Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

# Estimation of COVID-19 Impact in Virginia

May 4th, 2022

(data current to April 30th – May 3rd)

Biocomplexity Institute Technical report: BI-2022-1120

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# About Us

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


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# Overview

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

# Key Takeaways

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

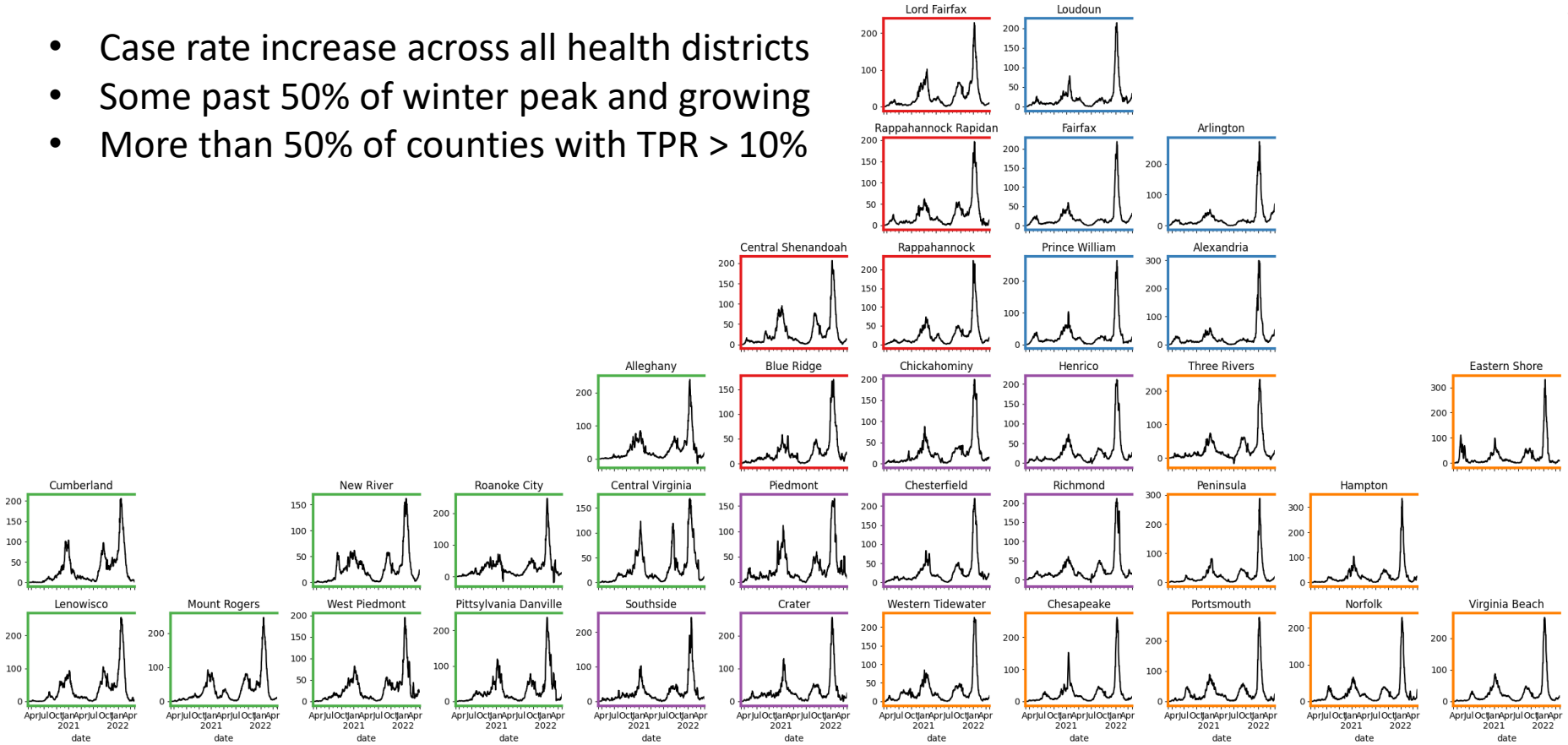
- **Case rates and hospitalizations continue to plateau**
- VA 7-day mean daily case rate continue to increase to 18.5/100K from 15/100K
  - US also increased to 18.5/100K (from 14/100K)
- District level fitting seems to have helped with the projection's accuracy
- BA.2.12.1 continues to rise, but pace of growth remains slow and steady

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

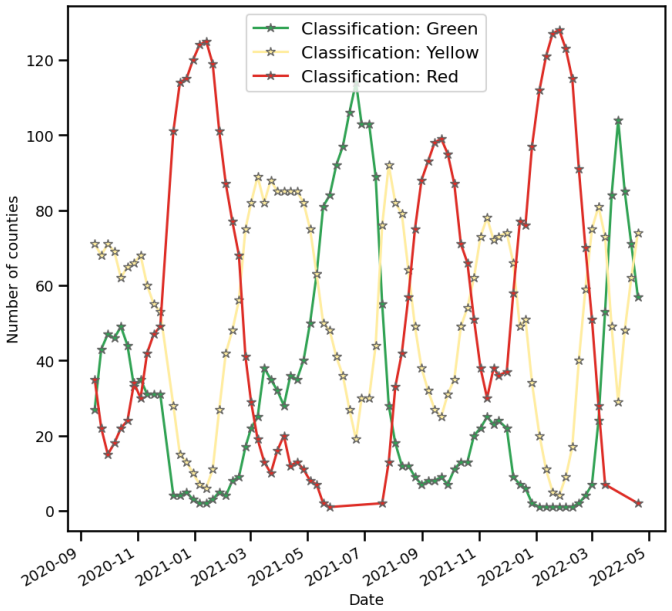
# Situation Assessment

# Case Rates (per 100k) and Test Positivity

- Case rate increase across all health districts
- Some past 50% of winter peak and growing
- More than 50% of counties with TPR > 10%




Data source: https://data.cms.gov/covid-19/covid-19-nursing-home-data




**County level RT-PCR test positivity**

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

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

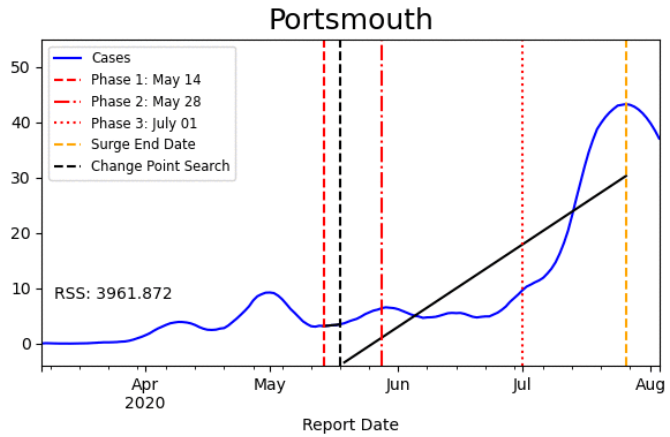
Red: >10.0% (and not "Green" or "Yellow")

# District Trajectories

**Goal:** Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

**Method:** Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

Hockey stick fit

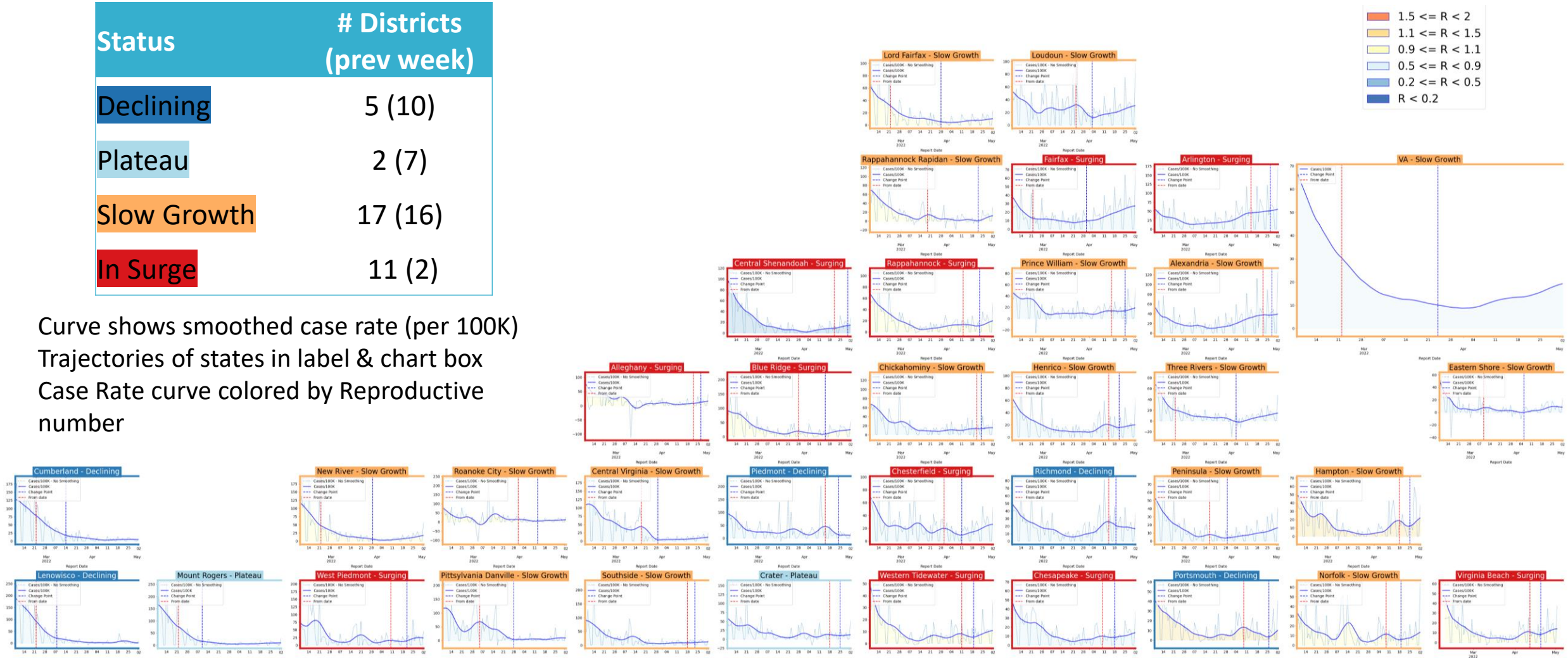



| Trajectory | Description | Weekly Case Rate (per 100K) bounds |
|---|---|---|
| **Declining** | Sustained decreases following a recent peak | below -0.9 |
| **Plateau** | Steady level with minimal trend up or down | above -0.9 and below 0.5 |
| **Slow Growth** | Sustained growth not rapid enough to be considered a Surge | above 0.5 and below 2.5 |
| **In Surge** | Currently experiencing sustained rapid and significant growth | 2.5 or greater |

# District Trajectories – last 10 weeks

| Status | # Districts (prev week) |
|---|---|
| Declining | 5 (10) |
| Plateau | 2 (7) |
| Slow Growth | 17 (16) |
| In Surge | 11 (2) |

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



# CDC's new COVID-19 Community Levels

## What Prevention Steps Should You Take Based on Your COVID-19 Community Level?

| Low | Medium | High |
|---|---|---|
| • Stay up to date with COVID-19 vaccines<br>• Get tested if you have symptoms | • If you are at high risk for severe illness, talk to your healthcare provider about whether you need to wear a mask and take other precautions<br>• Stay up to date with COVID-19 vaccines<br>• Get tested if you have symptoms | • Wear a mask indoors in public<br>• Stay up to date with COVID-19 vaccines<br>• Get tested if you have symptoms<br>• Additional precautions may be needed for people at high risk for severe illness |

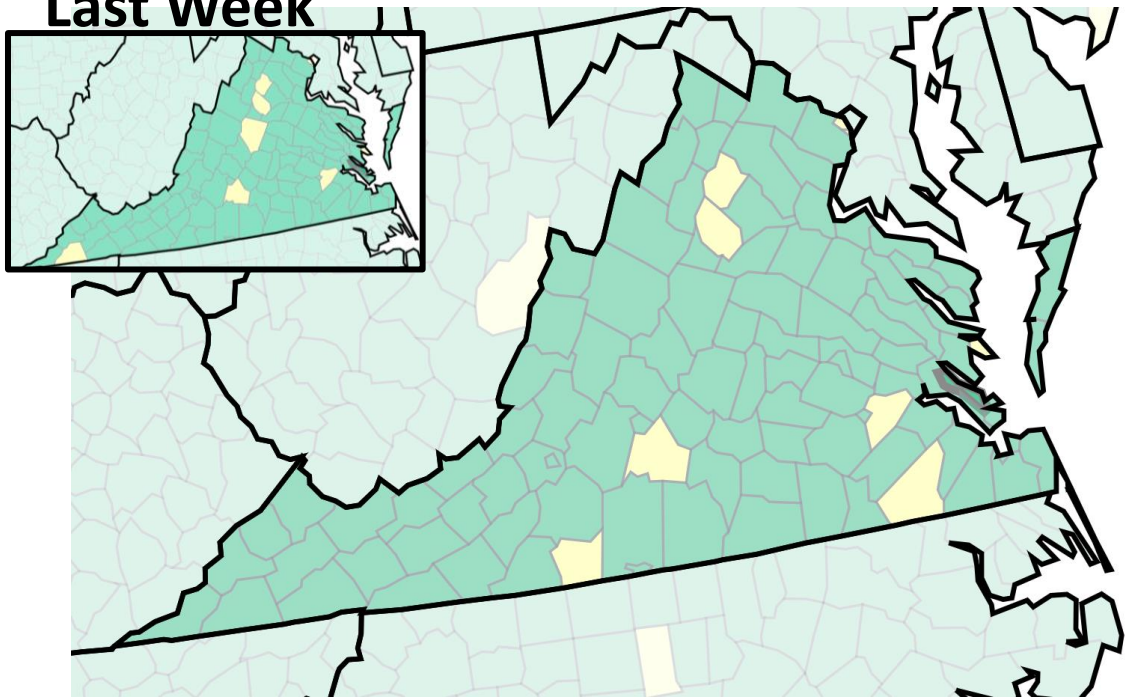
People may choose to mask at any time. People with symptoms, a positive test, or exposure to someone with COVID-19 should wear a mask.

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% |

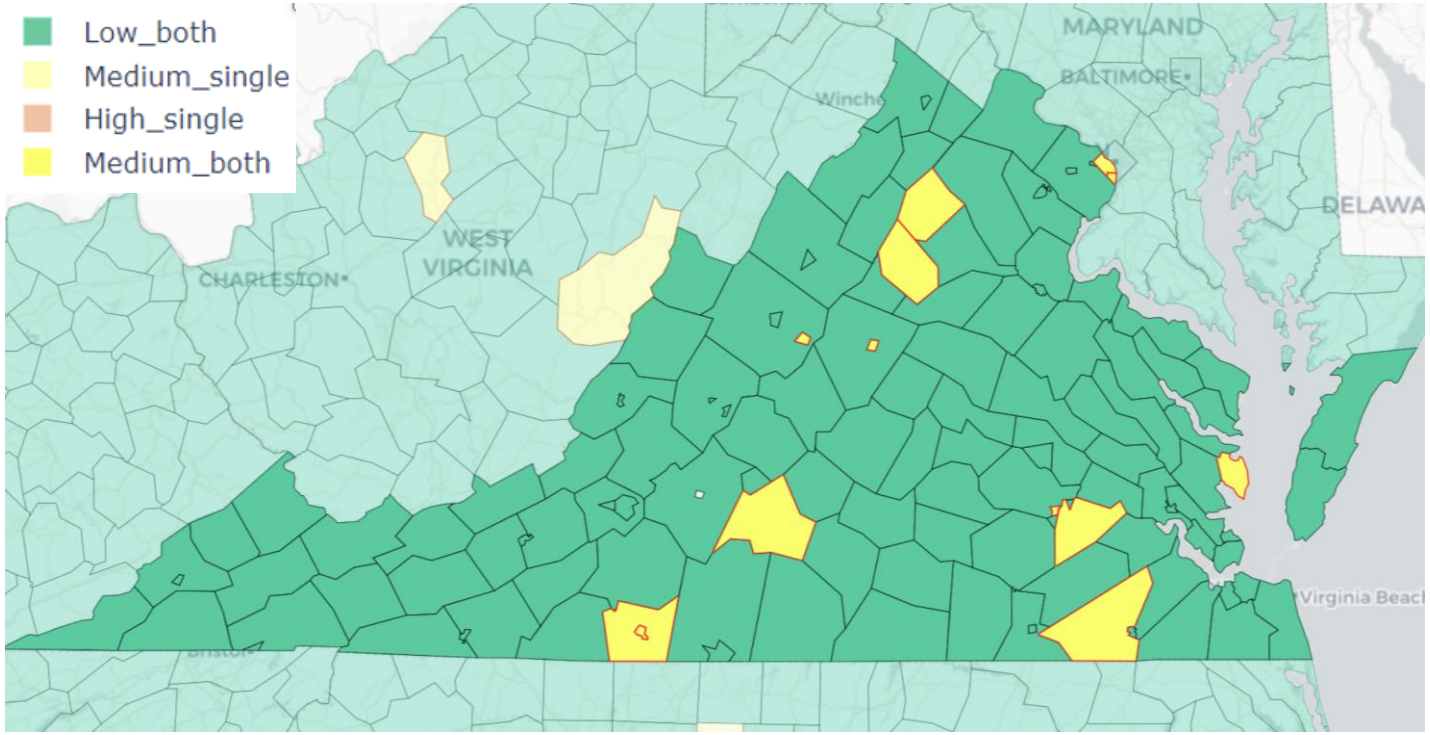
The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

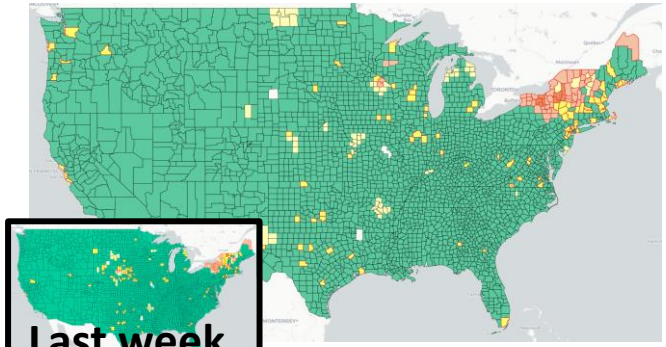
**Last Week**

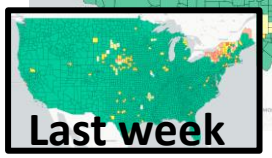


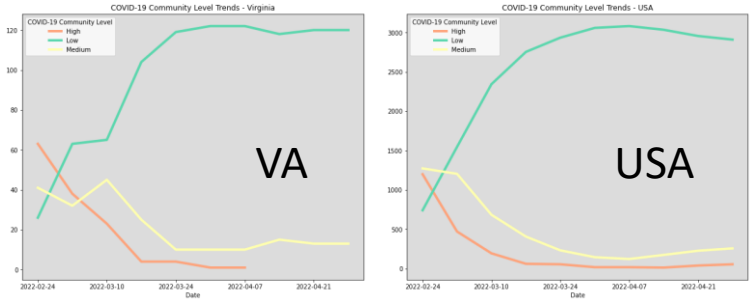
[CDC Data Tracker Portal]

# CDC's new COVID-19 Community Levels






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

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

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

COVID-19 Community Levels – Use the Highest Level that Applies to Your Community

| New COVID-19 Cases Per 100,000 people in the past 7 days | Indicators | Low | Medium | High |
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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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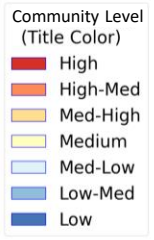
Data from: [CDC Data Tracker Portal]

# District Trajectories with Community Levels



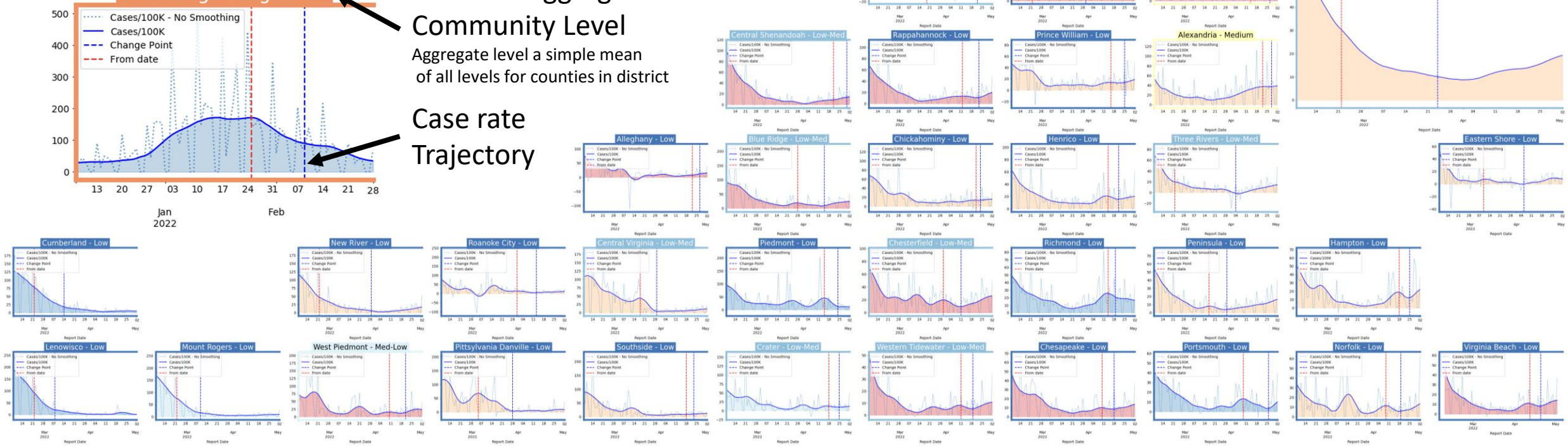

Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory




District's Aggregate Community Level

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

Case rate Trajectory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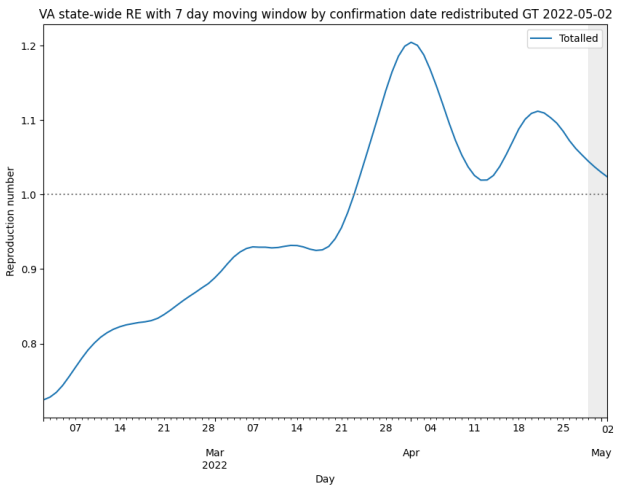
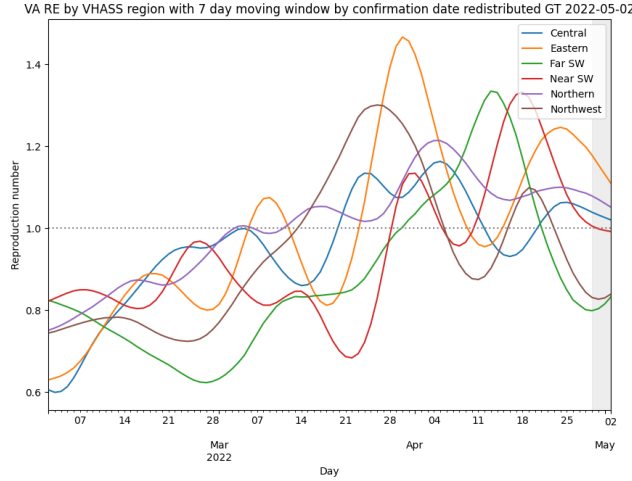
# Estimating Daily Reproductive Number – Redistributed gap

## May 2nd Estimates

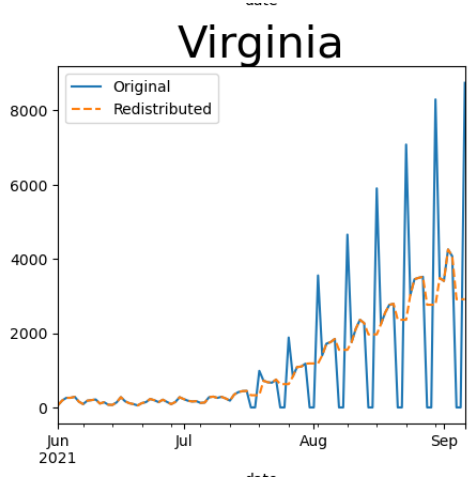
| Region | Date Confirmed $R_e$ | Date Confirmed Diff Last Week |
|---|---|---|
| State-wide | 1.024 | -0.020 |
| Central | 1.020 | 0.064 |
| Eastern | 1.108 | 0.050 |
| Far SW | 0.832 | -0.149 |
| Near SW | 0.991 | -0.152 |
| Northern | 1.051 | 0.029 |
| Northwest | 0.839 | -0.293 |




## Skipping Weekend Reports & holidays biases estimates

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




**Methodology**

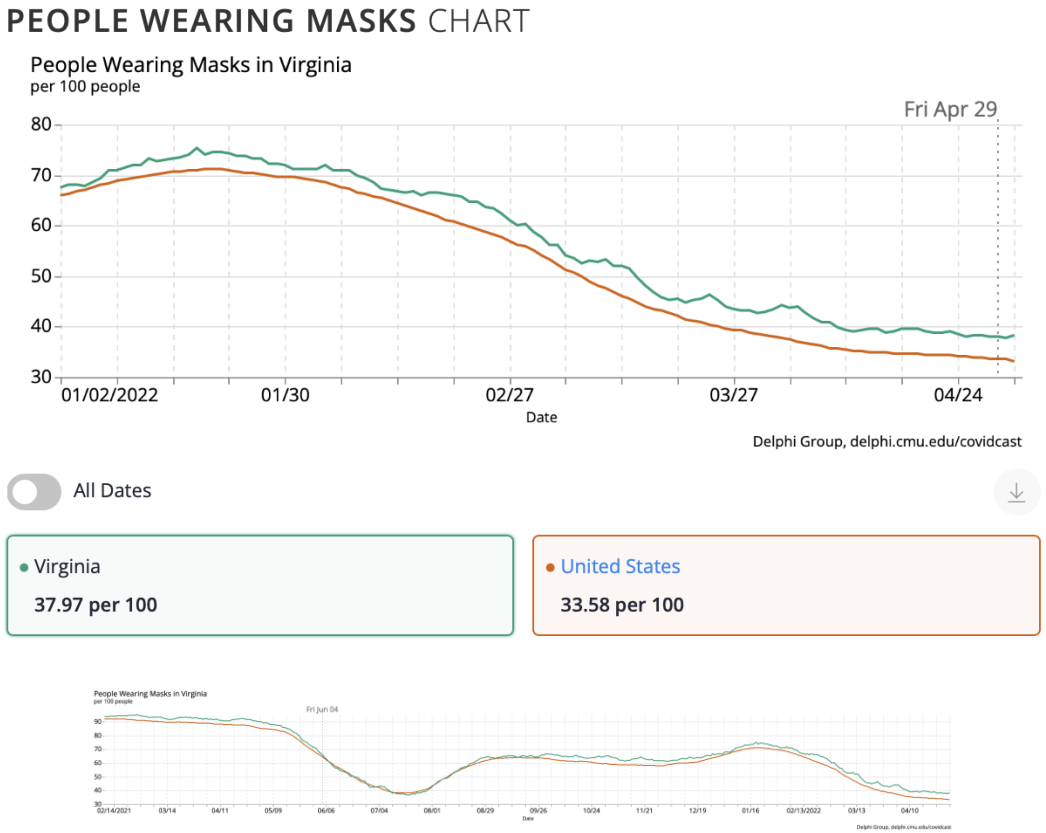
- Wallinga-Teunis method (EpiEstim[1]) for cases by **<u>confirmation date</u>**
- Serial interval: Discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

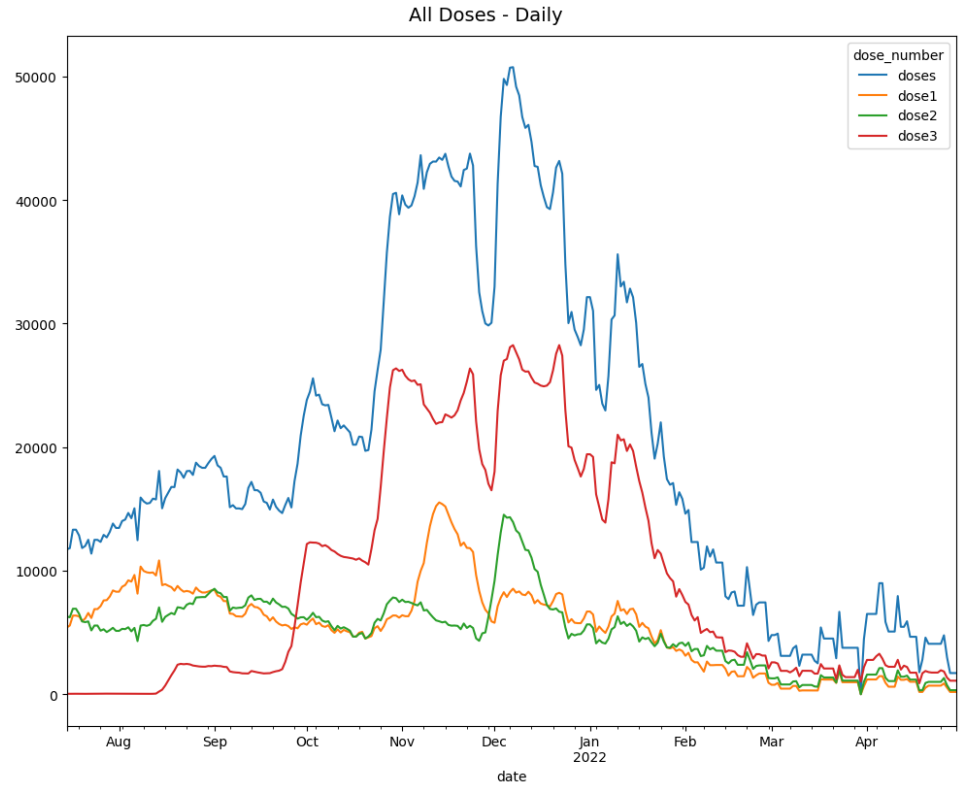

1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

# Mask Usage and Vaccination

**Self-reported mask usage continues to fall**

- US and VA continue to slightly decrease
- Mask wearing remains lower amongst unvaccinated especially among least willing to be vaccinated



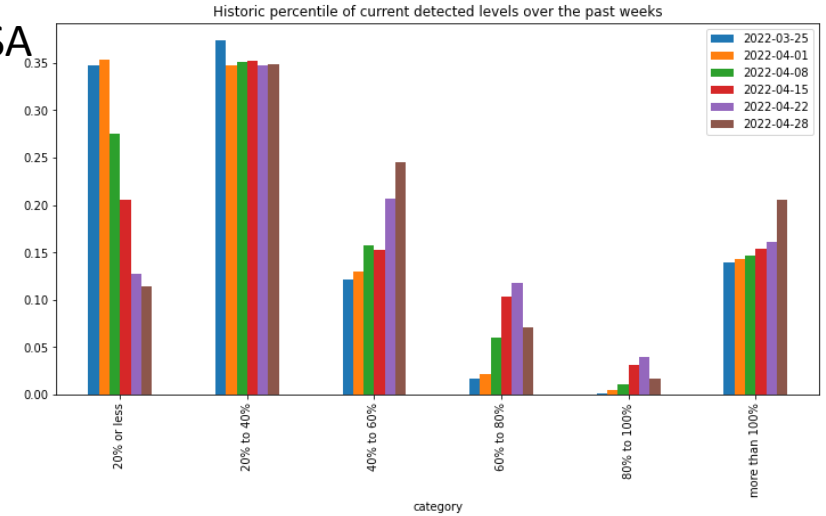

Data Source: https://covidcast.cmu.edu

# Wastewater Monitoring

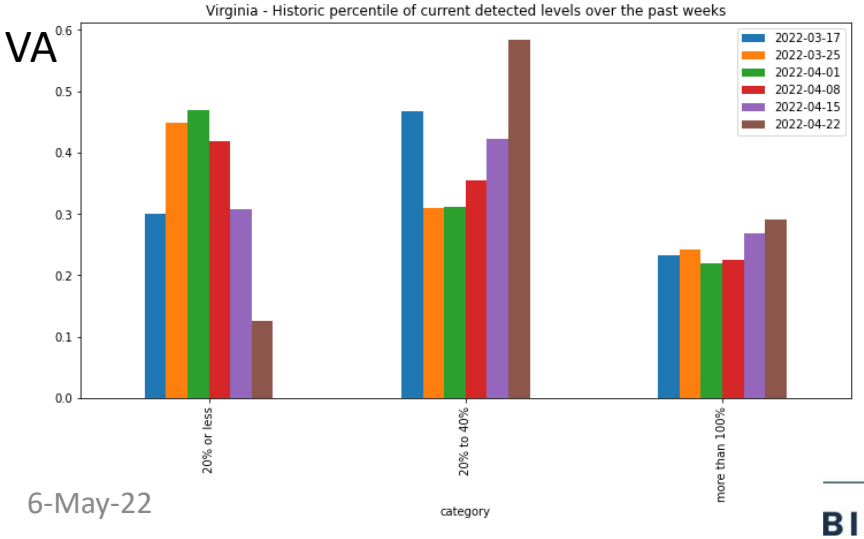
**Wastewater provides a coarse early warning of COVID-19 levels in communities**

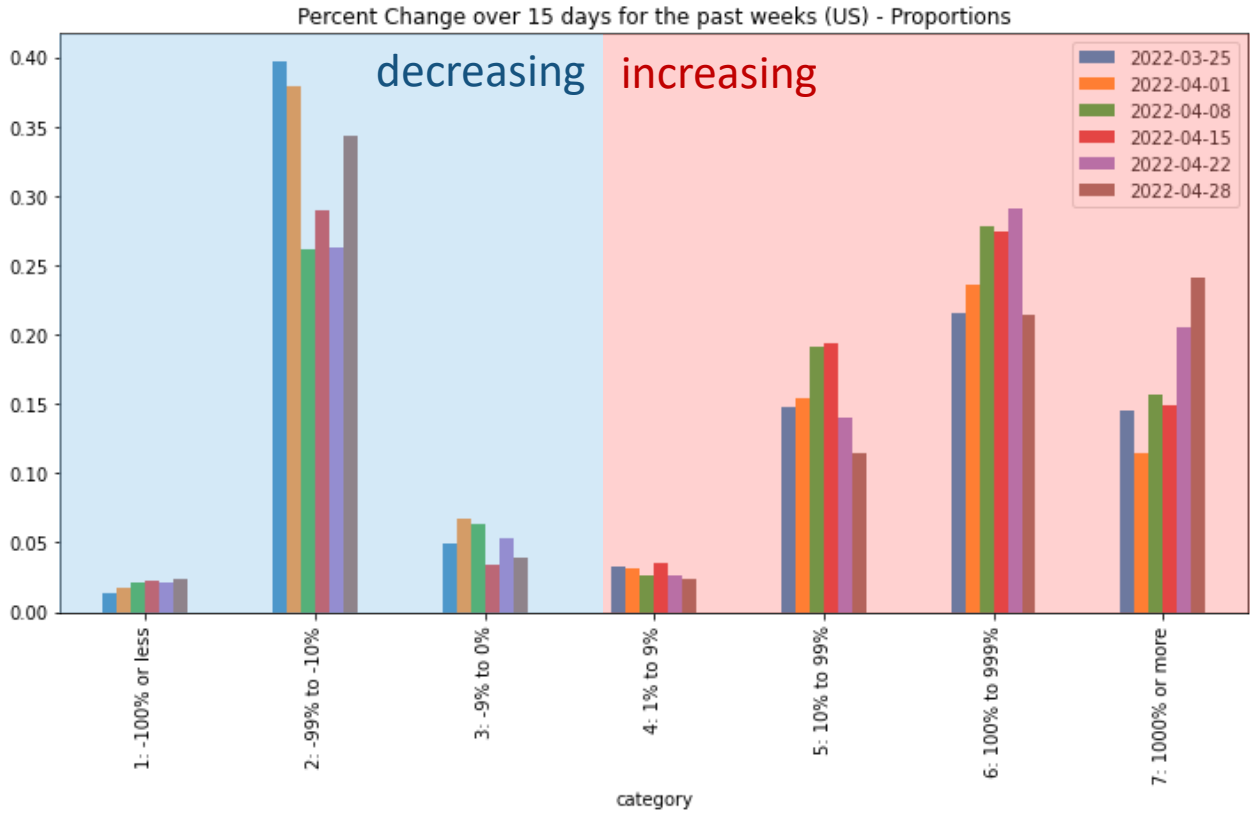
- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago
- Proportion of sites with current virus levels at or exceeding the max of previous historical levels, has further increased since last week

USA




VA



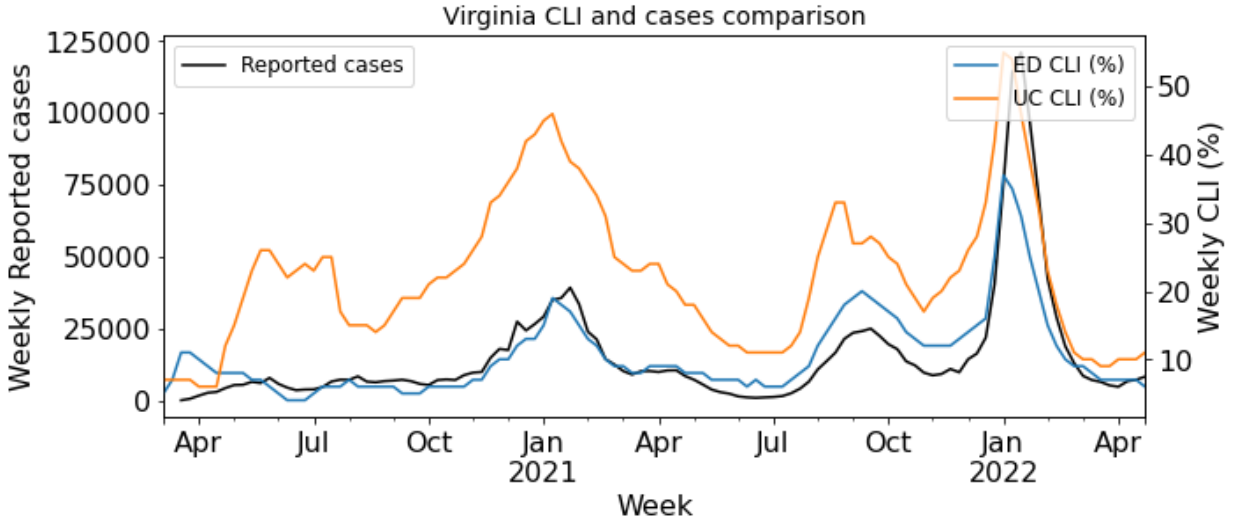



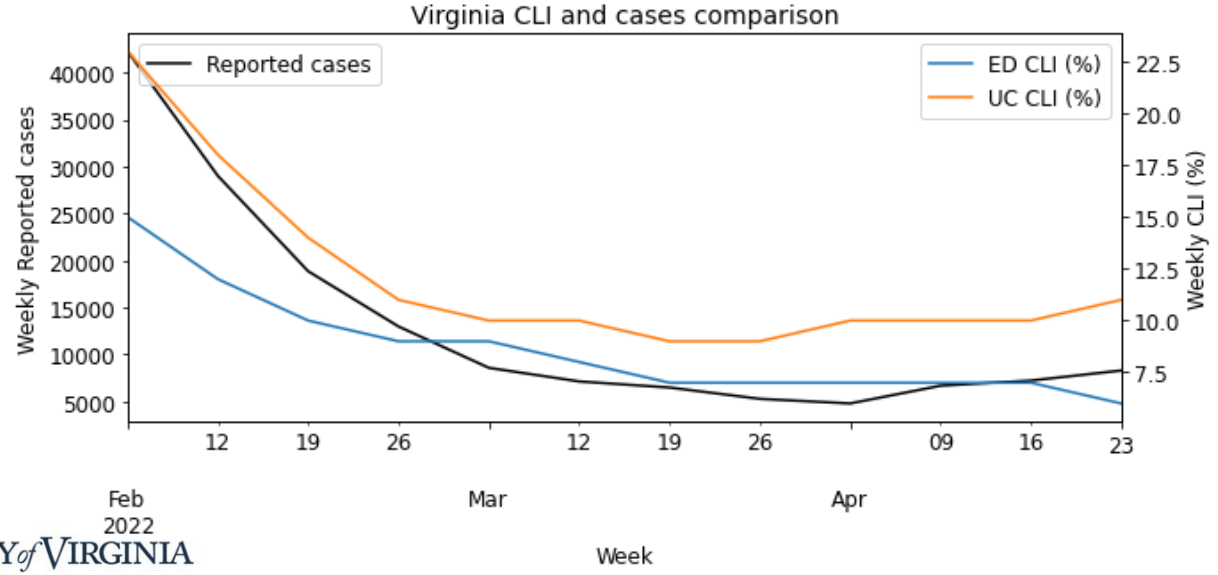

Data Source: [CDC Data Tracker]

# COVID-like Illness Activity

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

- Emergency Dept (ED) based CLI is more correlated with Case reporting
- Urgent Care (UC) is more sensitive and is a leading indicator but is prone to some false positives.
- As testing behaviors and case ascertainment levels shift these measures may capture disease better than confirmed cases
- Current trends in UC CLI are slightly up

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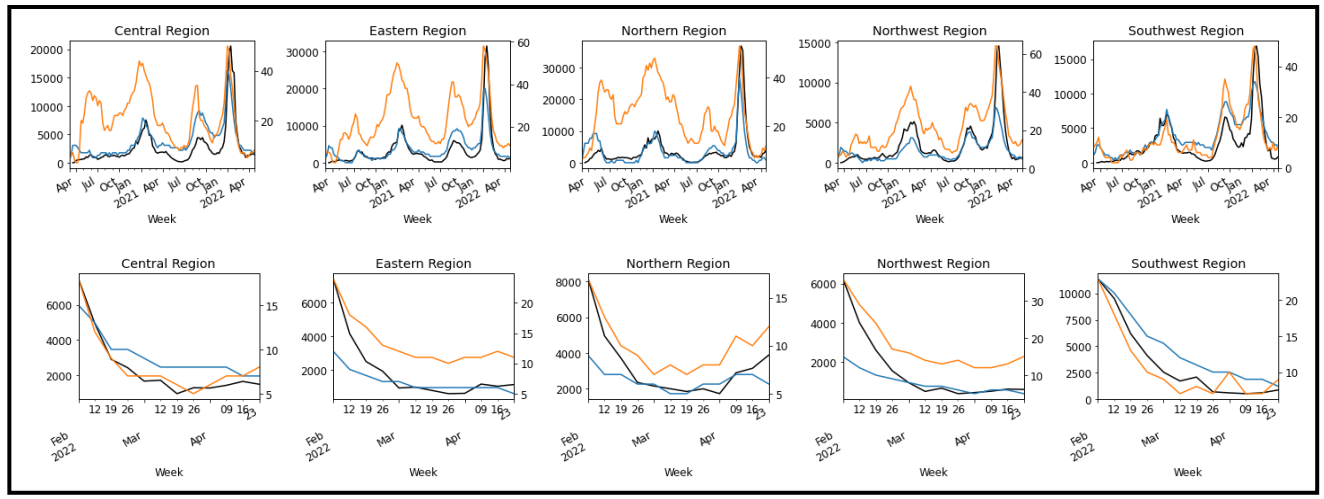
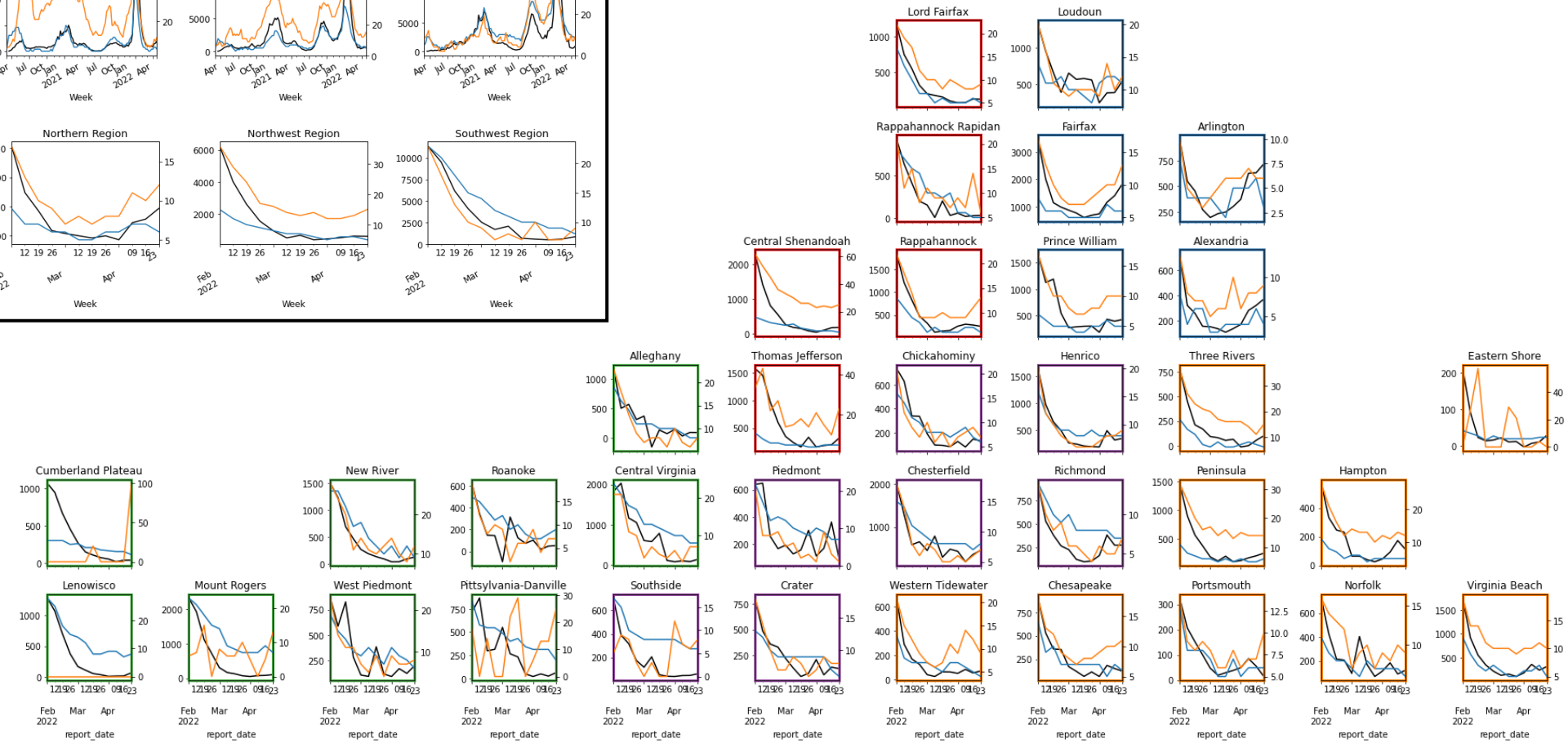
# COVID-like Illness Activity (Region and District)




- Northern and Northwest are increasing in recent weeks
- UC CLI is more decoupled from cases in the Southwest

# SARS-CoV2 Variants of Concern

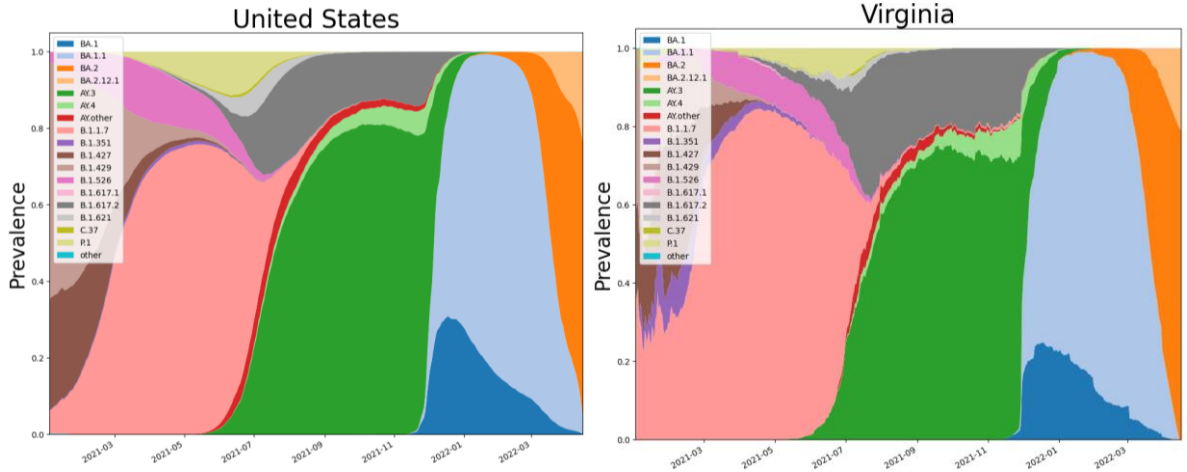
**Emerging new variants will alter the future trajectories of pandemic and have implications for future control**

- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations
- Genomic surveillance remains very limited
  - Challenges ability to estimate impact in US to date and estimation of arrival and potential impact in future

| WHO label | Pango lineage* | GISAID clade | Nextstrain clade | Additional amino acid changes monitored* | Earliest documented samples | Date of designation |
|---|---|---|---|---|---|---|
| Alpha | B.1.1.7 | GRY | 20I (V1) | +S:484K<br>+S:452R | United Kingdom, Sep-2020 | 18-Dec-2020 |
| Beta | B.1.351 | GH/501Y.V2 | 20H (V2) | +S:L18F | South Africa, May-2020 | 18-Dec-2020 |
| Gamma | P.1 | GR/501Y.V3 | 20J (V3) | +S:681H | Brazil, Nov-2020 | 11-Jan-2021 |
| Delta | B.1.617.2 | G/478K.V1 | 21A, 21I, 21J | +S:417N<br>+S:484K | India, Oct-2020 | VOI: 4-Apr-2021<br>VOC: 11-May-2021 |
| Omicron* | B.1.1.529 | GRA | 21K, 21L | +R346K | Multiple countries, Nov-2021 | VUM: 24-Nov-2021<br>VOC: 26-Nov-2021 |

World Health Organization [WHO]

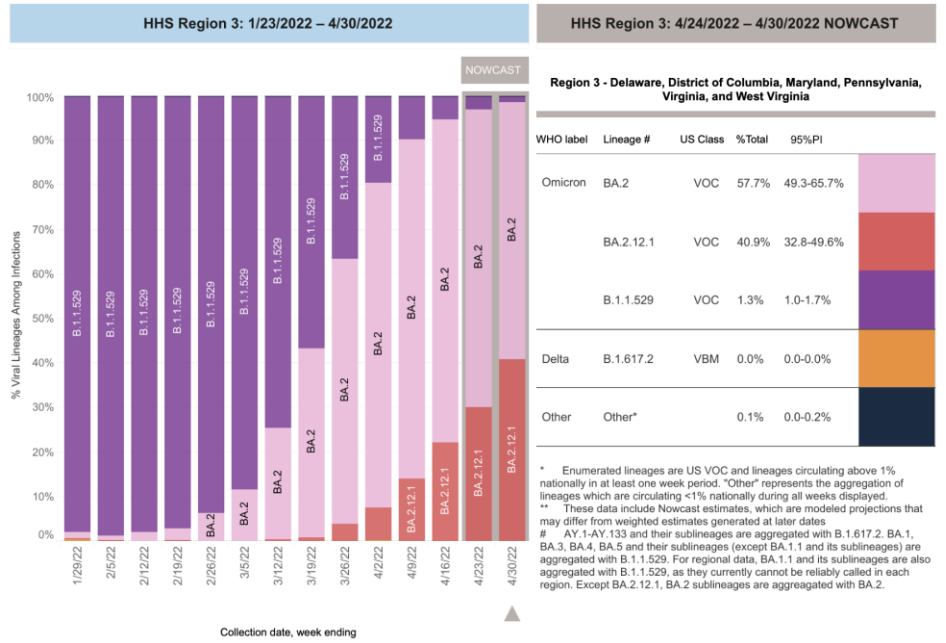
GISAID outbreak.info




**Omicron Prevalence**

**CDC nowcast for week ending April 2nd shows 98% overall BA.2 in Region 3 with BA 2.12.1 at 41% (last week 31%)**

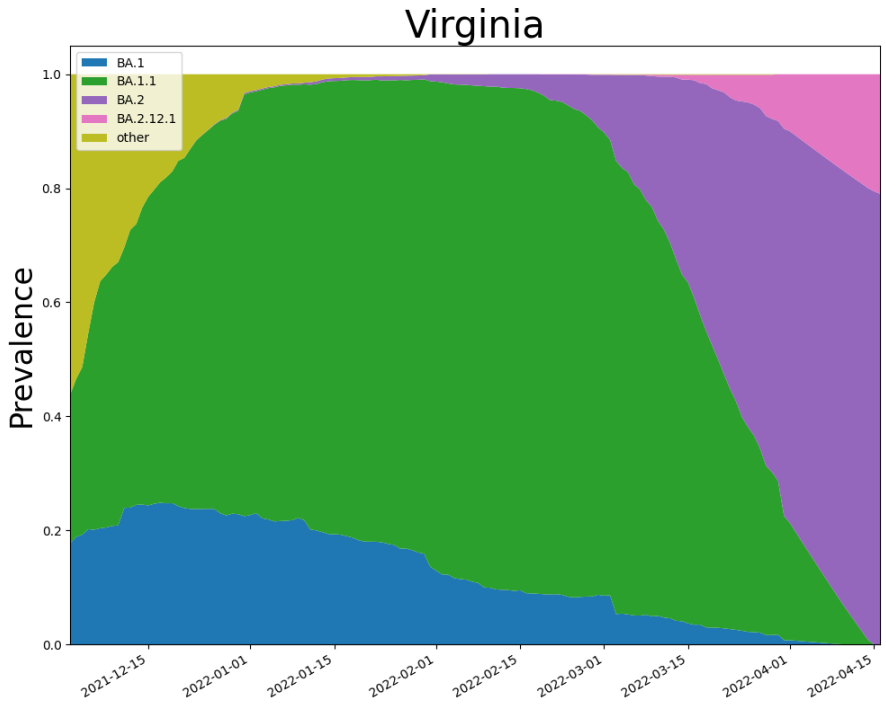
**Overall BA.2 in USA now at 99% (BA.2.12.1 at 37%, last week 27%)**

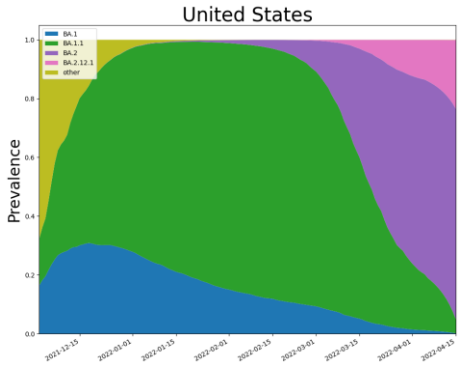



CDC [CDC Variant Tracking]

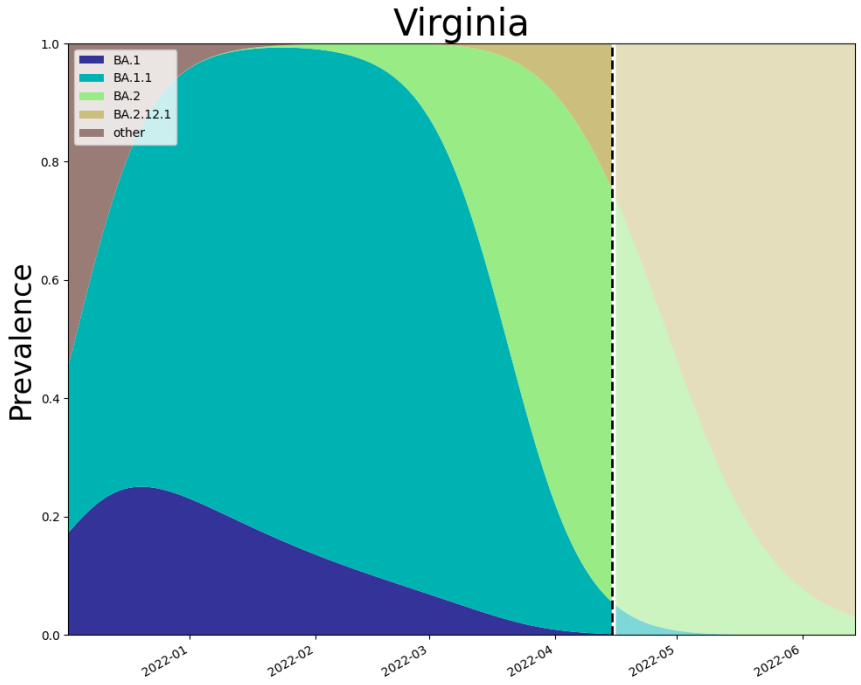
# SARS-CoV2 Omicron and Sub-Variants

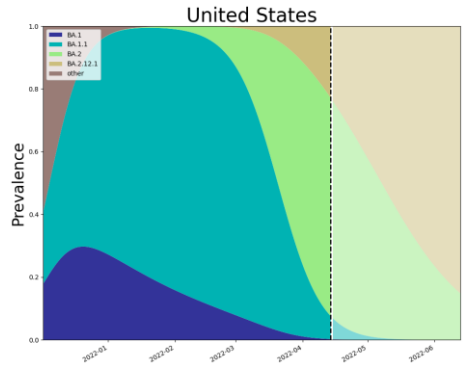
**As detected in whole Genomes in public repositories**




VoC Polynomial Fit Projections




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

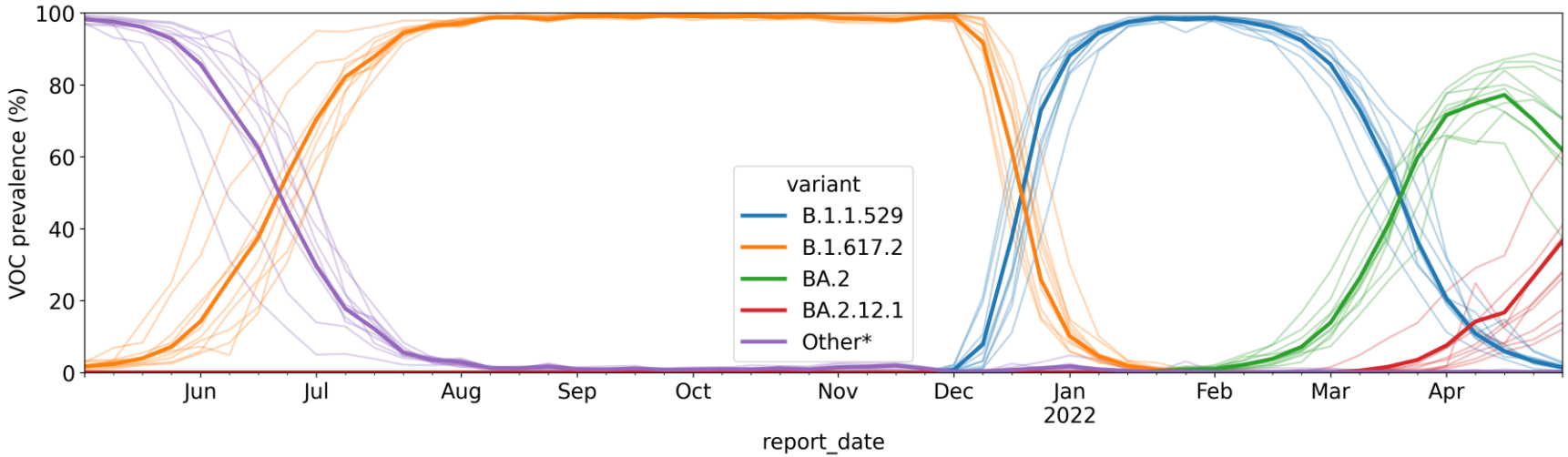
GISAID outbreak.info

# Influence of Previous Waves on Next Wave

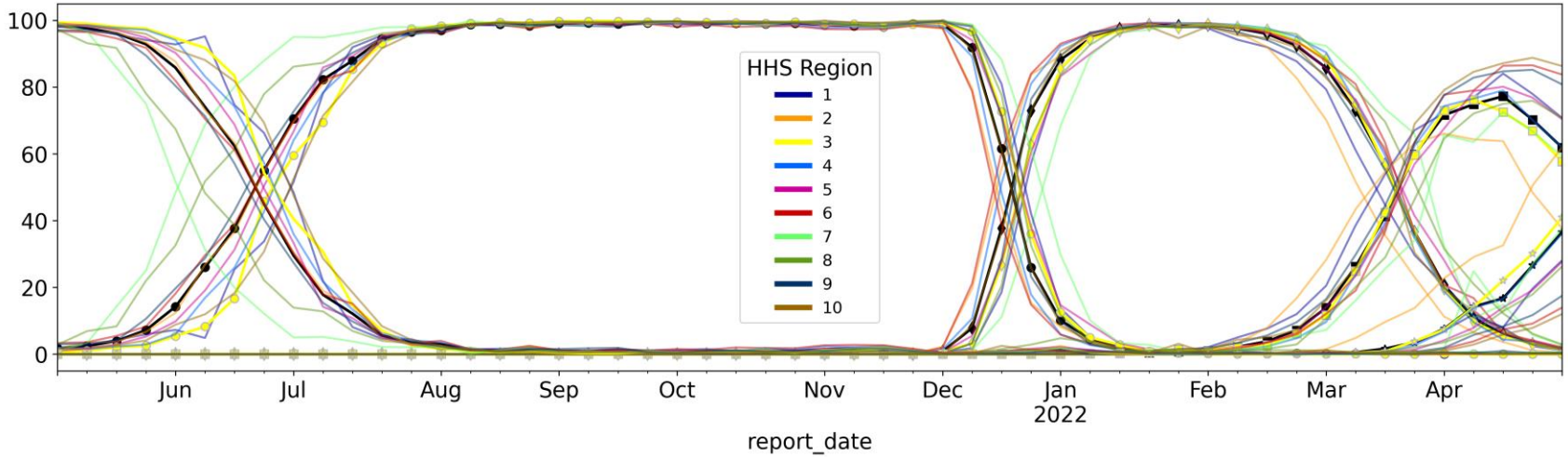
**Variability in timing and intensity of some variant-driven waves influence the timing and severity of subsequent waves**

- Some state had early Delta waves, others lagged. Subvariants of Omicron have similar variability.
- Not all states are in sync within their HHS regions
- Note outliers for Omicron subvariants

Region level Variant prevalence



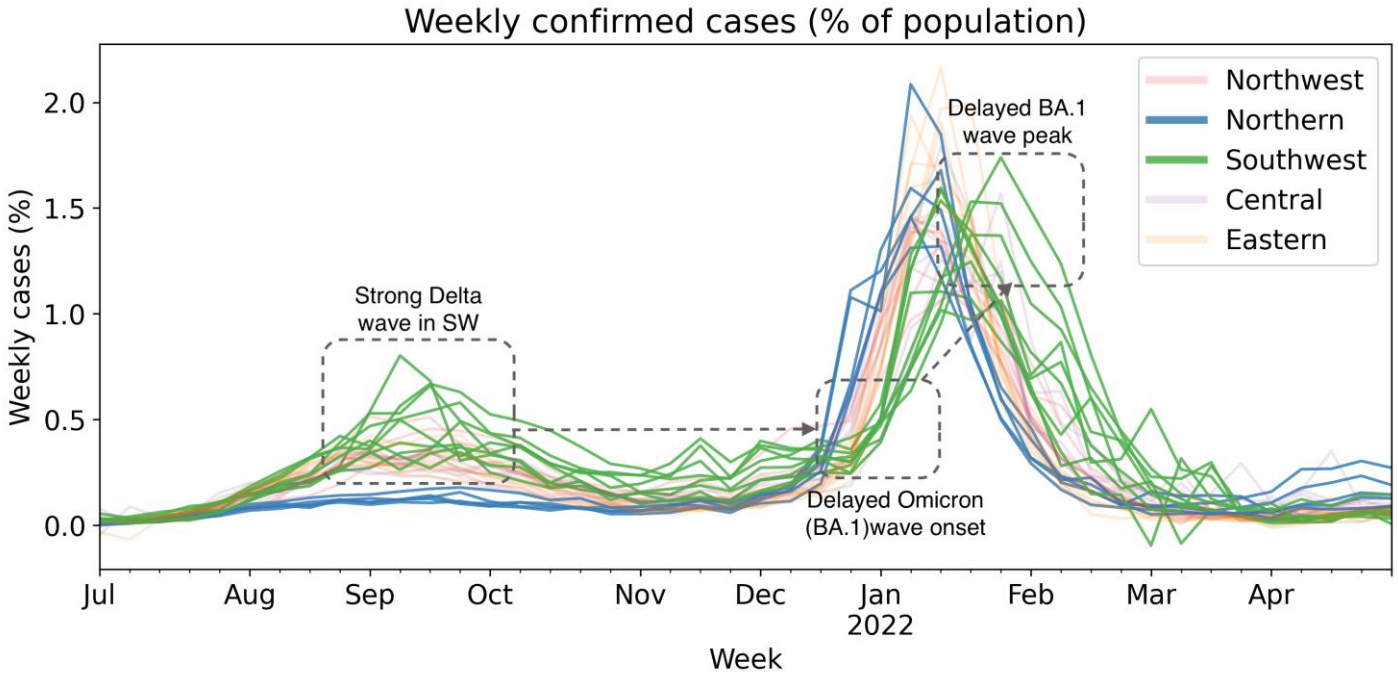

Region and prevalence of each successive VoC



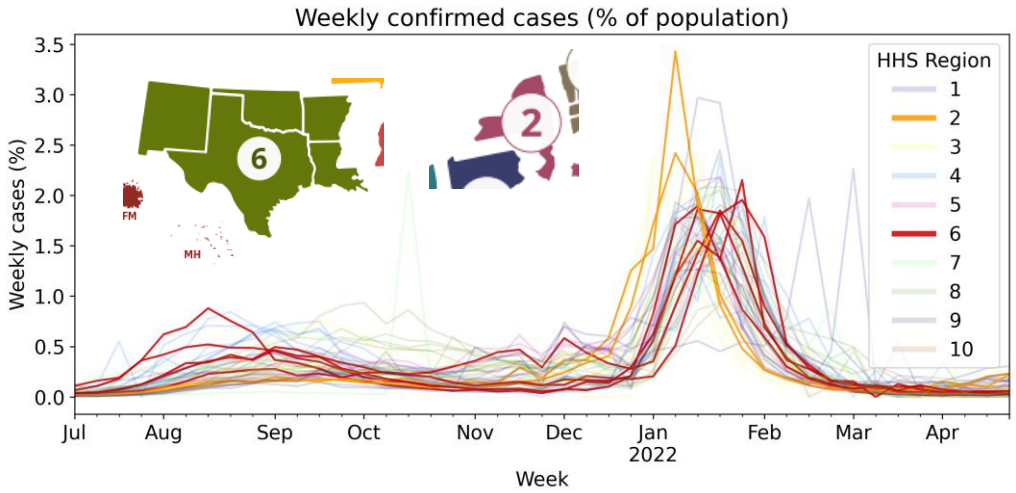
# Influence of Previous Waves on Next Wave

**Strong Delta wave leads to delayed Omicron BA.1 wave**

- At US state level (right), Region 6 (AK, TX, OK, LA, NM) was hit early and hard with Delta, however, Omicron arrived later than in Region 2 (NY, NJ) which had a negligible Delta wave




Proportion of cases since July by state



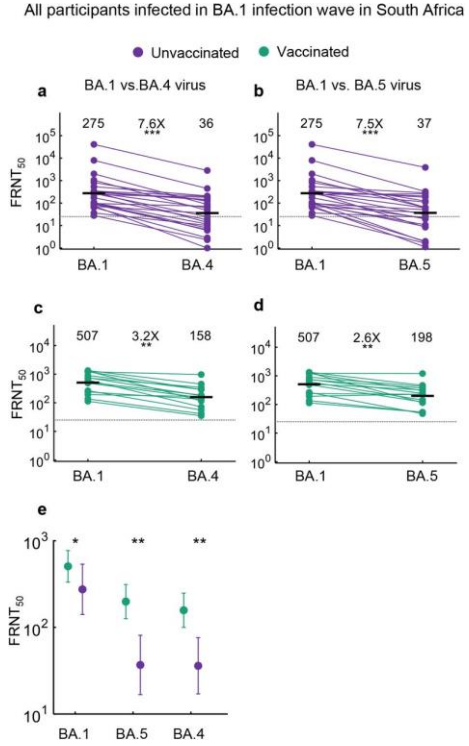

**Similar pattern plays our in the regions of VA**

- The Southwest had a strong Delta wave and a more delayed Omicron BA.1 wave.
- The Northern region had very minimal cases during Delta, but experience an early and strong, Omicron BA.1 wave.
- Current uptick in Northern regions from BA.2 and BA.2.12.1 may presage a delayed wave in Southwest as well

# Pandemic Pubs

**1.** In South Africa BA.4 and BA.5 demonstrate a transmission advantage. Multiple provinces are showing increasing hospitalizations.
**2.** Survey on testing behavior estimates home testing now accounts for more positive results than all other testing
**3.** Recent NEJM article shows benefits of 4th dose in reducing infections and all outcomes.
**4.** Walgreens Nationwide tests show increasing positivity rate including Virginia corresponding to a wave of BA.2 infections. Positivity is reportedly highest in those with 3 doses more than 5 months ago

1




A recent analysis by Tom Wenseleers on the pandemic status of South Africa highlights the benefits of vaccination, the cost of continued waves of infection, and the transmission advantage of BA.4 and BA.5..
https://twitter.com/twenseleers/status/1518673358845620225?s=12&t=v6hXWXImT3a0xam7b24dPQ

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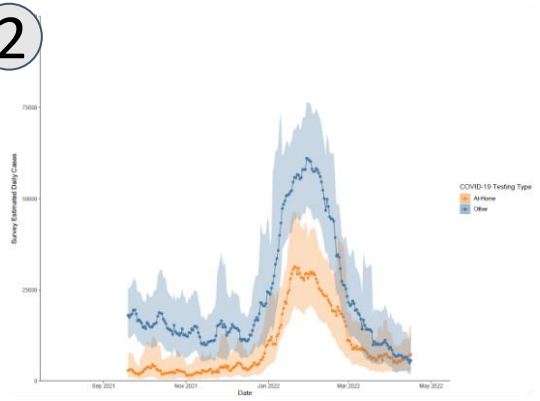

Survey of testing behaviors described in recent MMWR estimates that home testing now provides more positives than all other testing
https://twitter.com/johnbrownstein/status/1517218593422950400

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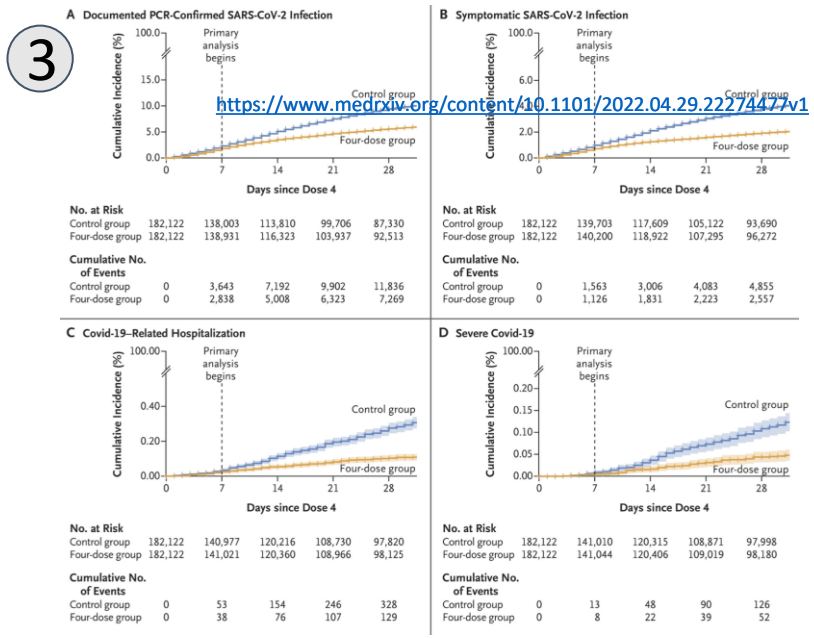


https://www.medrxiv.org/content/10.1101/2022.04.29.22274477v1

Analysis of Israeli data measured benefits of a 4th dose and found, a fourth dose of the BNT162b2 vaccine was effective in reducing the short-term risk of Covid-19–related outcomes among persons who had received a third dose at least 4 months earlier.
https://www.nejm.org/doi/full/10.1056/NEJMoa2201688

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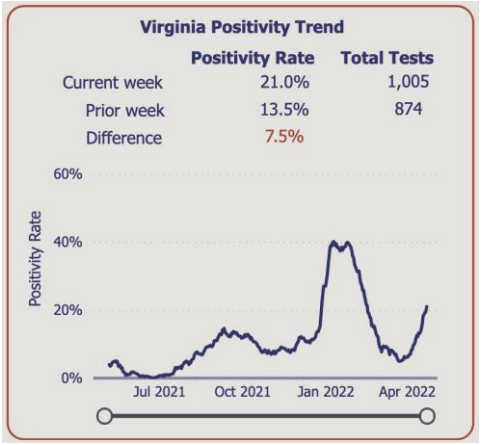
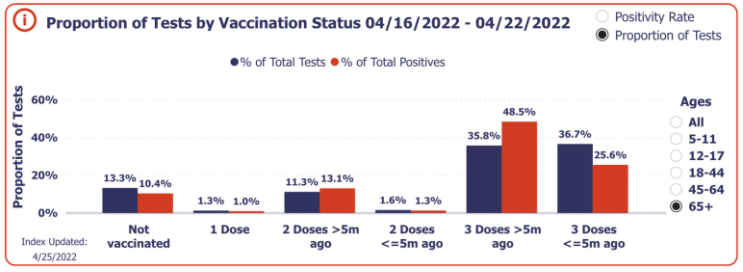


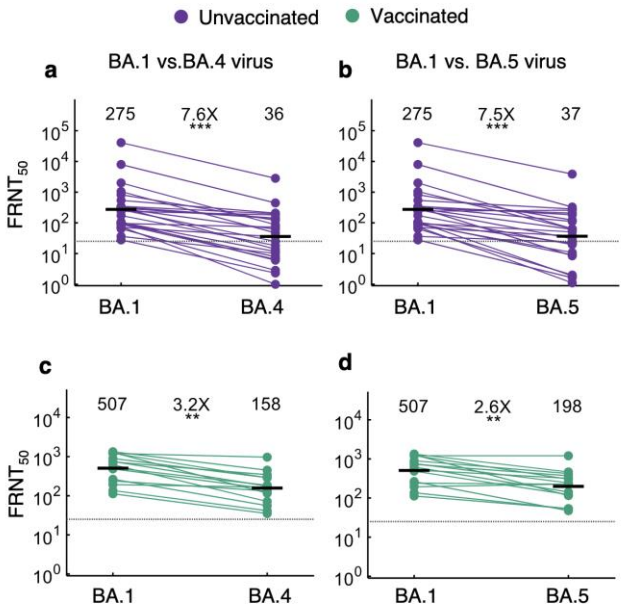




Recent Walgreens testing shows an increase in positivity rate for Virginia and many states throughout the nation. The contracted sequencing through Aegis shows increasing BA.2.12.1 proportions to the dominant BA.2
https://www.walgreens.com/businesssolutions/covid-19-index.jsp

# Pandemic Pubs

**1.** Observed escape of BA.4 and BA.5 from BA.1 immunity is not as severe as BA.1 against previous immunity but low absolute neutralization levels for BA.4 and BA.5, particularly in the unvaccinated group, indicate low protection against infection.
**2.** BA.4 and BA.5 have weaker ACE2 binding than BA.2 which may result in lower intrinsic transmissibility
**3.** Estimated US seroprevalence increased from 33.5% to 57.7% from December 2021 to February 2022. Higher among children.
**4.** A systematic review of Long-Covid studies show prevalence from 51-80% for mild to severe infections.

1




Researchers in SA isolated live BA.4 and BA.5 viruses and tested them against neutralizing immunity elicited to BA.1 infection in participants who were Omicron/BA.1 infected but unvaccinated (n=24) and participants vaccinated with Pfizer BNT162b2 or Johnson and Johnson Ad26.CoV.2S with breakthrough Omicron/BA.1 infection (n=15)
https://www.medrxiv.org/content/10.1101/2022.04.29.22274477v1

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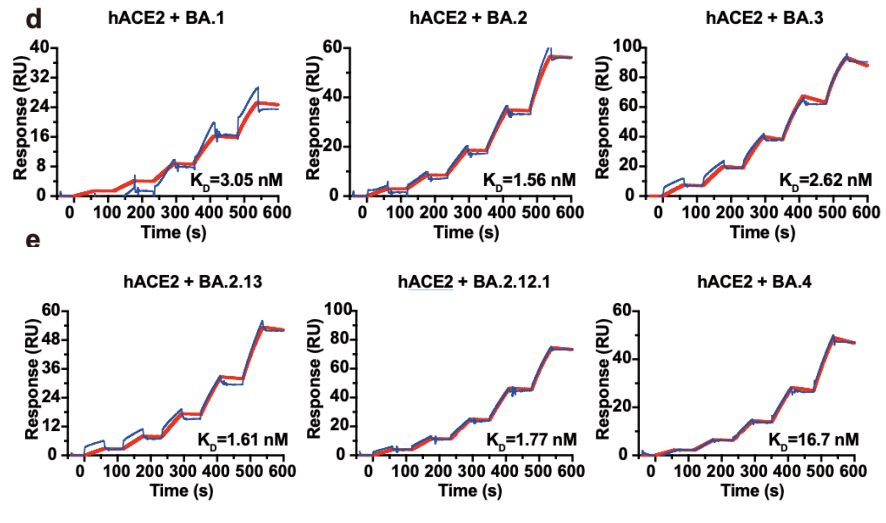


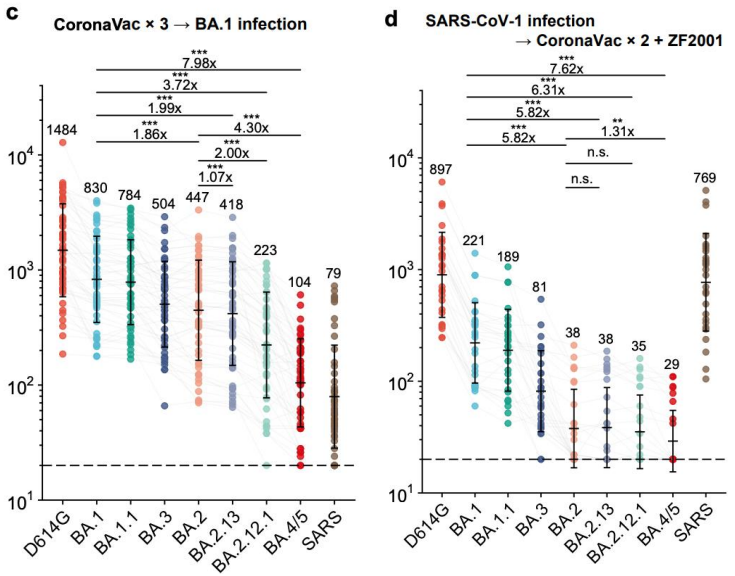


Researchers show variants BA.2..12.1, BA.4 and BA.5 have increased immune evasion relative to BA.2 but some associated mutations result in weaker ACE2 binding which may lead to reduced intrinsic transmissibility.
https://www.researchsquare.com/article/rs-1611421/v1

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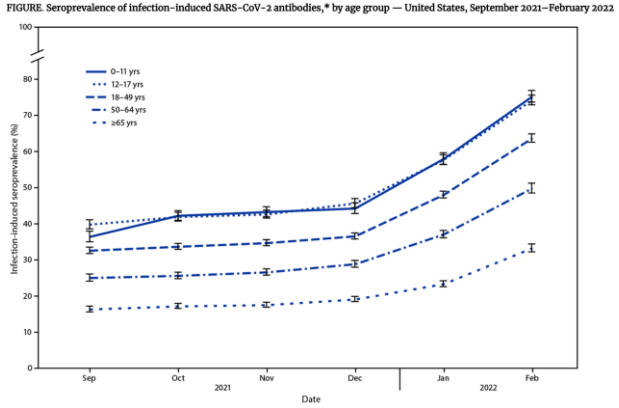


https://www.cdc.gov/mmwr/volumes/71/wr/mm7117e3.htm

4

Pooled mean prevalence results for any experience of PACS, extracted from nine systematic reviews, ranged from 51%–80%.
-Evidence indicates PACS is a condition experienced by a substantial number of individuals with previous SARS-CoV-2 infection. Care for patients with PACS will likely place added stresses on health care and social support systems, including increased emergency department visits, outpatient care, inpatient care and rehabilitation involving multidisciplinary teams

https://www.publichealthontario.ca/-/media/Documents/nCoV/ipac/2022/04/post-acute-covid-syndrome-pacs.pdf?sc_lang=en

05/03/22 Pandemic news

1.

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Article | Published: 28 April 2022

# Daily longitudinal sampling of SARS-CoV-2 infection reveals substantial heterogeneity in infectiousness

Ruian Ke, Pamela P. Martinez, ... Christopher B. Brooke + Show authors

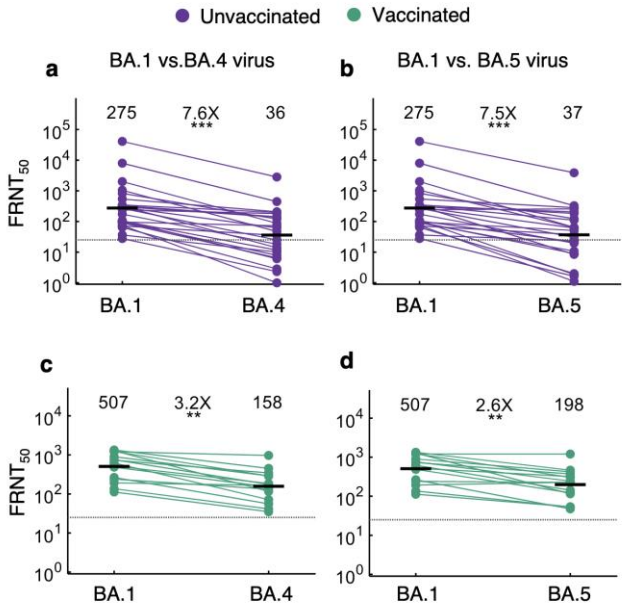
*Nature Microbiology* 7, 640–652 (2022) | Cite this article

87k Accesses | 664 Altmetric | Metrics

https://www.nature.com/articles/s41564-022-01105-z

## Abstract

The dynamics of SARS-CoV-2 replication and shedding in humans remain poorly understood. We captured the dynamics of infectious virus and viral RNA shedding during acute infection through daily longitudinal sampling of 60 individuals for up to 14 days. By fitting mechanistic models, we directly estimated viral expansion and clearance rates and overall infectiousness for each individual. Significant person-to-person variation in infectious virus shedding suggests that individual-level heterogeneity in viral dynamics contributes to




.medrxiv.org/content/10.1101/2022.04.29.22274477v1

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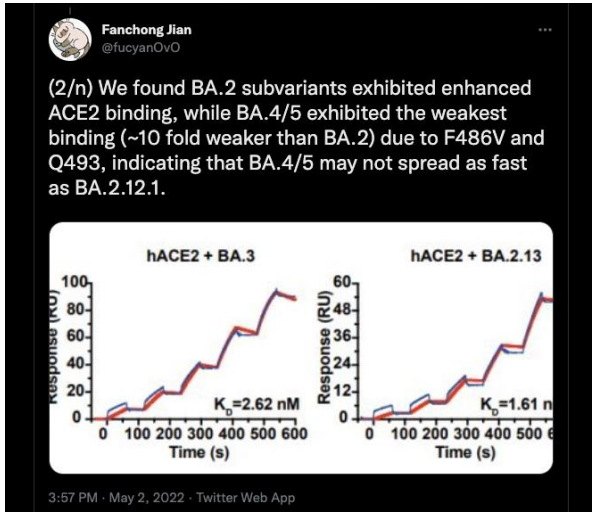


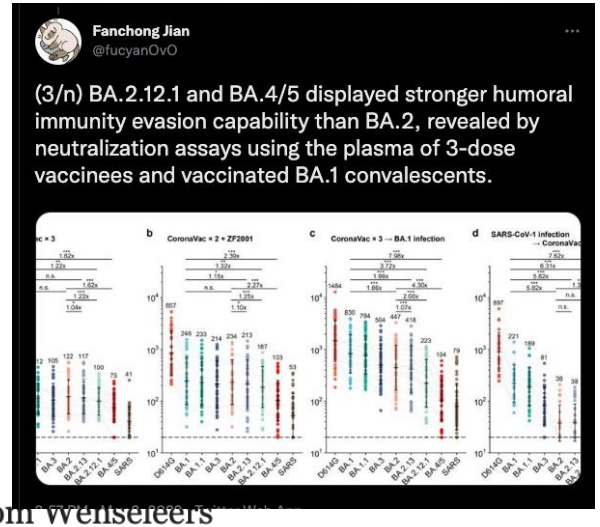


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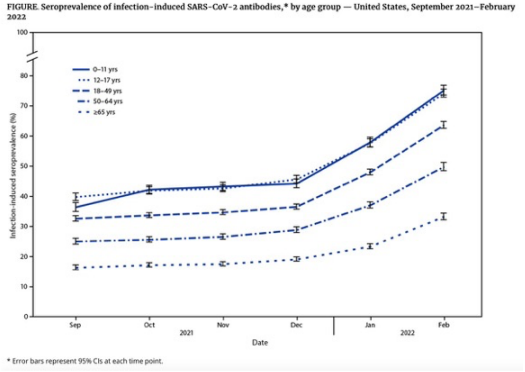
## Dr. Tom Frieden

by Dr. Tom Frieden, twitter.com — May 2, 2022 06:27 PM

Overall estimated US seroprevalence (estimated proportion with antibodies to the virus), increased from 33.5% to 57.7% during December 2021 to February 2022. That means something like 80 million infections in just two months. https://t.co/AjueJHDFWG




https://twitter.com/drtomfrieden/status/1521270097976864768?s=12&t=XfALRJn8H4kY0FqrTuB2MA

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Key Messages

- The definition of and diagnostic criteria for post-acute COVID-19 syndrome (PACS) are not yet well established. This rapid review considered PACS as persistent or new sequelae present 3 or more weeks after severe, mildly symptomatic or asymptomatic SARS-CoV-2 infection.
- Pooled mean prevalence results for any experience of PACS, extracted from nine systematic reviews, ranged from 51%–80%.
- Pooled mean prevalence results for specific PACS symptoms were extracted, when available, from 32 systematic reviews. Symptoms and prevalence results varied widely across reviews, however some of the most commonly reported symptoms included fatigue; shortness of breath; anxiety; depression; sleep disorder; cognitive and memory impairments; and negative impacts on quality of life (QoL). The most commonly reported risk factors for developing PACS were increased disease severity during acute SARS-CoV-2 infection and female sex.
- Few included studies used control groups of individuals not infected with SARS-CoV-2 (e.g., healthy controls, patients with alternative diagnoses). These studies consistently found overall greater rates or risk of persistent symptoms consistent with PACS among patients with COVID-19 compared to symptoms in those without COVID-19. Further case-control studies would help disentangle the impact of public health measures, other confounders and SARS-CoV-2 infection on symptoms consistent with PACS.
- Results across reviews and studies with multiple follow up periods did not consistently indicate if prevalence of PACS or PACS sequelae increased, decreased or remained stable over time.
- Overall, while ongoing research is needed to better characterize PACS characteristics and prevalence, this body of evidence indicates PACS is a condition experienced by a substantial number of individuals with previous SARS-CoV-2 infection. Care for patients with PACS will likely place added stresses on health care and social support systems, including increased emergency department visits, outpatient care, inpatient care and rehabilitation involving multidisciplinary teams.

https://www.publichealthontario.ca/-/media/Documents/nCoV/ipac/2022/04/post-acute-covid-syndrome-pacs.pdf?sc_lang=en

## Tom Wenseleers

by Tom Wenseleers, twitter.com — May 3, 2022 04:33 AM

New study confirms that Omicron BA.4&5 gets its selective benefit from immune escape, but that it also has lower ACE2 binding affinity. Hopefully means that immune escape is traded off against contagiousness and that this could cause evolution towards lower R0 over the long term. https://t.co/mnrYbWMqqV

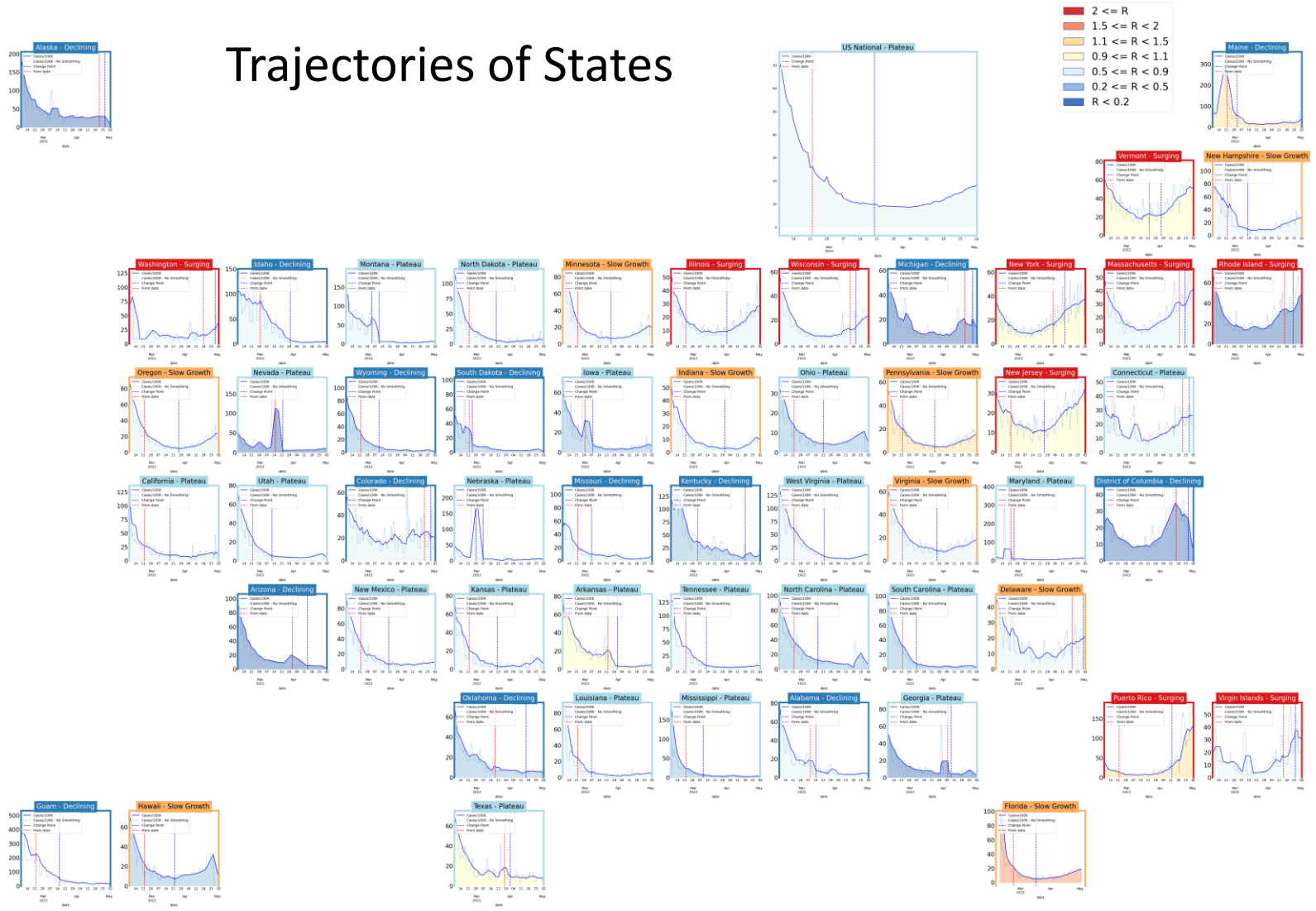
https://twitter.com/twenseleers/status/1521422717421031424?s=12&t=XfALRJn8H4kY0FqrTuB2MA

# United States Overall

- Nation pivoting towards more growth, focused in Northeast
- Most are sustained declines

| Status | # States |
|---|---|
| Declining | 14 (27) |
| Plateau | 21 (16) |
| Slow Growth | 9 (7) |
| In Surge | 10 (4) |

Trajectories of States

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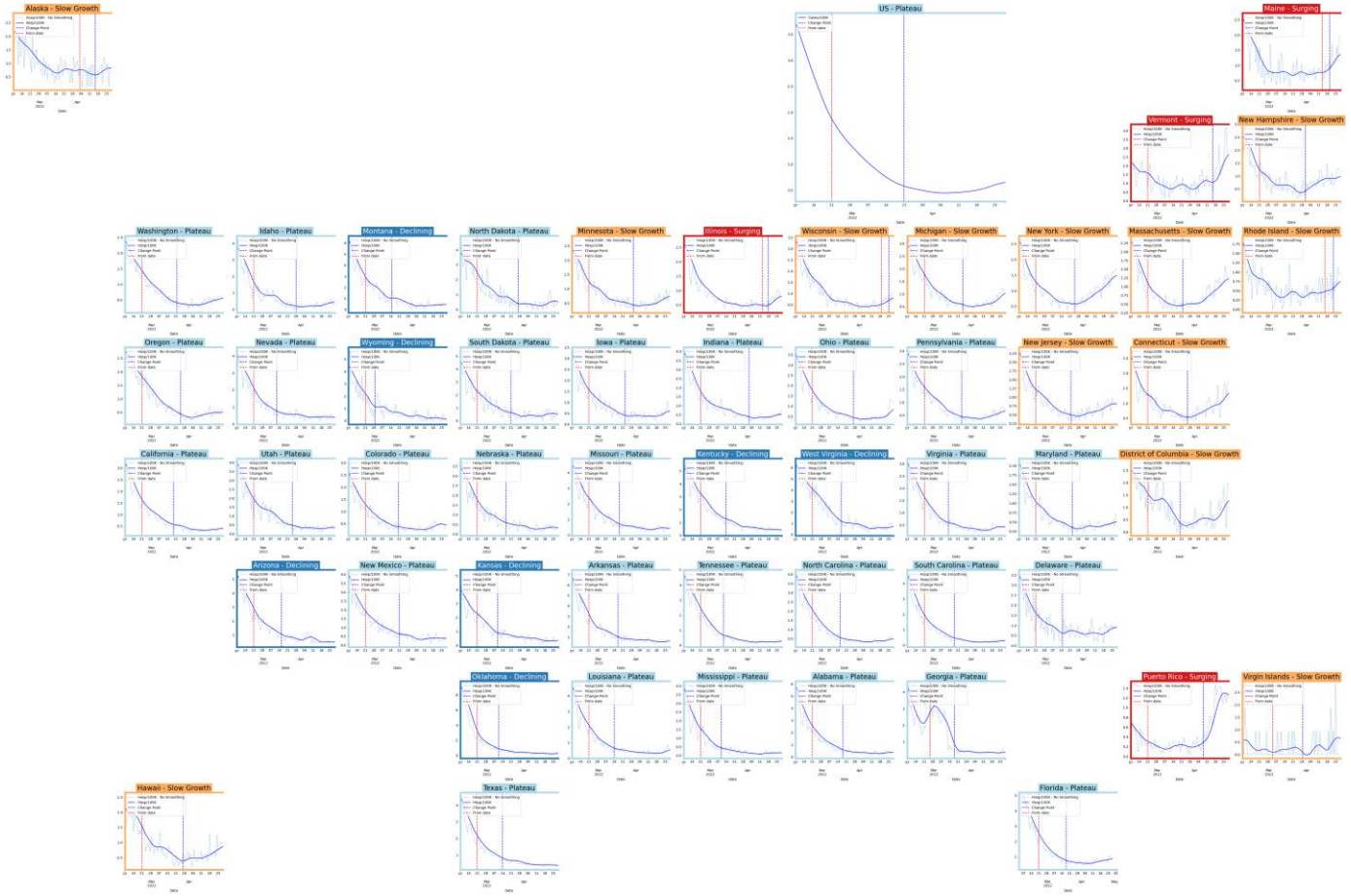
# United States Hospitalizations

- Hospital admissions are lagging case rates
- Rising hospitalization rates seen in the Northeast

| Status | # States (prev week) |
|---|---|
| Declining | 7 (1) |
| Plateau | 26 (51) |
| Slow Growth | 13 (1) |
| In Surge | 4 (0) |

Trajectories of States

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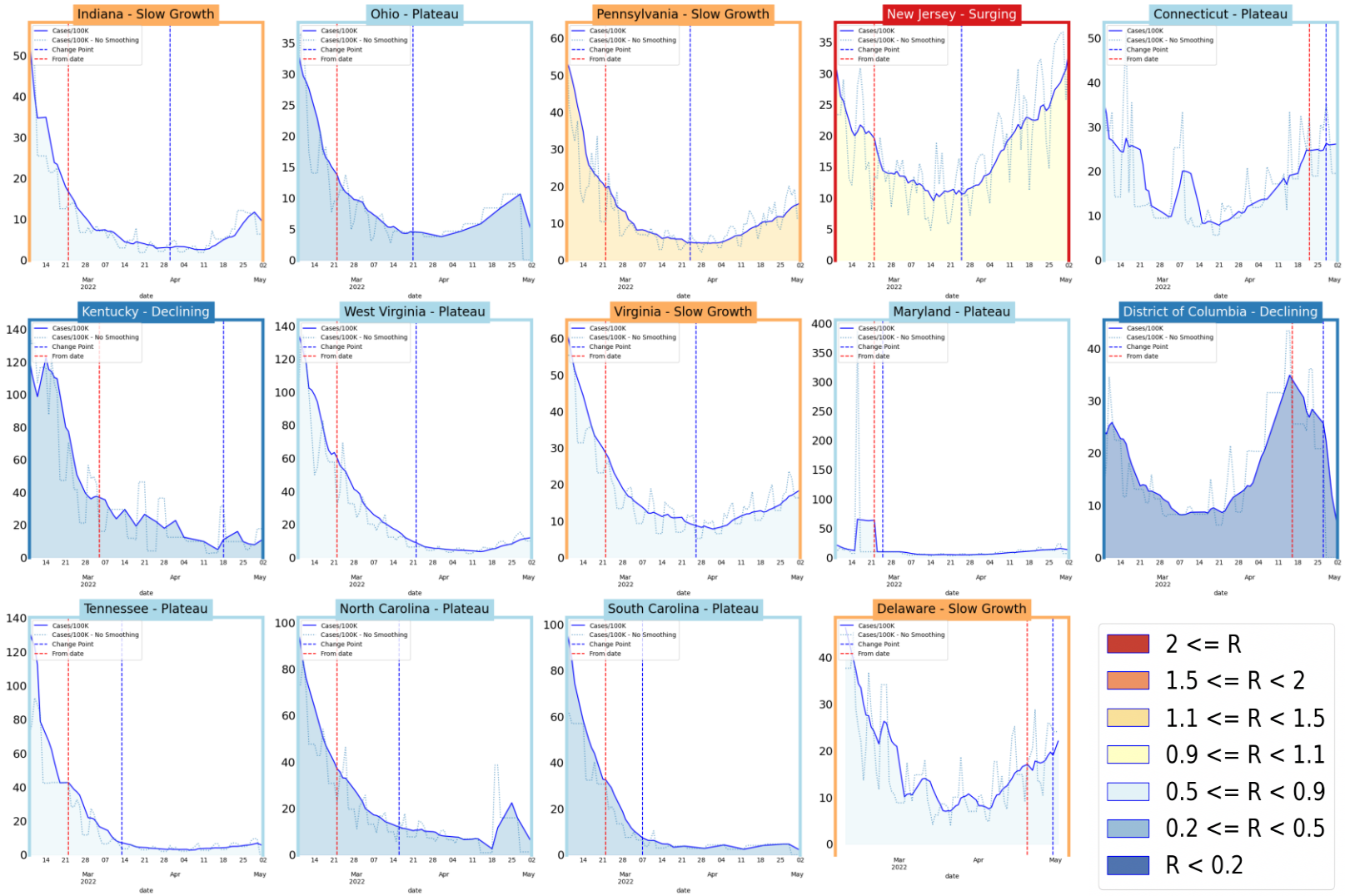
# Virginia and Her Neighbors

- Neighbors to north and east are growing again
- Case rates remain relatively low, but are quite flat to the south and west
- Many are ticking above 10/100K now

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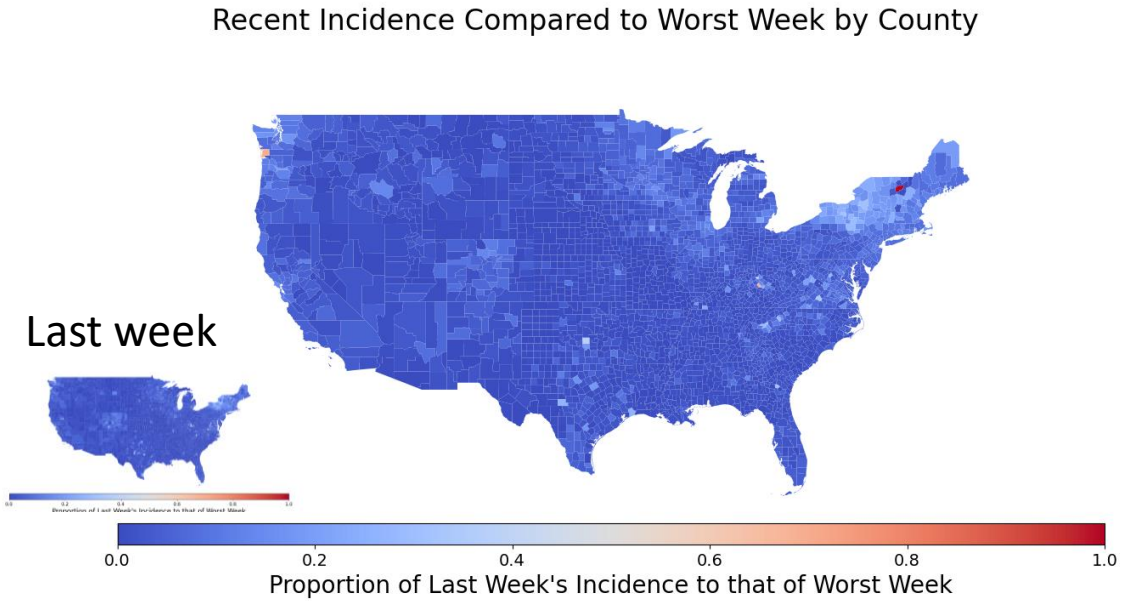
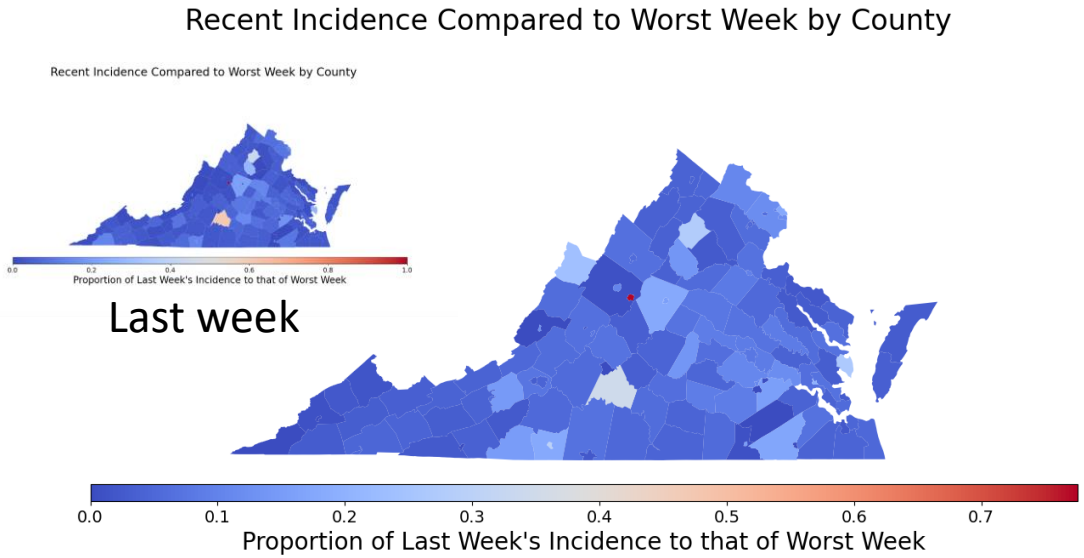
# County-level comparison to previous highest peak

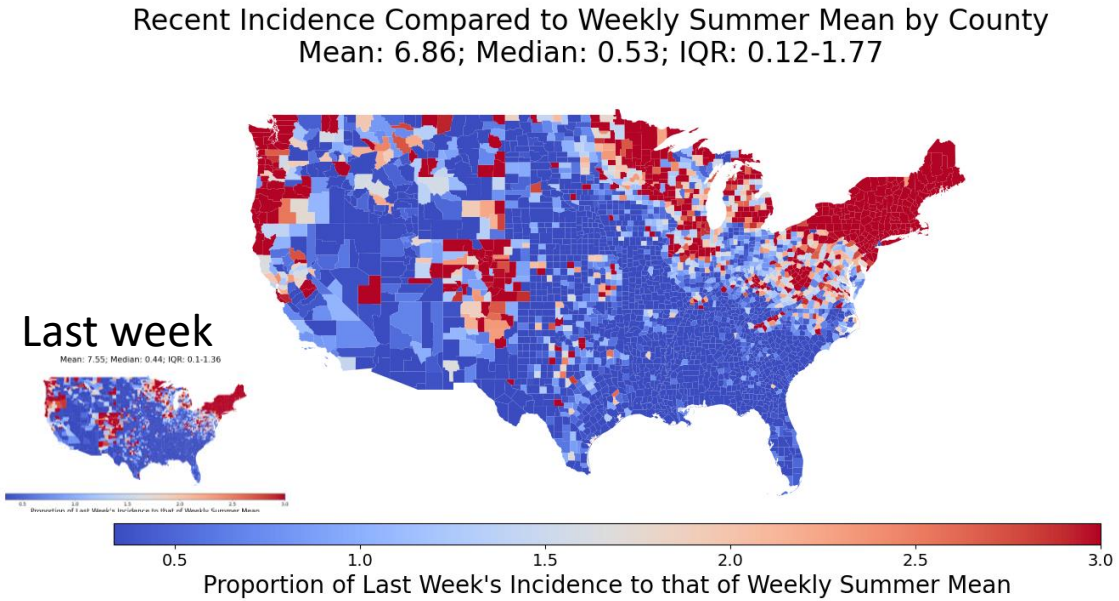
- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably

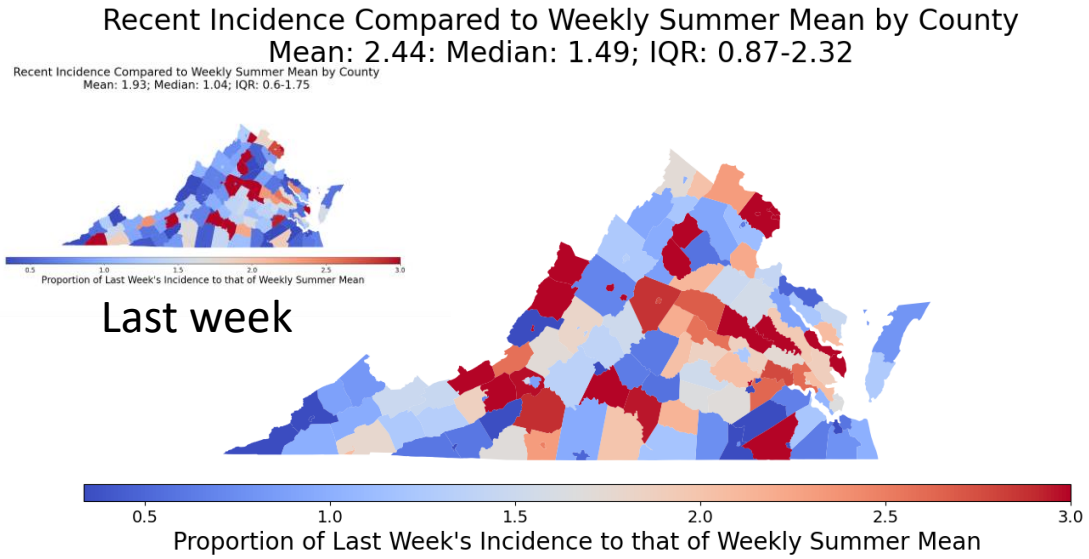


# County-level comparison to last Summer

- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably



# Using Ensemble Model to Guide Projections

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

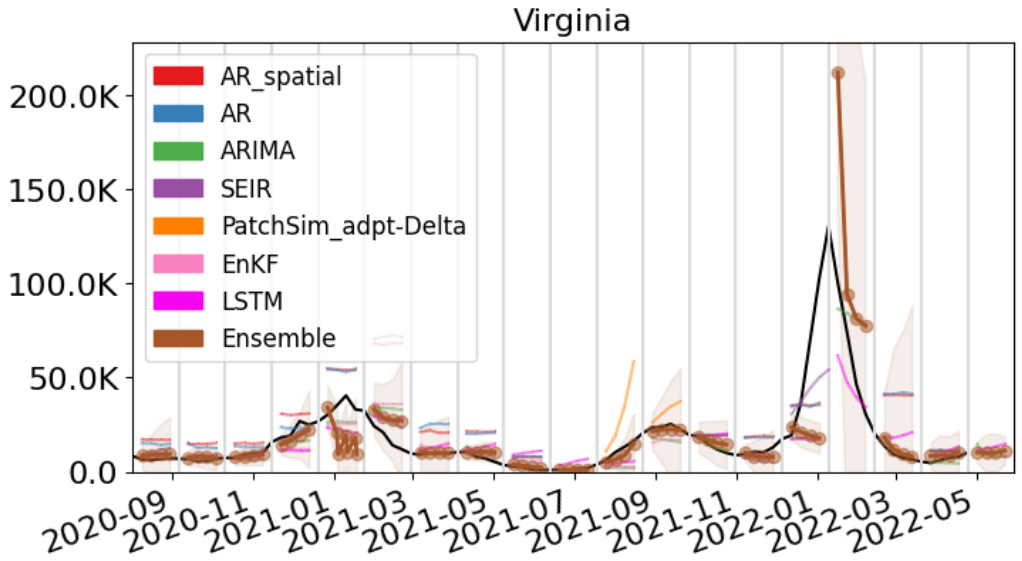
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

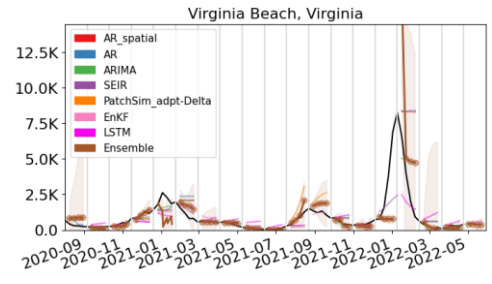
<u>Weekly forecasts</u> done at county level.

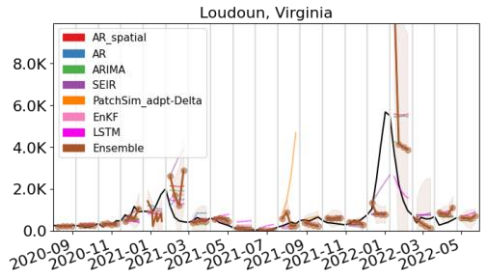
Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

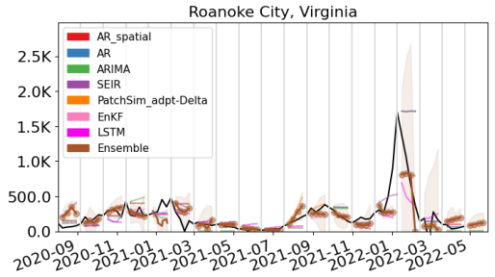
Ensemble forecast provides additional ‘surveillance’ for making scenario-based projections.

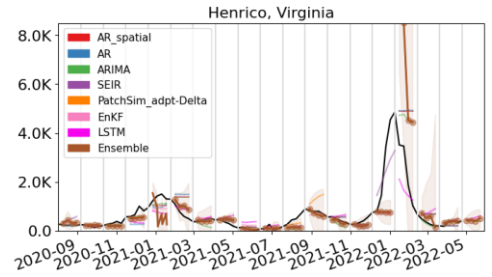
Also submitted to CDC Forecast Hub.



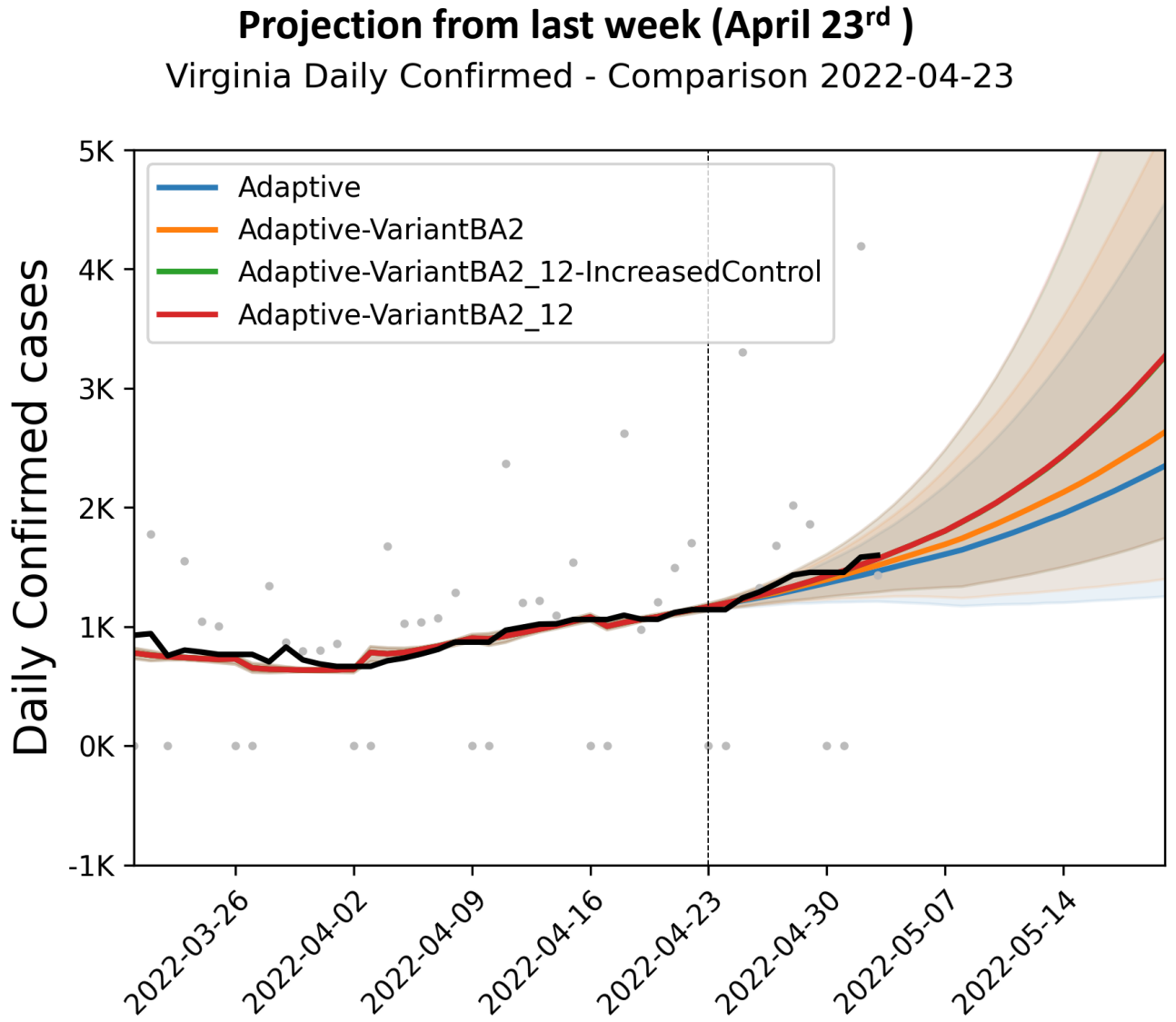



# Last week's projection comparison

- New district level fitting seems to have corrected for surveillance artifacts
- Growth to present unfortunately still tracking projections, perhaps leaning towards BA2.12.1 scenario



# Additional Analyses

# COVID-19 Scenario Modeling Hub – Round 13

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

- Round 13 results getting finalized
  - Scenarios:  New Variant in Summer and waning compared (yes/no new variant vs. 4 month or 10 month waning)
- Prelim results shared internally
- Only national consortium tracking Omicron wave well
- Rounds 4-12 now available

*Round 4 Results were published May 5th, 2021 in MMWR*

https://covid19scenariomodelinghub.org/viz.html