Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

# Estimation of COVID-19 Impact in Virginia

June 15th, 2022

(data current to June 11th – June 14th)

Biocomplexity Institute Technical report: TR BI-2022-1548

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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

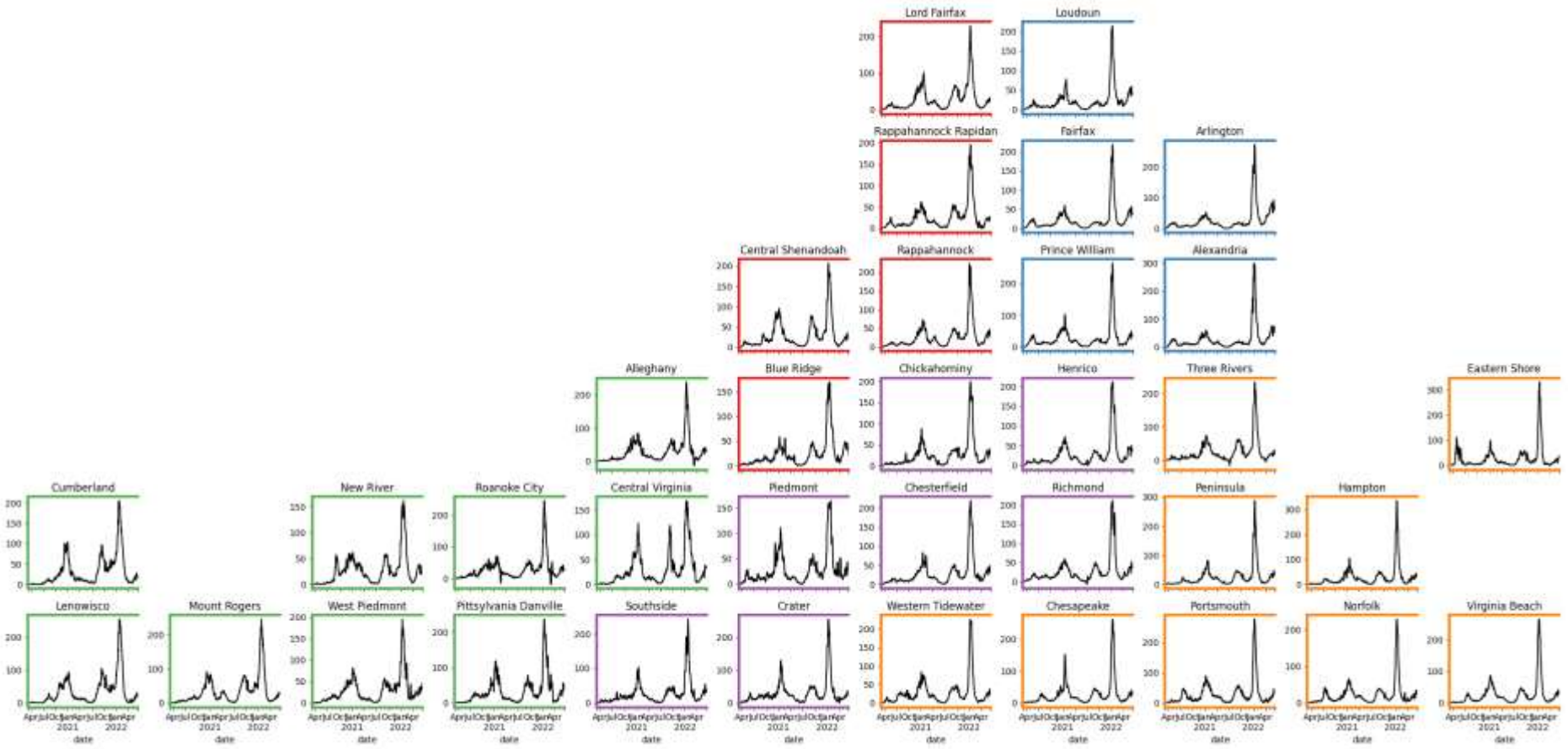
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

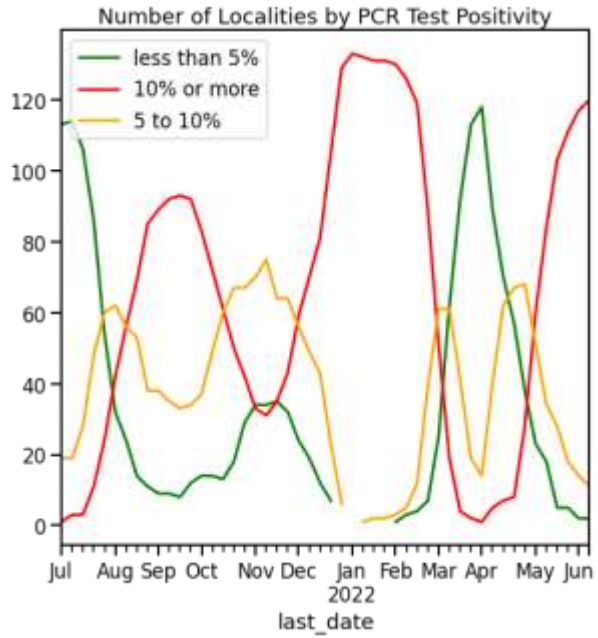
- **Case rates remain high but are slowly declining, hospitalizations remain flat**
- VA 7-day mean daily case rate slightly down to 34/100K from 35/100K
  - US has declined recently to 29/100K from 37/100K
  - VA hospital occupancy (rolling 7 day mean of 574) remains in a plateau steady, though may be entering a plateau
- Projections anticipate a plateau and declining rates near term with potential for growth due to BA4/5:
  - VA case rates have started a slow decline, though variant prevalences seem to be shifting
  - Rise in hospitalizations remain steady since the start of June
- Model updates:
  - Omicron subvariant BA.2.12.1 growth has stagnated, thus this scenario is now replaced by plain Adaptive which assumes no variant growth
  - More information about BA.4 and BA.5 have refined the next variant scenario, and seems likely to drive future dynamics
  - Hospitalization fitted models have been completed, may replace case-based models in the future

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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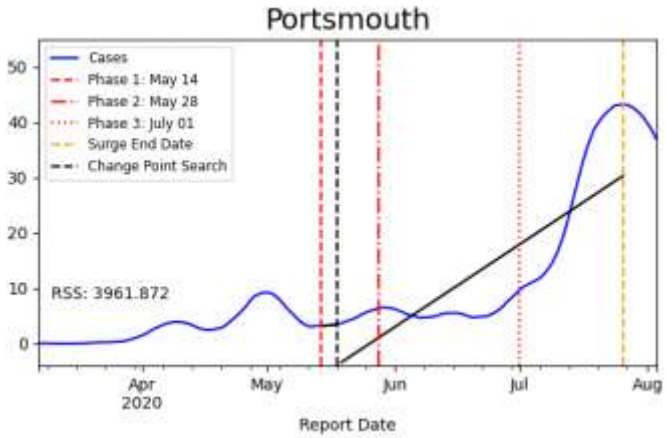
# District Trajectories

**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

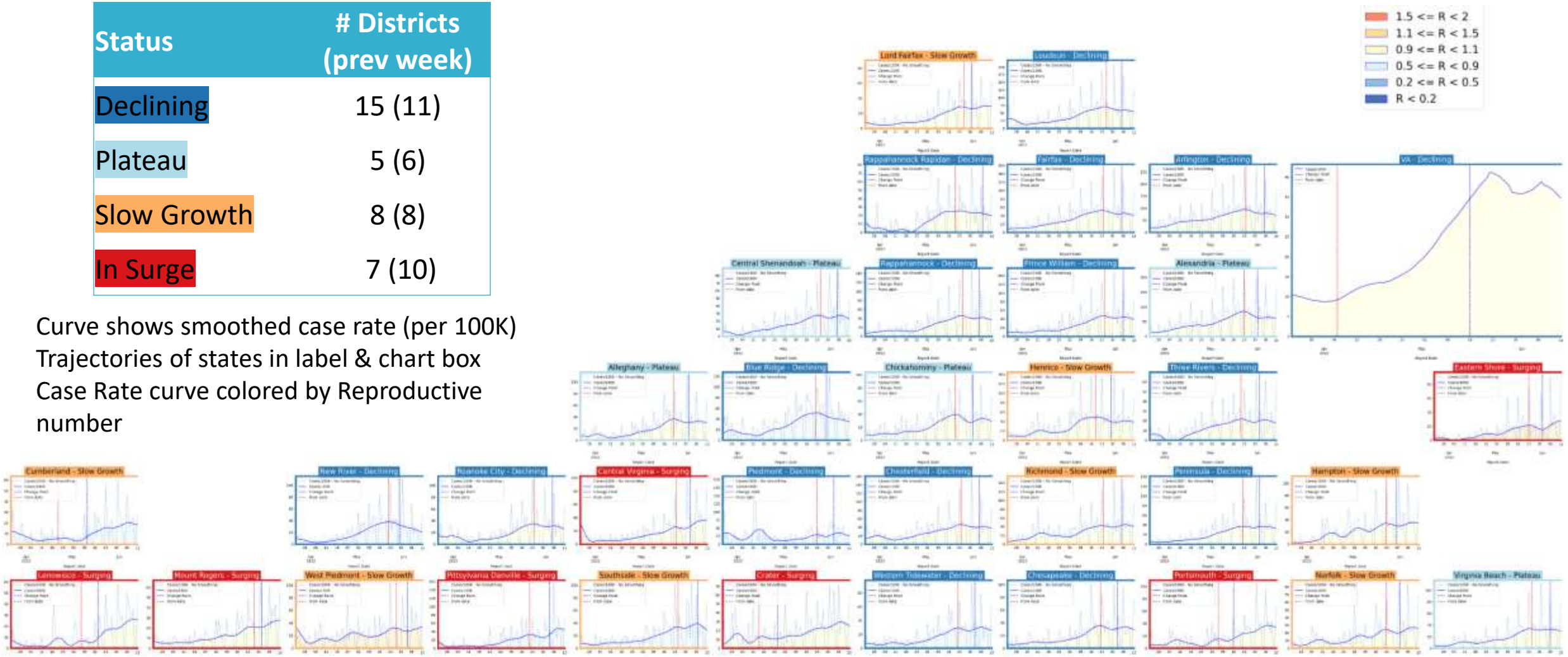



| Trajectory | Description | Weekly Case Rate (per 100K) bounds |
|---|---|---|
| **Declining** | Sustained decreases following a recent peak | below -0.9 |
| **Plateau** | Steady level with minimal trend up or down | above -0.9 and below 0.5 |
| **Slow Growth** | Sustained growth not rapid enough to 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 | 15 (11) |
| Plateau | 5 (6) |
| Slow Growth | 8 (8) |
| In Surge | 7 (10) |

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?

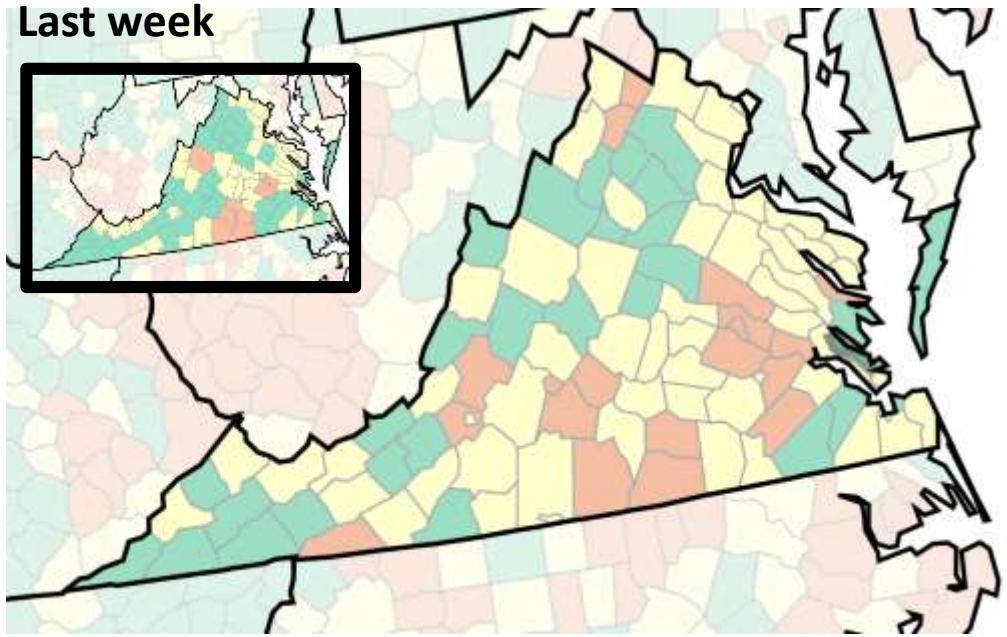
| Low | Medium | High |
|---|---|---|
| • Stay up to date with COVID-19 vaccines<br>• Get tested if you have symptoms | • If you are at high risk for severe illness, talk to your healthcare provider about whether you need to wear a mask and take other precautions<br>• Stay up to date with COVID-19 vaccines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




[CDC Data Tracker Portal]

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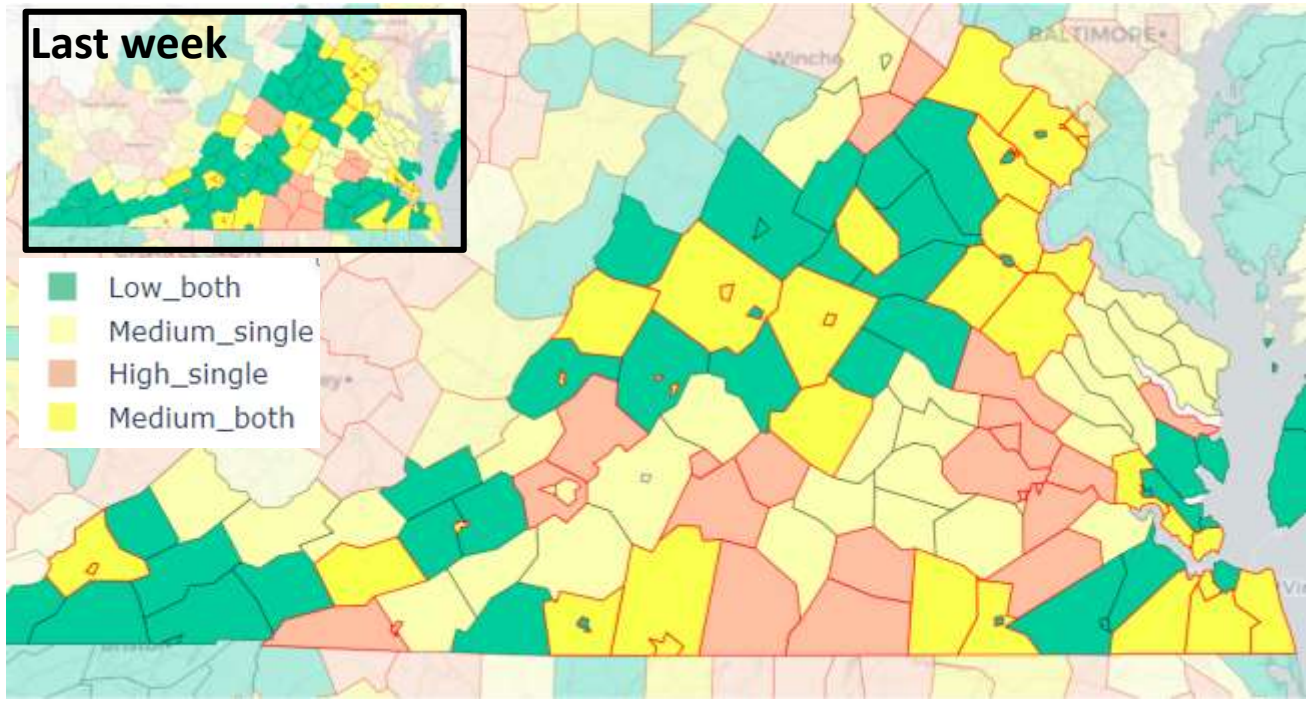
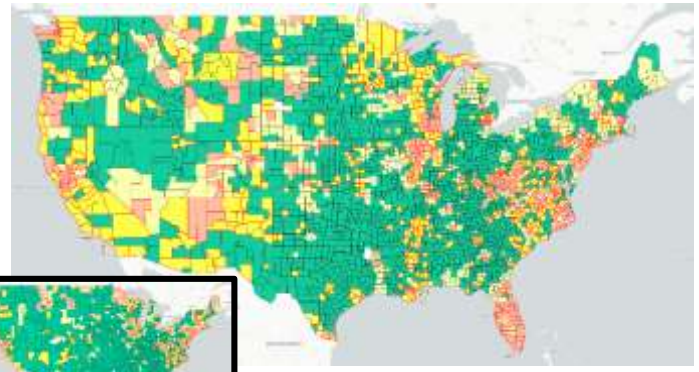
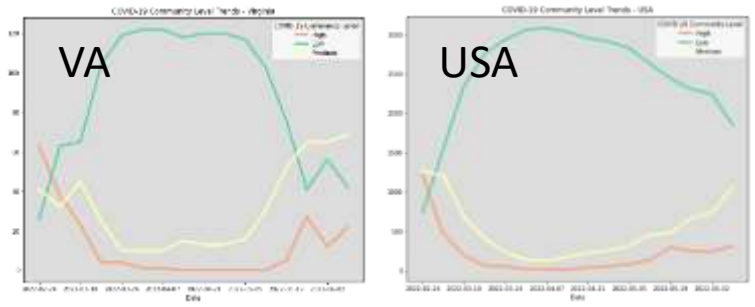
# CDC's new COVID-19 Community Levels





Last week




**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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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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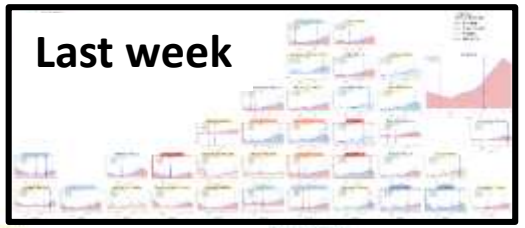
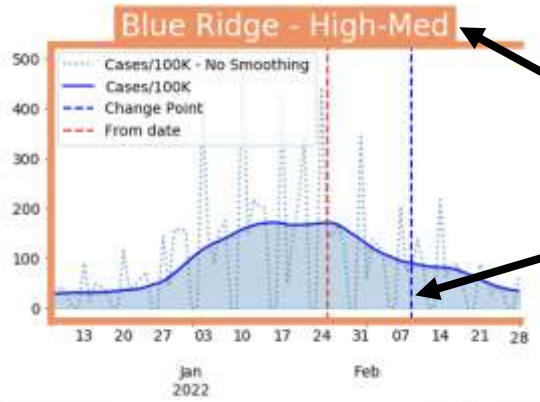
Data from: CDC Data Tracker Portal

# 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

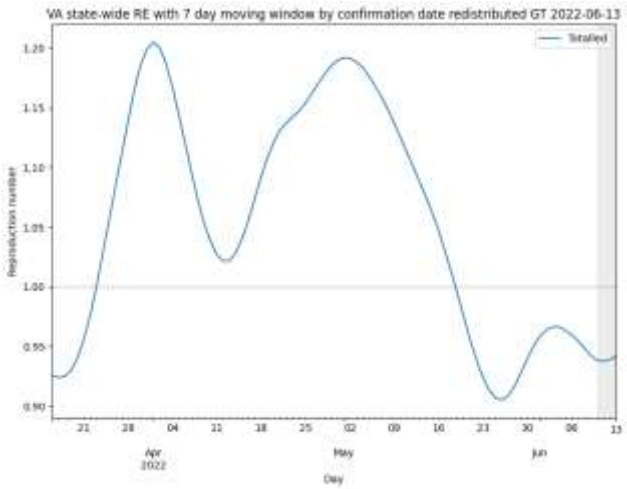

District's Aggregate Community Level
Aggregate level a simple mean of all levels for counties in district

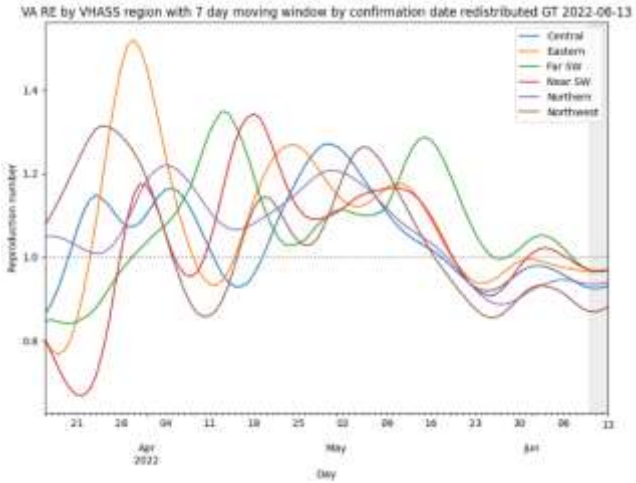
Case rate Trajectory

# Estimating Daily Reproductive Number – Redistributed gap

## June 13th Estimates

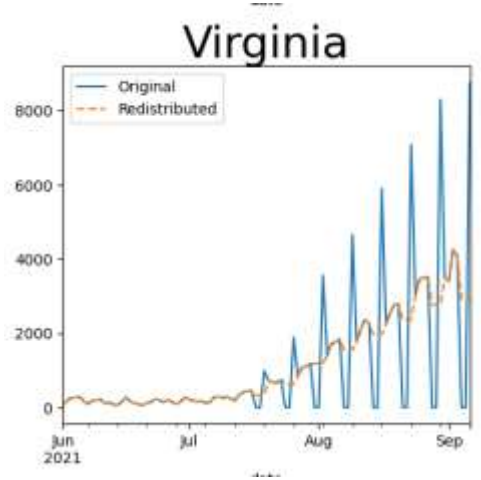
| Region | Date Confirmed $R_e$ | Date Confirmed Diff Last Week |
|---|---|---|
| State-wide | 0.942 | -0.036 |
| Central | 0.930 | -0.070 |
| Eastern | 0.966 | -0.050 |
| Far SW | 0.972 | -0.026 |
| Near SW | 0.965 | -0.049 |
| Northern | 0.940 | -0.010 |
| Northwest | 0.885 | -0.041 |




## Skipping Weekend Reports & holidays biases estimates

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




**Methodology**

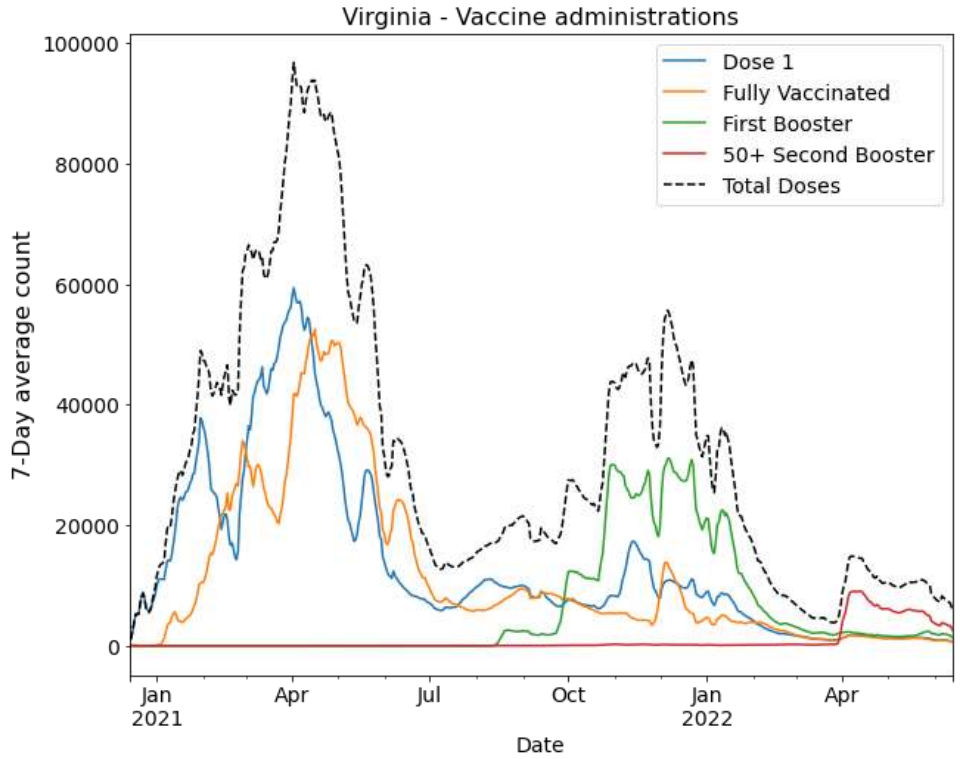
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill


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

# Mask Usage and Vaccination

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

- VA has rebounded slightly while US continues decline
- Vaccination has leveled off and has leveled off after a slight rise in early April, majority 2nd boosters

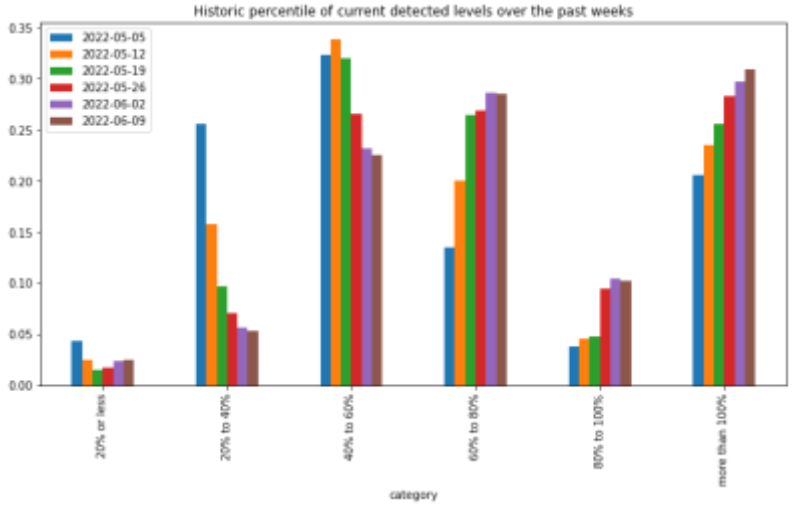

Data Source: [https://covidcast.cmu.edu](https://covidcast.cmu.edu)

# Wastewater Monitoring

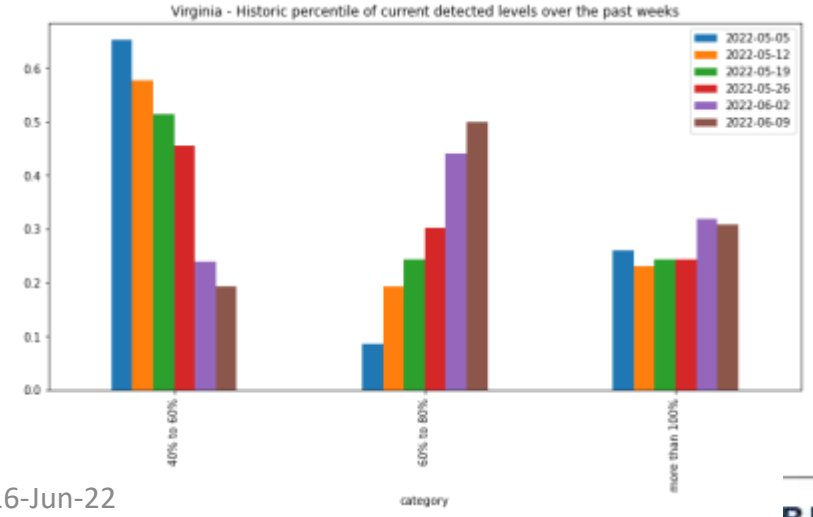
**Wastewater provides a coarse early warning of COVID-19 levels in communities**

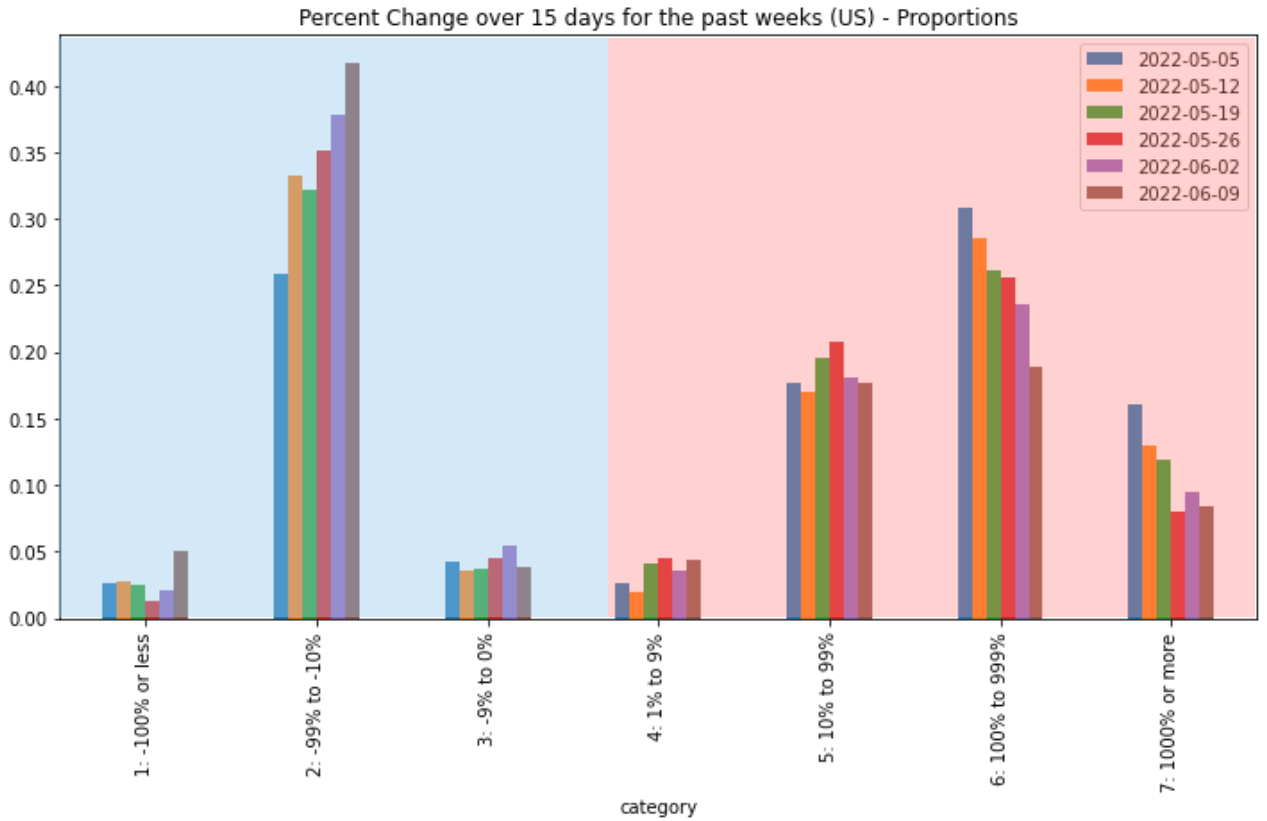
- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago
- Current virus levels are at or exceeding max of previous historical levels, has slowed, though more sites are entering upper quintiles

USA




VA




Data Source: [CDC Data Tracker]

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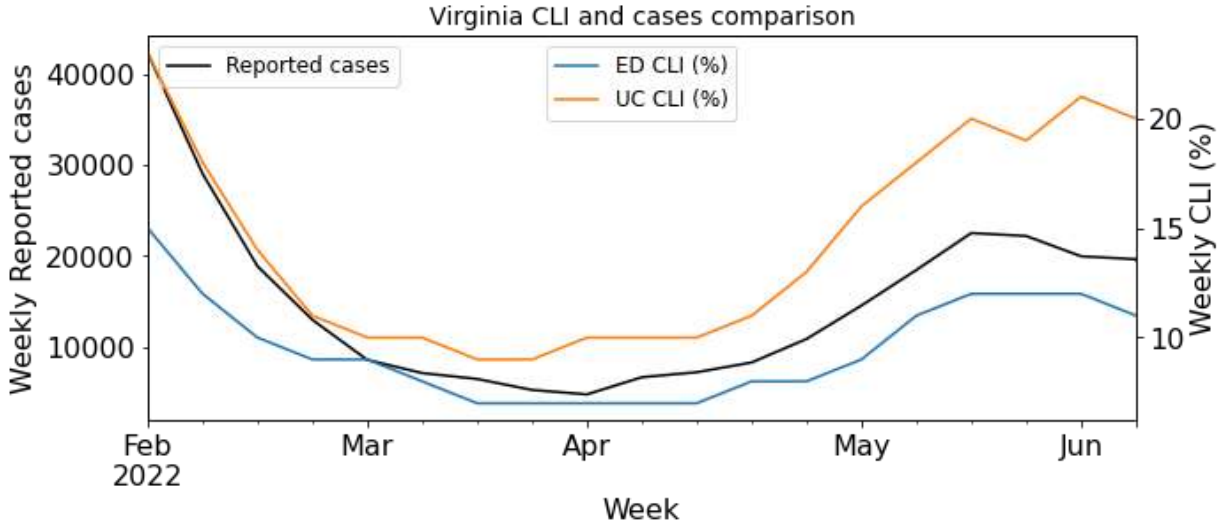
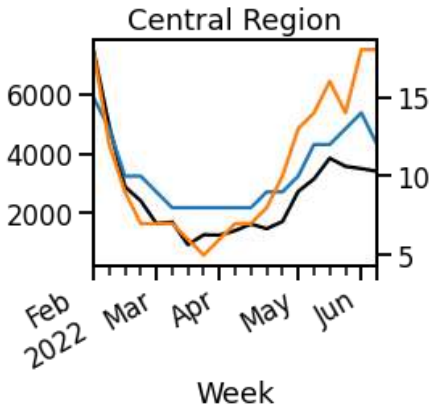
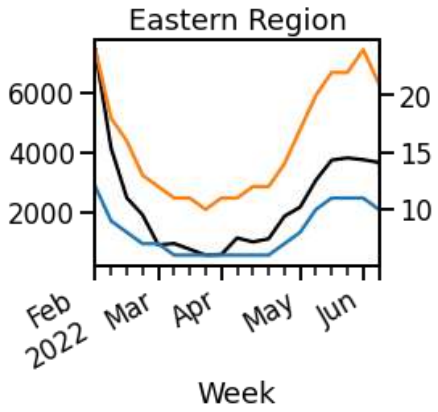
# COVID-like Illness Activity

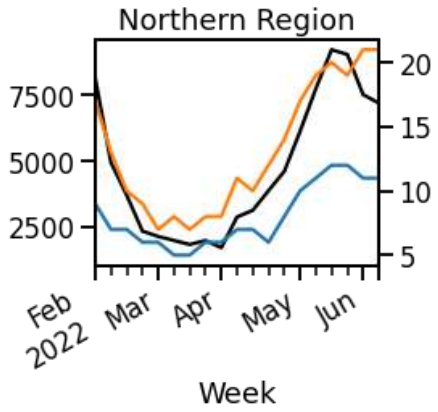
**COVID-like Illness (CLI) gives a measure of COVID transmission in the community**

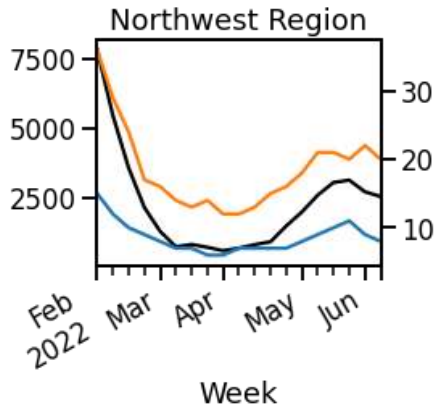
- Emergency Dept (ED) based CLI is more correlated with case reporting
- Urgent Care (UC) is a leading indicator but prone to some false positives
- **Current trends in UC CLI have plateaued for last four weeks state-wide, mixed by region**

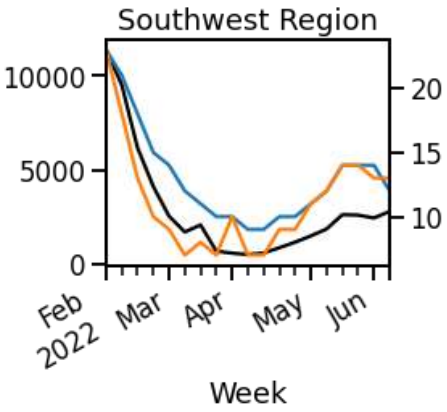
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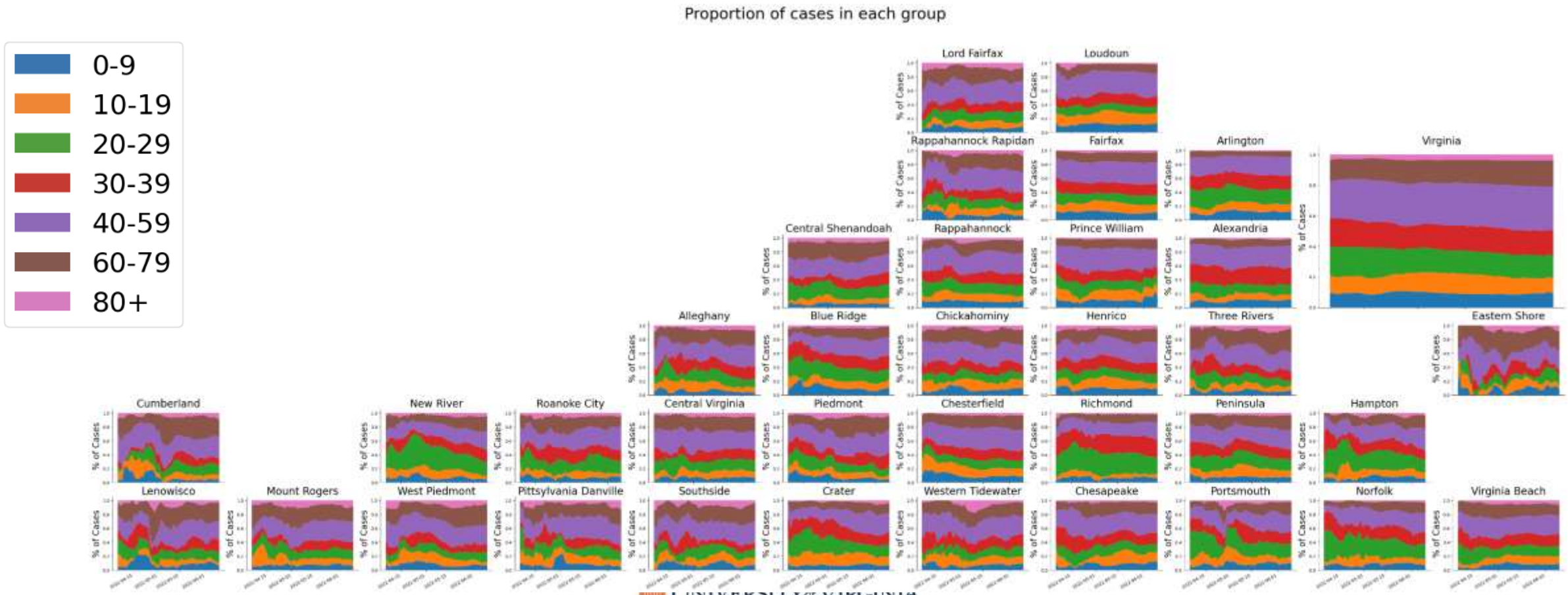
# Age-specific case rates across Virginia

**Normalized case-rates across age groups**

- Steady shift to older cases over the past couple months



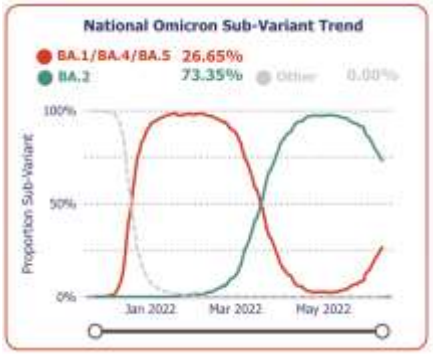
# SARS-CoV2 Variants of Concern

**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

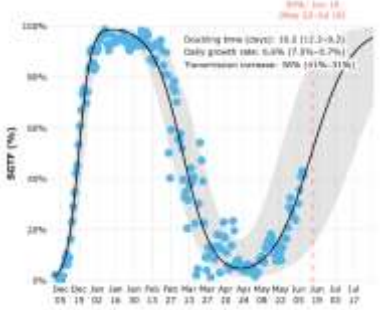
## Omicron Updates

- BA.2.12.1 growth has stagnated, remaining in the 65%-75% prevalence range for the last 4 weeks (Region 3)
- BA.4 growing rapidly, nowcasted at 8% (up from 7% last week)
- BA.5 also growing rapidly, nowcasted at 6% (up from 4% last week)
- BA.4 and BA.5 have same mutation as BA.1 that produces S-gene target failure, so can be tracked in more real time with SGTF from some PCR tests

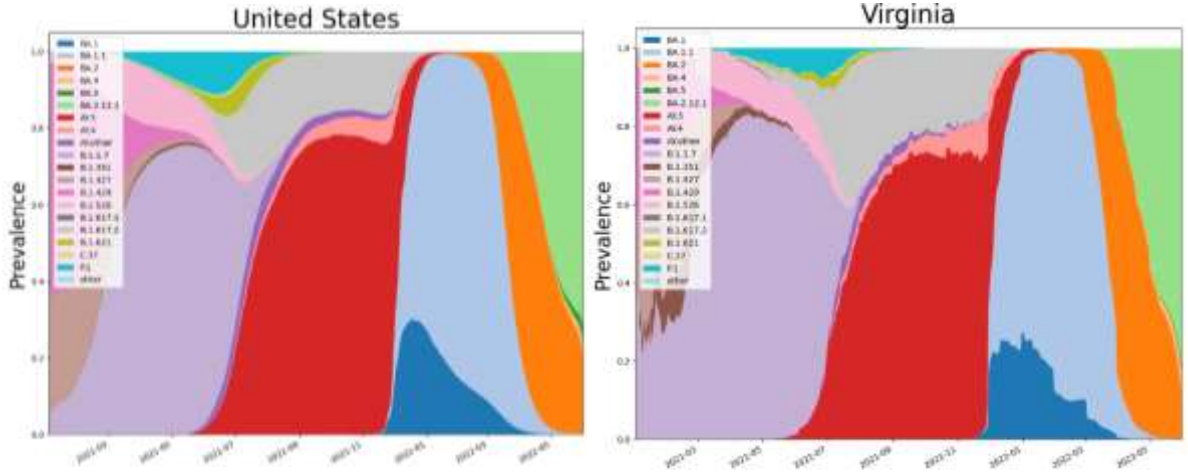


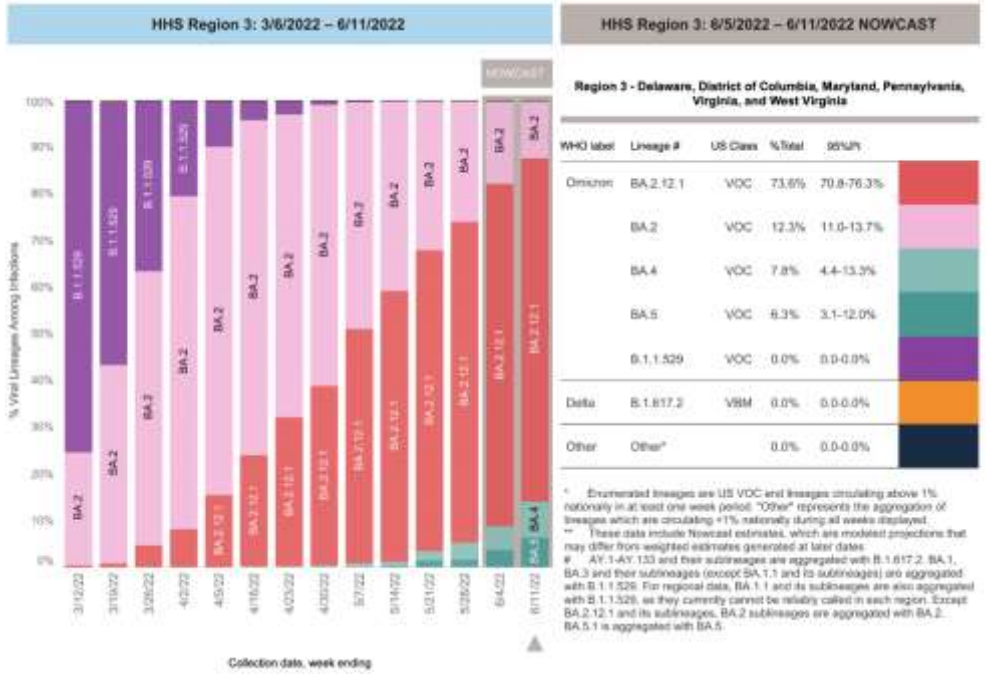

[Walgreens](#) detecting BA.4 / BA.5 in 27% of their typed samples

[SGTF in San Diego](#)




Estimated 50% on June 16th, sooner than last week (June 22nd) with wide bounds

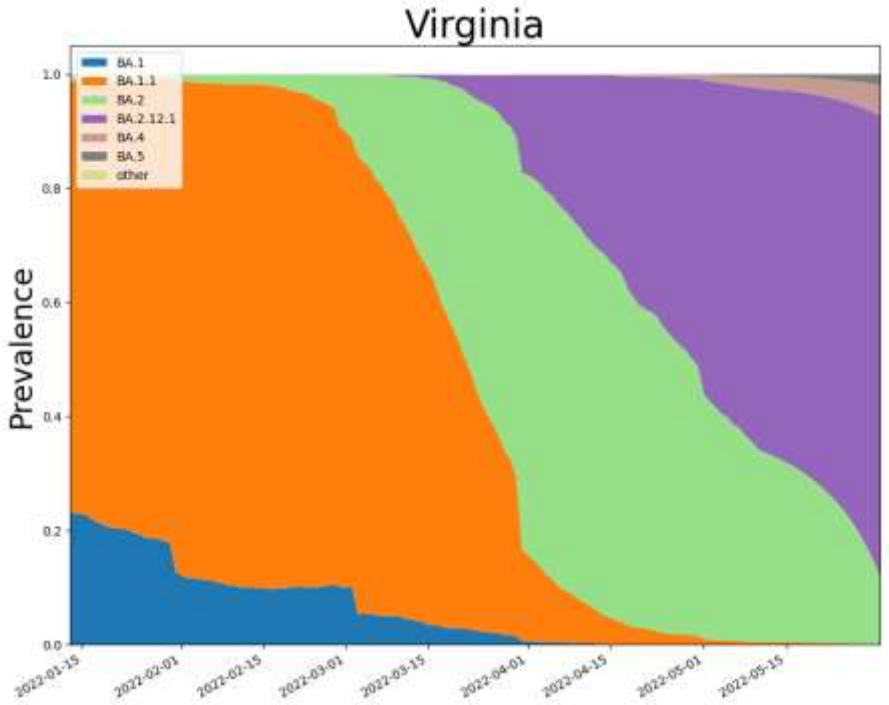


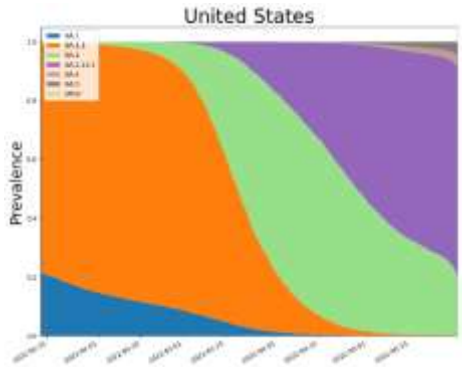




[CDC Variant Tracking](#)

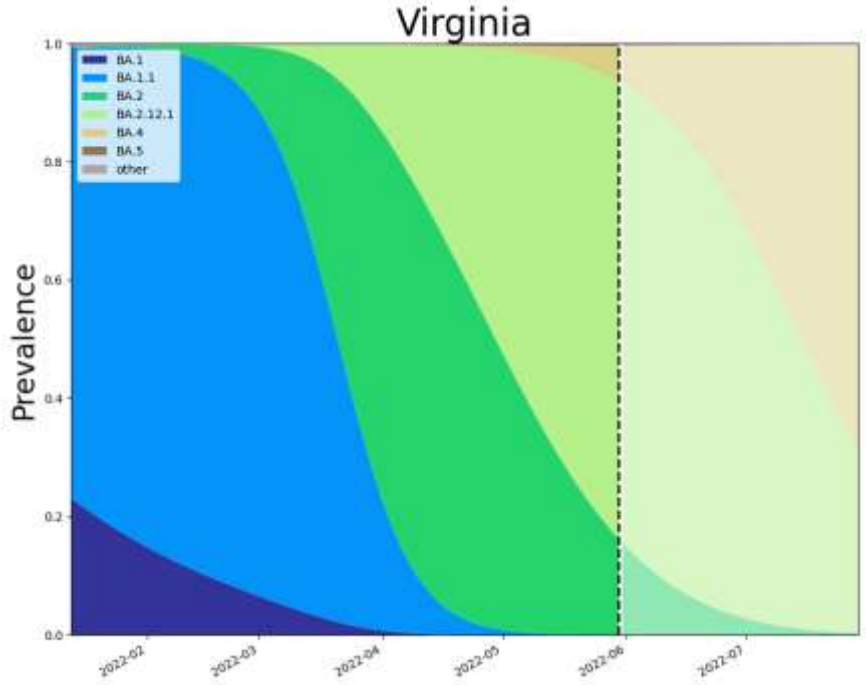
# SARS-CoV2 Omicron and Sub-Variants

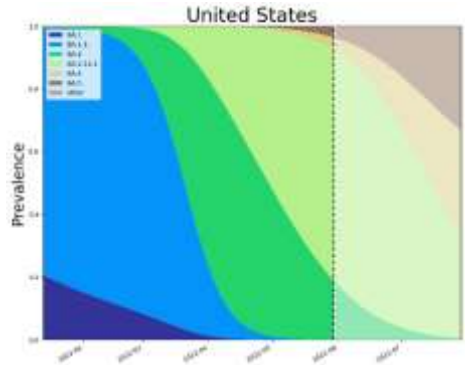
**As detected in whole Genomes in public repositories**




VoC Polynomial Fit Projections



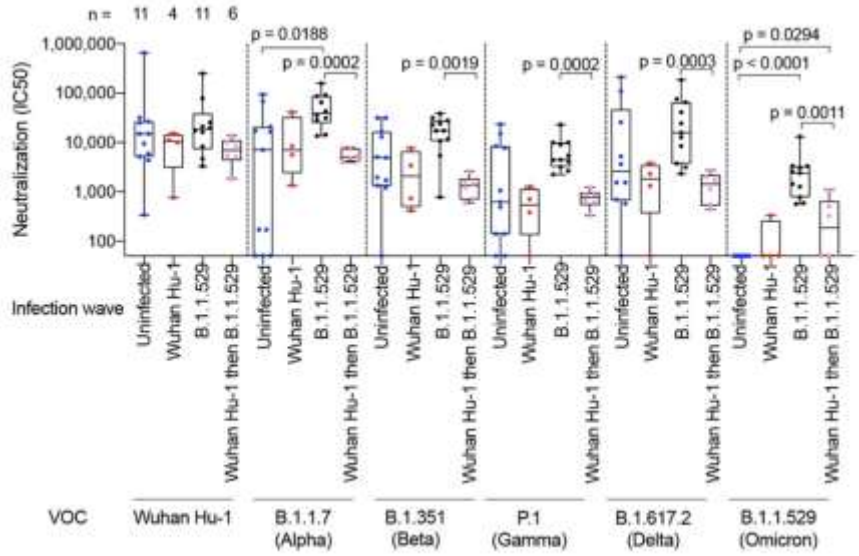




Note: Data lags force projections to start in past. Everything from dotted line forward is a projection.

# Pandemic Pubs

**1.** HCW who became infected during the B.1.1.529 wave showed enhanced immunity against earlier variants, but reduced nAb potency and T cell responses against B.1.1.529 itself.
**2.** T cells specific for SARS-CoV-2 elevated in blood of pulmonary PASC, associated with increased IL-6, a cytokine strongly associated with COVID-19 severity, and decreased lung function.
**3.** Cohort study of 7772 infants delivered during the COVID-19 pandemic, those born to the 222 mothers with a positive PCR test during pregnancy were more likely to receive a neurodevelopmental diagnosis in the first 12 months after delivery, even after accounting for preterm delivery.
**4.** Antigen test swabs are comparable to nasopharyngeal swabs for sequencing of SARS-CoV-2

1

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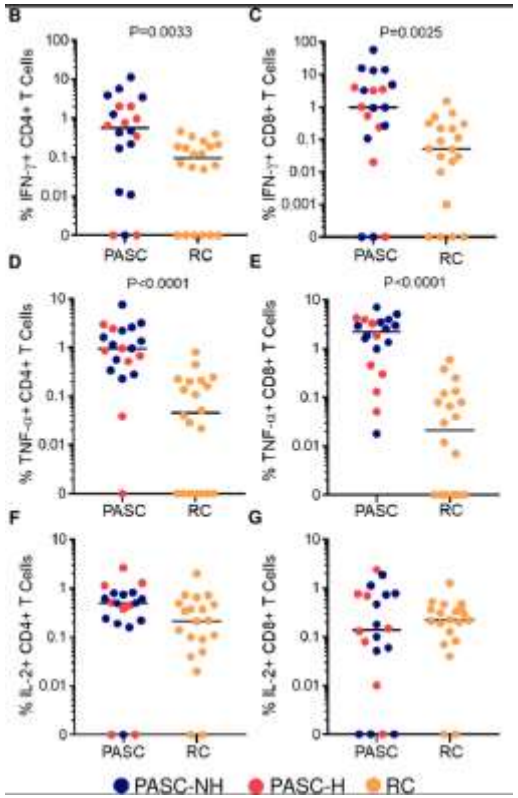
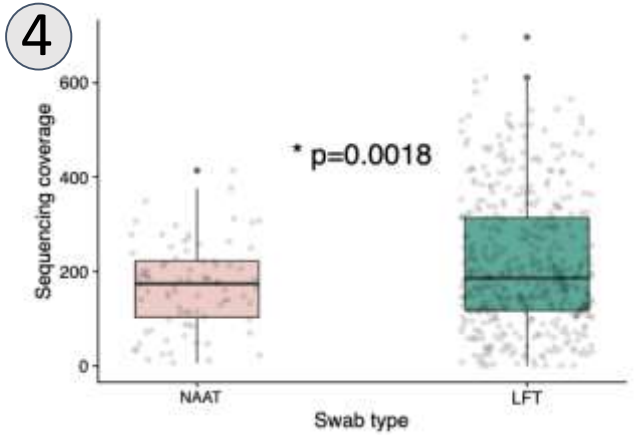



**Ab immunity in triple-vaccinated HCW following infection during the B.1.1.529 (Omicron) wave.** Analysis of a cohort of London healthcare workers with heterogeneous, immune-imprinted repertoires derived from their distinctive histories of infection and vaccination. Concerningly, the authors suggest that "(Omicron) infections and reinfections likely reflects considerable subversion of immune recognition at both the B, T cell, antibody binding and nAb level, although with considerable differential modulation through immune imprinting."
https://www.science.org/doi/10.1126/science.abq1841

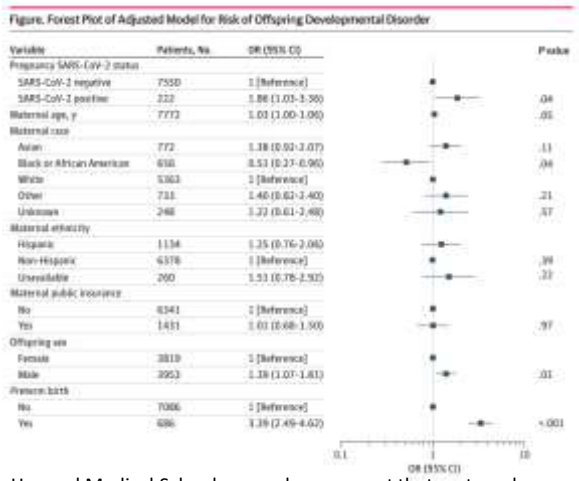
Researchers at University of Colorado found that individuals with pulmonary symptoms associated with Long Covid were more likely to have elevated SARS-CoV-2-specific CD4+ and CD8+ T cells in peripheral blood. Indicate pulmonary PASC may be, in part, driven by the production of inflammatory cytokines by SARS-CoV-2-specific T cells. Pulmonary complications include tussis, dyspnea, fatigue, exercise intolerance and hypoxia
https://journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1010359

4




Authors compare the results of RT-qPCR and viral genome sequencing using samples from positive BinaxNOW™ COVID-19 Antigen Card swabs (N=555) to those obtained from previously collected nasopharyngeal (NP) swabs used for nucleic acid amplification testing (N=135). They show that swabs obtained from antigen cards are comparable in performance to clinical excess samples from NP swabs
https://www.medrxiv.org/content/10.1101/2022.06.09.22276150v1

3

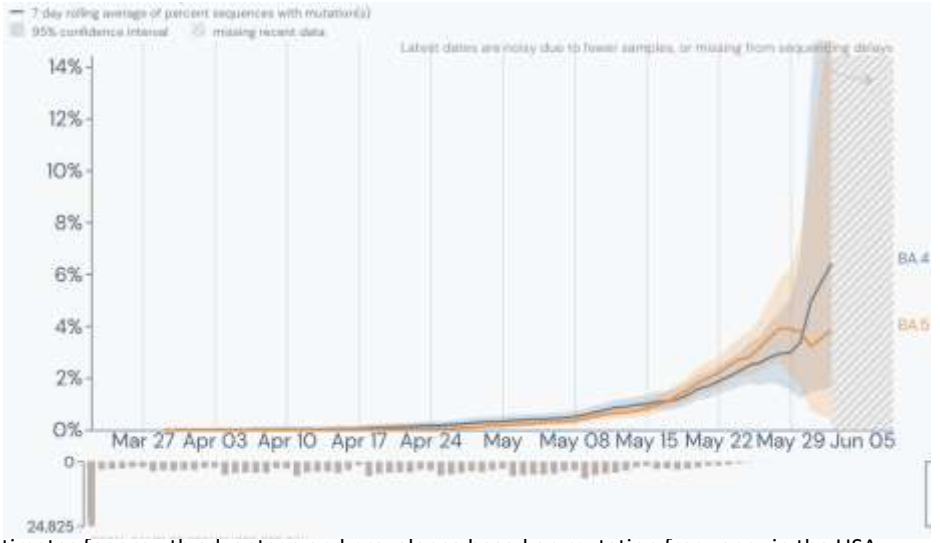



Harvard Medical School researchers suggest that maternal immune activation during pregnancy may be associated with neurodevelopmental effects in offspring.
https://www.biorxiv.org/content/10.1101/2022.05.25.493397v1

# Pandemic Pubs (last week)

**1.** Observed across multiple countries the immune escape variants show growth advantage over BA.2.12.1
**2.** UKHSA characterizes immune escape potential of BA.4/BA.5 based on prior immunity.
**3.**Twin Cities wastewater analysis reveals increasing prevalence of BA.4 and BA.5 mutations, peak in viral copies, and subsequent potential levelling off.
https://twitter.com/dhmontgomery/status/1534207458104578048

1




Estimates for growth advantage and prevalence based on mutation frequency in the USA
https://cov-spectrum.org/
https://twitter.com/RajlabN/status/1534241350727651330
https://twitter.com/corneliusroemer/status/1534314001122861057

BA.4

BA.5

https://outbreak.info/location-reports?loc=USA&pango=BA.4&pango=BA.5&dark=true&selected=BA.4&selected=BA.5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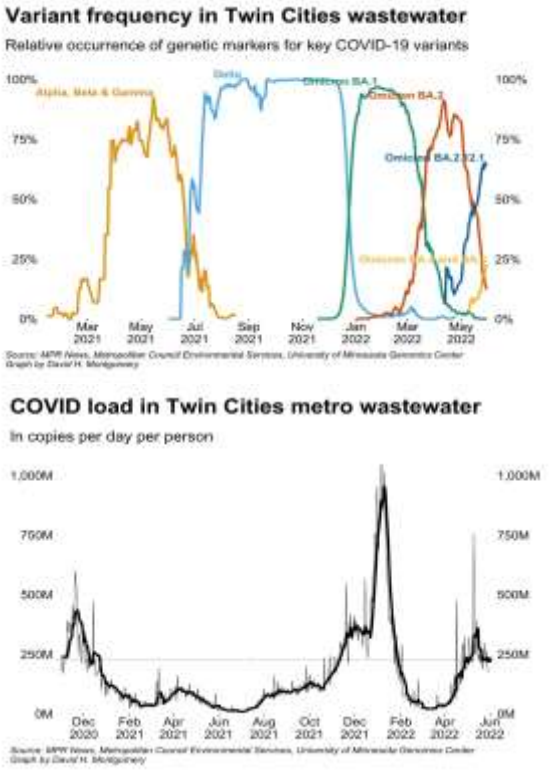


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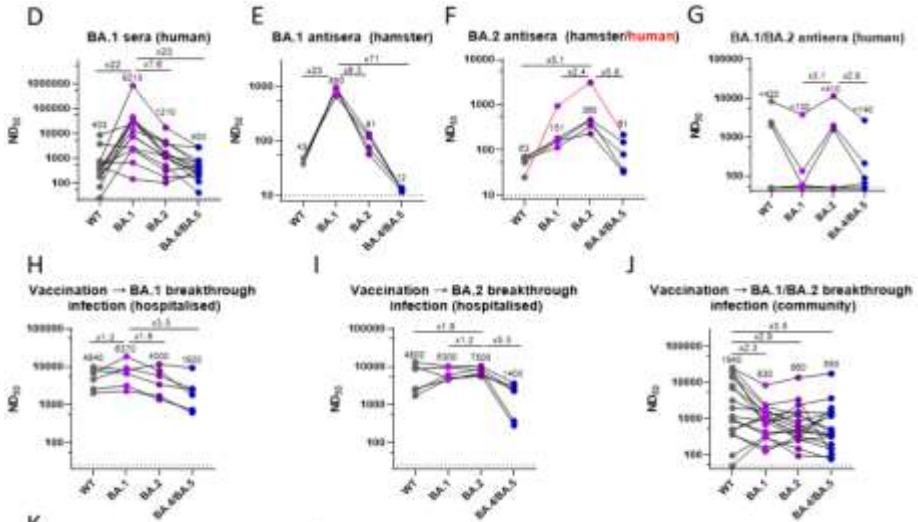
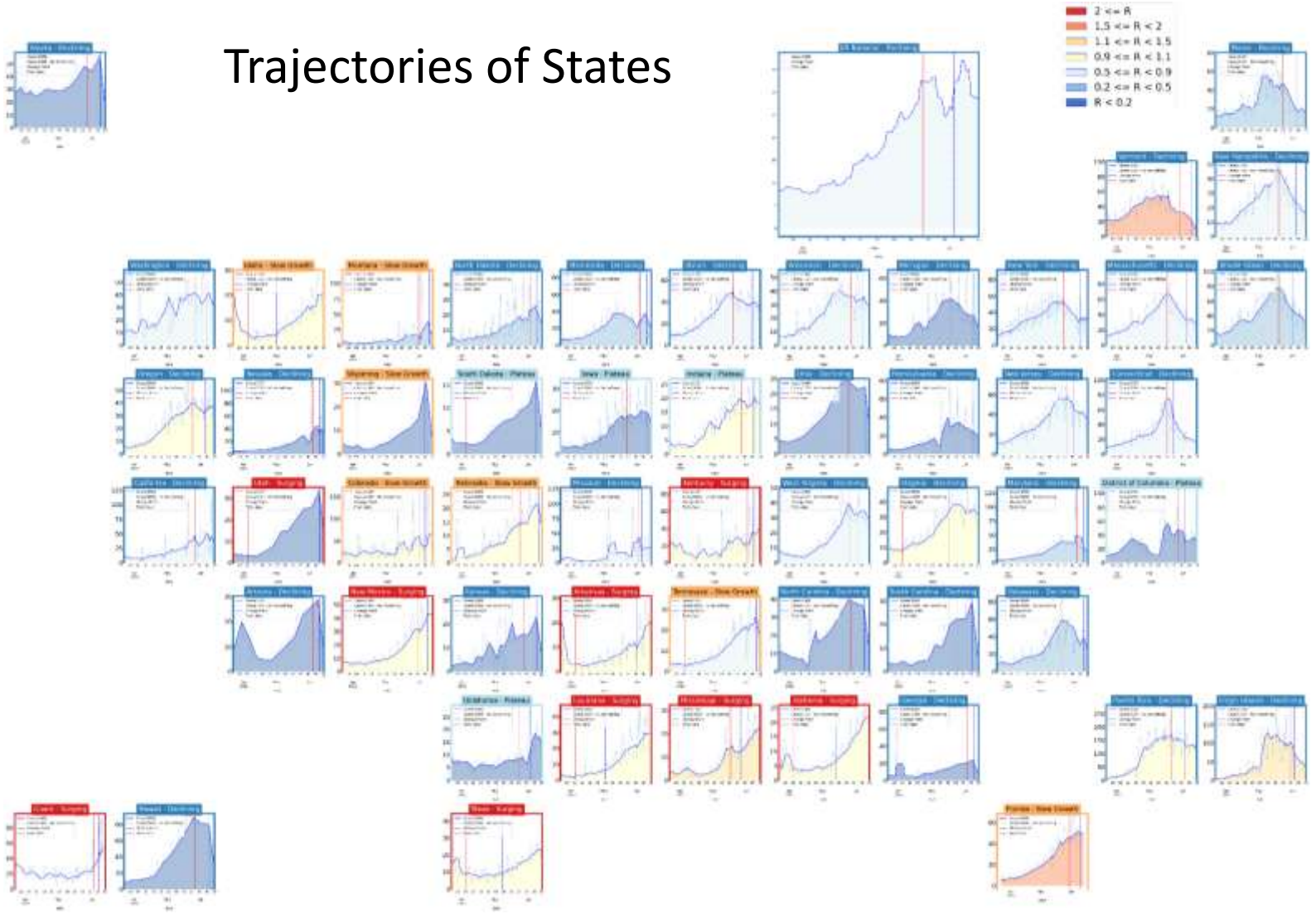



"Sera collected post-vaccination have a similar ability to neutralise BA.1, BA.2 and BA.4/BA.5. In contrast, in the absence of vaccination, prior infection with BA.2 or, in particular, BA.1 results in an antibody response that neutralises BA.4/BA.5 poorly. Breakthrough infection with Omicron in vaccinees leads to a broad neutralising response against the new variants. The sensitivity of BA.4/BA.5 to neutralisation by therapeutic monoclonal antibodies was similar to that of BA.2."
https://www.biorxiv.org/content/10.1101/2022.05.25.493397v1

# United States Case Rates

- Rebounding activity, mainly in the Northeast

| Status | # States |
|---|---|
| Declining | 26 (31) |
| Plateau | 4 (9) |
| Slow Growth | 11 (6) |
| In Surge | 13 (8) |

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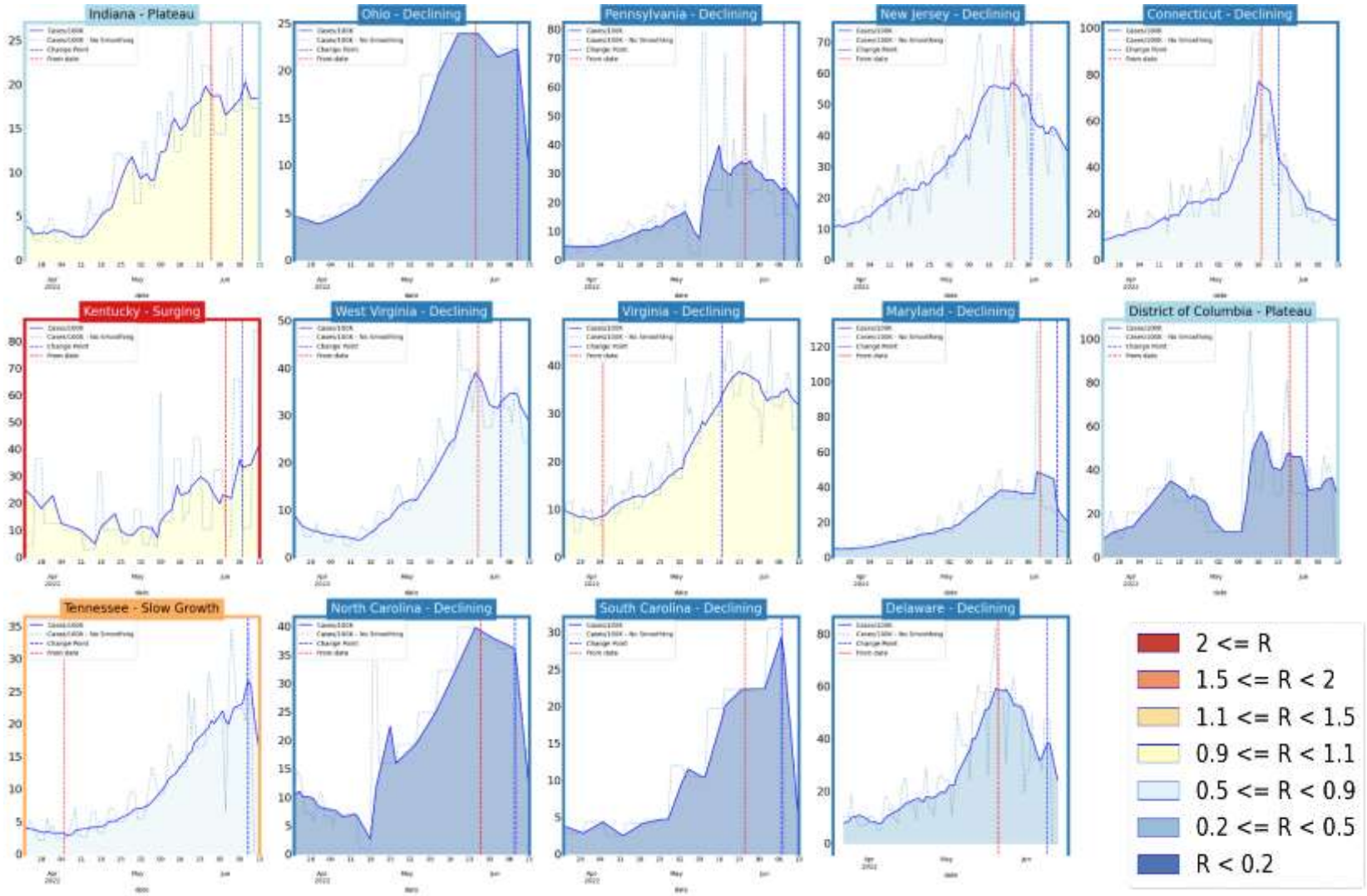
# Virginia and Her Neighbors

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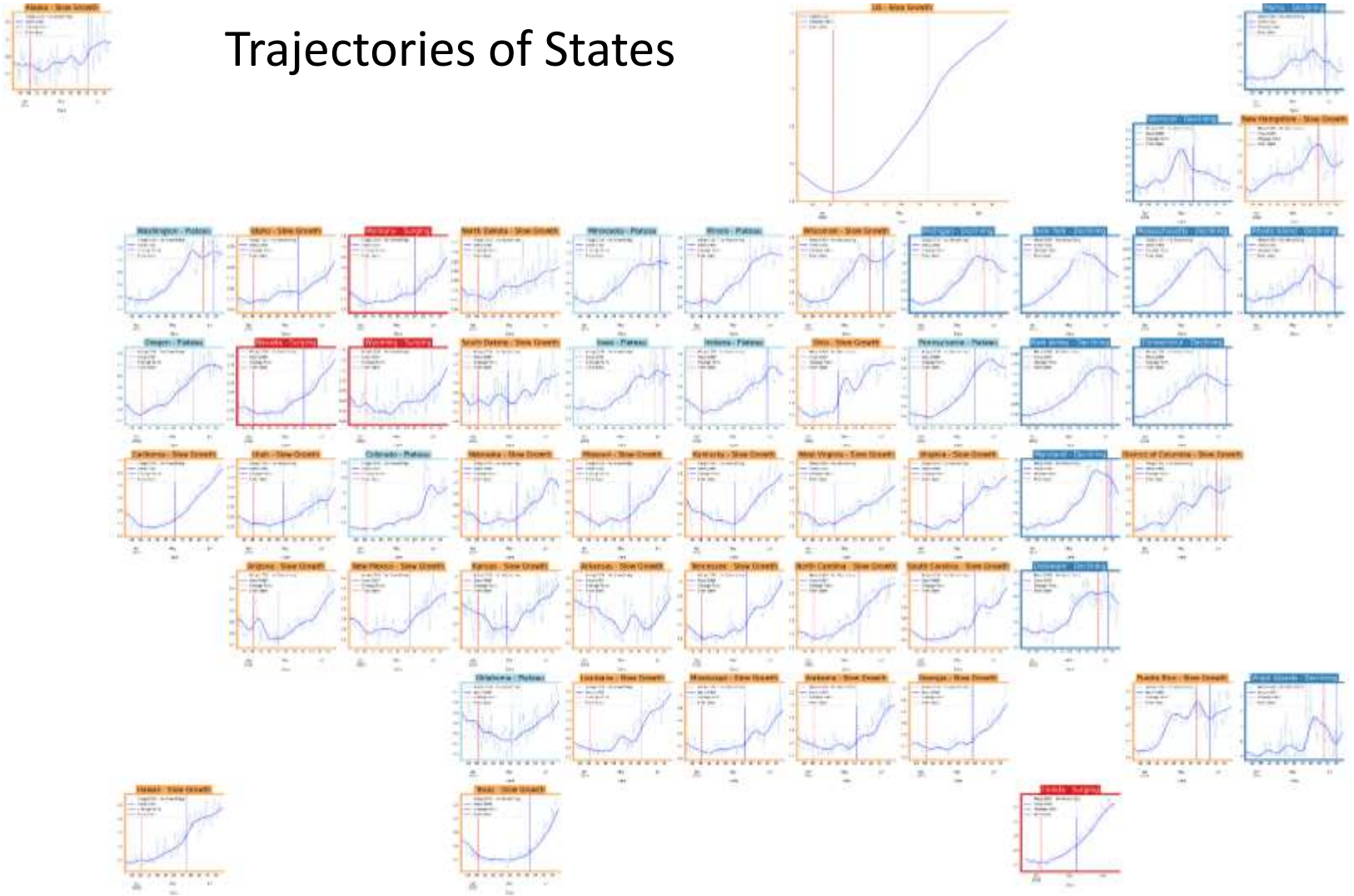
# United States Hospitalizations

- Hospital admissions are lagging case rates, and have mainly entered plateaus
- Rebounds in the Northeast seen with some rising hospitalization rates

| Status | # States |
|---|---|
| Declining | 11 (8) |
| Plateau | 9 (12) |
| Slow Growth | 29 (28) |
| In Surge | 4 (5) |

Trajectories of States



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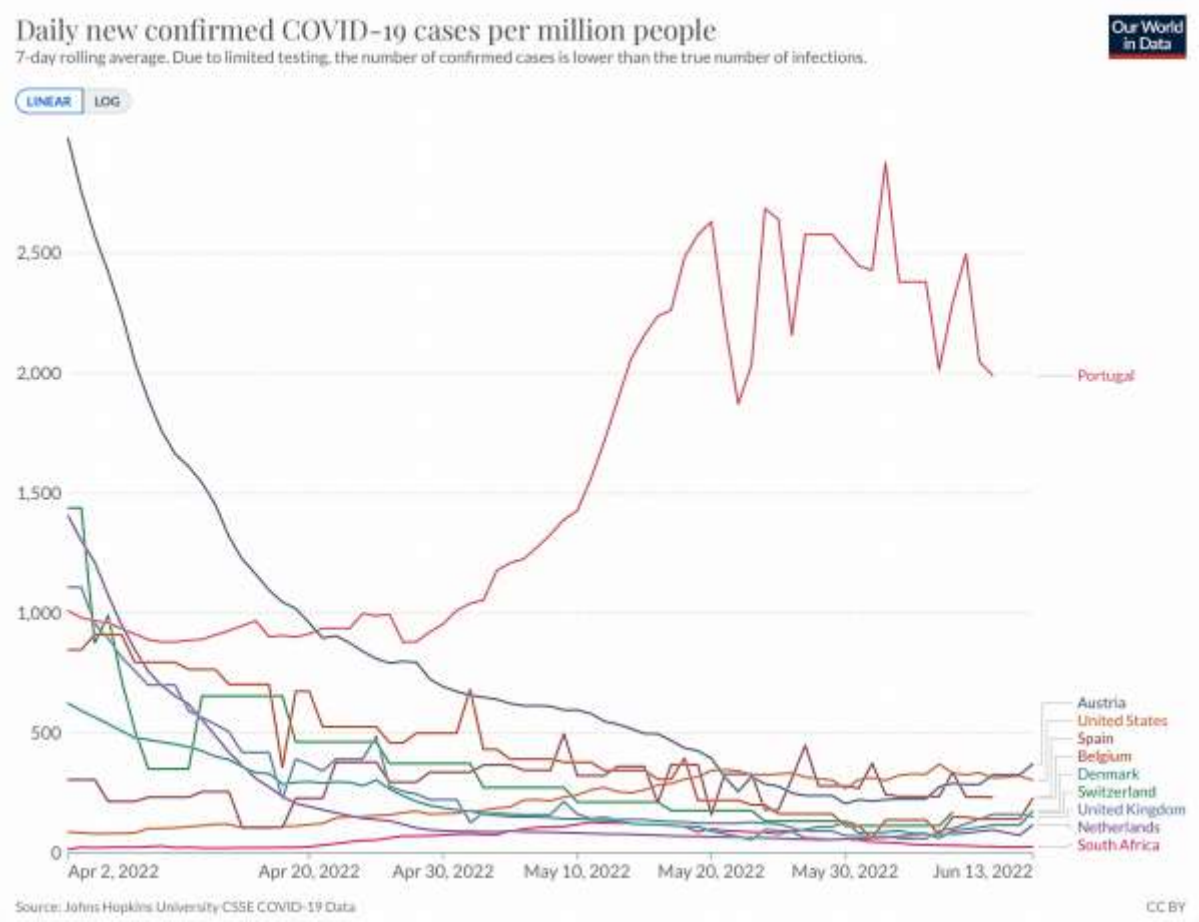
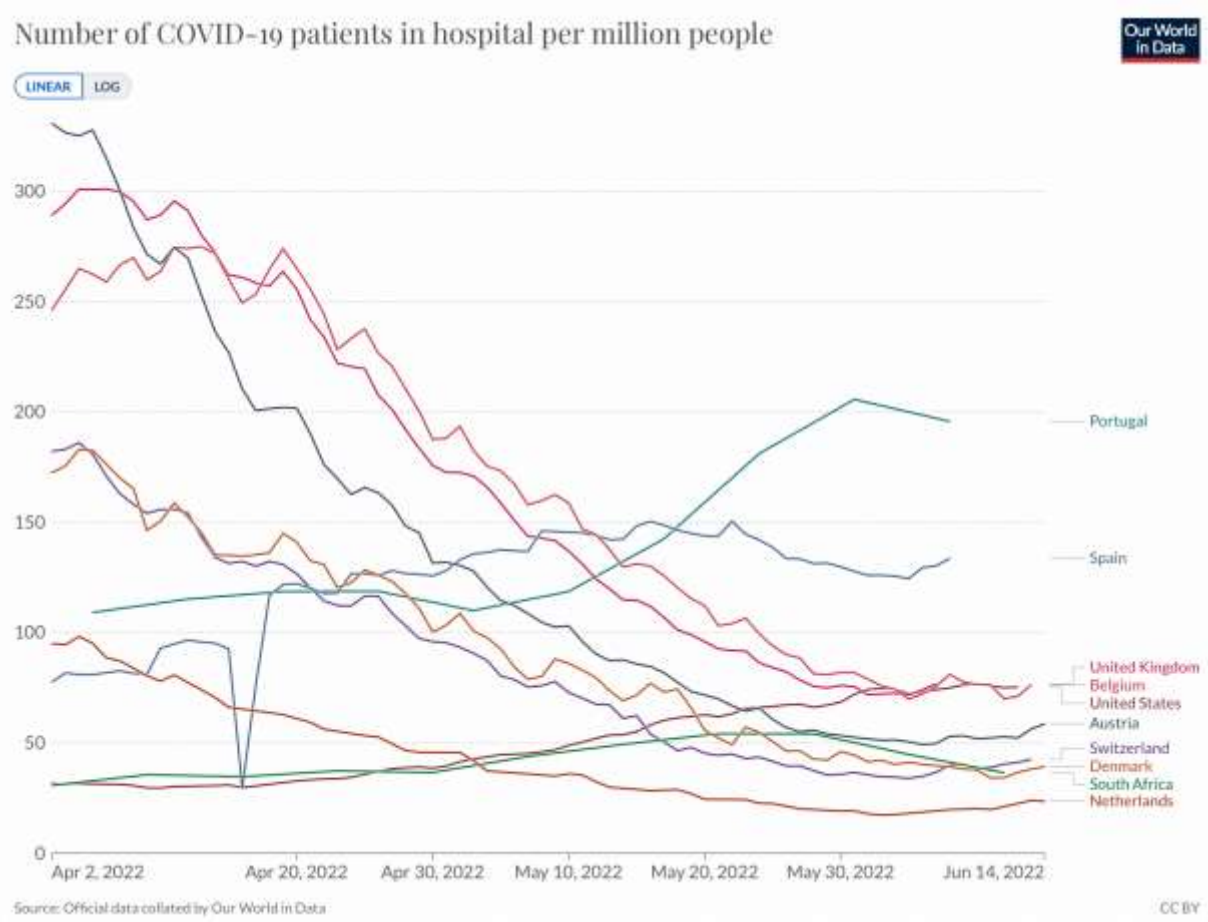
# Around the World – BA.4 and BA.5 impacted countries

## Confirmed cases

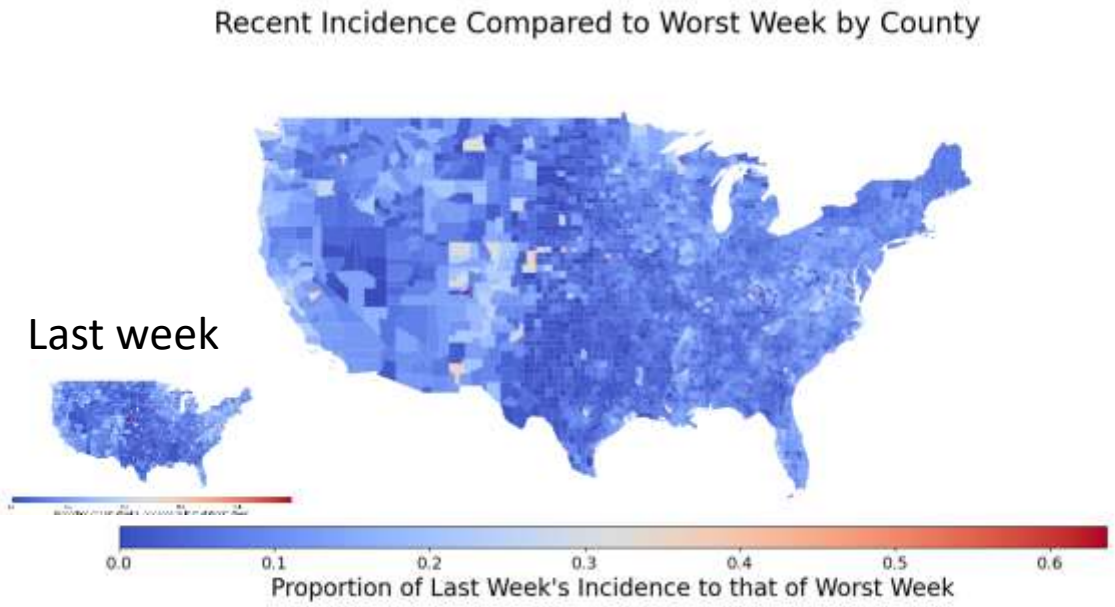


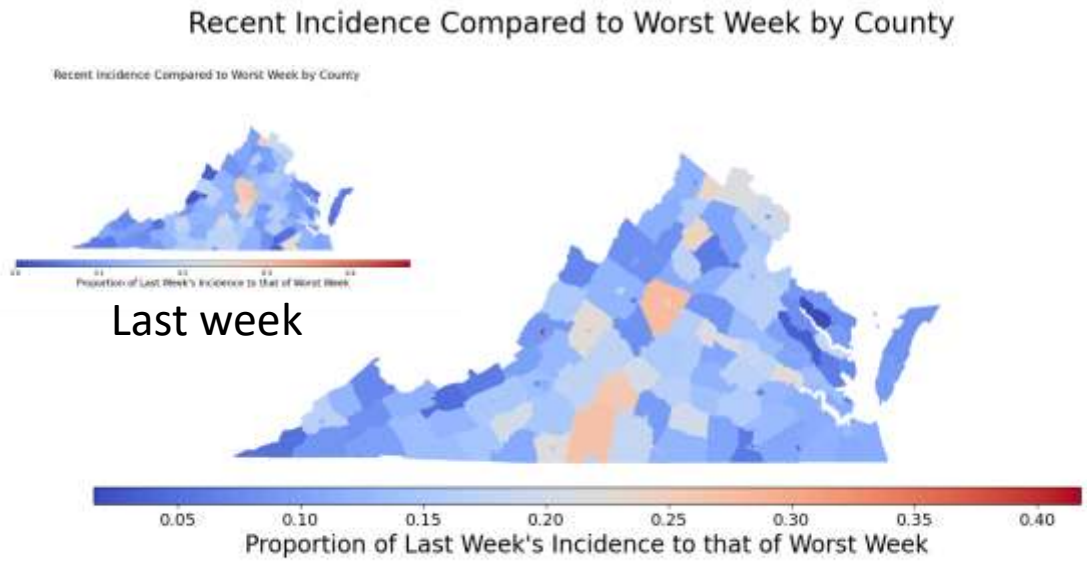

## Hospitalizations



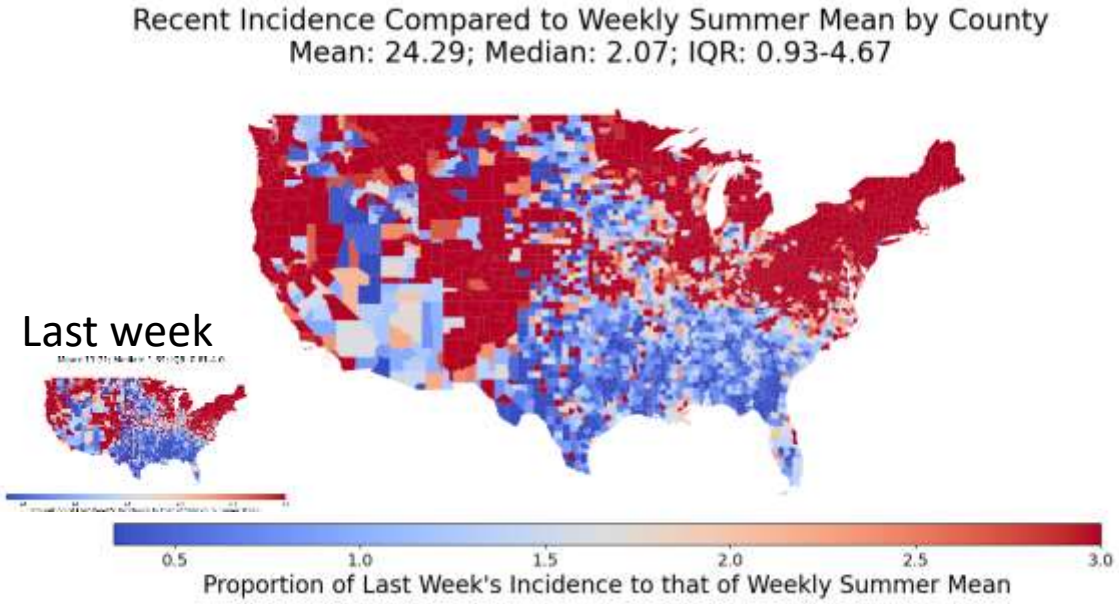

[Our World in Data]

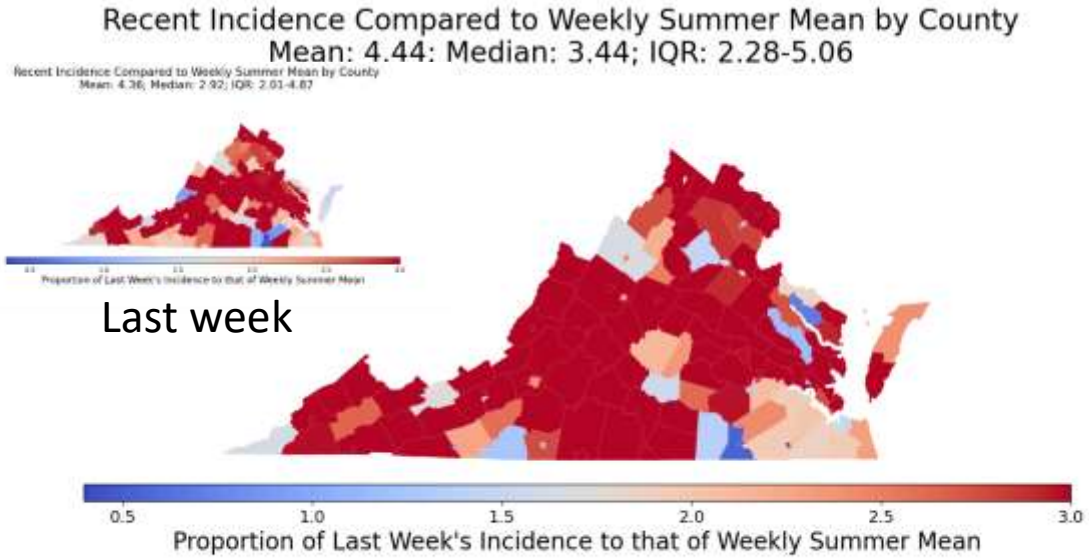
# County-level comparison to previous highest peak



# County-level comparison to last Summer



# Zip code level weekly Case Rate (per 100K)

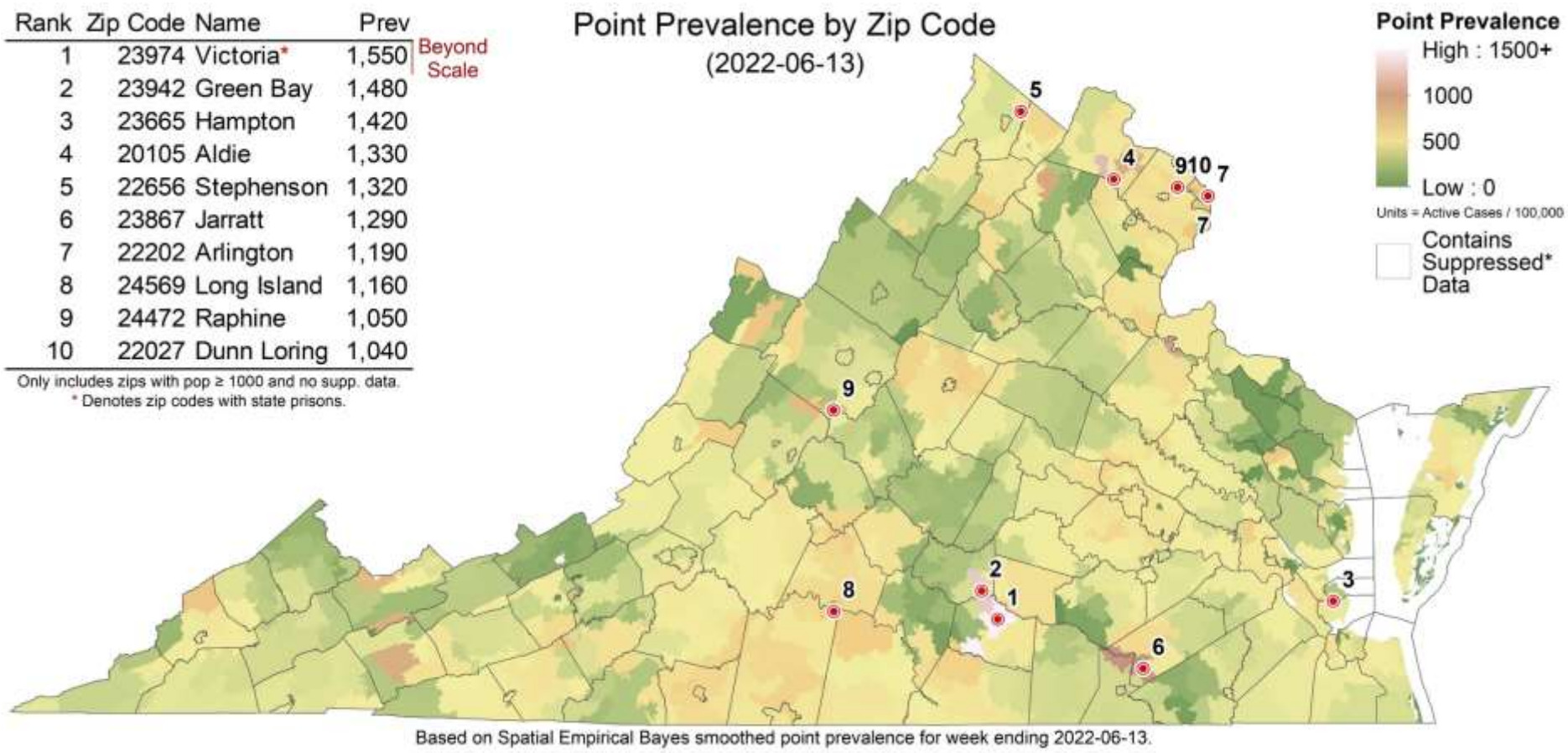
**Case Rates in the last week by zip code**

- Some counts are low and suppressed to protect anonymity, those are shown in white

| Rank | Zip Code | Name | Prev |
|---|---|---|---|
| 1 | 23974 | Victoria* | 1,550 |
| 2 | 23942 | Green Bay | 1,480 |
| 3 | 23665 | Hampton | 1,420 |
| 4 | 20105 | Aldie | 1,330 |
| 5 | 22656 | Stephenson | 1,320 |
| 6 | 23867 | Jarratt | 1,290 |
| 7 | 22202 | Arlington | 1,190 |
| 8 | 24569 | Long Island | 1,160 |
| 9 | 24472 | Raphine | 1,050 |
| 10 | 22027 | Dunn Loring | 1,040 |

Beyond Scale

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

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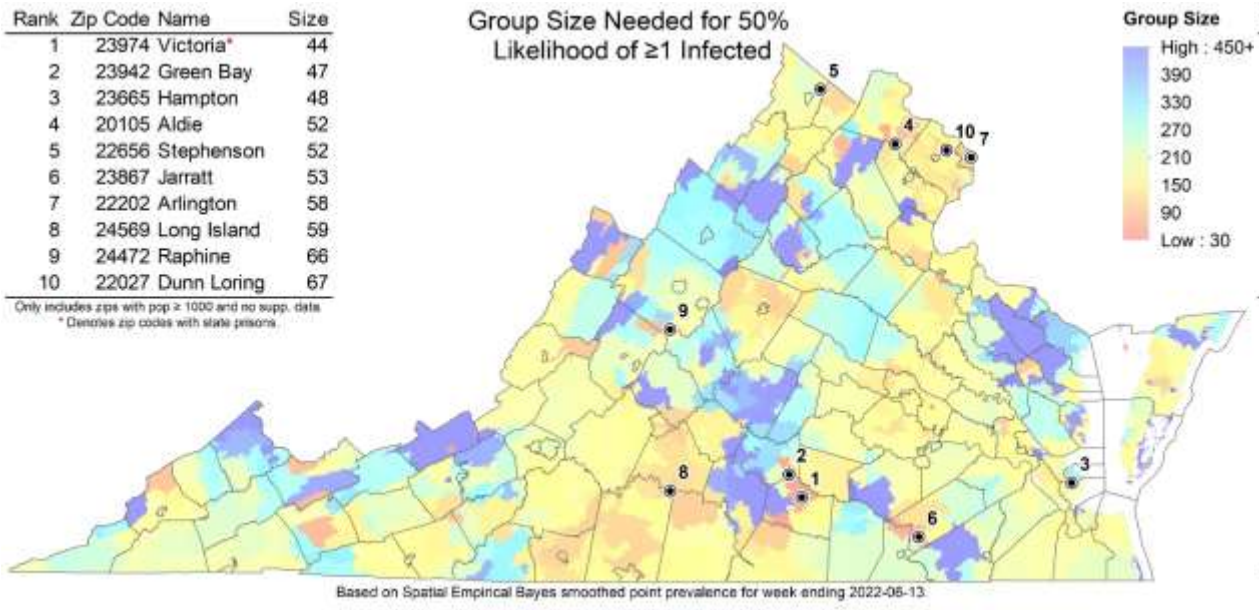
# Risk of Exposure by Group Size and HCW prevalence

**Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people (group size 25)**

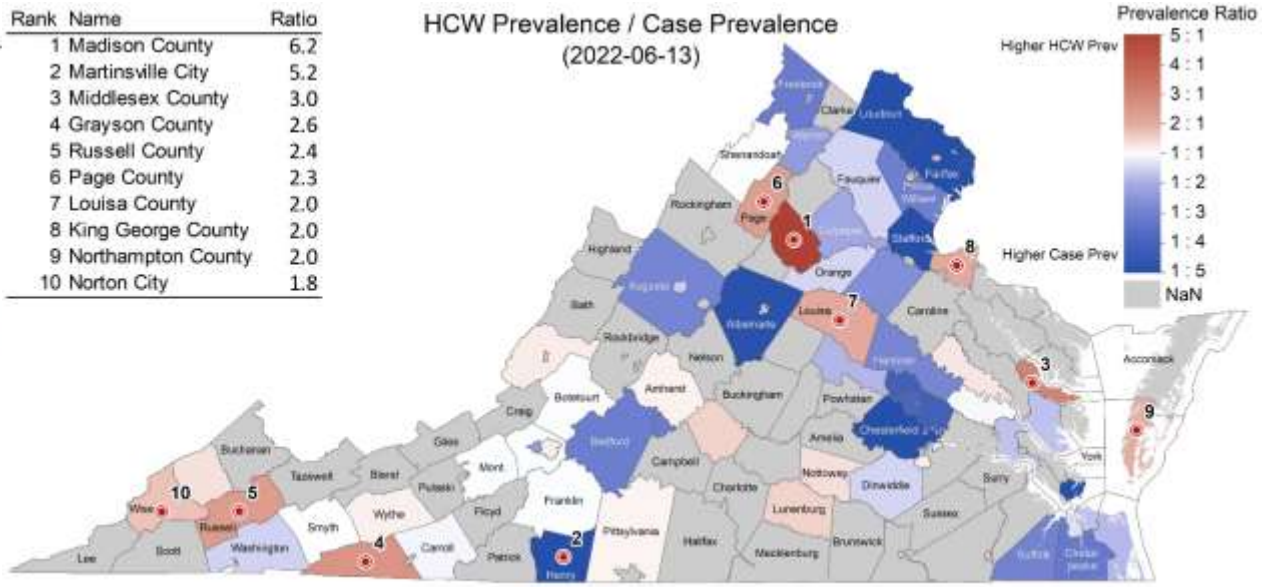
- **Group Size**: Assumes 2 undetected infections per confirmed case (ascertainment rate from recent seroprevalence survey), and shows minimum size of a group with a 50% chance an individual is infected by zip code (eg in a group of 43 in Dillwyn, there is a 50% chance someone will be infected)
- **HCW ratio**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator / general population's case prevalence

| Rank | Zip Code | Name | Size |
|---|---|---|---|
| 1 | 23974 | Victoria* | 44 |
| 2 | 23942 | Green Bay | 47 |
| 3 | 23665 | Hampton | 48 |
| 4 | 20105 | Aldie | 52 |
| 5 | 22656 | Stephenson | 52 |
| 6 | 23867 | Jarratt | 53 |
| 7 | 22202 | Arlington | 58 |
| 8 | 24569 | Long Island | 59 |
| 9 | 24472 | Raphine | 66 |
| 10 | 22027 | Dunn Loring | 67 |

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




| Rank | Name | Ratio |
|---|---|---|
| 1 | Madison County | 6.2 |
| 2 | Martinsville City | 5.2 |
| 3 | Middlesex County | 3.0 |
| 4 | Grayson County | 2.6 |
| 5 | Russell County | 2.4 |
| 6 | Page County | 2.3 |
| 7 | Louisa County | 2.0 |
| 8 | King George County | 2.0 |
| 9 | Northampton County | 2.0 |
| 10 | Norton City | 1.8 |



# Current Hot-Spots

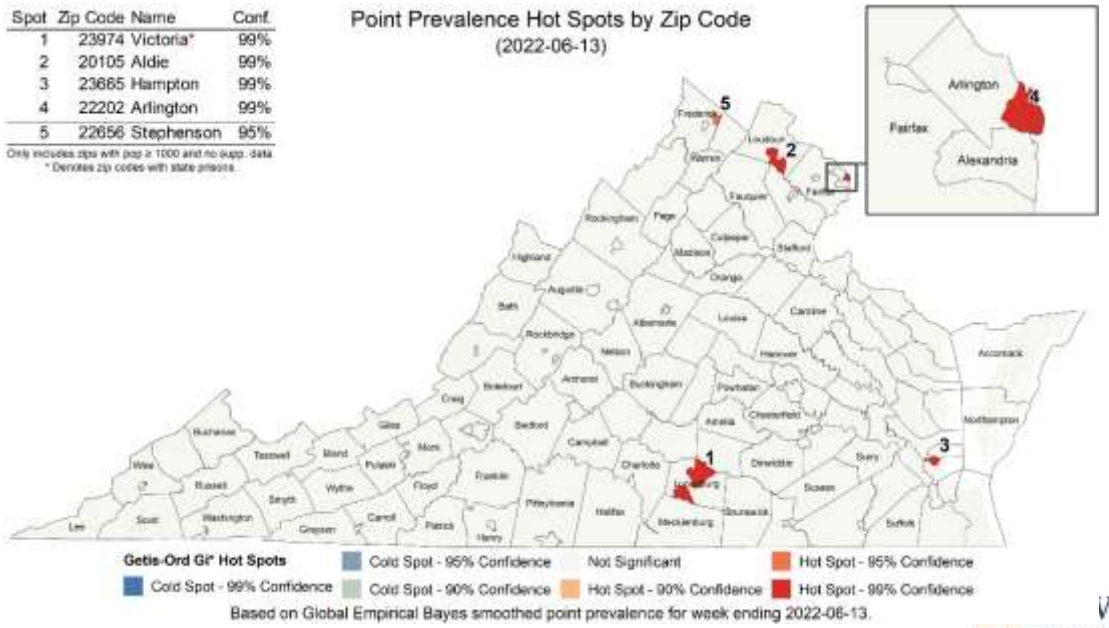
**Case rates that are significantly different from neighboring areas or model projections**

- **Spatial**: Getis-Ord Gi* based hot spots compare clusters of zip codes with weekly case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations
- **Temporal**: The weekly case rate (per 100K) projected last week compared to observed by county, which highlights temporal fluctuations that differ from the model's projections

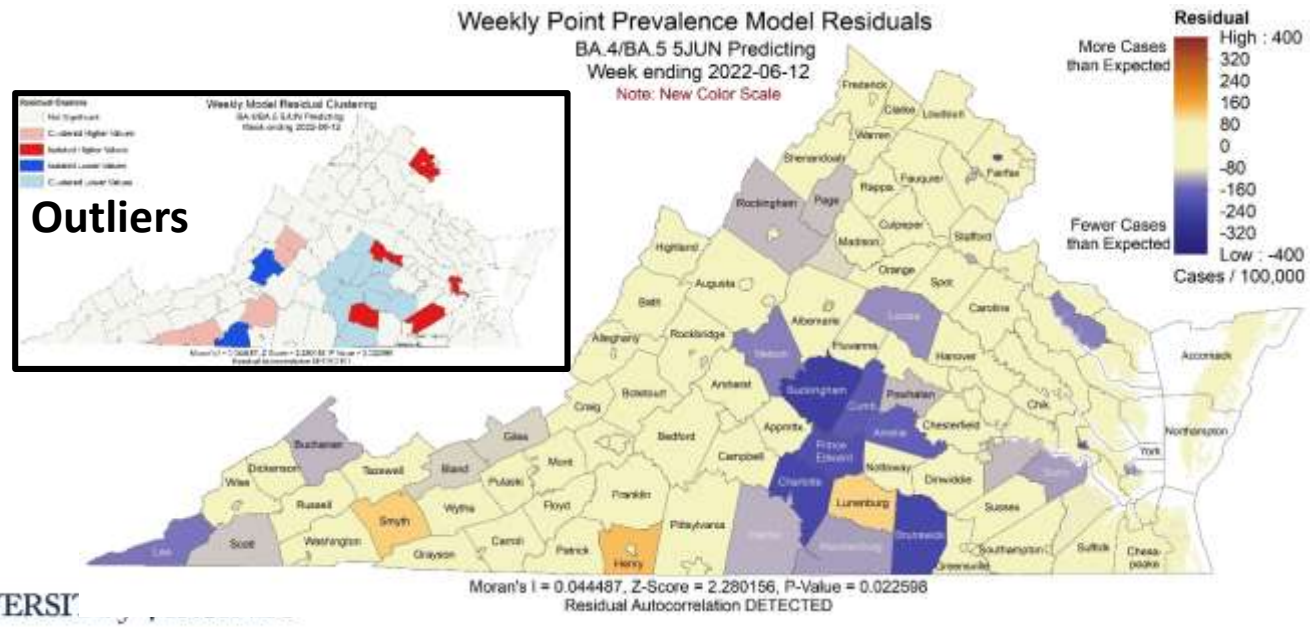
**Spatial Hotspots**

| Spot | Zip Code | Name | Conf. |
|---|---|---|---|
| 1 | 23974 | Victoria* | 99% |
| 2 | 20105 | Aldie | 99% |
| 3 | 23665 | Hampton | 99% |
| 4 | 22202 | Arlington | 99% |
| 5 | 22656 | Stephenson | 95% |

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



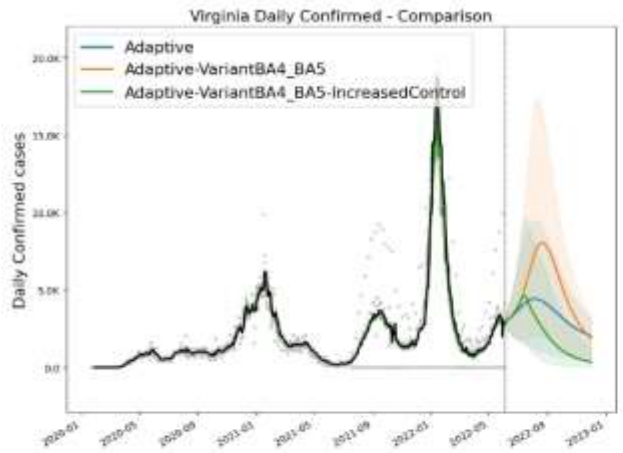

**Clustered Temporal Hotspots from BA.4_BA.5**



# Scenario Trajectory Tracking

**Which scenario from last projection did each county track closest?**

- Minimal difference between projections overall
- State level trend tracking BA.2.12.1 scenarios (red and green), but not all, likely due to variation in prevalence across the state

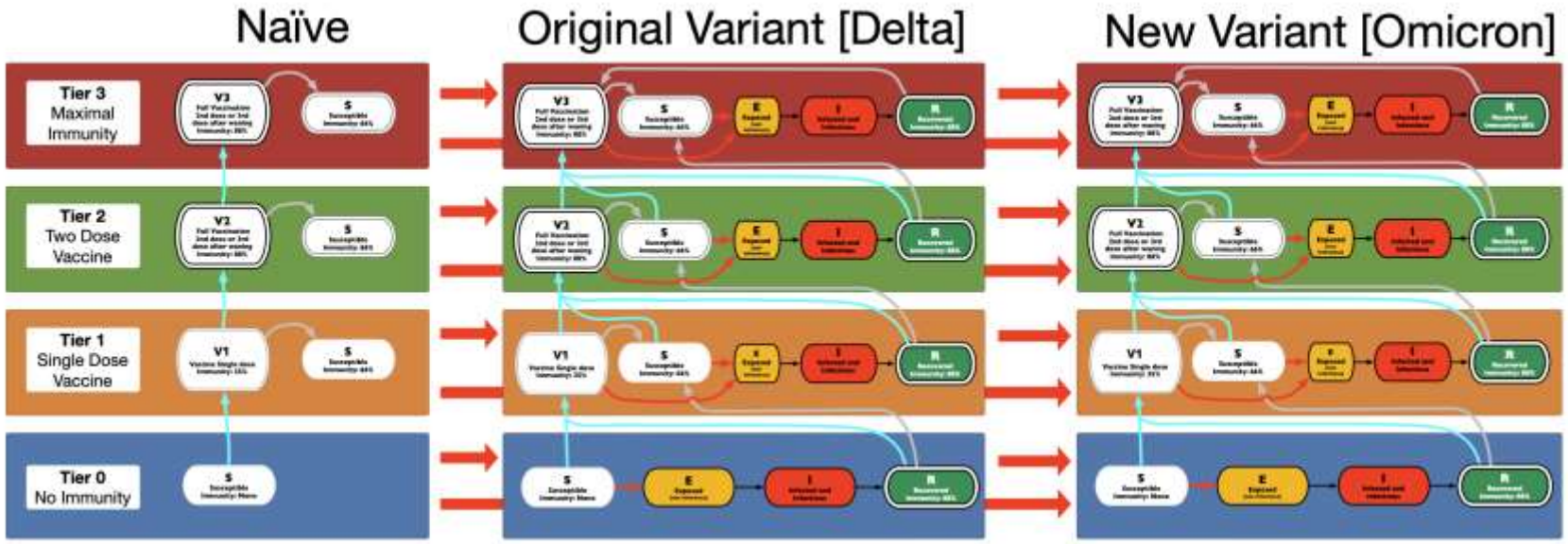


# Model Update – Adaptive Fitting

# Model Structure Extended for Multiple Strains

**Omicron escapes immunity from vaccinated and those infected with Delta**

- Multiple strain support allows representation of differential protection based on immunological history
- Severity of outcomes varies by strain and level of immunity, thus allowing model to better capture hospitalizations and deaths from Omicron
- Adaptive fitting approach continues to use simulation to generate the full distribution of immune states across the population



# Adaptive Fitting Approach

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

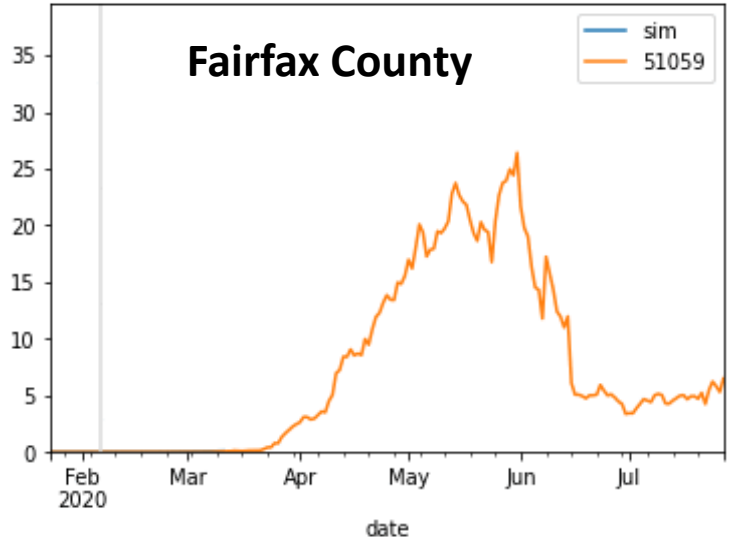
- Allows history to be precisely captured, and used to guide bounds on projections

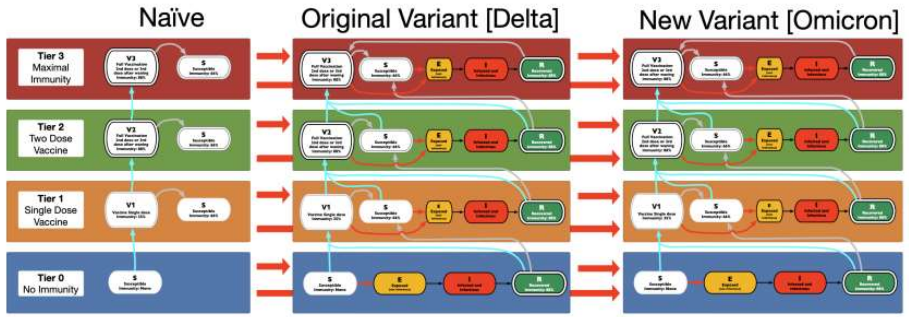
**Model:** An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- Allows for future "what-if" Scenarios to be layered on top of calibrated model
- Allows for waning of immunity and for partial immunity against different outcomes (eg lower protection for infection than death)

**External Seeding:** Steady low-level importation

- Widespread pandemic eliminates sensitivity to initial conditions, we use steady 1 case per 10M population per day external seeding



# Using Ensemble Model to Guide Projections

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

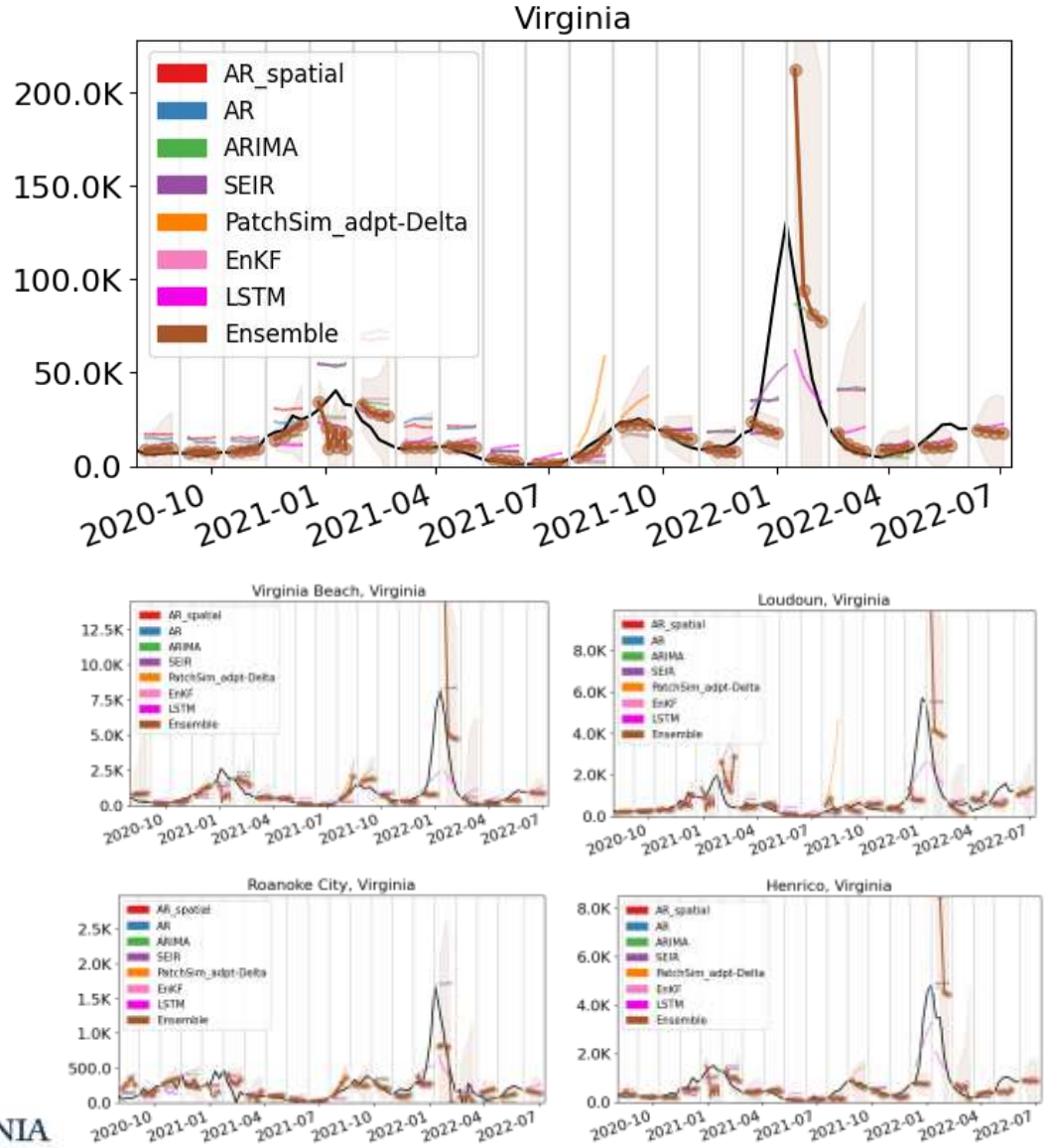
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

<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.



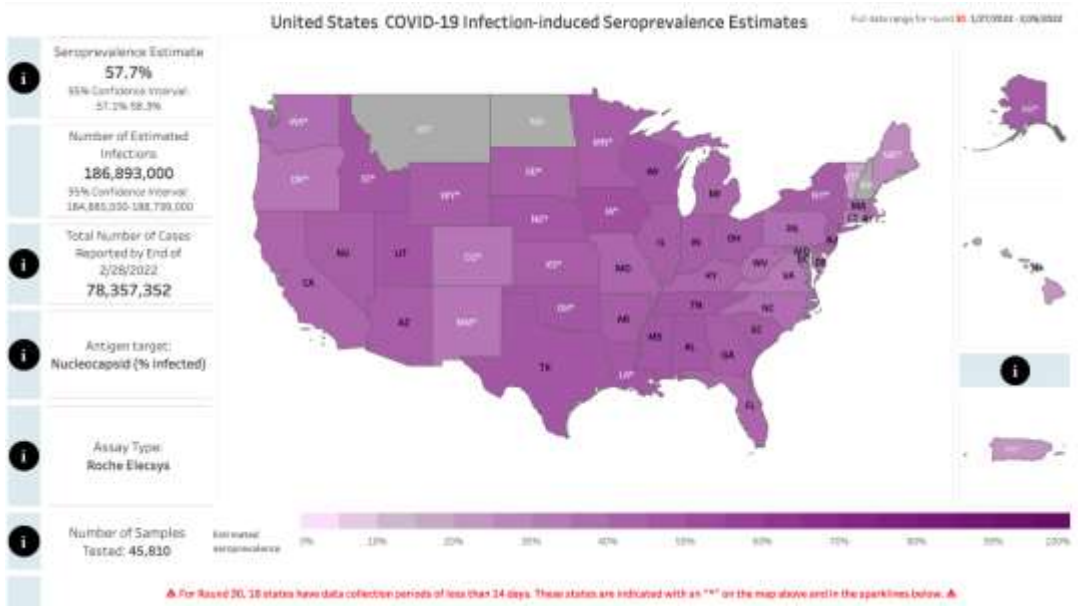
# Seroprevalence updates to model design

**Several seroprevalence studies provide better picture of how many actual infections have occurred**

- CDC Nationwide Commercial Laboratory Seroprevalence Survey

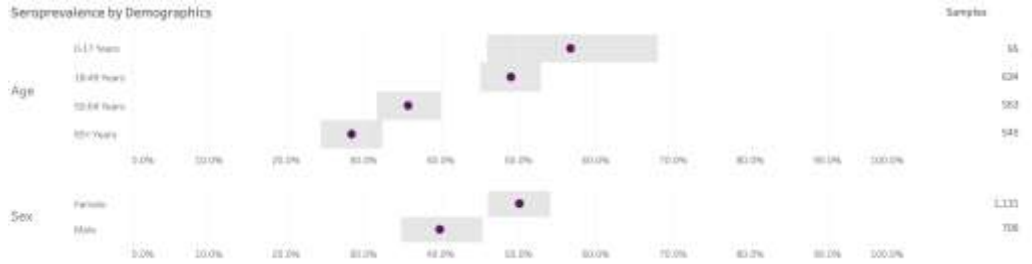
**Pre-Omicron these findings were consistent with an ascertainment ratio of ~2-3x**

- Thus there were 2.5 total infections in the population for every confirmed case recently
- **Case ascertainment for Omicron infections are half of that for pre-Omicron, thus for every case there are ~5 total infections**
- During the peak of Omicron, the degradation of test seeking and capacity were modeled to have fallen by 3x with a rebound to pre-Omicron levels by mid-Feb




**Virginia**

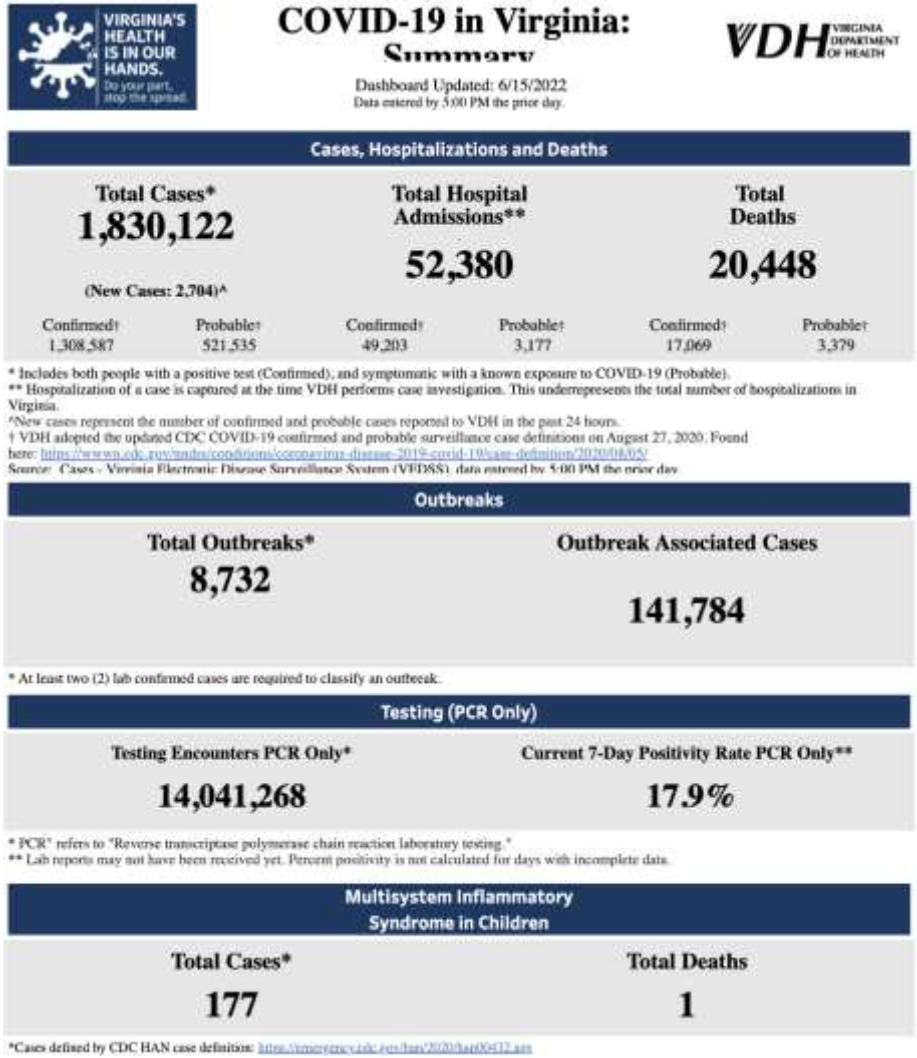
Feb 22nd: 45% [42% - 48%]; Jan 22nd: 34% [31%-39%]




https://covid.cdc.gov/covid-data-tracker/#national-lab

# Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data and ensemble's forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak
- **Project:** future cases and outcomes generated using the collection of fit models run into the future
  - **Mean trend from last 7 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories
- **Outcomes**: Data driven by shift and ratio that has least error in last month of observations
  - Hospitalizations: 3 days from confirmation, 6.8% of cases hospitalized
  - Deaths: 11 days from confirmation, 1.45% of cases die



VIRGINIA'S HEALTH IS IN OUR HANDS. Do your part, stop the spread.

**COVID-19 in Virginia: Summary**

VDH Virginia Department of Health

Dashboard Updated: 6/15/2022
Data entered by 5:00 PM the prior day.

**Cases, Hospitalizations and Deaths**

| Total Cases* | Total Hospital Admissions** | Total Deaths |
|---|---|---|
| 1,830,122 | 52,380 | 20,448 |
| (New Cases: 2,704)^ | | |

| Confirmed† | Probable† | Confirmed† | Probable† | Confirmed† | Probable† |
|---|---|---|---|---|---|
| 1,308,587 | 521,535 | 49,203 | 3,177 | 17,069 | 3,379 |

* Includes both people with a positive test (Confirmed), and symptomatic with a known exposure to COVID-19 (Probable).
** Hospitalization of a case is captured at the time VDH performs case investigation. This underrepresents the total number of hospitalizations in Virginia.
^New cases represent the number of confirmed and probable cases reported to VDH in the past 24 hours.
† VDH adopted the updated CDC COVID-19 confirmed and probable surveillance case definitions on August 27, 2020. Found here: https://www.cdc.gov/nndss/conditions/coronavirus-disease-2019-covid-19/case-definition/2020/08/05/
Source: Cases - Virginia Electronic Disease Surveillance System (VEDSS), data entered by 5:00 PM the prior day

**Outbreaks**

| Total Outbreaks* | Outbreak Associated Cases |
|---|---|
| 8,732 | 141,784 |

* At least two (2) lab confirmed cases are required to classify an outbreak.

**Testing (PCR Only)**

| Testing Encounters PCR Only* | Current 7-Day Positivity Rate PCR Only** |
|---|---|
| 14,041,268 | 17.9% |

* PCR" refers to "Reverse transcriptase polymerase chain reaction laboratory testing."
** Lab reports may not have been received yet. Percent positivity is not calculated for days with incomplete data.

**Multisystem Inflammatory Syndrome in Children**

| Total Cases* | Total Deaths |
|---|---|
| 177 | 1 |

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

Accessed 9:35am June 15, 2022
https://www.vdh.virginia.gov/coronavirus/

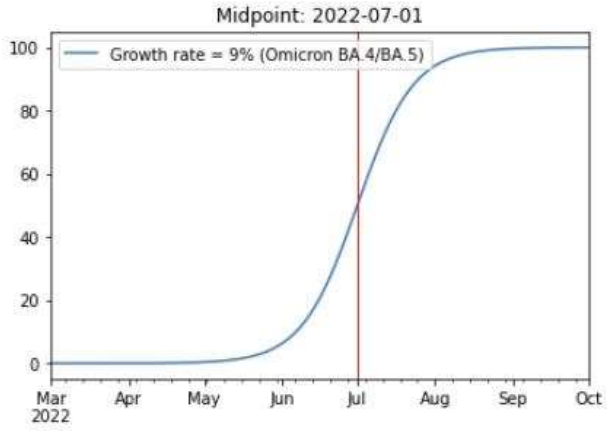
# Scenarios – Transmission Conditions

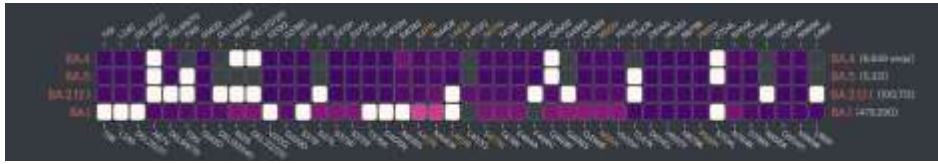
- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity**: Mean of 6 months to a year protection (rate of 0.0027) similar to Pfizer study, Omicron waning with a mean of 4 months
- **Projection Scenarios**:
  - **Adaptive:** Control remains as is currently experienced into the future with assumption that Omicron BA.2.12.1 remains at the same relative level as it has for the last several weeks. Infection with Omicron provides protection against Omicron infection in the future, though with fast waning (4 months)
  - **Adaptive-VariantBA4_BA5:** Same as Adaptive, but with BA.4 and BA.5 subvariants continuing growth towards predominance (50% prevalence on July 1st). They have 80% immune escape compare to prior Omicron subvariants but have slightly reduced transmission advantage (20% reduction) over existing Omicron (mainly BA.2.12.1 subvariant)
  - **Adaptive-VariantBA4_BA5-IncreasedControl**: Same as Adaptive-VariantBA4_BA5, but with a 25% reduction in transmission to increased mitigations starting in 30 days and phasing into full effect over 1 week

# Scenarios – Omicron BA.4 / BA.5 Description

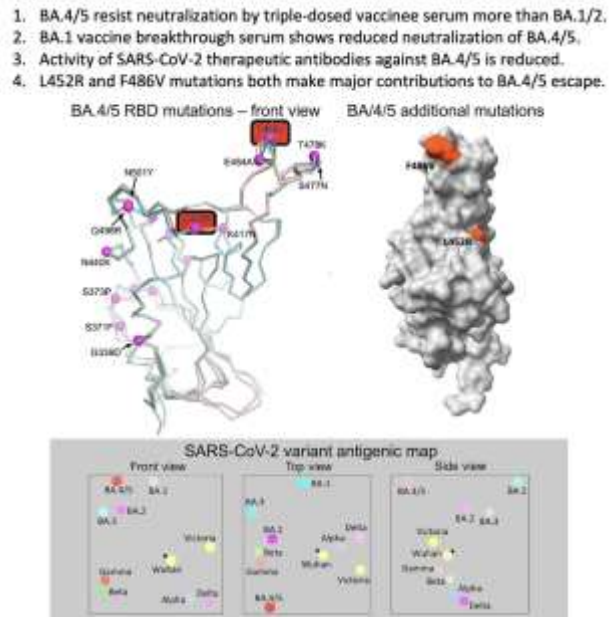
**BA.4 and BA.5 subvariants are continue to show significant growth in many countries including the US, may dominant in the coming weeks**

- **Immune Escape**: Lab studies demonstrate that BA.4 and BA.5 demonstrate substantial immune escape for both vaccinated and unvaccinated people who have been previously infected with BA.1 subvariants
- **Using an 80% reduction in immunity for those previously infected with Omicron (BA.1 and BA.2)**
- **Transmissibility:** Lab studies suggest may actually be less transmissible
- **Assume a 20% reduction in transmissibility compared to BA.2.12.1**
- **Prevalence**: Growth rate is different in different countries; Region 3 of US seems to have 8 day doubling time
  - **With increased current prevalence and and this doubling time, 50% prevalence estimated to occur on July 1st**
- **Severity:** Same as previous Omicron, evidence from personal from South Africa



BA.4 and BA.5 share many similar mutations compared to other Omicron sub-variants
Outbreak.info




Substantial immune escape seen for BA.4, comparable to original BA.1 subvariant of the initial Omicron wave compared to Delta
Cell
originally
BioRxiv

# Projection Scenarios – Combined Conditions

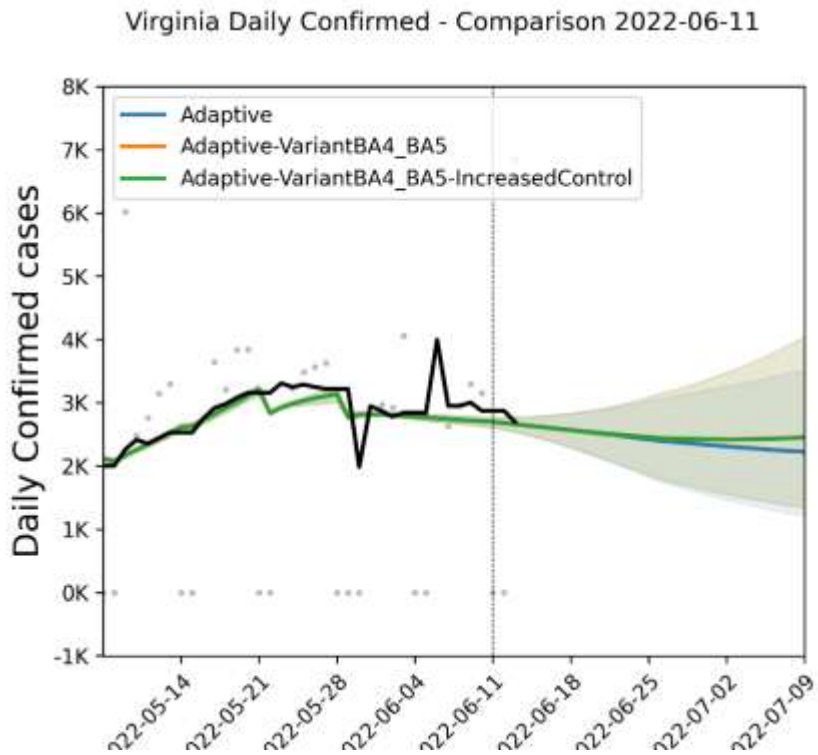
| Name | Txm Controls | Vax | Description |
|---|---|---|---|
| Adaptive | C | SQ | Likely trajectory based on conditions remaining similar to the current experience, includes immune escape due to Omicron |
| Adaptive-VariantBA4_BA5 | C | SQ | Emerging BA.4 and BA.5 subvariants have substantial immune escape from previous BA., with BA.2.12.1 prevalence reaching 50% on June 1st and rising to ~95% 4 weeks after |
| Adaptive-VariantBA4_BA5 -IncreasedControl | Increased | SQ | Same as Adaptive-VariantBA2_12 with increased mitigations reducing transmission by 25% starting in 30 days |

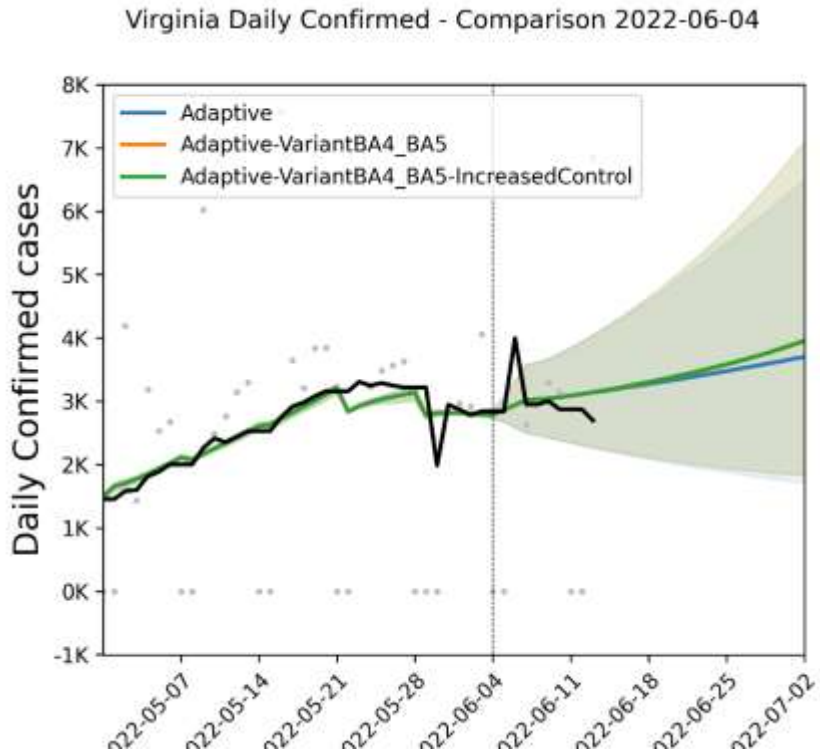
**Transmission Controls:**
C = Current levels persist into the future
Increased = Transmission rates are reduced by 25% over 2 weeks starting May 1st
Spring = Transmission rates from mid-Jan 2021 through mid-March 2021 are coarsely replayed, representing a 60% reduction in transmission rate drivers, with Omicron remaining dominant

**Vaccinations:**
SQ = Status quo acceptance leads to low rates of vaccination through the summer
VO = Vaccination acceptance optimistically expands with increased rates through the summer

# Last projection comparison – 1 week ago

- Last week's projection corrected for holiday and had slight growth, this week falls well within projection bounds but is
- Update this week tracks slight decline of growth

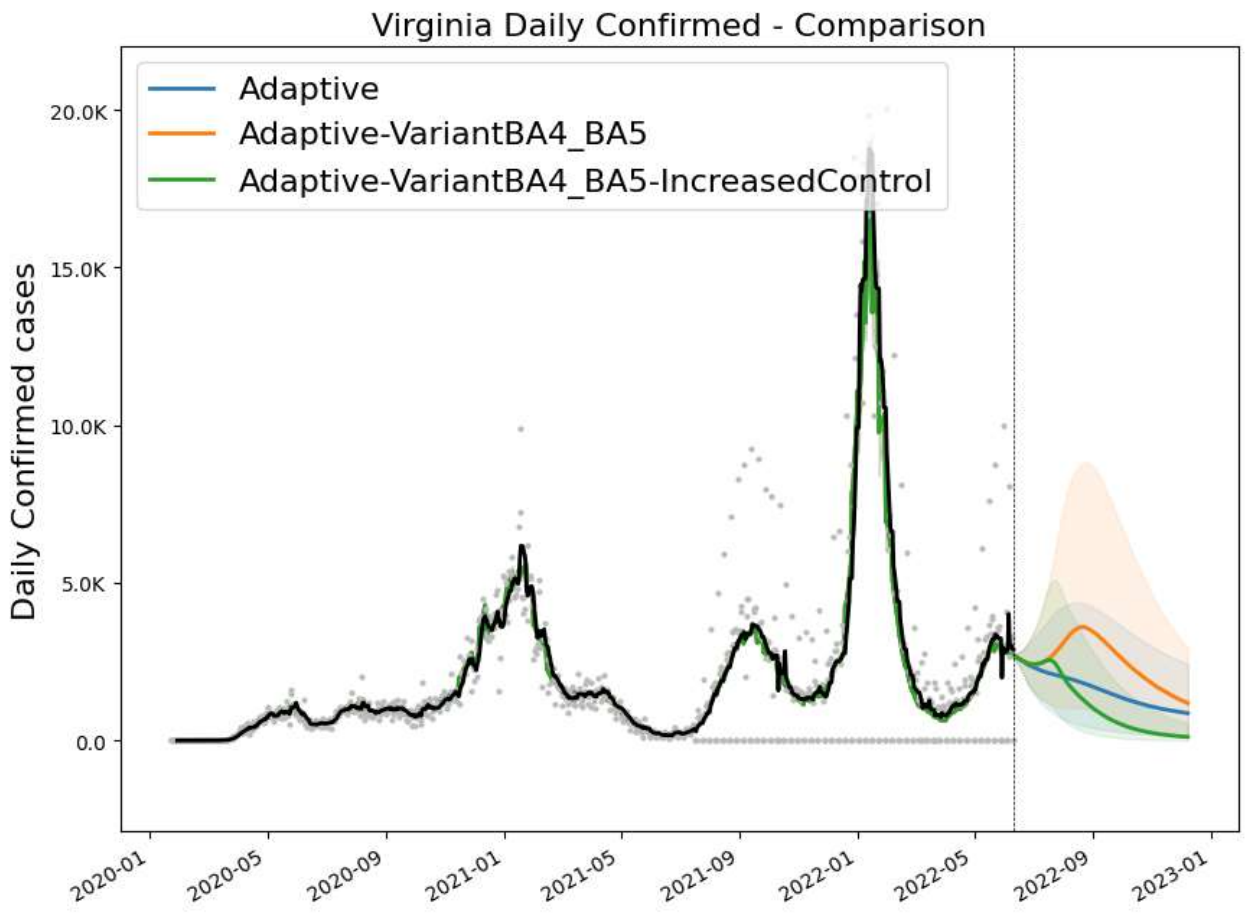


# Model Results

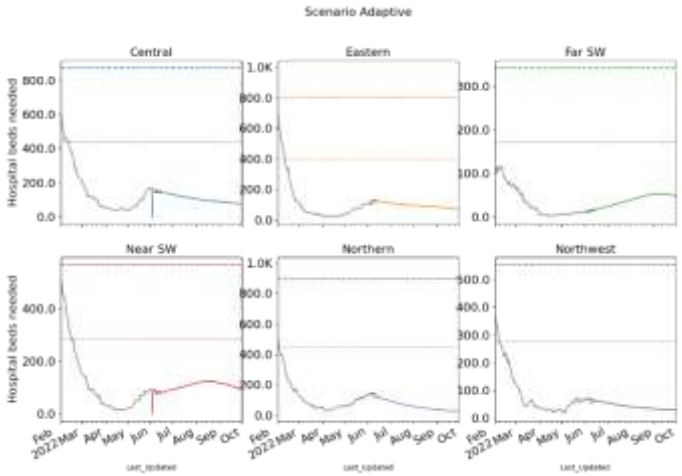
# Outcome Projections

## Confirmed cases

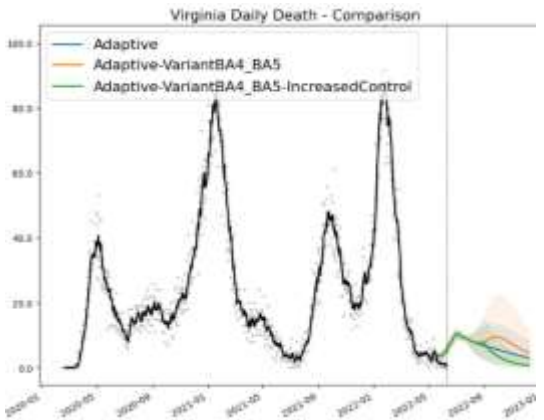



* without surveillance correction VariantBA2 peaked over 10K in July

## Estimated Hospital Occupancy

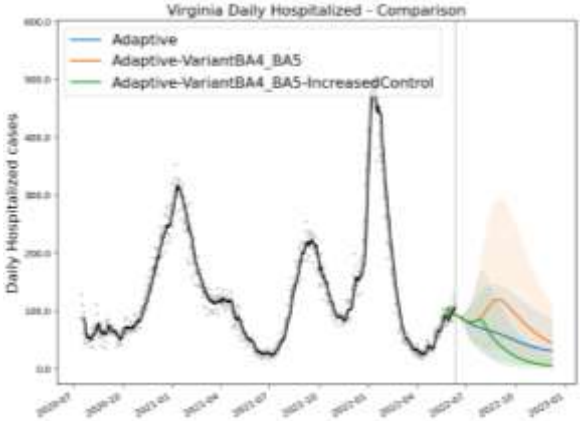



## Daily Deaths




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

## Daily Hospitalized

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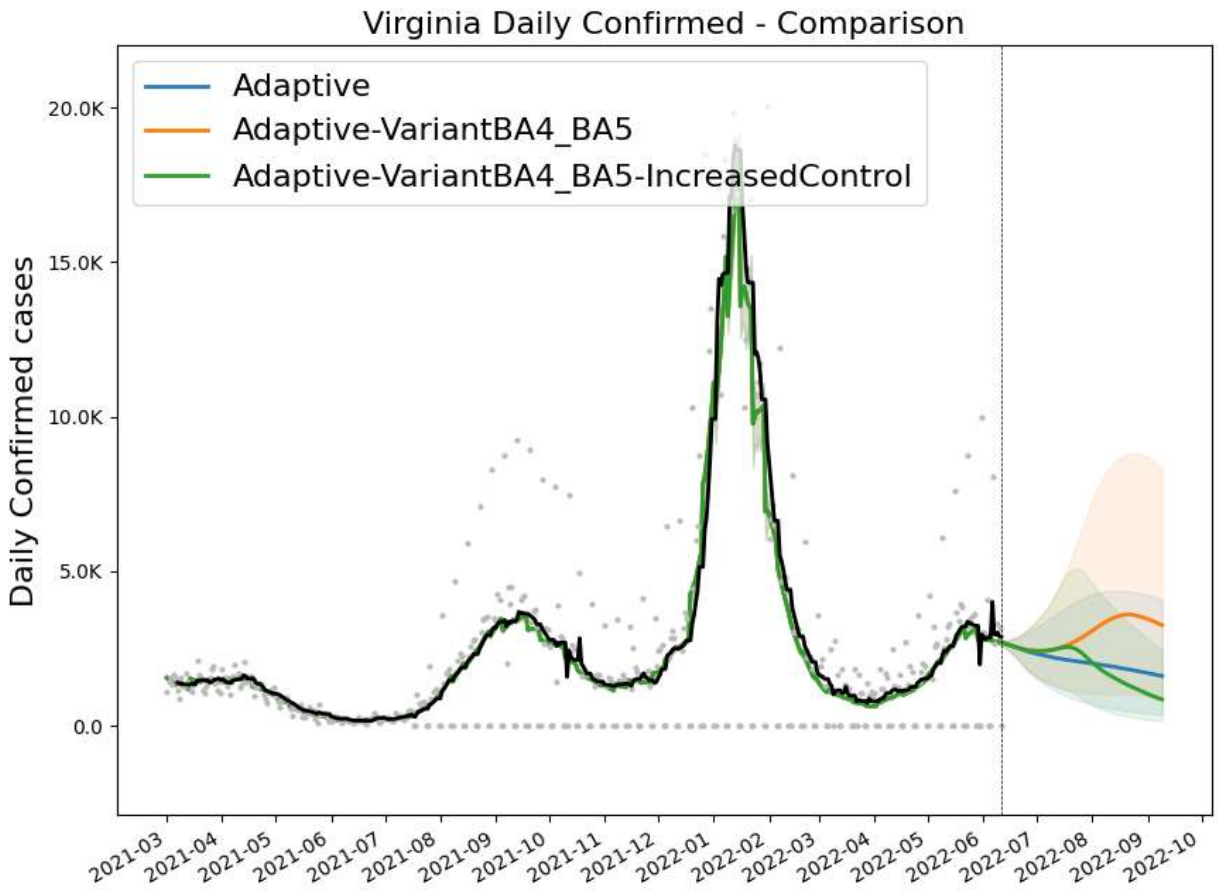
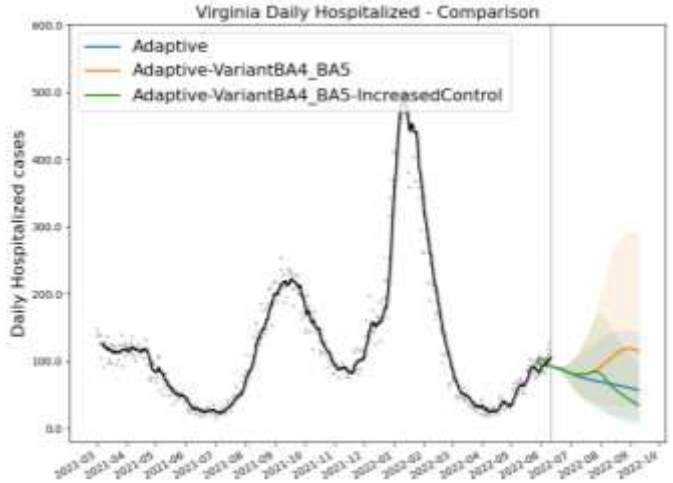
# Outcome Projections – Closer Look

## Confirmed cases

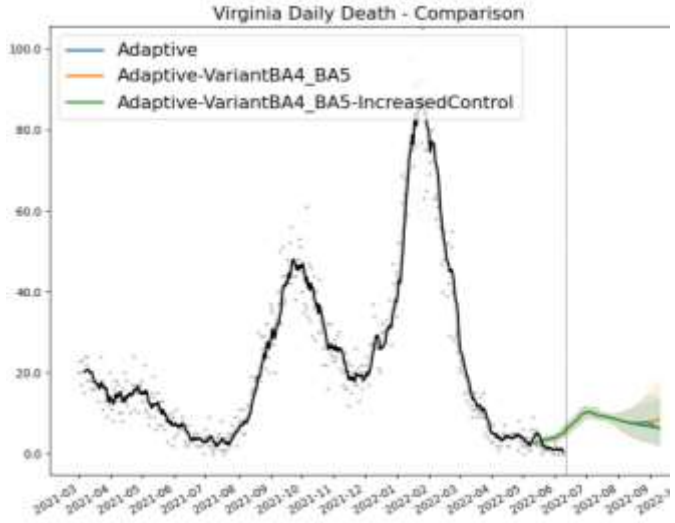



* without surveillance correction VariantBA2 peaked over 10K in July

## Daily Hospitalized




## Daily Deaths




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

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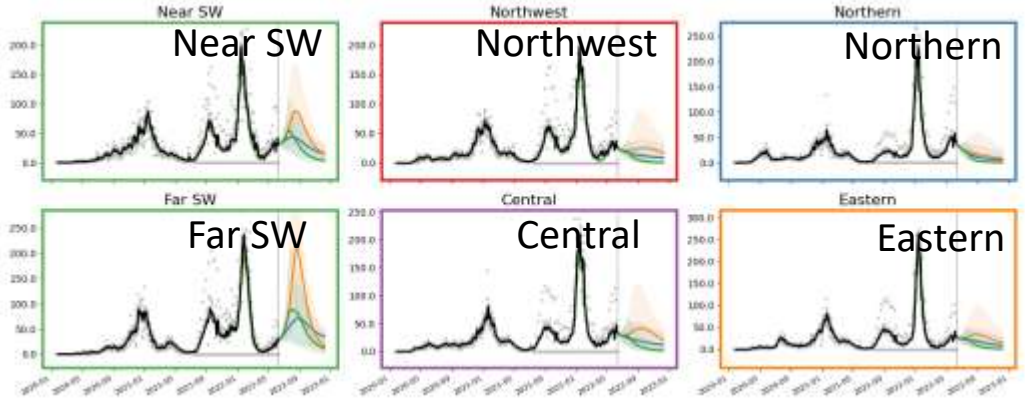
# Detailed Projections: All Scenarios

## Projections by Region



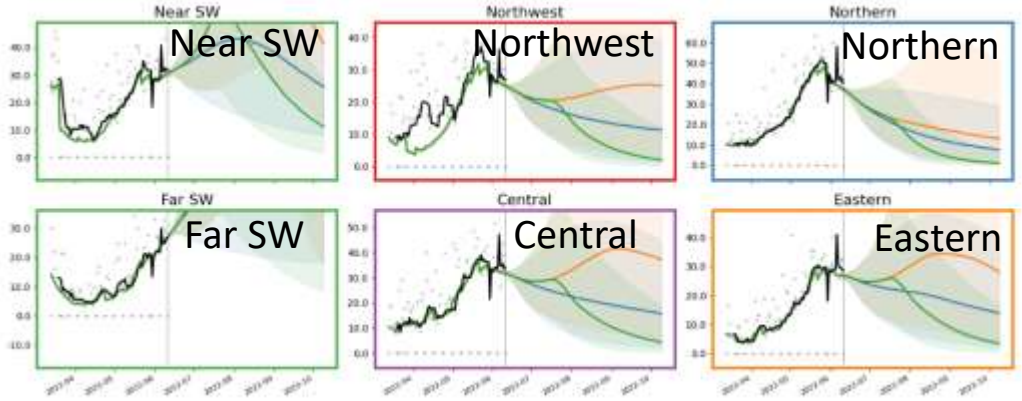

## Projections by District




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

# Detailed Projections: All Scenarios - Closer Look

## Projections by Region




## Projections by District



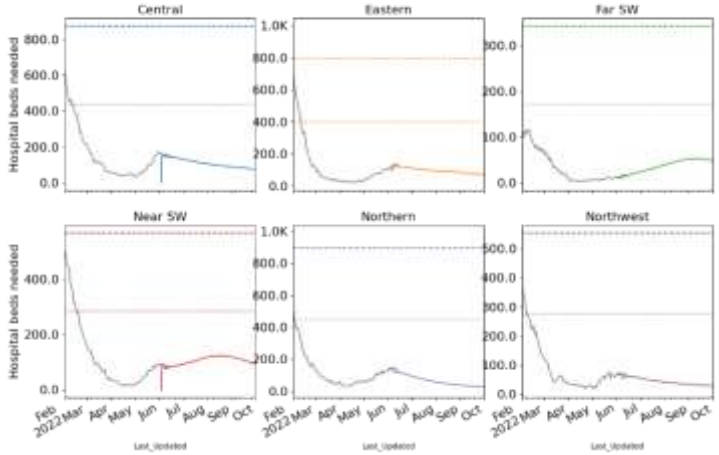

Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

# Hospital Demand and Bed Capacity by Region

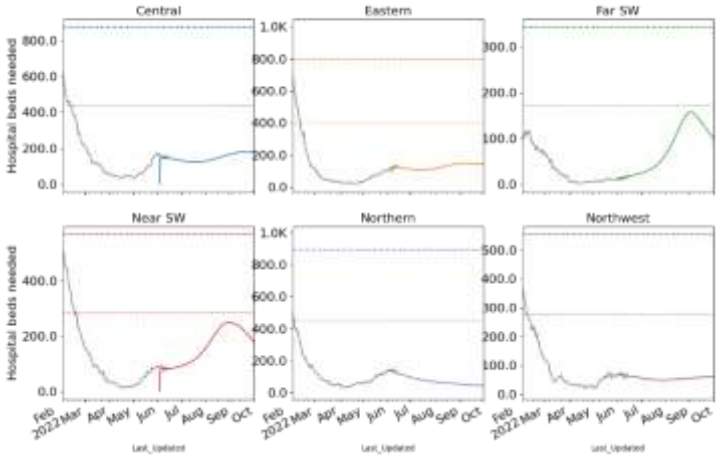
**Capacities by Region**

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

**Adaptive**




**Adaptive – Variant BA4_BA5**




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

**Estimated LOS lengthened slightly to better fit observed data**

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

**Length of Stay Estimates**

| | |
|---|---|
| Central | 9 |
| Eastern | 7 |
| Far SW | 6 |
| Near SW | 9 |
| Northern | 3 |
| Northwestern | 8 |

Interactive Dashboard with regional projections

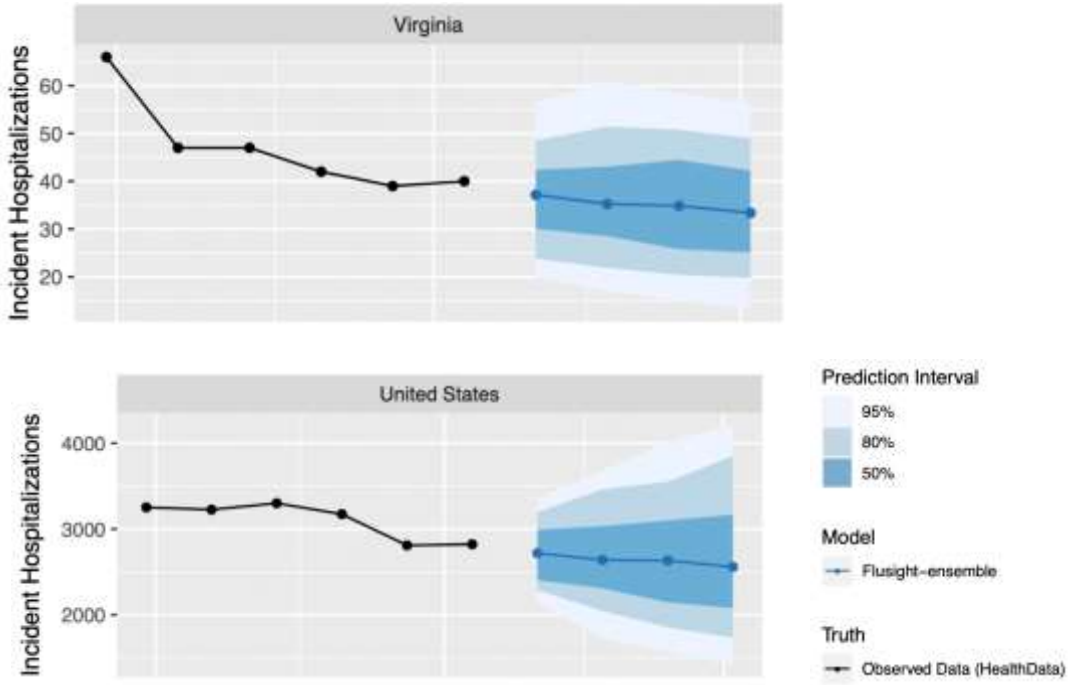
https://nssac.bii.virginia.edu/covid-19/vmrddash/

# Current Influenza Hospitalization Forecast

**Statistical models for submitting to CDC FluSight forecasting challenge**

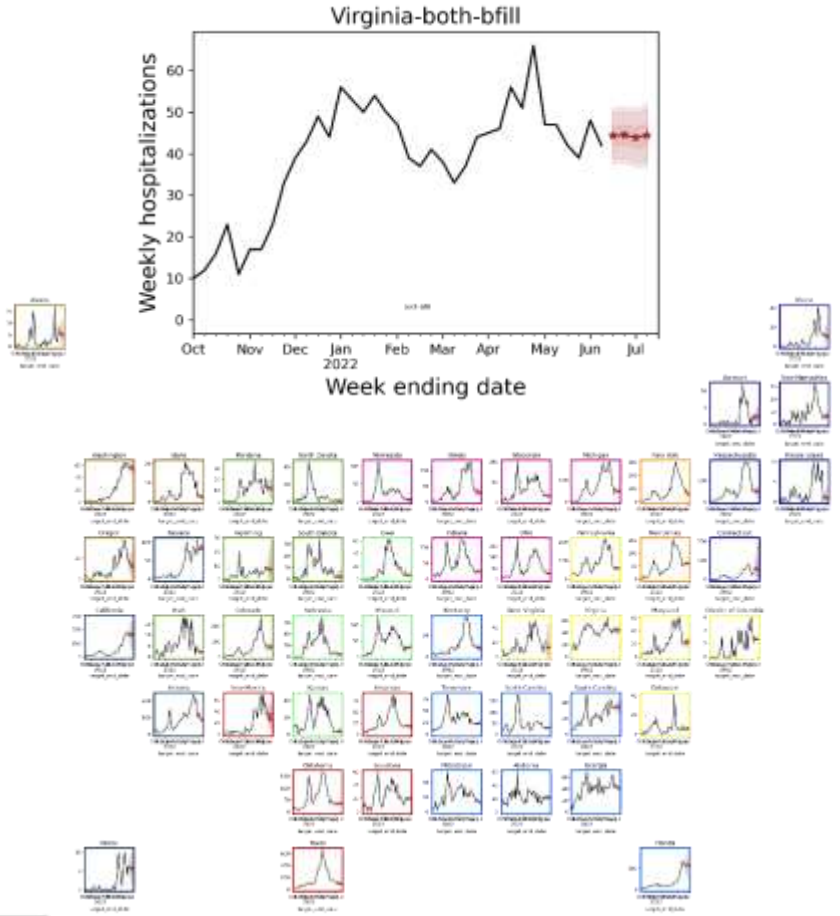
- Hospitalizations nationwide are slowing

Not updated this week
June 6th forecasts




[CDC FluSight](#)
Ensemble Forecasts

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

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# Key Takeaways

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

- **Case rates remain high but are slowly declining, hospitalizations remain flat**
- VA 7-day mean daily case rate slightly down to 34/100K from 35/100K
  - US has declined recently to 29/100K from 37/100K
  - VA hospital occupancy (rolling 7 day mean of 574) remains in a plateau steady, though may be entering a plateau
- Projections anticipate a plateau and declining rates near term with potential for growth due to BA4/5:
  - VA case rates have started a slow decline, though variant prevalences seem to be shifting
  - Rise in hospitalizations remain steady since the start of June
- Model updates:
  - Omicron subvariant BA.2.12.1 growth has stagnated, thus this scenario is now replaced by plain Adaptive which assumes no variant growth
  - More information about BA.4 and BA.5 have refined the next variant scenario, and seems likely to drive future dynamics
  - Hospitalization fitted models have been completed, may replace case-based models in the future

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

# Additional Analyses

# Overview of relevant on-going studies

Other projects coordinated with CDC and VDH:

- **Scenario Modeling Hub:** Consortium of academic teams coordinated via MIDAS / CDC to that provides regular national projections based on timely scenarios
- **Genomic Surveillance:** Analyses of genomic sequencing data, VA surveillance data, and collaboration with VA DCLS to identify sample sizes needed to detect and track outbreaks driven by introduction of new variants etc.
- **Mobility Data driven Outreach locations:** Collaboration with VDH state and local, Stanford, and SafeGraph to leverage anonymized cell data to help identify sites most frequently visited by different demographic groups

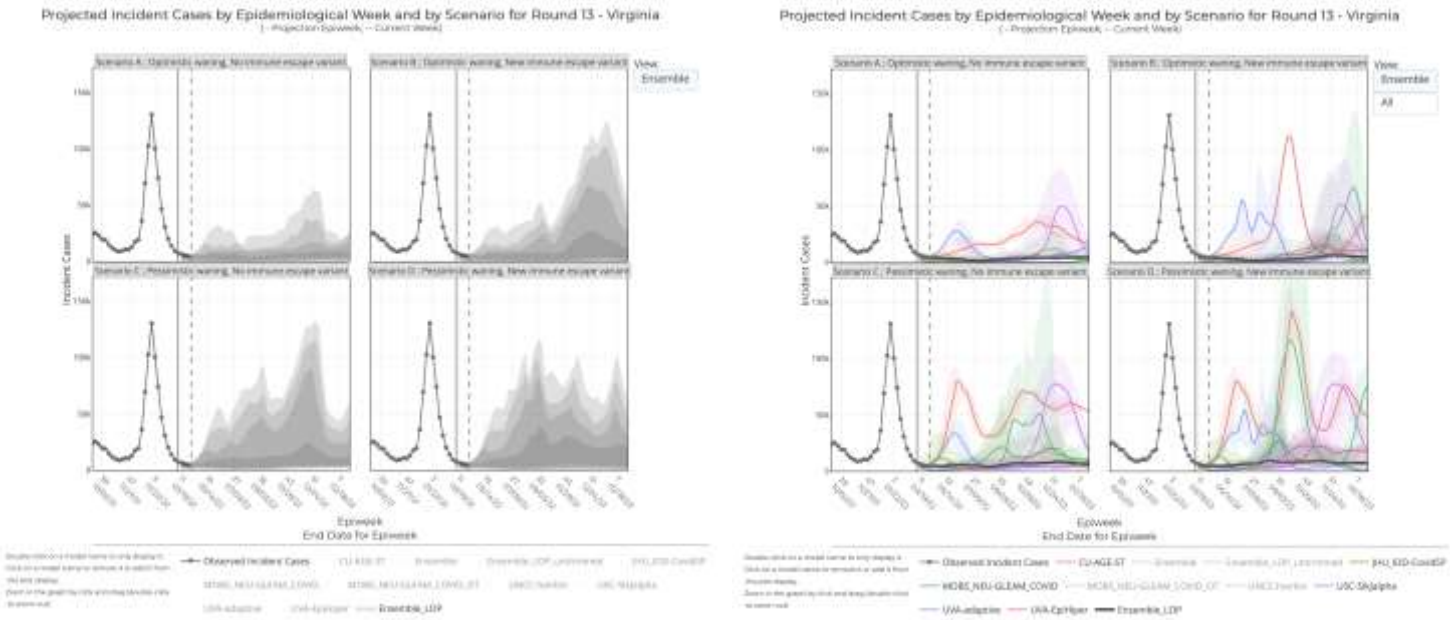
# COVID-19 Scenario Modeling Hub – Round 13

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



# Busiest Places: Mobility Data Can Assist

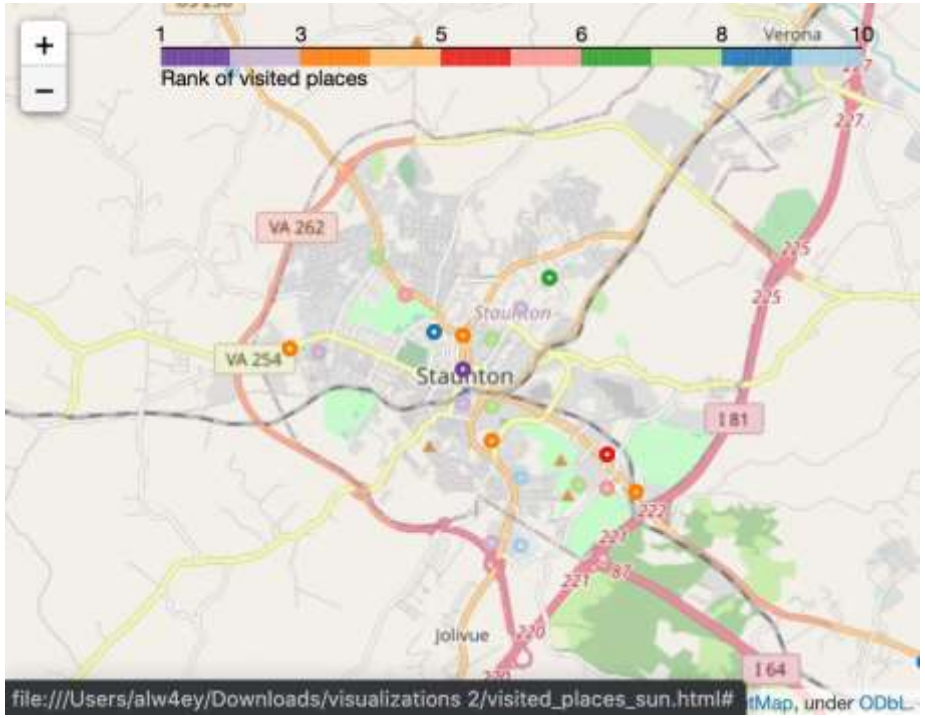
**SafeGraph provides fine-grained mobility measures**

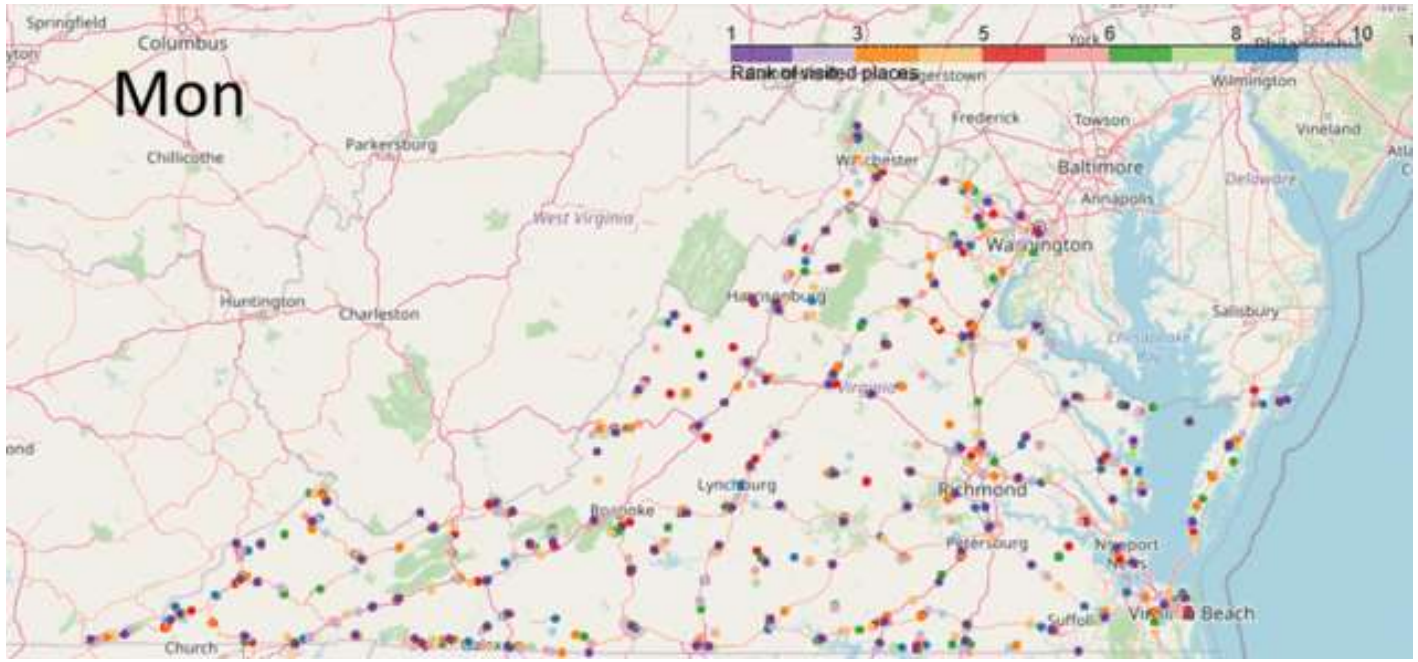
- SafeGraph: anonymized geolocation data aggregated from numerous cell phone apps
- One of the most fine-grained and high-coverage mobility data sources available: 6.4 million POIs in the US; 158,869 POIs in VA
- Has been utilized by hundreds of researchers, governments, and the CDC to aid COVID-19 efforts (Chang, Pierson, Koh, et al., *Nature* 2020; Chang et al, KDD 2021)
- Daily and hourly number of visits to points-of-interest (POIs), i.e., non-residential locations such as restaurants, bars, gas stations, malls, grocery stores, churches, etc.
- Weekly reports per POI of ***where visitors are coming from*** (at the census block group level)
- Still has limitations to be aware of (e.g., less representation among children and seniors)

SAFEGRAPH

# Find the Busiest Locations

POIs are individual addresses, need some aggregation to busy areas

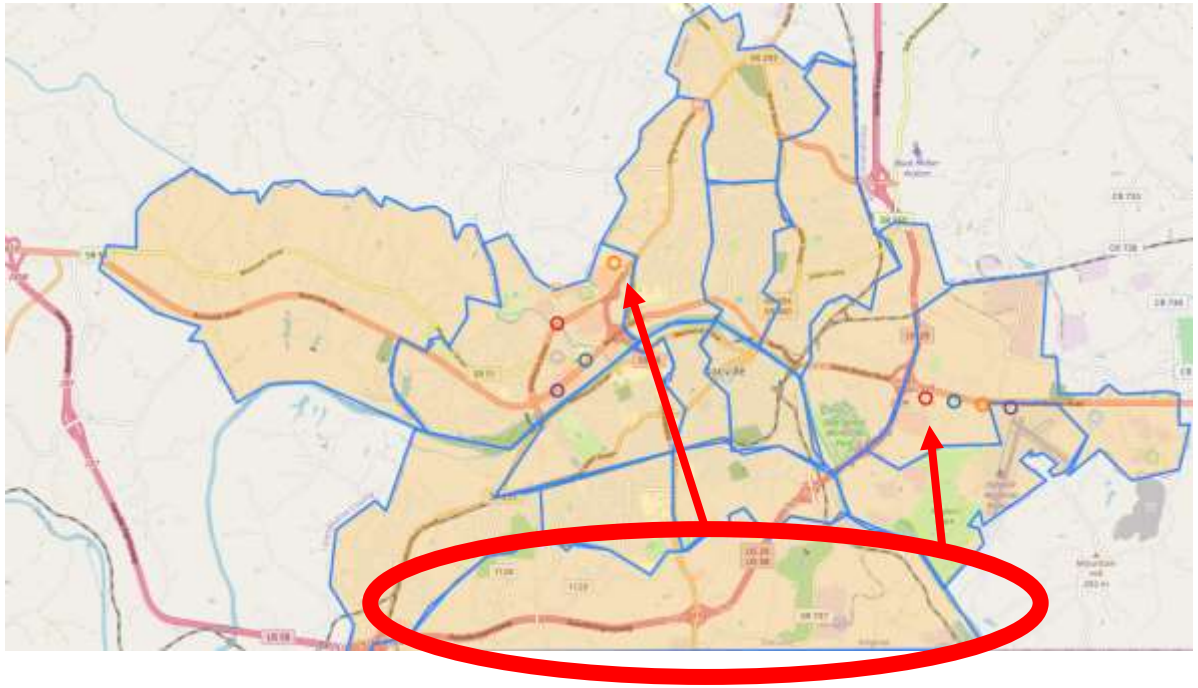



Busiest locations vary by day of week (and time of day)

# Find locations visited by Target Population

Census Block Groups in Danville



1. Use census data to characterize the populations of the different census block groups
2. Identify most frequently visited POIs for each CBG
3. Cluster most visited POIs
4. Provide potential sites grouped by the demographic groups they likely serve

**Goal:** Provide frequently visited locations based on populations and vaccination levels one desires to reach

**Example:** List of locations in the Southside frequented by Black Virginians

# Overview of the current roster of targeted populations

These are the current roster of targeted population groups that we are providing as part of the weekly delivery to VDH.  (This roster is subject to change.)

- Whole population (eg, no target population filters are applied)
- Race Black
- Ethnicity Latinx
- Ages 20-40
- Ages 20-30
- Ages 30-40
- Unvaccinated populations
- Latinx or Black 

# Data Elements in the CSV

**HighlyVisitedAddress**
This is the address of the POI in the L14 that sees the most visits. It is provided to make it easier to find the L14 on the map.

**Rank & LocationWeight**
The LocationWeight is estimated # of visits to POIs in the L14 from the target group. Rank indicates the order from most- to 25th most-visited

**AreaMostVisitedPeriod**
**This is the 4-hour period in the week when the L14 sees its highest traffic. This is not target group-specifi**

NEW

**Population Group**
For a targeted file like this one, these will all be the same value.

**AreaMostVisitedDay**
This is the day of the week when most visitors go to this S2 location. This is not target group-specific.

**Lat and Lon**
This is the latitude and longitude for the center of the L14.

VDH District

S2 Key (L14)

County

| Locality | District | PopulationGroup | LocationID | Rank | LocationWeight | AreaMostVisitedDay | HighlyVisitedAddress | AreaMostVisitedPeriod | Lat | Lon |
|---|---|---|---|---|---|---|---|---|---|---|
| Accomack Cc | Eastern Shor | Latinx or Black | 89ba2b55 | 1 | 4966.030095 | Friday | 25297 Lankford Hwy Rt 13 N, C | Friday 17:00-21:00 | 37.6978738 | -75.716796 |
| Accomack Cc | Eastern Shor | Latinx or Black | 89ba2caf | 2 | 3728.476605 | Friday | 26036 Lankford Hwy, Onley, VA | Friday 15:00-19:00 | 37.6881681 | -75.722612 |
| Accomack Cc | Eastern Shor | Latinx or Black | 89ba2b57 | 3 | 3508.193676 | Saturday | 25274 Lankford Hwy, Onley, VA | Saturday 13:00-17:00 | 37.69859 | -75.722612 |
| Accomack Cc | Eastern Shor | Latinx or Black | 89bbd4ad | 4 | 2582.802769 | Wednesday | 25102 Lankford Hwy, Onley, VA | Sunday 11:00-15:00 | 37.7023677 | -75.710981 |
| Accomack Cc | Eastern Shor | Latinx or Black | 89ba2b53 | 5 | 1844.868961 | Sunday | 25102 Lankford Hwy, Onley, VA | Friday 16:00-20:00 | 37.7030842 | -75.716796 |
| Albemarle Cc | Blue Ridge | Latinx or Black | 89b38647 | 1 | 14088.0684 | Thursday | 1215 Lee St, University of Virg | Thursday 07:00-11:00 | 38.0327733 | -78.500766 |
| Albemarle Cc | Blue Ridge | Latinx or Black | 89b477ff | 2 | 6999.363545 | Saturday | 1980 Rio Hill Ctr, Charlottesvill | Saturday 12:00-16:00 | 38.087391 | -78.472353 |
| Albemarle Cc | Blue Ridge | Latinx or Black | 89b38645 | 3 | 5824.383454 | Wednesday | Cabell Hall 525 Mccormick Roa | Wednesday 11:00-15:00 | 38.033334 | -78.506447 |
| Albemarle Cc | Blue Ridge | Latinx or Black | 89b3888d | 4 | 5078.488029 | Friday | 540 Pantops Ctr, Pantops, VA, | Thursday 11:00-15:00 | 38.0334982 | -78.455301 |
| Albemarle Cc | Blue Ridge | Latinx or Black | 89b387fd | 5 | 4655.844131 | Saturday | 100 Twentyninth Place Ct, Cha | Saturday 11:00-15:00 | 38.077516 | -78.478036 |

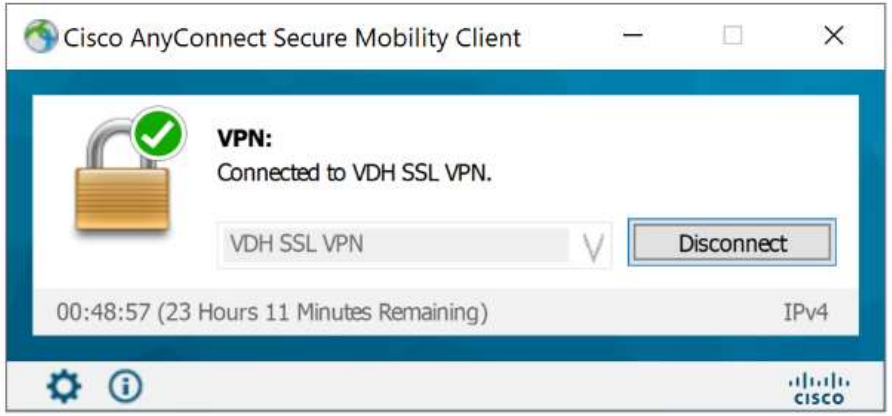
# Mobility Data Updated Weekly

Box: https://virginia.box.com/s/03kq8el0kzd9w43wz2g3myozov76uizo

- Excel sheets and simple HTML maps packaged for use

VDH has a dashboard available upon request to allow interactive viewing

- https://arcgis.vdh.virginia.gov/portal/apps/opsdashboard/index.html#/8631cfc4f181460fafc7e1923f41d581
- Dashboard is restricted to VDH offices and those who VPN into the CoV Network



# References


Venkatramanan, S., et al. "Optimizing spatial allocation of seasonal influenza vaccine under temporal constraints." *PLoS Computational Biology* 15.9 (2019): e1007111.

Arindam Fadikar, Dave Higdon, Jiangzhuo Chen, Bryan Lewis, Srinivasan Venkatramanan, and Madhav Marathe. Calibrating a stochastic, agent-based model using quantile-based emulation. SIAM/ASA Journal on Uncertainty Quantification, 6(4):1685–1706, 2018.

Adiga, Aniruddha, Srinivasan Venkatramanan, Akhil Peddireddy, et al. "Evaluating the impact of international airline suspensions on COVID-19 direct importation risk." *medRxiv* (2020)

NSSAC. PatchSim: Code for simulating the metapopulation SEIR model. https://github.com/NSSAC/PatchSim

Virginia Department of Health. COVID-19 in Virginia. http://www.vdh.virginia.gov/coronavirus/

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

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


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

# Questions?

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