Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

# Estimation of COVID-19 Impact in Virginia

May 18th, 2022

(data current to May 15th – May 17th)

Biocomplexity Institute Technical report: BI-2022-1439

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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

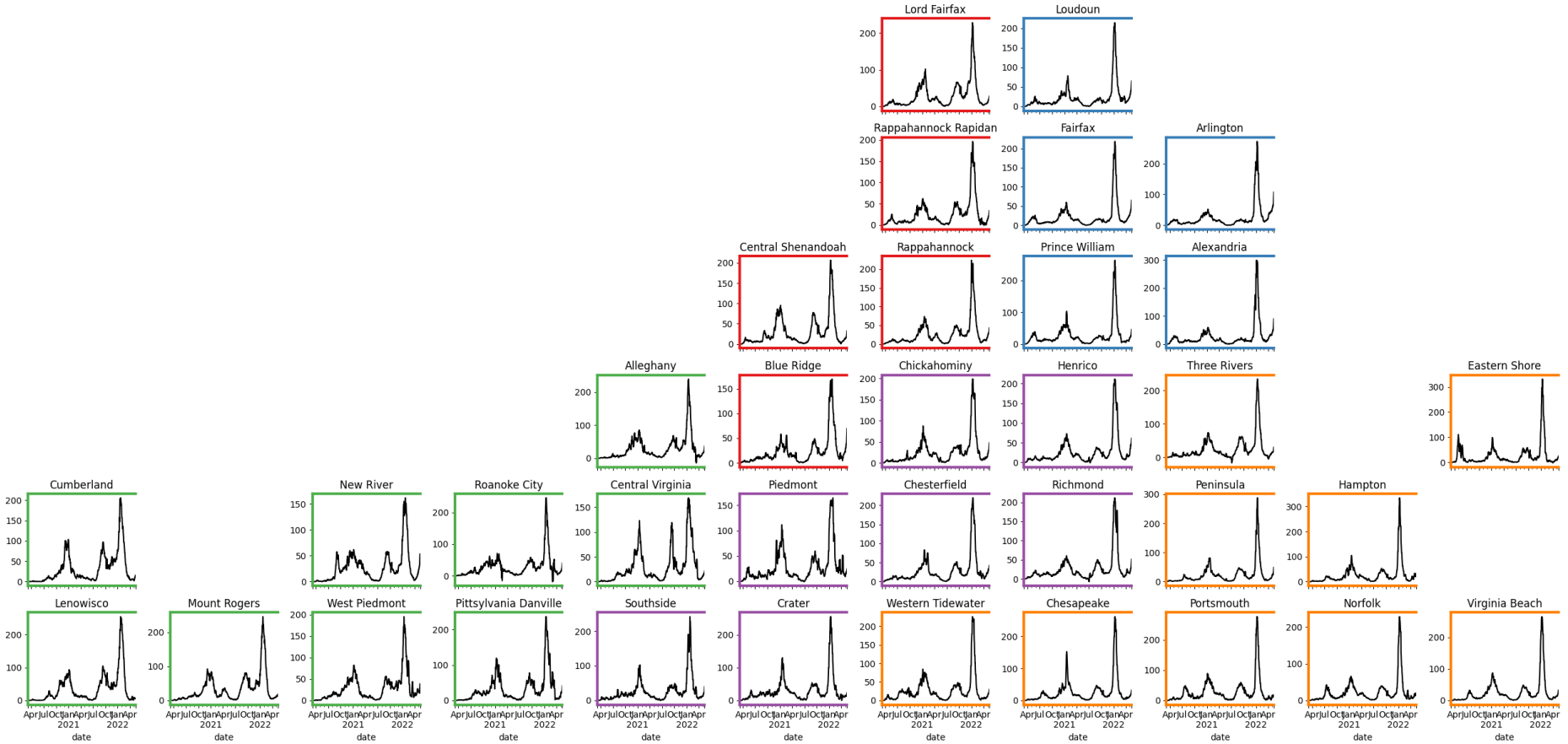
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

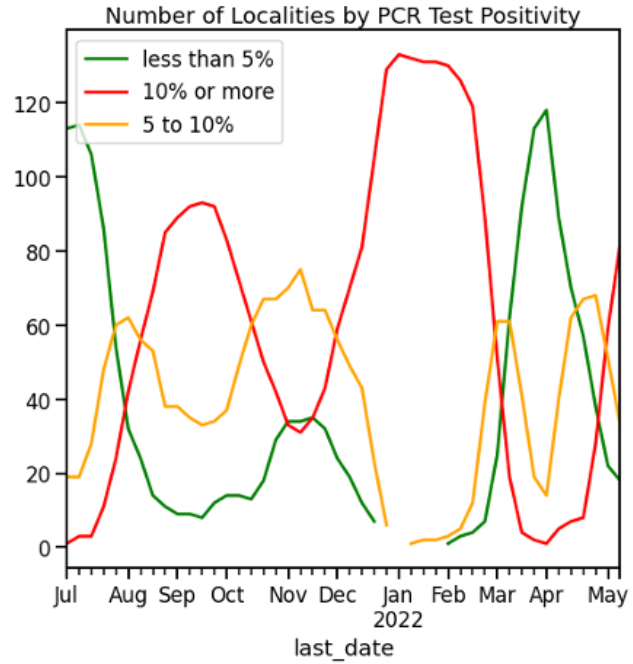
- **Case rates and hospitalizations continue to plateau**
- VA 7-day mean daily case rate continues to increase to 32/100K from 26/100K
  - US also increased to 36/100K (from 22/100K)
- District level fitting seems to have helped with the projection's accuracy
- BA.2.12.1 continues to rise, but pace 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




**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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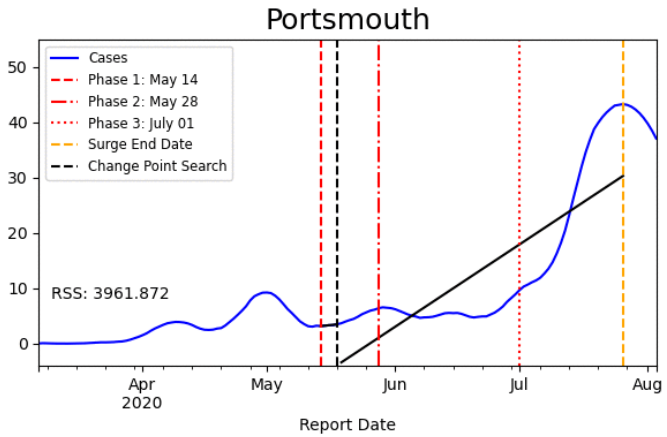
# District Trajectories

**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

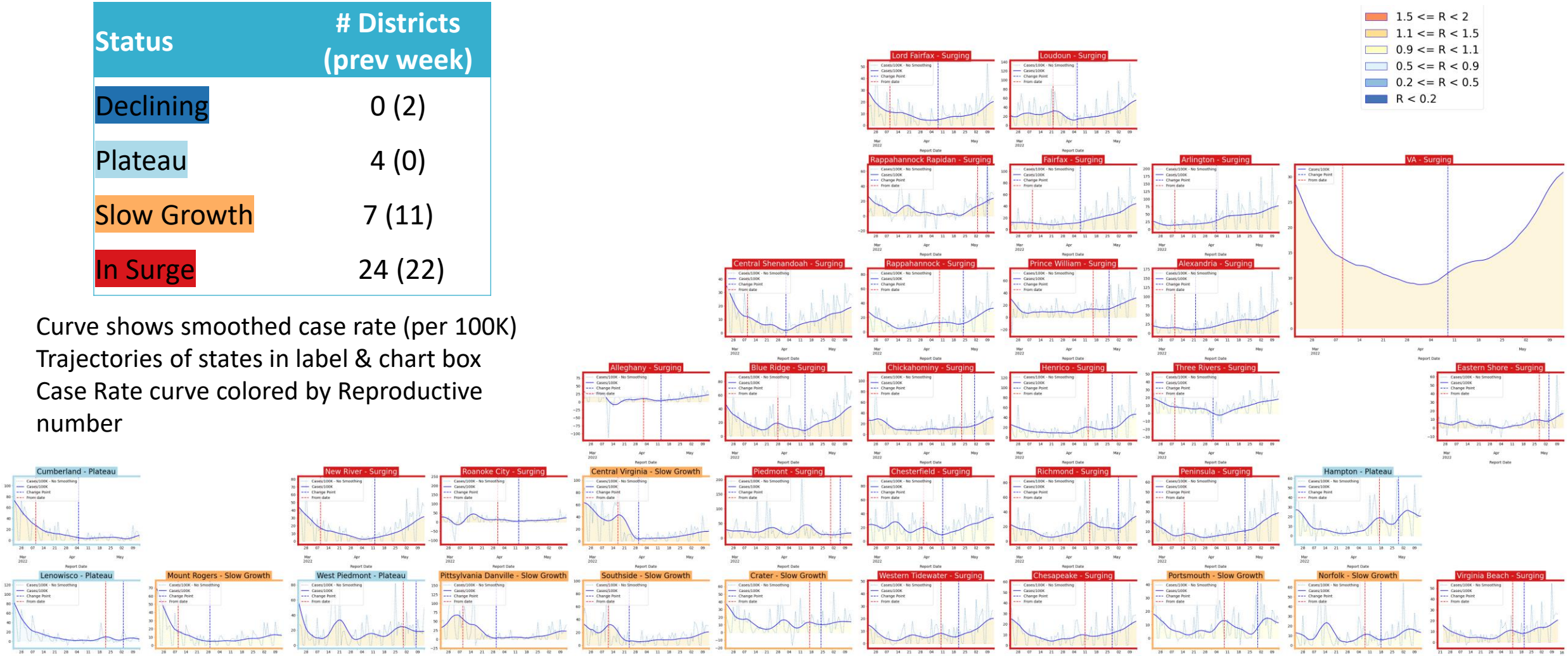



| Trajectory | Description | Weekly Case Rate (per 100K) bounds |
|---|---|---|
| **Declining** | Sustained decreases following a recent peak | below -0.9 |
| **Plateau** | Steady level with minimal trend up or down | above -0.9 and below 0.5 |
| **Slow Growth** | Sustained growth not rapid enough to 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 | 0 (2) |
| Plateau | 4 (0) |
| Slow Growth | 7 (11) |
| In Surge | 24 (22) |

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 |

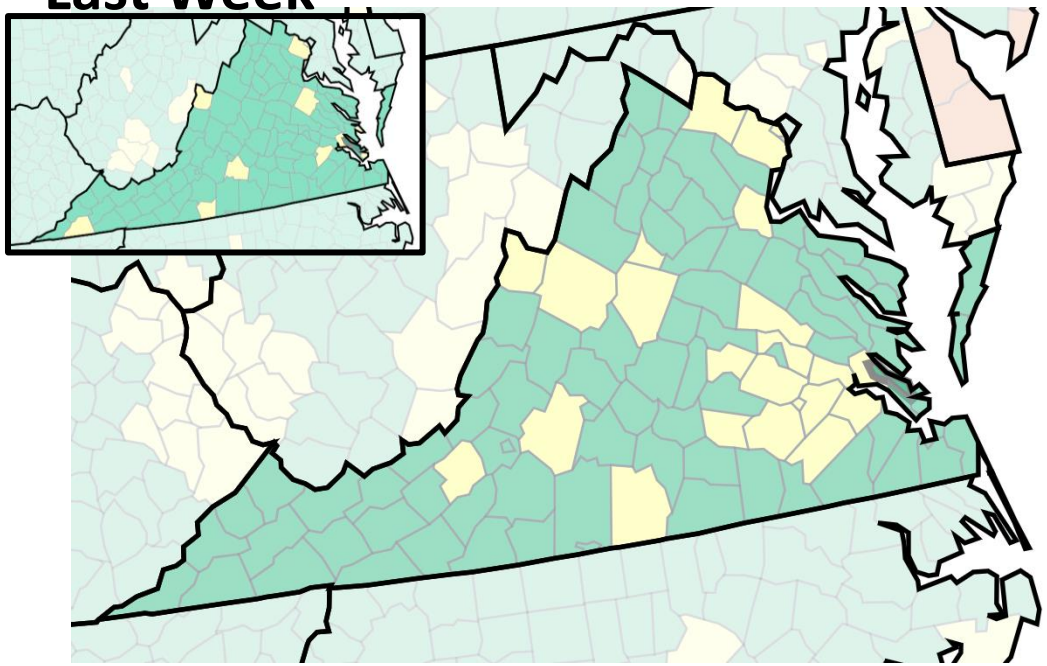
People may choose to mask at any time. People with symptoms, a positive test, or exposure to someone with COVID-19 should wear a mask.

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% |

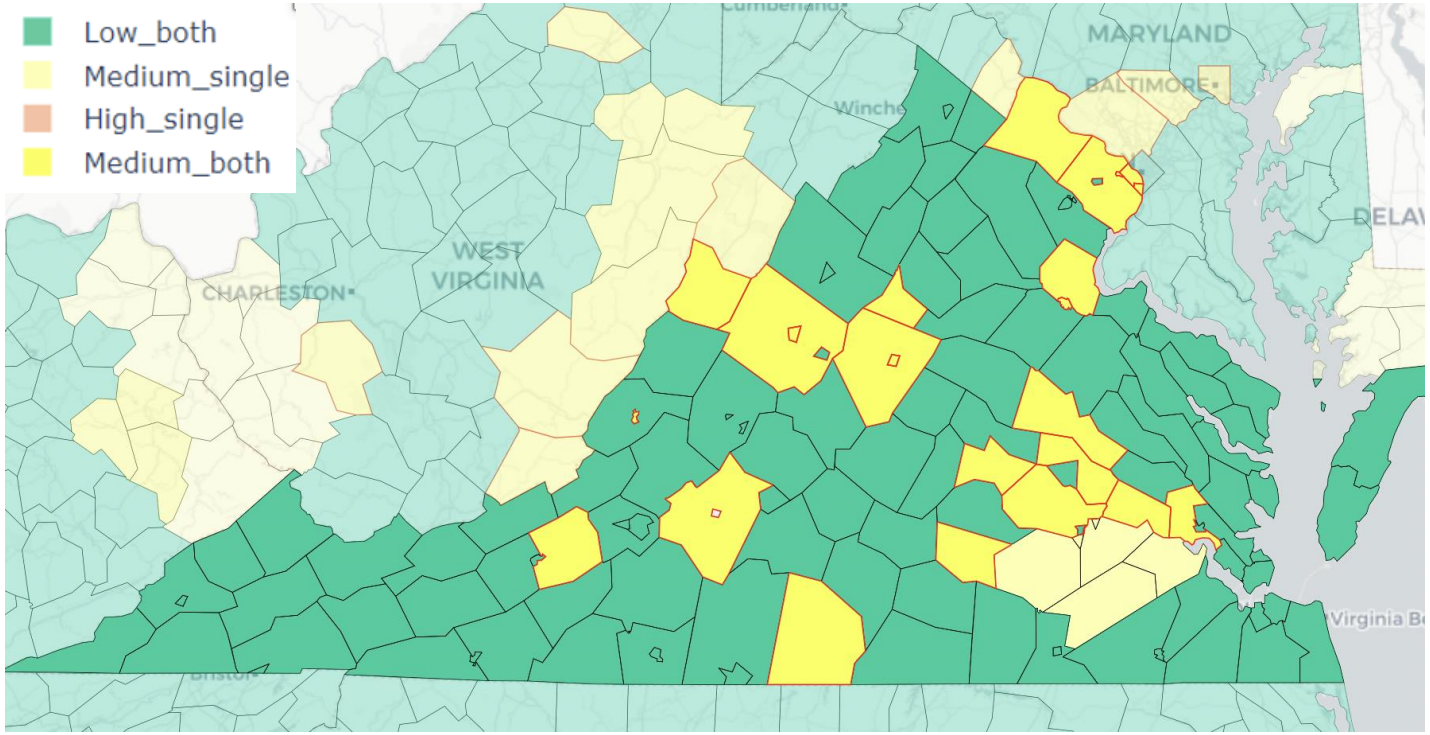
The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

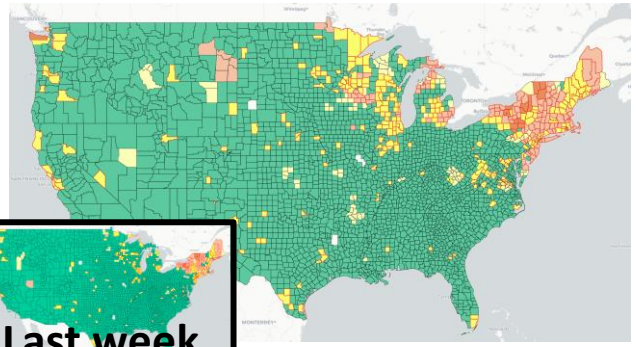
**Last Week**

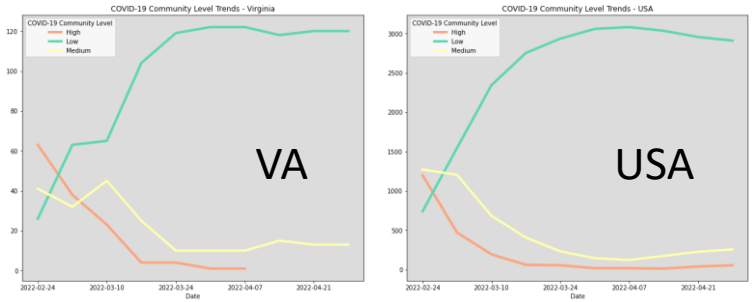


[CDC Data Tracker Portal]

# 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

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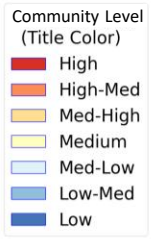
 Data from: [CDC Data Tracker Portal]

# District Trajectories with Community Levels



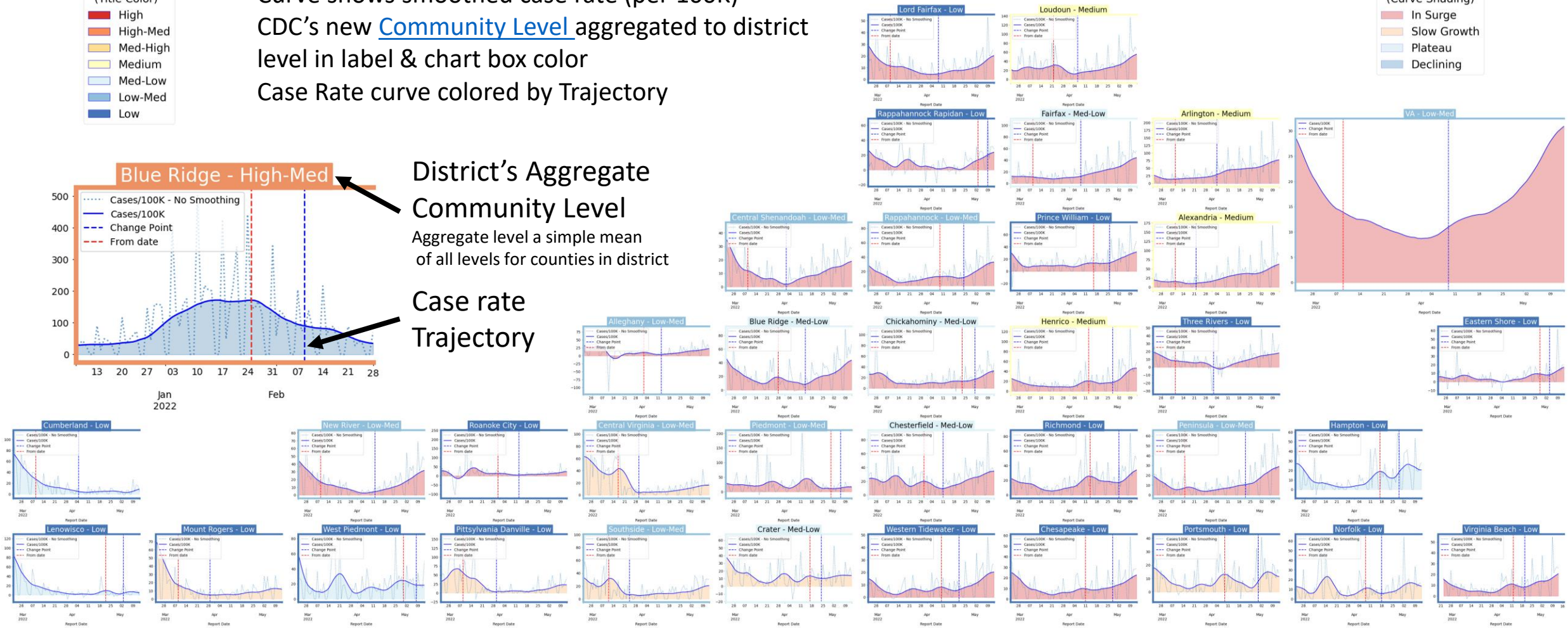

Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory




District's Aggregate Community Level

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

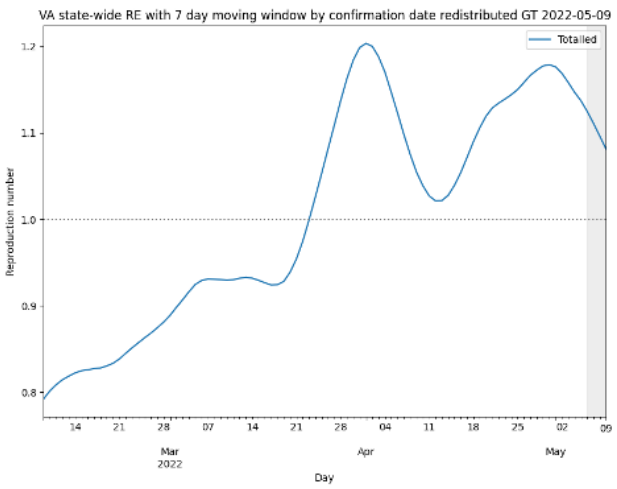
Case rate Trajectory

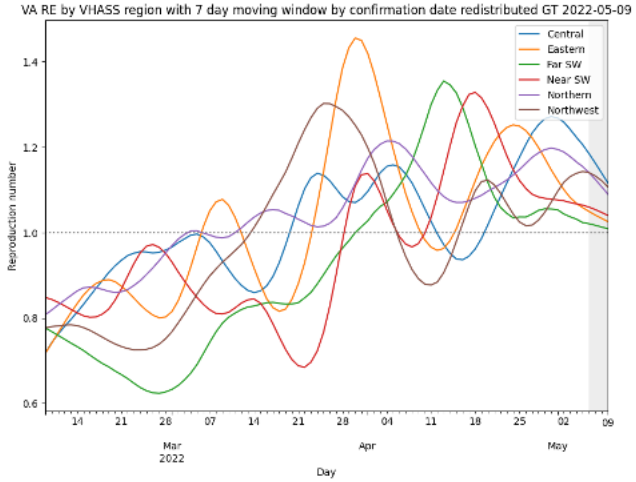



# Estimating Daily Reproductive Number –
## Redistributed gap

### May 13th Estimates

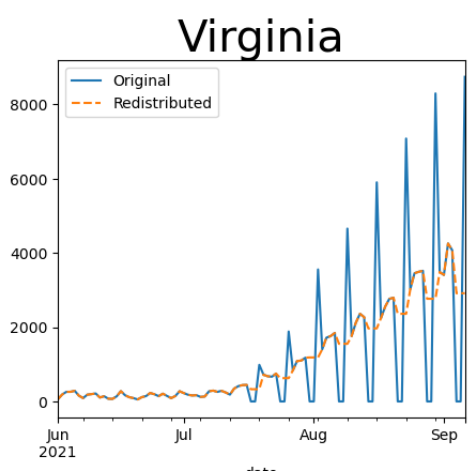
| Region | Date Confirmed $R_e$ | Date Confirmed Diff Last Week |
|---|---|---|
| State-wide | 1.111 | 0.030 |
| Central | 1.096 | -0.020 |
| Eastern | 1.090 | 0.065 |
| Far SW | 1.026 | 0.017 |
| Near SW | 1.124 | 0.084 |
| Northern | 1.115 | 0.025 |
| Northwest | 1.155 | 0.049 |




### Skipping Weekend Reports & holidays biases estimates

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




**Methodology**

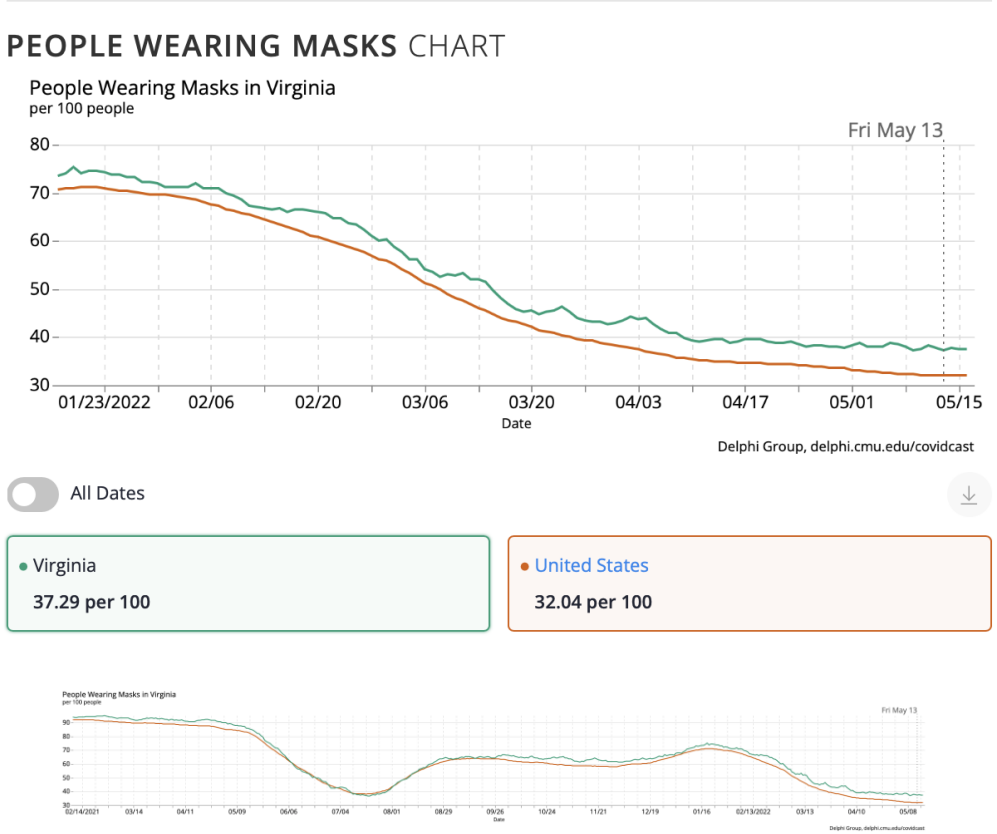
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: Discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

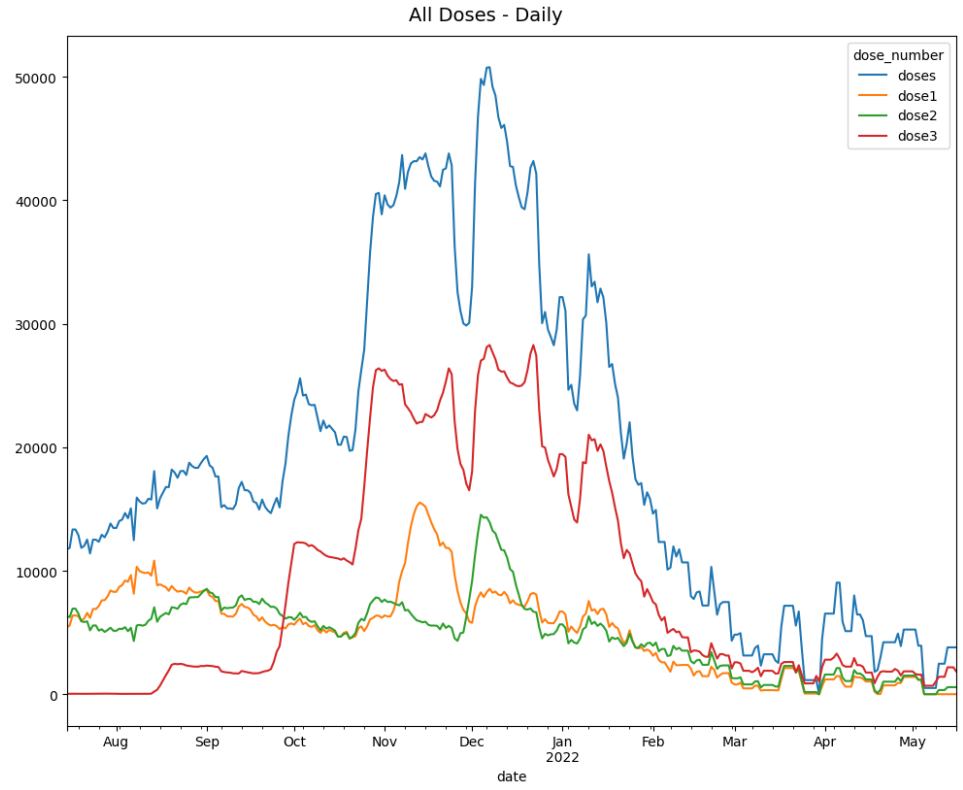

1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

# 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



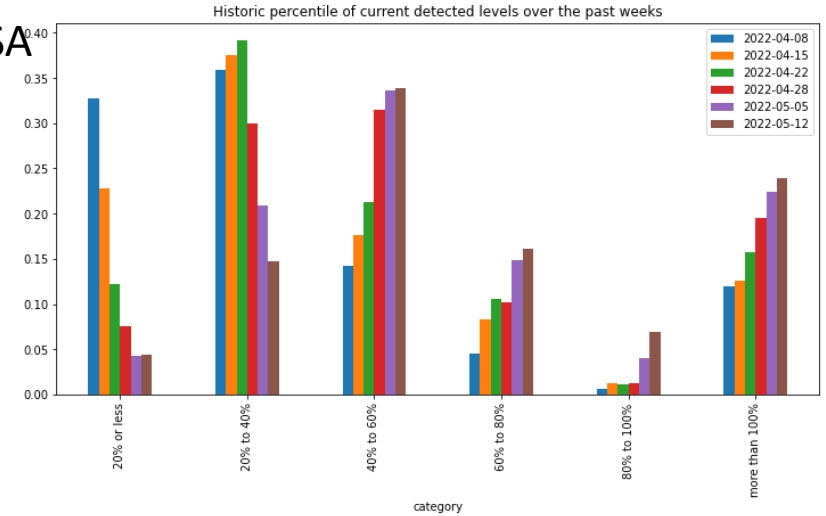

Data Source: https://covidcast.cmu.edu

# Wastewater Monitoring

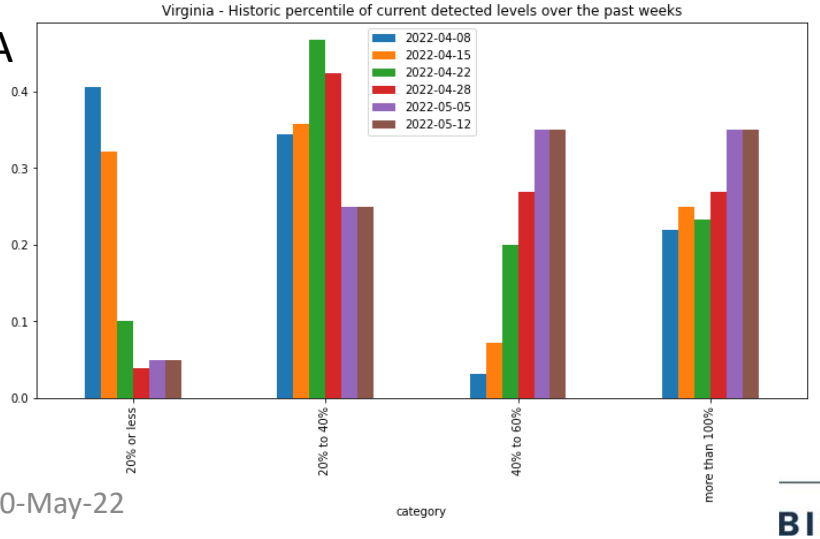
**Wastewater provides a coarse early warning of COVID-19 levels in communities**

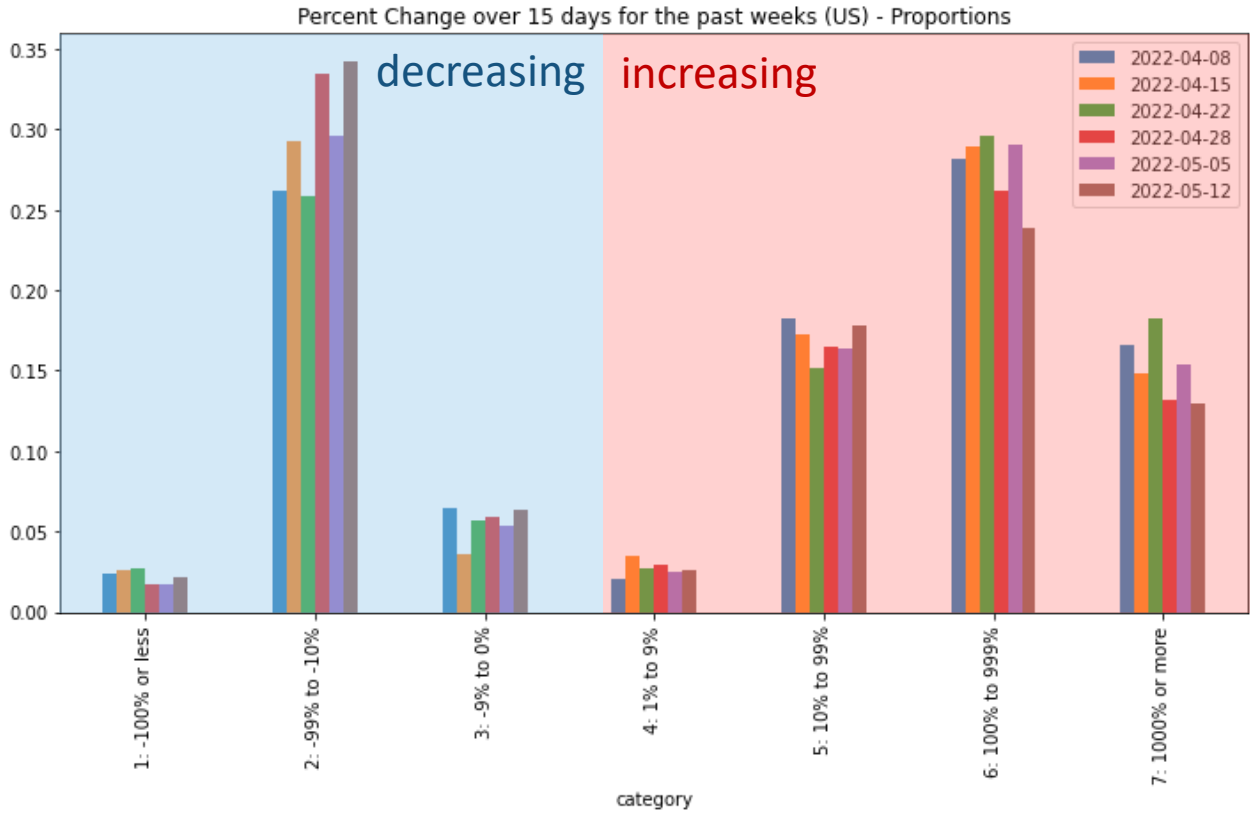
- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago
- Proportion of sites with current virus levels at or exceeding the max of previous historical levels, has further increased since last week

USA




VA



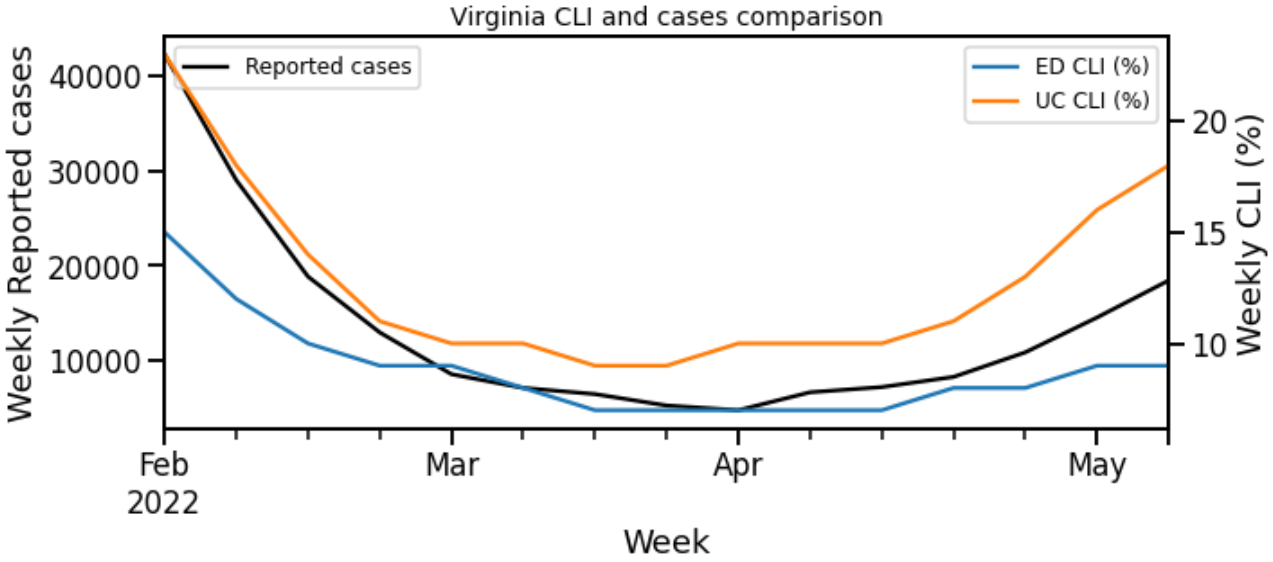



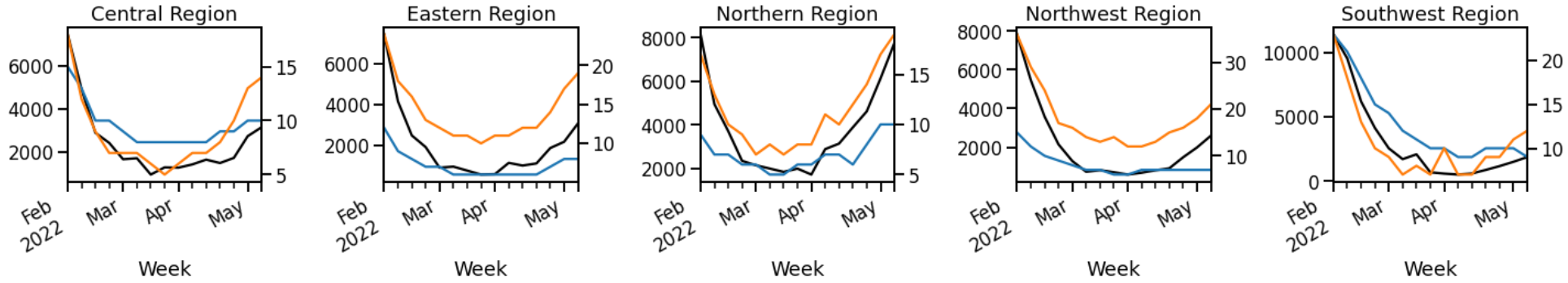

Data Source: [CDC Data Tracker]

# COVID-like Illness Activity

**COVID-like Illness (CLI) gives 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



# SARS-CoV2 Variants of Concern

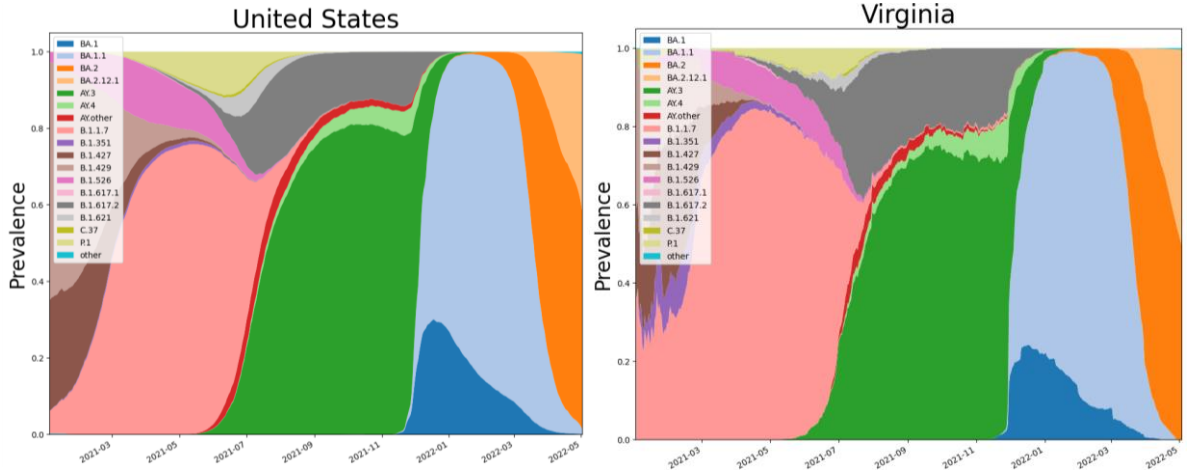
**Emerging new variants will alter the future trajectories of pandemic and have implications for future control**

- 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](#)

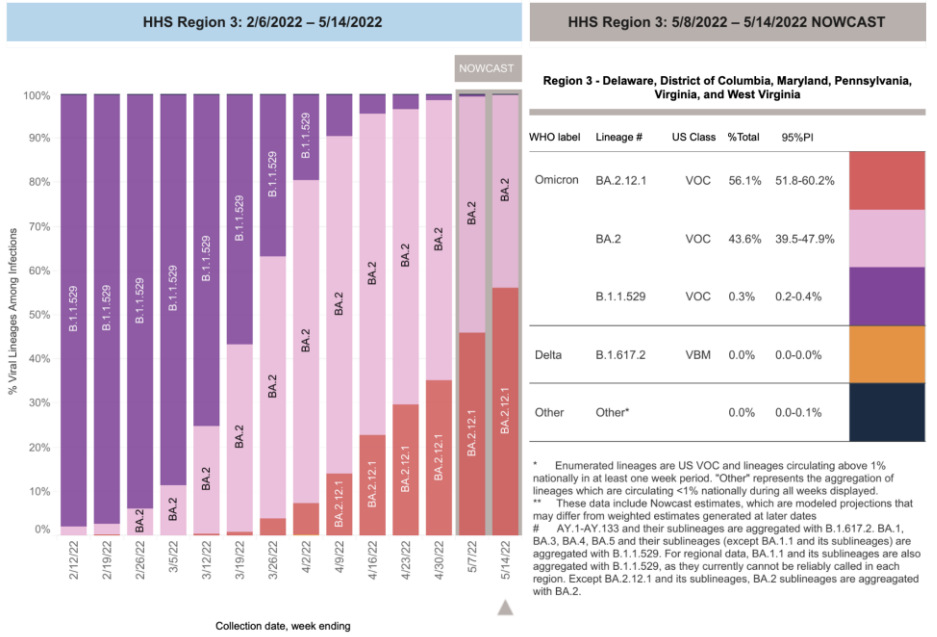
GISAID outbreak.info




**Omicron Prevalence**

**CDC nowcast for week ending April 2nd shows 98% overall BA.2 in Region 3 with BA 2.12.1 at 56% (last week 48%)**

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

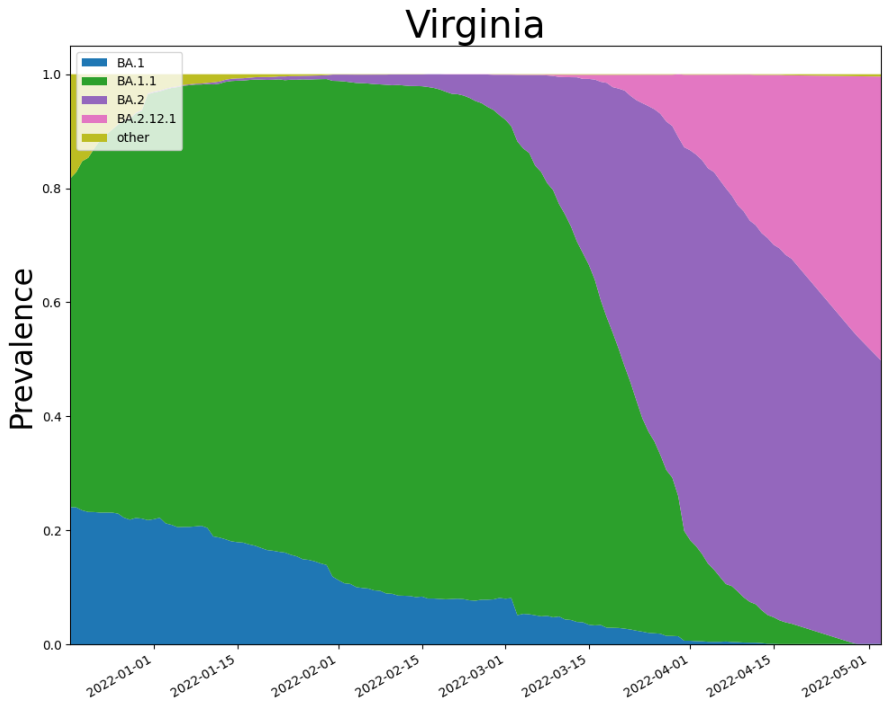


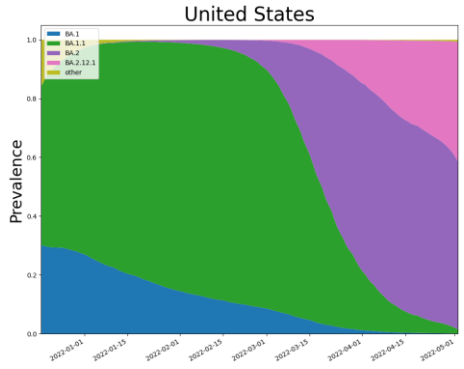

* Enumerated lineages are US VOC and lineages circulating above 1% nationally in at least one week period. "Other" represents the aggregation of lineages which are circulating <1% nationally during all weeks displayed.
** These data include Nowcast estimates, which are modeled projections that may differ from weighted estimates generated at later dates
# AY.1-AY.133 and their sublineages are aggregated with B.1.617.2. BA.1, BA.3, BA.4, BA.5 and their sublineages (except BA.1.1 and its sublineages) are aggregated with B.1.1.529. For regional data, BA.1.1 and its sublineages are also aggregated with B.1.1.529, as they currently cannot be reliably called in each region. Except BA.2.12.1 and its sublineages, BA.2 sublineages are aggregated with BA.2.

CDC [CDC Variant Tracking](#)

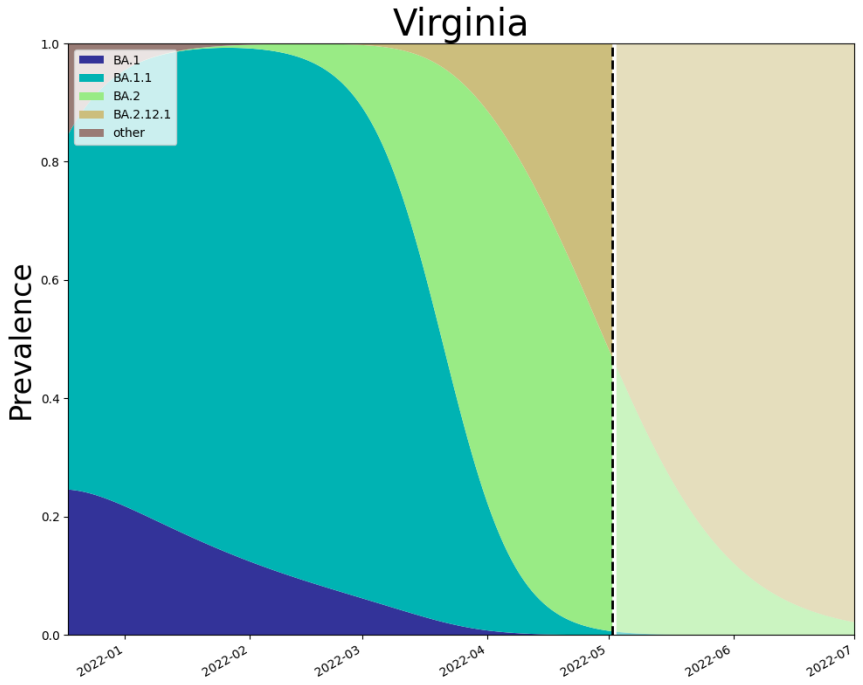
# SARS-CoV2 Omicron and Sub-Variants

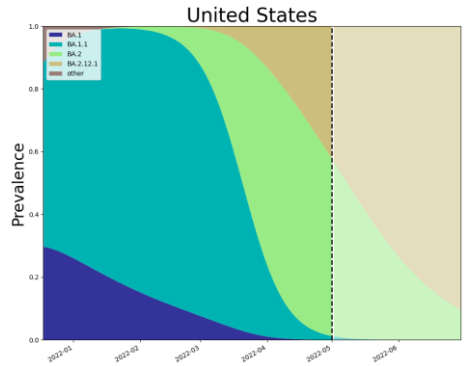
**As detected in whole Genomes in public repositories**




VoC Polynomial Fit Projections




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

GISAID outbreak.info

# Pandemic Pubs

**1.** New data gives estimates on the degree of protection from post-acute sequelae PASC offered by vaccines.
**2.** European study gives baseline risk of 1% of venous or arterial thromboembolism among COVID patients. Increases among males, hospitalizations and the elderly.
**3.** ECDC list BA.4 and BA.5 as VoCs. Cases appear to have peaked in S. Africa with low severe outcomes.
**4.** UK: Bank of England's Monetary Policy Committee reports concern that share of the 16-64 y/o population who are outside the workforce and do not seeking a job because of long-term sickness is a record high.

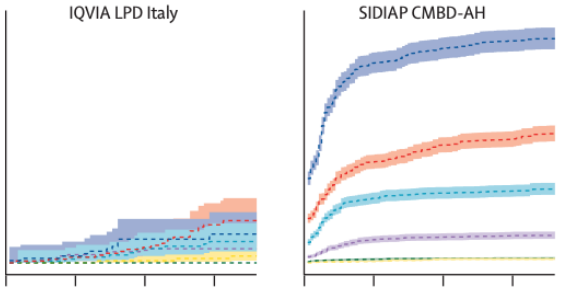
1

Table 2. Post-Acute Sequelae of Sars-Cov-2 (PASC) Mortality and Morbidity Risk at 28 days: vaccine vs. no-vaccine.

| | | 28 day risk (Rates per 1,000) | | | |
|---|---|---|---|---|---|
| | Total (n) | Vaccine + COVID | No-Vaccine + COVID | Relative Risk (95% CIs) | Attributable Risk (95% CIs) |
| **Outcomes** | | n (incident rate) | | | |
| Mortality | 50450 | 171 (6.78) | 522 (20.69) | 0.33 (0.28, 0.39) | -13.91 (-15.94, -11.89) |
| **New Conditions since COVID** | | | | | |
| Hypertension | 25862 | 176 (13.52) | 384 (29.90) | 0.45 (0.38, 0.54) | -16.38 (-19.93, -12.83) |
| Diabetes mellitus | 38762 | 116 (5.98) | 269 (13.88) | 0.43 (0.35, 0.54) | -7.90 (-9.87, -5.93) |
| Thyroid Disease | 43481 | 82 (3.80) | 193 (8.80) | 0.43 (0.33, 0.56) | -5.00 (-6.48, -3.51) |
| Heart Disease | 33836 | 253 (15.41) | 543 (31.17) | 0.49 (0.43, 0.57) | -15.76 (-18.96, 12.57) |
| Malignant Neoplasms | 42705 | 84 (3.95) | 260 (12.14) | 0.32 (0.25, 0.42) | -8.20 (-9.89, -6.50) |
| Thrombosis | 43486 | 137 (6.36) | 332 (15.14) | 0.42 (0.34, 0.51) | -8.78 (-10.72, -6.85) |
| Rheumatoid Arthritis | 49289 | 16 (0.65) | 32 (1.30) | 0.50 (0.28, 0.91) | -0.65 (-1.20, -0.09) |
| Mental Disorders | 32307 | 231 (14.77) | 604 (36.23) | 0.41 (0.35, 0.47) | -21.45 (-24.86, -18.05) |
| **New Symptoms since COVID** | | | | | |
| Respiratory Symptoms | 50450 | 2263 (89.71) | 3219 (127.61) | 0.70 (0.67, 0.74) | -37.90 (-43.32, -32.48) |
| Headache | 50450 | 450 (17.84) | 804 (31.87) | 0.56 (0.50, 0.63) | -14.03 (-16.75, -11.32) |
| Fatigue | 50450 | 1138 (45.14) | 1750 (69.38) | 0.65 (0.61, 0.70) | -24.26 (-28.31, -20.21) |
| Body Ache | 50450 | 235 (9.32) | 480 (19.03) | 0.50 (0.42, 0.57) | -9.71 (-11.77, -7.65) |
| Diarrhea or constipation | 50450 | 857 (33.97) | 1424 (56.45) | 0.60 (0.55, 0.65) | -22.48 (-26.10, -18.86) |



2

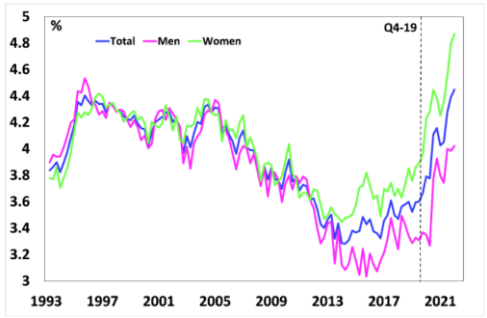



A distributed network cohort study using primary care records from the Netherlands, Italy, Spain, and the UK, and outpatient specialist records from Germany. Overall, 909 473 COVID-19 cases and 32329 patients hospitalised with COVID-19 on or after Sept 1, 2020, were studied. Cumulative 90-day incidence of venous thromboembolism ranged from 0·2% to 0·8% among COVID-19 cases, and up to 4·5% for those hospitalised. The occurrence of venous thromboembolism in patients with COVID-19 was associated with an increased risk of death (adjusted HRs 4·42 [3·07–6·36] for those not hospitalised and 1·63 [1·39–1·90] for those hospitalised), as was the occurrence of arterial thromboembolism (3·16 [2·65–3·75] and 1·93 [1·57–2·37]).
https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(22)00223-7/fulltext

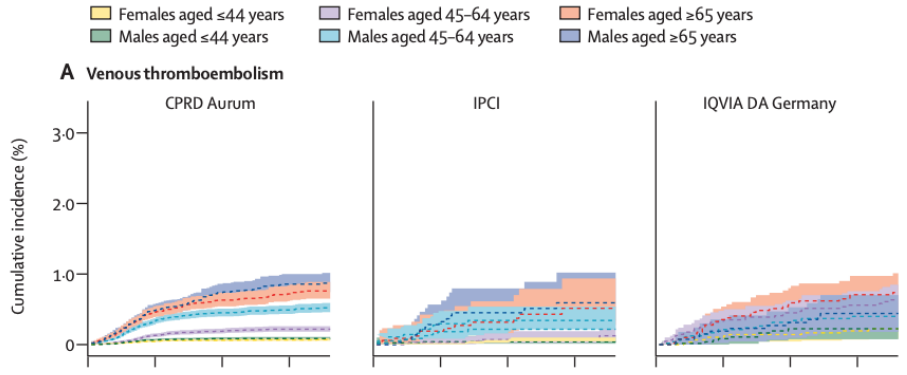
4

https://www.bankofengland.co.uk/speech/2022/may/michael-saunders-speech-at-the-resolution-foundation-event

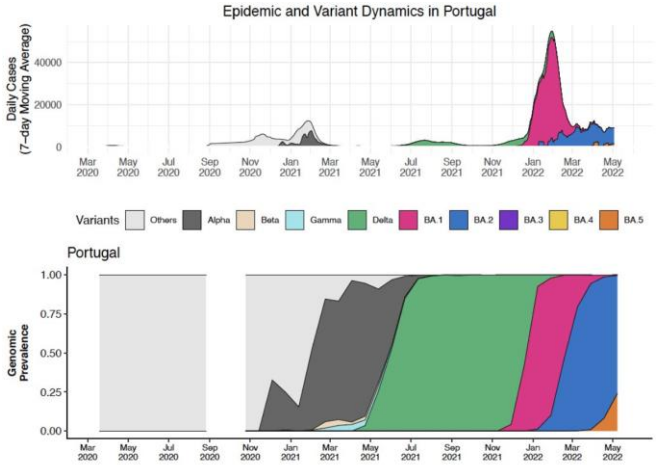
Figure 6. UK – Per cent of Adult Population Aged 16-64 Who Are Outside the Workforce and Do Not Want a Job Because of Long-term Sickness

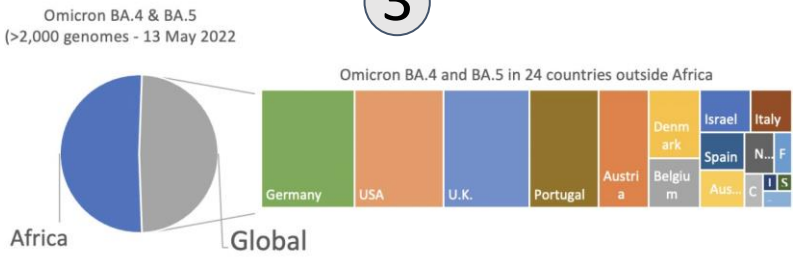



Patients with confirmed COVID-19 diagnosis, minimum age of 18 years with 3 month follow-up post-diagnosis between September 21, 2020 and December 14, 2021 were identified from TriNetX research network platform. 1,578,719 patients with confirmed COVID-19 were identified and 1.6% (n=25,225) completed vaccination. Before matching vaccinated individuals who were found to be positive tended to be older and have more comorbidities.
https://academic.oup.com/ofid/advance-article/doi/10.1093/ofid/ofac228/6582238?login=false#.Yn2vXtn7Cpg.twitter

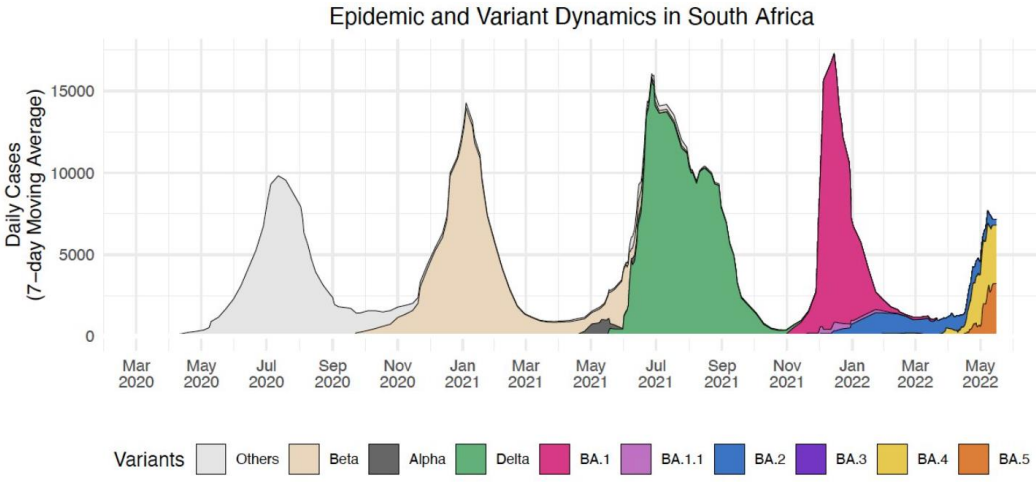



3




Tulio de Oliveira Director of CERI (Centre for Epidemic Response & Innovation S.Africa) reports BA.4 and BA.5 have significantly increased cases in countries with strong BA.1 but minimal BA.2 waves, S. Africa and Portugal. Locations w similar conditions could be more vulnerable to these immune escape variants
https://twitter.com/Tuliodna/status/1526470866762141697

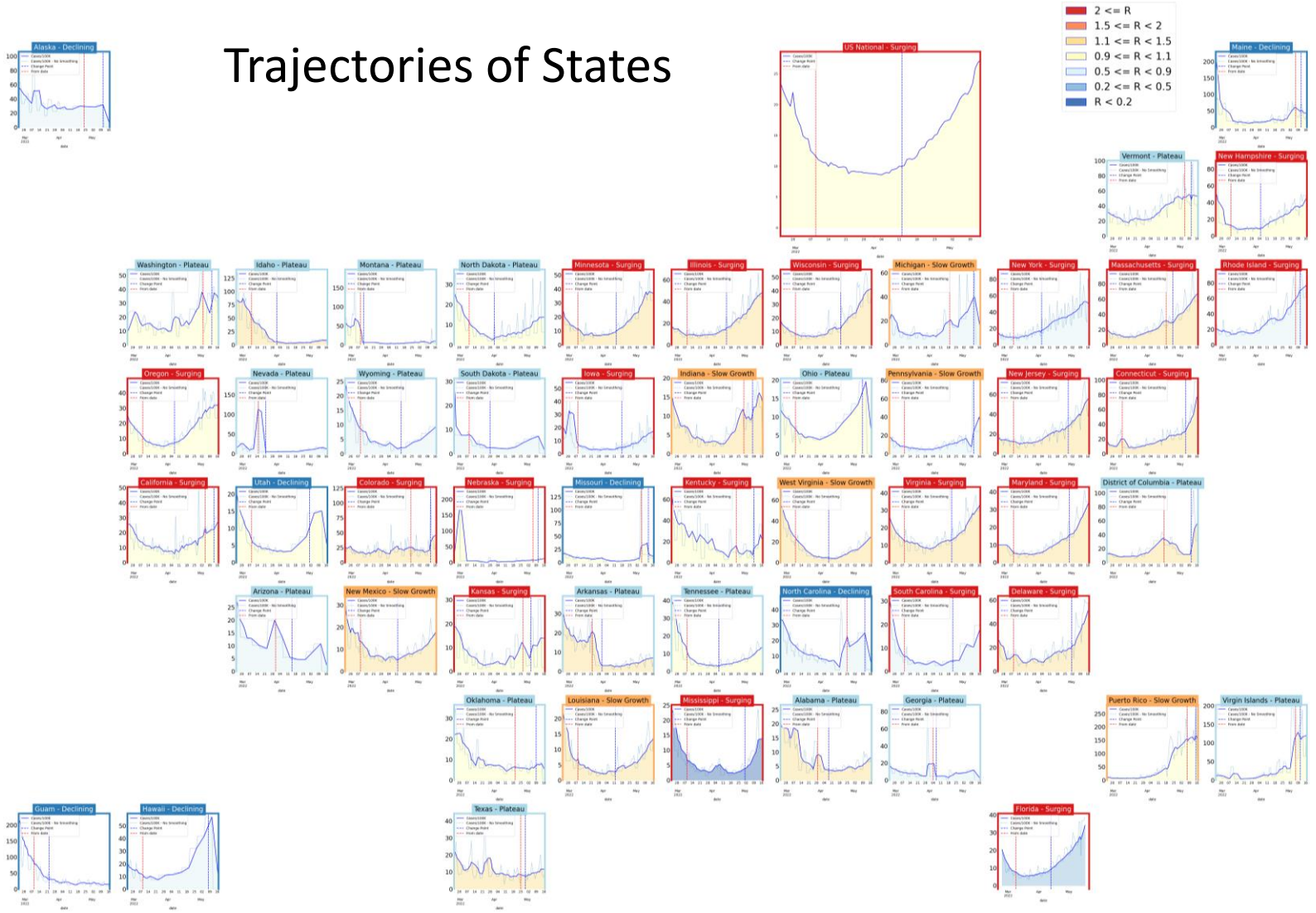


# United States Overall

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

| Status | # States |
|---|---|
| Declining | 7 (8) |
| Plateau | 18 (22) |
| Slow Growth | 7 (6) |
| In Surge | 22 (18) |

Trajectories of States

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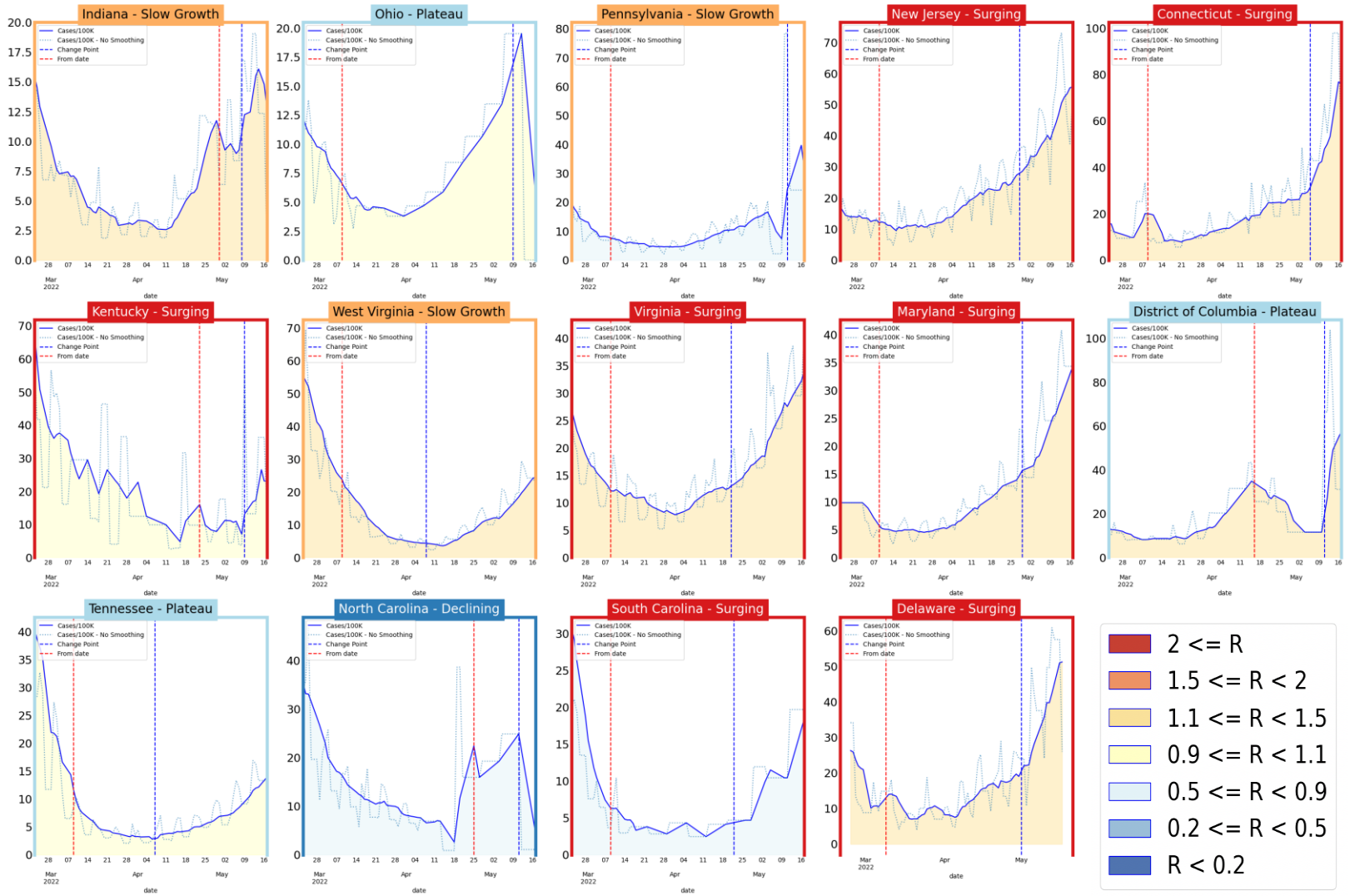
# Virginia and Her Neighbors

- More growth experienced across neighbors
- Some states at very high levels (CT, NJ)
- Neighbors to south starting to ramp up as well

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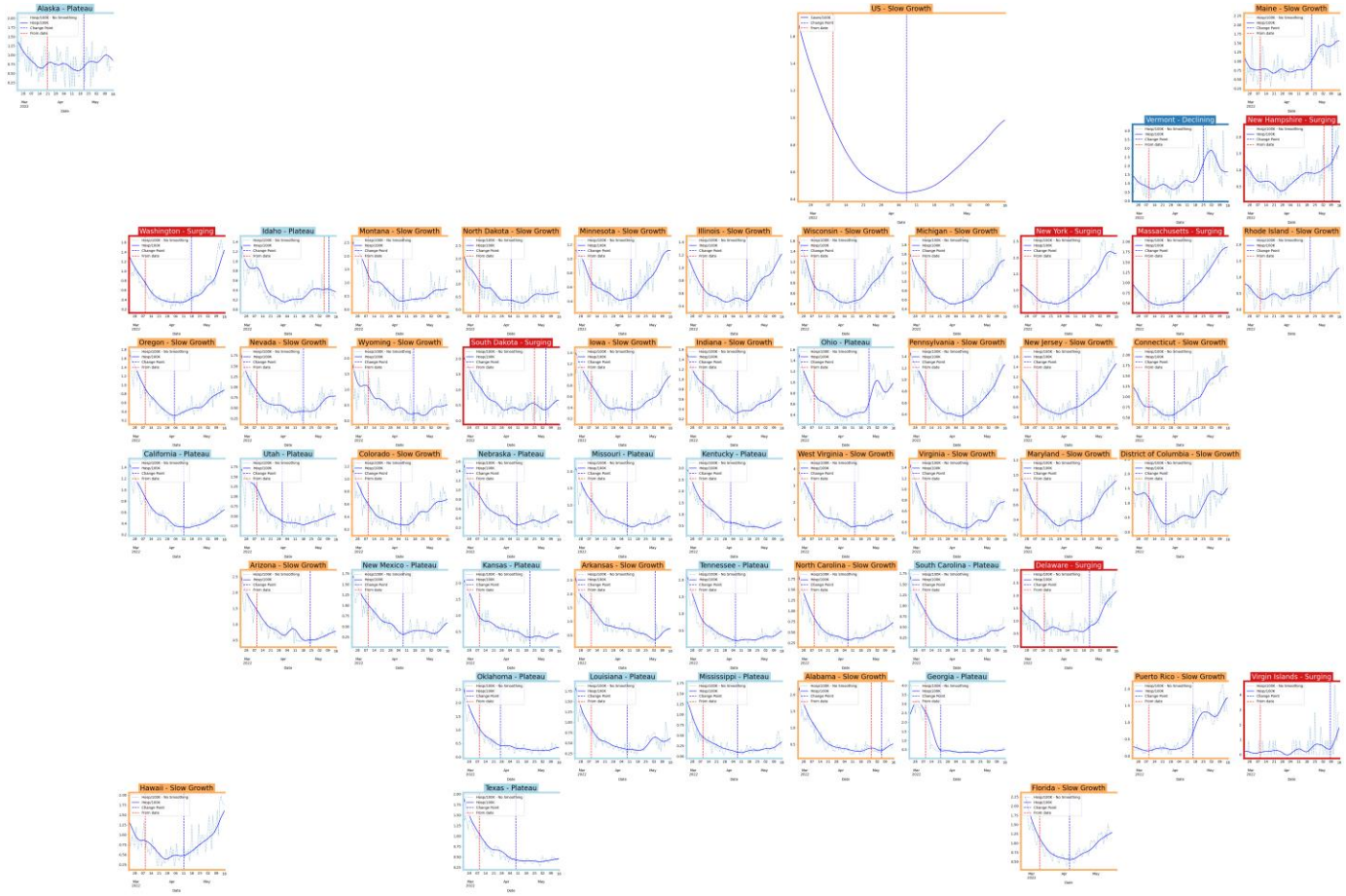
# United States Hospitalizations

- Hospital admissions are lagging case rates

| Status | # States (prev week) |
|---|---|
| Declining | 1 (1) |
| Plateau | 17 (21) |
| Slow Growth | 28 (23) |
| In Surge | 7 (5) |

Trajectories of States

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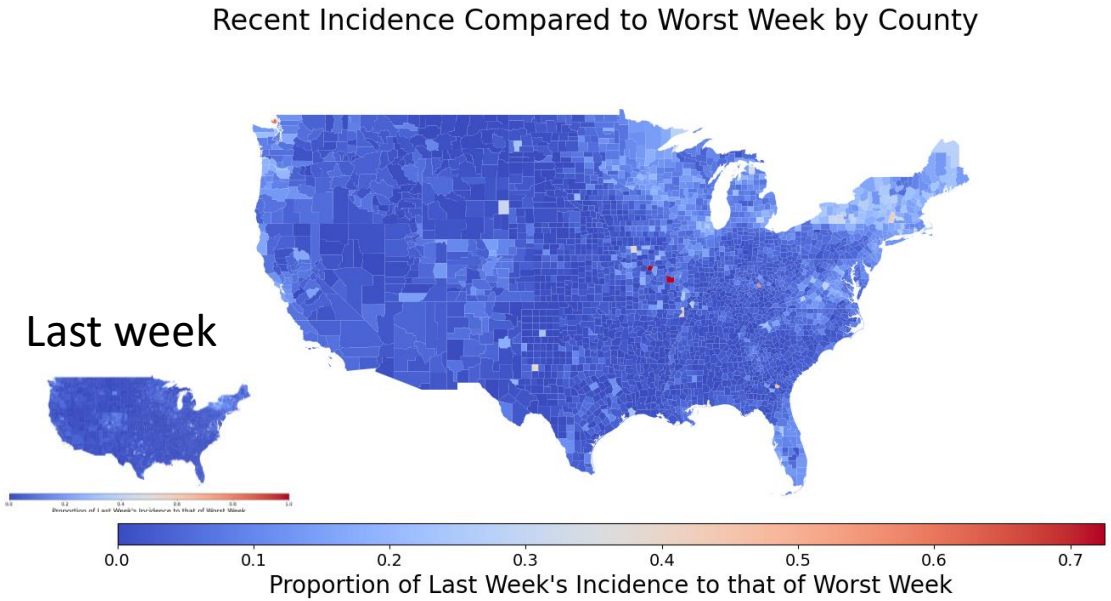
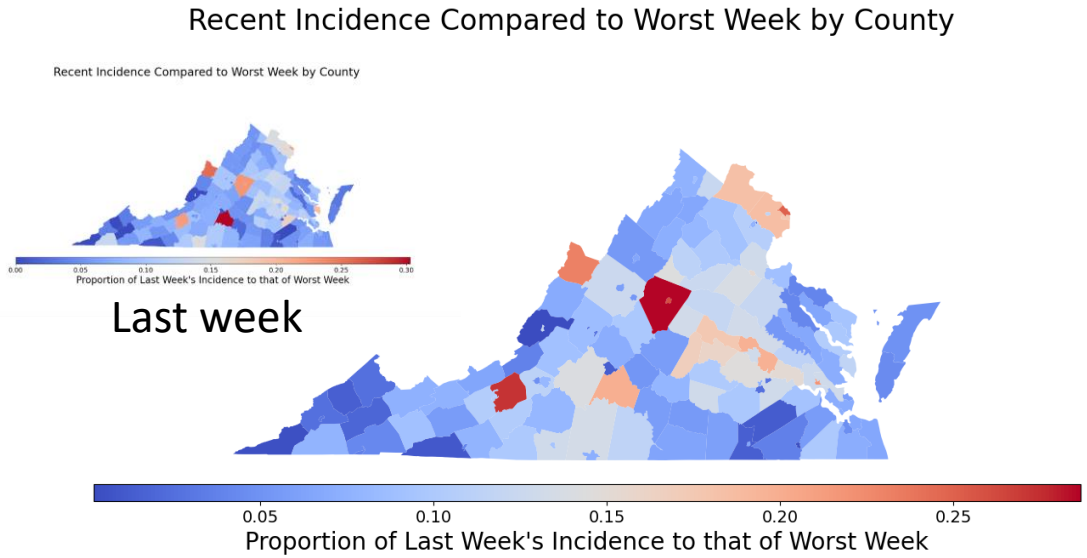
# County-level comparison to previous highest peak

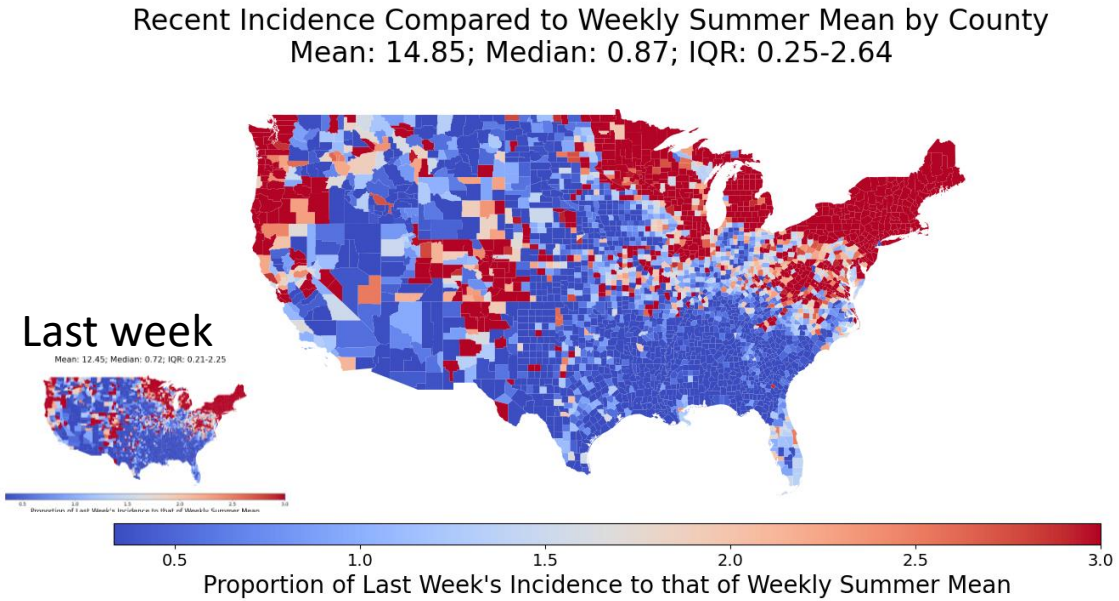
- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably

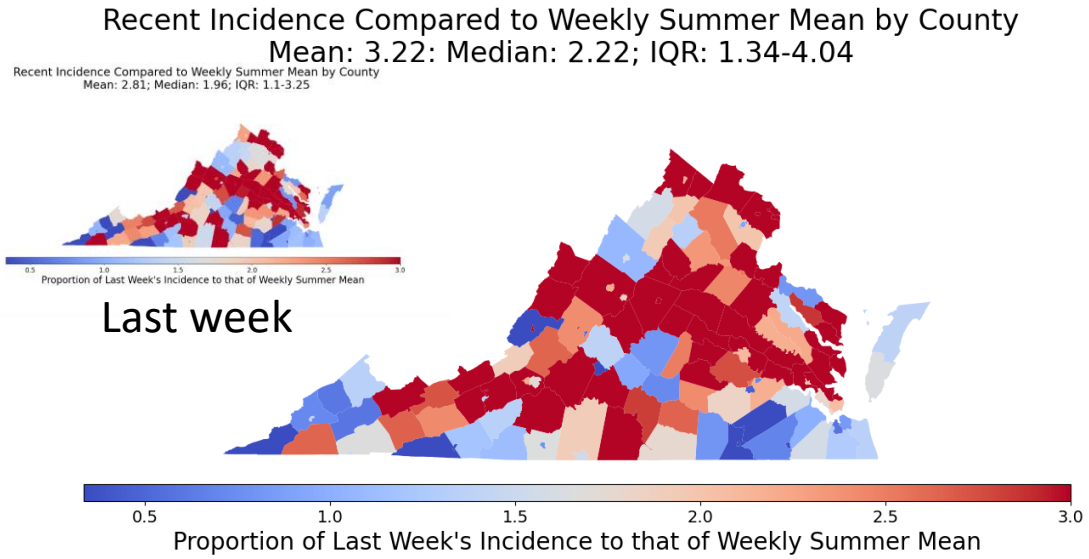


# County-level comparison to last Summer

- 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:

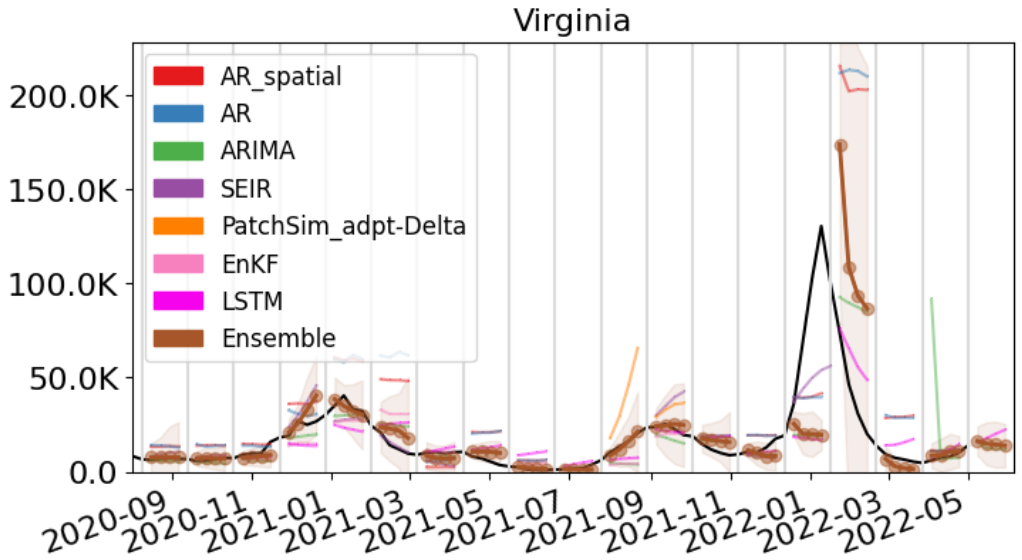
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

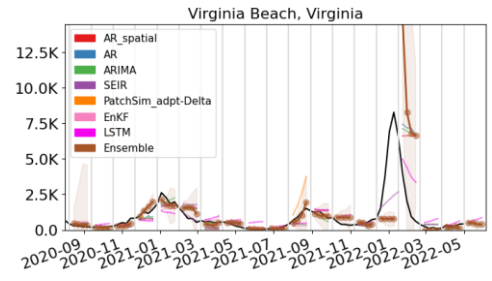
<u>Weekly forecasts</u> done at county level.

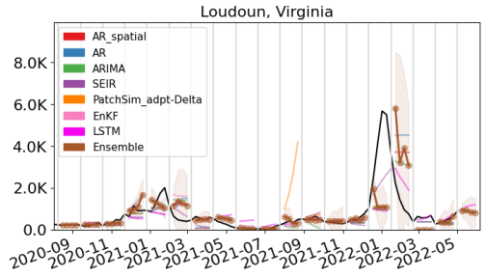
Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

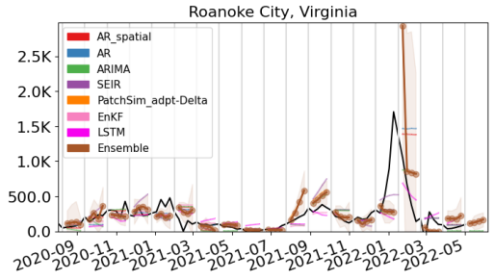
Ensemble forecast provides additional ‘surveillance’ for making scenario-based projections.

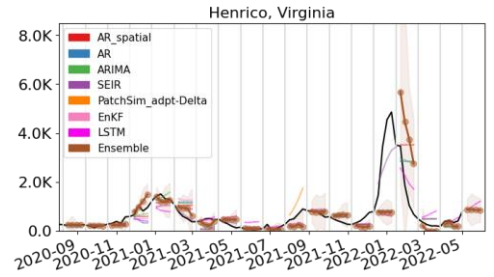
Also submitted to CDC Forecast Hub.



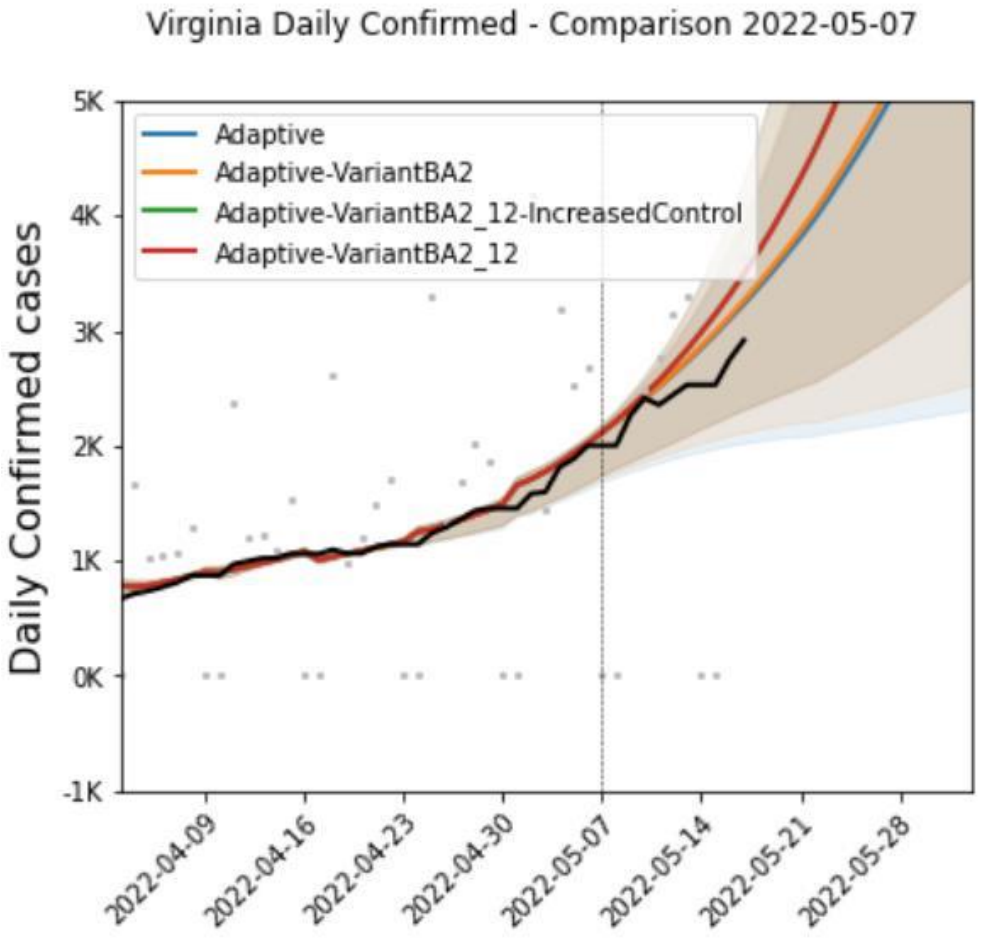



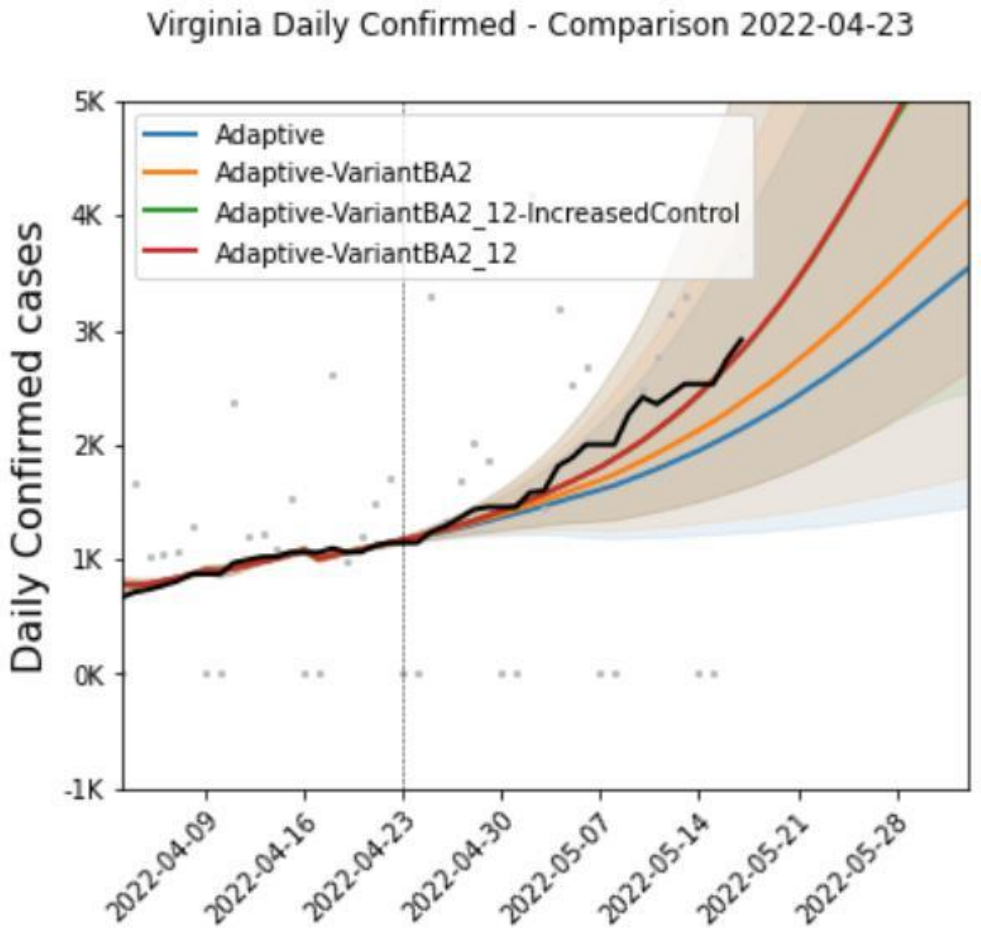



# Last week's projection comparison

**Projection from last week (May 7th)**




**Projection from 3 weeks ago (April 23rd )**



# 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