Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

June 8th, 2022

(data current to June 4th – June 7th)
Biocomplexity Institute Technical report: TR BI-2022-1547

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biocomplexity.virginia.edu

About Us

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

Points of Contact

Bryan Lewis
brylew@virginia.edu

Srini Venkatramanan
srini@virginia.edu

Madhav Marathe
marathe@virginia.edu

Chris Barrett
ChrisBarrett@virginia.edu

Model Development, Outbreak Analytics, and Delivery Team
Przemyslaw Porebski, Joseph Outten, Brian Klahn, Alex Telionis,
Srinivasan Venkatramanan, Bryan Lewis,
Aniruddha Adiga, Hannah Baek, Chris Barrett, Jiangzhuo Chen, Patrick Corbett,
Stephen Eubank, Galen Harrison, Ben Hurt, Dustin Machi, Achla Marathe,
Madhav Marathe, Mark Orr, Akhil Peddireddy, Erin Raymond, James Schlitt, Anil Vullikanti,
Lijing Wang, James Walke, Andrew Warren, Amanda Wilson, Dawen Xie

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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

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Key Takeaways

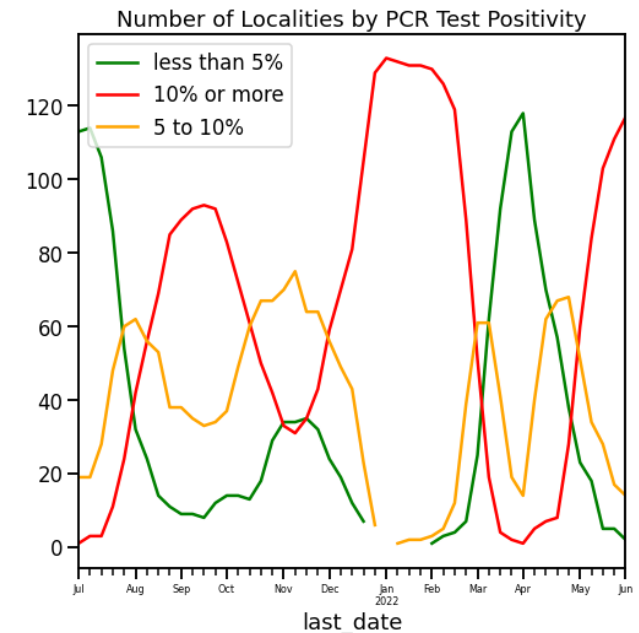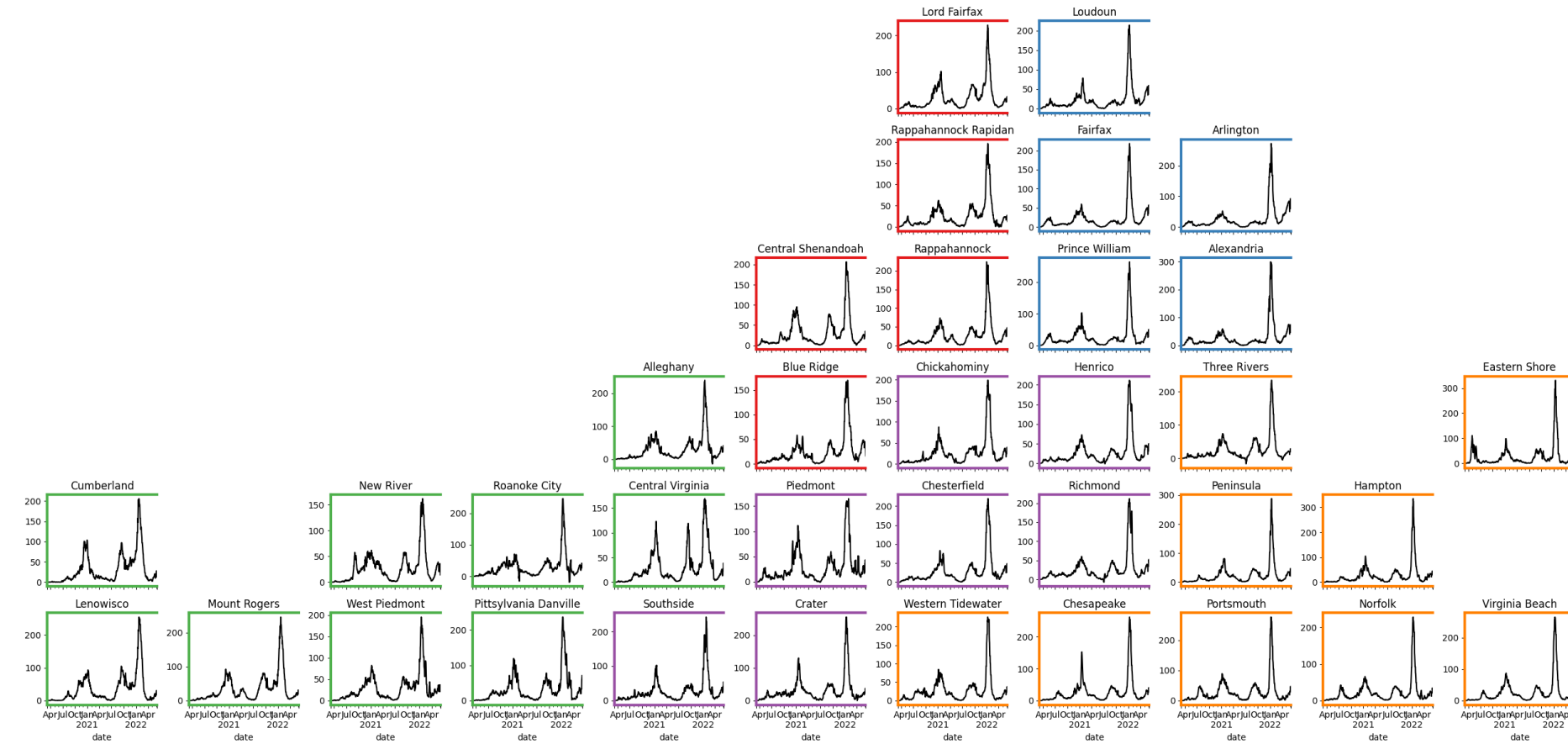Projecting future cases precisely is impossible and unnecessary.

Even without perfect projections, we can confidently draw conclusions:

- **Case rates remain high but may have plateaued, hospitalizations have risen**

- VA 7-day mean daily case rate slightly down to 35/100K from 37/100K

  - US remains relatively flat at 37/100K from 36/100K

  - VA hospital occupancy (rolling 7 day mean of 574) continues to rise, though may be entering a plateau

- Projections anticipate future growth in cases, with potential for growth to continue for several weeks:

  - VA case rates have slowed since last projection

  - Rise in hospitalizations tracking cases

- 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

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Case Rates (per 100k) and Test Positivity

Number of Localities by PCR Test Positivity
- less than 5%
- 10% or more
- 5 to 10%

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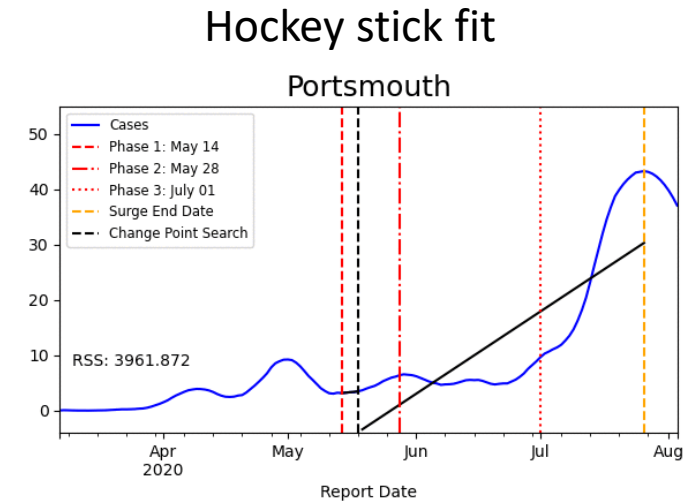
Trajectory	Description	Weekly Case Rate (per 100K) bounds
Declining	Sustained decreases following a recent peak	below -0.9
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5
In Surge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

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District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	11 (7)
Plateau	6 (3)
Slow Growth	8 (4)
In Surge	10 (21)

Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
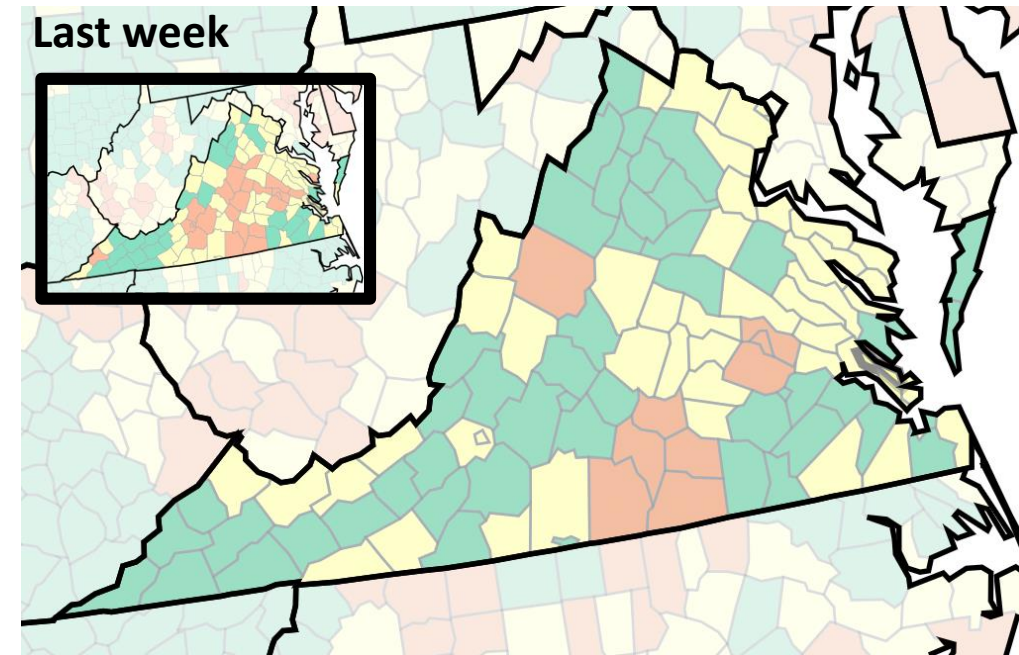Case Rate curve colored by Reproductive number
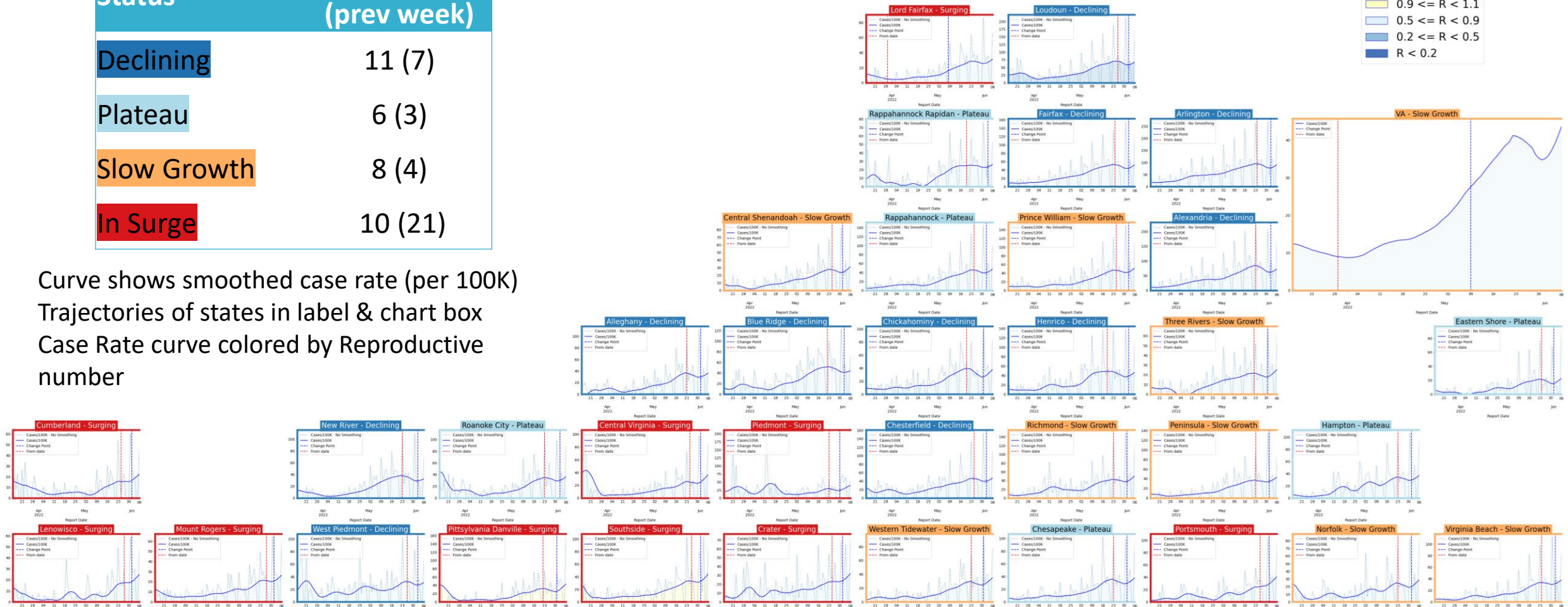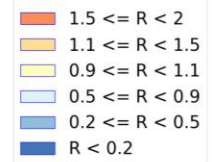
CDC's new COVID-19 Community Levels

What Prevention Steps Should You Take Based on Your COVID-19 Community Level?
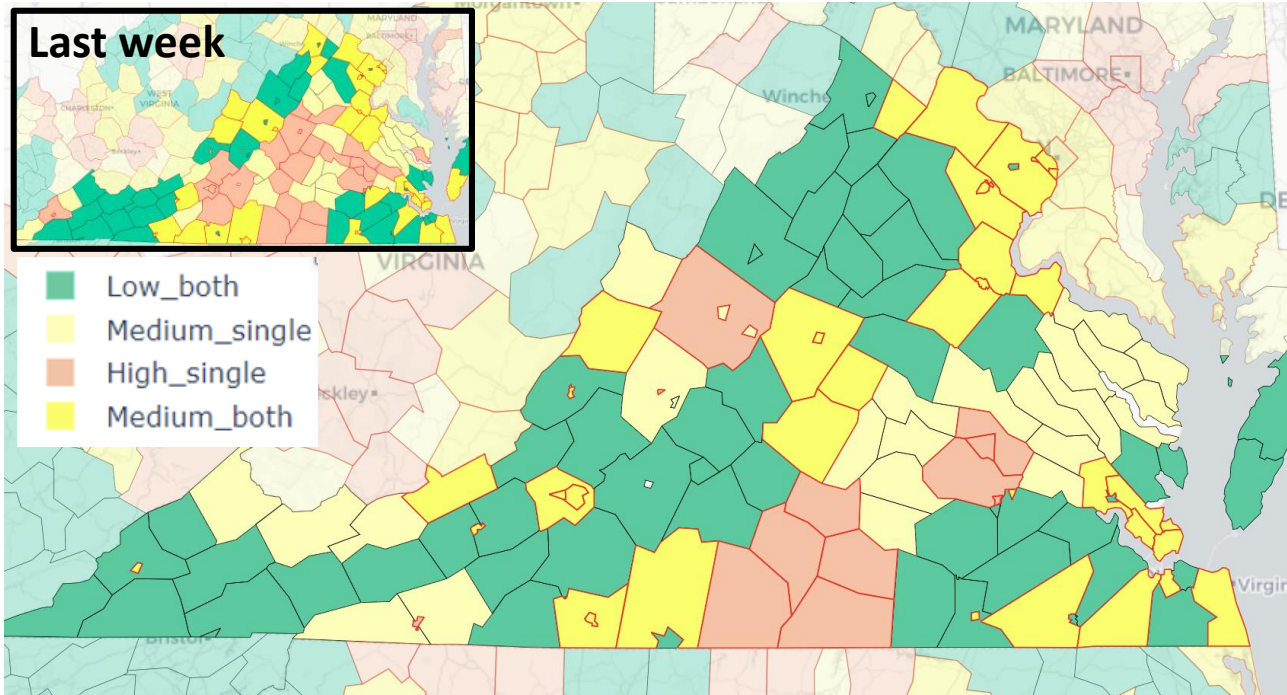
Low	Medium	High
• Stay up to date with COVID-19 vaccines • Get tested if you have symptoms	• If you are at high risk for severe illness, talk to your healthcare provider about whether you need to wear a mask and take other precautions • Stay up to date with COVID-19 vaccines • Get tested if you have symptoms	• Wear a mask indoors in public • Stay up to date with COVID-19 vaccines • Get tested if you have symptoms • 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
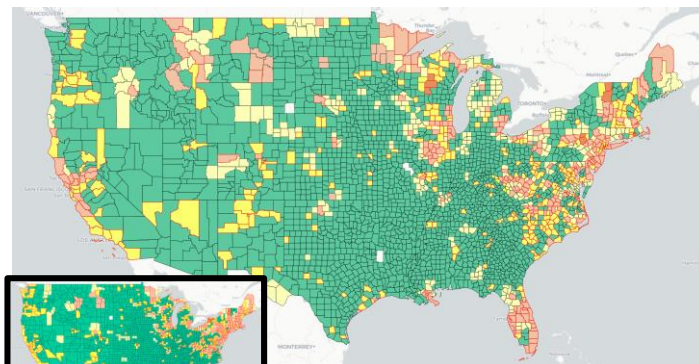

Last week

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CDC Data Tracker Portal

CDC's new COVID-19 Community Levels

Last week

Legend:
- Low_both
- Medium_single
- High_single
- Medium_both

VA

USA

Last week

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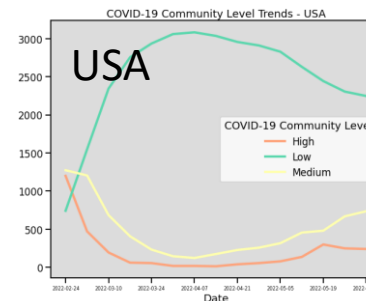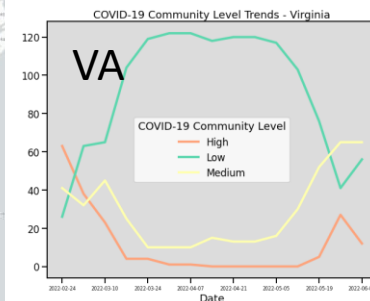
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Red outline indicates county had 200 or more cases per 100k in last week

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

Data from: CDC Data Tracker Portal

District Trajectories with Community Levels

Community Level (Title Color):
- High (Red)
- High-Med (Orange)
- Med-High (Light Orange)
- Medium (Yellow)
- Med-Low (Light Blue)
- Low-Med (Blue)
- Low (Dark Blue)

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

Trajectory (Curve Shading):
- In Surge
- Slow Growth
- Plateau
- Declining

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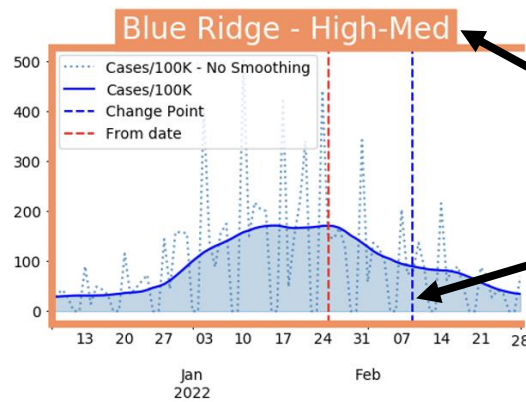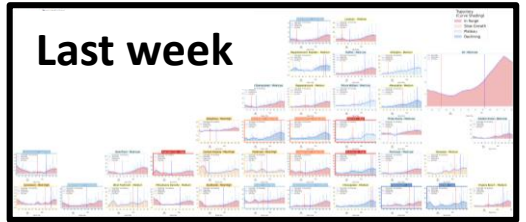
District's Aggregate Community Level
Aggregate level a simple mean of all levels for counties in district

Case rate Trajectory

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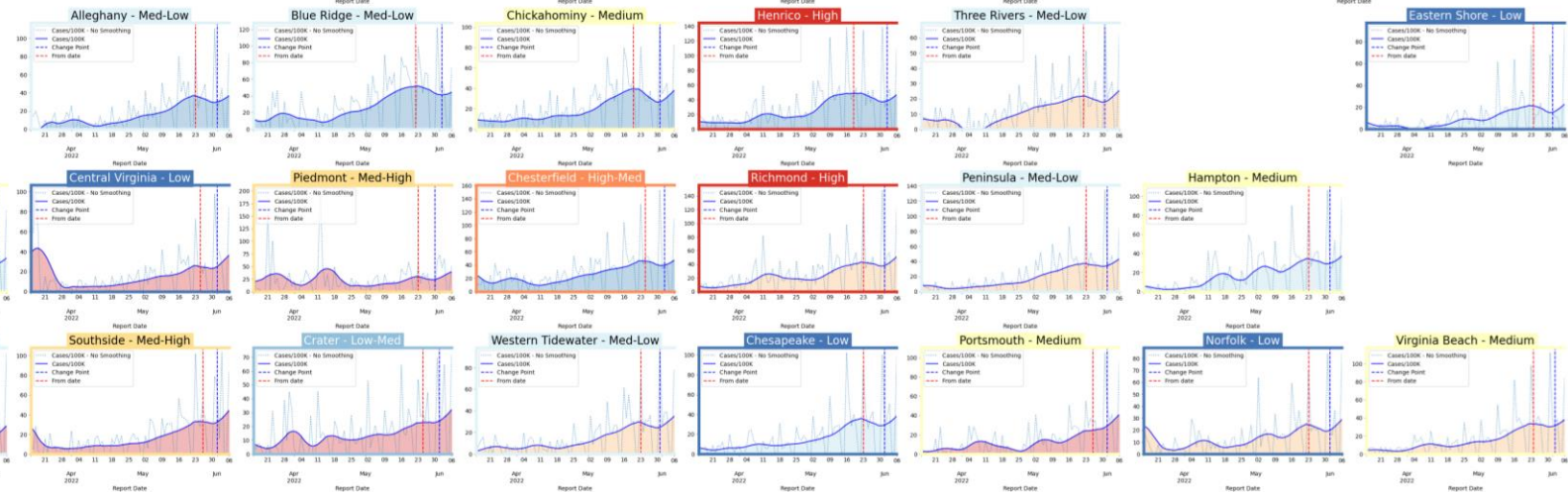
Estimating Daily Reproductive Number –
Redistributed gap

June 6th Estimates

Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.977	0.100
Central	1.000	0.122
Eastern	1.016	0.086
Far SW	0.998	0.089
Near SW	1.014	0.157
Northern	0.950	0.072
Northwest	0.926	0.131

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

VA state-wide RE with 7 day moving window by confirmation date redistributed GT 2022-06-06

VA RE by VHASS region with 7 day moving window by confirmation date redistributed GT 2022-06-06
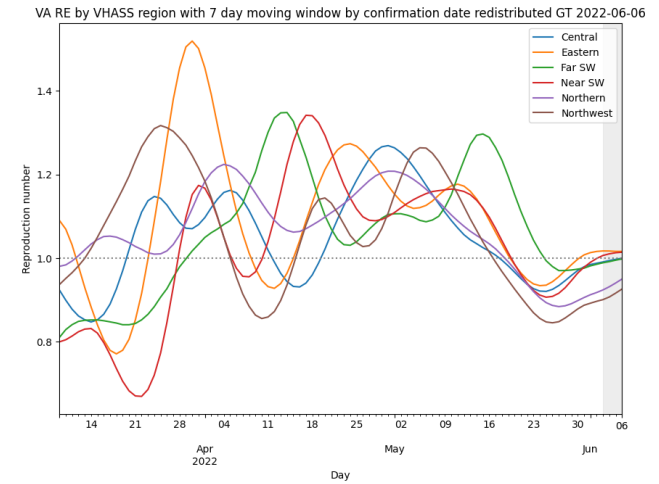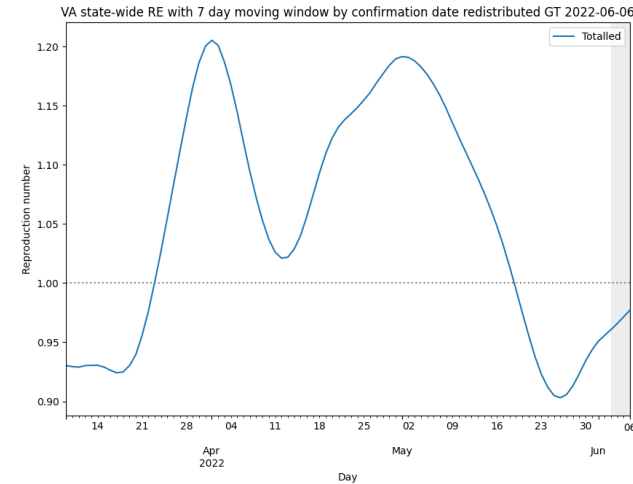
Skipping Weekend Reports & holidays biases estimates
Redistributed "big" report day to fill in gaps, and then estimate R from "smoothed" time series
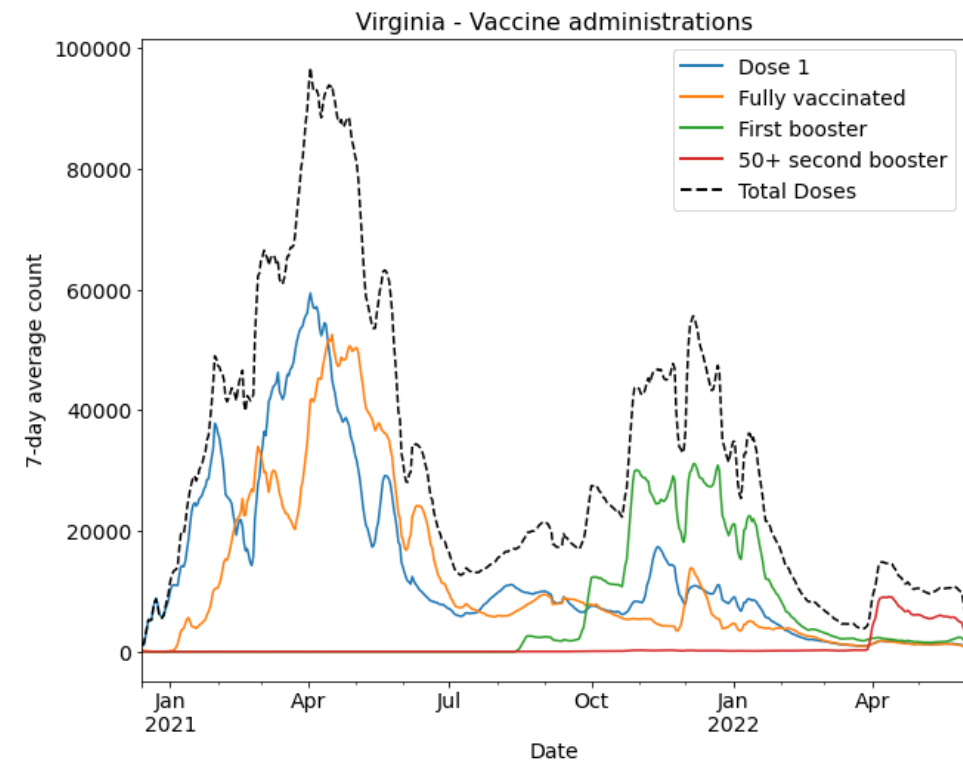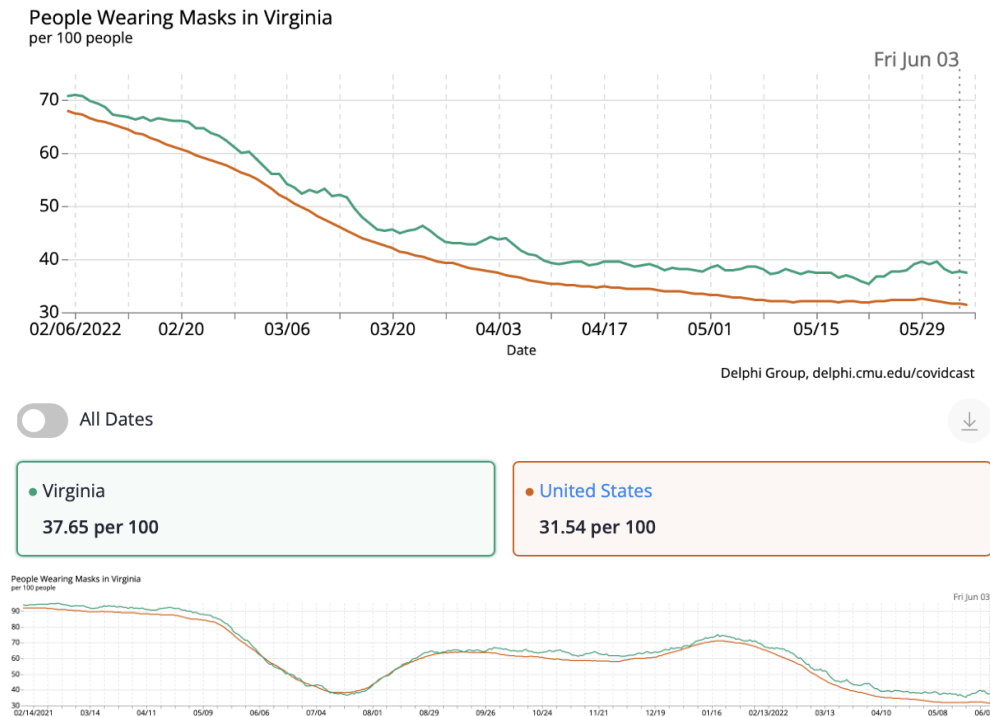

Virginia
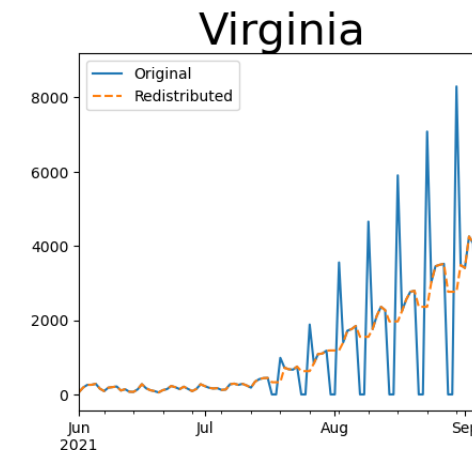
Mask Usage and Vaccination

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

As of June 1st, 2022

Wastewater Monitoring

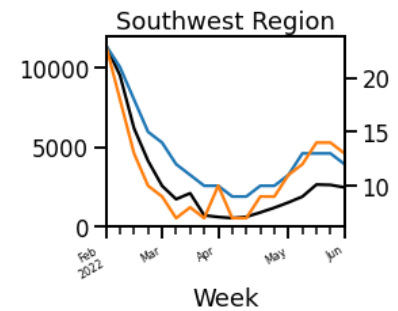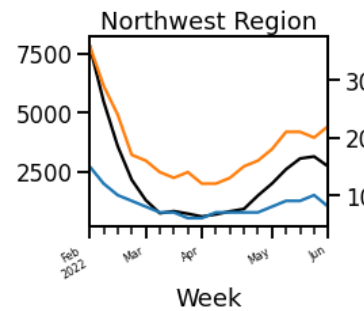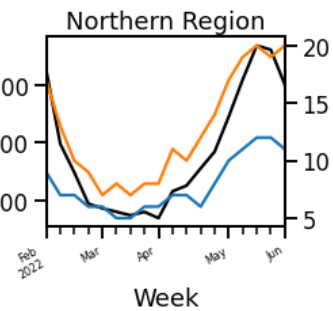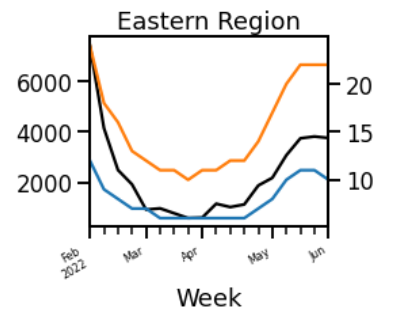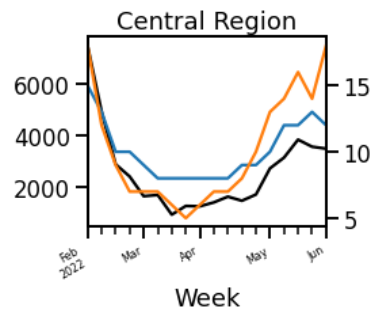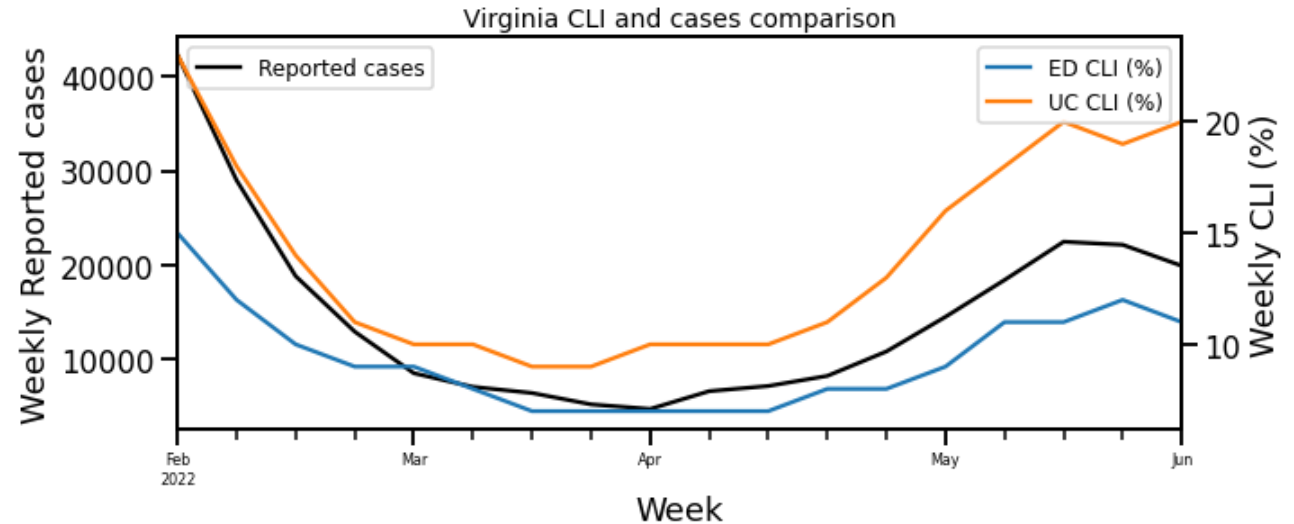**Wastewater provides a coarse early warning of COVID-19 levels in communities**

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

Data Source: CDC Data Tracker

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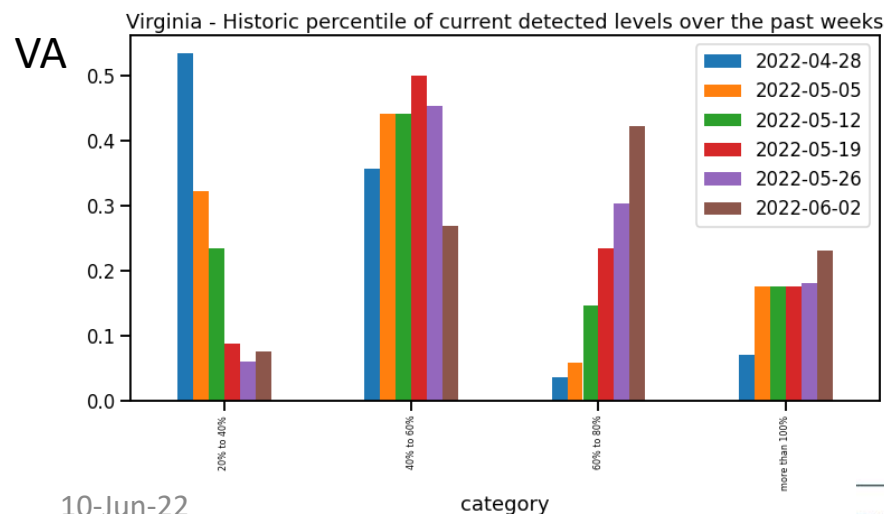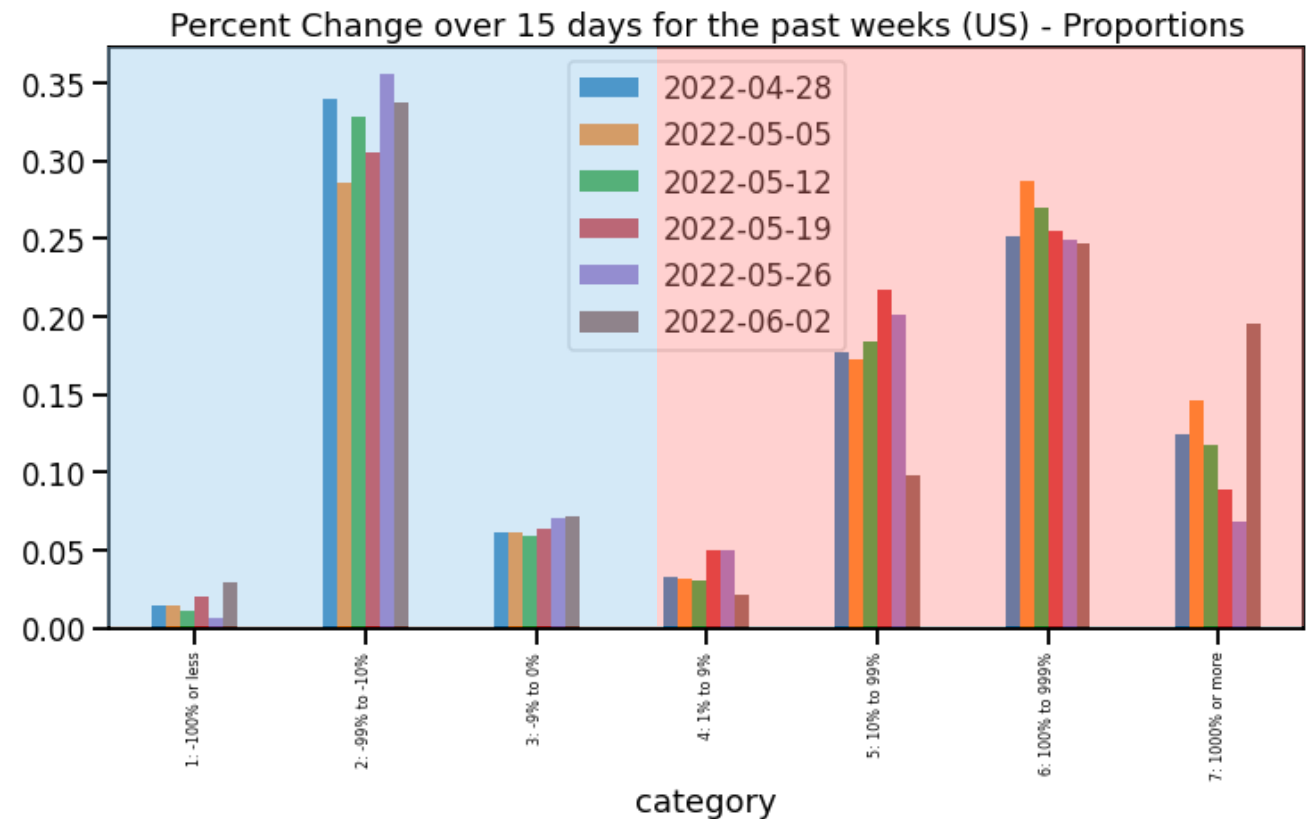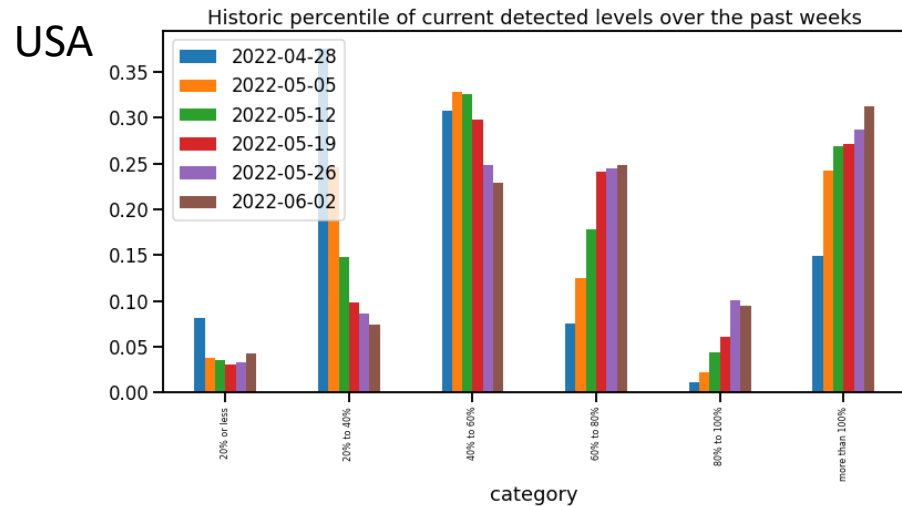
COVID-like Illness Activity

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 three weeks state-wide, mixed by region**

Virginia CLI and cases comparison

Central Region | Eastern Region | Northern Region | Northwest Region | Southwest 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
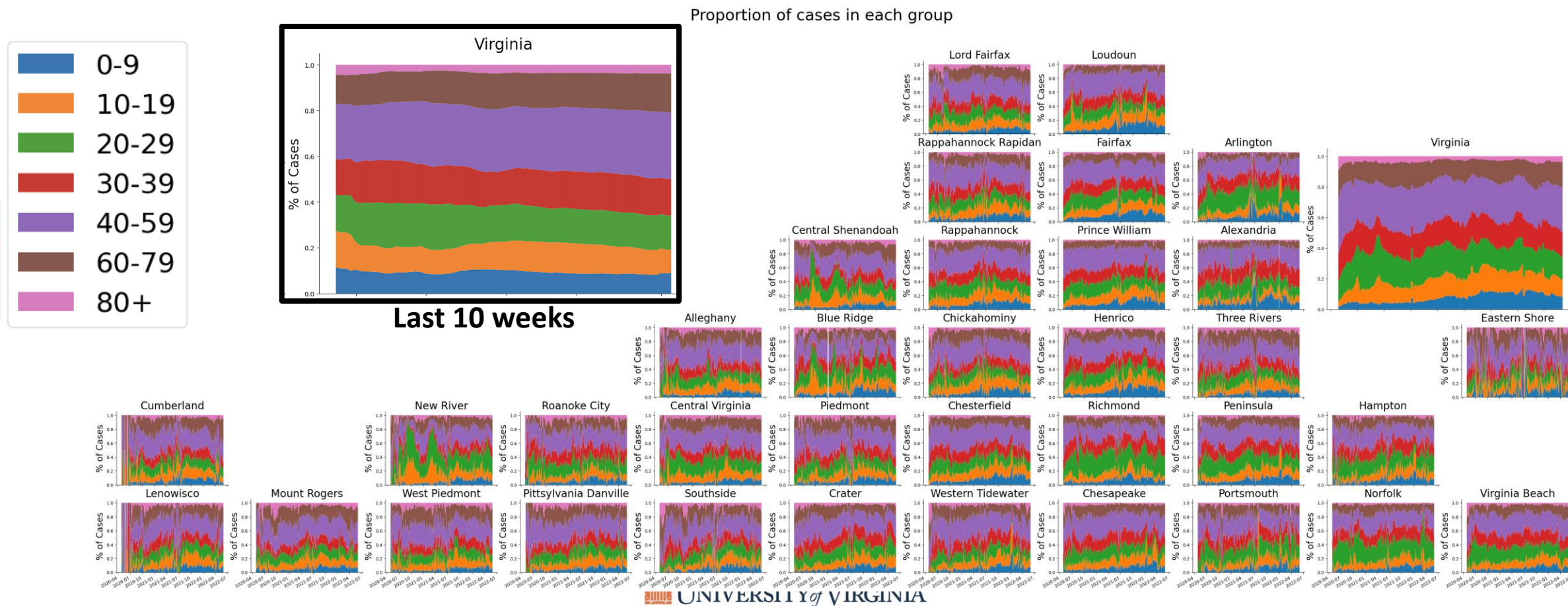
SARS-CoV2 Variants of Concern

Emerging new variants will alter the future trajectories of pandemic and have implications for future control
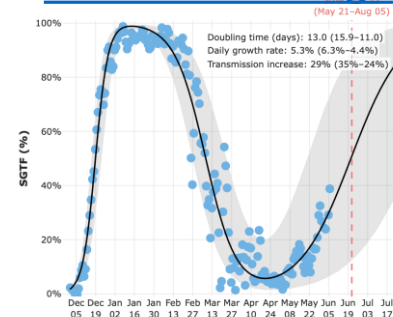
- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations

Omicron Updates

- BA.2.12.1 growth has stagnated, remaining in the 60-70% prevalence range for the last 3 weeks (Region 3)

- BA.4 growing rapidly, nowcasted at 7% (up from 4% last week)

- BA.5 also growing rapidly, nowcasted at 4% (up from 2% 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

SGTF in San Diego

Estimated 50% on June 22nd, with wide bounds

CDC Variant Tracking

SARS-CoV2 Omicron and Sub-Variants

As detected in whole Genomes in public repositories
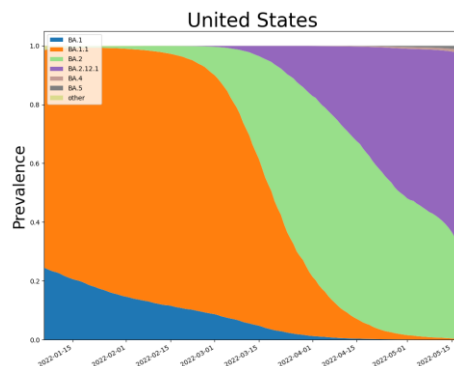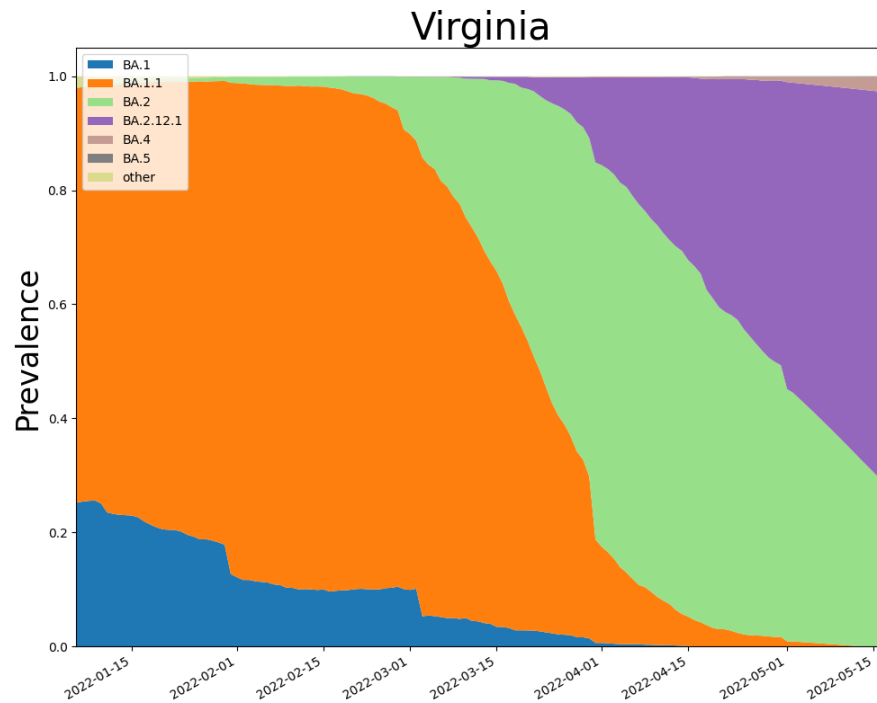
VoC Polynomial Fit Projections
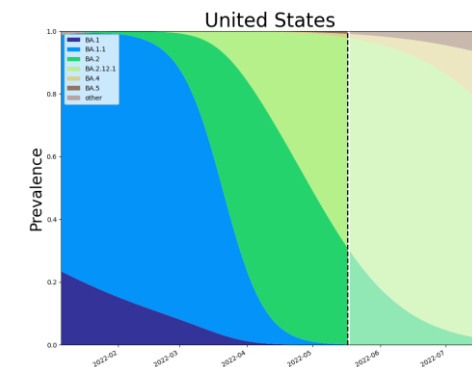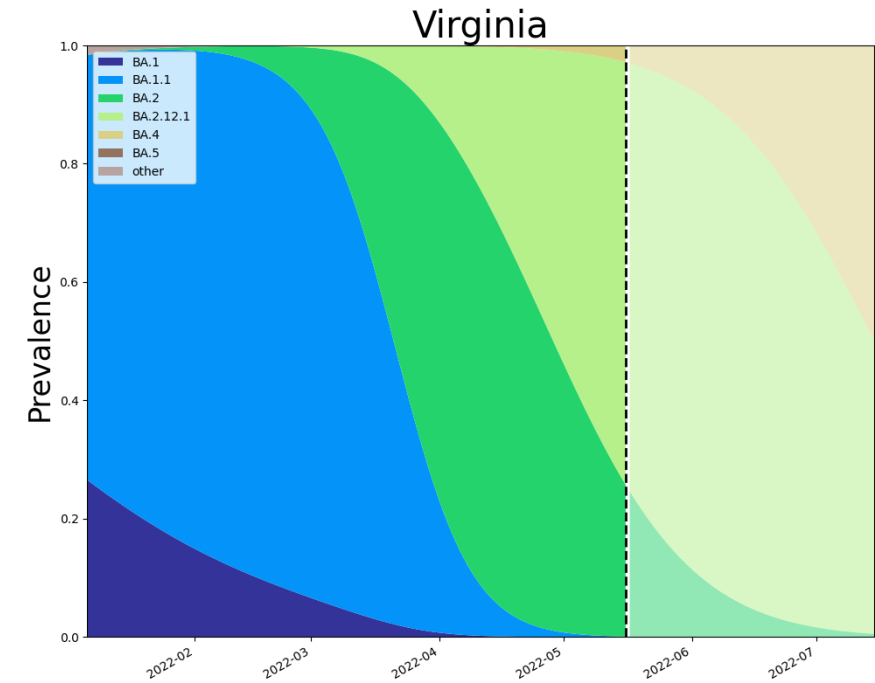
Note: Data lags force projections to start in past. Everything from dotted line forward is a projection.

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Pandemic Pubs

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

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
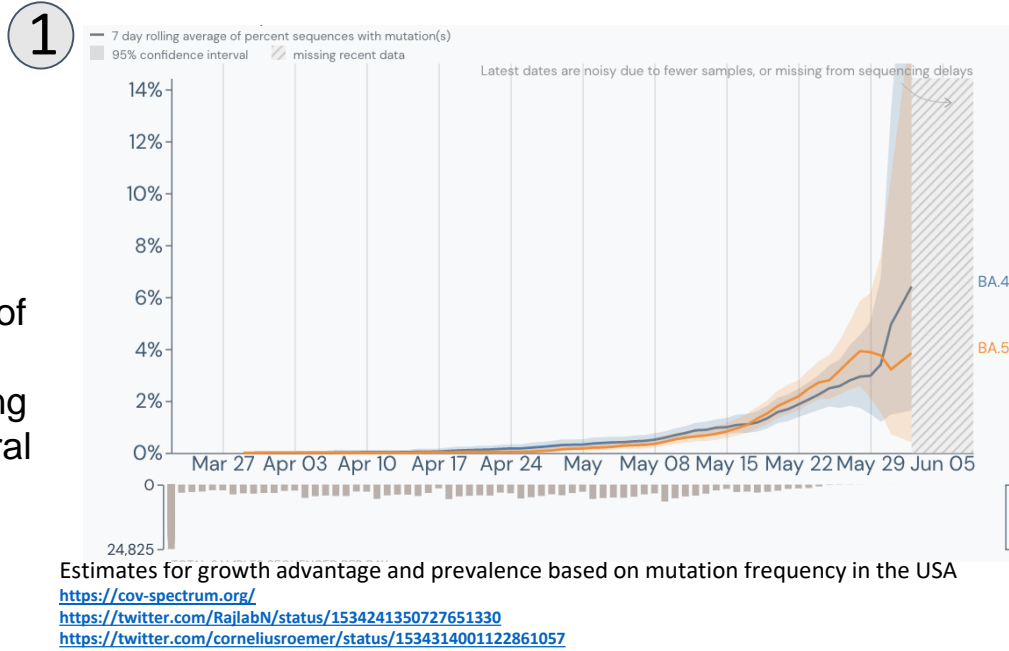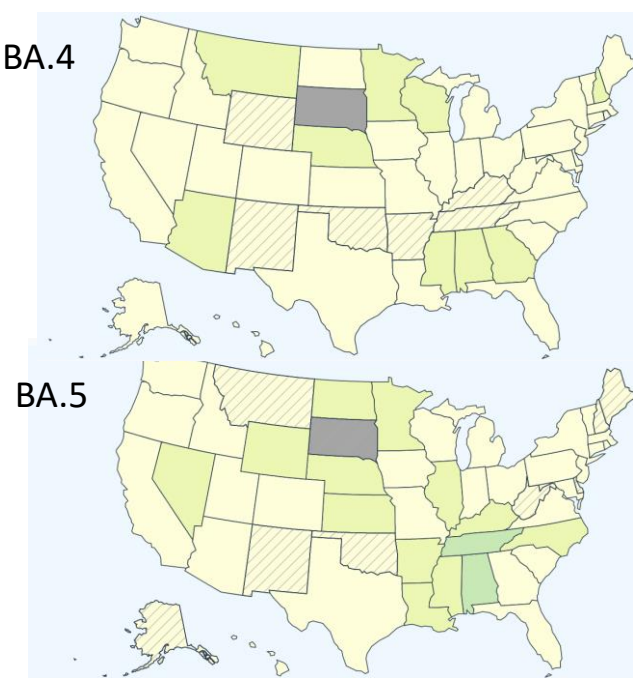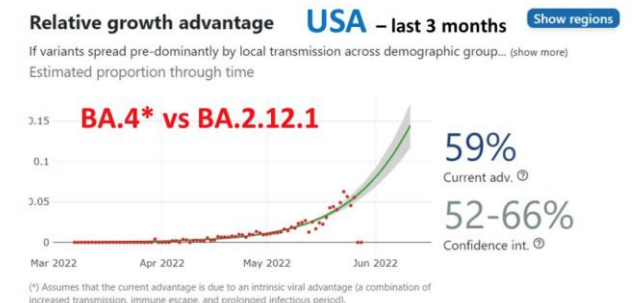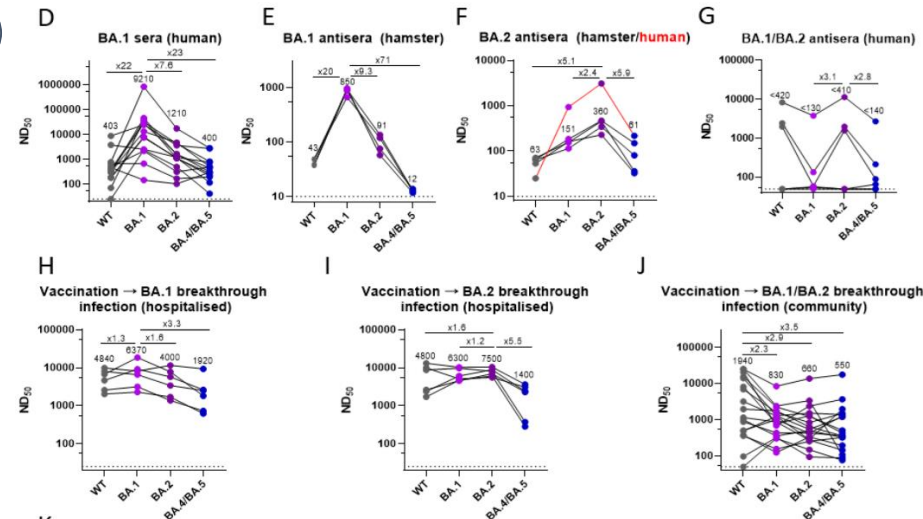
"Sera collected post vaccination have a similar ability to neutralise BA.1, BA.2 and BA.4/BA.5. In contrast, in the absence of vaccination, prior infection with BA.2 or, in particular, BA.1 results in an antibody response that neutralises BA.4/BA.5 poorly. Breakthrough infection with Omicron in vaccinees 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

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

Relative growth advantage **USA** – last 3 months
If variants spread pre-dominantly by local transmission across demographic group... (show more)
Estimated proportion through time

BA.5* vs BA.2.12.1

108% Current adv.
95-120% Confidence int.

Relative growth advantage **USA** – last 3 months
If variants spread pre-dominantly by local transmission across demographic group... (show more)
Estimated proportion through time

BA.4* vs BA.2.12.1

59% Current adv.
52-66% Confidence int.
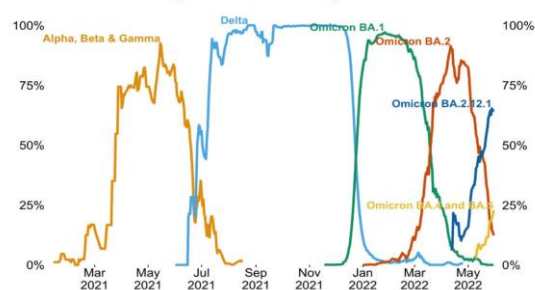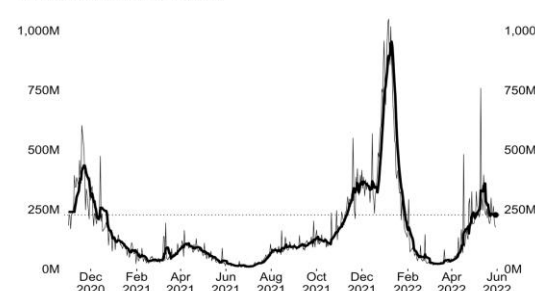
Pandemic Pubs (last week)

1. Mt. Sinai documents BA.1 immunocompromised infection, accumulation of eight AA substitutions over 12 weeks and likely onward transmission in the same health system.
2. Refresher: the stages of Covid-19 go well beyond a 5 day process.
3. Recent estimates of Rt using sequence surveillance place BA.4 and BA.5 as both having a growth advantage over BA.2.12.1
4. Vaccines reduce but do not eliminate risk of Long COVID

The majority of amino acid changes occur at positions known to confer either immune escape or altered viral fusogenicity, some of the mutations have rarely been seen in other lineages, and represent a unique combination. Highlights need to limit spread and employ therapeutic strategies to limit duration of infection.
https://www.medrxiv.org/content/10.1101/2022.05.25.22275533v1

This 2021 article from researchers and medical professionals across the country highlights the phases of infection and the challenges posed by the timeline for exposure to infection. **One important note is that symptoms often present earlier than shown here.**
https://www.aidsreviews.com/get.php?x=aids_21_23_1_040-047.pdf&dp=0
https://twitter.com/danielgriffinmd/status/1531447216493174789

Researchers in St. Louis found that vaccines reduce Long COVID risk by 15% with the largest risk reduction in blood clots and pulmonary sequelae but less protection of other organ systems in Breakthrough Infections (BtI).
https://twitter.com/virusesimmunity/status/1529691455866155009?s=12&t=URVOvQl-fZSKAhfsNb9xMg
https://www.nature.com/articles/s41591-022-01840-0

Risk and 6-month excess burden of post-acute sequelae in those with BtI by acute phase care setting.

Risk and 6-month excess burden of post-acute sequelae in those with BtI compared to those with SARS-CoV-2 infection without prior vaccination by acute phase care setting.

33,940 individuals with BTI and several controls of people without evidence of SARS-CoV-2 infection, including contemporary (n = 4,983,491), historical (n = 5,785,273) and vaccinated (n = 2,566,369) controls.
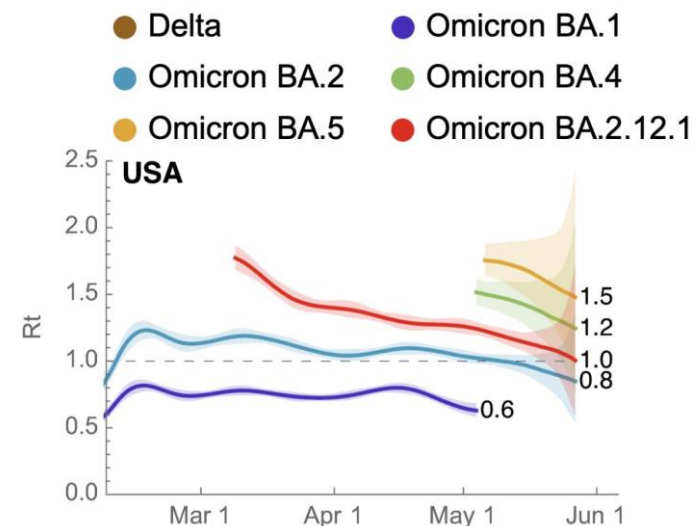
The transmission advantage, estimated from US surveillance, may stem from immune escape mutations that make it more resilient to neutralization provided by vaccination and prior infection.
https://twitter.com/trvrb/status/1530649638277029888

United States Case Rates

- Rebounding activity, mainly in the Northeast

Trajectories of States
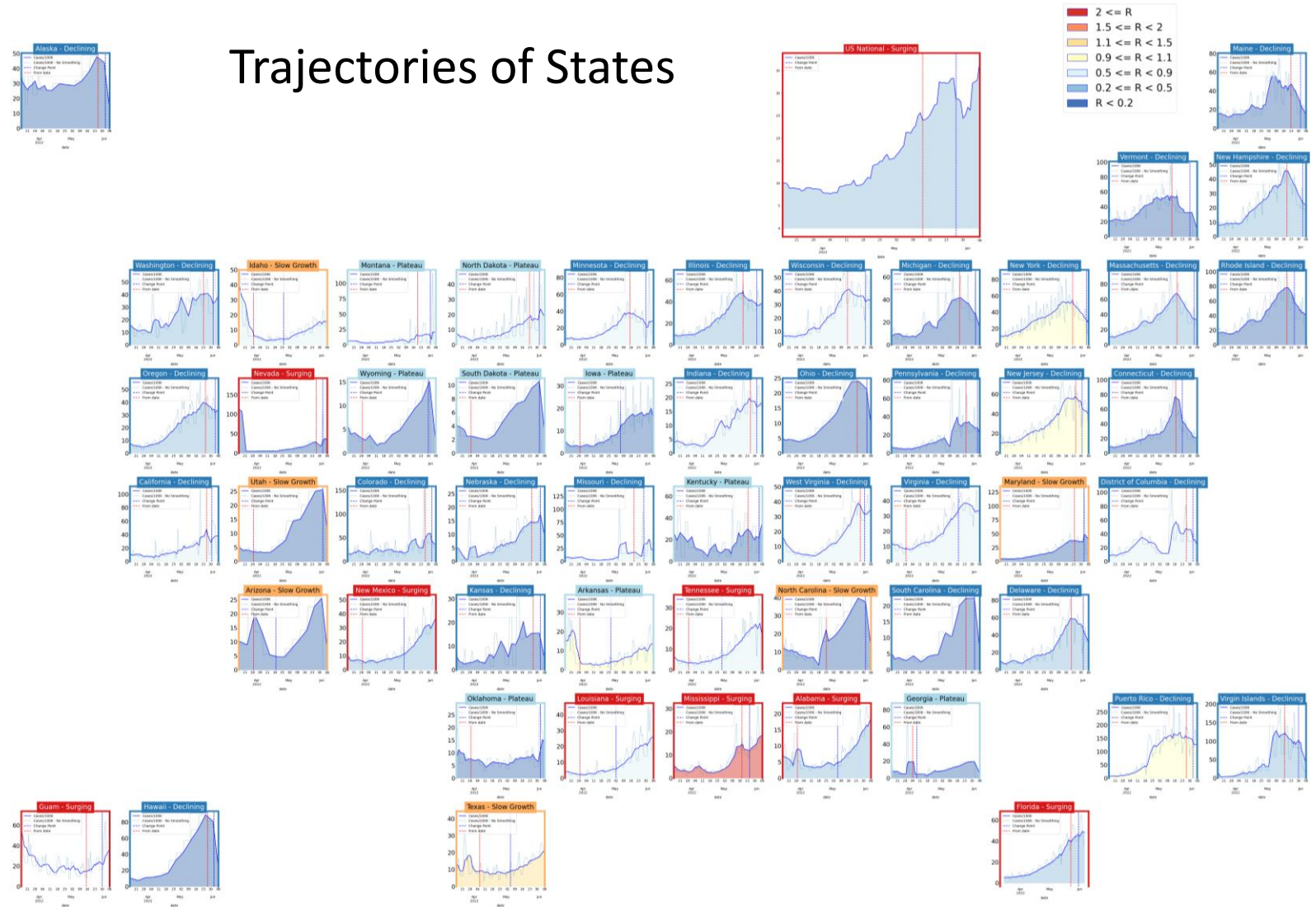
Status	# States
Declining	31 (25)
Plateau	9 (10)
Slow Growth	6 (8)
In Surge	8 (11)

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Virginia and Her Neighbors

- Most states are in surge
- Some signs of slowing growth
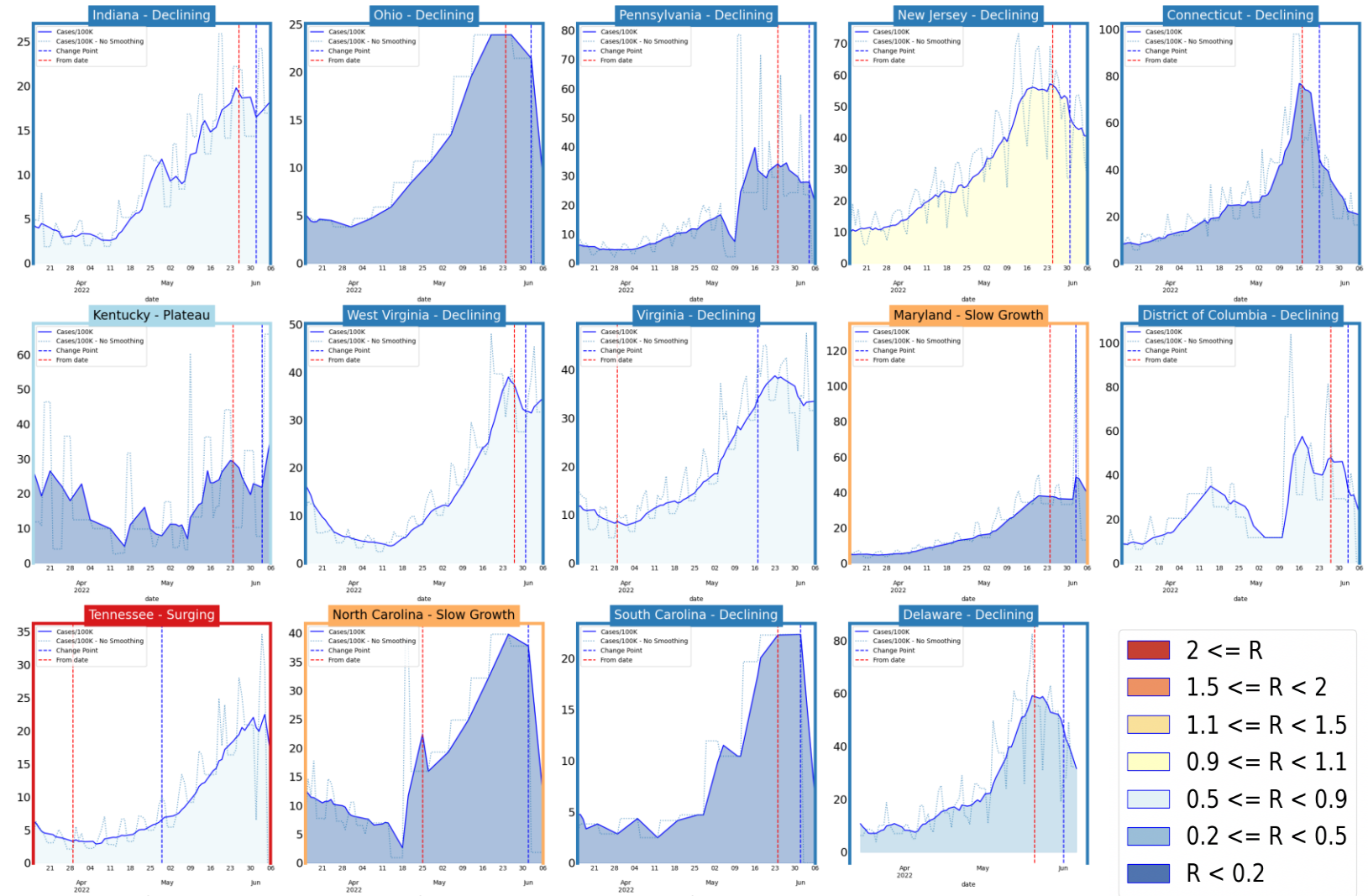
United States Hospitalizations

- Hospital admissions are lagging case rates, and have mainly entered plateaus
- Rebounds in the Northeast seen with some rising hospitalization rates
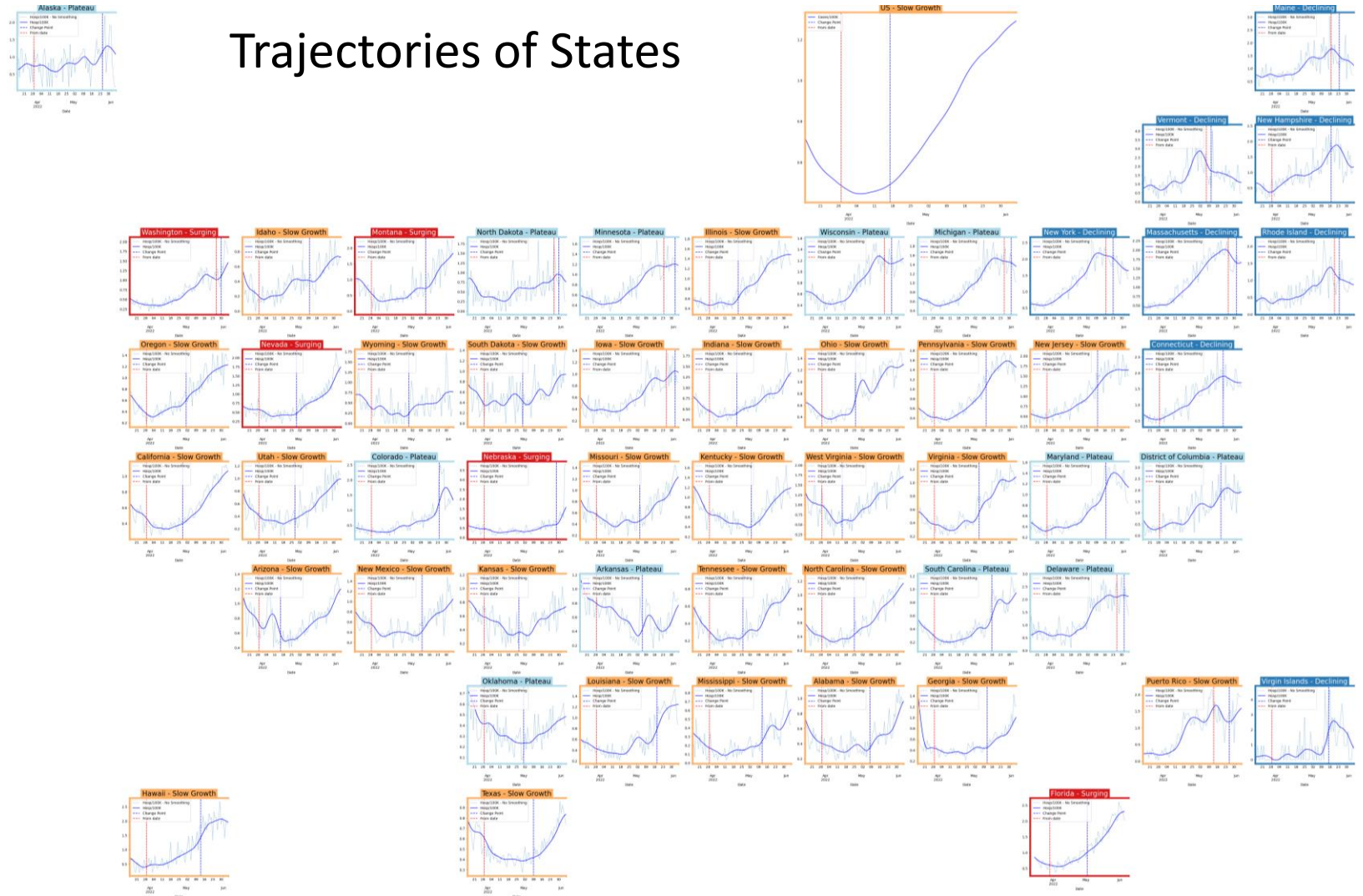
Status	# States
Declining	8 (6)
Plateau	12 (6)
Slow Growth	28 (32)
In Surge	5 (9)

Trajectories of States

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

Confirmed cases

Hospitalizations

Daily new confirmed COVID-19 cases per million people

7-day rolling average. Due to limited testing, the number of confirmed cases is lower than the true number of infections.

Portugal
United States
Austria
Switzerland
United Kingdom
Netherlands
South Africa

Jul 1, 2021 Sep 12, 2021 Dec 21, 2021 Jun 8, 2022
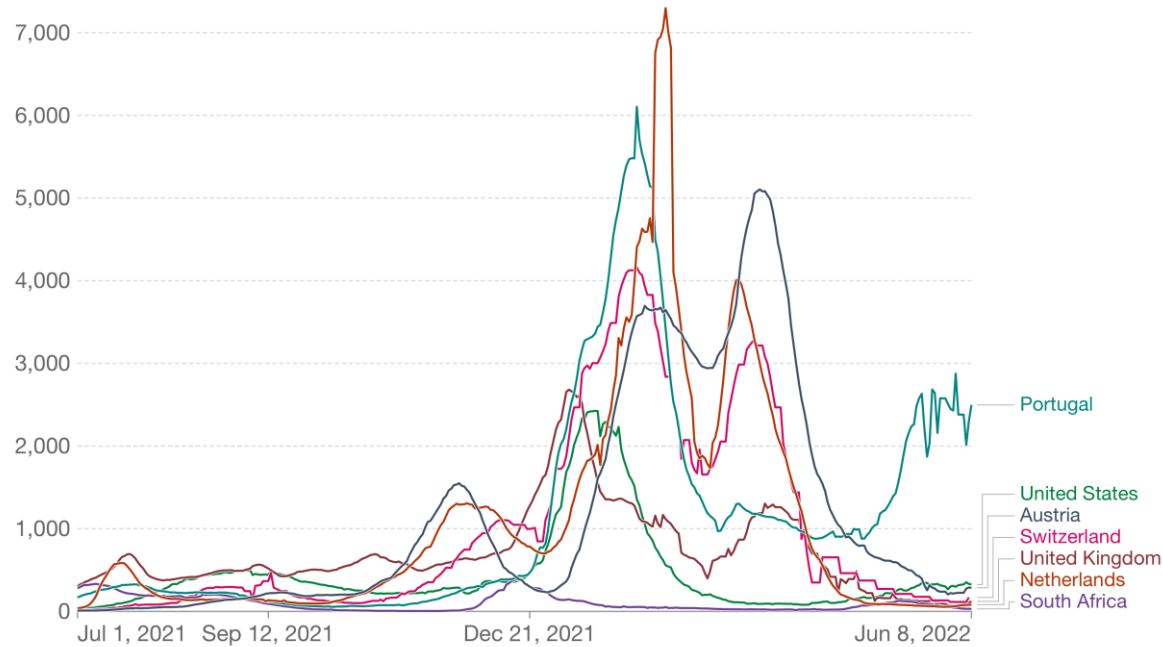
Source: Johns Hopkins University CSSE COVID-19 Data

Number of COVID-19 patients in hospital per million people

Portugal
United States
United Kingdom
Austria
South Africa
Switzerland
Netherlands

Jul 1, 2021 Sep 12, 2021 Dec 21, 2021 Jun 8, 2022
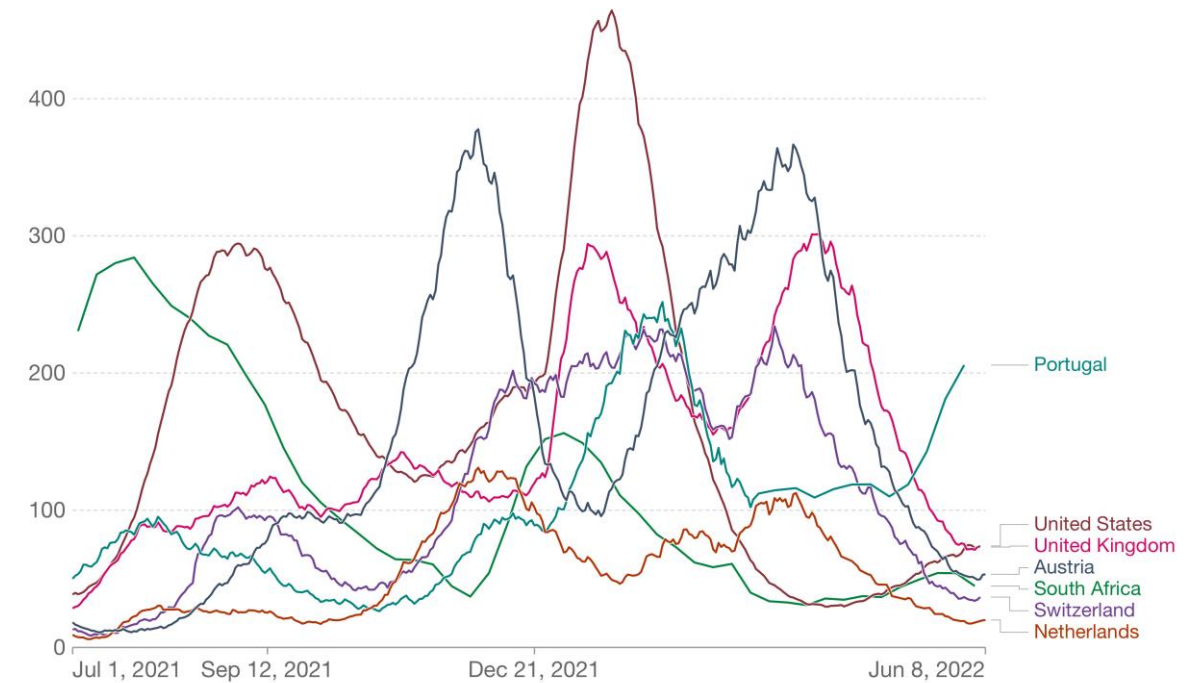
Source: Official data collated by Our World in Data

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Our World in Data

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County-level comparison to previous highest peak

Recent Incidence Compared to Worst Week by County

Last week

Proportion of Last Week's Incidence to that of Worst Week

Recent Incidence Compared to Worst Week by County

Last week

Proportion of Last Week's Incidence to that of Worst Week

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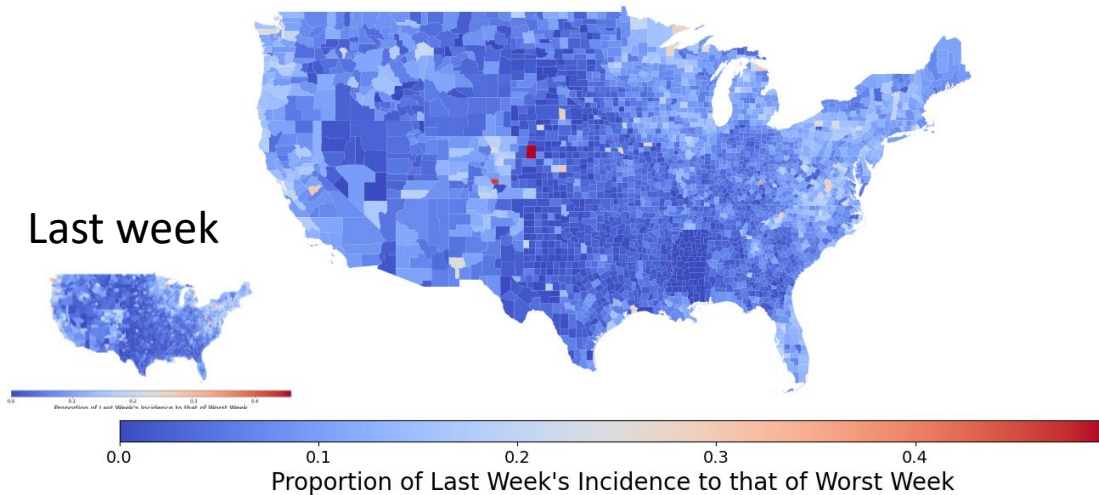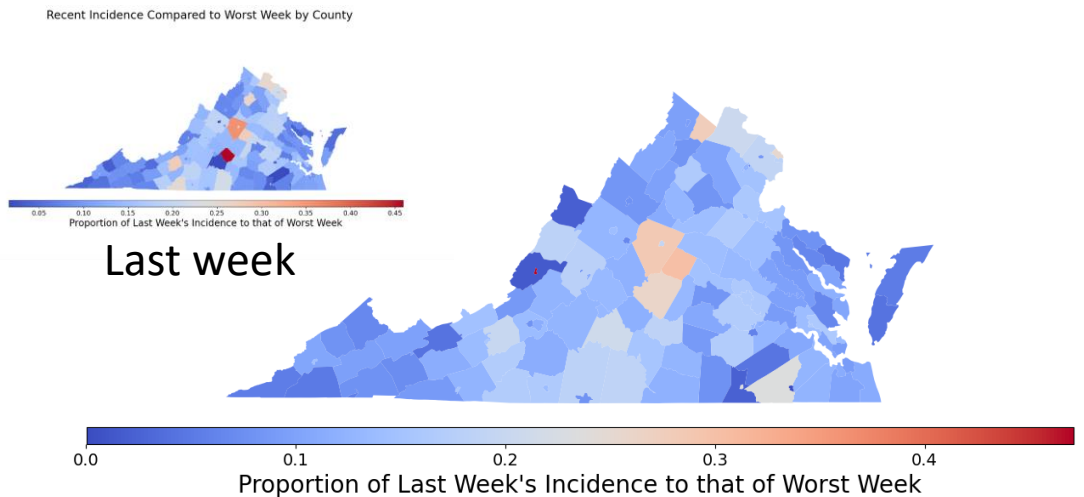
County-level comparison to last Summer

- 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

Recent Incidence Compared to Weekly Summer Mean by County
Mean: 11.71; Median: 1.59; IQR: 0.61-4.0

Last week

Proportion of Last Week's Incidence to that of Weekly Summer Mean
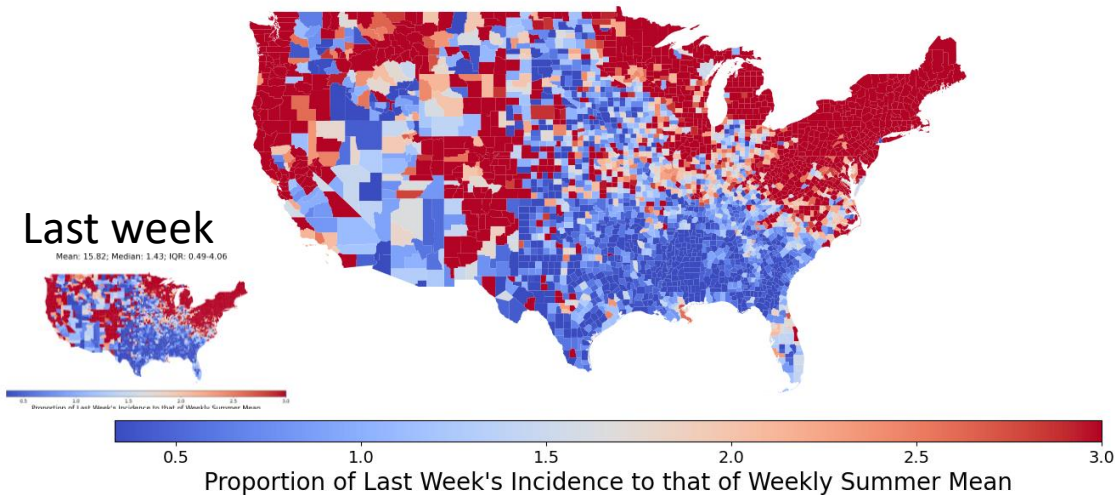
Recent Incidence Compared to Weekly Summer Mean by County
Mean: 4.36; Median: 2.92; IQR: 2.01-4.87

Last week

Proportion of Last Week's Incidence to that of Weekly Summer Mean

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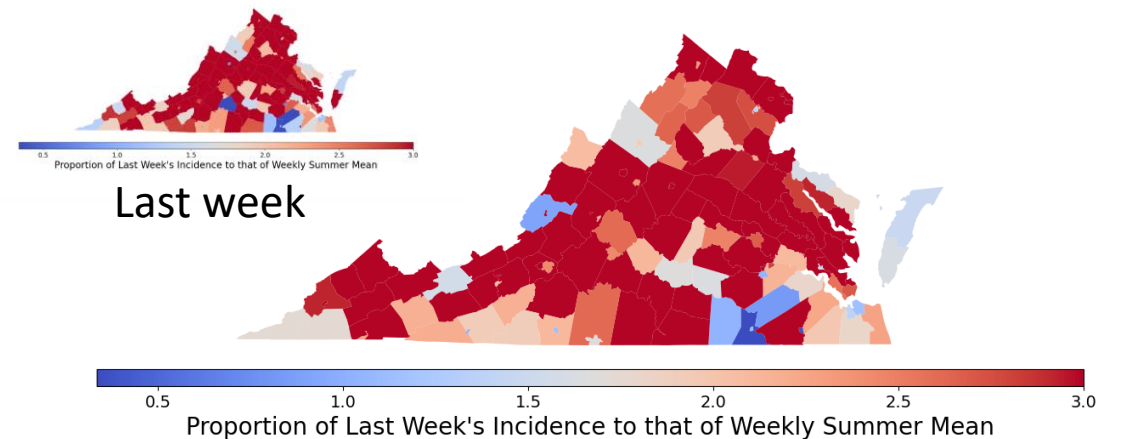
Zip code level weekly Case Rate (per 100K)

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	23936	Dillwyn*	1,790	Beyond Scale
2	23075	Henrico	1,540	
3	20166	Sterling	1,450	
4	24557	Gretna	1,420	
5	23974	Victoria*	1,310	
6	24520	Alton	1,290	
7	24594	Sutherlin	1,280	
8	23924	Chase City	1,230	
9	24473	Rockbridge Baths	1,210	
10	24534	Clover	1,180	

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

Point Prevalence by Zip Code
(2022-06-06)
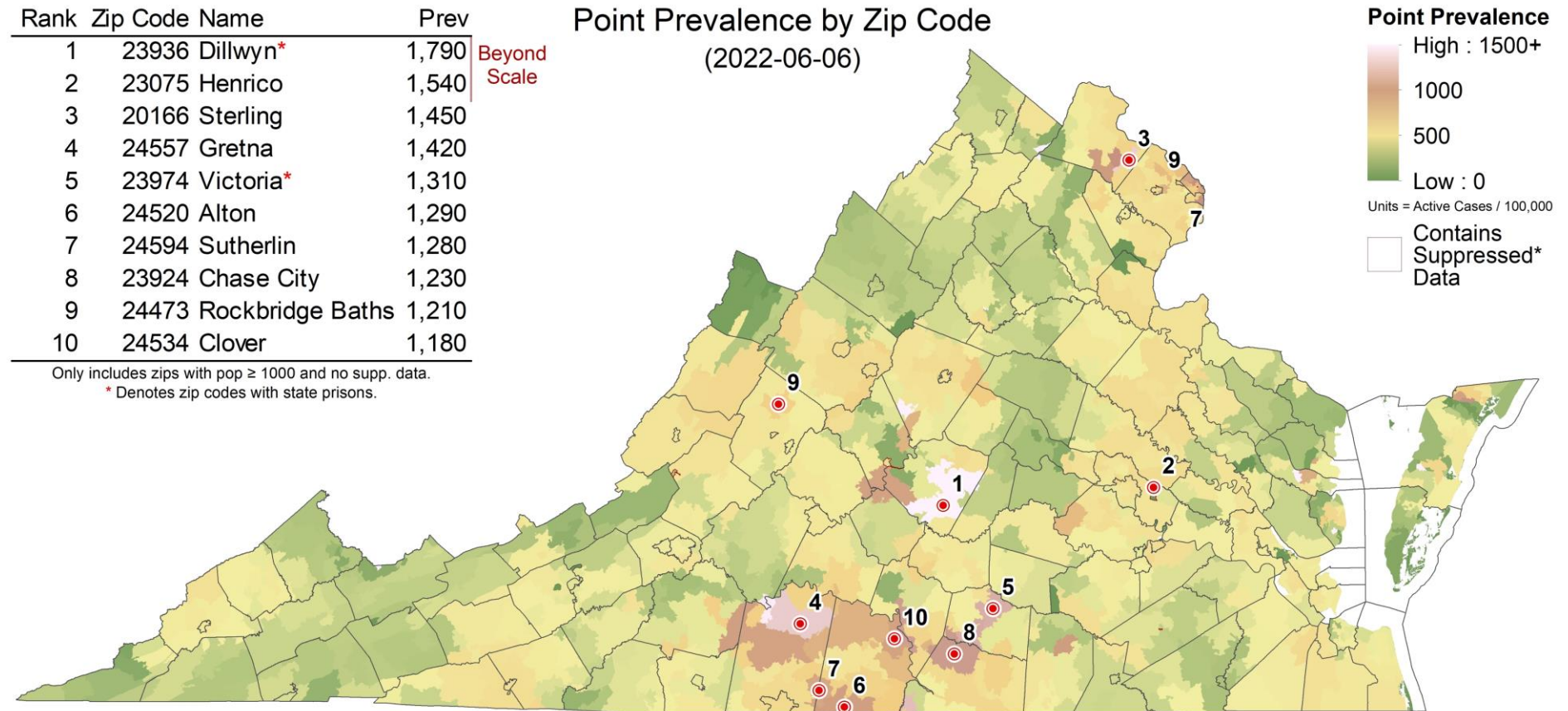
Point Prevalence
High : 1500+
1000
500
Low : 0
Units = Active Cases / 100,000

Contains Suppressed* Data

Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-06-06.
Note: Values based on an 11% inflated six-day average due to a lack of reporting on Memorial Day.

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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	23936	Dillwyn*	43
2	23075	Henrico	50
3	20166	Sterling	53
4	24557	Gretna	54
5	23974	Victoria*	58
6	24520	Alton	60
7	24594	Sutherlin	60
8	23924	Chase City	62
9	24473	Rockbridge Baths	63
10	24534	Clover	65

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

Group Size Needed for 50% Likelihood of ≥1 Infected

Group Size
High : 450+
390
330
270
210
150
90
Low : 30

Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-06-06.
Note: Values based on an 11% inflated six-day average due to a lack of reporting on Memorial Day.

Rank	Name	Ratio
1	Dickenson County	3.2
2	Nottoway County	3.0
3	Martinsville City	2.6
4	Essex County	2.5
5	Smyth County	2.4
6	Buena Vista City	2.3
7	Scott County	2.3
8	Northampton County	2.2
9	Mathews County	2.1
10	Grayson County	1.9

HCW Prevalence / Case Prevalence (2022-06-06)

Prevalence Ratio
Higher HCW Prev
5 : 1
4 : 1
3 : 1
2 : 1
1 : 1
1 : 2
1 : 3
1 : 4
1 : 5
Higher Case Prev
NaN

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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
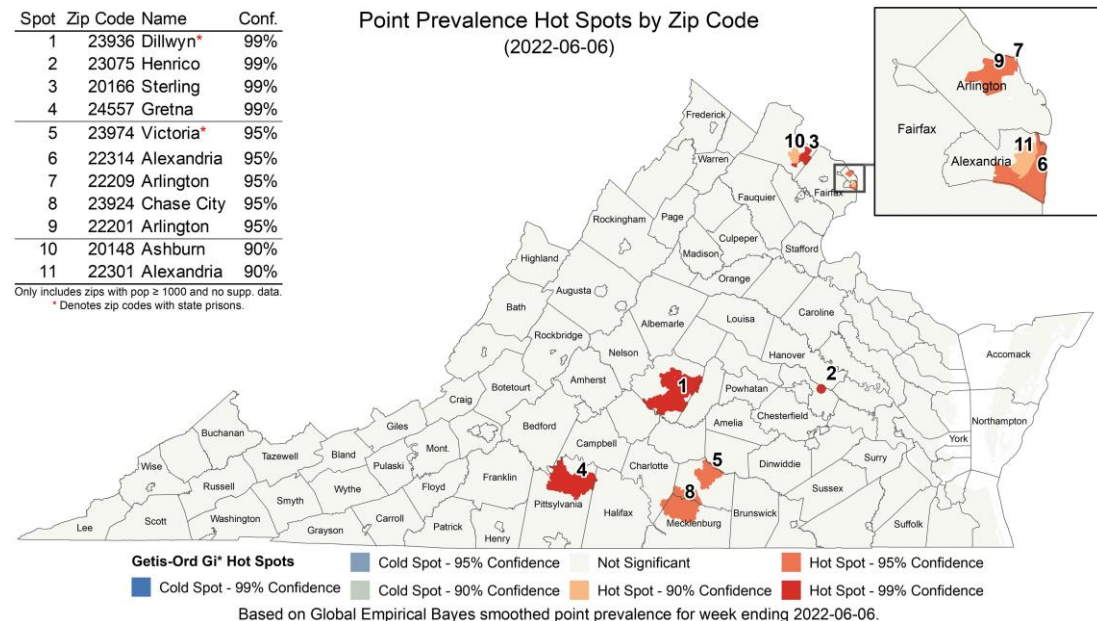
Clustered Temporal Hotspots from BA.2.12.1

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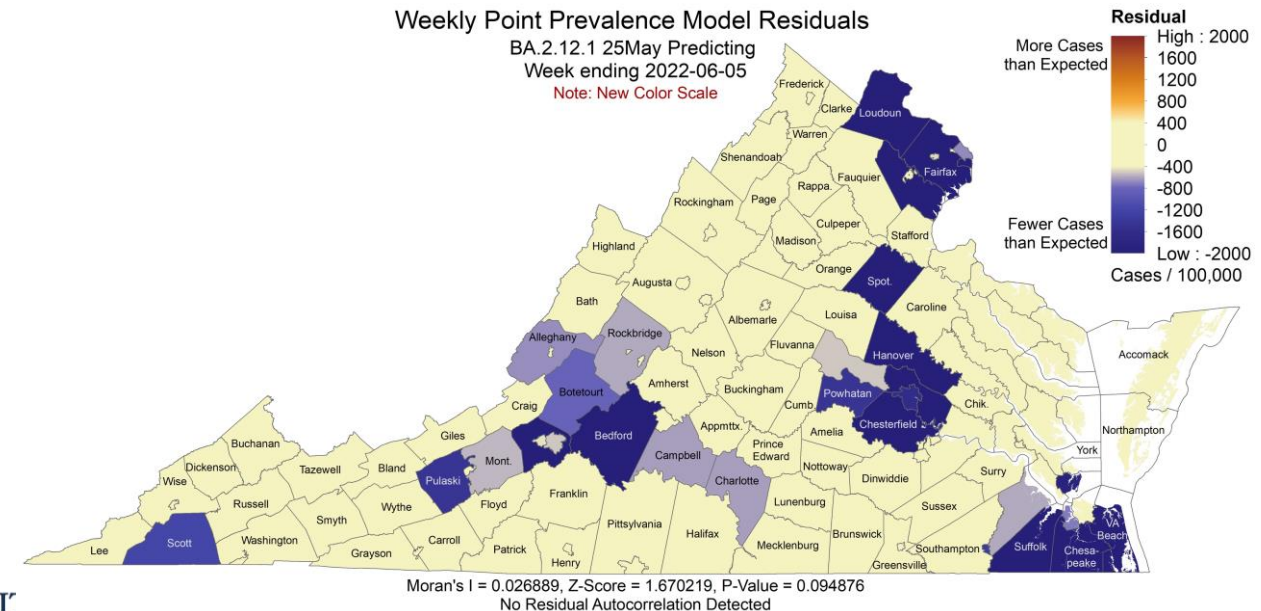
Scenario Trajectory Tracking

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

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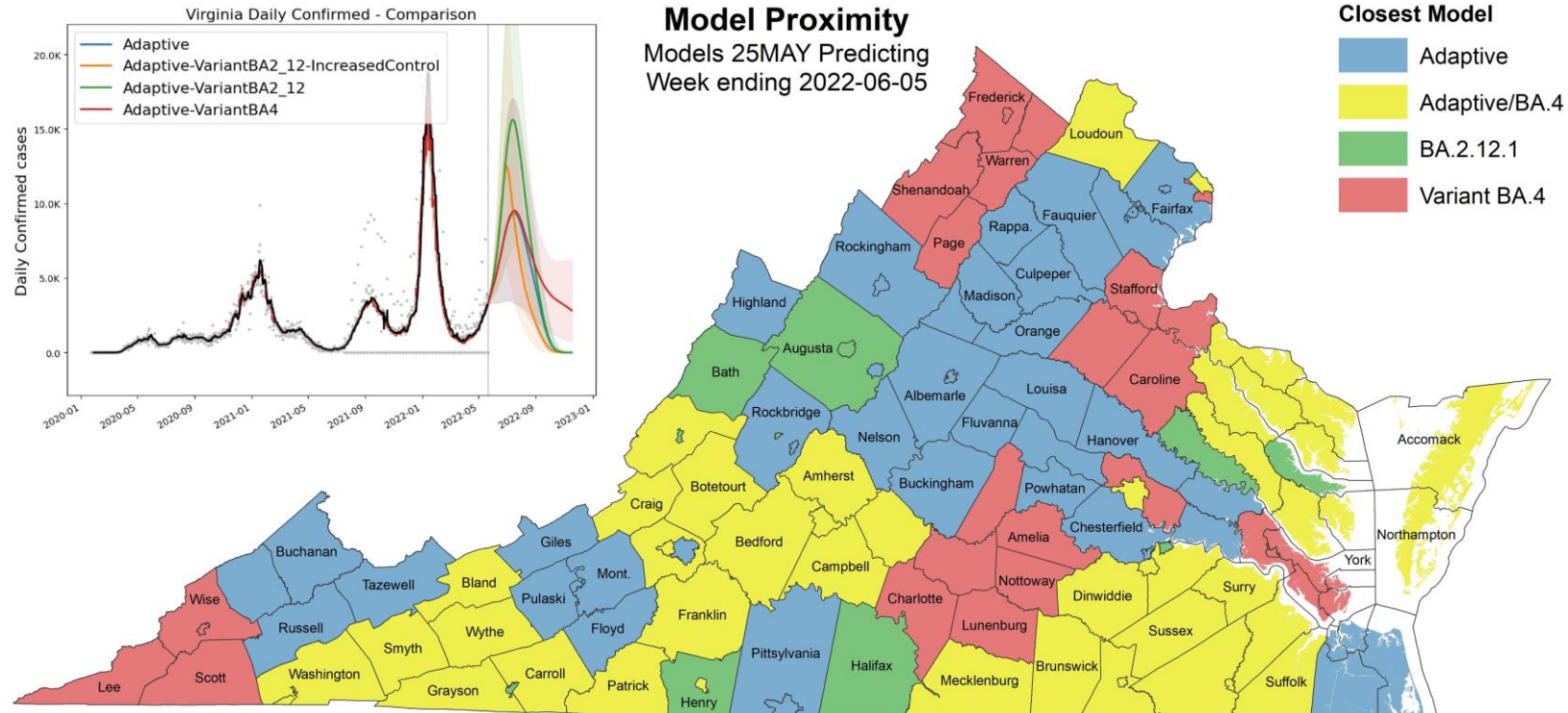
Model Update – Adaptive Fitting

University *of* Virginia

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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
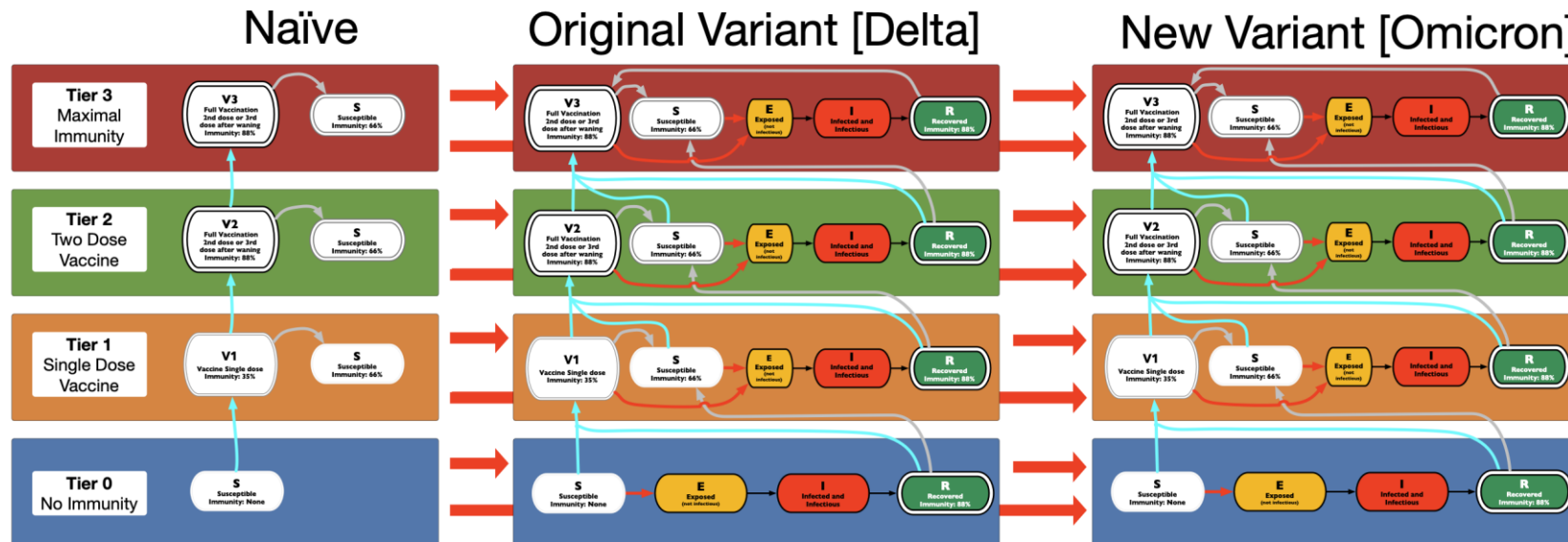
Adaptive Fitting Approach

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

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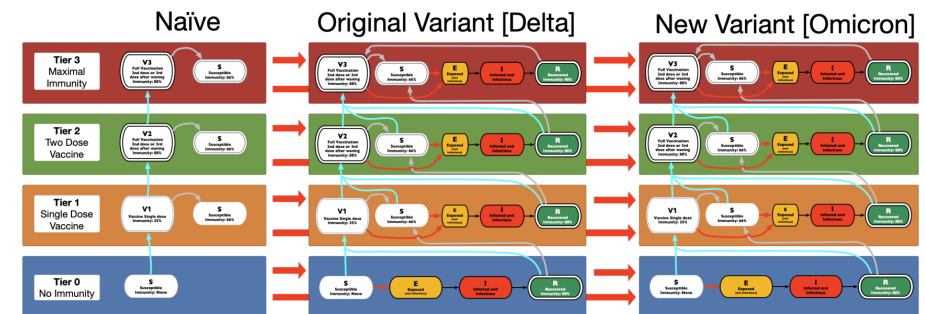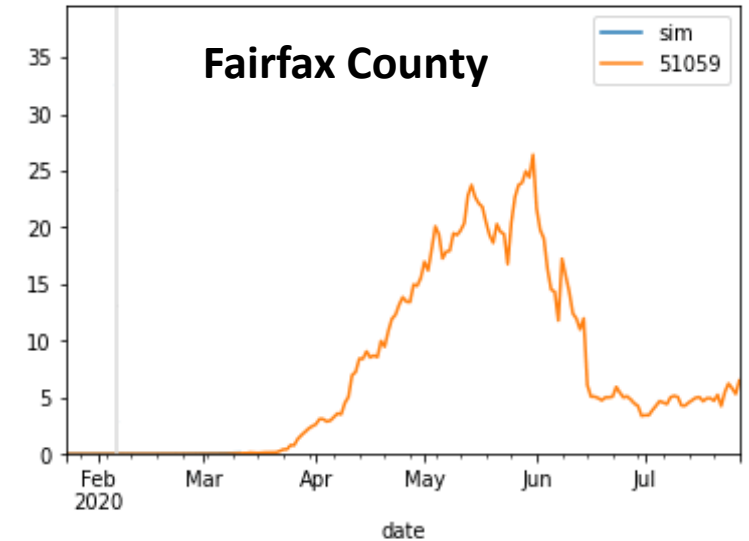
Using Ensemble Model to Guide Projections

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

- Autoregressive (AR, ARIMA)

- Neural networks (LSTM)

- Kalman filtering (EnKF)

Weekly forecasts 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.

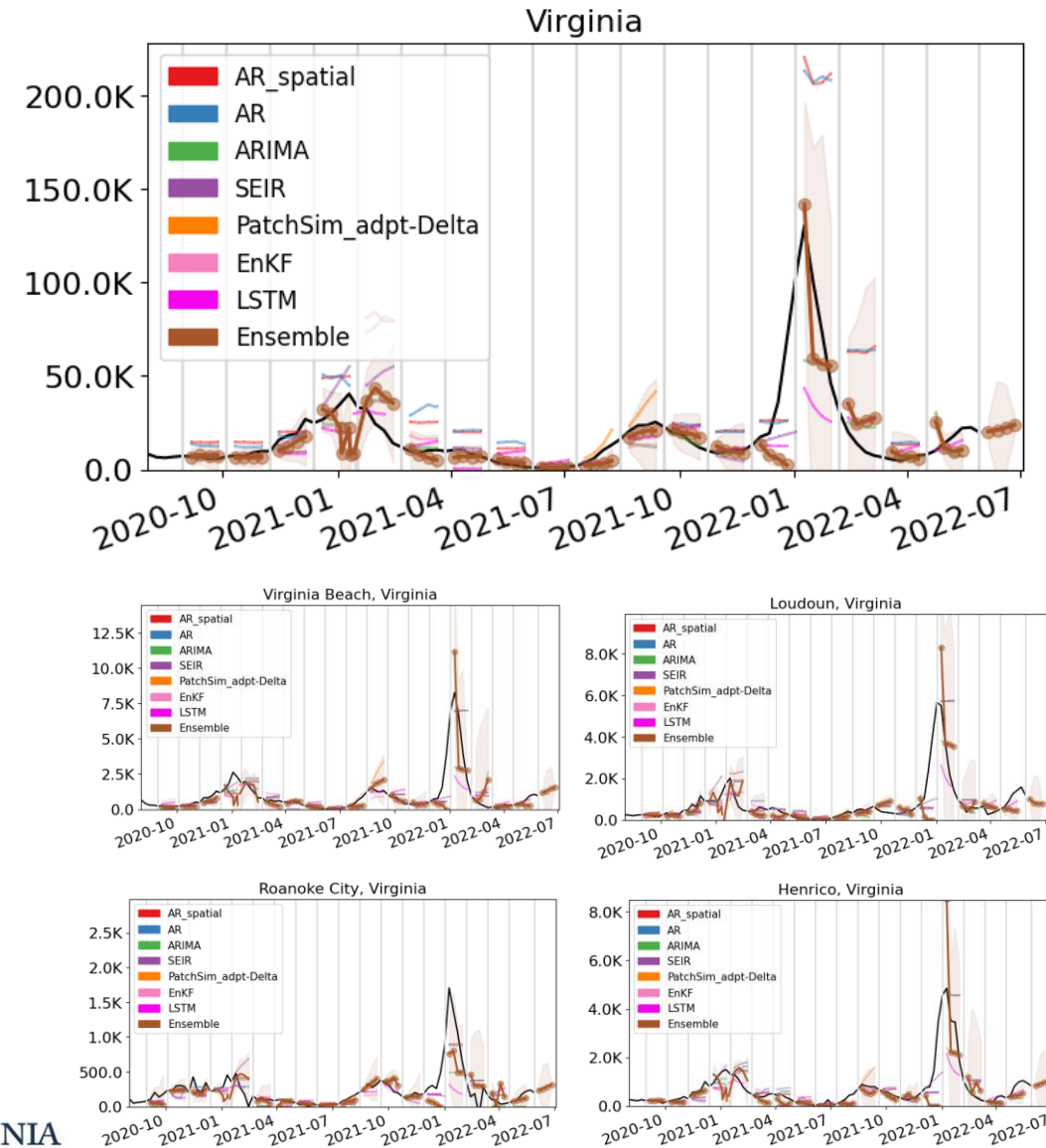Also submitted to CDC Forecast Hub.

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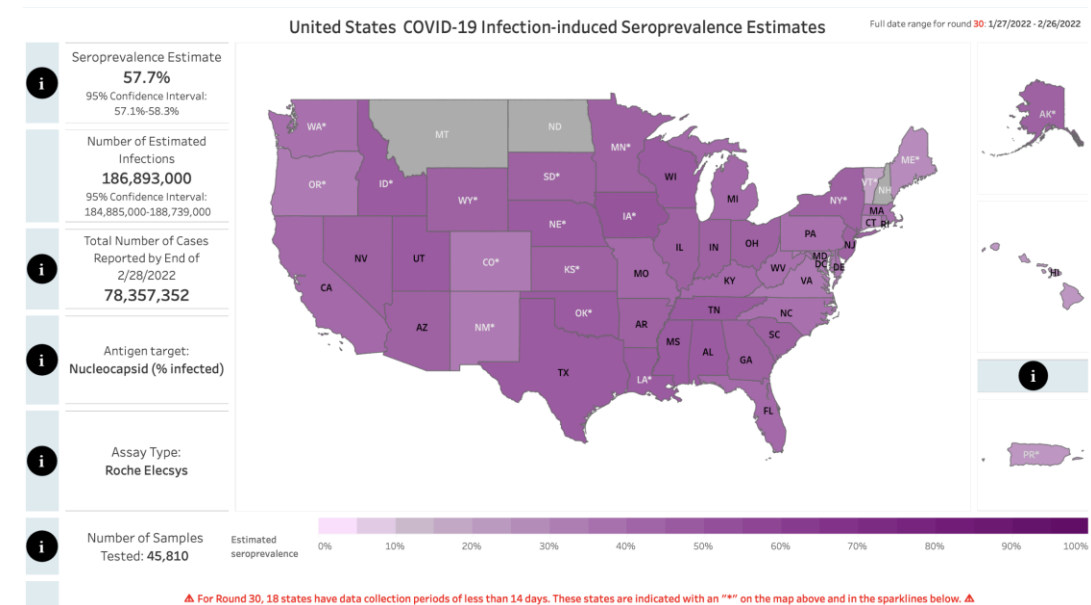
Virginia
Feb 22nd: 45% [42% - 48%]; Jan 22nd: 34% [31%-39%]

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

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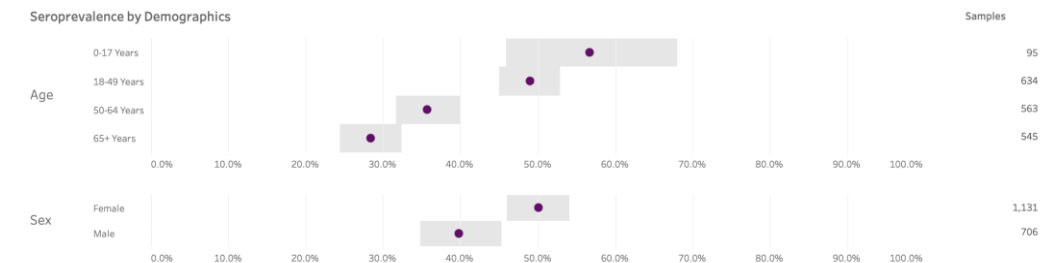
Calibration Approach

- **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

COVID-19 in Virginia: Summary

Dashboard Updated: 6/8/2022
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospital Admissions**	Total Deaths
1,811,366	**52,123**	**20,436**
(New Cases: 2,958)^		

Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
1,295,586	515,780	48,961	3,162	17,054	3,382

* 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://wwwn.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
8,309	**136,712**

* 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**
13,959,714	**18.8%**

* 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
181	**1**

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

Accessed 8:35am June 8, 2022
https://www.vdh.virginia.gov/coronavirus/

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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

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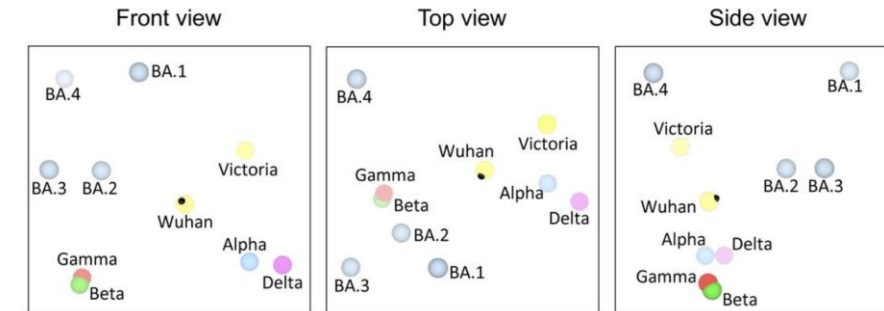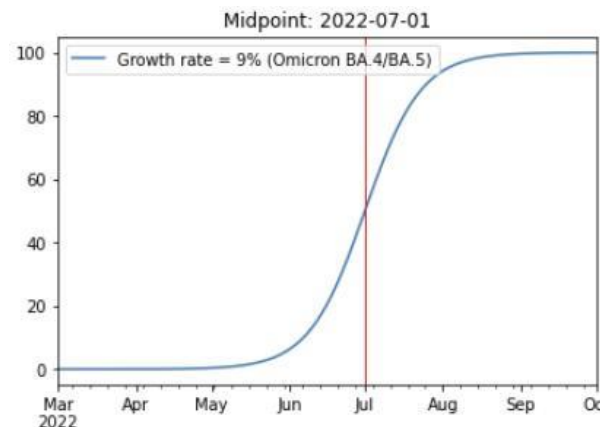
Scenarios – Omicron BA.4 / BA.5 Description

BA.4 and BA.5 subvariants are showing significant growth in some countries; while low prevalence in US, may dominant in the coming month.

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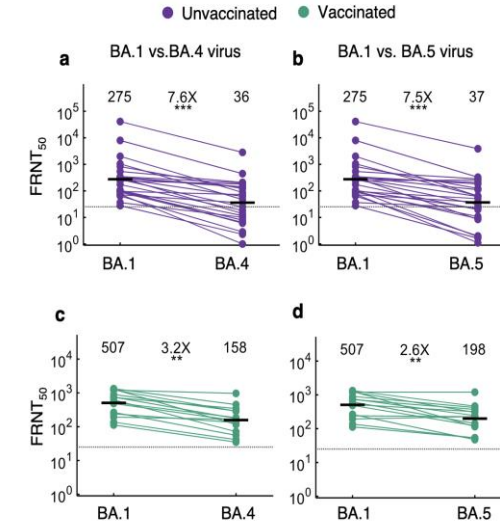
Researchers in SA isolated live BA.4 and BA.5 viruses and tested them against neutralizing immunity elicited to BA.1 infection in participants who were Omicron/BA.1 infected but unvaccinated (n=24) and participants vaccinated with Pfizer BNT162b2 or Johnson and Johnson Ad26.CoV.2S with breakthrough Omicron/BA.1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

Substantial immune escape seen for BA.4, comparable to original BA.1 subvariant of the initial Omicron wave compared to Delta
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
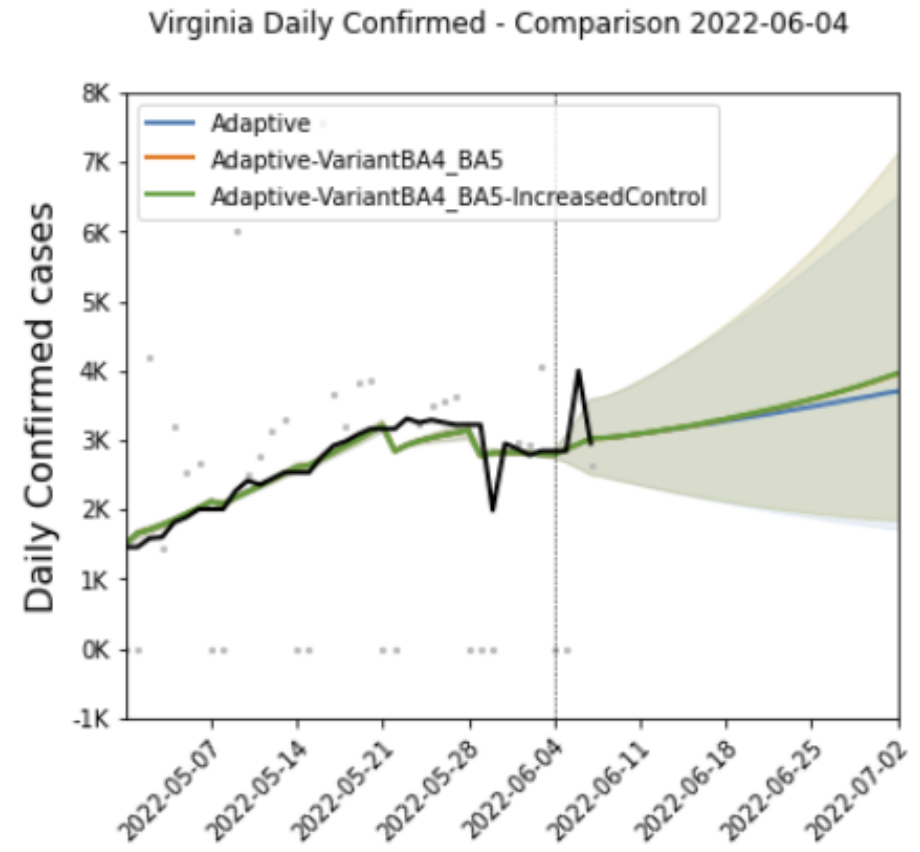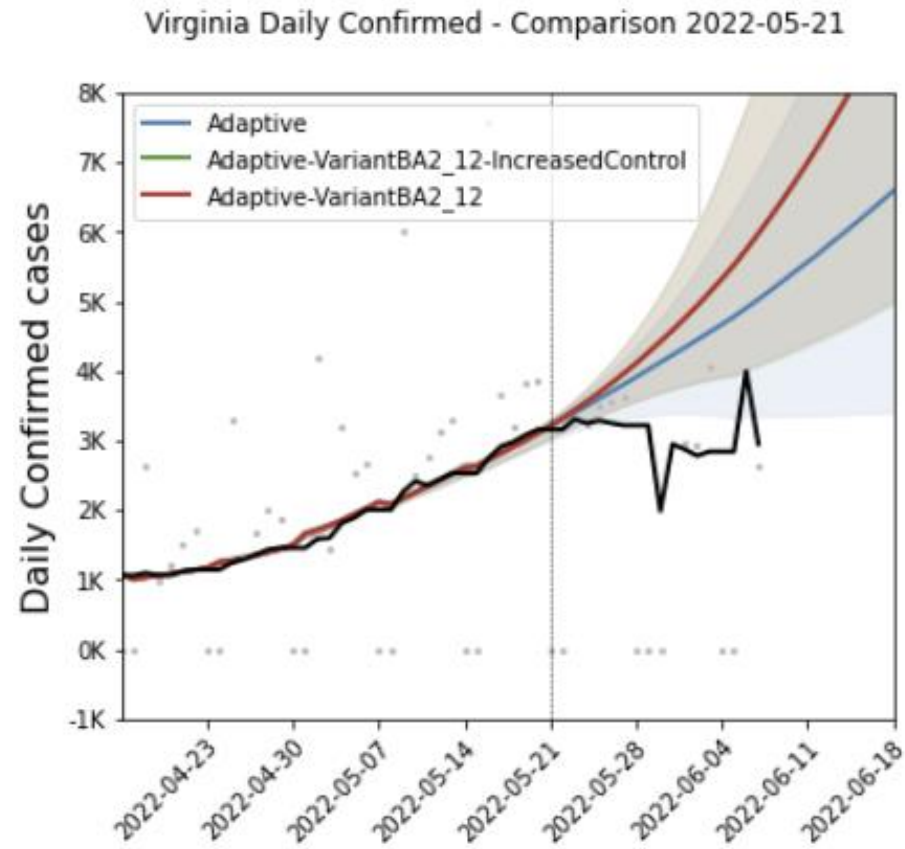
Vaccinations: SQ = Status quo acceptance leads to low rates of vaccination through the summer
VO = Vaccination acceptance optimistically expands with increased rates through the summer

Last projection comparison – 2 weeks ago

- Growth rate slowed before Memorial Day, may be related to testing behavior shifts
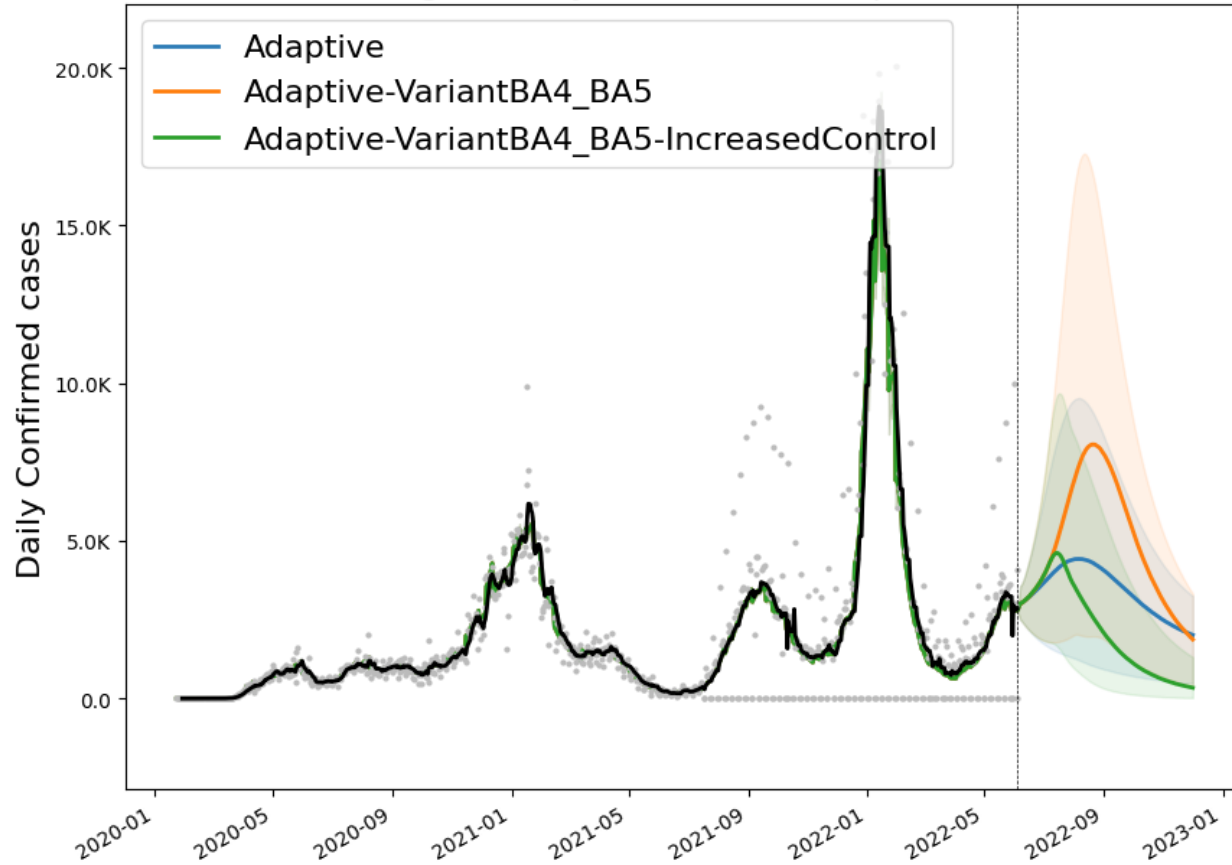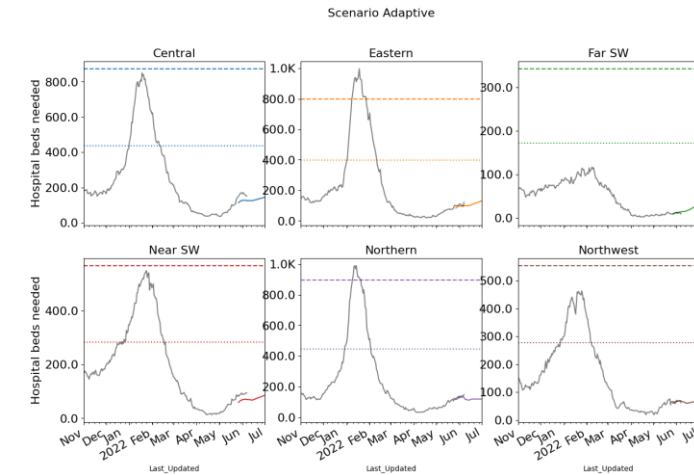- Update this week tracks reduced rate of growth

Model Results

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Outcome Projections

Estimated Hospital Occupancy

Confirmed cases

Virginia Daily Confirmed - Comparison

Legend:
- Adaptive
- Adaptive-VariantBA4_BA5
- Adaptive-VariantBA4_BA5-IncreasedControl

* without surveillance correction VariantBA2 peaked over 10K in July

Scenario Adaptive — panels: Central, Eastern, Far SW, Near SW, Northern, Northwest

Daily Deaths

Virginia Daily Death - Comparison

Legend:
- Adaptive
- Adaptive-VariantBA4_BA5
- Adaptive-VariantBA4_BA5-IncreasedControl
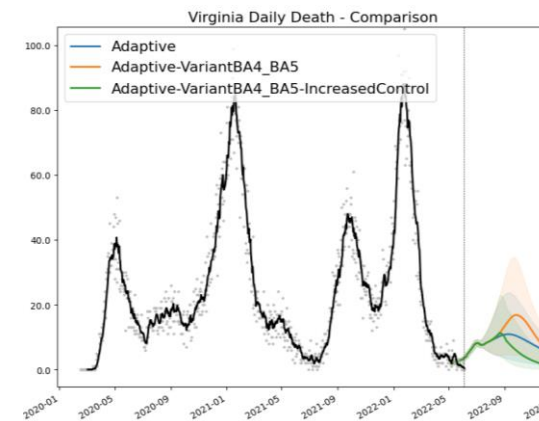
Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized

Virginia Daily Hospitalized - Comparison

Legend:
- Adaptive
- Adaptive-VariantBA4_BA5
- Adaptive-VariantBA4_BA5-IncreasedControl

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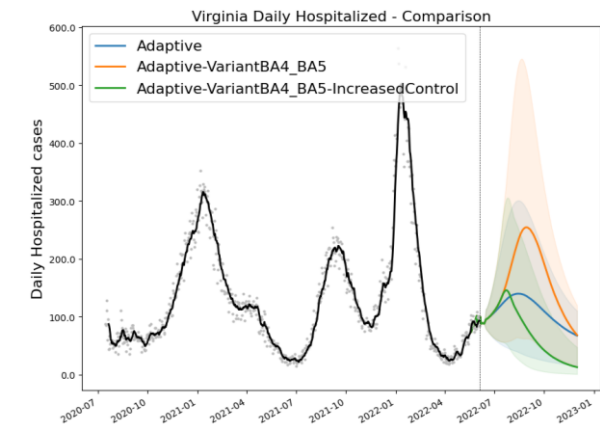
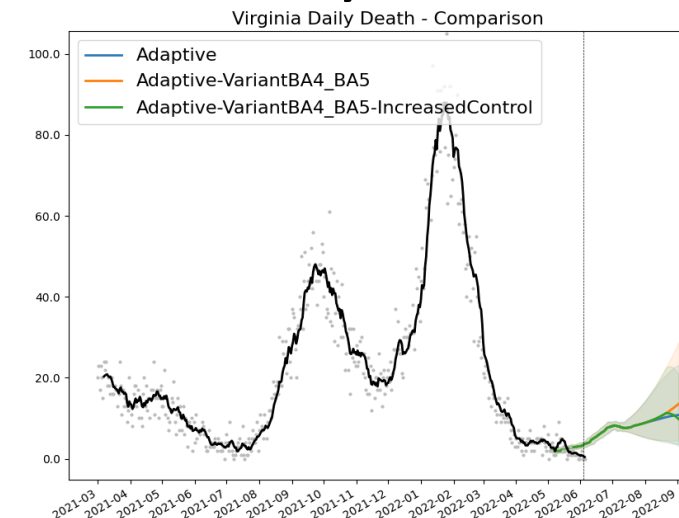# Outcome Projections – Closer Look

Confirmed cases

Daily Hospitalized
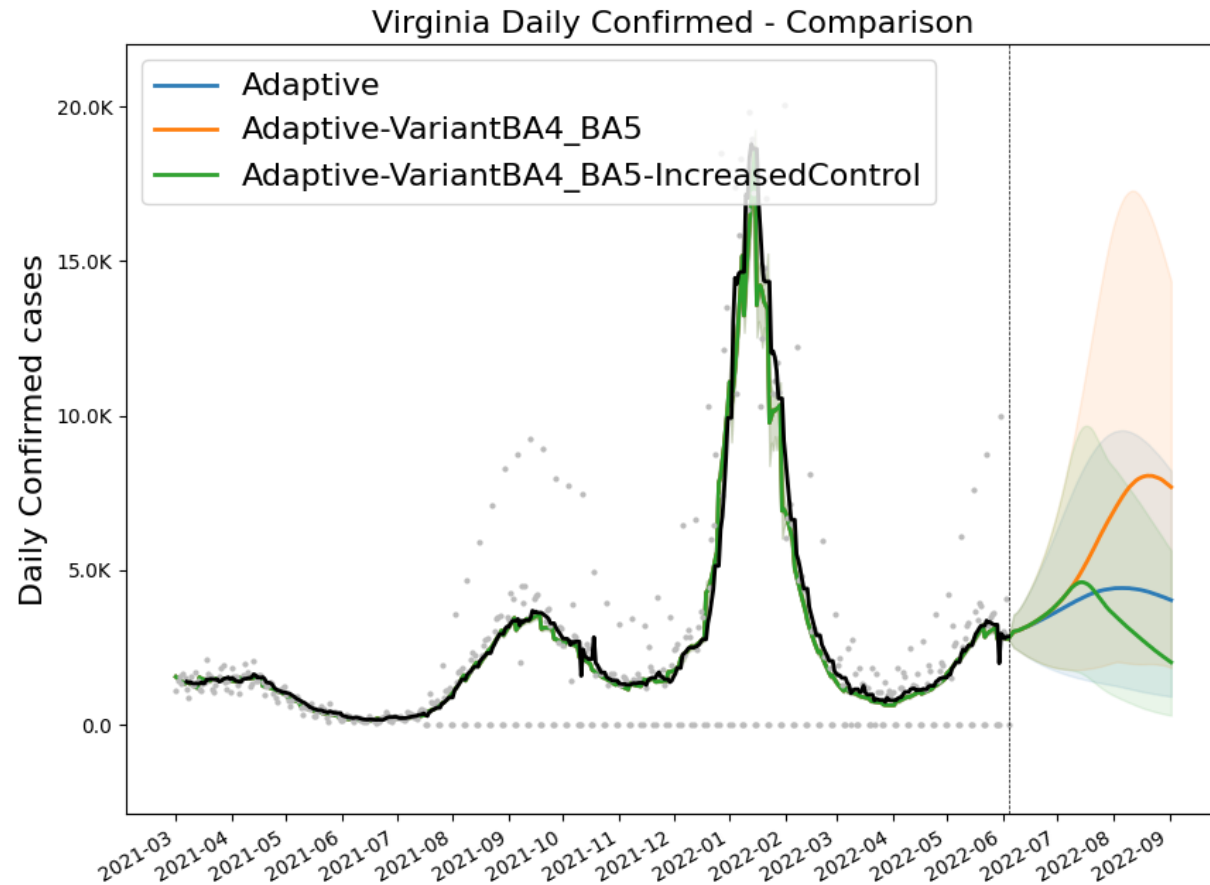
Daily Deaths

* without surveillance correction VariantBA2 peaked over 10K in July

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
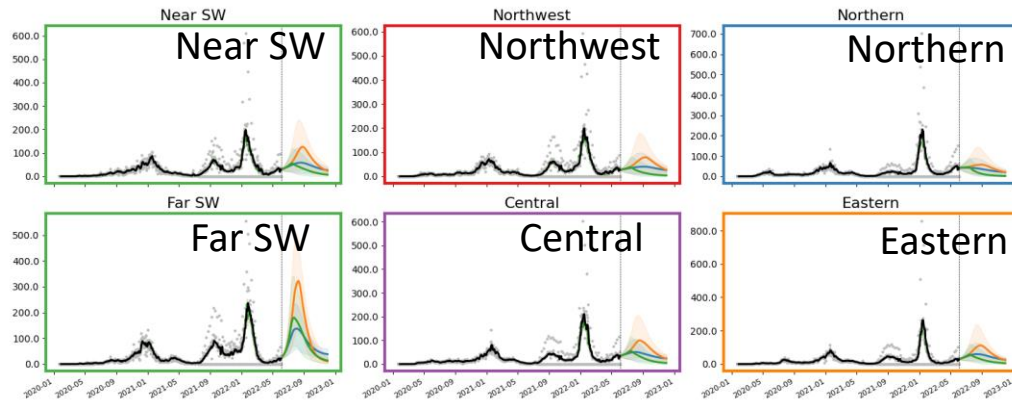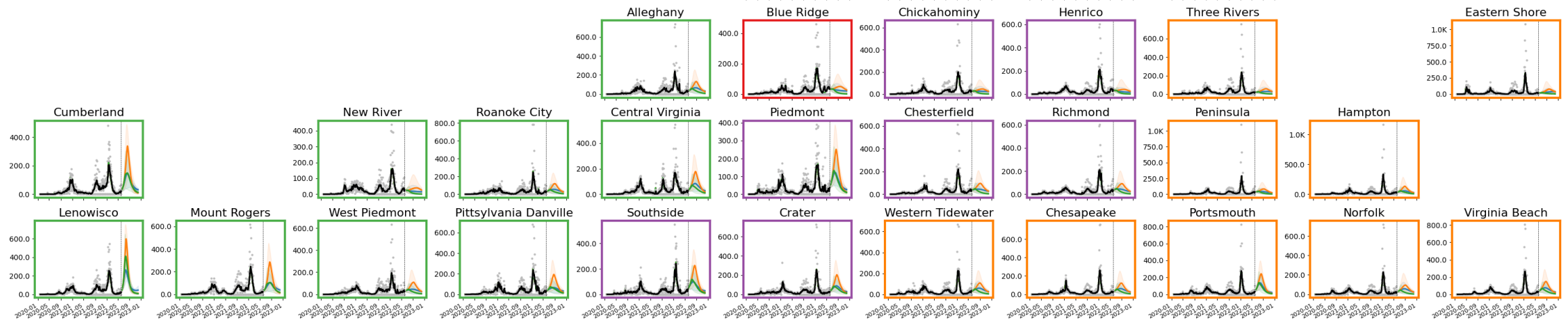
Projections by District

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

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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

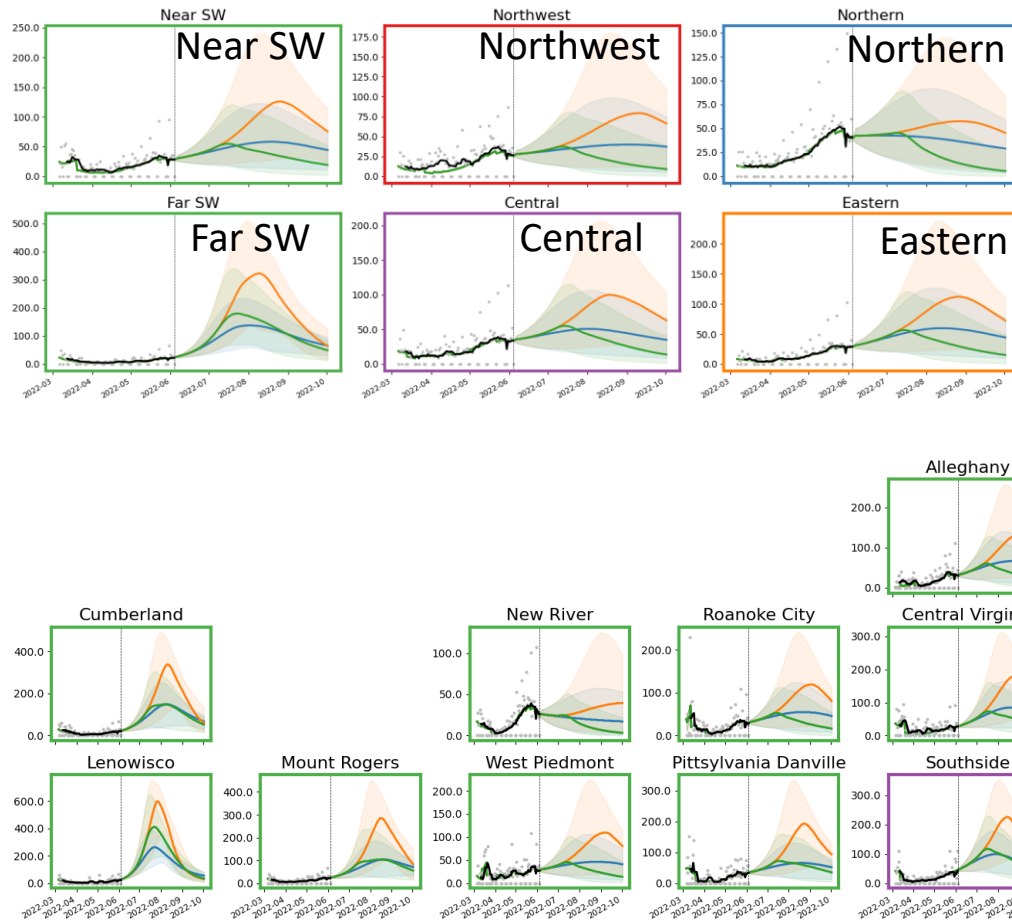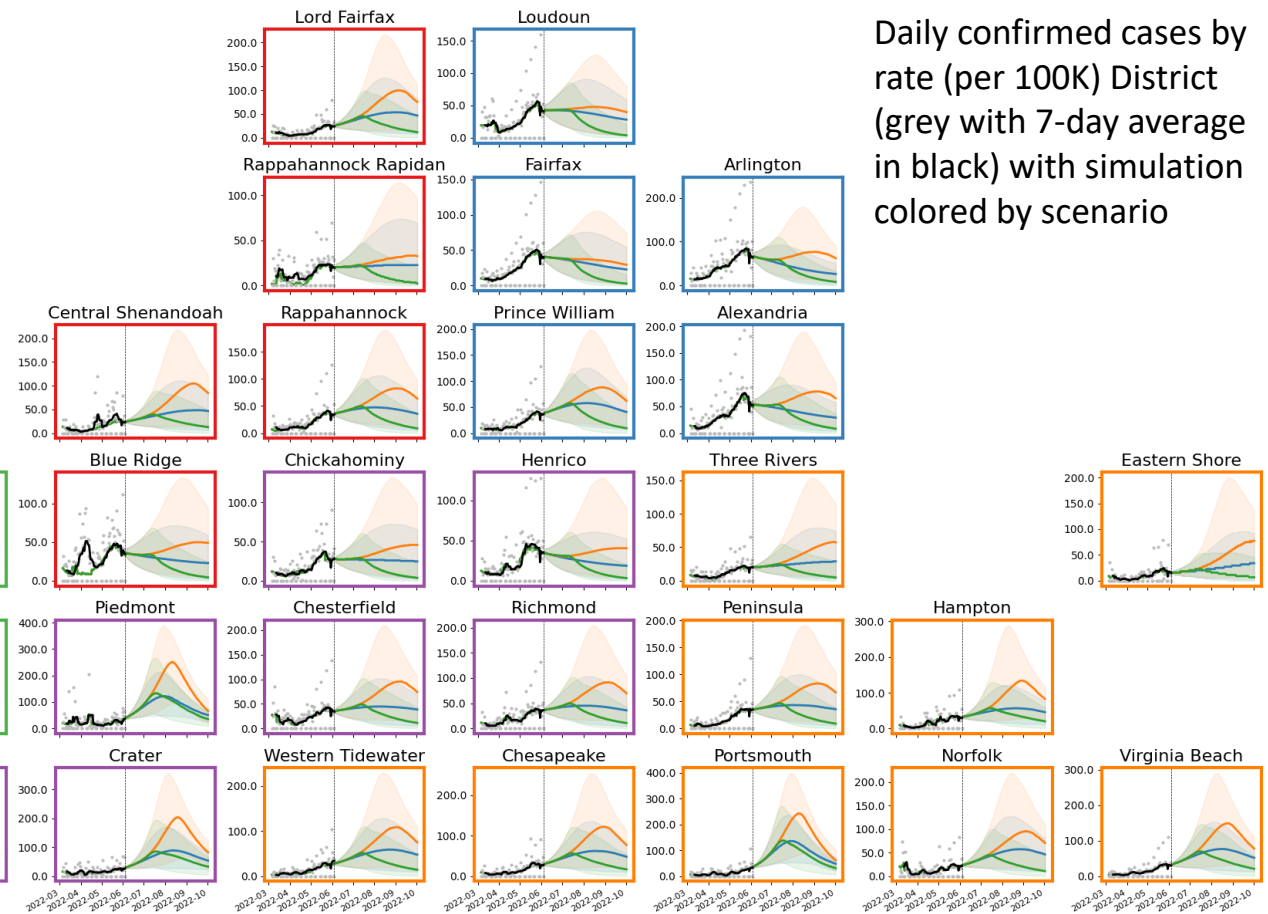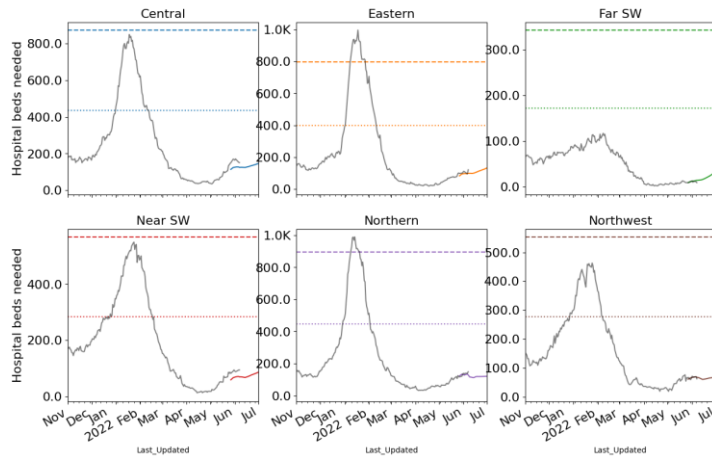# Hospital Demand and Bed Capacity by Region

Capacities by Region

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

Length of Stay Estimates

Region	
Central	8
Eastern	6
Far SW	6
Near SW	8
Northern	3
Northwestern	8

Adaptive

Adaptive – Variant BA4_BA5
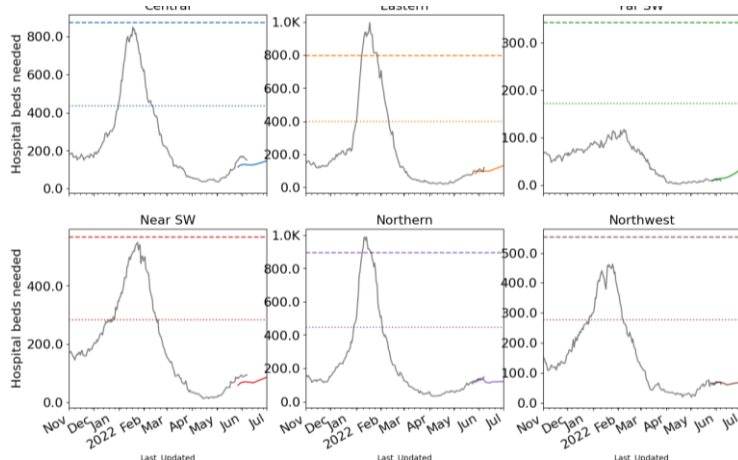
Length of Stay more variable with Omicron, occupancy projections may vary as a result, ad-hoc estimation performed per region

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

Interactive Dashboard with regional projections

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

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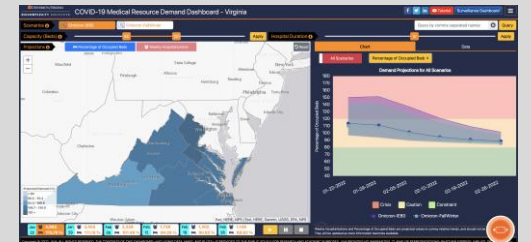
Current Influenza Hospitalization Forecast

Statistical models for submitting to CDC FluSight forecasting challenge

- Hospitalizations nationwide are slowing

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

CDC FluSight
Ensemble Forecasts
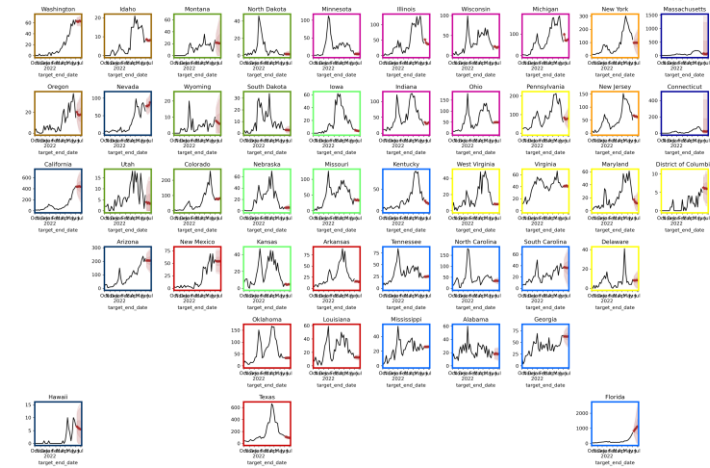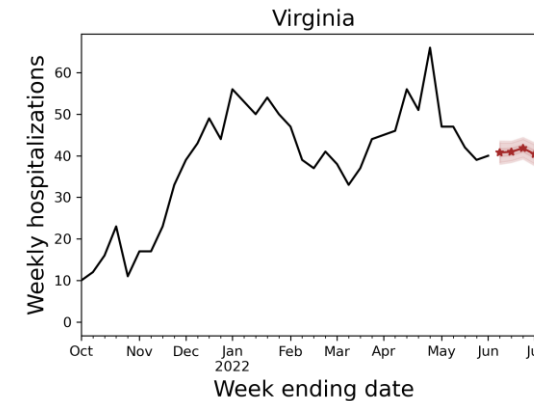
Key Takeaways

Projecting future cases precisely is impossible and unnecessary.

Even without perfect projections, we can confidently draw conclusions:

- **Case rates remain high but may have plateaued, hospitalizations have risen but may be slowing**

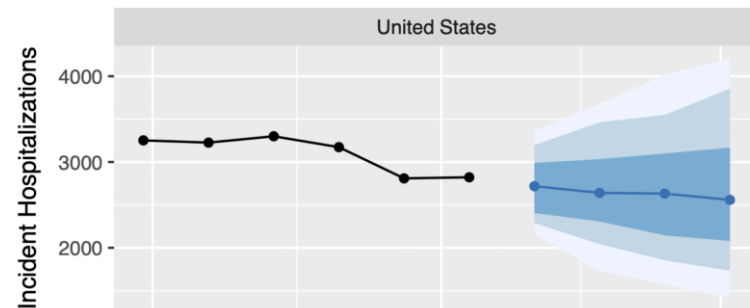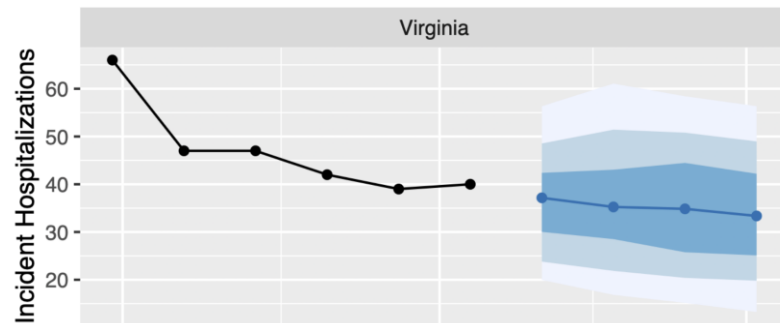- VA 7-day mean daily case rate slightly down to 35/100K from 37/100K
  - US remains relatively flat at 37/100K from 36/100K
  - VA hospital occupancy (rolling 7 day mean of 574) continues to rise, though may be entering a plateau

- Projections anticipate future growth in cases, with potential for growth to continue for several weeks:
  - VA case rates have slowed since last projection
  - Rise in hospitalizations tracking cases pretty closely for past uncertainty surrounds impact of weather and changing social interactions

- 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

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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

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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

Projected Incident Cases by Epidemiological Week and by Scenario for Round 13 - Virginia

Projected Incident Cases by Epidemiological Week and by Scenario for Round 13 - Virginia
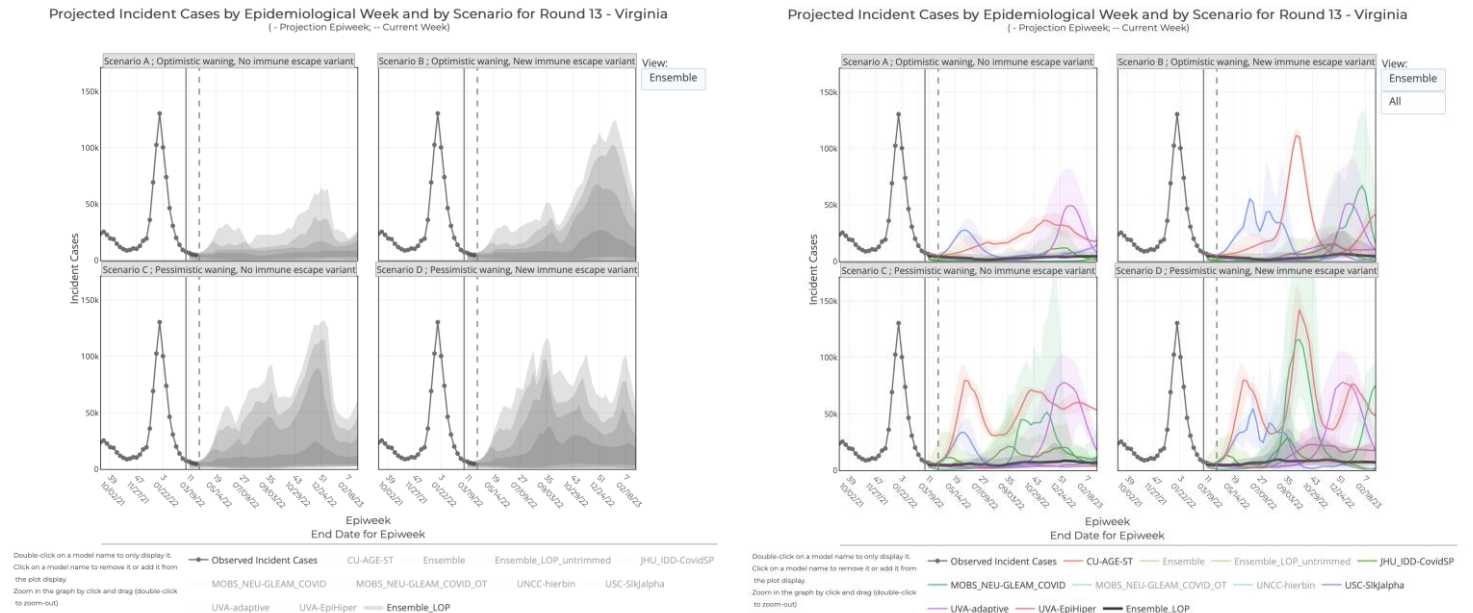
Busiest Places: Mobility Data Can Assist

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)

SAFE GRAPH

Find the Busiest Locations

POIs are individual addresses, need some aggregation to busy areas
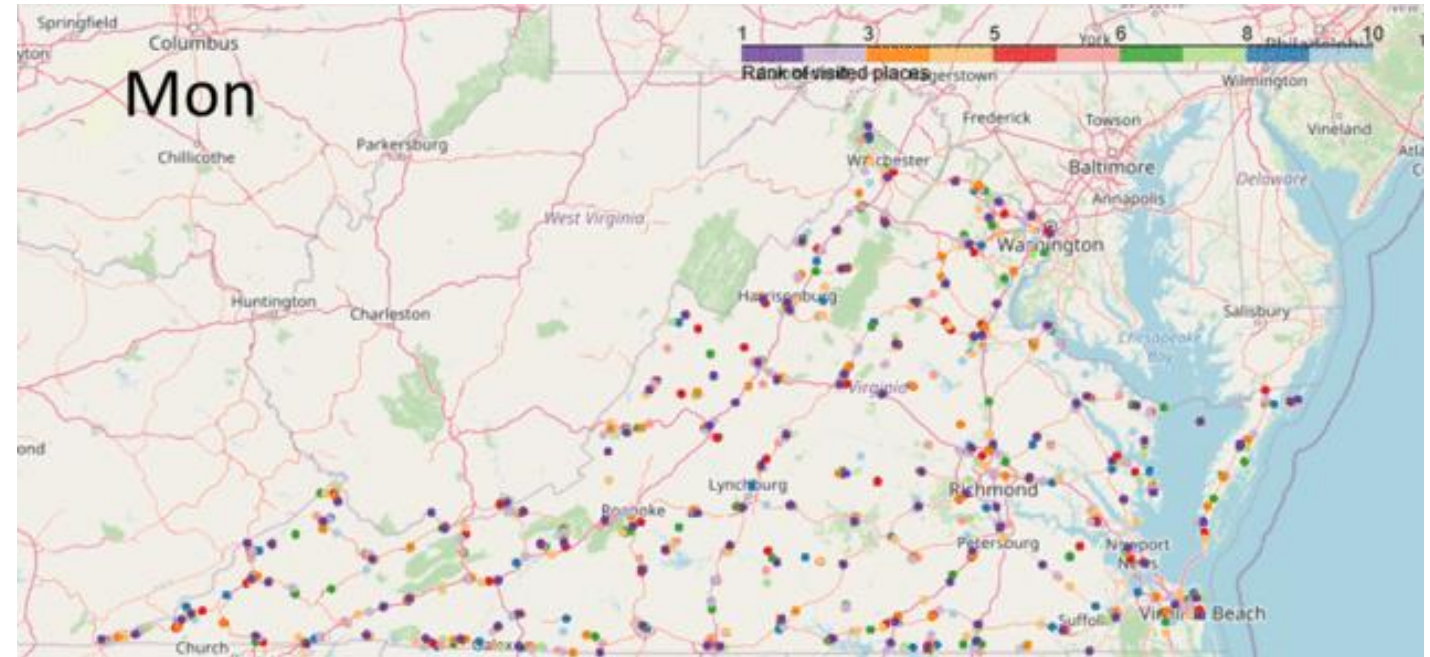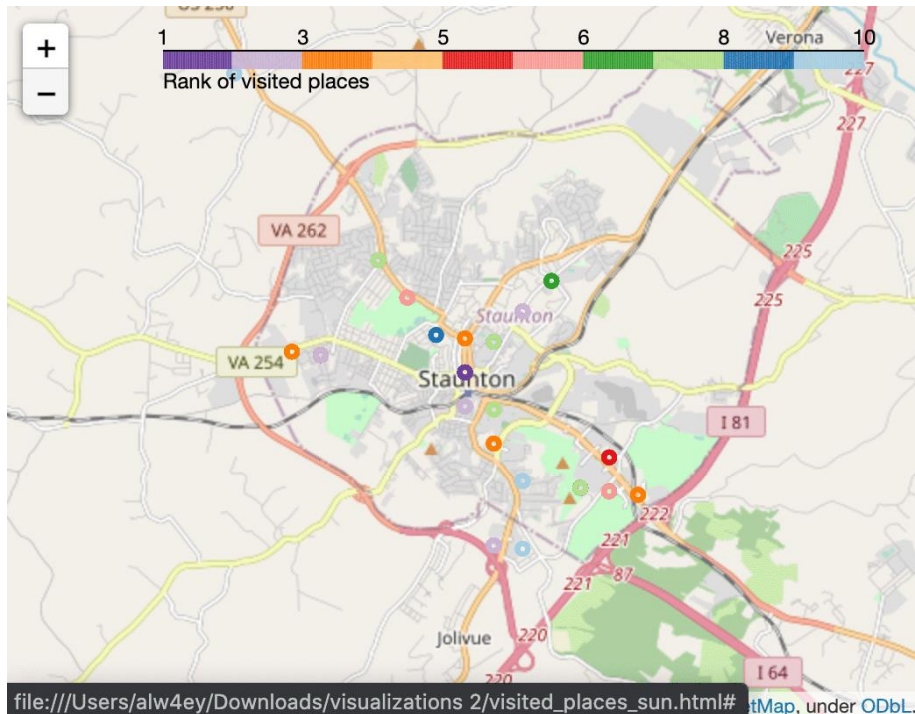
Busiest locations vary by day of week (and time of day)

Find locations visited by Target Population

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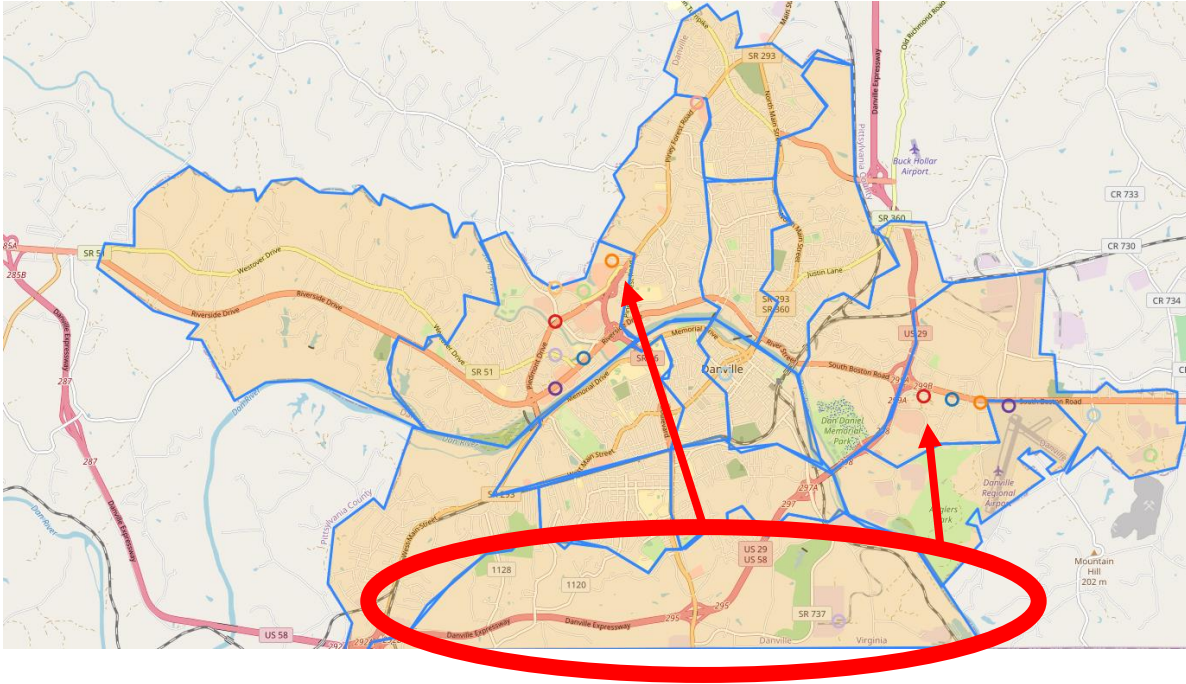
1. Use census data to characterize the populations of the different census block groups
2. Identify most frequently visited POIs for each CBG
3. Cluster most visited POIs
4. Provide potential sites grouped by the demographic groups they likely serve

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 **NEW**

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, (	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, V/	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, V/	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, V/	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, V/	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
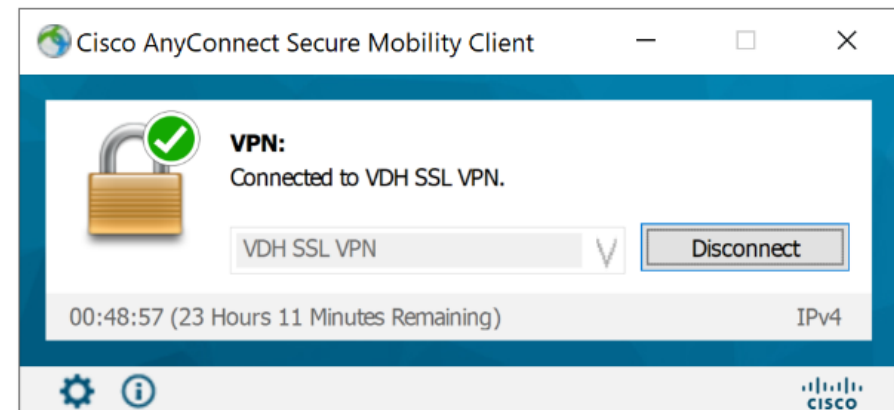
- Excel sheets and simple HTML maps packaged for use

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

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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/

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Questions?

Biocomplexity COVID-19 Response Team

Points of Contact

Bryan Lewis
brylew@virginia.edu

Srini Venkatramanan
srini@virginia.edu

Madhav Marathe
marathe@virginia.edu

Chris Barrett
ChrisBarrett@virginia.edu

Aniruddha Adiga, Abhijin Adiga, Hannah Baek, Chris Barrett, Golda Barrow, Richard Beckman, Parantapa Bhattacharya, Jiangzhuo Chen, Clark Cucinell, Patrick Corbett, Allan Dickerman, Stephen Eubank, Stefan Hoops, Ben Hurt, Ron Kenyon, Brian Klahn, Bryan Lewis, Dustin Machi, Chunhong Mao, Achla Marathe, Madhav Marathe, Henning Mortveit, Mark Orr, Joseph Outten, Akhil Peddireddy, Przemyslaw Porebski, Erin Raymond, Jose Bayoan Santiago Calderon, James Schlitt, Samarth Swarup, Alex Telionis, Srinivasan Venkatramanan, Anil Vullikanti, James Walke, Andrew Warren, Amanda Wilson, Dawen Xie

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