Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

April 27th, 2022

(data current to April 23rd – 26th)

Biocomplexity Institute Technical report: TR BI-2022-1119

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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

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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:

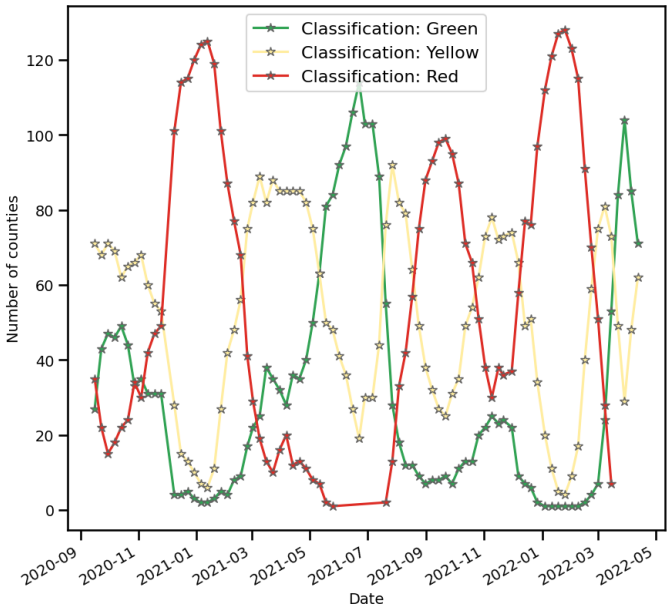
- **Case rates continue to slowly rise as do hospitalizations**
- VA 7-day mean daily case rate increased to 15/100K from 13/100K
  - US continues to increase slightly to 14/100K (from 11.5/100K)
  - VA hospital occupancy (rolling 7 day mean of 173) has rebounded slightly from a near all-time low
- Surveillance anomalies continue as QA processes rebalance previously reported cases though seems to be slowing
- Projections anticipate future growth in cases but more limited growth in more severe outcomes:
  - Current trends alone drive some future growth, in most regions of VA, though uncertainty is a bit high
  - Recently emerging BA.2.12.1 subvariant may drive more rapid growth as it becomes more dominant across other parts of the state
- Model updates:
  - Adjusted fitting to work on district level to reduce biases from limited outbreaks within counties and surveillance anomalies
  - Adaptive scenario captures BA.2, have added a BA.2.12.1 scenario to capture the future growth of this more transmissible variant
  - Models need to change their focused outcome to hospitalization or aggregate counties to districts to minimize noisy fluctuations

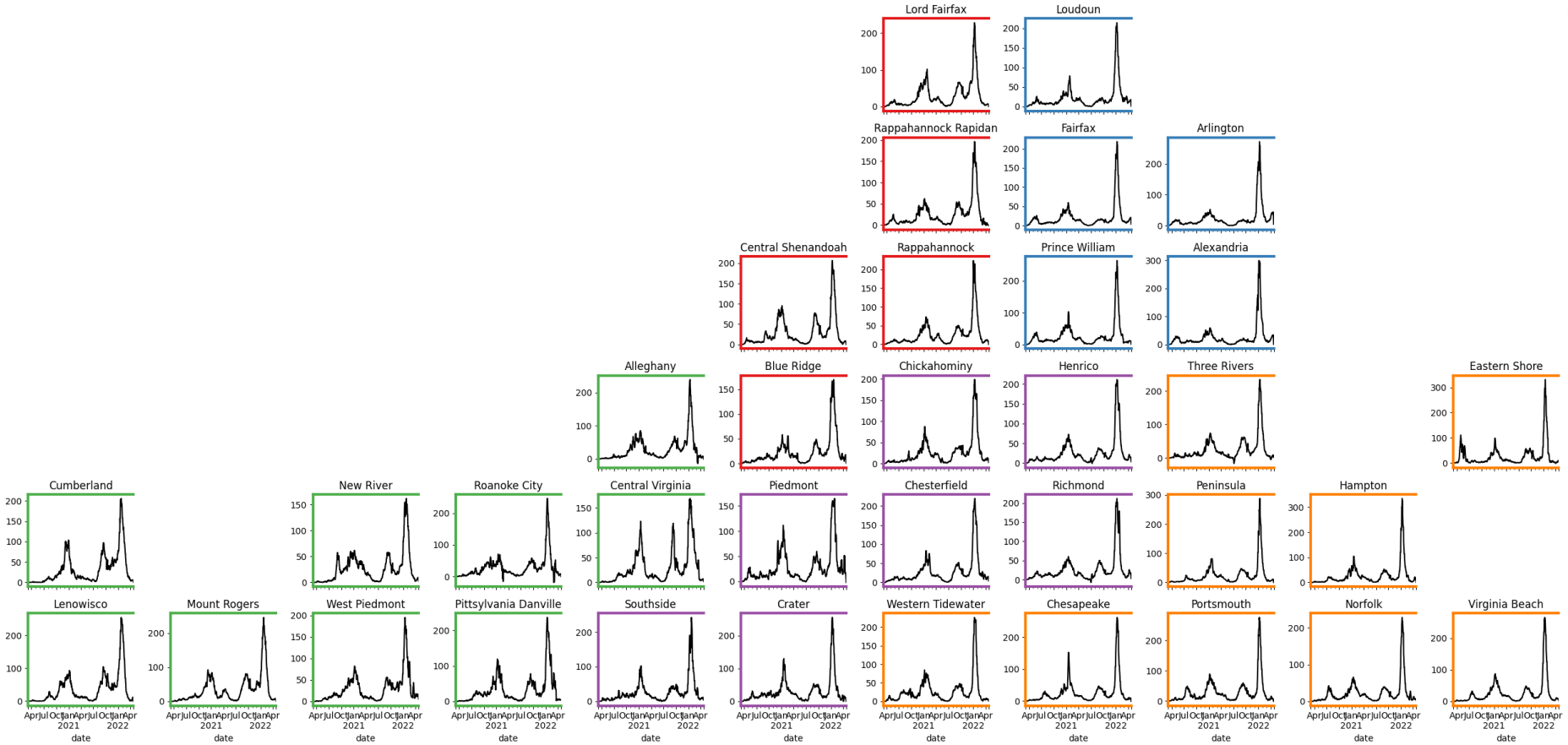
The situation continues to change. Models continue to be updated regularly.

Situation Assessment

Case Rates (per 100k) and Test Positivity

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





County level RT-PCR test positivity

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

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

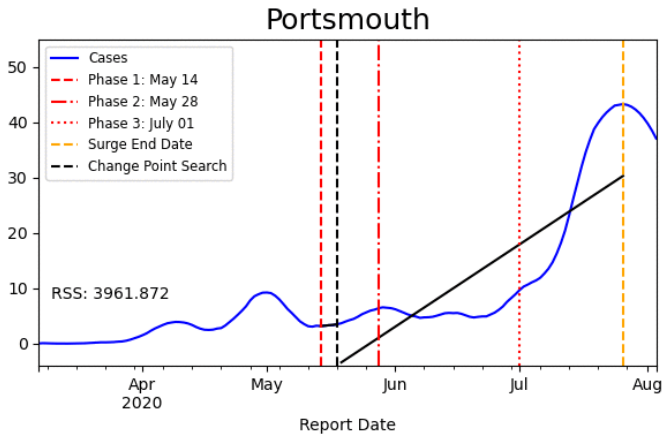
Red: >10.0% (and not "Green" or "Yellow")

District Trajectories

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

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

Hockey stick fit

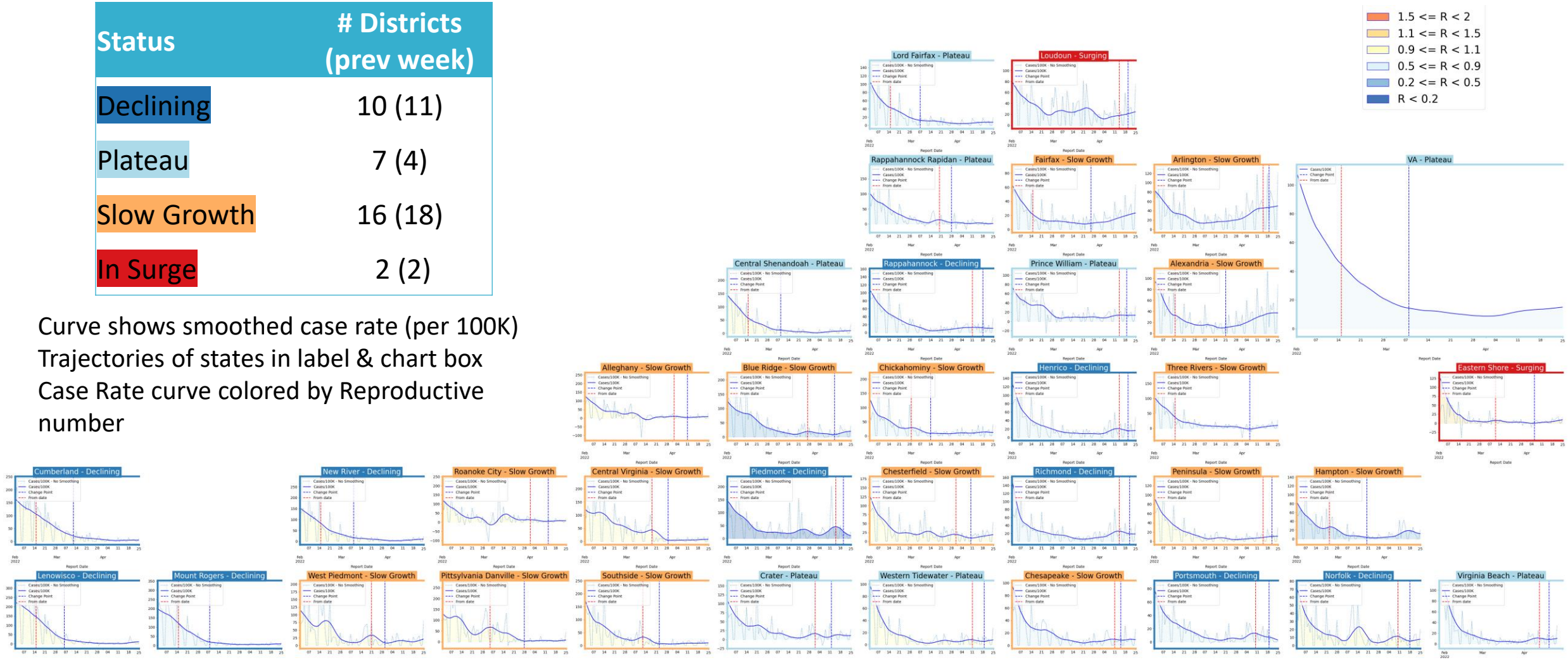


Trajectory	Description	Weekly Case Rate (per 100K) bounds
Declining	Sustained decreases following a recent peak	below -0.9
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5
In Surge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

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	10 (11)
Plateau	7 (4)
Slow Growth	16 (18)
In Surge	2 (2)

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



CDC's new COVID-19 Community Levels

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

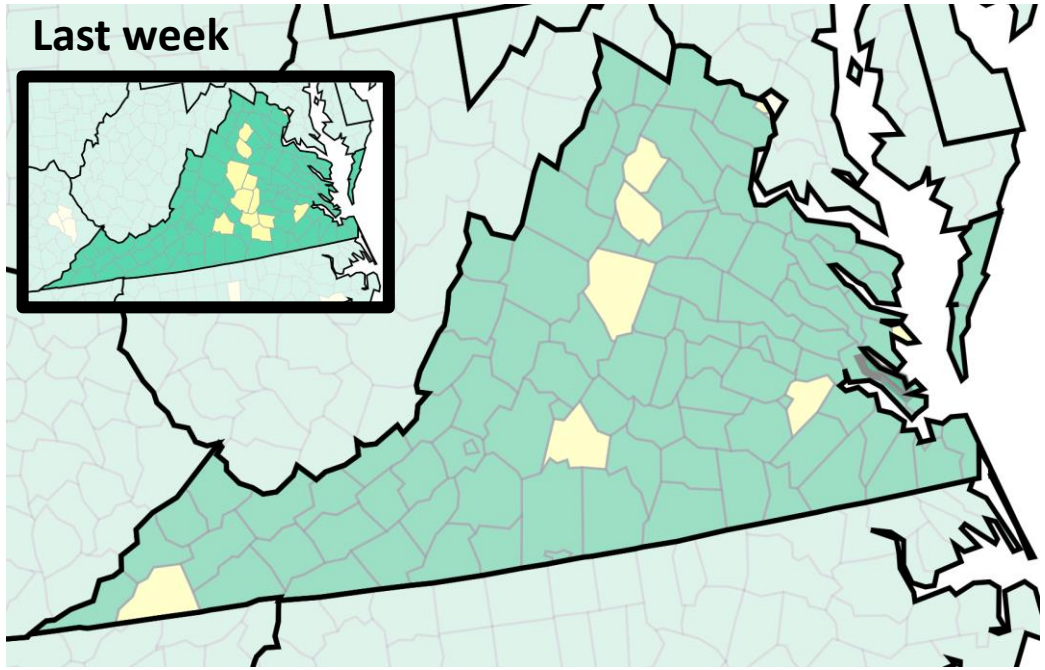
Low	Medium	High
• Stay up to date with COVID-19 vaccines • Get tested if you have symptoms	• If you are at high risk for severe illness, talk to your healthcare provider about whether you need to wear a mask and take other precautions • Stay up to date with COVID-19 vaccines • Get tested if you have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

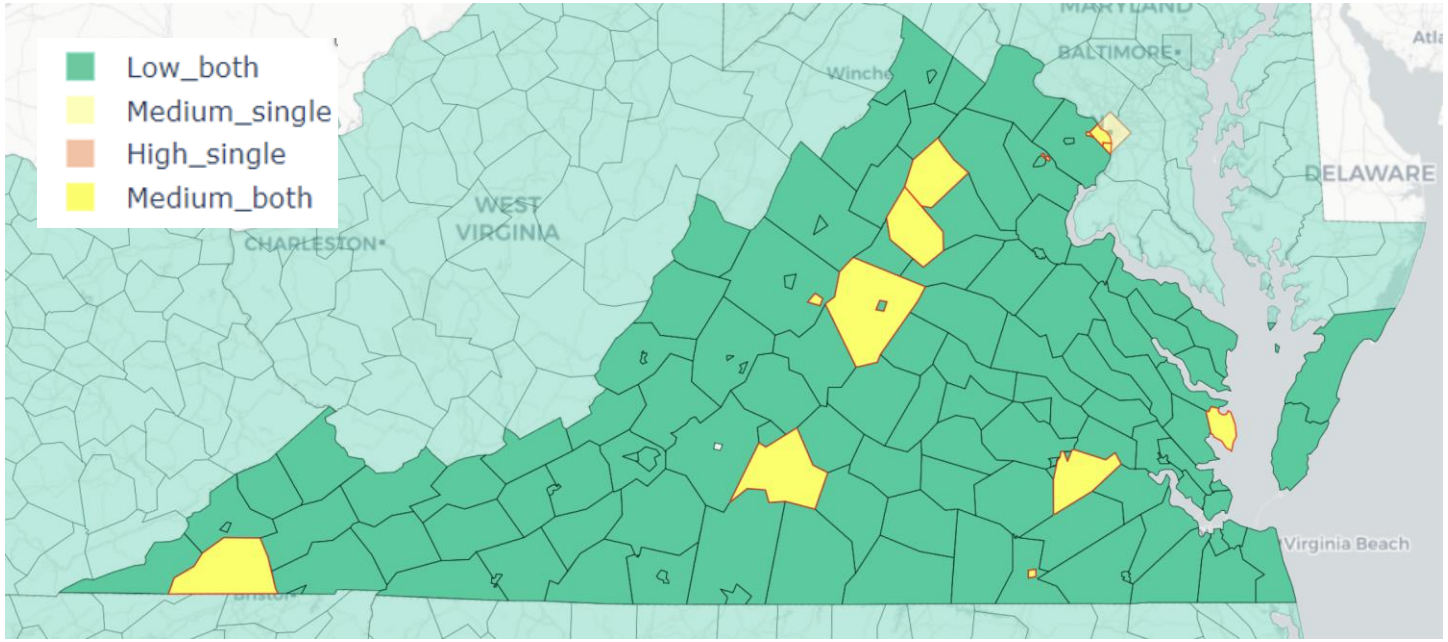
New COVID-19 Cases Per 100,000 people in the past 7 days	Indicators	Low	Medium	High
Fewer than 200	New COVID-19 admissions per 100,000 population (7-day total)	<10.0	10.0-19.9	≥20.0
	Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)	<10.0%	10.0-14.9%	≥15.0%
200 or more	New 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



[CDC Data Tracker Portal]

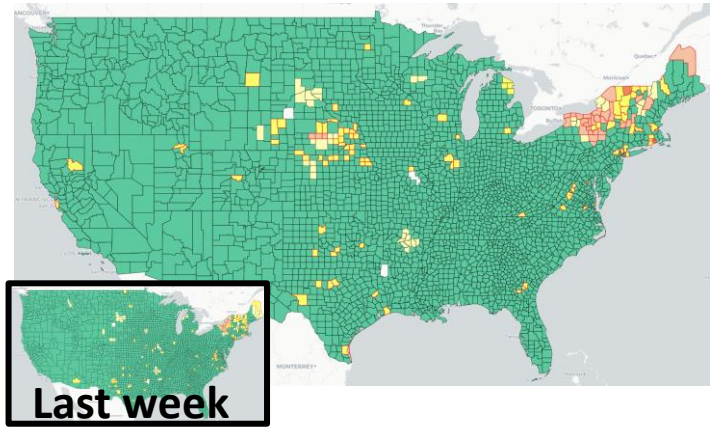
CDC's new COVID-19 Community Levels

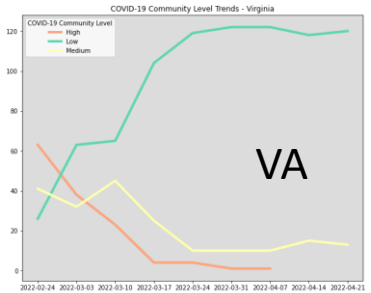


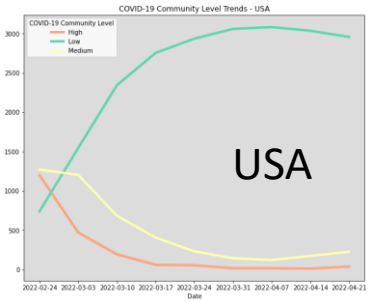
Red outline indicates county had 200 or more cases per 100k in last week

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

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







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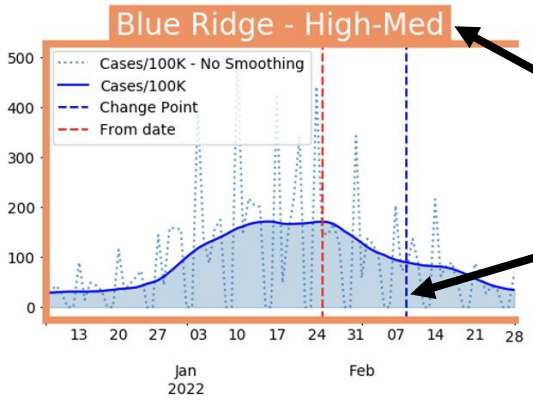
Data from: CDC Data Tracker Portal

District Trajectories with Community Levels

Community Level (Title Color)
- High
- High-Med
- Med-High
- Medium
- Med-Low
- Low-Med
- Low

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

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



District's Aggregate Community Level

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

Case rate Trajectory

Last week

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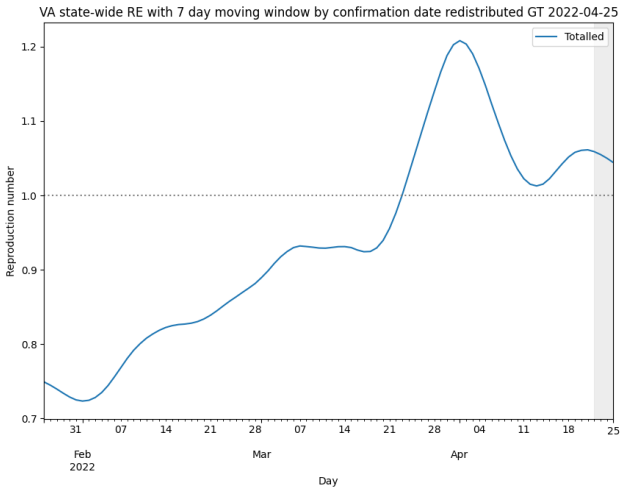
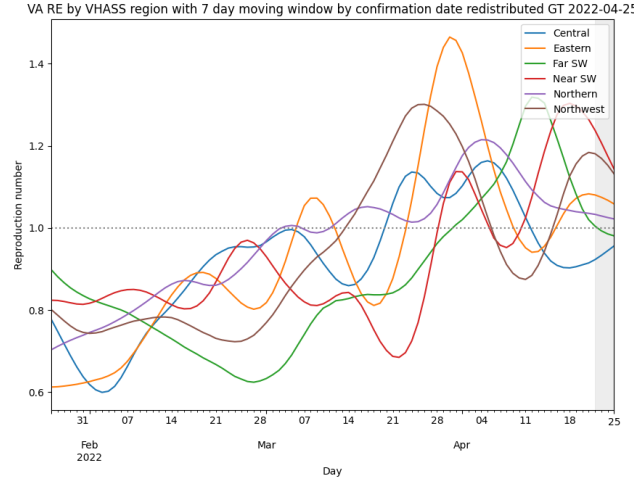
Estimating Daily Reproductive Number – Redistributed gap

April 25th Estimates

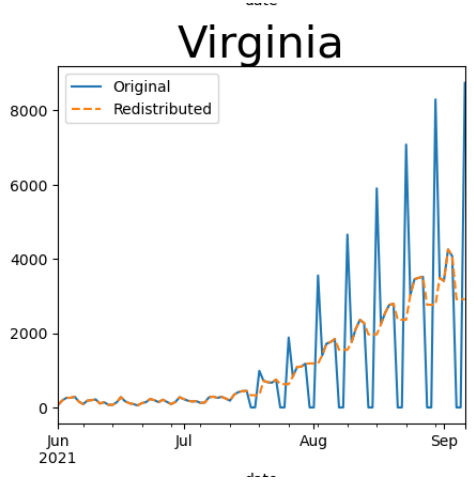
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	1.044	0.113
Central	0.956	0.040
Eastern	1.058	0.190
Far SW	0.980	-0.094
Near SW	1.144	0.256
Northern	1.022	0.000
Northwest	1.132	0.488





Skipping Weekend Reports & holidays biases estimates

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



Methodology

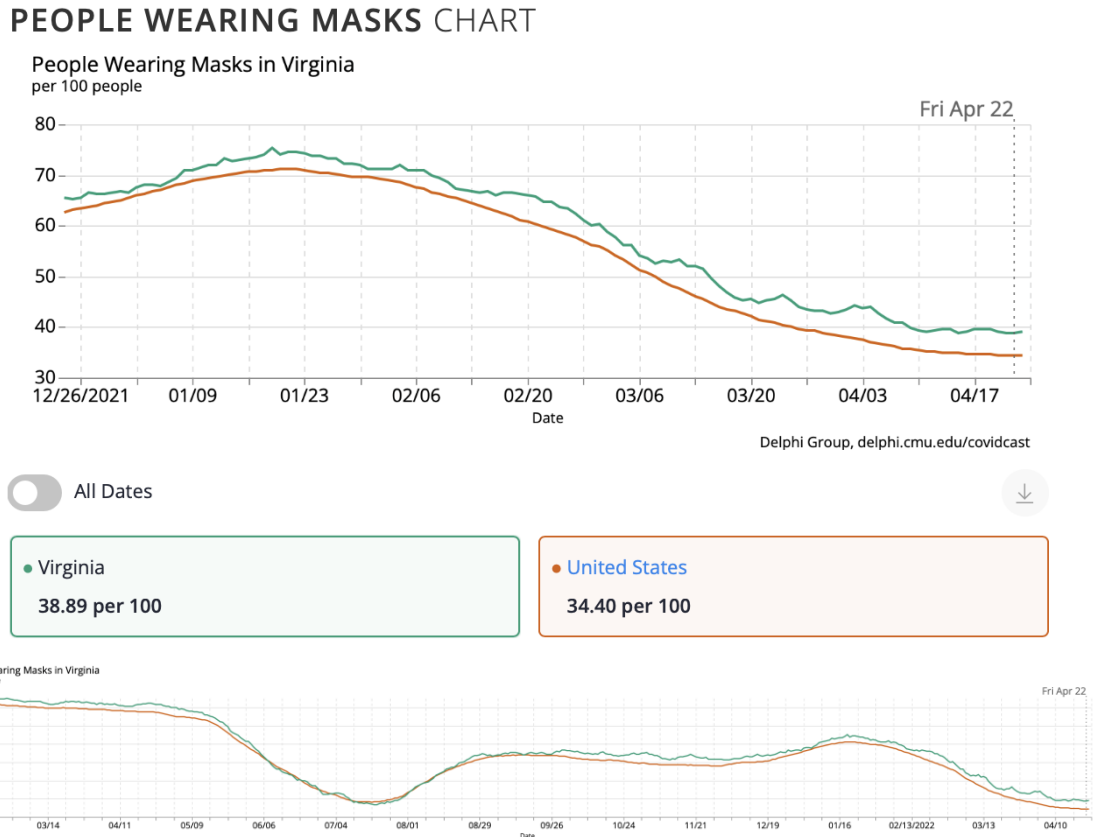
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

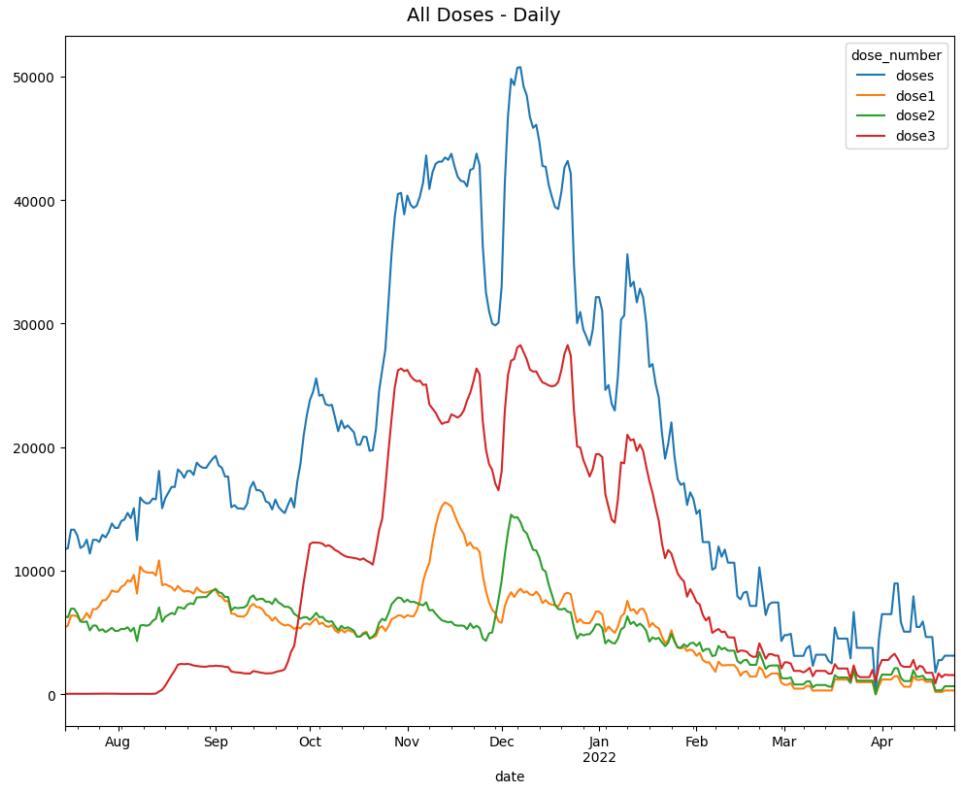
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Mask Usage and Vaccination

Self-reported mask usage continues to fall

- US and VA experienced similar decreases
- Vaccination has leveled off and seen a slight rise since the start of April





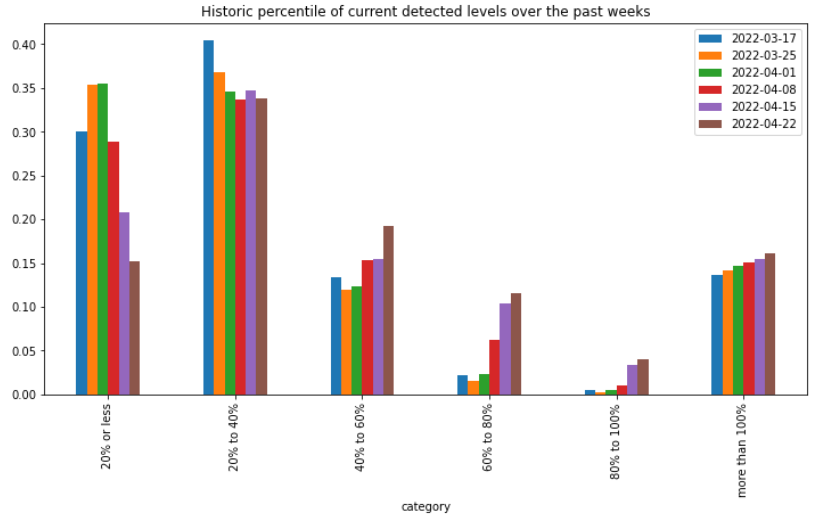
Data Source: https://covidcast.cmu.edu

Wastewater Monitoring

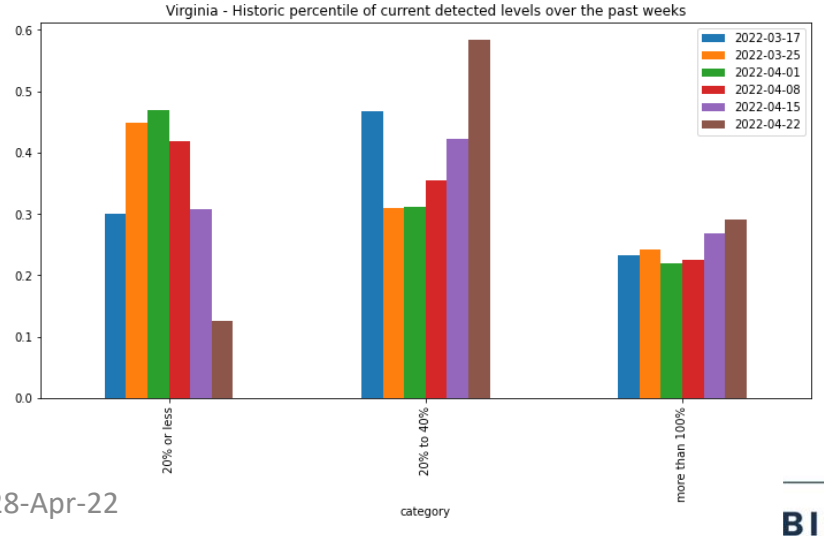
Wastewater provides a coarse early warning of COVID-19 levels in communities

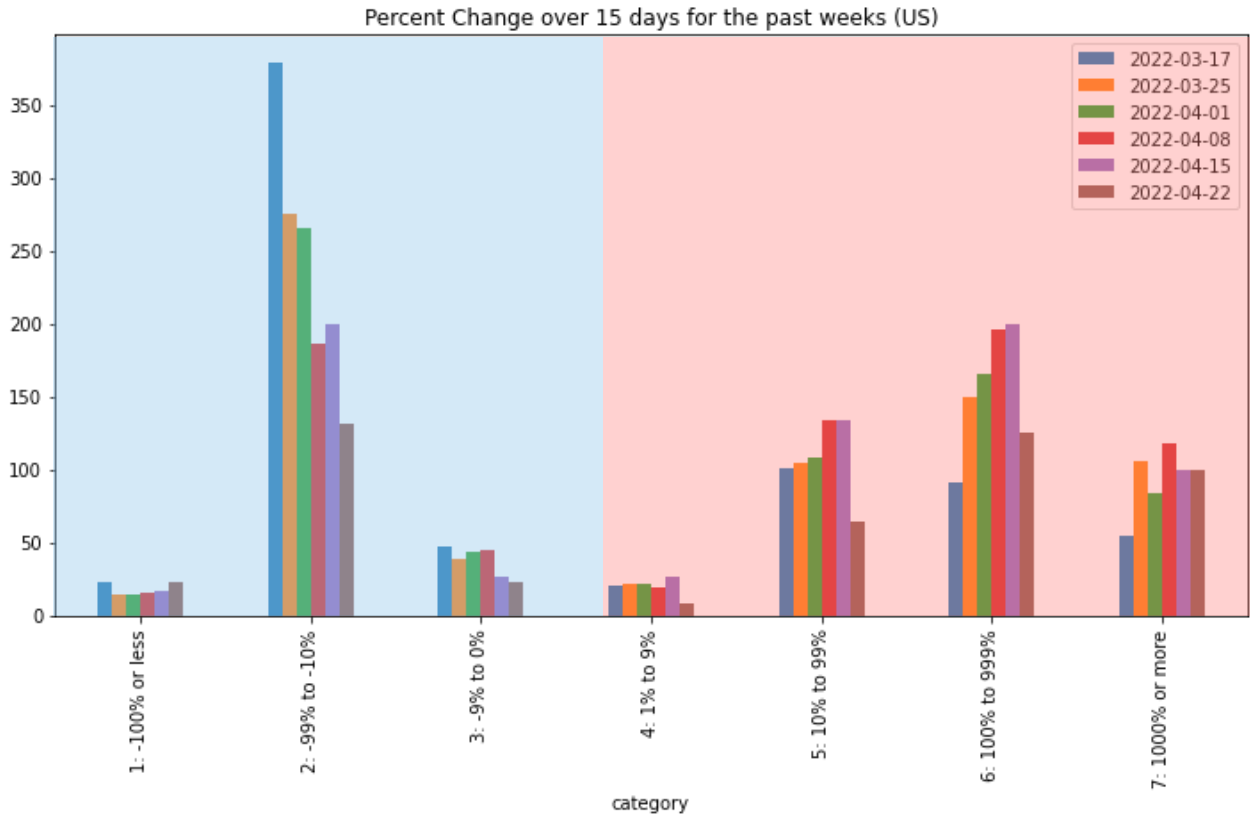
- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago, however the pace of growth slows
- Current virus levels are at or exceeding max of previous historical levels, has slowed, though more sites are entering upper quintiles

USA



VA



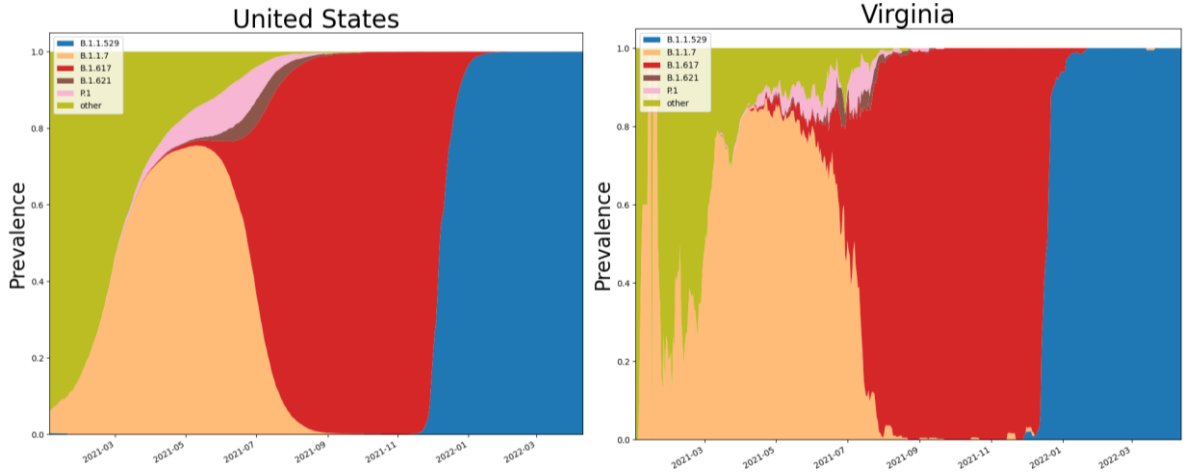


Data Source: [CDC Data Tracker]

SARS-CoV2 Variants of Concern

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

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



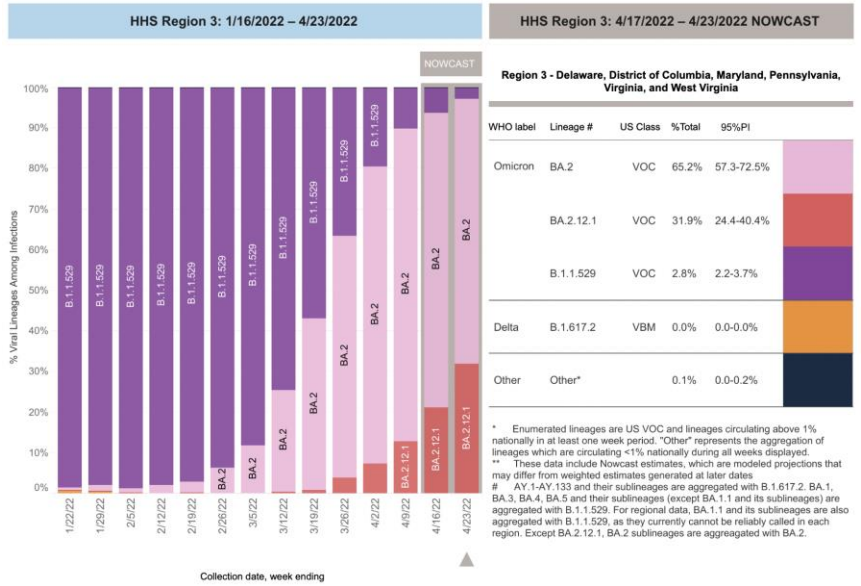
WHO label	Pango lineage*	GISAID clade	Nextstrain clade	Additional amino acid changes monitored*	Earliest documented samples	Date of designation
Alpha	B.1.1.7	GRY	20I (V1)	+S:484K +S:452R	United Kingdom, Sep-2020	18-Dec-2020
Beta	B.1.351	GH/501Y.V2	20H (V2)	+S:L18F	South Africa, May-2020	18-Dec-2020
Gamma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

World Health Organization [WHO](#)

Omicron Prevalences
subvariant BA.2 dominates

CDC nowcast for week ending April 23rd shows 97% overall BA.2 in Region 3 with BA 2.12.1 at 31%

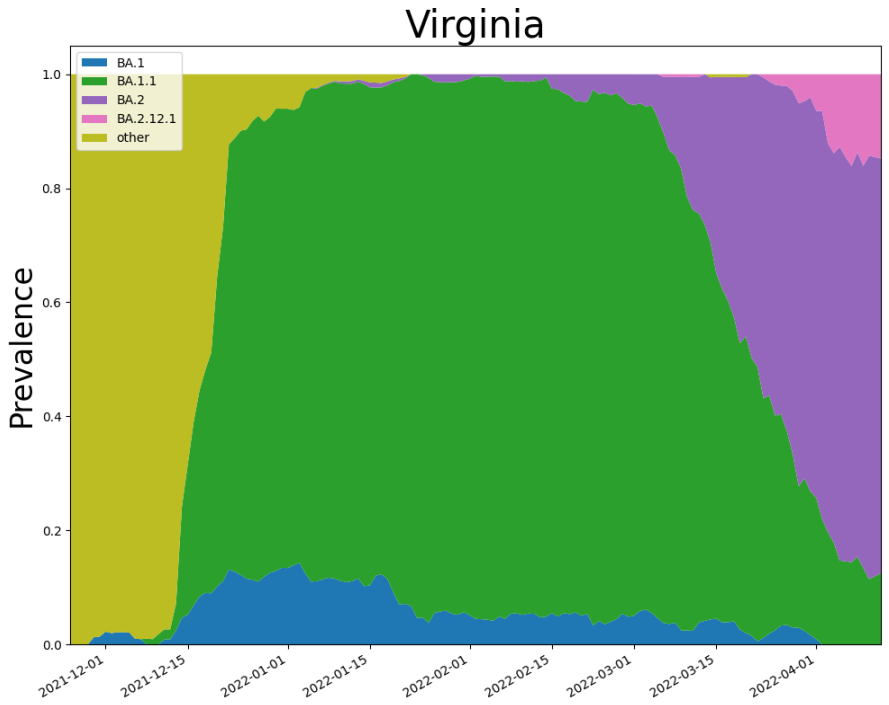
Overall BA.2 in USA now at 97% (BA.2.12.1 at 27%)

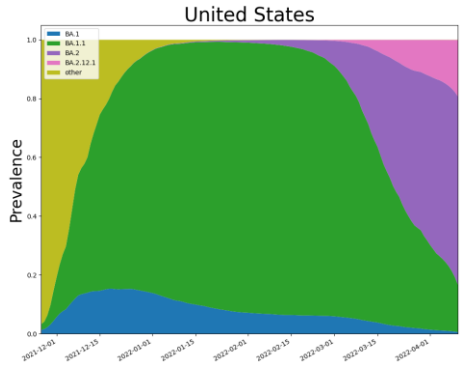


CDC [CDC Variant Tracking](#)

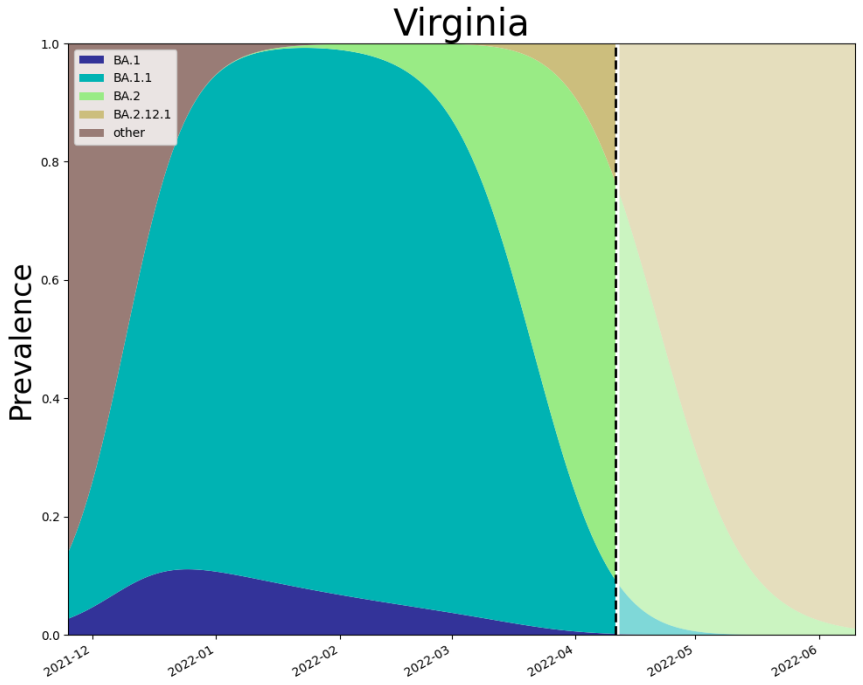
SARS-CoV2 Omicron and Sub-Variants

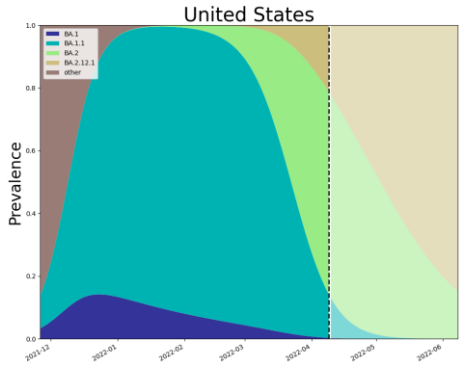
As detected in whole Genomes in public repositories





VoC Polynomial Fit Projections





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

GISAID outbreak.info

Pandemic Pubs

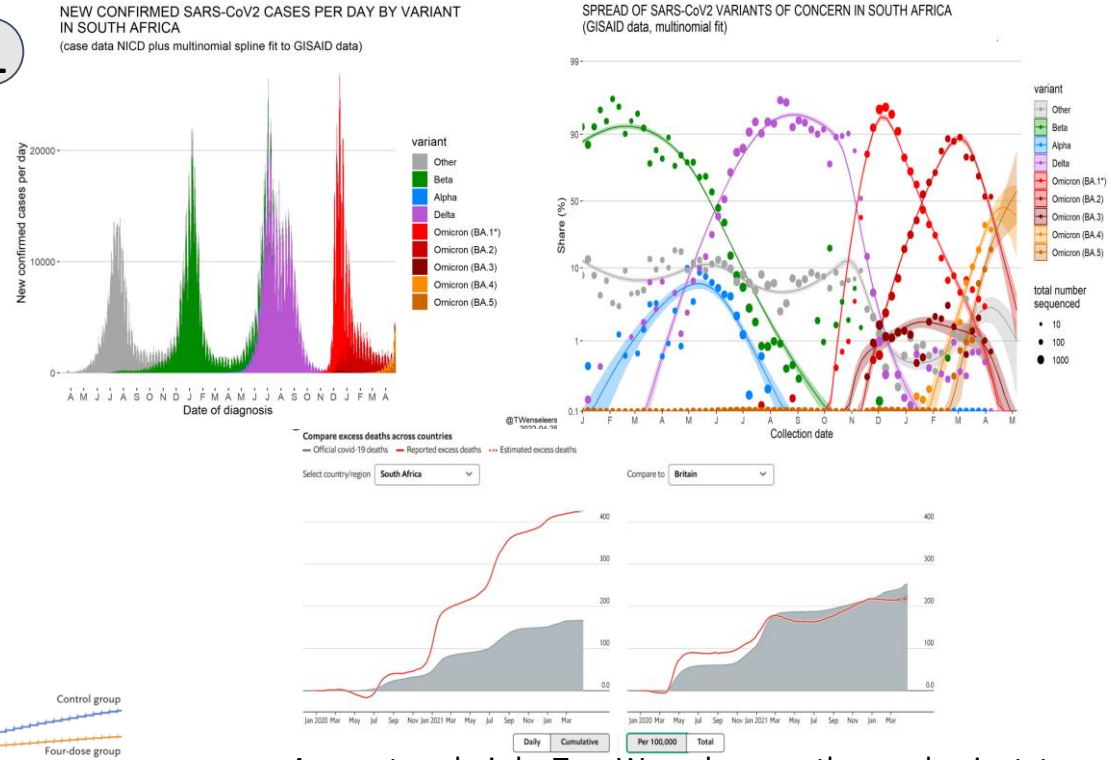
1. In South Africa BA.4 and BA.5 demonstrate a transmission advantage. Multiple provinces are showing increasing hospitalizations.

2. Survey on testing behavior estimates home testing now accounts for more positive results than all other testing

3. Recent NEJM article shows benefits of 4th dose in reducing infections and all outcomes.

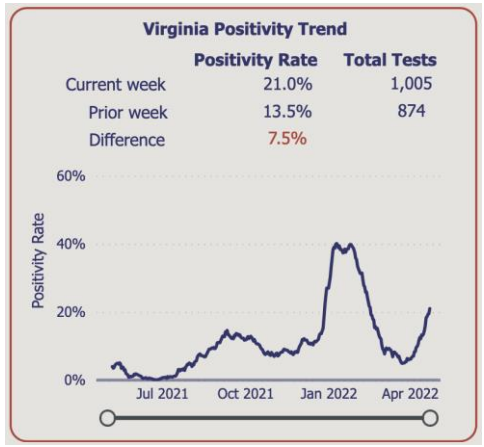
4. Walgreens Nationwide tests show increasing positivity rate including Virginia corresponding to a wave of BA.2 infections. Positivity is reportedly highest in those with 3 doses more than 5 months ago

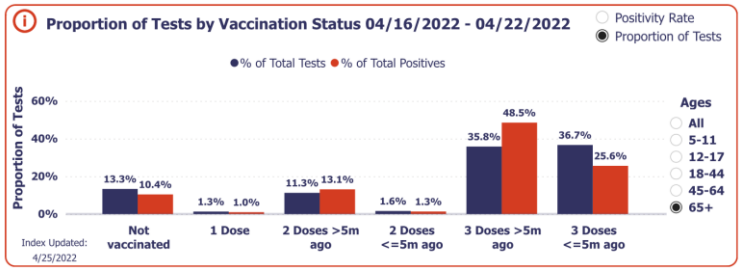
1



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

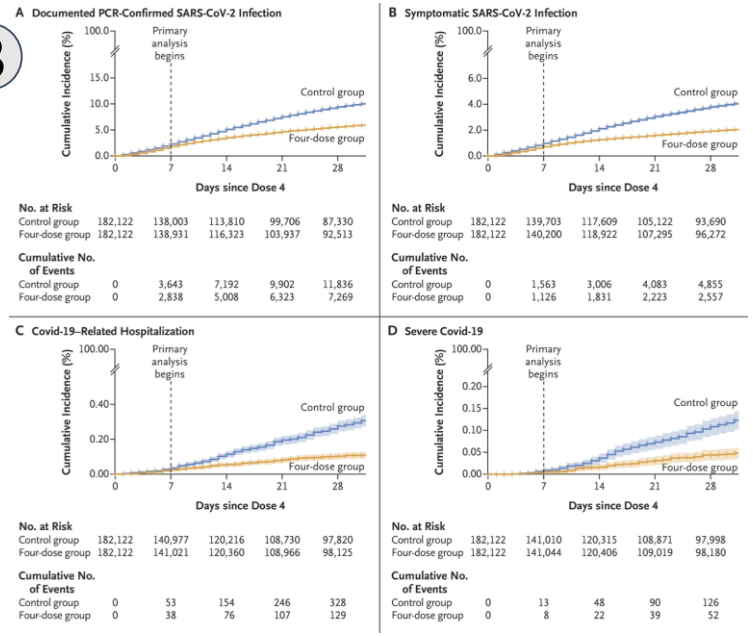
4





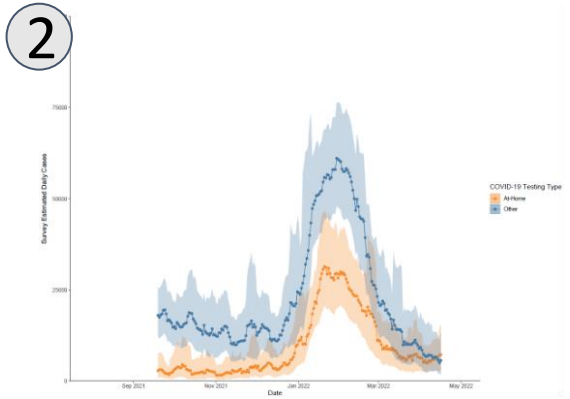
Recent Walgreens testing shows an increase in positivity rate for Virginia and many states throughout the nation. The contracted sequencing through Aegis shows increasing BA.2.12.1 proportions to the dominant BA.2
https://www.walgreens.com/businesssolutions/covid-19-index.jsp

3



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

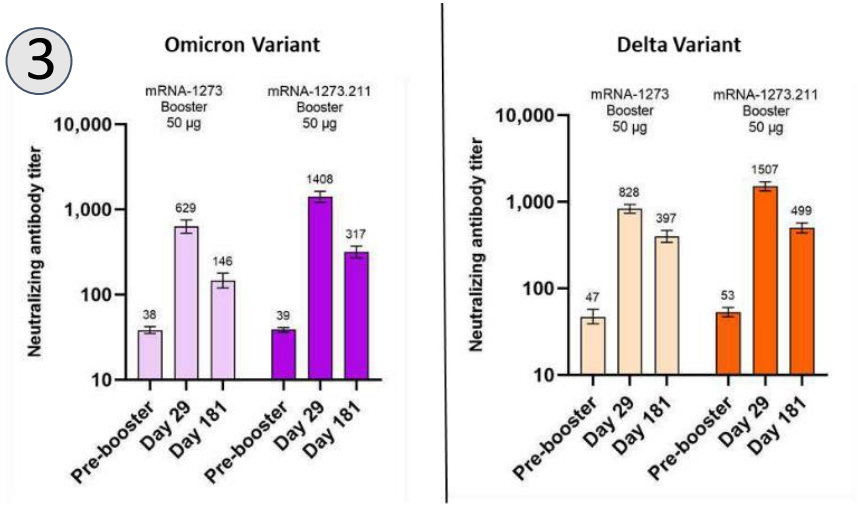
2



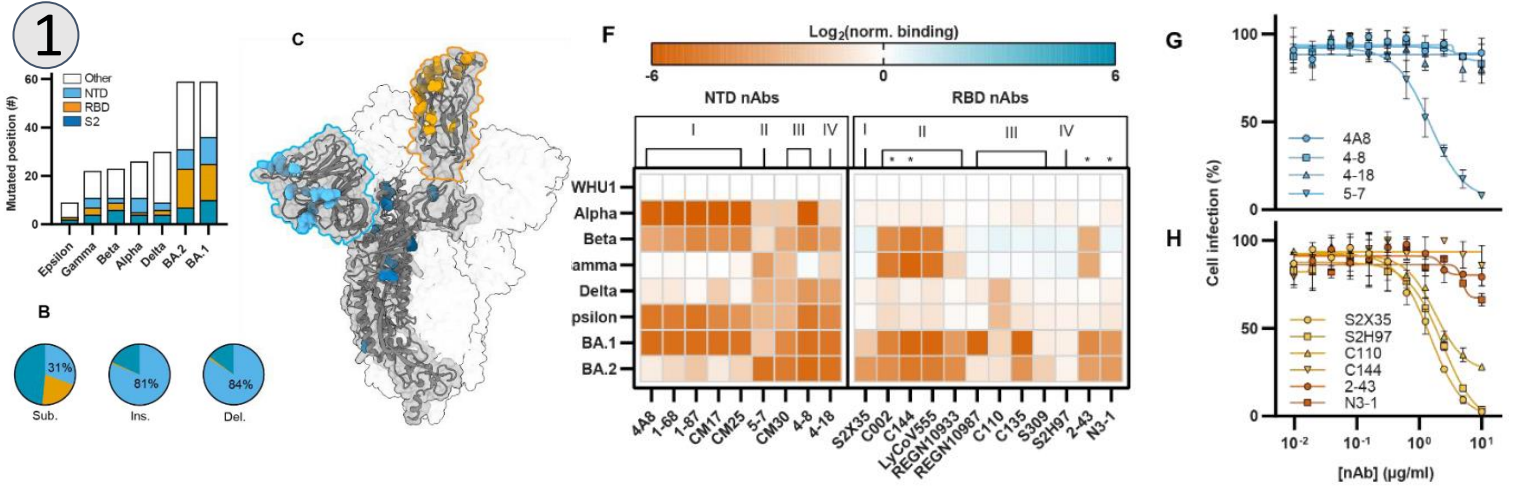
Survey of testing behaviors described in recent MMWR estimates that home testing now provides more positives than all other testing
https://twitter.com/johnbrownstein/status/1517218593422950400

Pandemic Pubs (last week)

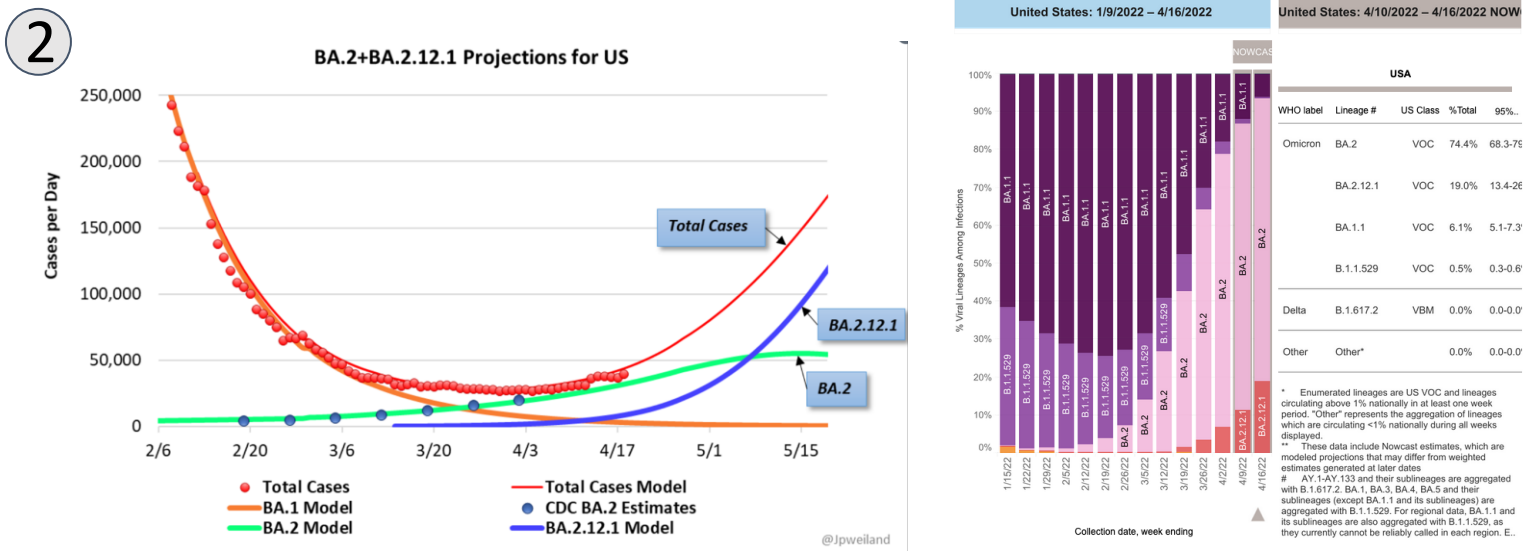
1. Compensating Spike mutations outside of the RBD enable sublineages of Omicron to increase diversity in RBD, leading to immune and monoclonal escape.
2. BA.2.12.1 has appears to have increased transmissibility advantage over BA.2.
3. Moderna's bivalent vaccine approach shows promising neutralization profile



Moderna recently released data on a bivalent booster vaccine which contains mRNAs for both the original and Beta spike protein. The mRNA-1273.211 booster (50 and 100-µg) elicited higher neutralizing antibody responses against the ancestral SARS-CoV-2 and the Beta variant than that after the second mRNA-1273 dose. It also elicited a 2.15 fold increase against Omicron compared to the original.
https://assets.researchsquare.com/files/rs-1555201/v1_covered.pdf?c=1650045900



Texas researchers find that "stabilizing mutations in the N-terminal and S2 domains of the spike protein compensate for destabilizing mutations in the receptor binding domain, thereby enabling the record number of mutations in Omicron sub-lineages." The compensating region, N-terminal and S2 domains, are highlighted in shades of blue, in panels A&C. Panel F shows monoclonal binding affinity to the receptor binding domain. Panels G and H compare virus neutralization of NTD and RBD directed monoclonal antibodies respectively.
https://www.biorxiv.org/content/10.1101/2022.04.18.488614v1



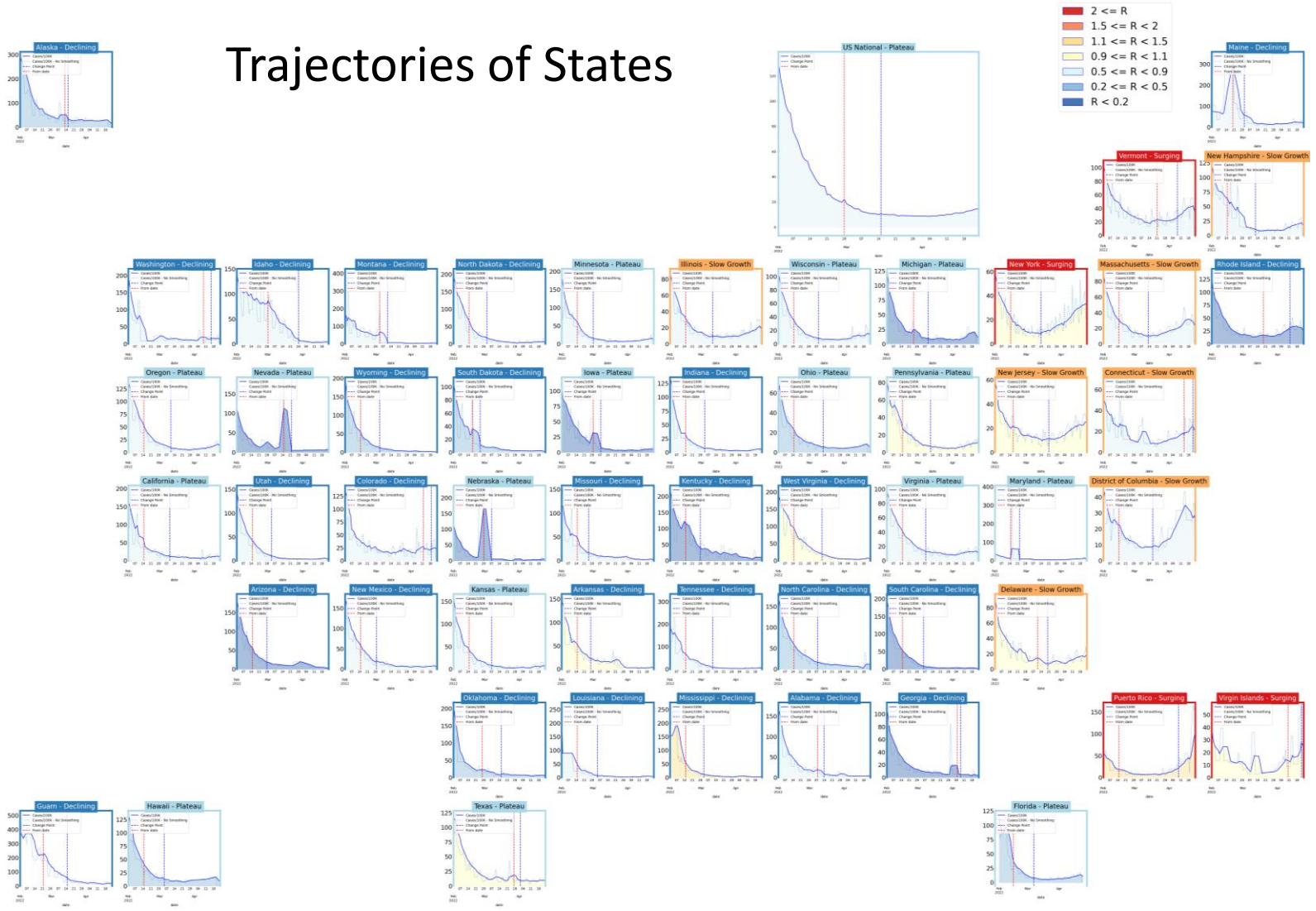
BA.2 advantage over BA.1 is from increased intrinsic transmissibility. Further BA.2.12.1 appears to have a transmission advantage over BA.2. Hypothesis that "452R/Q is conferring some additional intrinsic transmission advantage. Distinguishing these scenarios is challenging however and largely relies on assessing neutralization titer in assays with 452R/Q viruses and recent human sera." Previous mutational analysis does not implicate 452R/Q in immune escape.
https://covid.cdc.gov/covid-data-tracker/#variant-proportions
https://twitter.com/trvrb/status/1516147508820398080
https://twitter.com/JPWeiland/status/1516551779013513220/

United States Case Rates

- Rebounding activity, mainly in the Northeast

Status	# States
Declining	27 (36)
Plateau	16 (9)
Slow Growth	7 (8)
In Surge	4 (1)

Trajectories of States

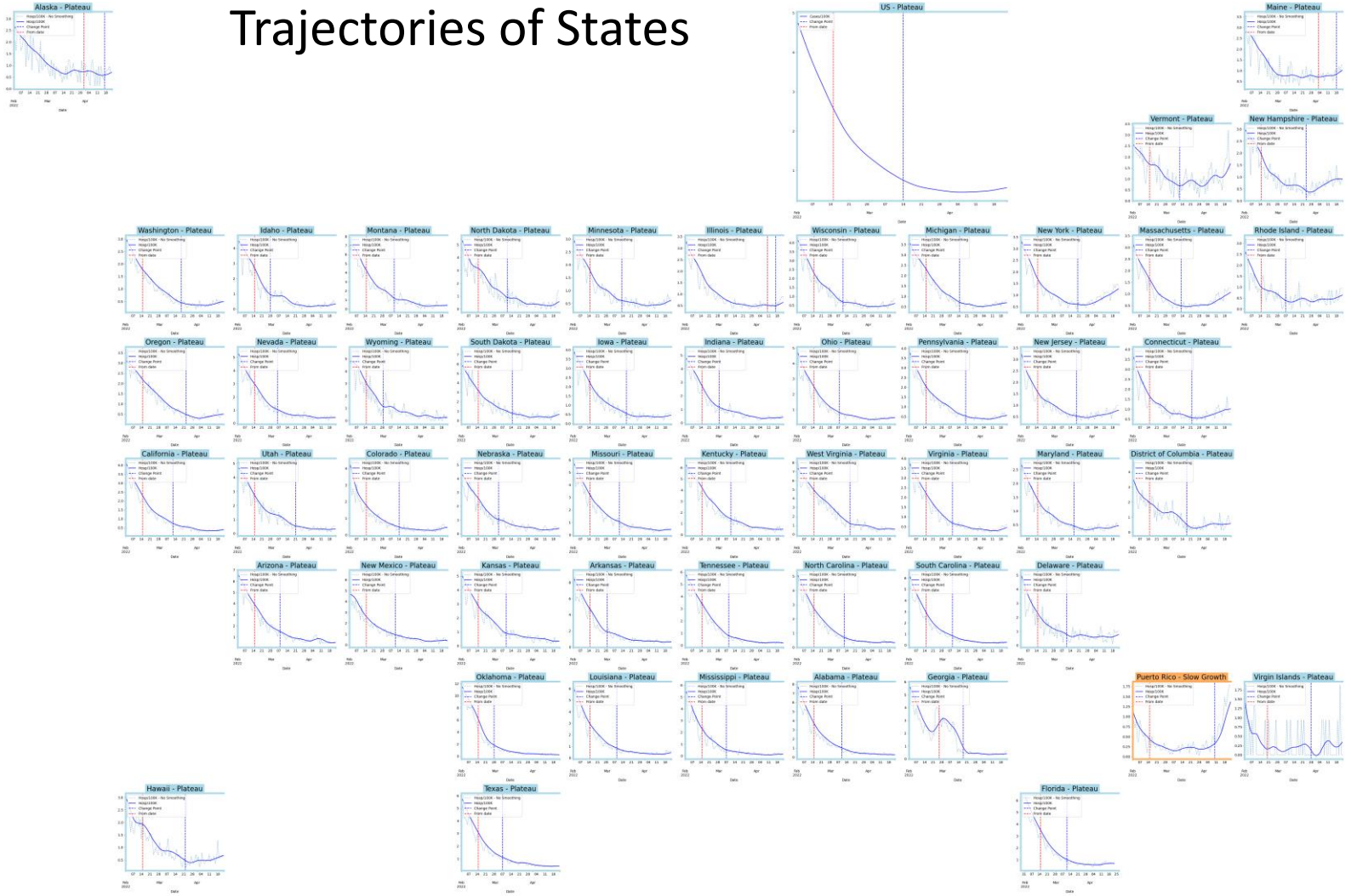


United States Hospitalizations

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

Status	# States
Declining	1 (3)
Plateau	51 (50)
Slow Growth	1 (1)
In Surge	0 (0)

Trajectories of States



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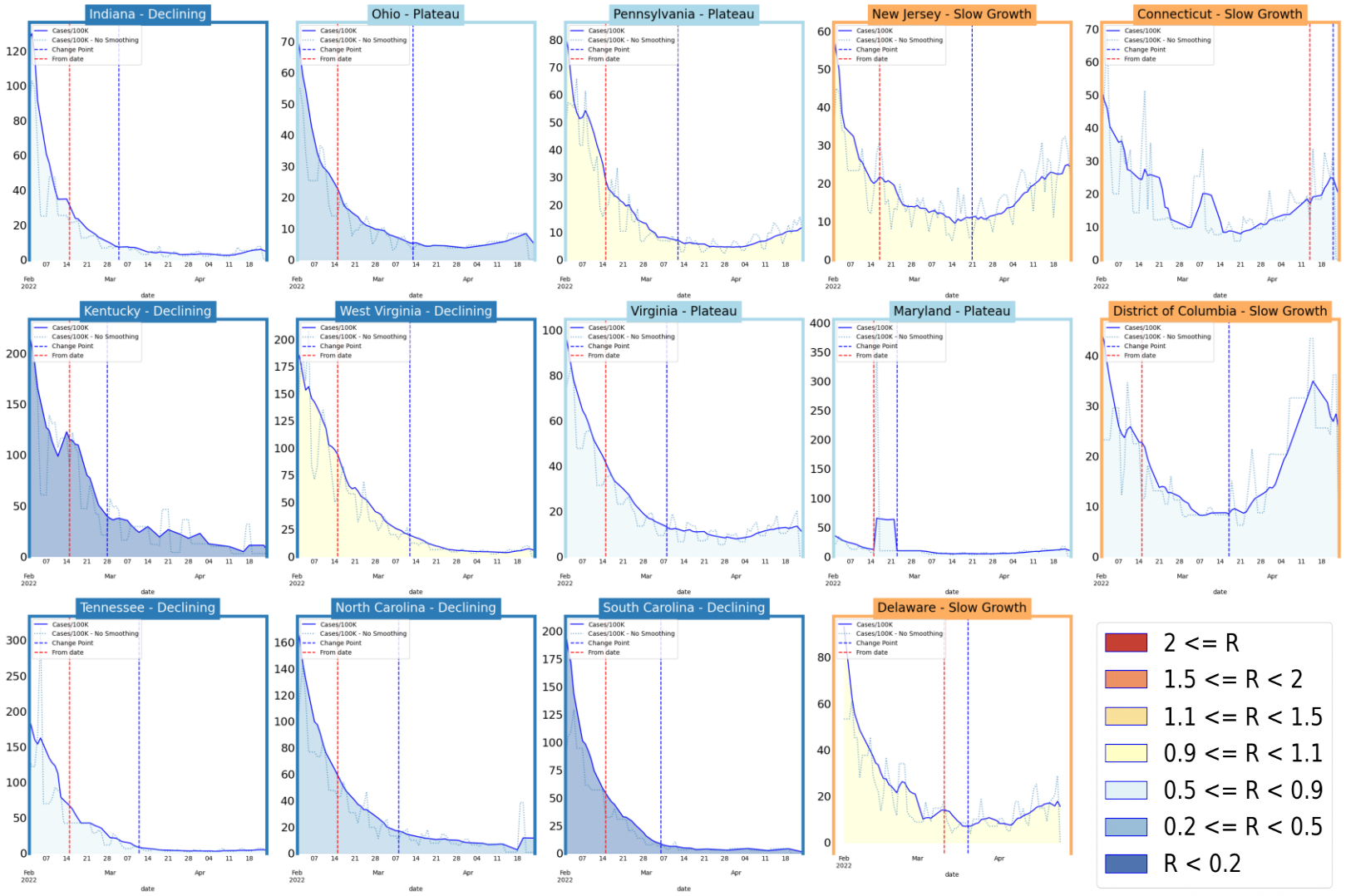
Virginia and Her Neighbors

- All have dramatically dropped from peaks
- Rates have moderated
- All but Kentucky are below 10/100K



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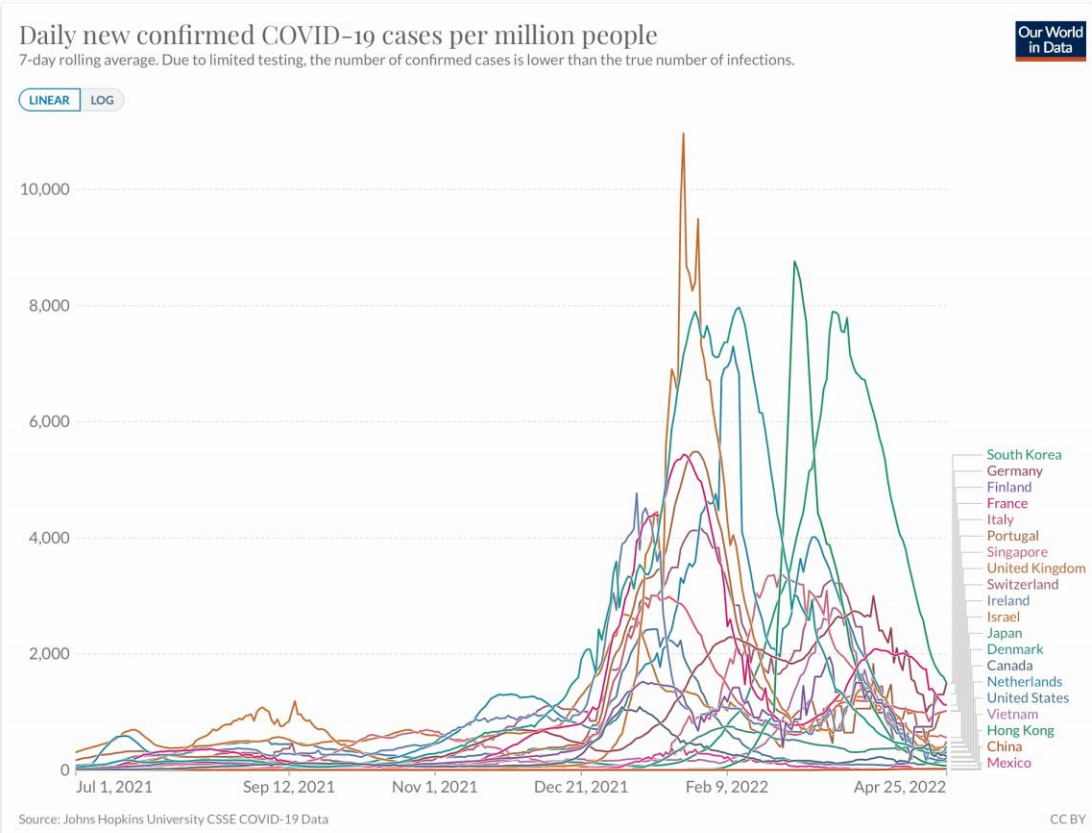
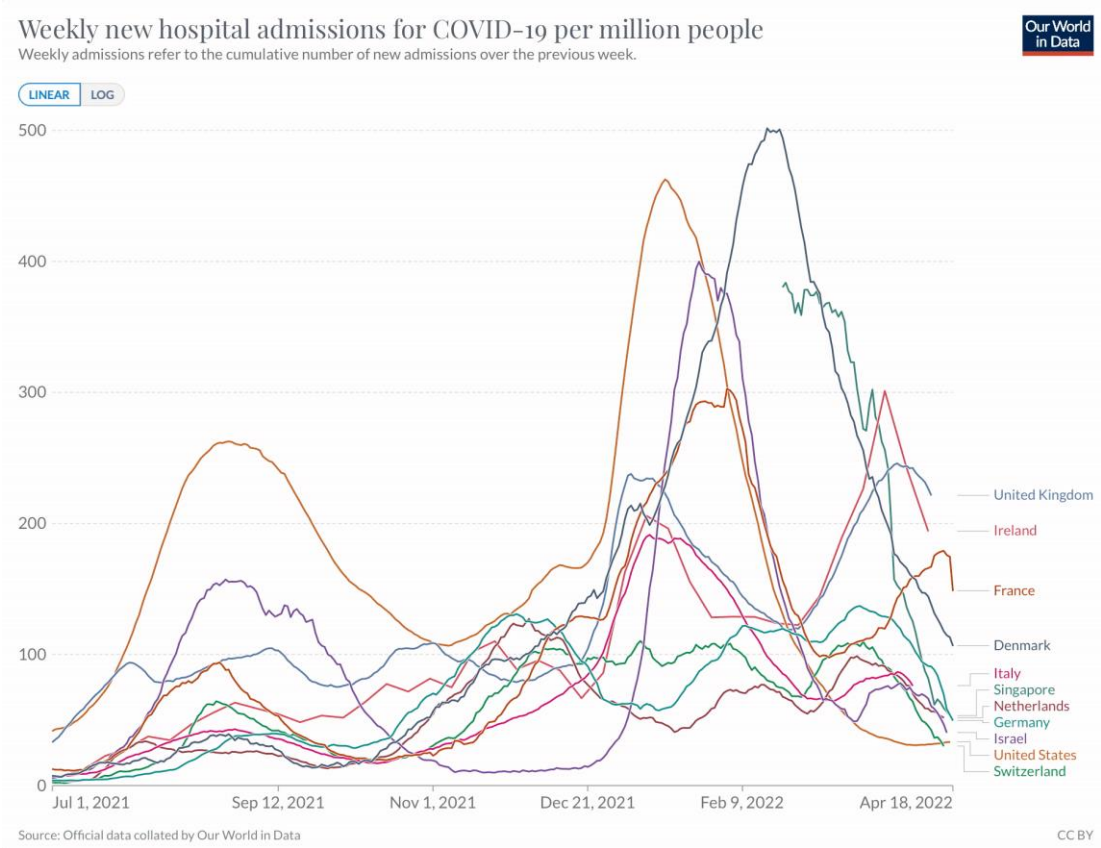
Other Countries

- Many, but not all, European countries are experiencing a rebound in cases
- Rebound in hospitalizations is a bit delayed but observed in some of these countries as well
- US per capita hospitalization rates lower than most European nations

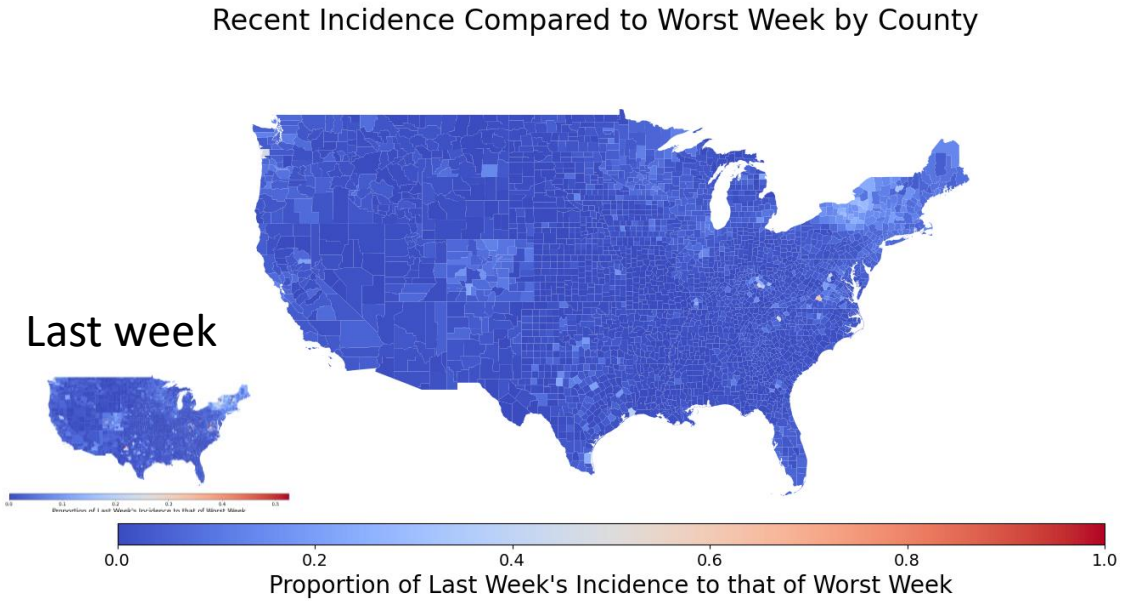


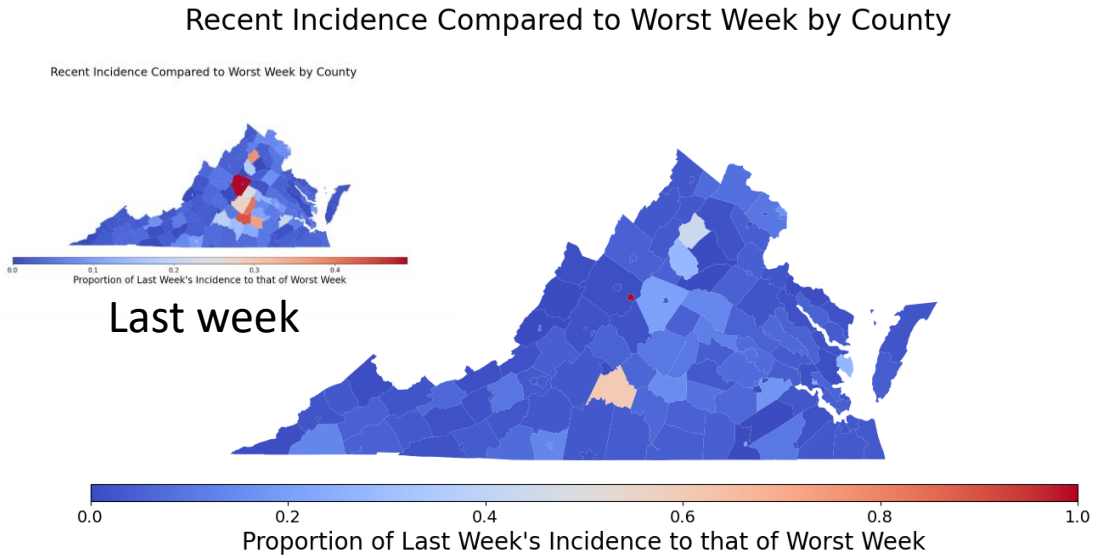


[Our World in Data]

County-level comparison to previous highest peak

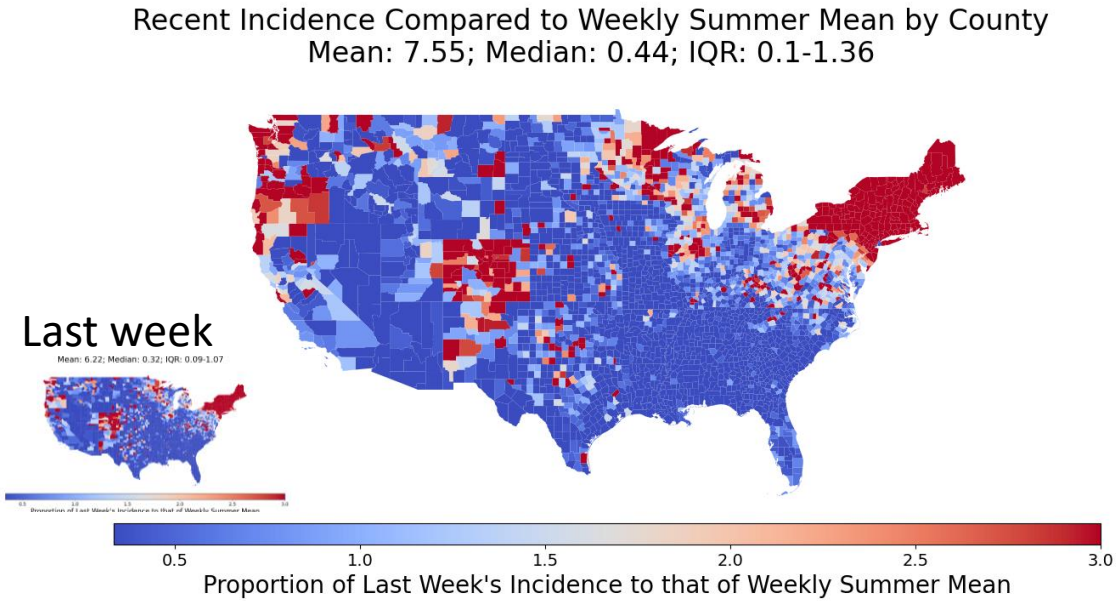
- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably

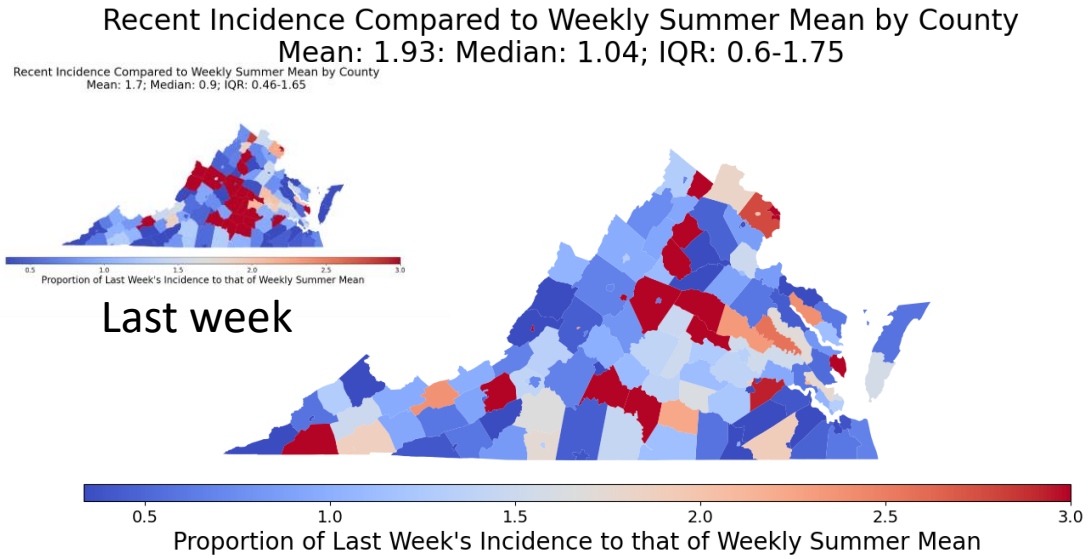




County-level comparison to last Summer

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





Zip code level weekly Case Rate (per 100K)

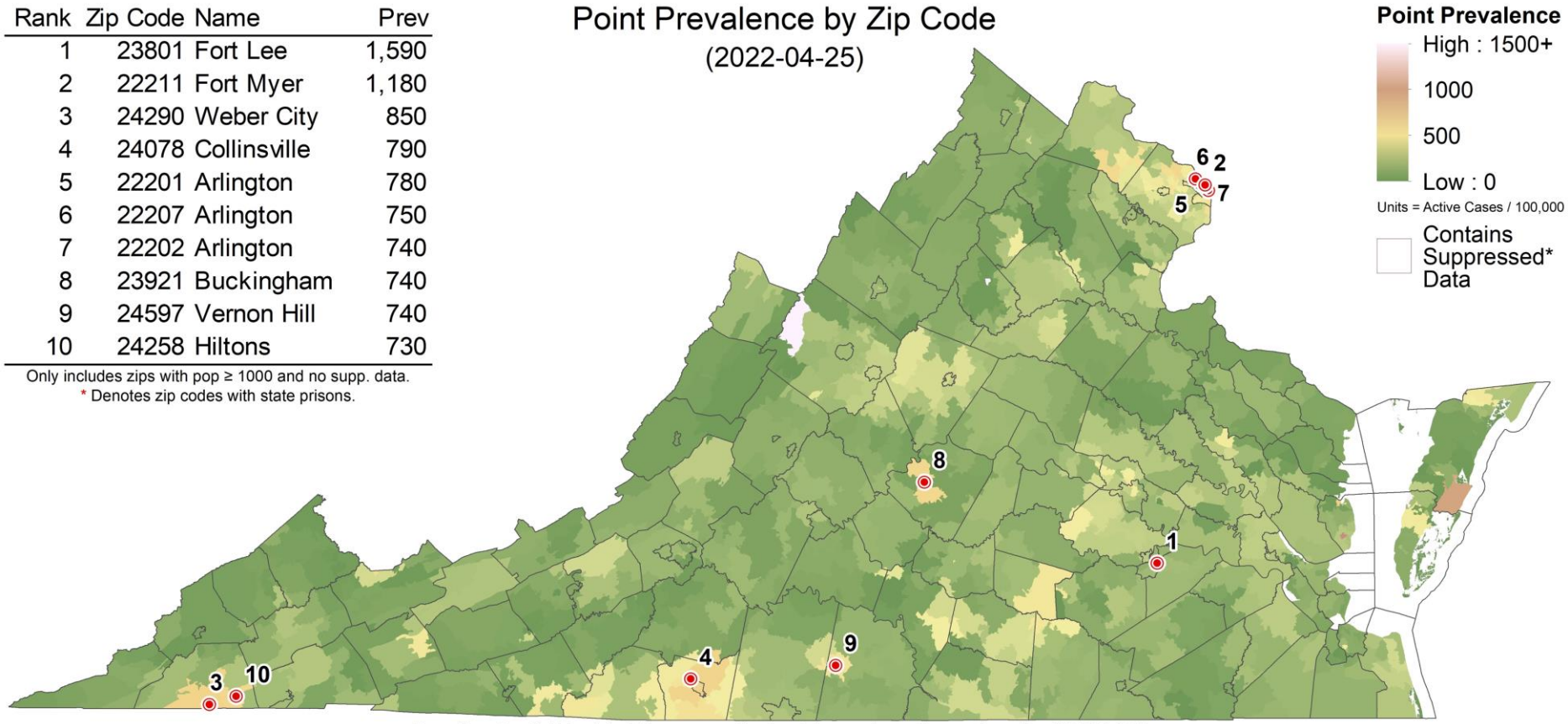
Case Rates in the last week by zip code

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

Rank	Zip Code	Name	Prev
1	23801	Fort Lee	1,590
2	22211	Fort Myer	1,180
3	24290	Weber City	850
4	24078	Collinsville	790
5	22201	Arlington	780
6	22207	Arlington	750
7	22202	Arlington	740
8	23921	Buckingham	740
9	24597	Vernon Hill	740
10	24258	Hiltons	730

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

Color gradient adjusted lower



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-04-25.
Note: New Color Scale

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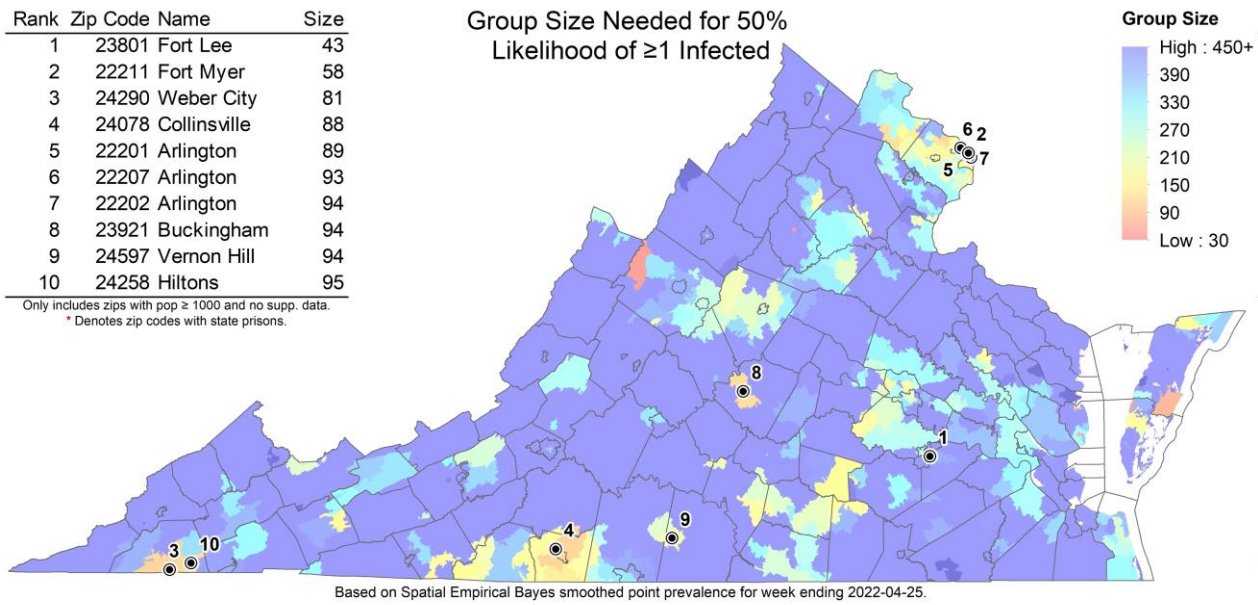
Risk of Exposure by Group Size and HCW prevalence

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 Fort Lee, 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

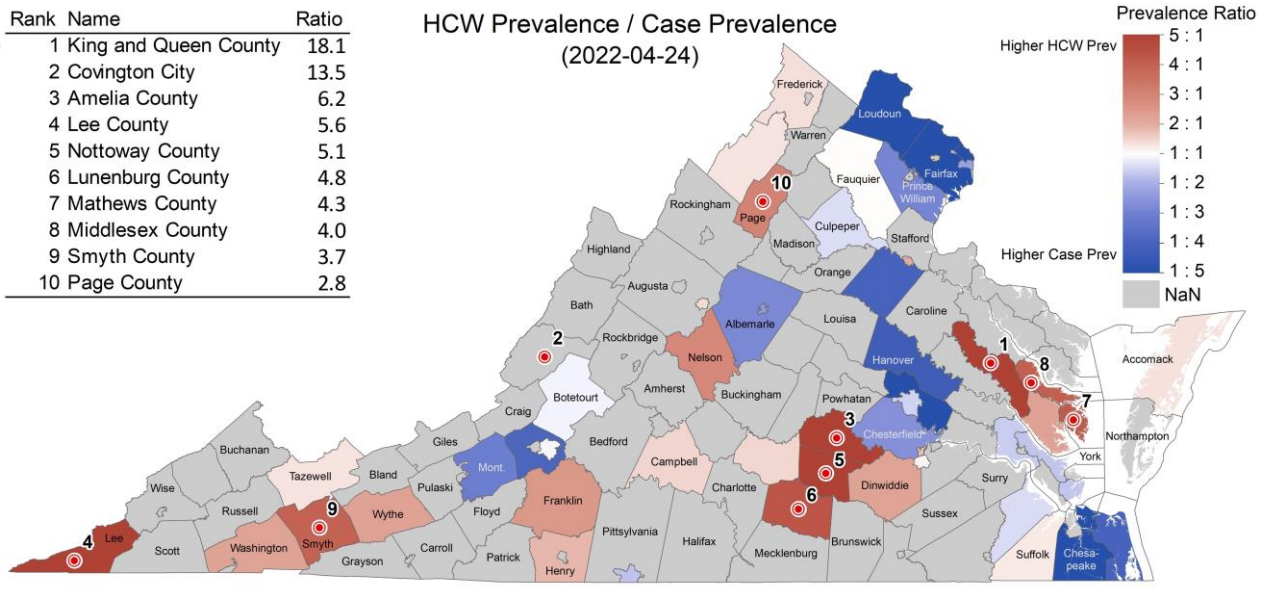
Rank	Zip Code	Name	Size
1	23801	Fort Lee	43
2	22211	Fort Myer	58
3	24290	Weber City	81
4	24078	Collinsville	88
5	22201	Arlington	89
6	22207	Arlington	93
7	22202	Arlington	94
8	23921	Buckingham	94
9	24597	Vernon Hill	94
10	24258	Hiltons	95

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



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-04-25.

Rank	Name	Ratio
1	King and Queen County	18.1
2	Covington City	13.5
3	Amelia County	6.2
4	Lee County	5.6
5	Nottoway County	5.1
6	Lunenburg County	4.8
7	Mathews County	4.3
8	Middlesex County	4.0
9	Smyth County	3.7
10	Page County	2.8



Current Hot-Spots

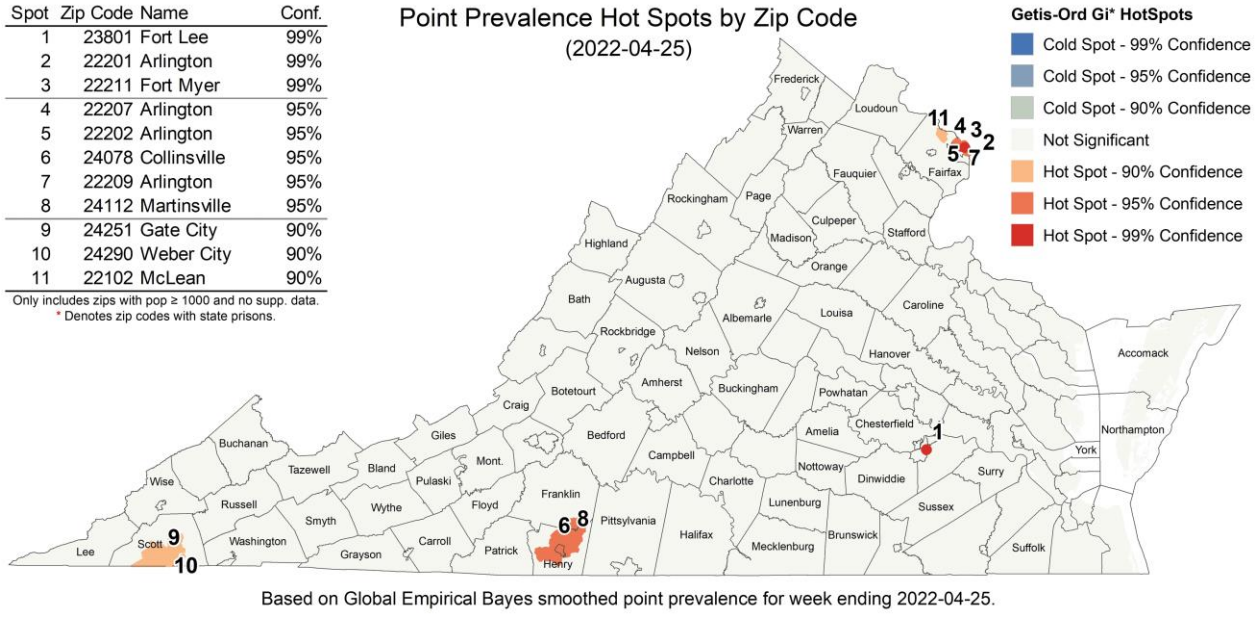
Case rates that are significantly different from neighboring areas or model projections

- **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

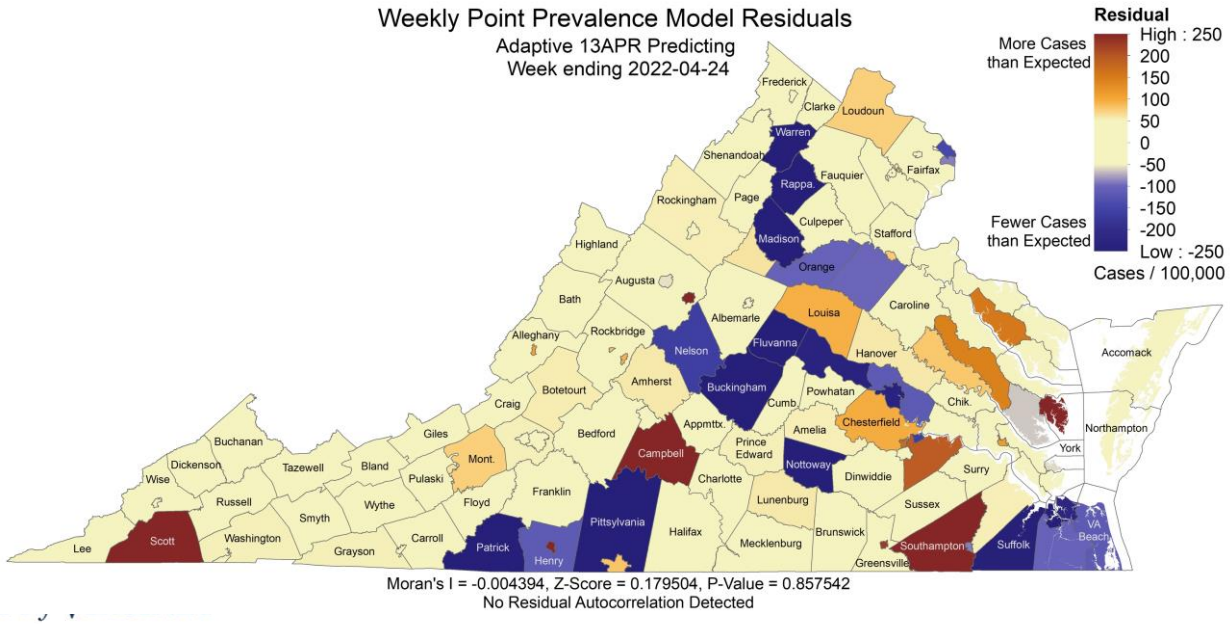
Spot	Zip Code	Name	Conf.
1	23801	Fort Lee	99%
2	22201	Arlington	99%
3	22211	Fort Myer	99%
4	22207	Arlington	95%
5	22202	Arlington	95%
6	24078	Collinsville	95%
7	22209	Arlington	95%
8	24112	Martinsville	95%
9	24251	Gate City	90%
10	24290	Weber City	90%
11	22102	McLean	90%

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



Based on Global Empirical Bayes smoothed point prevalence for week ending 2022-04-25.

Clustered Temporal Hotspots

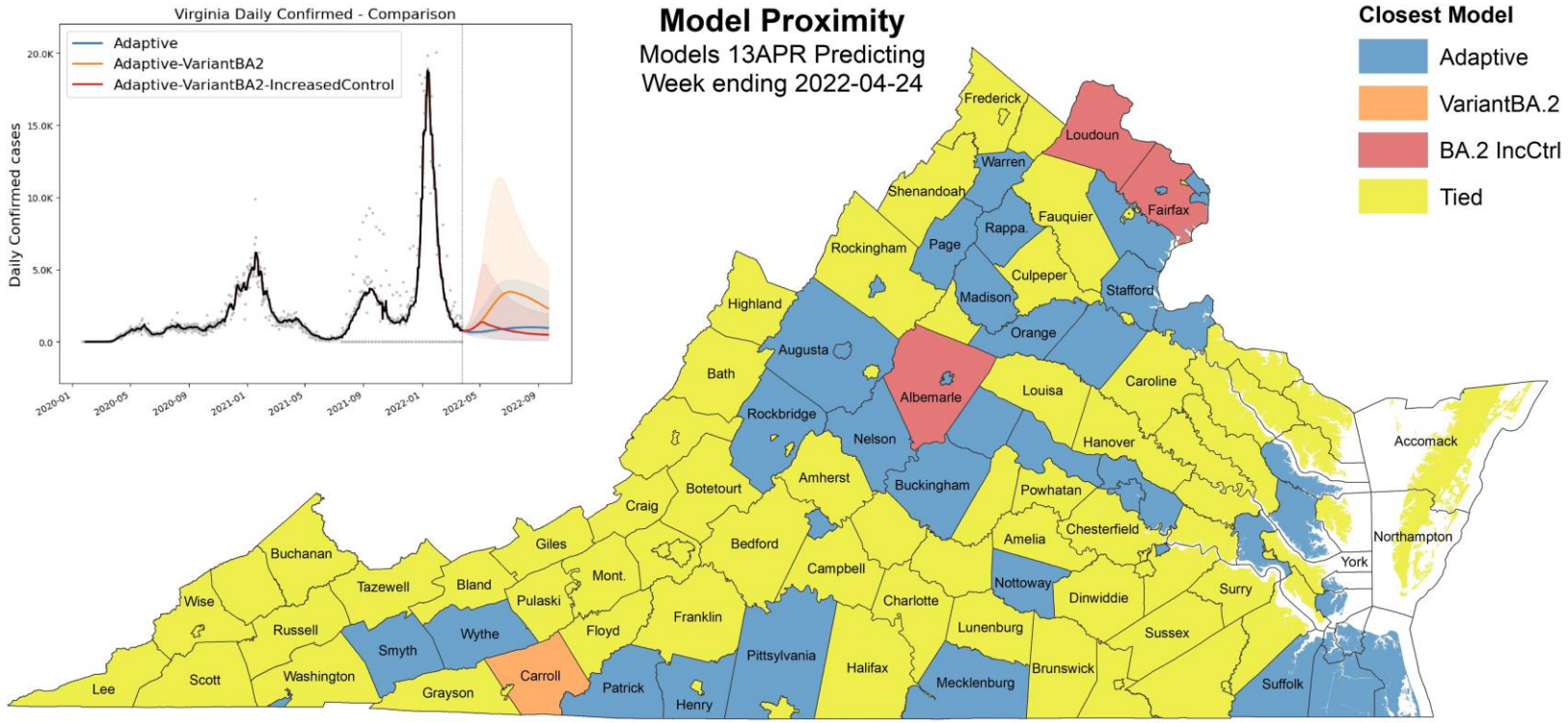


Moran's I = -0.004394, Z-Score = 0.179504, P-Value = 0.857542
No Residual Autocorrelation Detected

Scenario Trajectory Tracking

Which scenario from last projection did each county track closest?

- Minimal difference between projections overall
- Mixed results reflective of similarity of scenarios, most counties tracking slower decline scenarios (BA2 and DecreaseControl)

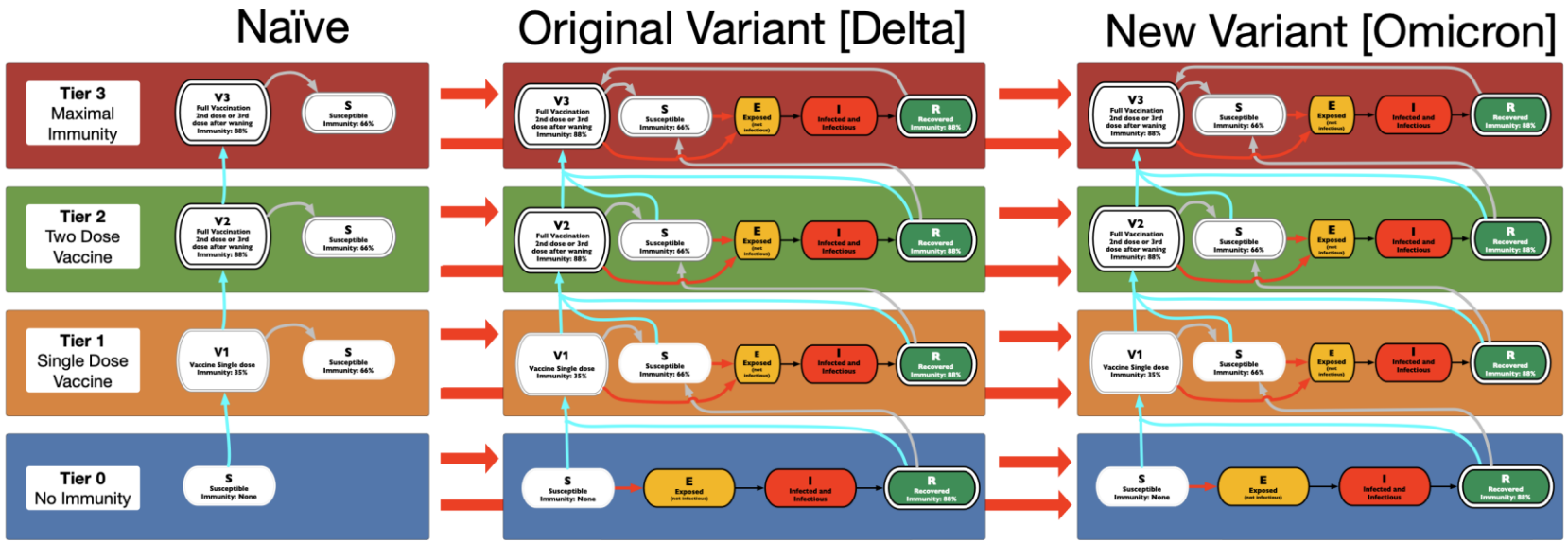


Model Update – Adaptive Fitting

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

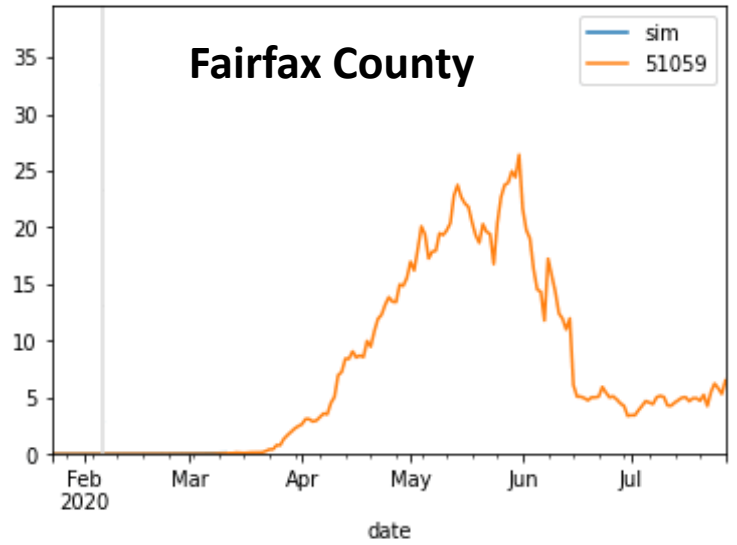
- Allows history to be precisely captured, and used to guide bounds on projections

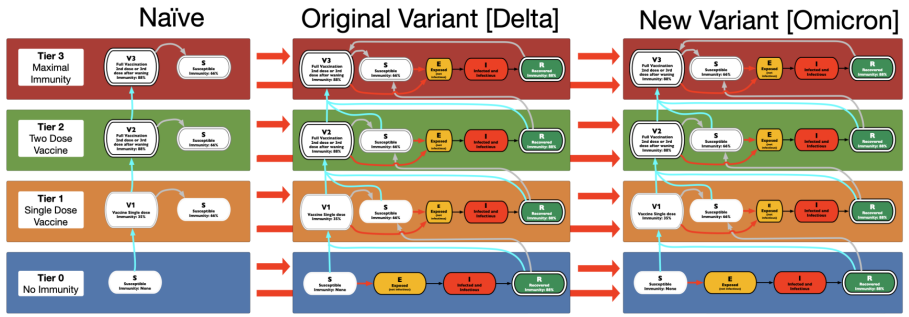
Model: An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- 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:

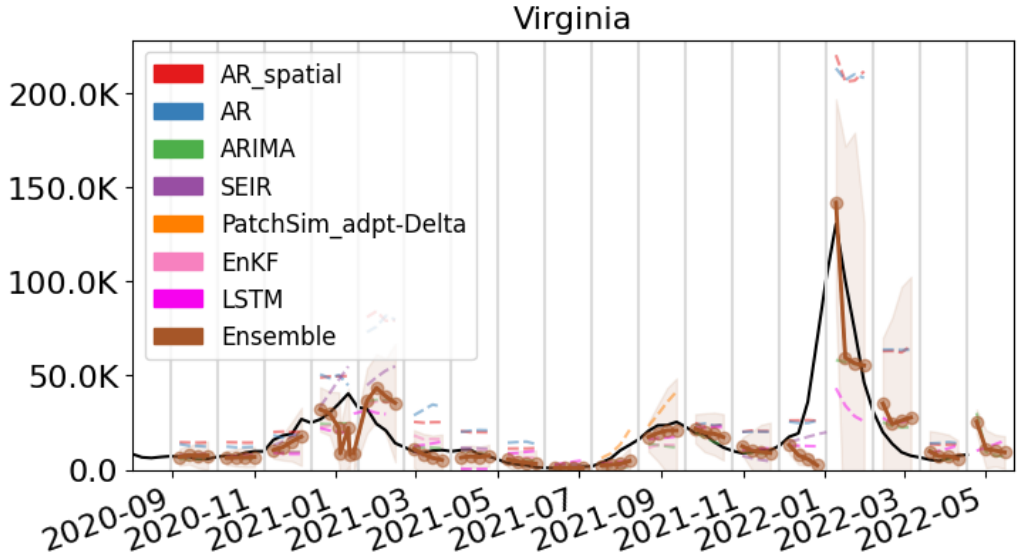
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

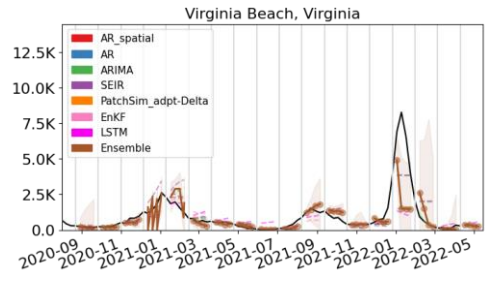
<u>Weekly forecasts</u> done at county level.

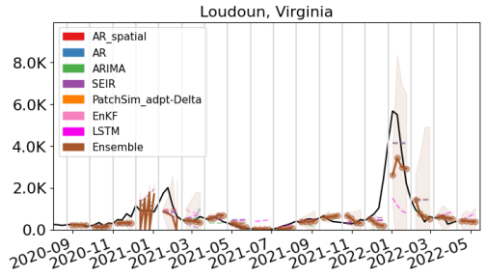
Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

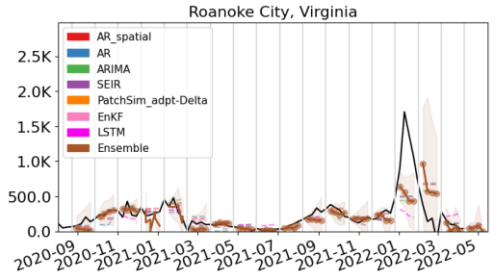
Ensemble forecast provides additional ‘surveillance’ for making scenario-based projections.

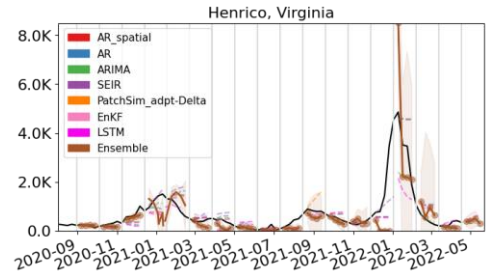
Also submitted to CDC Forecast Hub.











Seroprevalence updates to model design

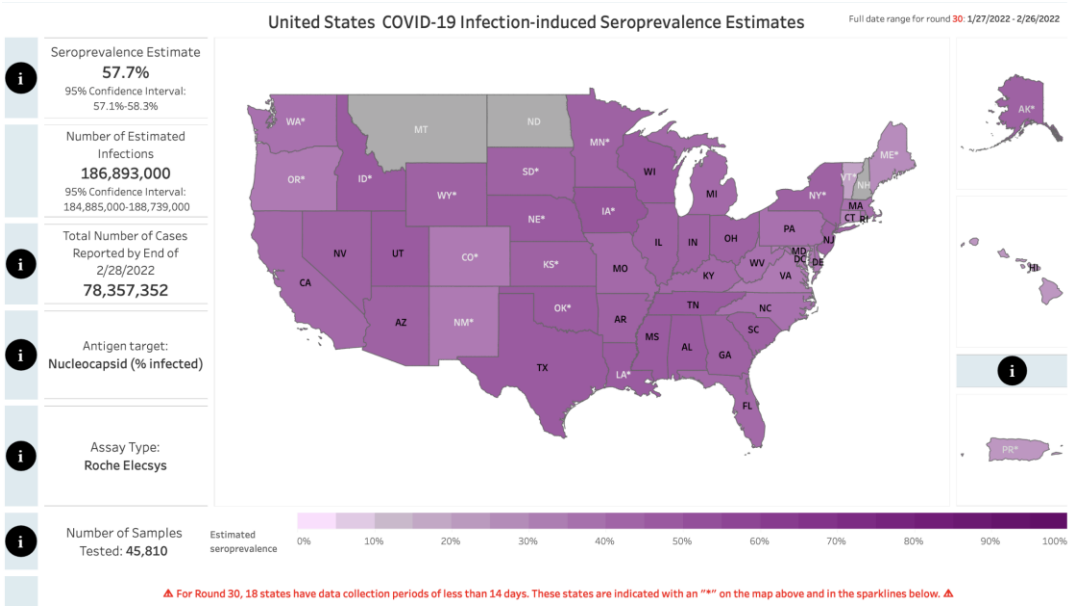
Several seroprevalence studies provide better picture of how many actual infections have occurred

- CDC Nationwide Commercial Laboratory Seroprevalence Survey

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

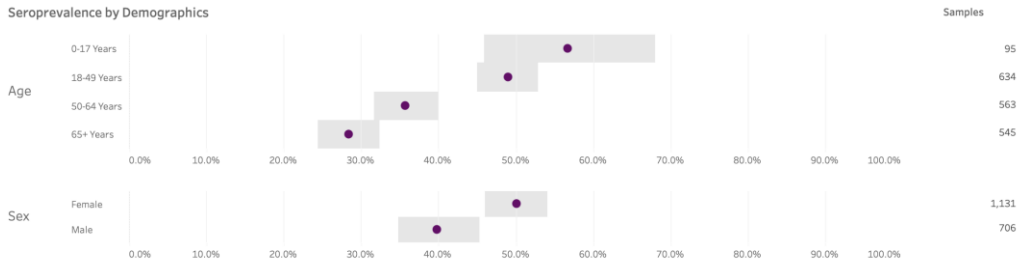
- Thus there were 2.5 total infections in the population for every confirmed case recently
- **Case ascertainment for Omicron infections are half of that for pre-Omicron, thus for every case there are ~5 total infections**
- During the peak of Omicron, the degradation of test seeking and capacity were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

New Data released late on April 26th not yet incorporated in model



Virginia

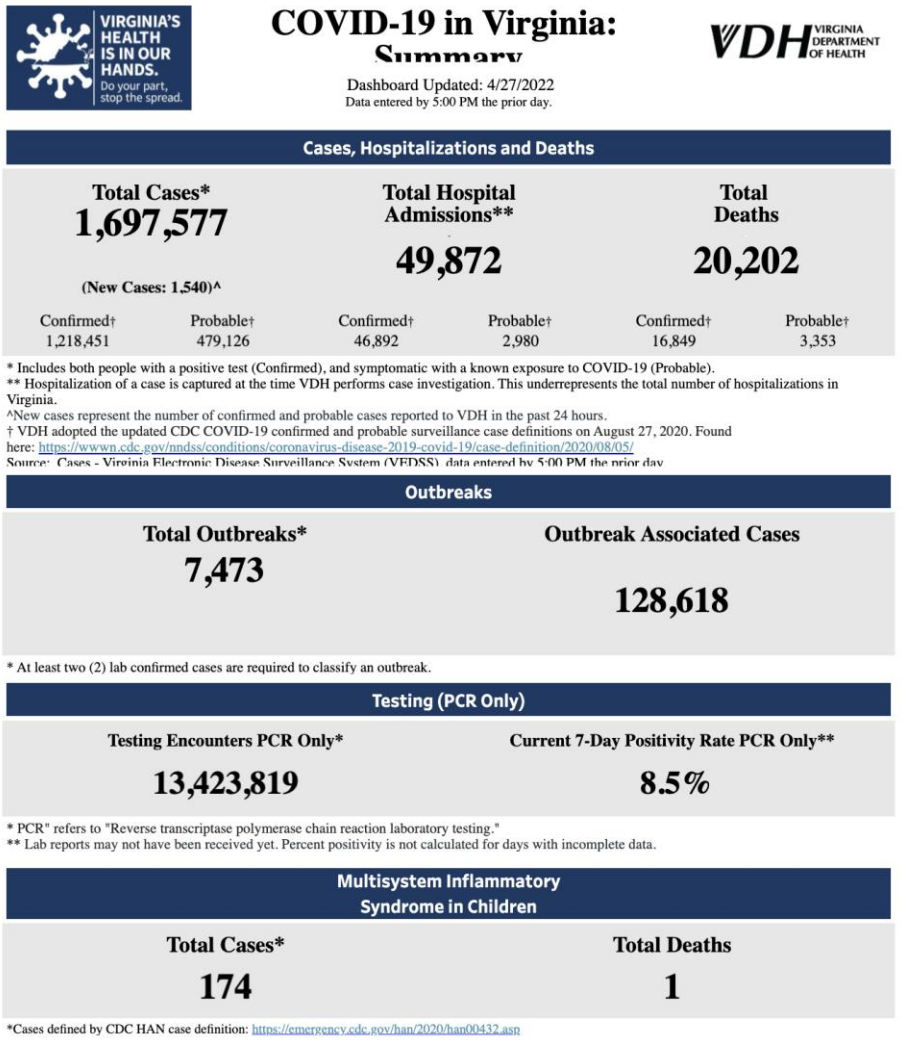
Feb 22nd: 45% [42% - 48%]; Jan 22nd: 34% [31%-39%]



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: 4/27/2022
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospital Admissions**	Total Deaths
1,697,577	49,872	20,202
(New Cases: 1,540)^		

Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
1,218,451	479,126	46,892	2,980	16,849	3,353

* 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
7,473	128,618

* 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**
13,423,819	8.5%

* 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
174	1

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

Accessed 10:20am April 27, 2022
https://www.vdh.virginia.gov/coronavirus/

Scenarios – Transmission Conditions

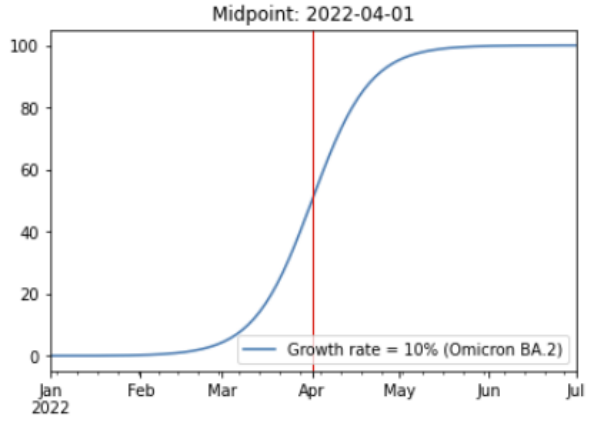
- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity**: Mean of 6 months to a year protection (rate of 0.0027) similar to Pfizer study, Omicron waning with a mean of 4 months
- **Projection Scenarios**:
  - **Adaptive:** Control remains as is currently experienced into the future with assumption that Omicron remains as the majority strain, and that infection with Omicron provides protection against Omicron infection in the future
  - **Adaptive-VariantBA2_12:** Same as Adaptive, but with BA.2.12.1 subvariant continuing predominance and having a 30% transmission advantage over existing Omicron (mainly the overall BA.2 subvariant)
  - **Adaptive-VariantBA2_12-IncreasedControl**: Same as Adaptive-VariantBA2_12, but with a 25% reduction in transmission to increased mitigations starting in 30 days and phasing into full effect over 2 weeks

Scenarios – Omicron BA.2 Description

BA.2 shows signs of increased transmissibility

- **Transmissibility**: Analysis of household contacts in Denmark and the UK suggests a 40% to 3x increase in transmission.
- **Now use a 30% boost to transmissibility only**
- **Prevalence**: Detection in US has been widespread but limited; given growth observed elsewhere and US, and current estimated prevalence, this would lead to BA.2 prevalence of 50% in early April
- **Severity:** Assumed to be same as for other Omicron subvariants

Estimated BA2 prevalence projection



This projected prevalence is based on the increase experienced in Denmark the growth rate in VA may be markedly different

Table 3: Relative effect of Omicron VOC BA.2 vs. BA.1

	Susceptibility			Transmissibility		
	Unvaccinated	Fully vaccinated	Booster vaccinated	Unvaccinated	Fully vaccinated	Booster vaccinated
Omicron BA.2 households	2.19 (1.58-3.04)	2.45 (1.77-3.40)	2.99 (2.11-4.24)	2.62 (1.96-3.52)	0.60 (0.42-0.85)	0.62 (0.42-0.91)
Omicron BA.1 households	ref (.)	ref (.)	ref (.)	ref (.)	ref (.)	ref (.)
Number of observations	17,945	17,945	17,945	17,945	17,945	17,945
Number of households	8,541	8,541	8,541	8,541	8,541	8,541

Notes: This table shows odds ratio estimates for the effect of living in a household infected with BA.2 relative to BA.1. Column 1 and 4 shows the relative transmission of BA.2, conditional on being unvac- cinated. Column 2 and 5 shows the relative transmission of BA.2, conditional on being fully vaccinated. Column 3 and 6 shows the relative transmission of BA.2, conditional on being booster vaccinated. Note, all estimates are from the same model, but with a different reference category across column 1-6. The estimates are adjusted for age and sex of the primary case, age and sex of the potential secondary case, size of the household, and primary case sample date. The estimates are furthermore adjusted for vacci- nation status of the potential secondary case and primary case interacted with the household subvariant. 95% confidence intervals are shown in parentheses. Standard errors are clustered on the household level. The odds ratio estimates for the full model are presented in Appendix Table 12, column I

Danish Household Study - MedArxiv

Table 4. Secondary attack rates for contacts of cases with confirmed sequenced VUI-22JAN-01 and all other Omicron (VOC-21NOV-01)

(Case test dates 1 January to 14 February 2022, variant data as of 7 March 2022 and contact tracing data as of 8 March 2022)

Variant	Setting	Number of exposing cases	Number of contacts	Adjusted* secondary attack rate (95% Confidence Interval)
VOC-21NOV-01	Household	178,069	369,011	10.7% (10.6%-10.8%)
VUI-22JAN-01	Household	20,072	41,621	13.6% (13.2%-14.0%)
VOC-21NOV-01	Non-household	30,325	74,343	4.2% (4.0%-4.3%)
VUI-22JAN-01	Non-household	3,565	8,763	5.3% (4.7%-5.8%)

UK HAS report shows 2ndary Attack rates ~30% higher in households and out of households.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1060337/Technical-Briefing-38-11March2022.pdf

Many countries Tracking a 2x Advantage for BA.2 vs. BA.1

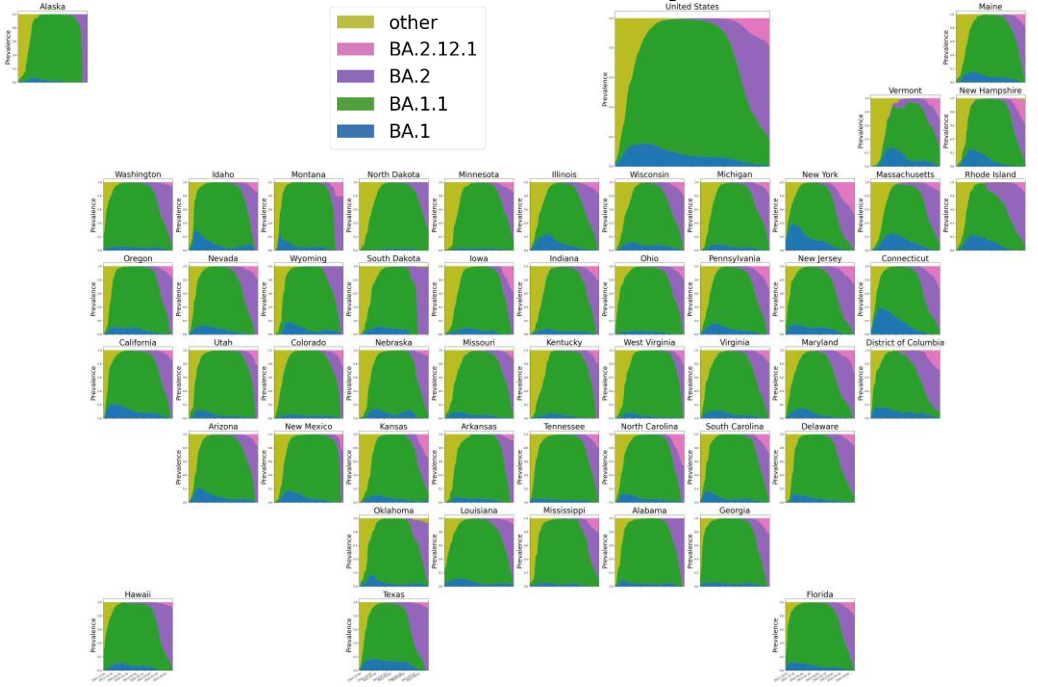
Barak Raveh via Twitter

Scenarios – Omicron BA.2.12 Description

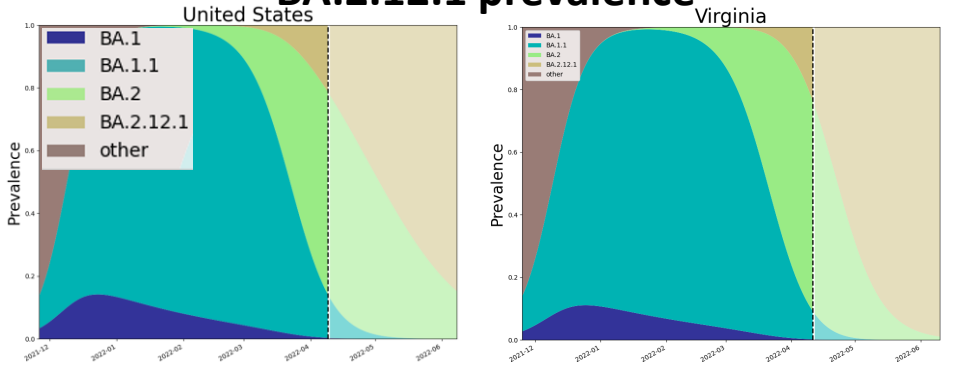
BA.2.12.1 shows signs of increased transmissibility via increasing prevalence in the US, especially the Northeast

- **Transmissibility**: Not as well observed as previous VoCs as mainly in US and worldwide genotyping efforts have slowed
- **Using a 30% boost to transmissibility**
- **Prevalence**: Growth rate compared to BA.2 seems to be similar as to BA.2's vs. BA.1 (and BA.1.1), thus assuming similar prevalence curve (30% growth advantage, doubling ~every 8 days)
- **Conservatively estimating prevalence to hit 50% on June 1st with ~95% 4 weeks later**
- **Severity:** Assumed to be same as for other Omicron subvariants

Observed BA.2.12.1 prevalence



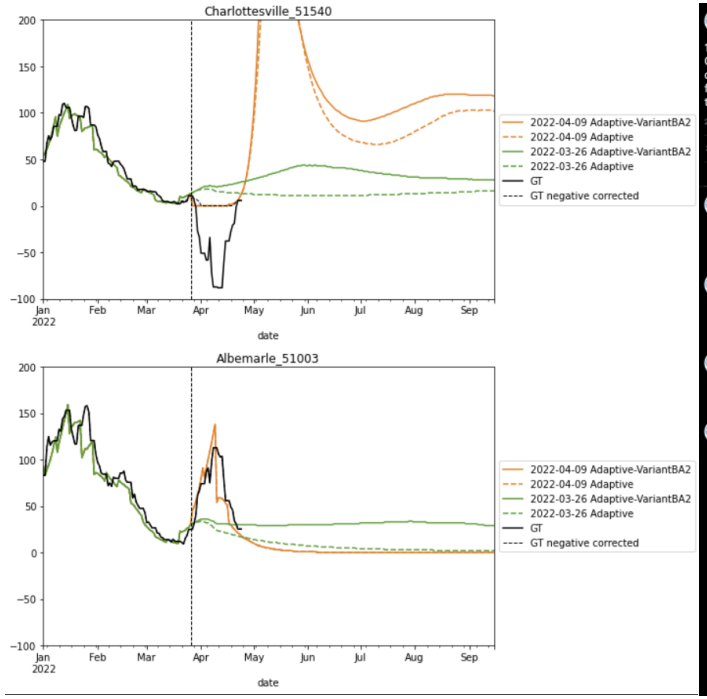
Coarse Polynomial fitted estimates of BA.2.12.1 prevalence



Scenarios – Surveillance Corrections

- Recent surveillance adjustments biased projections
  - Normal projections are sensitive to recent trends in reported cases, when there are adjustments it can lead to the appearance of a trend when there isn't one
- Blue Ridge health district example
  - QA process led to distribution of cases from C'ville to Albemarle seems to nearing end
  - C'ville is returning from negative cases, but thus
- To correct we now fit to cases at district level and then disaggregated district cases to county based on population
  - Will lead to county level mismatch of projections and ground truth surveillance
  - More robust to minor fluctuations in surveillance data

Twitter Link



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-VariantBA2	C	SQ	Transmission rates for BA.2 infections are 30% more infectious, BA.2 prevalence reached 50% on April 1st and rises to over 95% by mid-May
Adaptive-VariantBA2_12	C	SQ	Transmission rates for BA.2.12.1 infections are and additional 30% higher, with BA.2.12.1 prevalence reaching 50% on June 1st and rising to ~95% 4 weeks after
Adaptive-VariantBA2_12-IncreasedControl	Increased	SQ	Same as Adaptive-VariantBA2_12 with increased mitigations reducing transmission by 25% starting June 1st

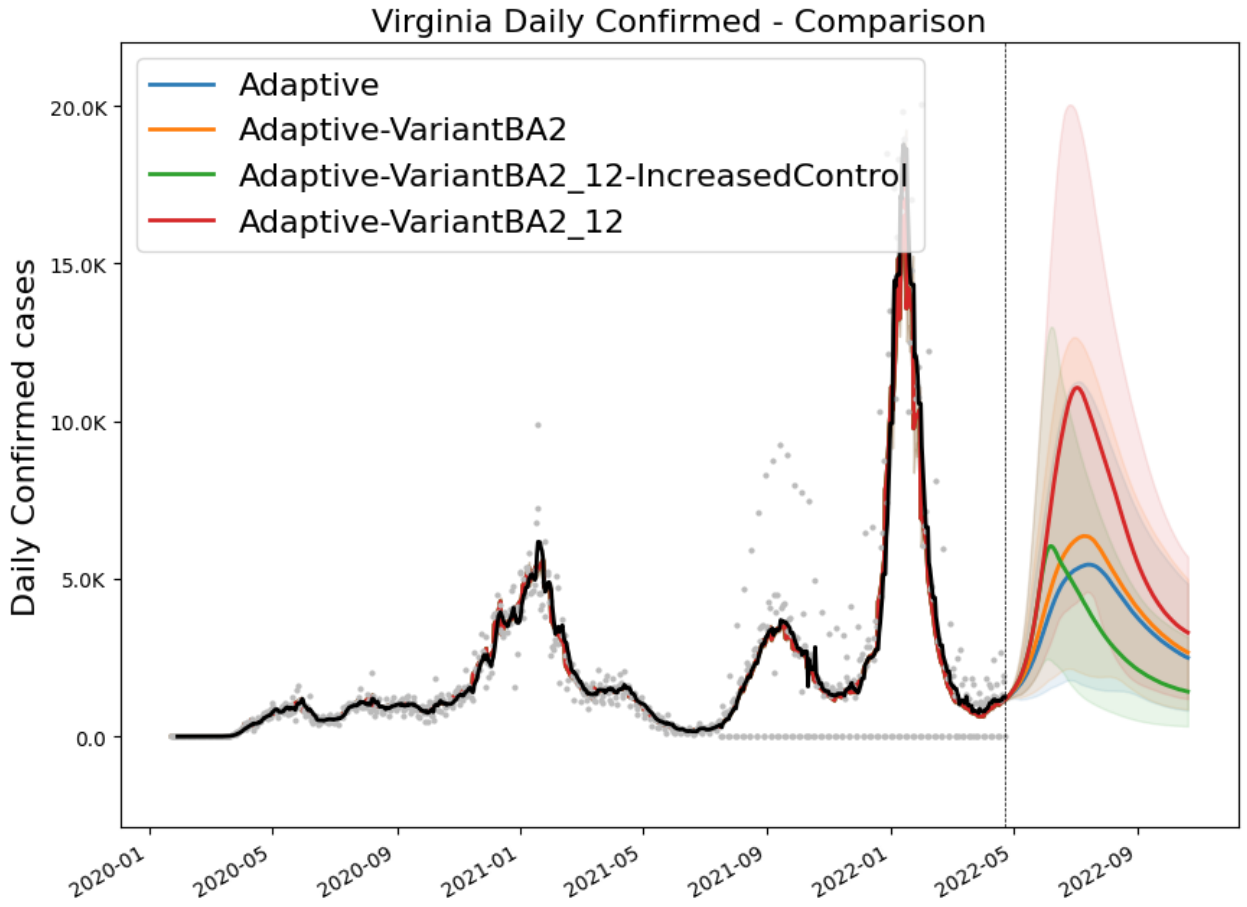
Transmission Controls:
C = Current levels persist into the future
Increased = Transmission rates are reduced by 25% over 2 weeks starting May 1st
Spring = Transmission rates from mid-Jan 2021 through mid-March 2021 are coarsely replayed, representing a 60% reduction in transmission rate drivers, with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

Model Results

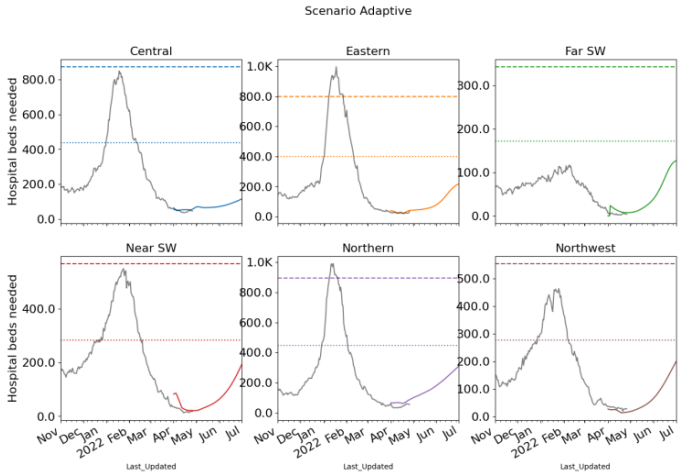
Outcome Projections

Confirmed cases

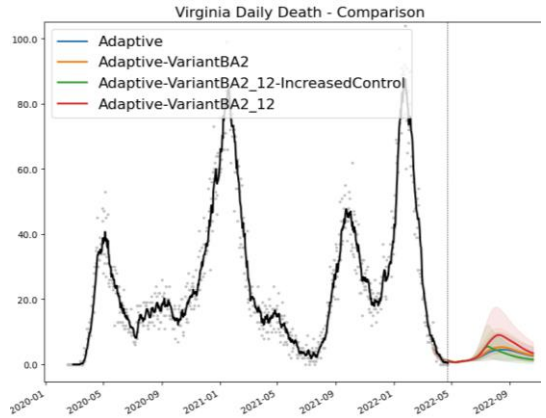


* without surveillance correction VariantBA2 peaked over 10K in July

Estimated Hospital Occupancy

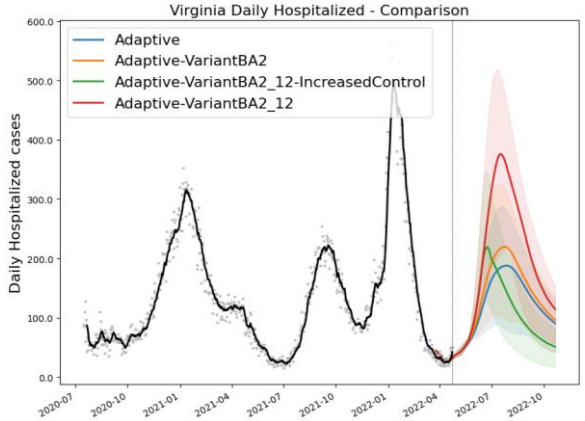


Daily Deaths



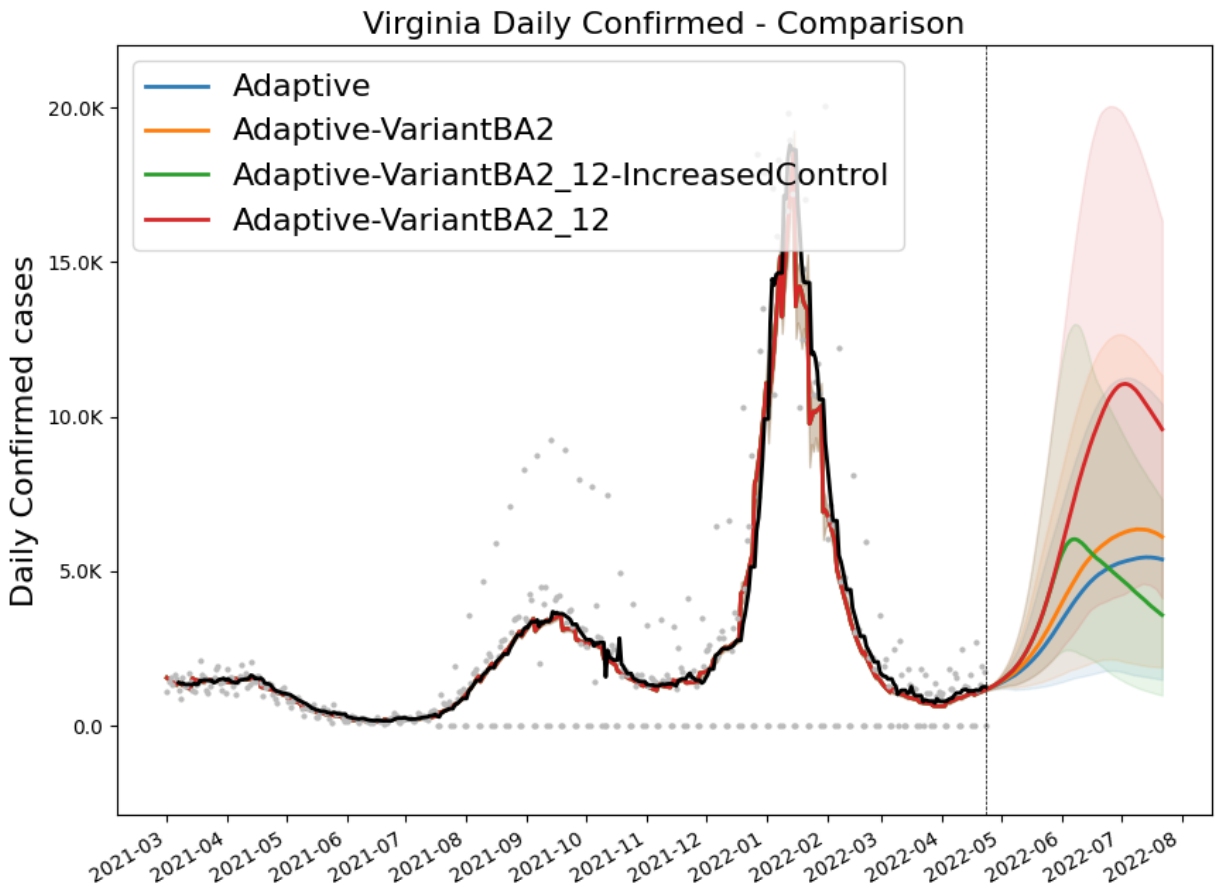
Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized



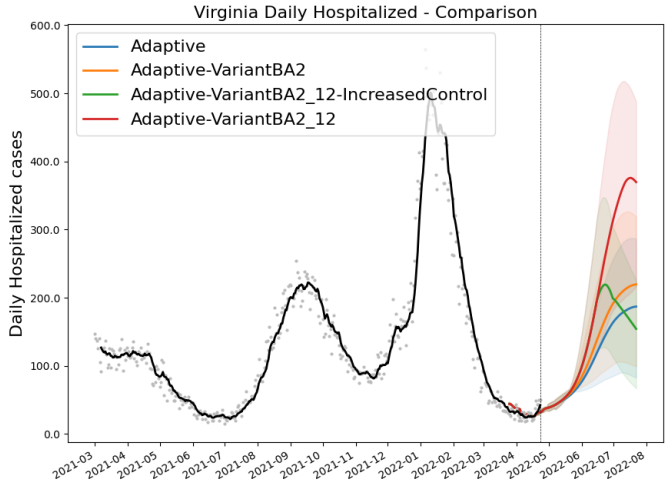
Outcome Projections – Closer Look

Confirmed cases

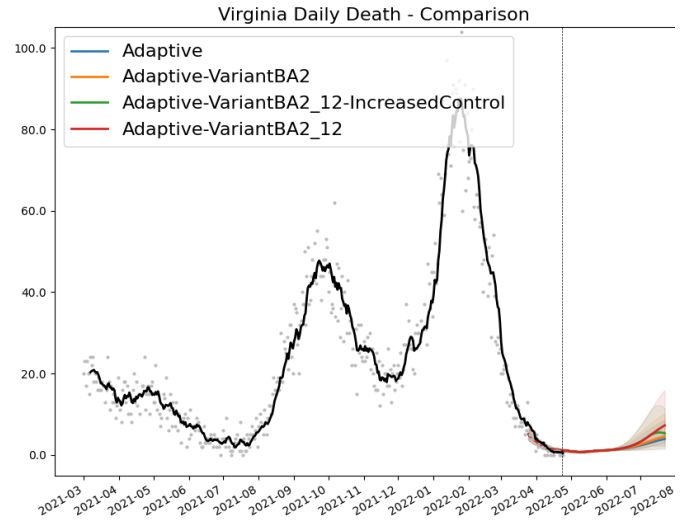


* without surveillance correction VariantBA2 peaked over 10K in July

Daily Hospitalized



Daily Deaths



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

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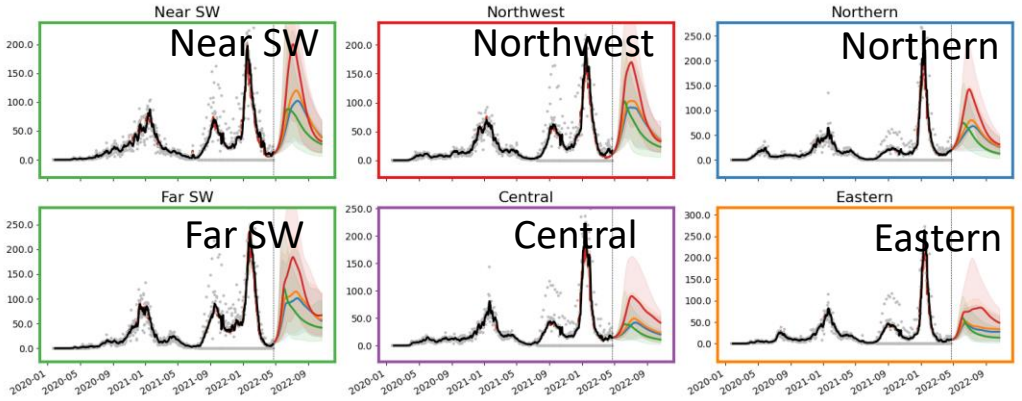
Detailed Projections: All Scenarios

Projections by Region

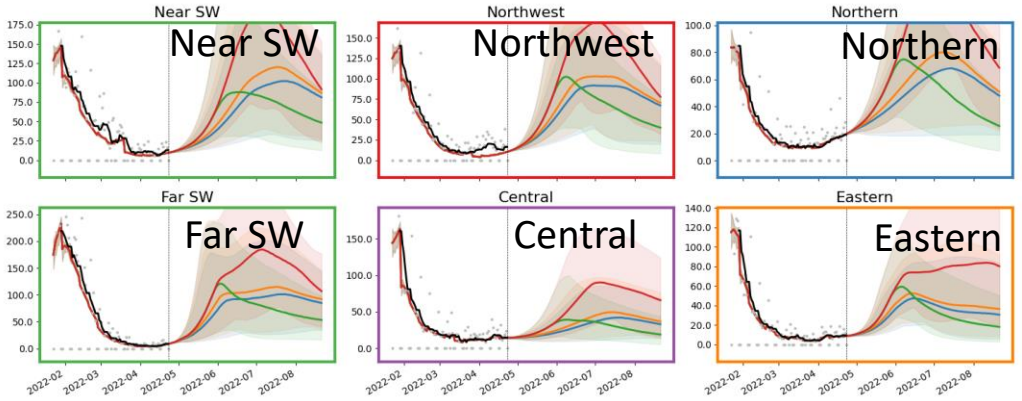


Projections by District

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

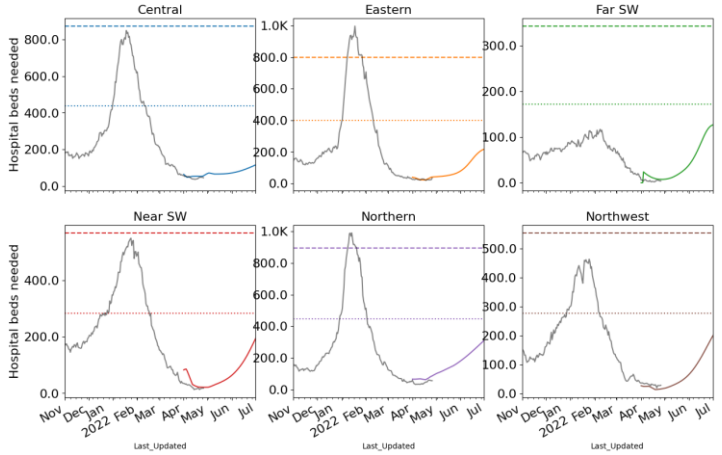
Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

Hospital Demand and Bed Capacity by Region

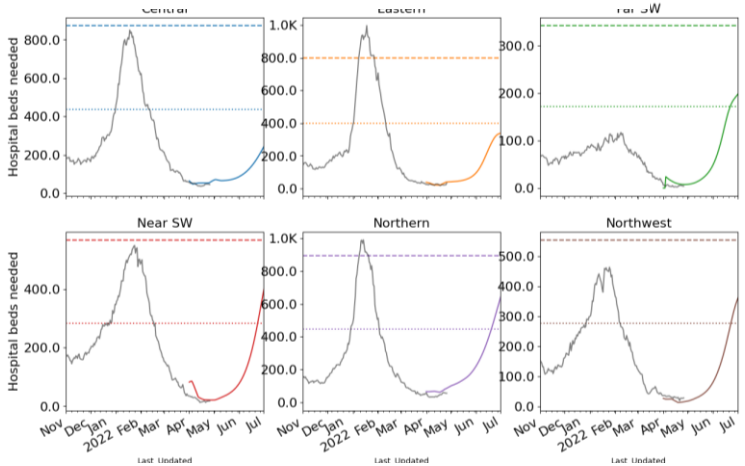
Capacities by Region

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

Adaptive



Adaptive – Variant BA2_12



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

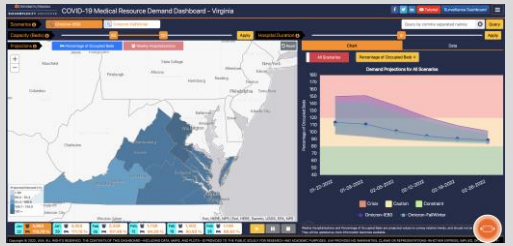
Estimated LOS stable

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

Length of Stay Estimates

Central	8
Eastern	7
Far SW	10
Near SW	8
Northern	6
Northwestern	8

Interactive Dashboard with regional projections

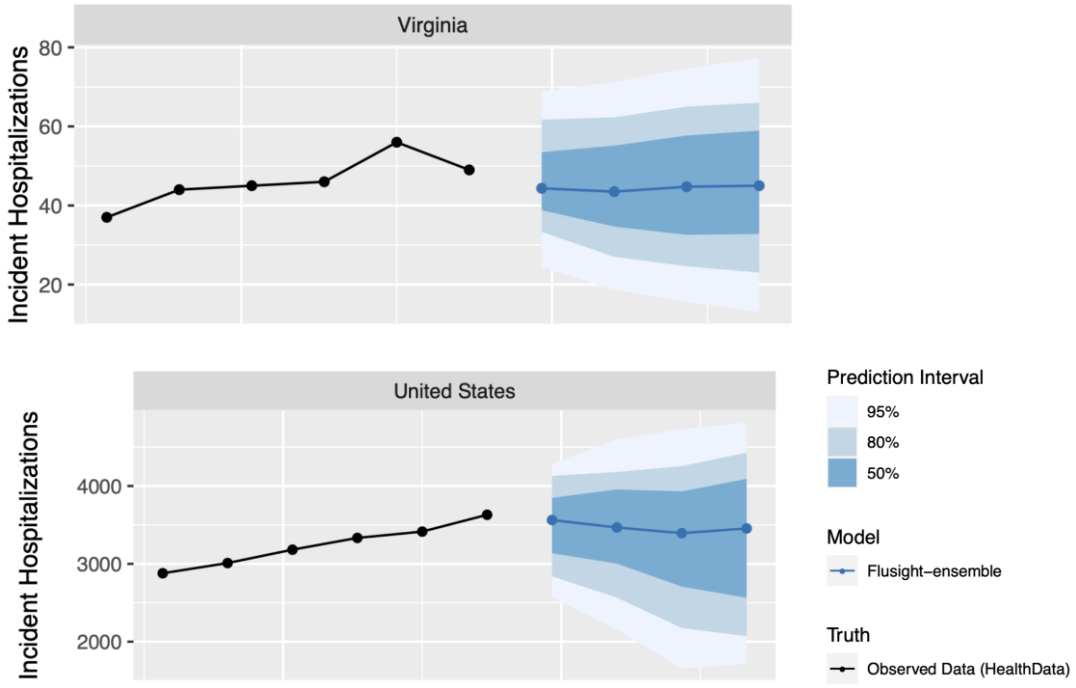


https://nssac.bii.virginia.edu/covid-19/vmrddash/

Current Influenza Hospitalization Forecast

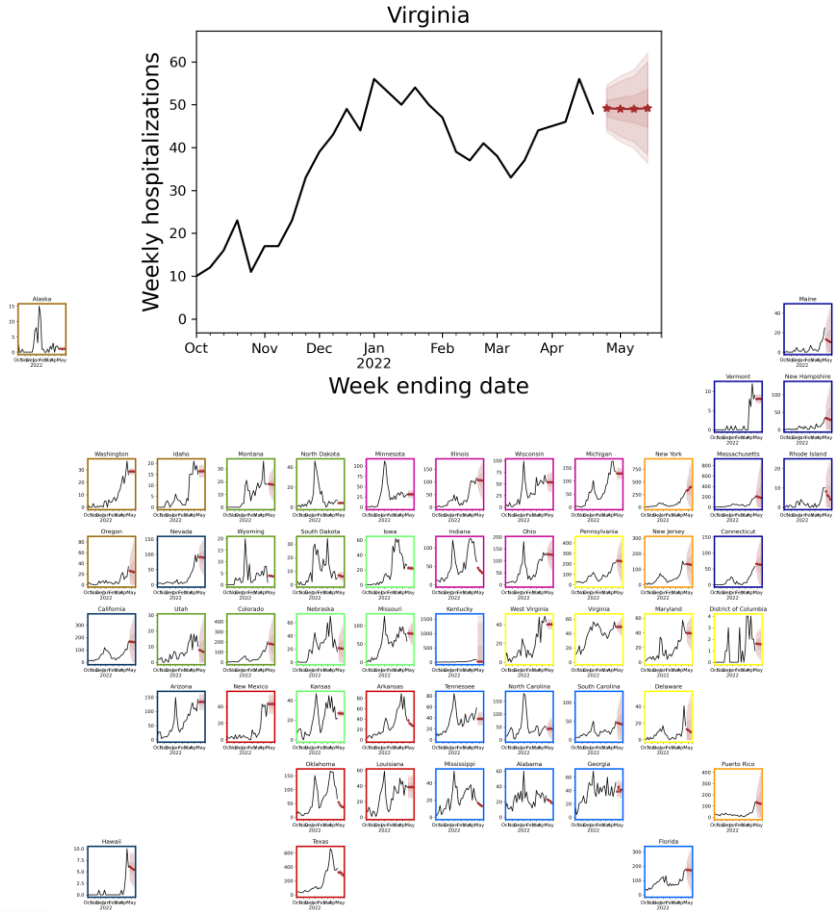
Statistical models for submitting to CDC FluSight forecasting challenge

- Hospitalizations nationwide are rising, VA still steady



[CDC FluSight](#)
Ensemble Forecasts
(Mar 14th)

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 continue to slowly rise as do hospitalizations**
- VA 7-day mean daily case rate increased to 15/100K from 13/100K
  - US continues to increase slightly to 14/100K (from 11.5/100K)
  - VA hospital occupancy (rolling 7 day mean of 173) has rebounded slightly from a near all-time low
- Surveillance anomalies continue as QA processes rebalance previously reported cases though seems to be slowing
- Projections anticipate future growth in cases but more limited growth in more severe outcomes:
  - Current trends alone drive some future growth, in most regions of VA, though uncertainty is a bit high
  - Recently emerging BA.2.12.1 subvariant may drive more rapid growth as it becomes more dominant across other parts of the state
- Model updates:
  - Adjusted fitting to work on district level to reduce biases from limited outbreaks within counties and surveillance anomalies
  - Adaptive scenario captures BA.2, have added a BA.2.12.1 scenario to capture the future growth of this more transmissible variant
  - Models need to change their focused outcome to hospitalization or aggregate counties to districts to minimize noisy fluctuations

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

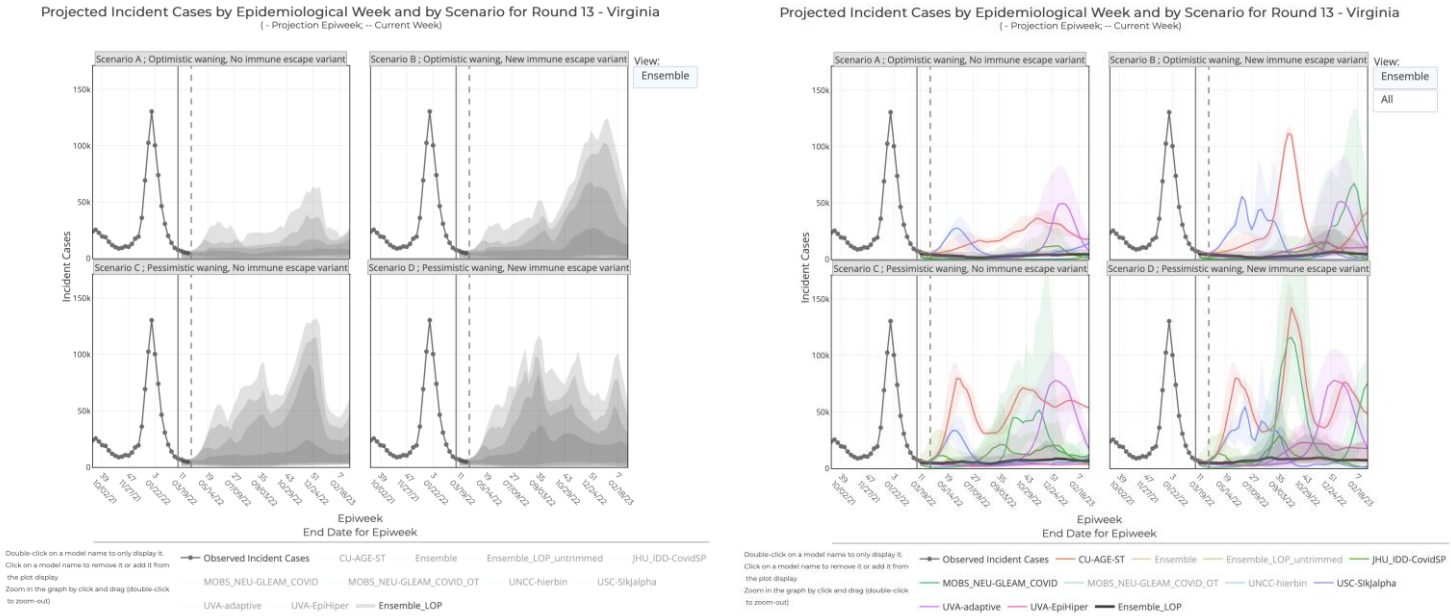
COVID-19 Scenario Modeling Hub – Round 13

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

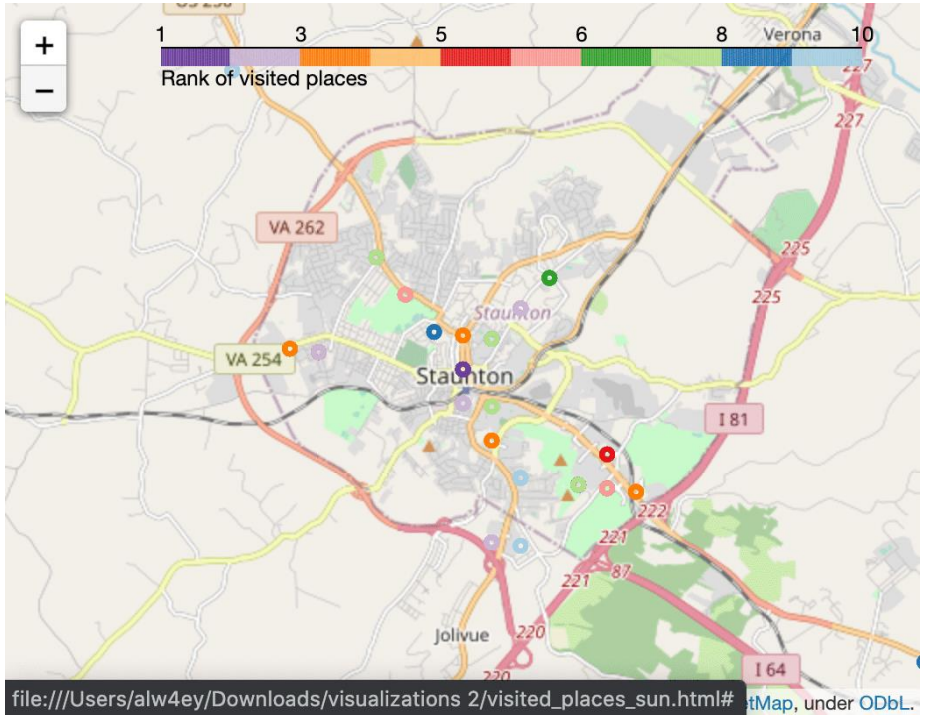
SafeGraph provides fine-grained mobility measures

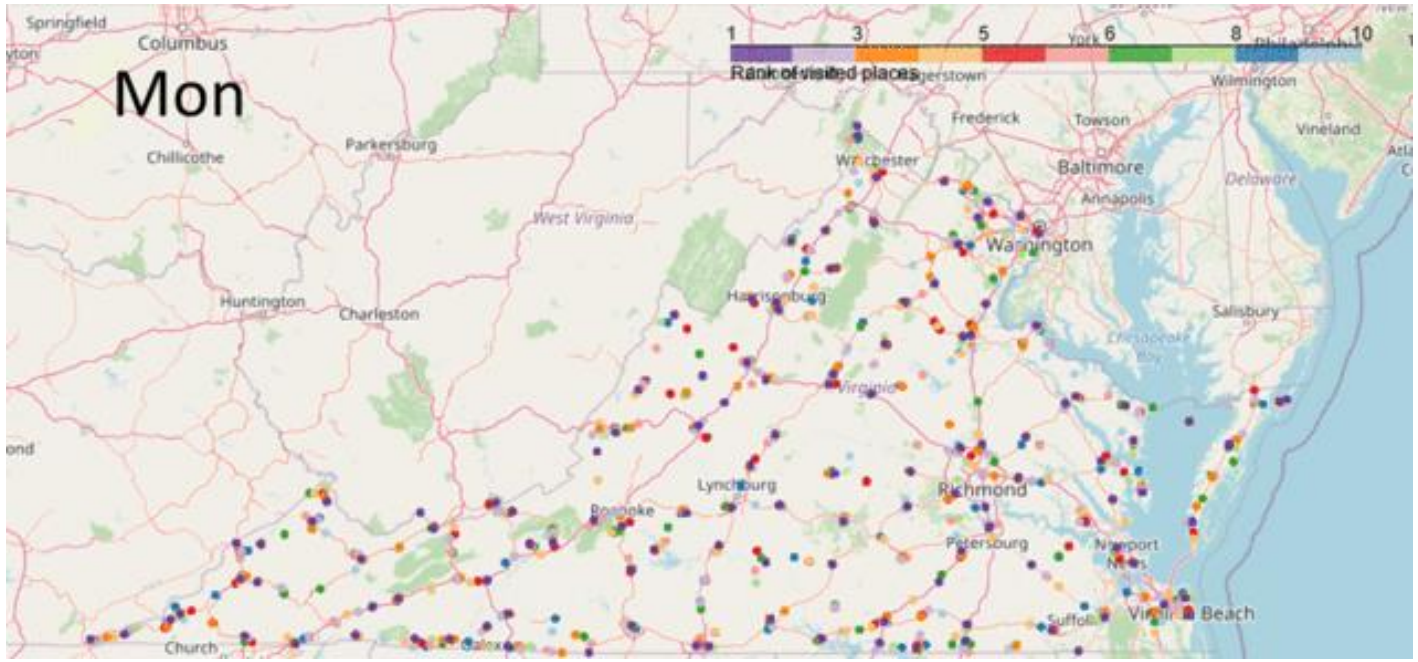
- SafeGraph: anonymized geolocation data aggregated from numerous cell phone apps
- One of the most fine-grained and high-coverage mobility data sources available: 6.4 million POIs in the US; 158,869 POIs in VA
- Has been utilized by hundreds of researchers, governments, and the CDC to aid COVID-19 efforts (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

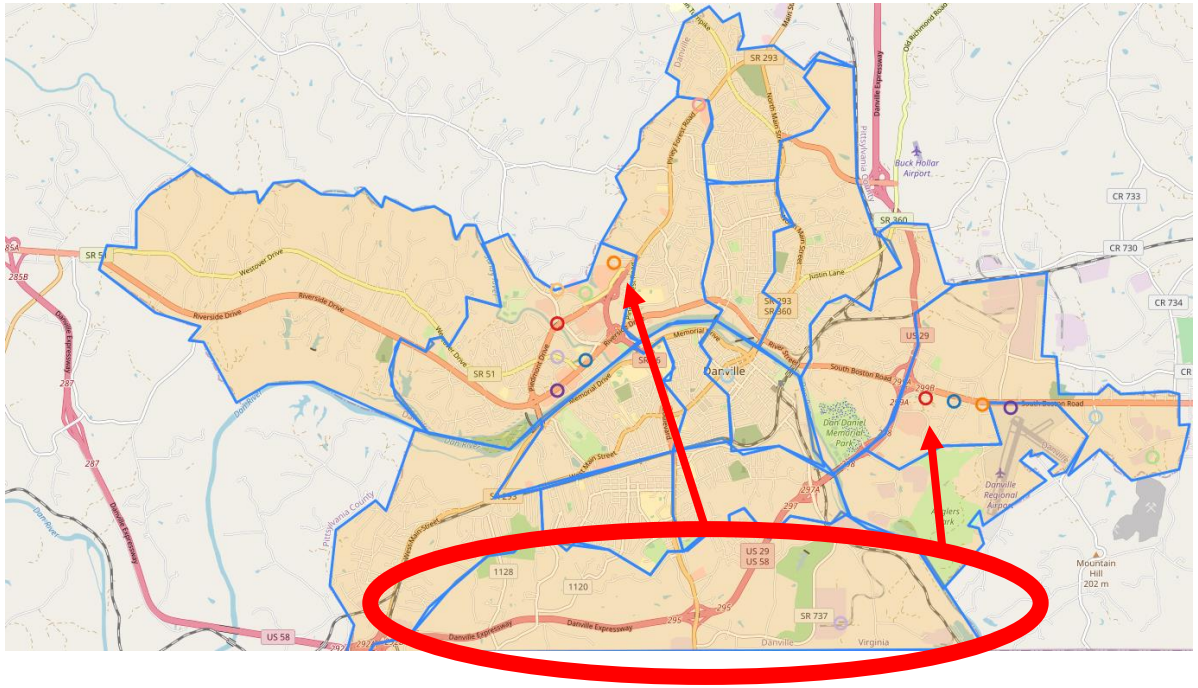




Busiest locations vary by day of week (and time of day)

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 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, 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

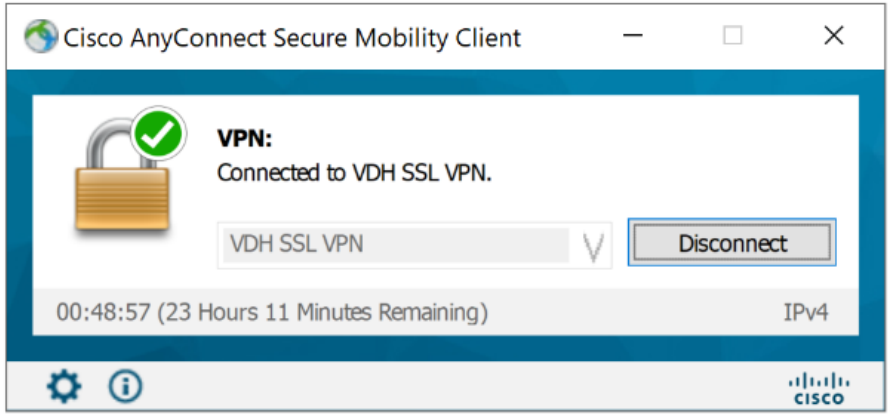
Mobility Data Updated Weekly

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



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

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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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