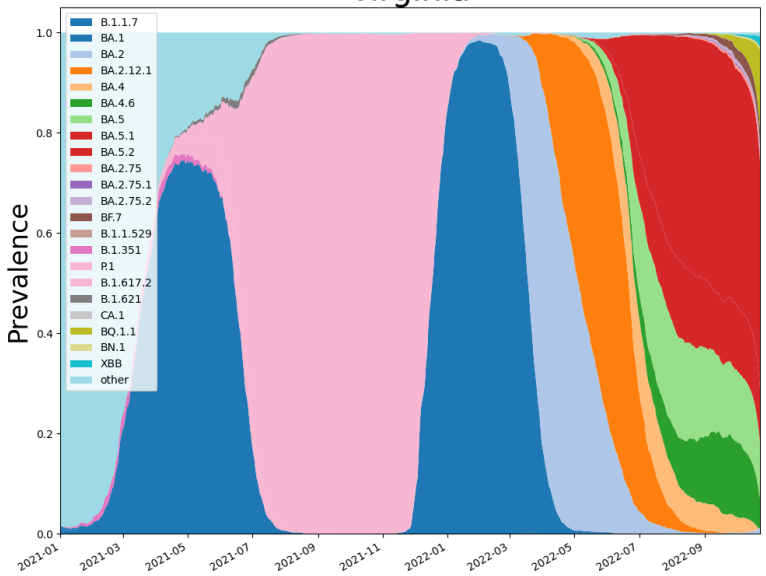
SARS-CoV2 Omicron Sub-Variants

covSPECTRUM
Enabled by data from GISAID

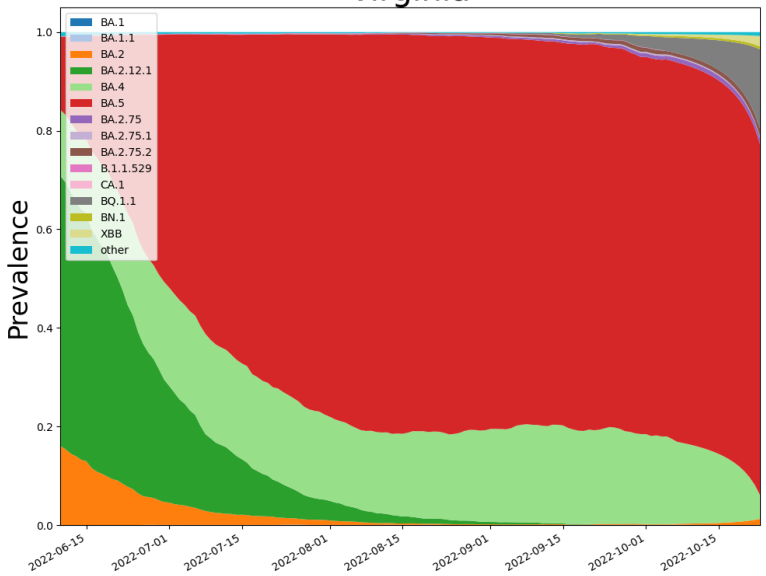
As detected in whole Genomes in public repositories

VoC Polynomial Fit Projections

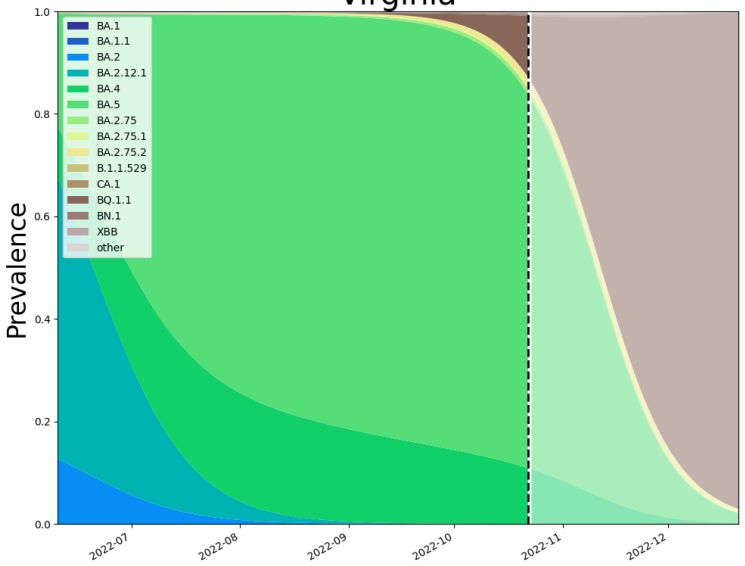
Virginia



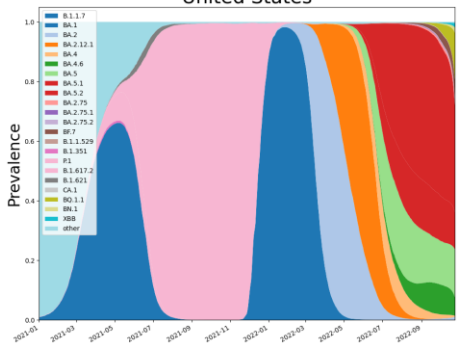
Virginia



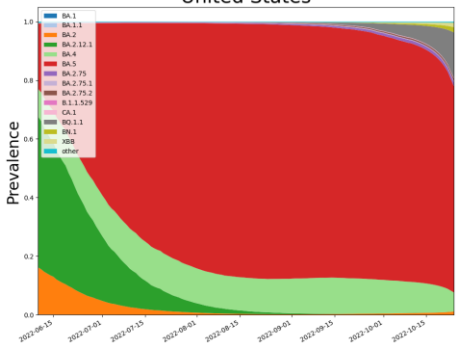
Virginia



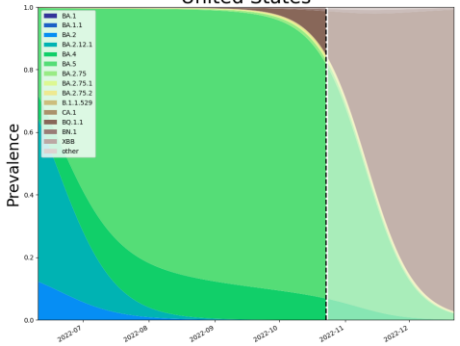
United States



United States



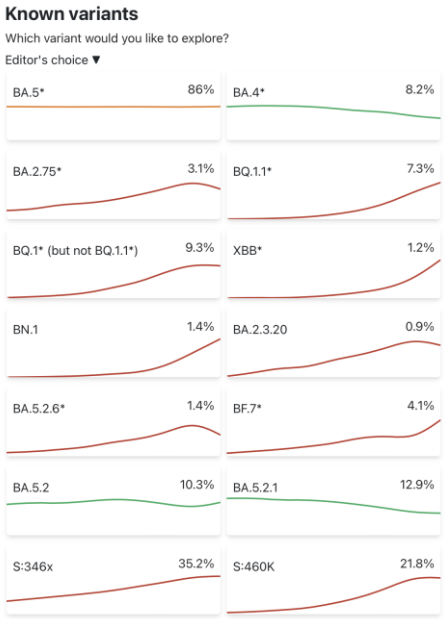
United States



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

SARS-CoV2 Omicron Sub-Variants

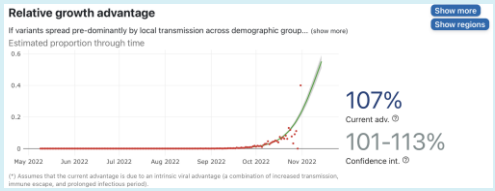
COV-spectrum
"Editor's choice"
Variants to watch

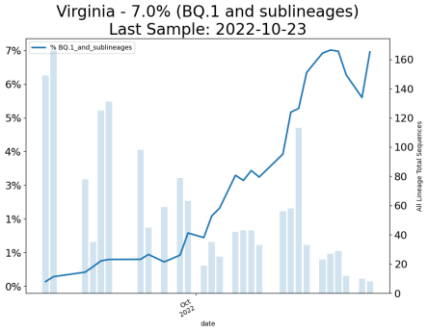


covSPECTRUM

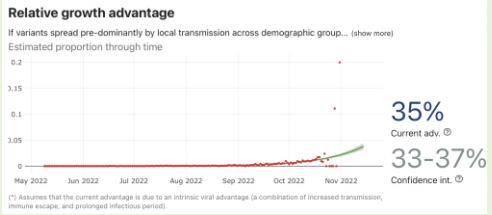
Enabled by data from GISAID

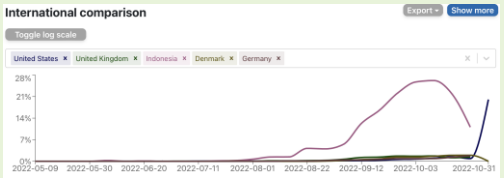
BQ.1.1



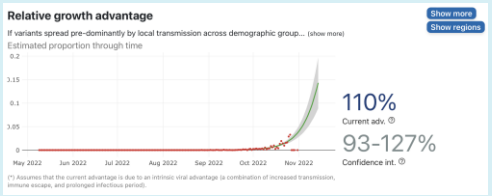


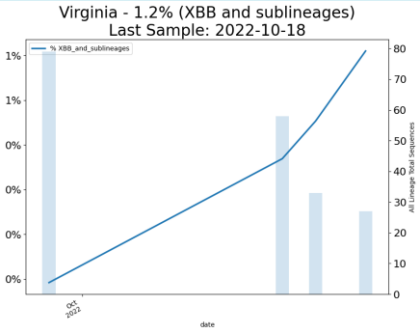
BA.5.2.6





XBB*





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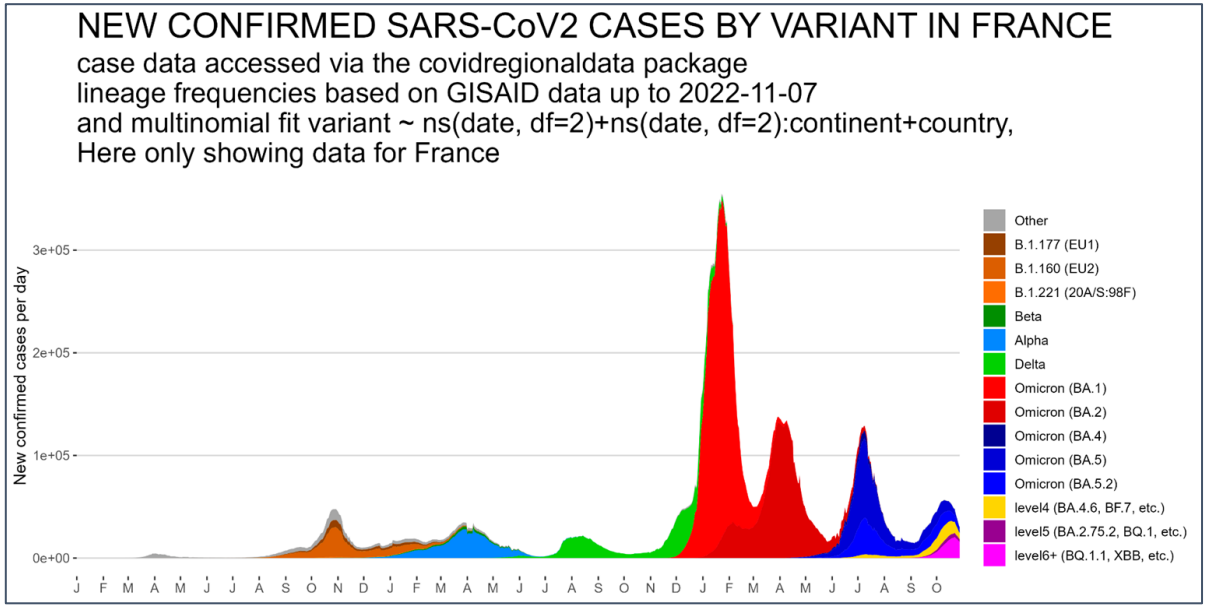
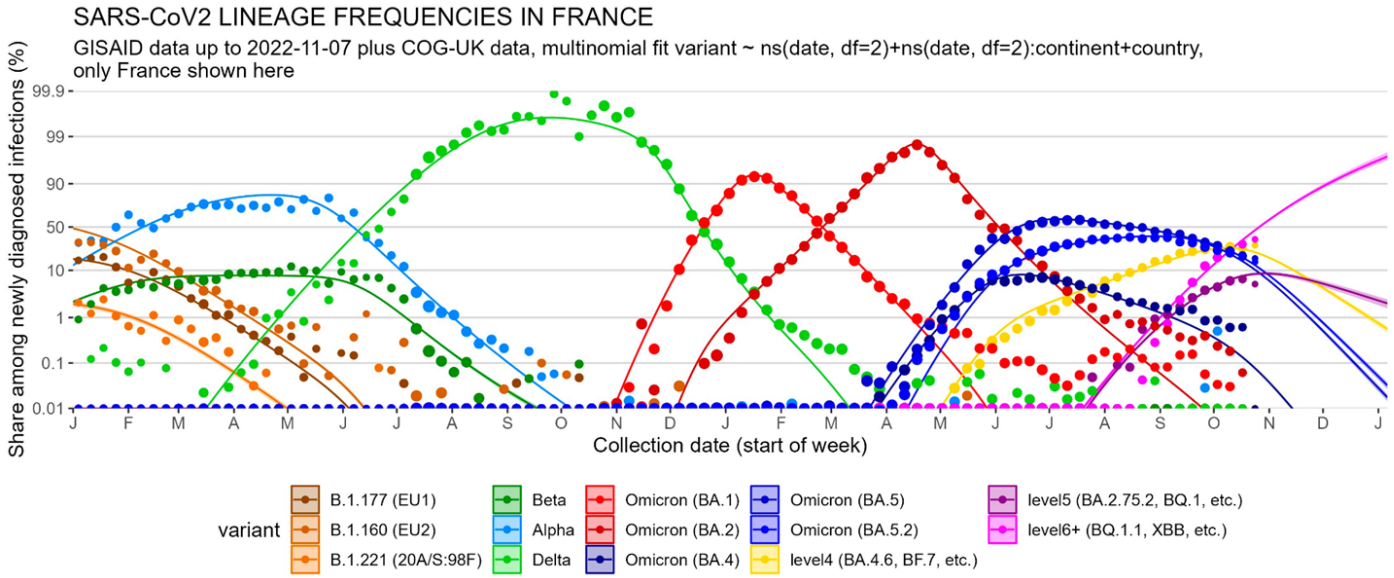
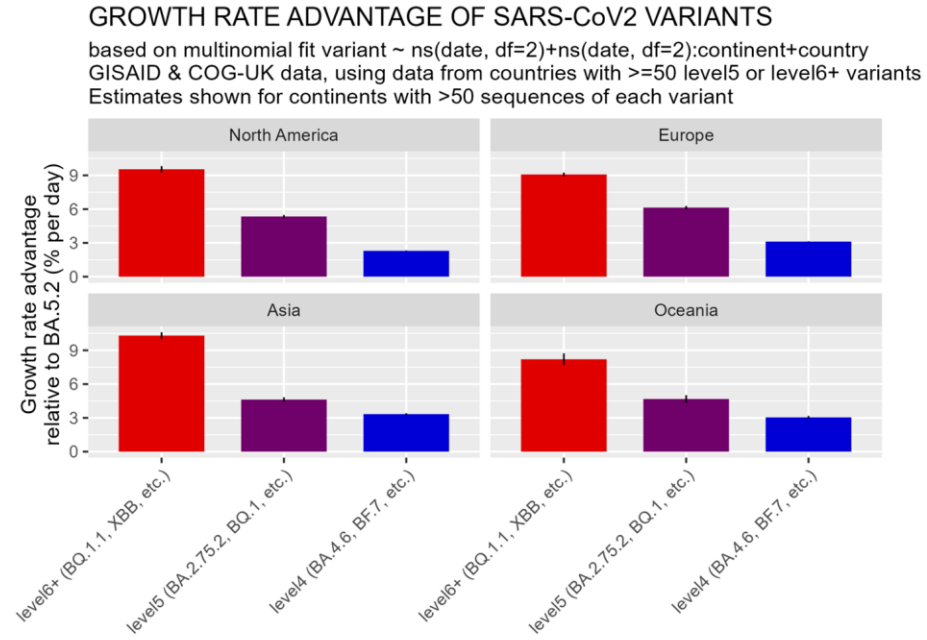
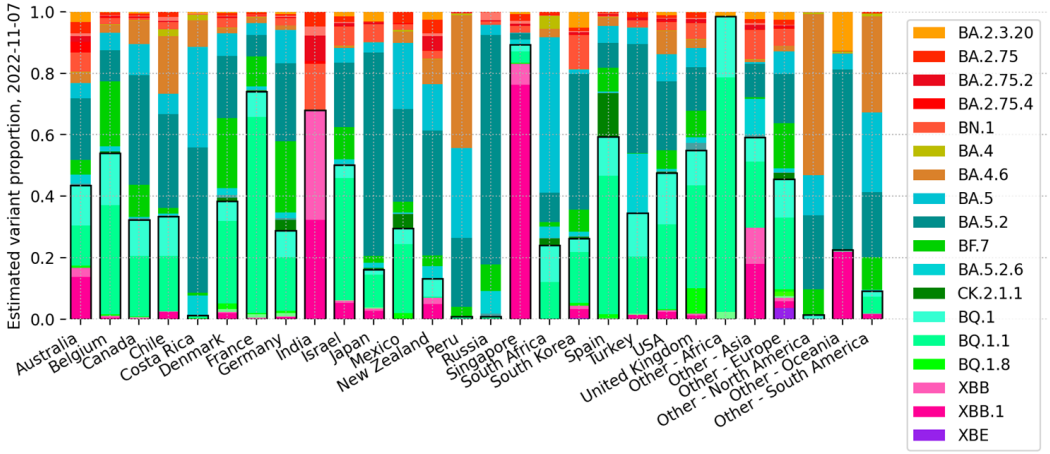
Pandemic Pubs (Nov 9th, 2022)

1. Trend in France shows positive signs for minimal BQ.1 wave







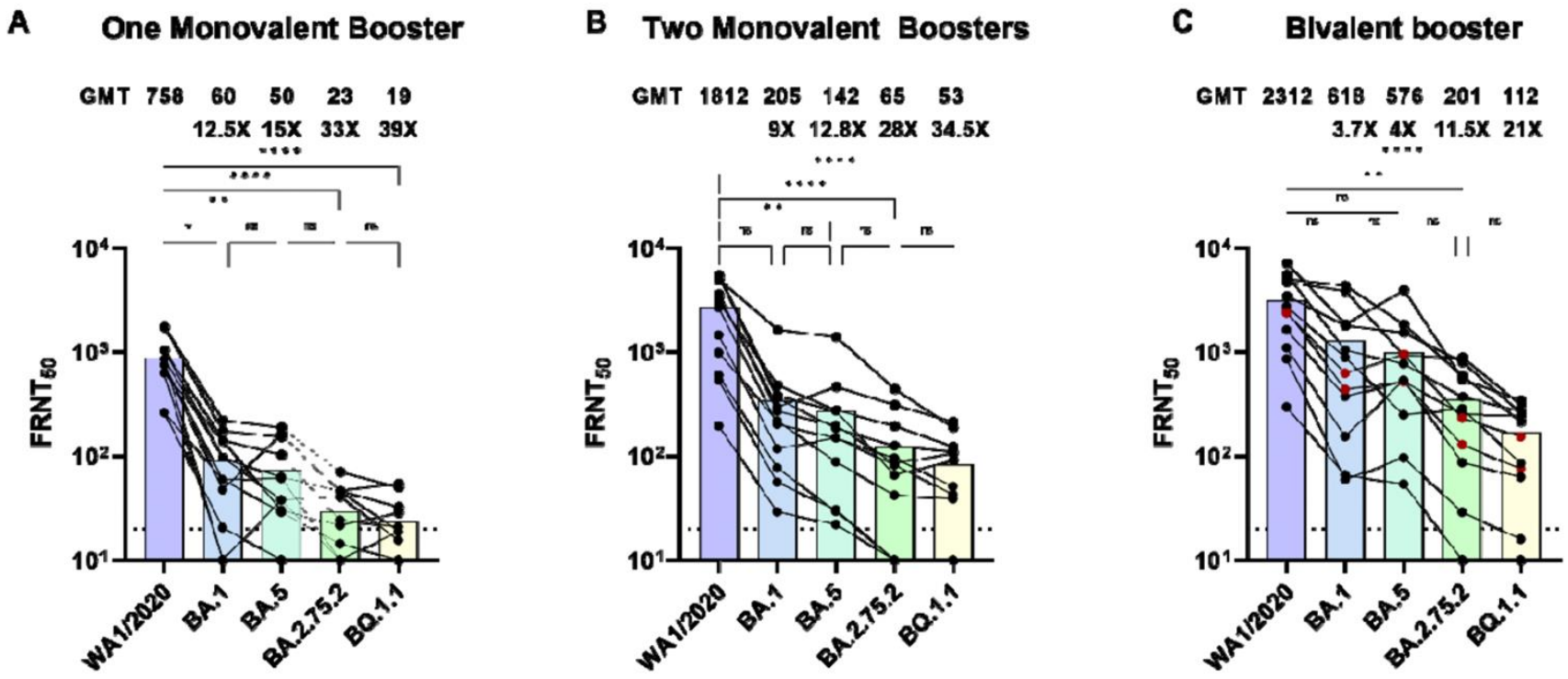


Tom Wenseleers, professor at KU Leuven and Professor Moritz Gersten at University of Heidelberg estimate a recent reduction in the growth advantage of BQ.1.1 (down to 9-10% over BA.5) and observe a reduction in the new cases confirmed per day. France has been marked as a bellwether relative to the BQ.1.1 variant due to early dominance of the variant there. It remains to be seen if immunity from previous BA.5 wave is the most likely cause of this trend.

https://twitter.com/TWenseleers/status/1589554986983206913
https://twitter.com/MoritzGerstung/status/1588466692014891008

Pandemic Pubs (Nov 2nd, 2022)

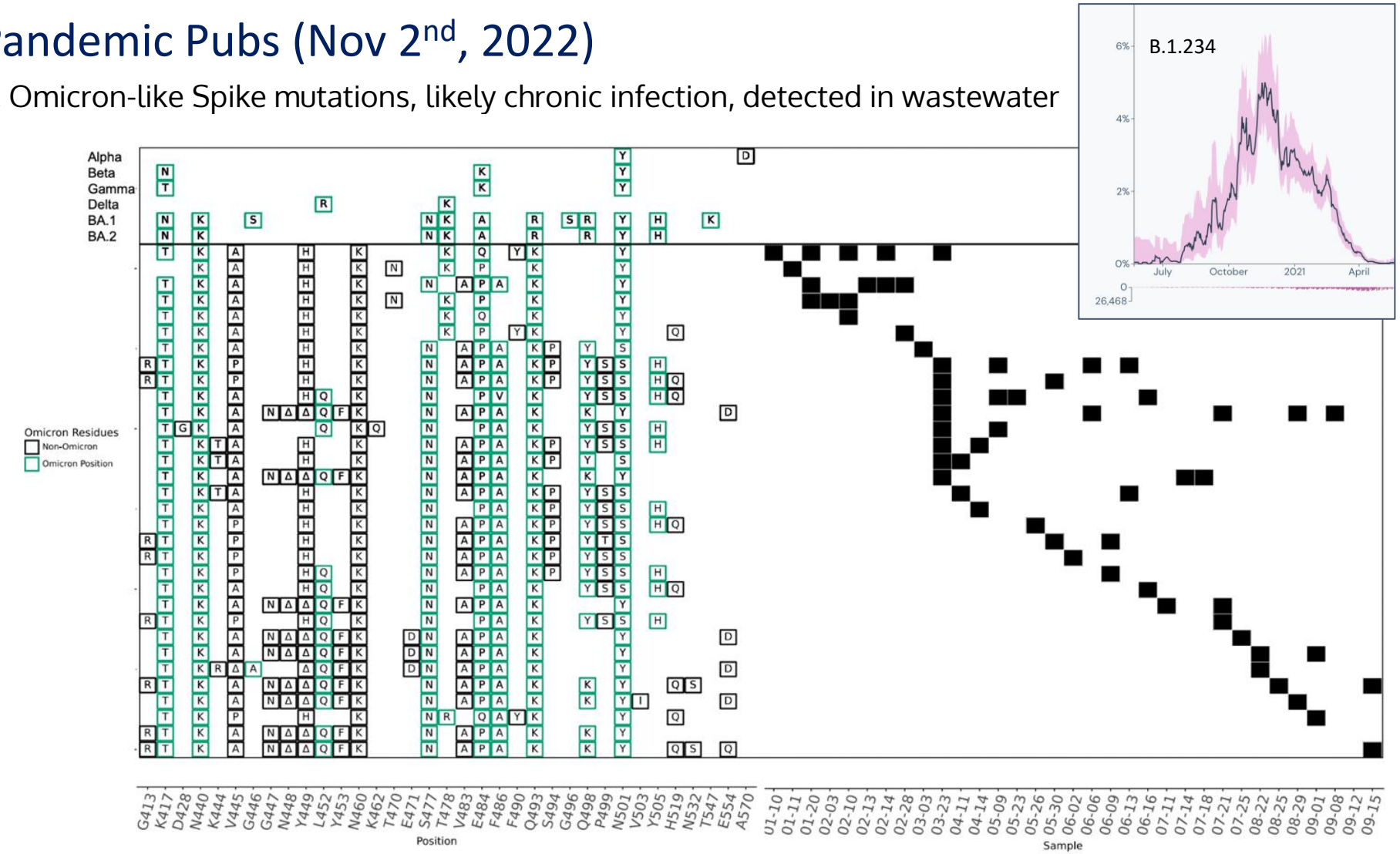
1. Data suggest that the bivalent mRNA booster vaccine broadens humoral immunity against the Omicron subvariants.



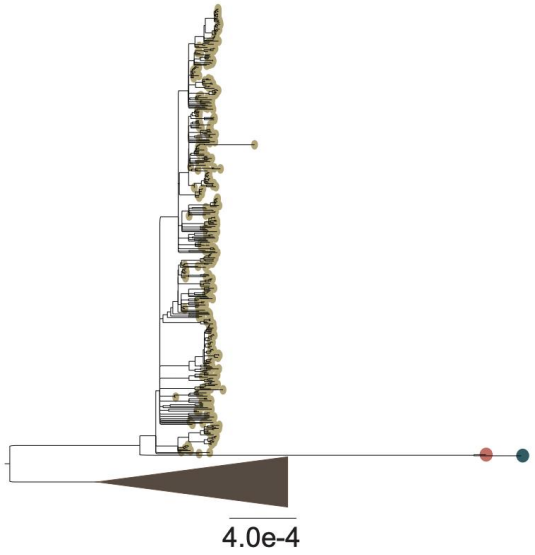
Researchers at Emory, Stanford, and NIAID evaluated serum samples from individuals who had received either one or two monovalent boosters or the bivalent booster to determine neutralizing activity against wild-type and Omicron subvariants BA.1, BA.5, BA.2.75.2, and BQ.1.1. Monovalent booster cohort: 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

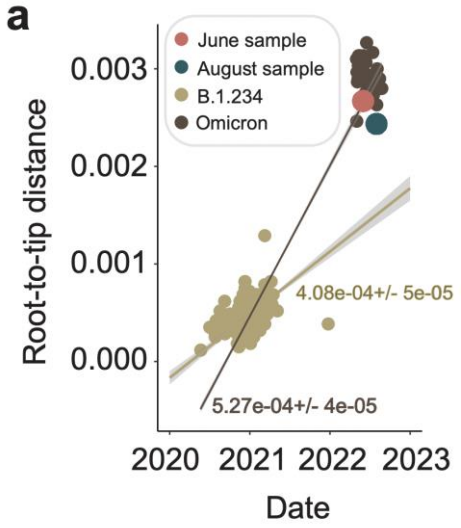
Pandemic Pubs (Nov 2nd, 2022)

2. Omicron-like Spike mutations, likely chronic infection, detected in wastewater



The authors suggest "**The simplest explanation of this data is that a single individual, originally infected when B.1.234 was in circulation, excreted viruses with the cryptic lineage in 2022.**"



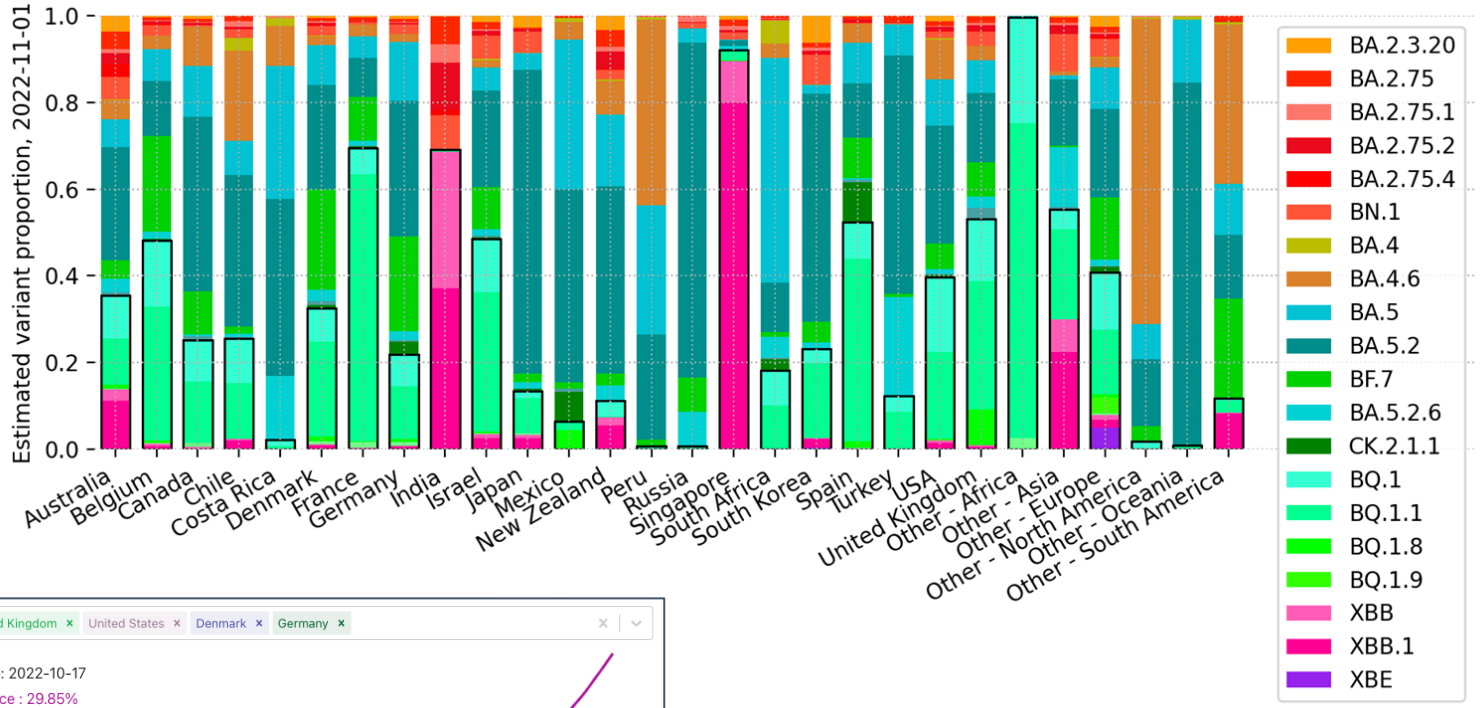


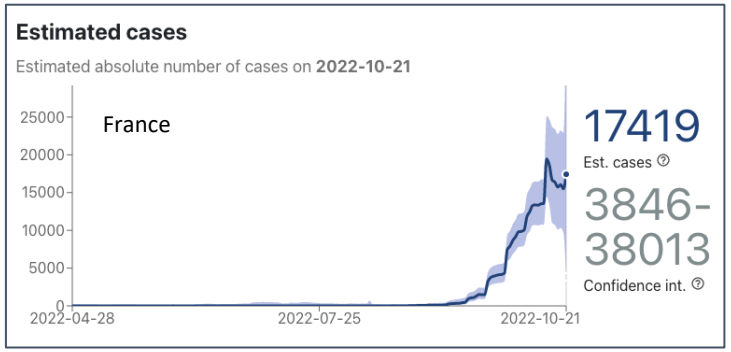
Researchers used wastewater to track unique lineage to its source. Mutations found in surveillance over time indicate a likely chronic intestinal infection. Mutational patterns are similar to that observed with Omicron and in immunocompromised individuals. On January 11, 2022, a cryptic lineage containing at least six unusual Spike RBD variants was first detected in a composite wastewater sample from a metropolitan area in Wisconsin. Wastewater samples for this study (January 2022 through September 2022) were collected in collaboration with experienced wastewater engineers from the city wastewater utility tracing it back to building of origin (human source). Haplotypes are displayed on each row which represented at least 25% of the total sequences in at least one sample. Green boxes indicate residues that are also altered in Omicron (BA.1 or BA.2). Δ indicates an in-frame amino acid deletion. Notably, mutations have accumulated in this lineage faster than expected based on the substitution rate that prevailed when B.1.234 viruses were circulating. A substantially elevated rate of nonsynonymous substitutions was detected in the spike gene, but not in other viral genes. These observations suggest that Spike variation in this virus is driven by diversifying selection
https://www.medrxiv.org/content/10.1101/2022.10.28.22281553v1

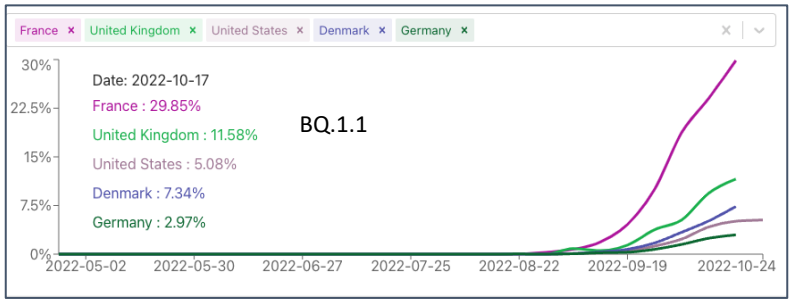
Pandemic Pubs (Nov 2nd, 2022)

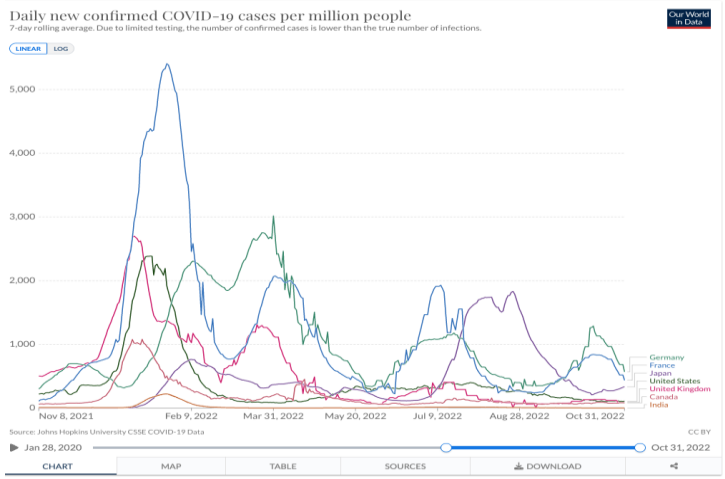
- Professor Moritz Gerstung provides analysis based on sequence surveillance around the world finding a likely BQ.1.1 growth advantage over XBB.1
- France will be an important country to watch in the coming weeks due to current BQ.1.1 dominance

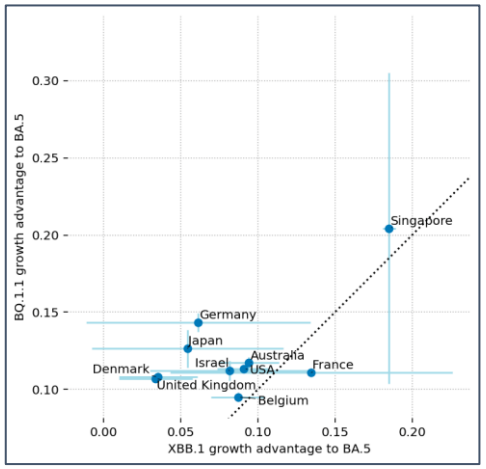
https://twitter.com/MoritzGerstung/status/1585667948311678978
https://cov-spectrum.org/explore/France/AllSamples/Past6M/variants?nextcladePangoLineage=bq.1.1*&
https://ourworldindata.org/covid-cases

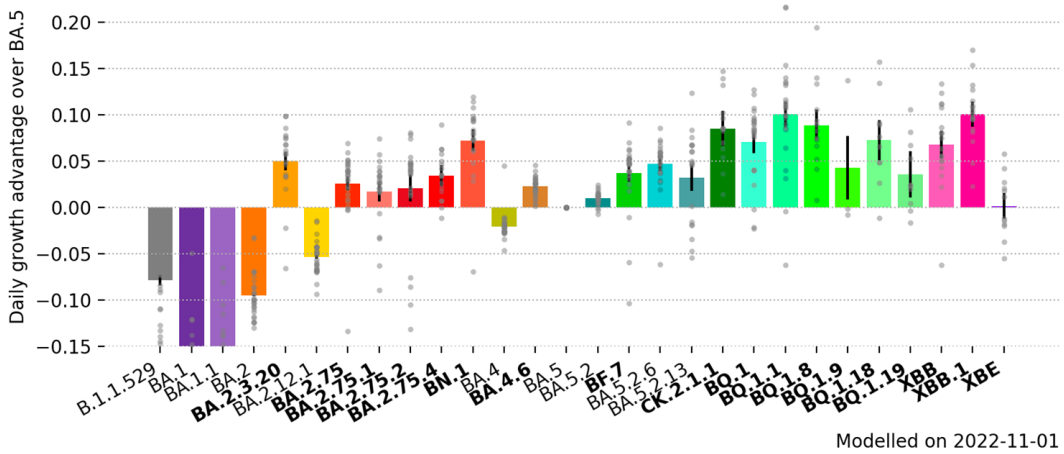






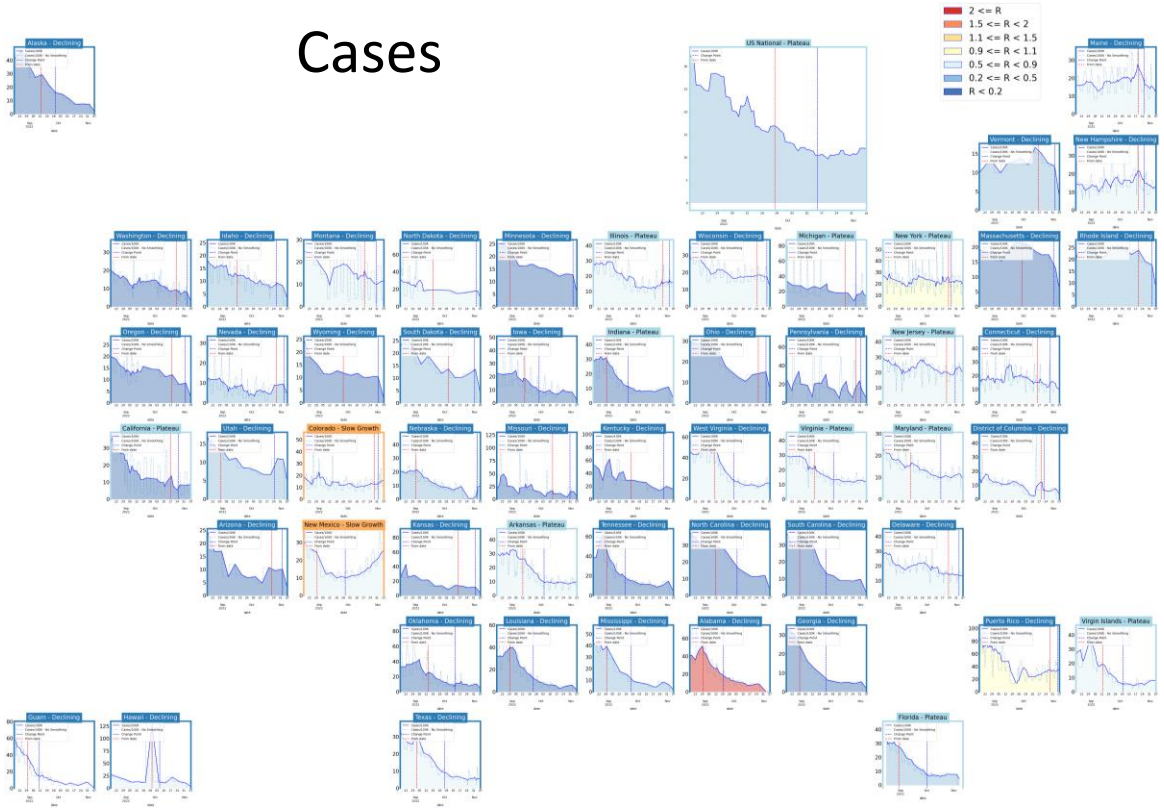


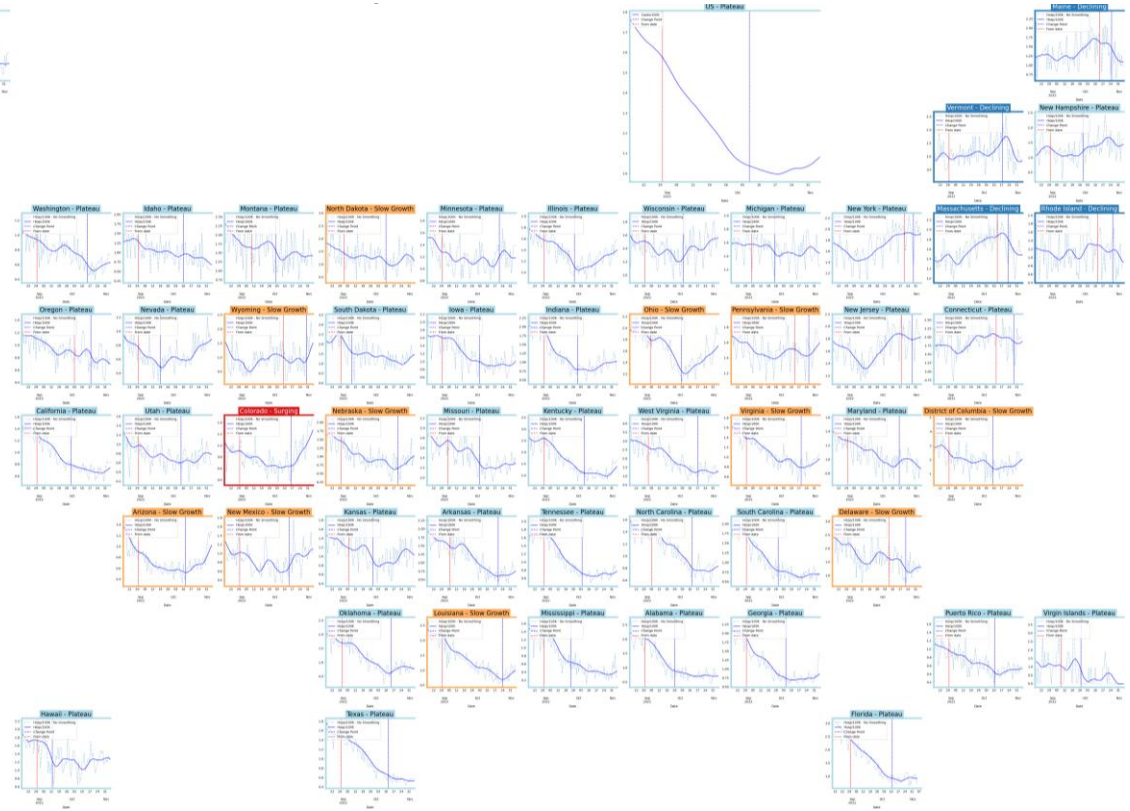




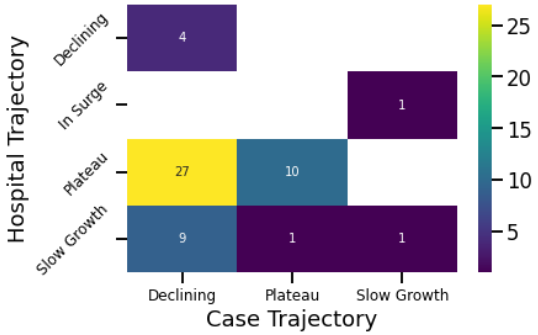
United States Case & Hospitalizations

Cases





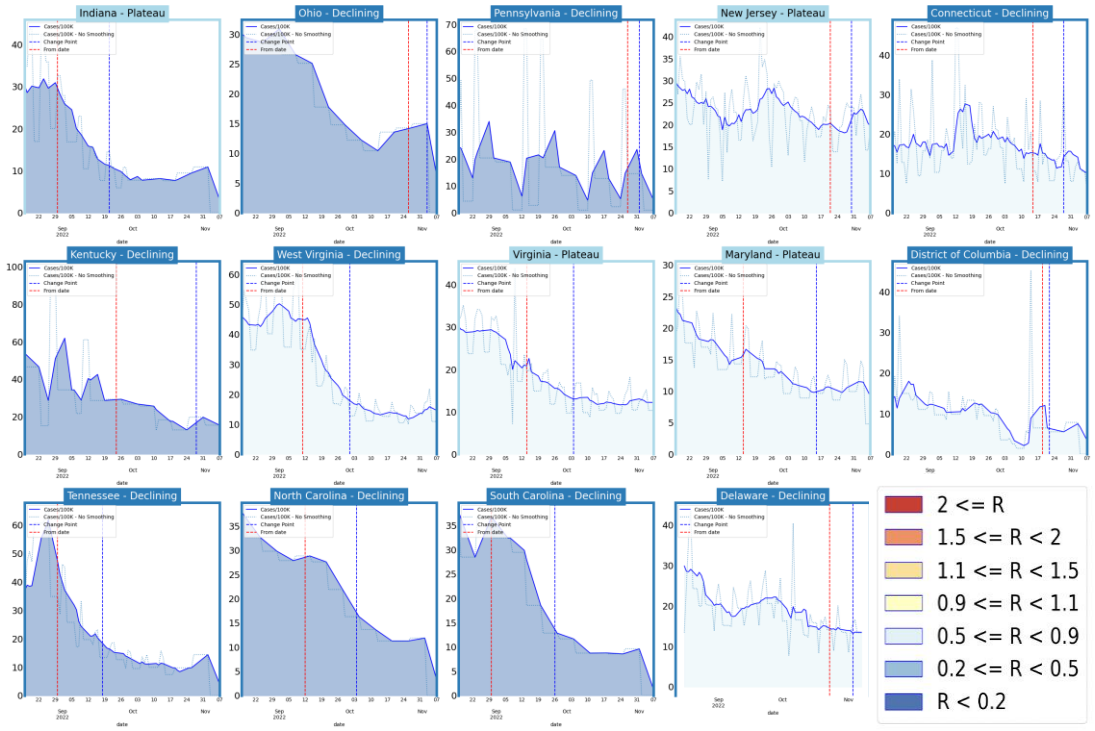
Status	Number of States	
	Current Week	Last Week
Declining	41	(44)
Plateau	11	(7)
Slow Growth	2	(3)
In Surge	0	(0)



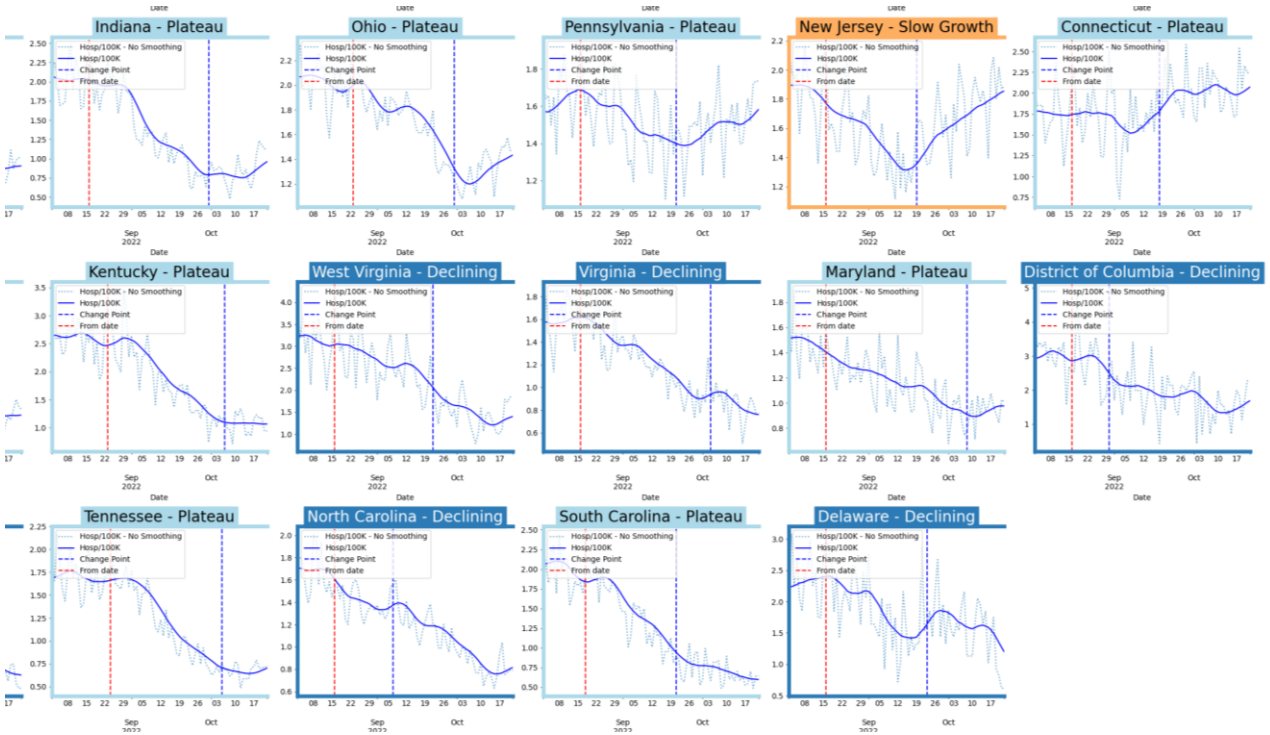
Status	Number of States	
	Current Week	Last Week
Declining	4	(12)
Plateau	37	(31)
Slow Growth	11	(10)
In Surge	1	(0)

Virginia and Her Neighbors

Cases

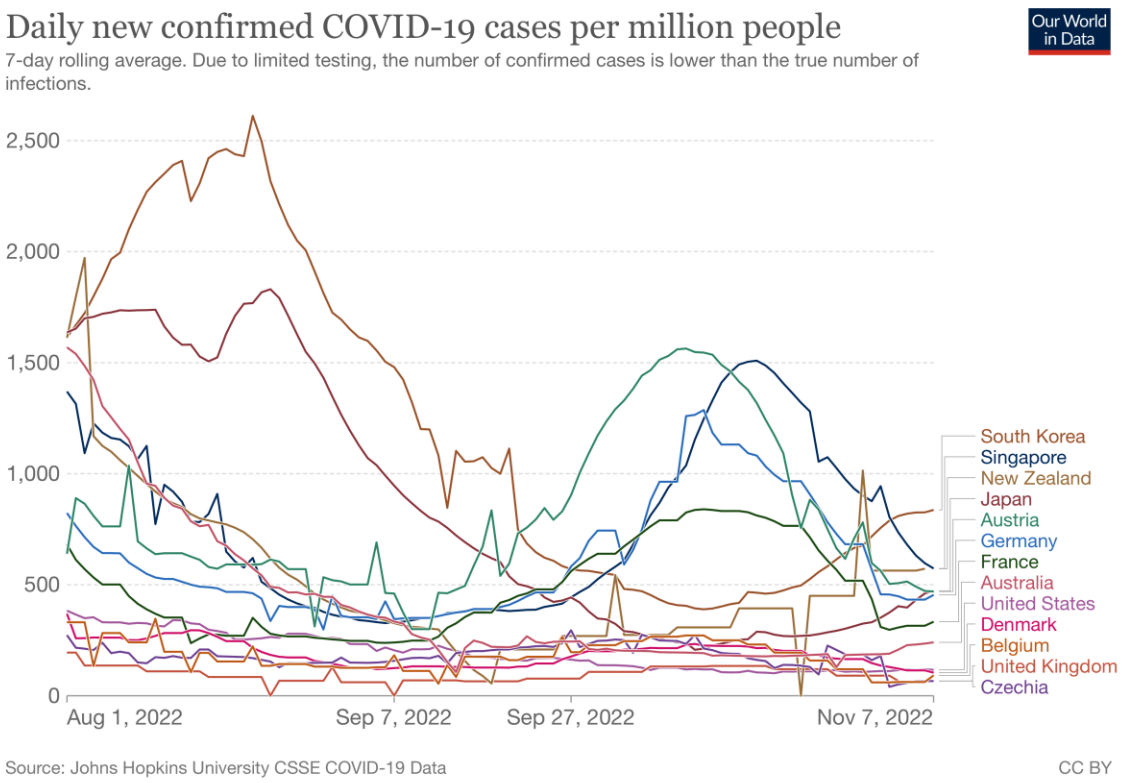


Hospitalizations

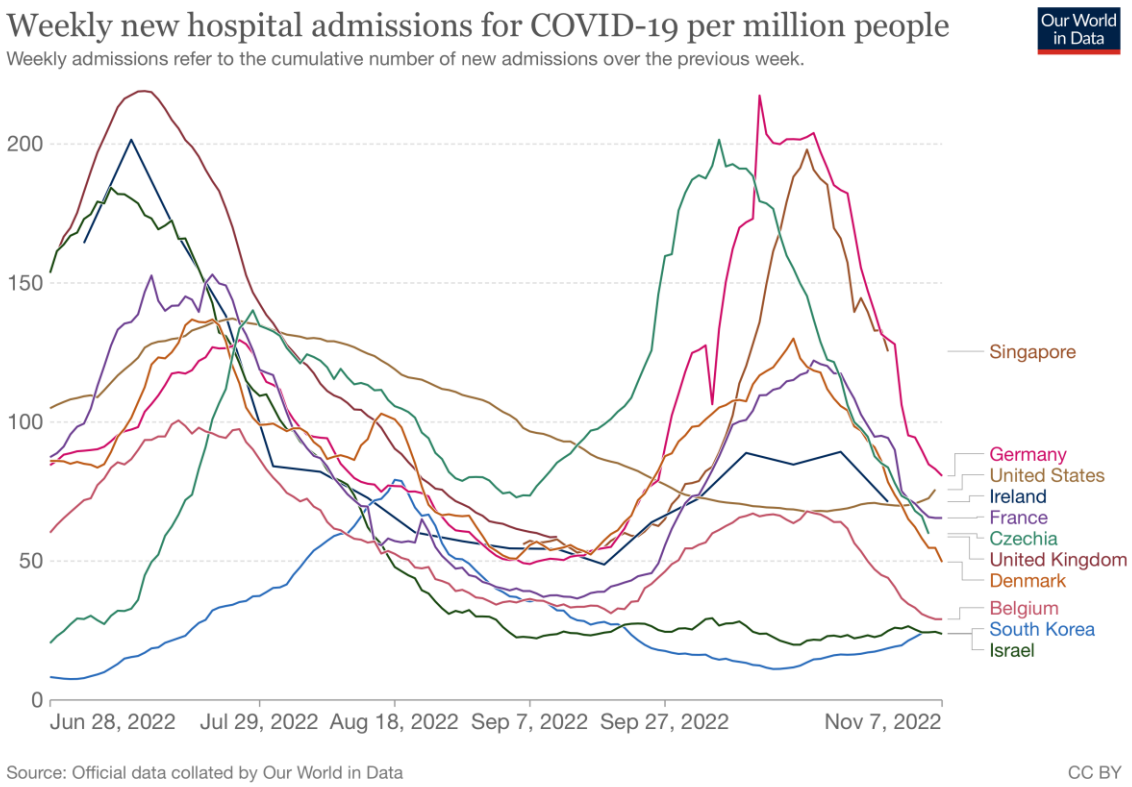


Around the World – Various trajectories

Confirmed cases



Hospitalizations



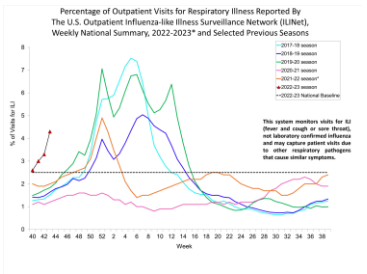
[Our World in Data]

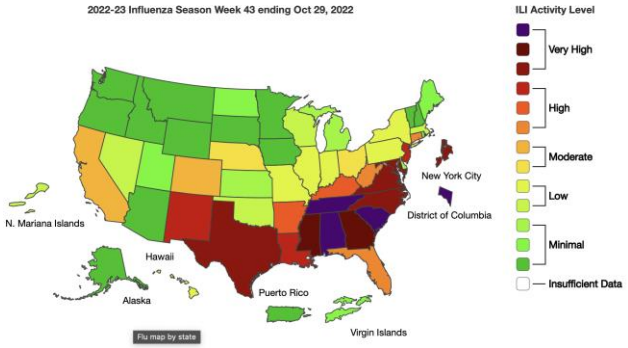
Current Influenza Situation

Influenza Cases and Activity are Higher than Usual

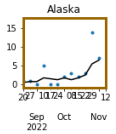
- Highest hospitalization rate for this time of year in past 8 years
- Significant changes in hospitalizations in last 4 weeks especially in Southern and Eastern states
- ILI activity significantly higher than previous seasons, concentrated in South and East

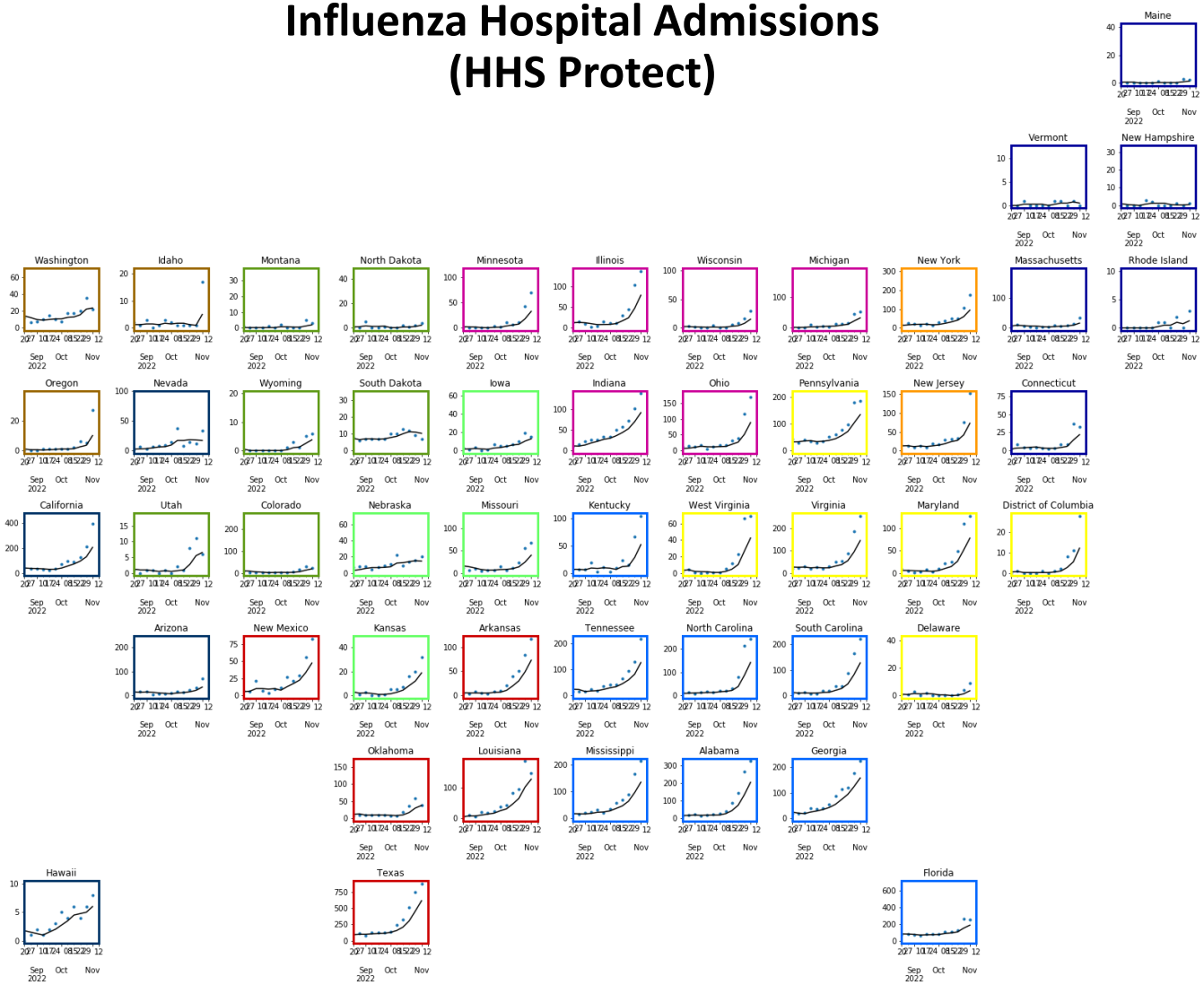
Influenza-Like Illness Activity (ILI Net)





Influenza Hospital Admissions (HHS Protect)





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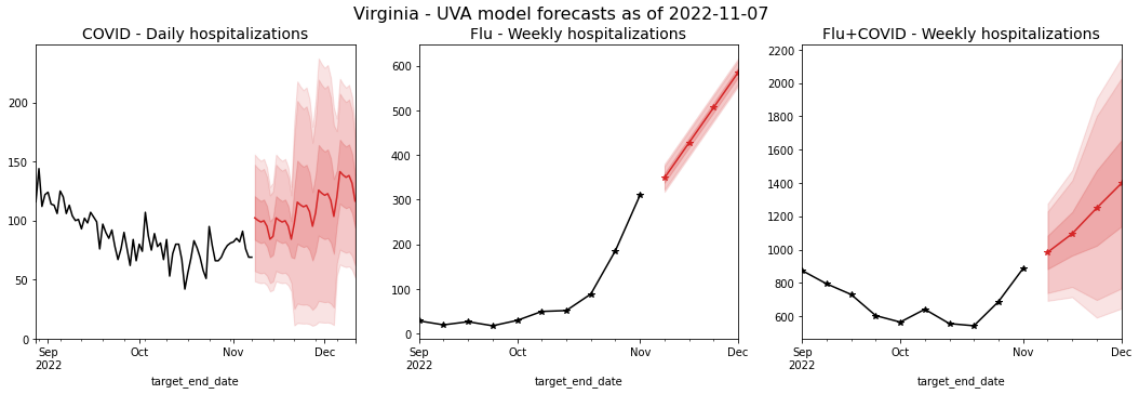
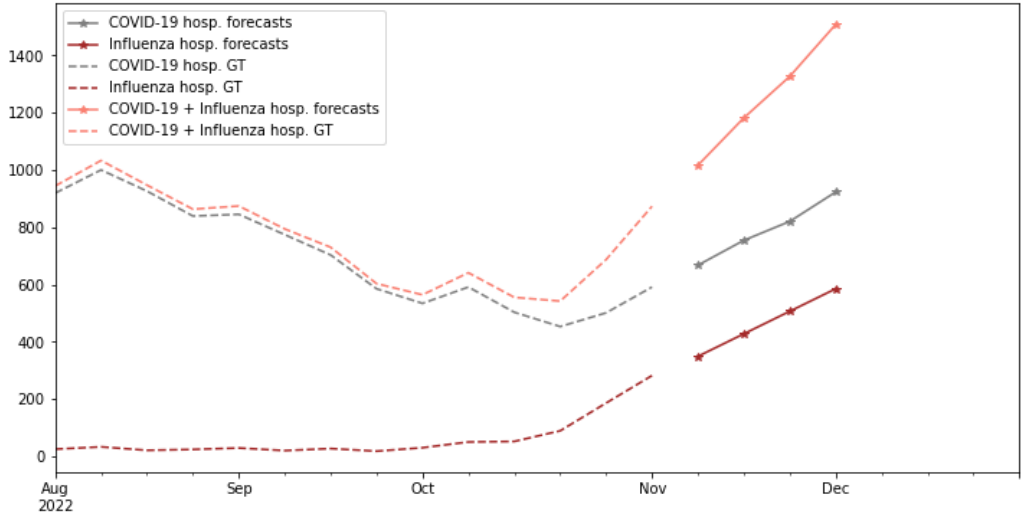
Statistical Ensemble Models - Hospitalizations

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

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



Weekly Hospitalizations
Short-term COVID-19 and Influenza Forecasts



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

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

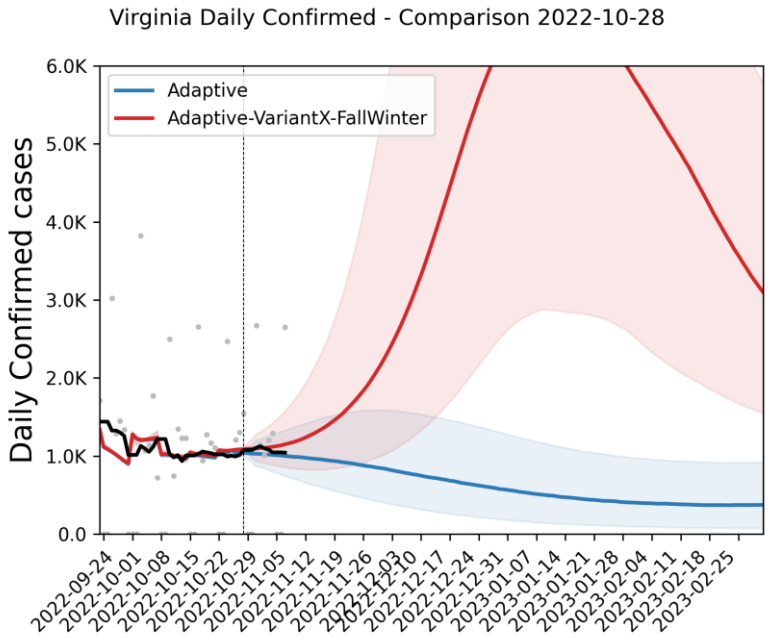
Ensemble forecast provides additional ‘surveillance’ for making scenario-based projections.

Also submitted to CDC Forecast Hub.

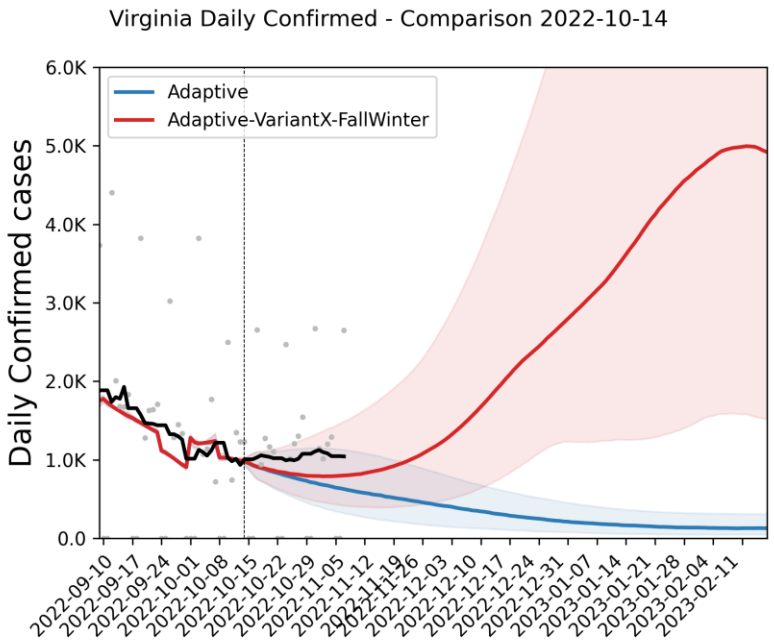
Previous projections comparison - Cases

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

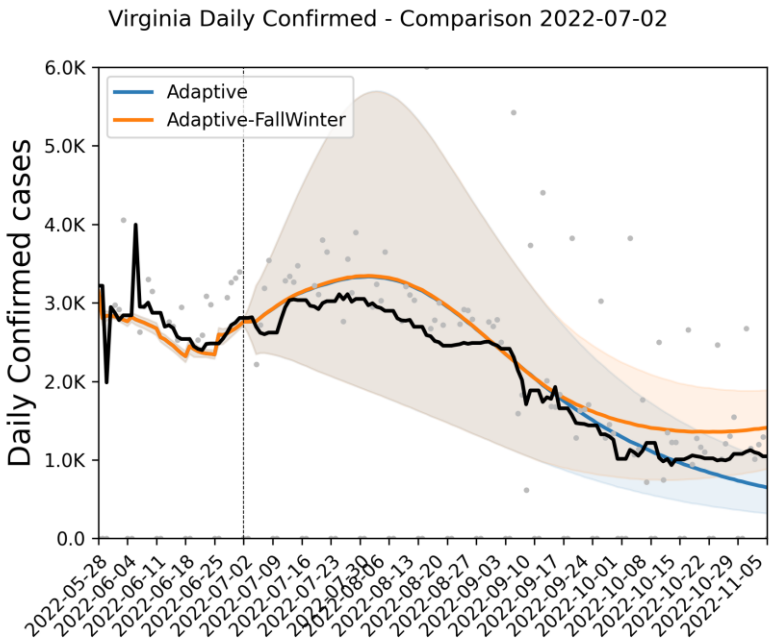
Projection from 1 week ago



Projection from 3 weeks ago



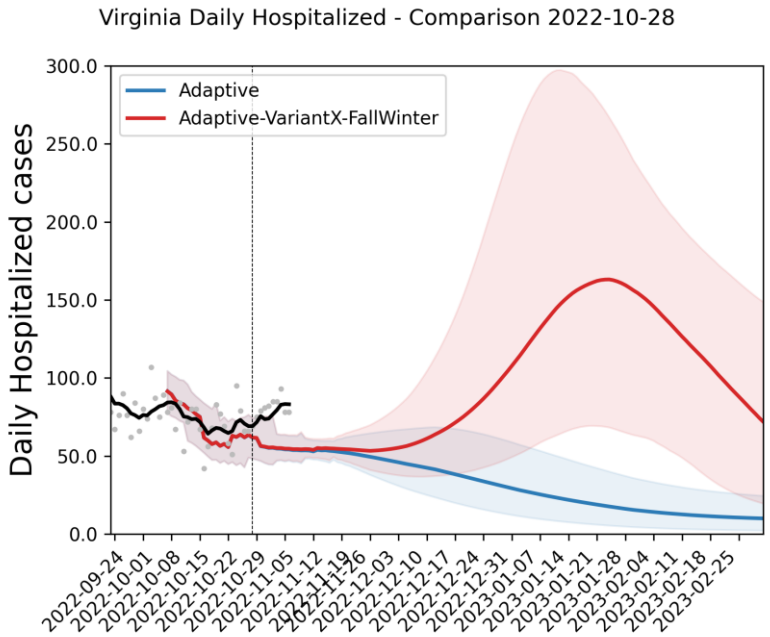
Projection from 3 months ago



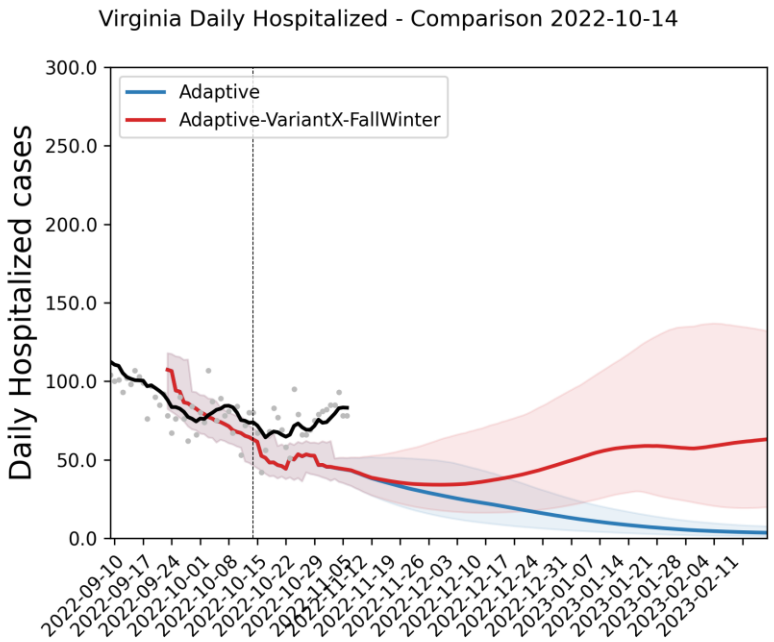
Previous projections comparison - Hospitalizations

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

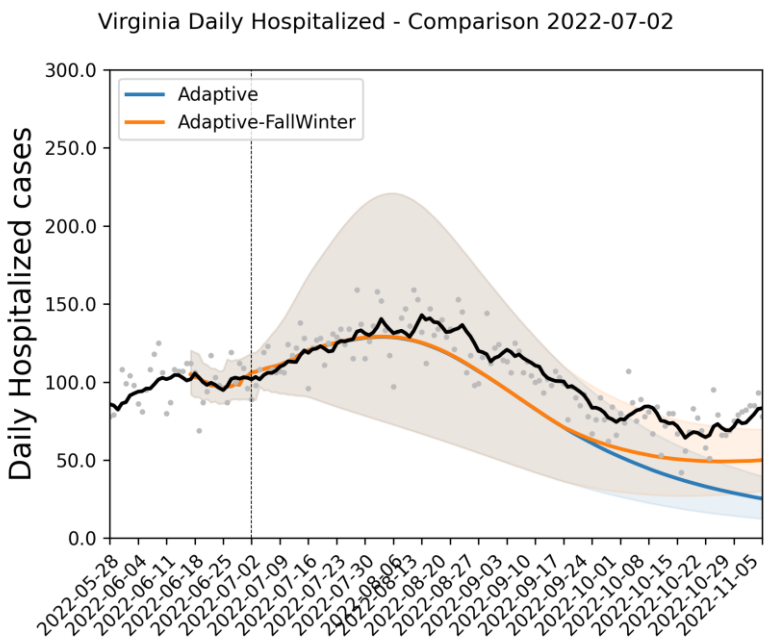
Projection from 1 week ago



Projection from 3 weeks ago



Projection from 3 months ago

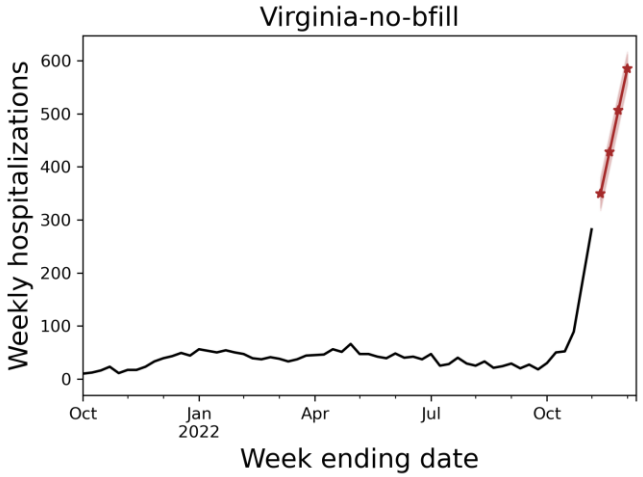


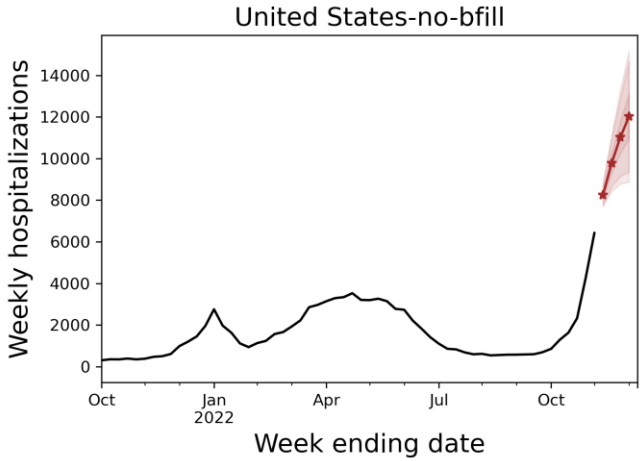
Current Influenza Hospitalization Forecast

Statistical models for submitting to CDC FluSight forecasting challenge

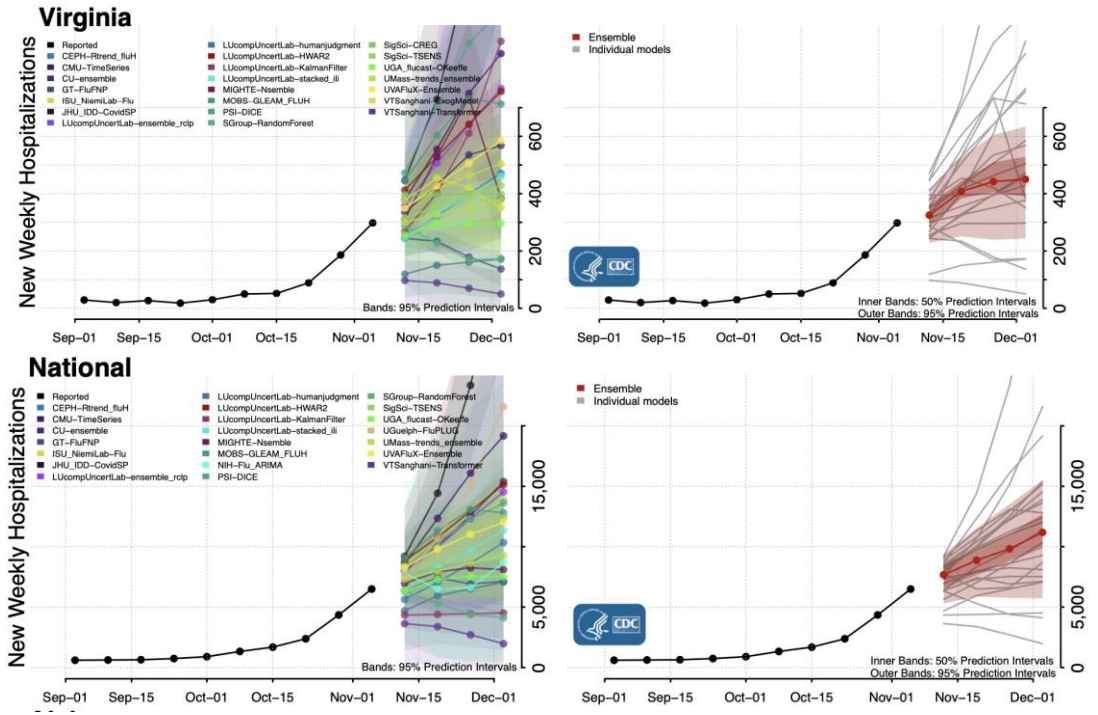
- Similar to COVID-19 case forecasts, uses a variety of statistical and ML approaches to forecast weekly hospital admissions for the next 4 weeks for all states in the US

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





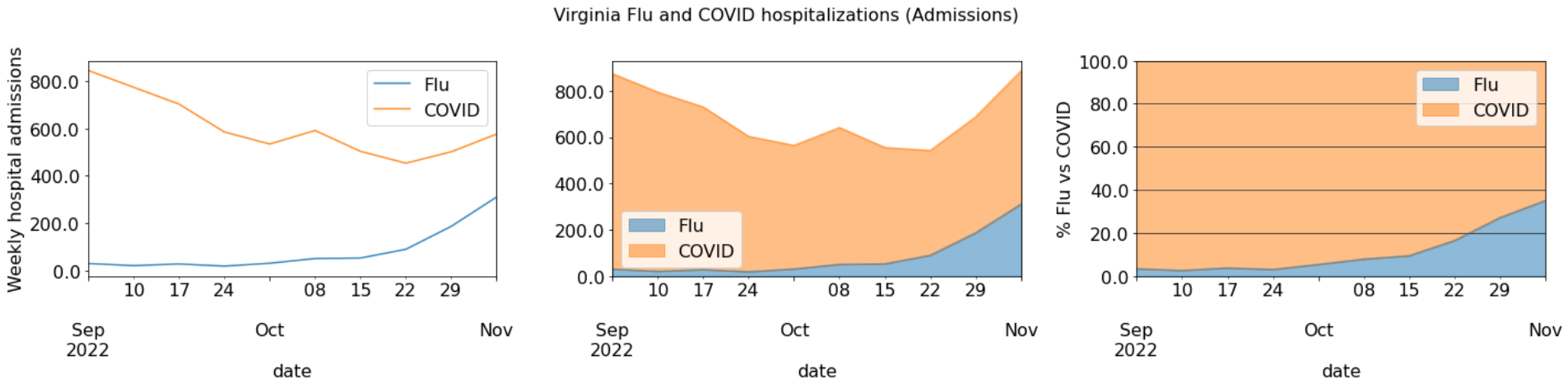
Hospital Admissions for Influenza and Forecast for next 4 weeks (CDC FluSight Ensemble)



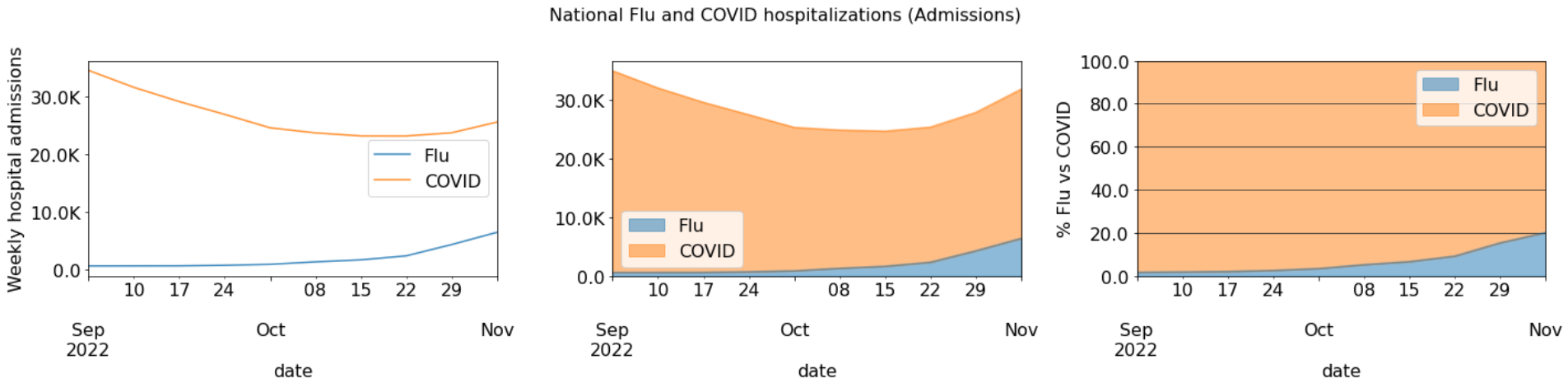
Current Combined Hospitalizations (COVID-19 & Influenza)

COVID-19 and Influenza Weekly Hospitalizations (HHS Protect)

Virginia



USA



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Scenario Modeling Hub – 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

  - ☑ **Scenario A**
    Early boosters
    No new variant
    (A-2022-07-19)
  - ☑ **Scenario B**
    Early boosters
    New immune escape variant
    (B-2022-07-19)
  - ☑ **Scenario C**
    Late boosters
    No new variant
    (C-2022-07-19)
  - ☑ **Scenario D**
    Late boosters
    New immune escape variant
    (D-2022-07-19)

- Influenza Scenarios

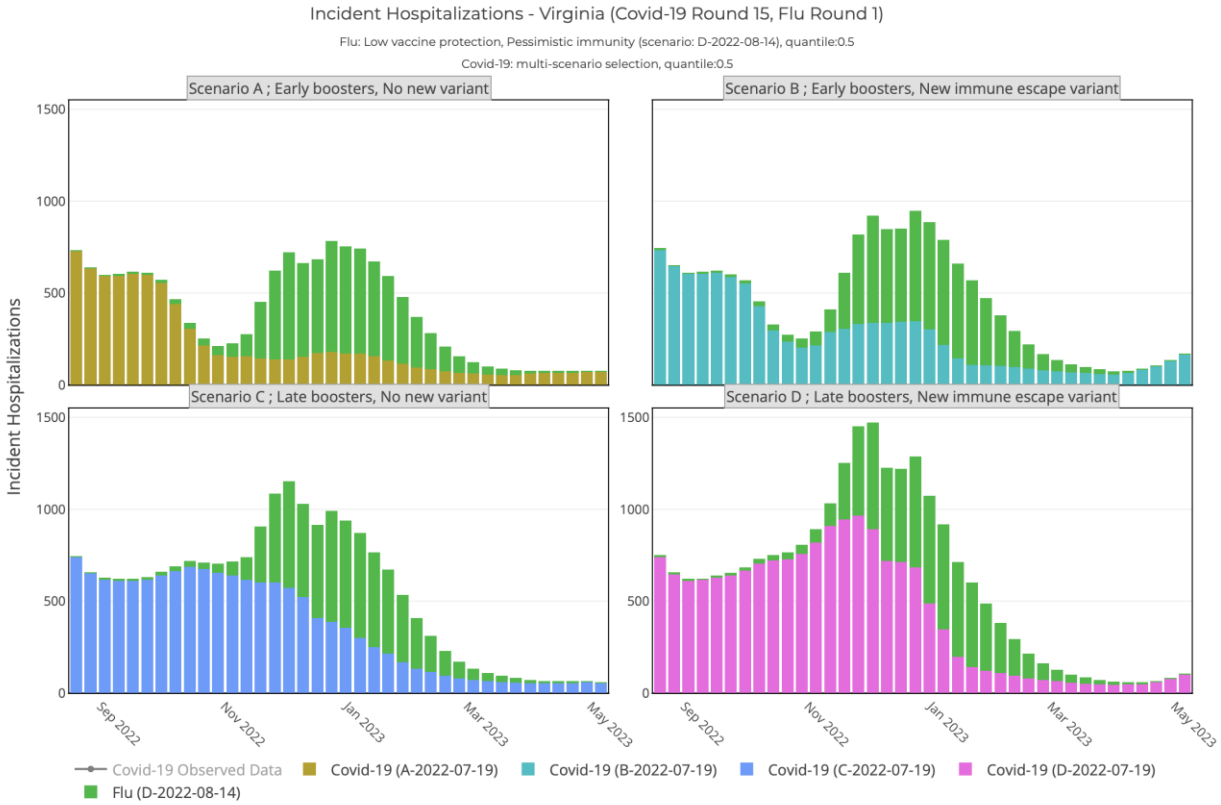
  - ○ High vaccine protection, Optimistic immunity (A-2022-08-14)
  - ○ High vaccine protection, Pessimistic immunity (B-2022-08-14)
  - ○ Low vaccine protection, Optimistic immunity (C-2022-08-14)
  - ◉ Low vaccine protection, Pessimistic immunity (D-2022-08-14)

Round 16 of COVID-19 in progress, Round 2 of Influenza in planning stages; should be available by Thanksgiving

Combined Hospitalizations (VA)

Interactive visualization – MultiPathogen Plot

https://covid19scenariomodelinghub.org/viz.html



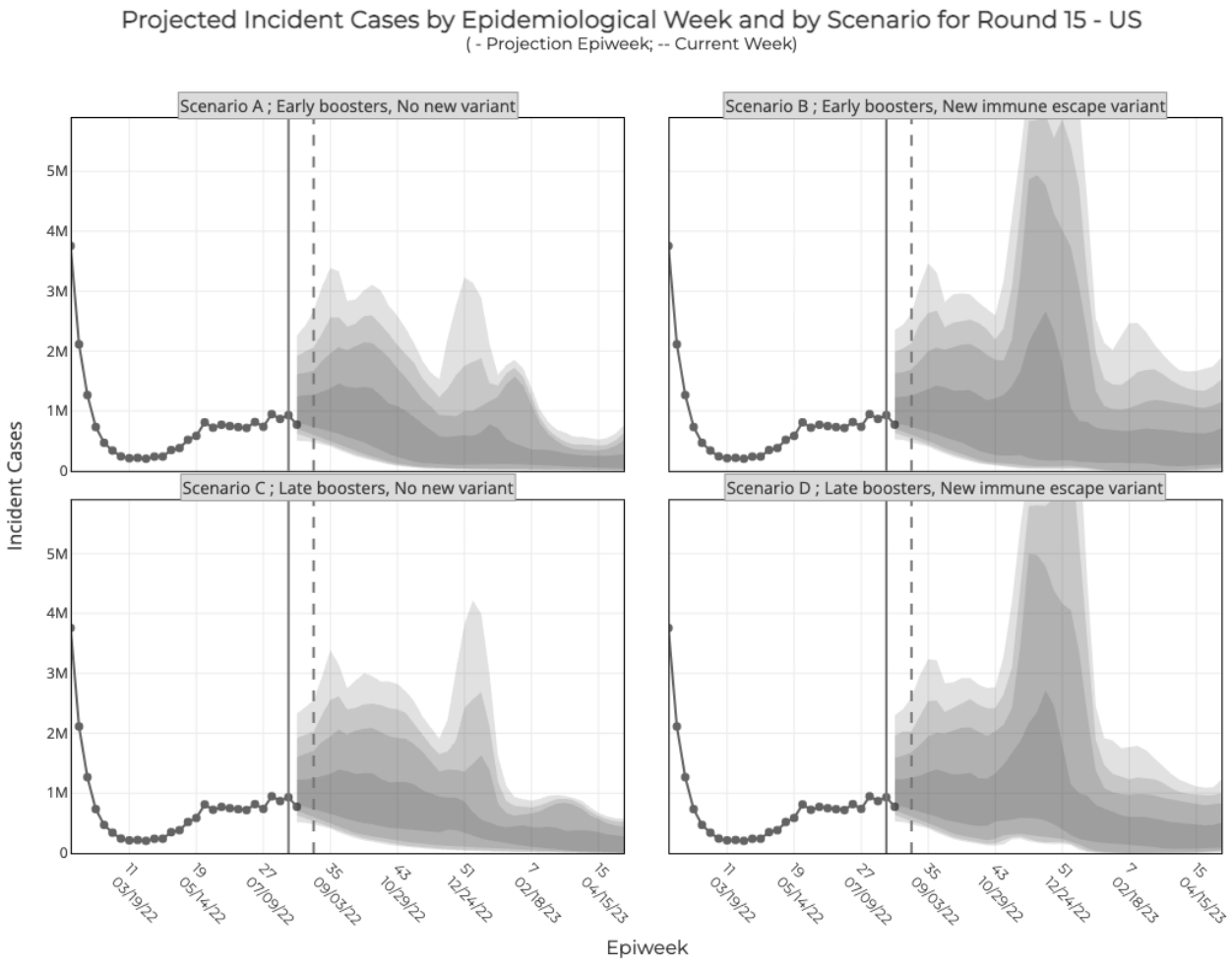
COVID -19 scenarios and most “pessimistic” influenza scenarios combined

Scenario Modeling Hub – COVID-19 (Round 15)

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

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

https://covid19scenariomodelinghub.org/viz.html

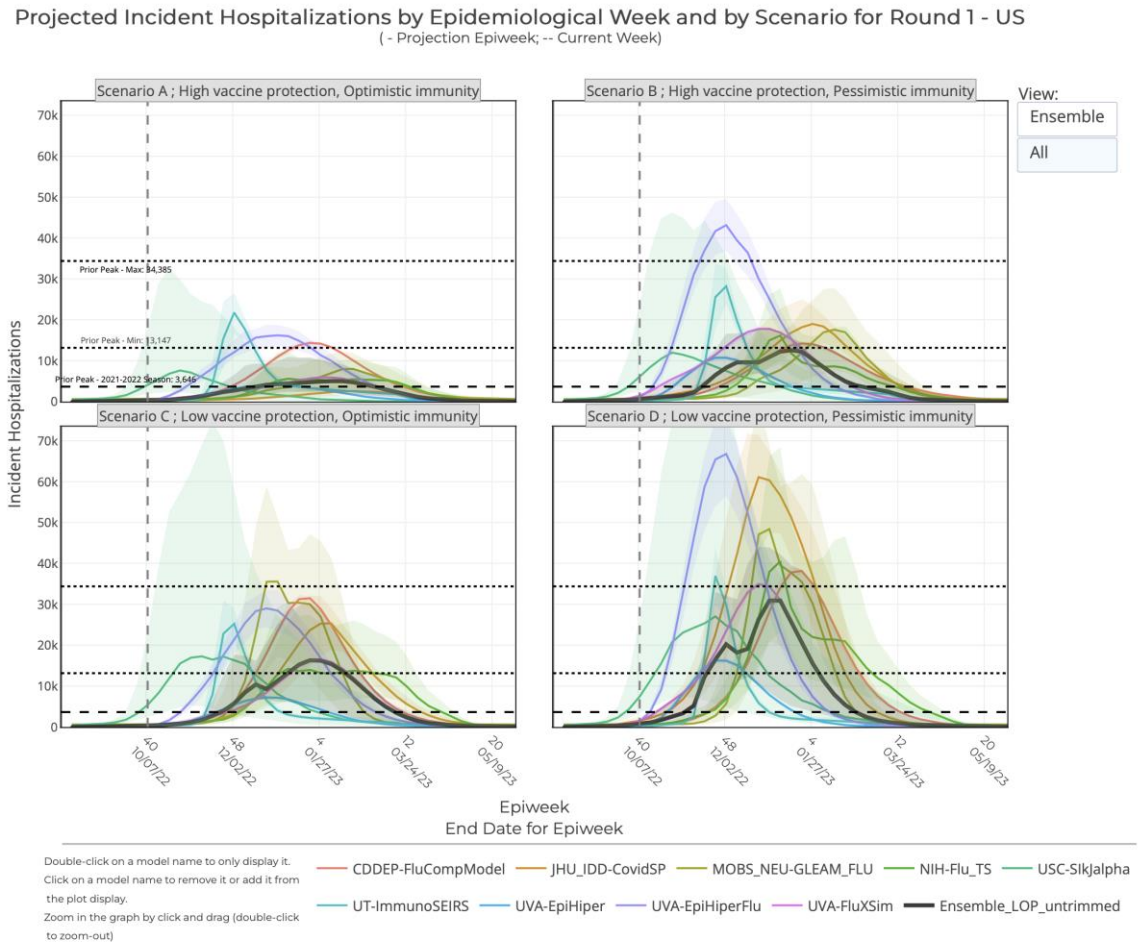


Scenario Modeling Hub – Influenza (Round 1)

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

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

https://fluscenariomodelinghub.org/viz.html



Key Takeaways

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

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

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

Additional Analyses

References

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

Questions?

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