Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

June 29th, 2022

(data current to June 25th – June 28th)

Biocomplexity Institute Technical report: TR BI-2022-1606

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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

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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

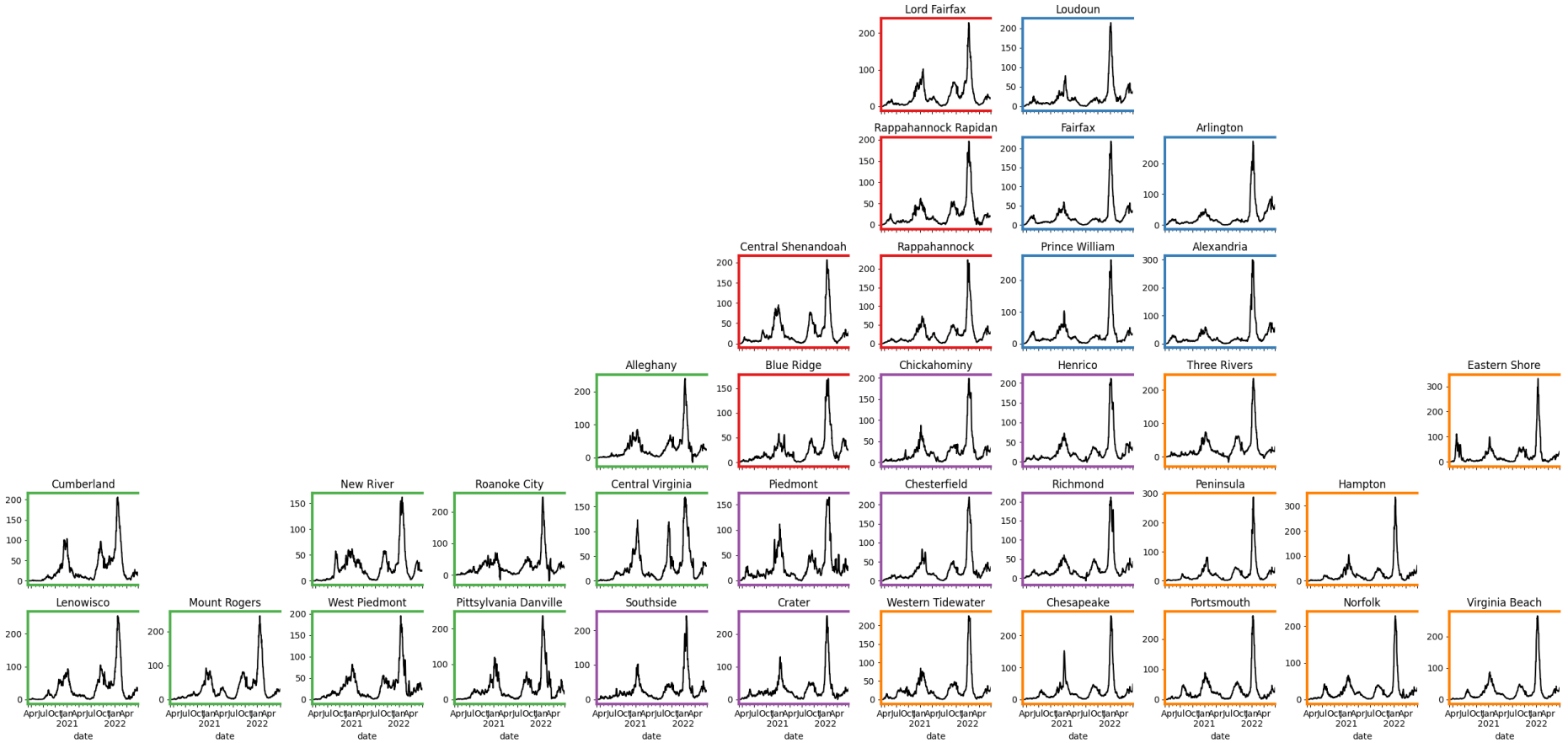
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

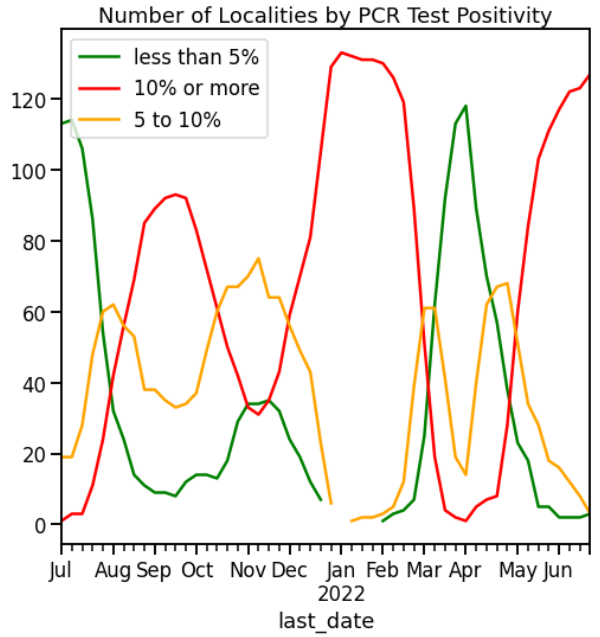
- **Case rates are flattening after slow declines, hospitalizations remain flat**
- VA weekly case rate slightly up to 215/100K from 203/100K
  - US also up to 233/100K from 196/100K
  - VA hospital occupancy (rolling 7 day mean of 534) is relatively flat, though shows signs of rebounding with a couple days of increase
- Projections anticipate a mix of trajectories across the districts, while remain in slow decline at state level, with near term with potential for growth due to BA4/5:
  - VA case rates may be flattening and with variant prevalence increasing BA.5 and BA.4 may drive growth
- Model updates:
  - BA.5 and BA.4 pick up the pace of growth while BA.2.12.1 has started to shrink, BA4/5 scenario seems likely to drive future dynamics
  - New data source for case ascertainment may explain more uncertainty and allow better model fits for future rounds

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

Situation Assessment

Case Rates (per 100k) and Test Positivity





County level RT-PCR test positivity

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

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

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

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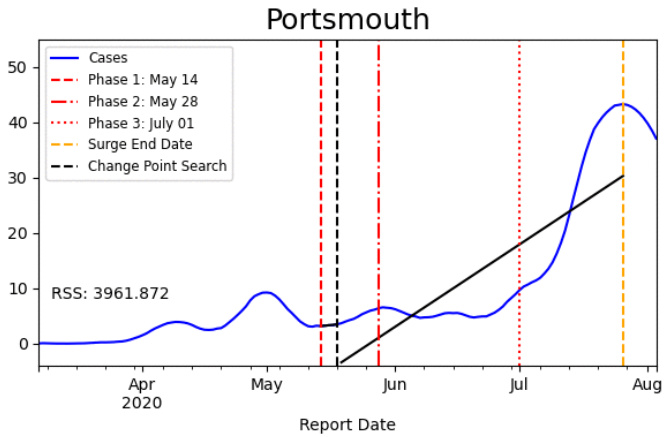
District Trajectories

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

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

Hockey stick fit

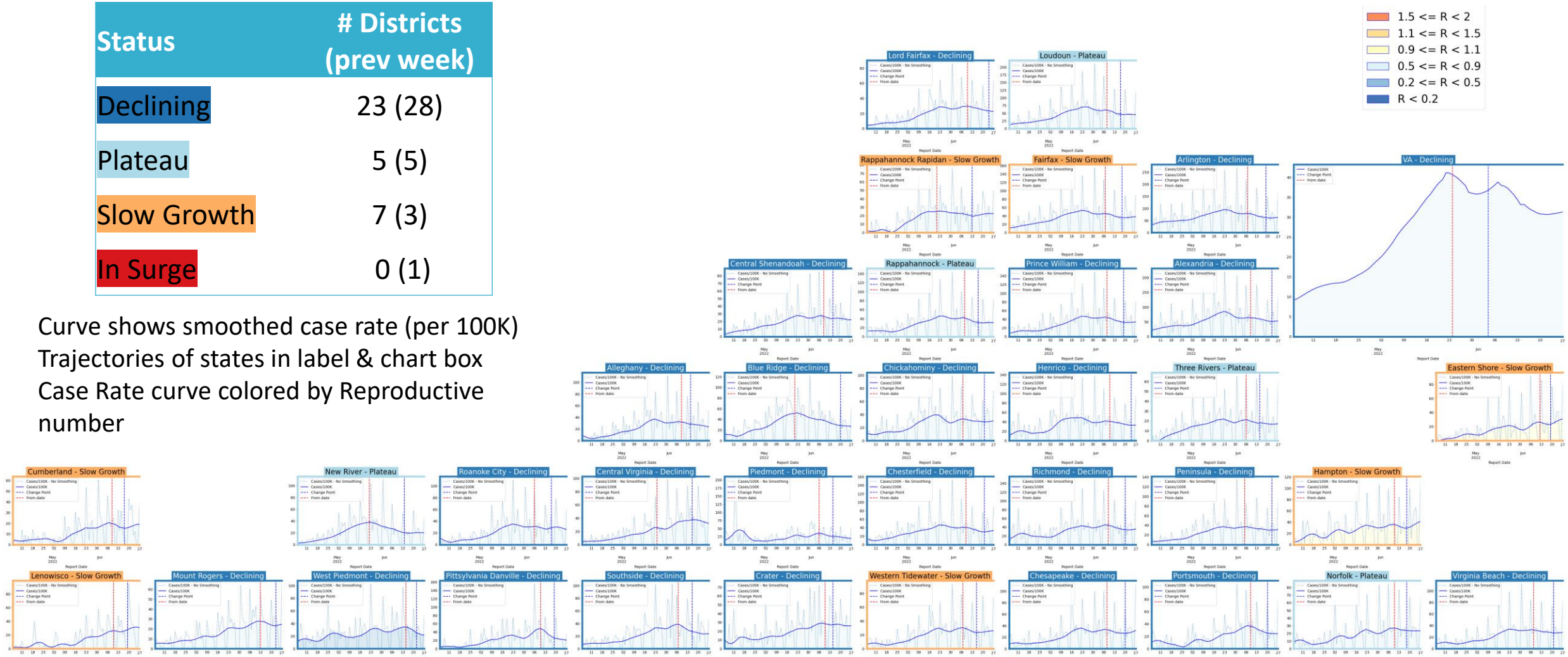


Trajectory	Description	Weekly Case Rate (per 100K) bounds
Declining	Sustained decreases following a recent peak	below -0.9
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5
In Surge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

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	23 (28)
Plateau	5 (5)
Slow Growth	7 (3)
In Surge	0 (1)

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?

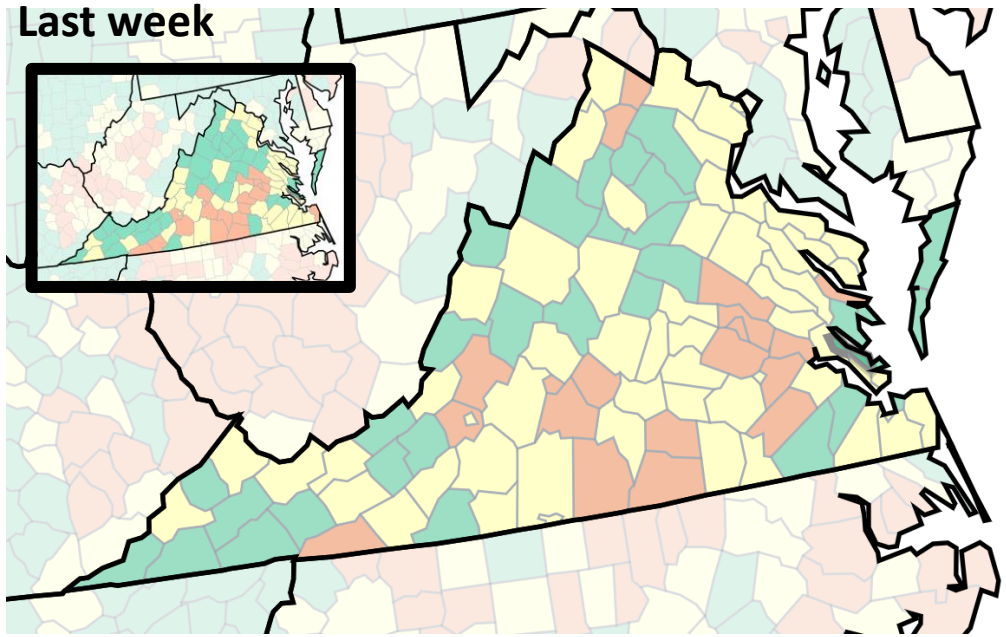
Low	Medium	High
• Stay up to date with COVID-19 vaccines • Get tested if you have symptoms	• If you are at high risk for severe illness, talk to your healthcare provider about whether you need to wear a mask and take other precautions • Stay up to date with COVID-19 vaccines • Get tested if you have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

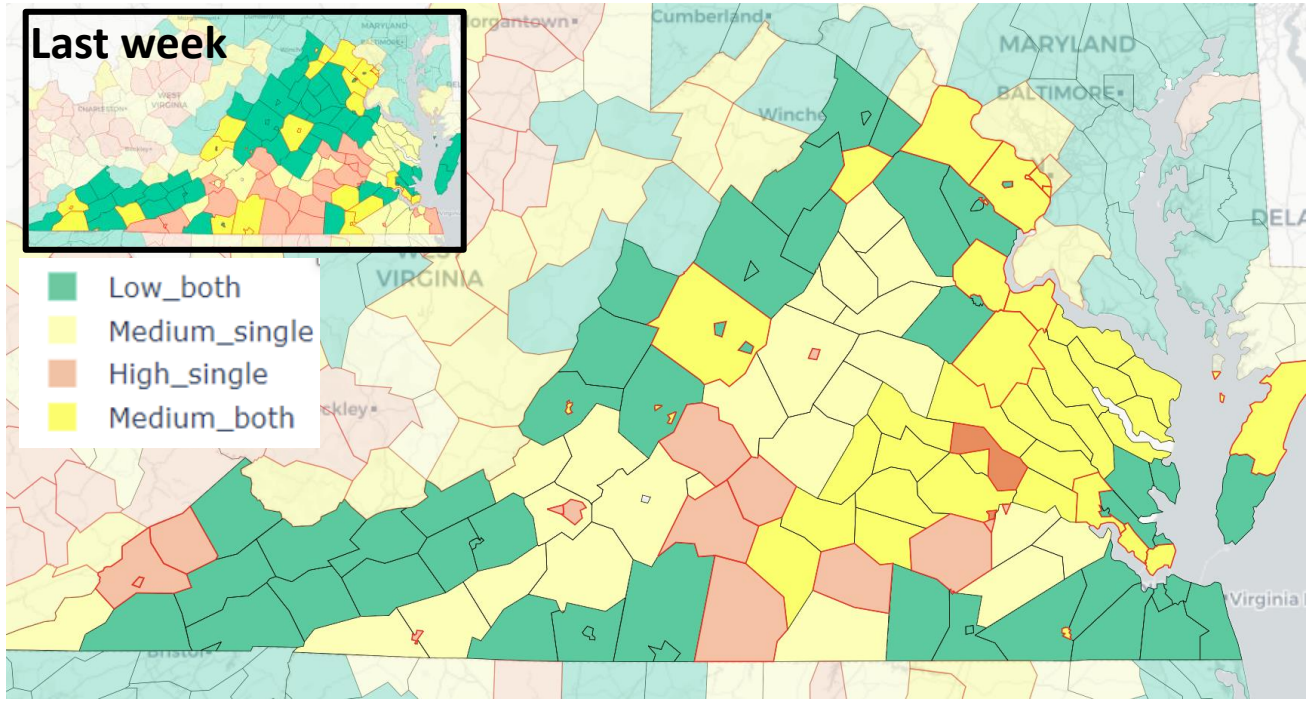
New COVID-19 Cases Per 100,000 people in the past 7 days	Indicators	Low	Medium	High
Fewer than 200	New COVID-19 admissions per 100,000 population (7-day total)	<10.0	10.0-19.9	≥20.0
	Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)	<10.0%	10.0-14.9%	≥15.0%
200 or more	New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

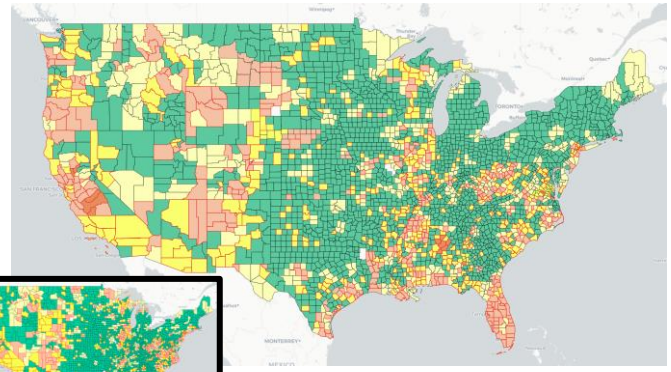
The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

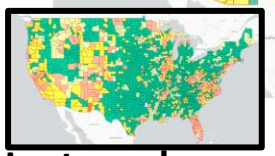


[CDC Data Tracker Portal]

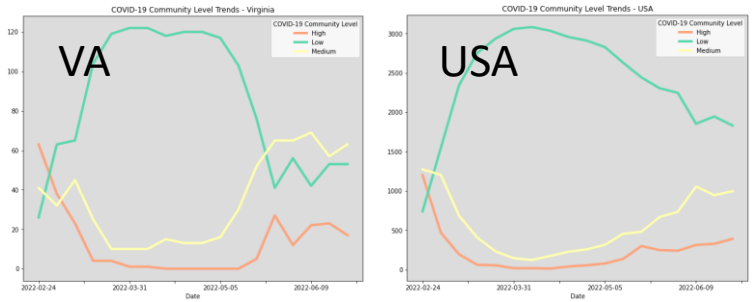
CDC's new COVID-19 Community Levels







Last week



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

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

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

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

New COVID-19 Cases Per 100,000 people in the past 7 days	Indicators	Low	Medium	High
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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

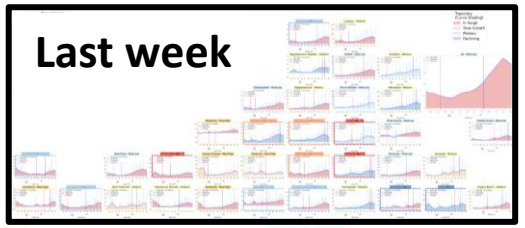
Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory

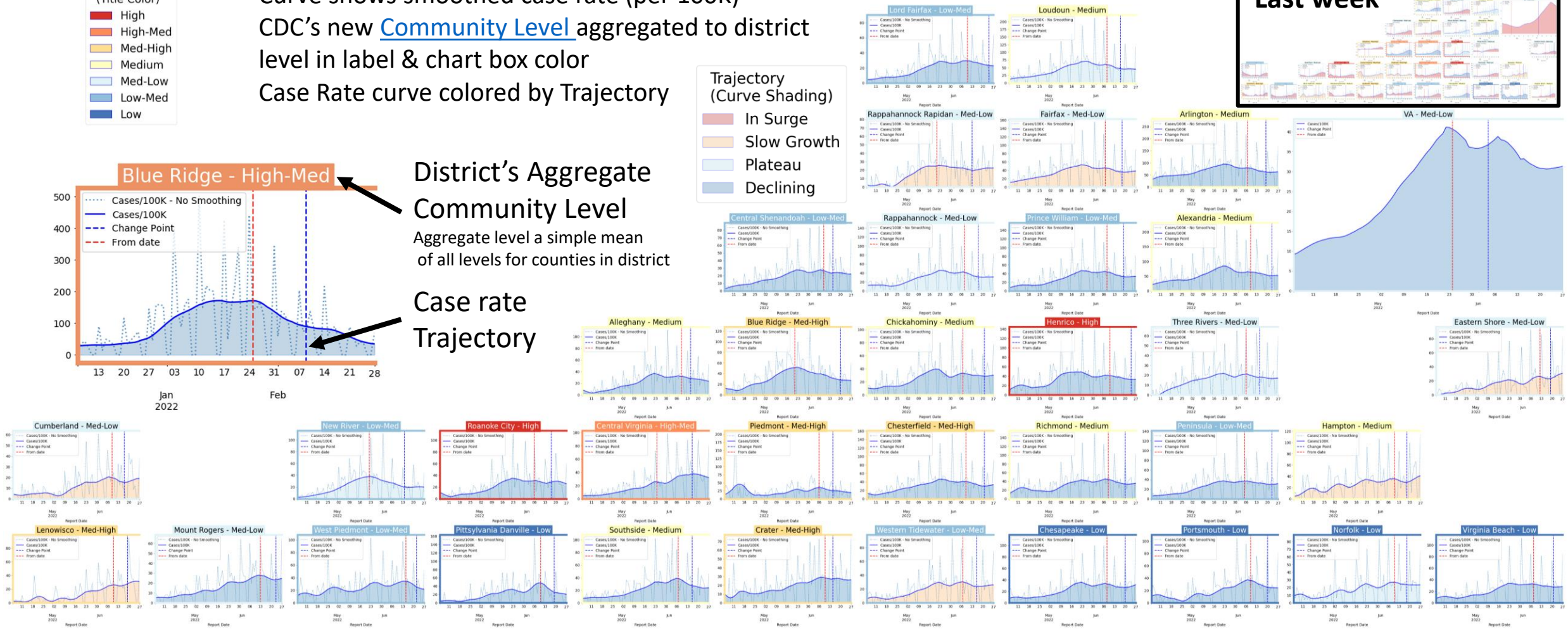
Trajectory (Curve Shading)
- In Surge
- Slow Growth
- Plateau
- Declining

District's Aggregate Community Level

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

Case rate Trajectory

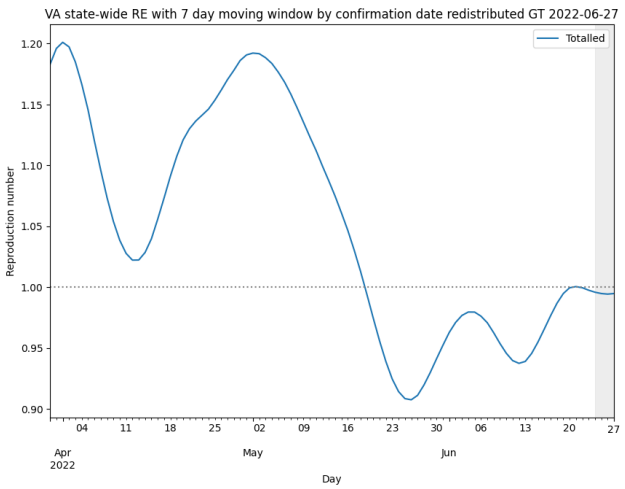


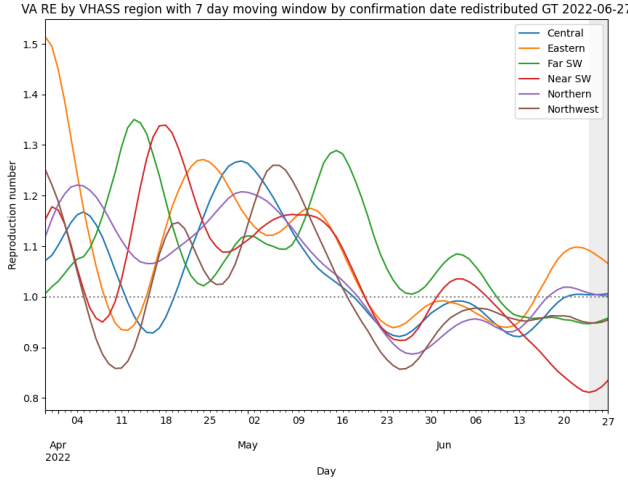


Estimating Daily Reproductive Number – Redistributed gap

June 27th Estimates

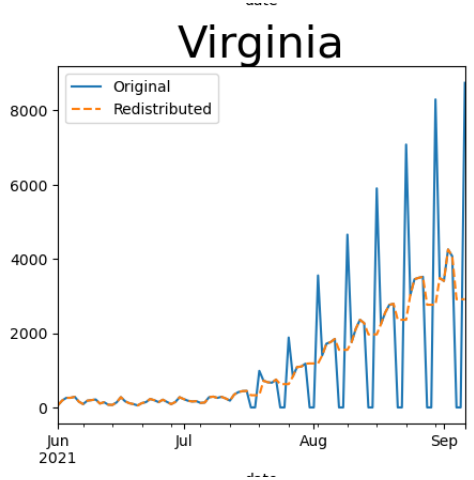
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.996	0.094
Central	1.008	0.141
Eastern	1.067	0.117
Far SW	0.954	0.057
Near SW	0.838	-0.078
Northern	1.000	0.110
Northwest	0.949	0.042





Skipping Weekend Reports & holidays biases estimates

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



Methodology

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

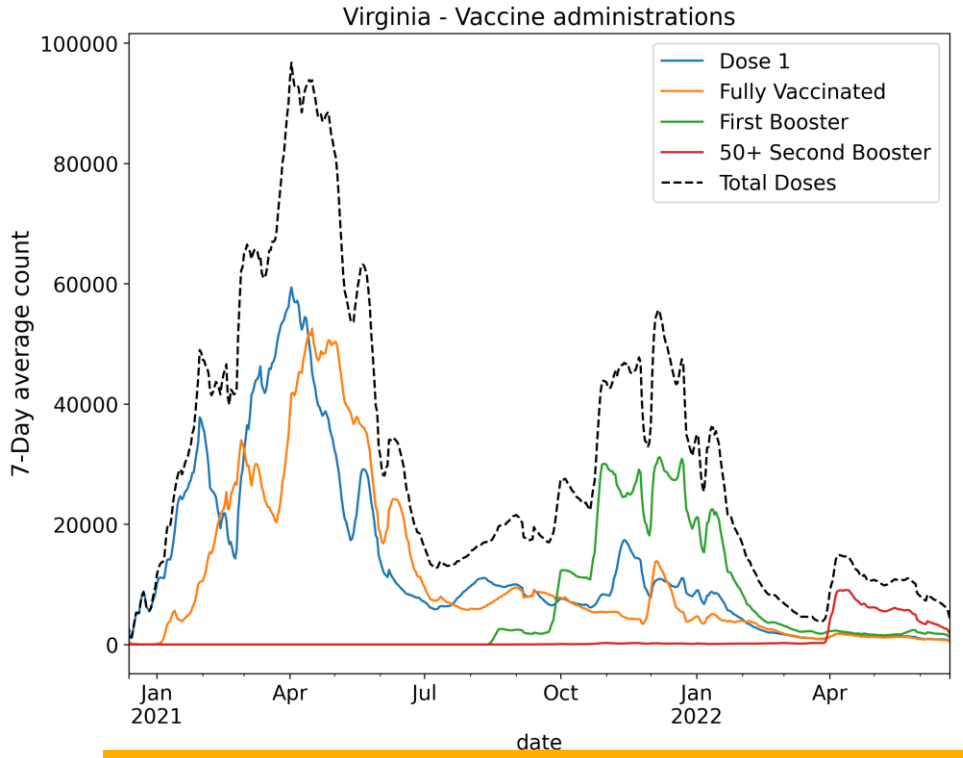
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Mask Usage and Vaccination

Self-reported mask usage continues to fall

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

Last update – This survey is no longer updating



Updates every Thursday (data as of June 23rd)

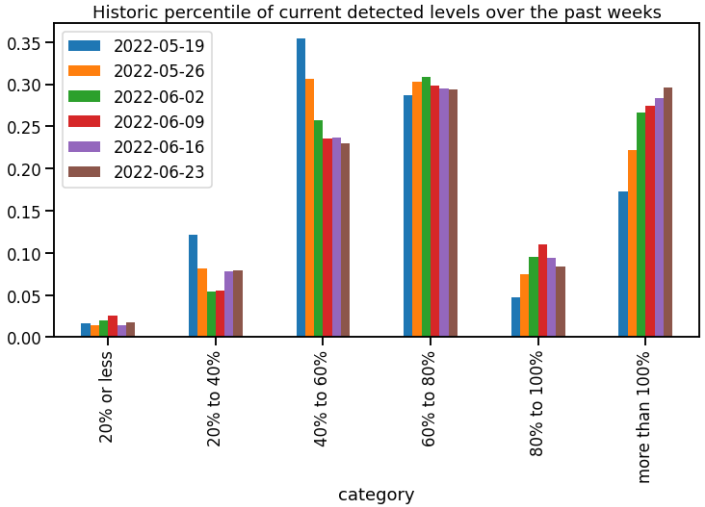
Data Source: https://covidcast.cmu.edu

Wastewater Monitoring

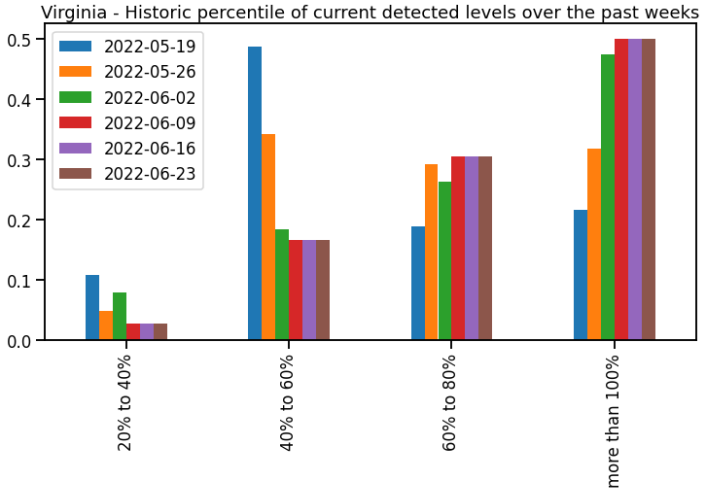
Wastewater provides a coarse early warning of COVID-19 levels in communities

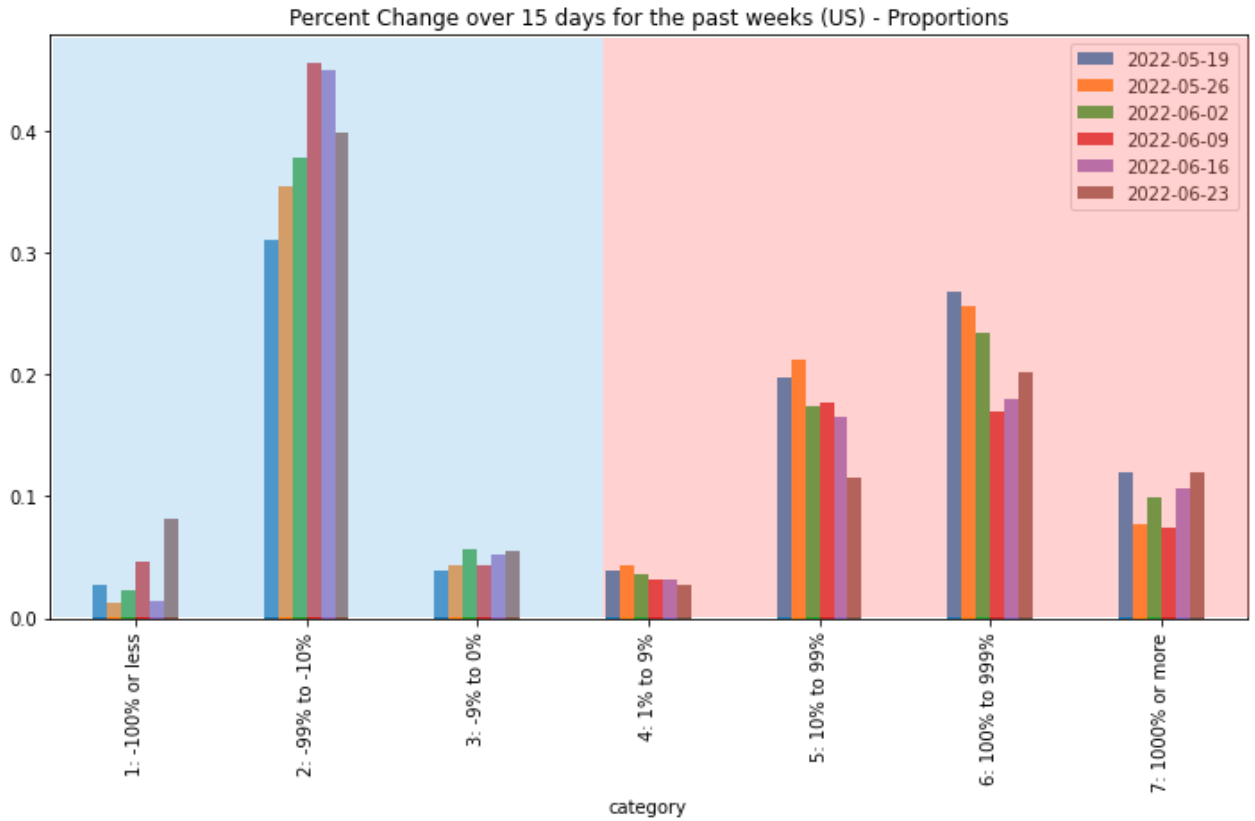
- Across the US, the number of sites with increased levels of virus compared to 15 days ago has remained steady, which indicates growth
- Current virus levels are at or exceeding max of previous historical levels, has remained stable or increased in the US and VA

USA



VA



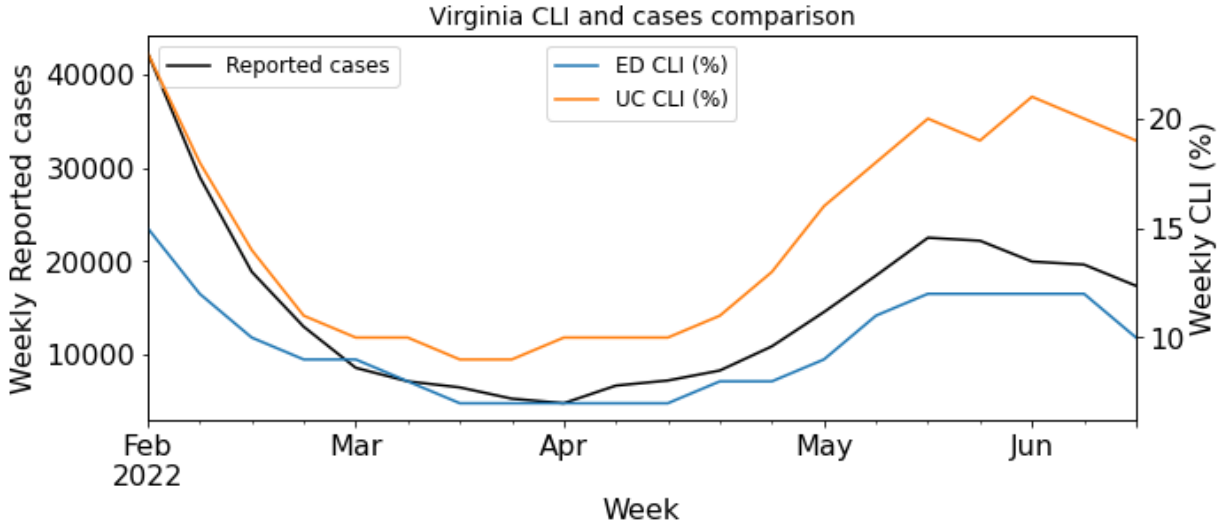


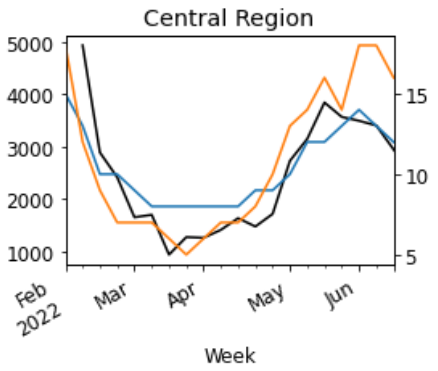
Data Source: [CDC Data Tracker]

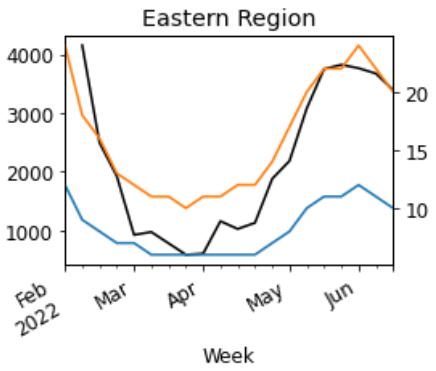
COVID-like Illness Activity

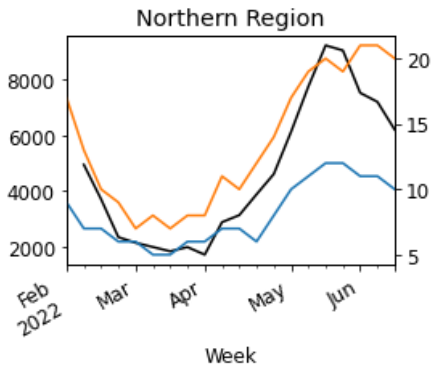
COVID-like Illness (CLI) gives a measure of COVID transmission in the community

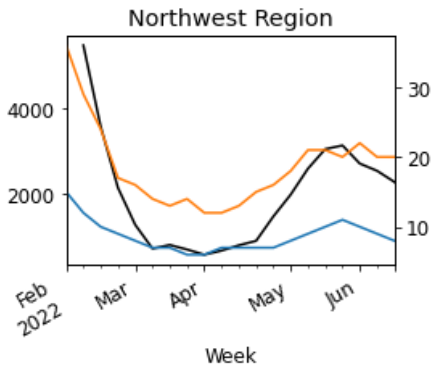
- Emergency Dept (ED) based CLI is more correlated with case reporting
- Urgent Care (UC) is a leading indicator but prone to some false positives
- **Current trends in UC CLI have plateaued for last six weeks state-wide with signs of declines**

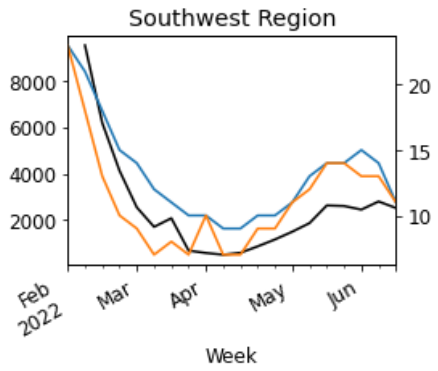










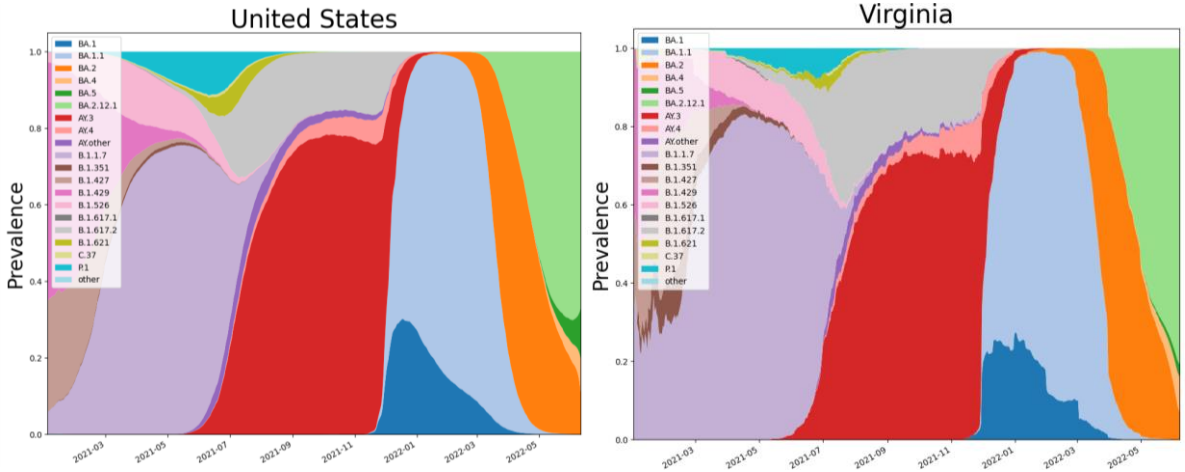


SARS-CoV2 Variants of Concern

GISAID outbreak.info

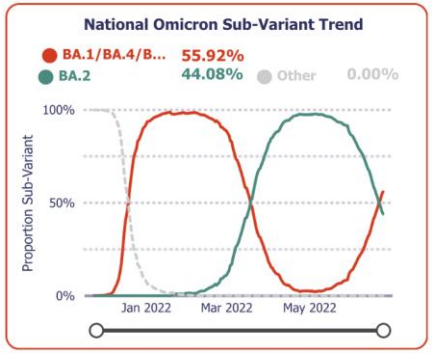
Emerging new variants will alter the future trajectories of pandemic and have implications for future control

- **Emerging variants can:** Increase transmissibility, increase severity (more hospitalizations and/or deaths), and limit immunity provided by prior infection and vaccinations



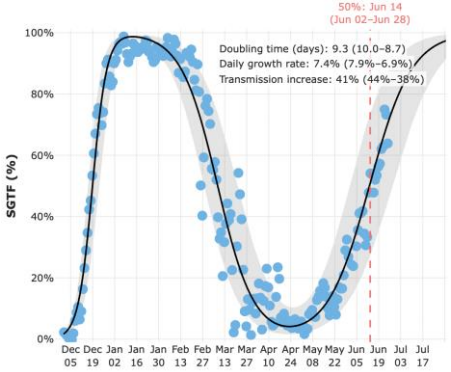
Omicron Updates

- BA.2.12.1 growth has started to decline, shrinking to 53% after 5 weeks in the the 65%-75% prevalence range (Region 3)
- BA.4 growing, nowcasted at 17% (up from 11% last week)
- BA.5 also growing rapidly, nowcasted at 25% (up from 14% last week)
- BA.4 and BA.5 have same mutation as BA.1 that produces S-gene target failure, so can be tracked in more real time with SGTF from some PCR tests

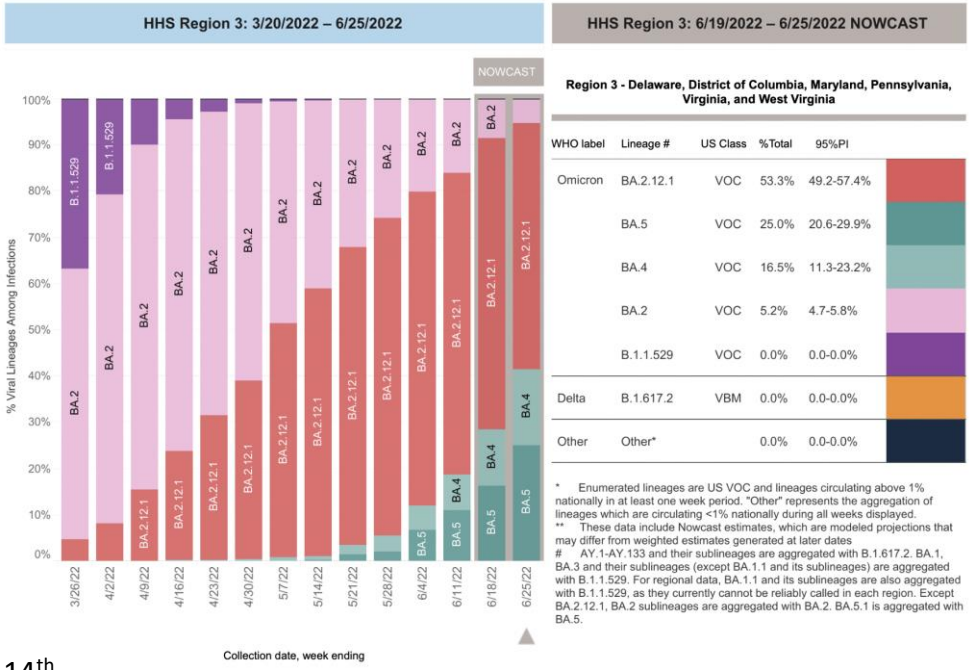


Walgreens detecting BA.4 / BA.5 in 56% of their typed samples

SGTF in San Diego



Estimated to be at ~75%, passing 50% on June 14th, Region 9 by CDC data tracker is at ~50% for week ending June 25th



Region 3 - Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia

WHO label	Lineage #	US Class	%Total	95%PI
Omicron	BA.2.12.1	VOC	53.3%	49.2-57.4%
	BA.5	VOC	25.0%	20.6-29.9%
	BA.4	VOC	16.5%	11.3-23.2%
	BA.2	VOC	5.2%	4.7-5.8%
	B.1.1.529	VOC	0.0%	0.0-0.0%
Delta	B.1.617.2	VBM	0.0%	0.0-0.0%
Other	Other*		0.0%	0.0-0.0%

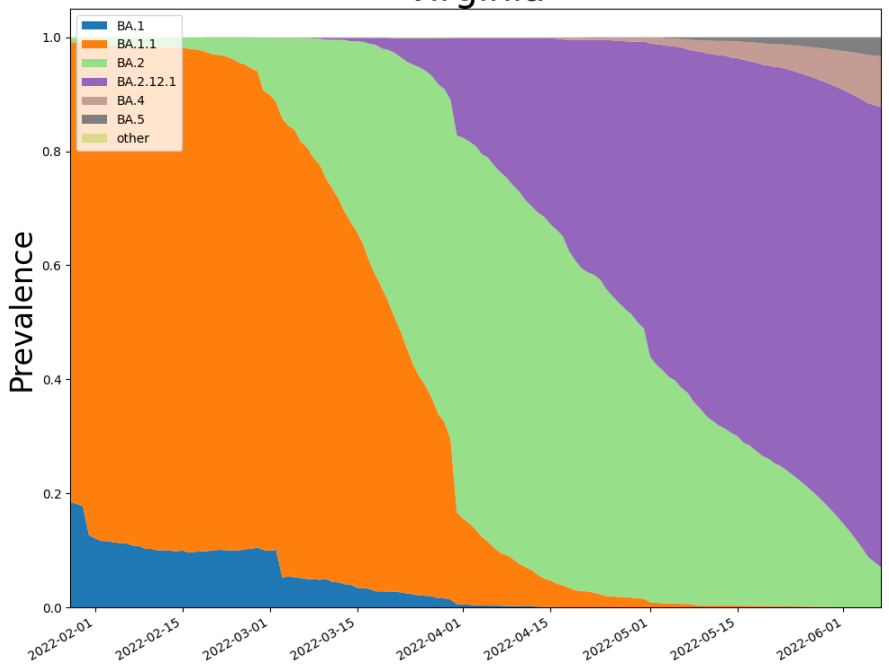
* Enumerated lineages are US VOC and lineages circulating above 1% nationally in at least one week period. "Other" represents the aggregation of lineages which are circulating <1% nationally during all weeks displayed.
** These data include Nowcast estimates, which are modeled projections that may differ from weighted estimates generated at later dates
# AY.1-AY.133 and their sublineages are aggregated with B.1.617.2. BA.1, BA.3 and their sublineages (except BA.1.1 and its sublineages) are aggregated with B.1.1.529. For regional data, BA.1.1 and its sublineages are also aggregated with B.1.1.529, as they currently cannot be reliably called in each region. Except BA.2.12.1, BA.2 sublineages are aggregated with BA.2. BA.5.1 is aggregated with BA.5.

CDC Variant Tracking

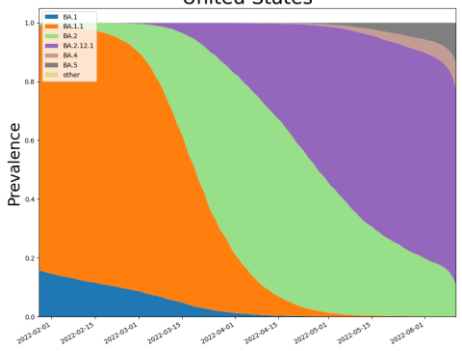
SARS-CoV2 Omicron and Sub-Variants

As detected in whole Genomes in public repositories

Virginia

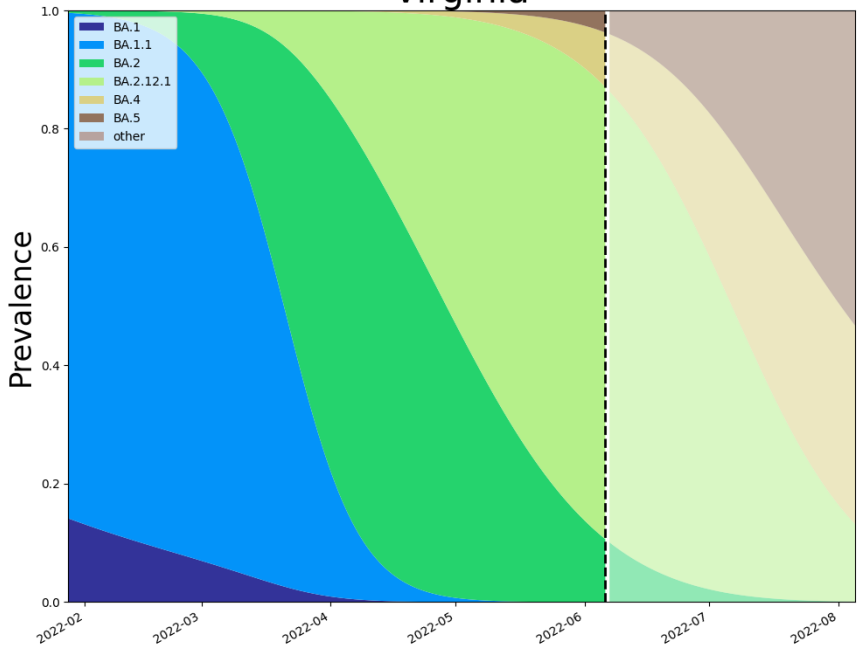


United States



VoC Polynomial Fit Projections

Virginia



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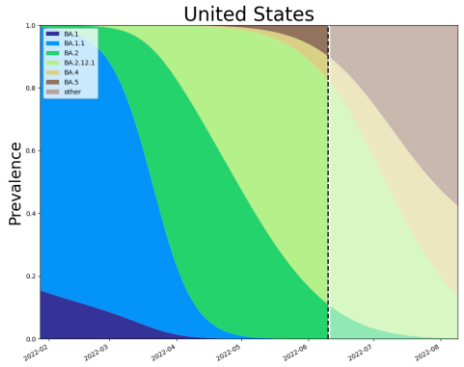

Note: Data lags force projections to start in past. Everything from dotted line forward is a projection.

GISAID outbreak.info

Pandemic Pubs

1. The National Center for Health Statistics (NCHS) reported an 18.4% increase in US maternal mortality.
2. UK analysis suggests wastewater analysis can be a cost effective early indicator of increasing case count.
3. New study from Denmark indicates people who tested positive had a 3.5 times increased risk of being diagnosed with Alzheimer's disease, 2.6 times with Parkinson's disease, 2.7 times with ischaemic stroke and a 4.8 times increased with intracerebral haemorrhage
4. UKHSA technical update highlights growth advantage of BA.5 due to immune escape. Increase in hospitalizations being monitored.
5. Constellation of symptoms 6 months after infection in young adults is suggestive of a higher risk of developing metabolic disorders and possible cardiovascular complications

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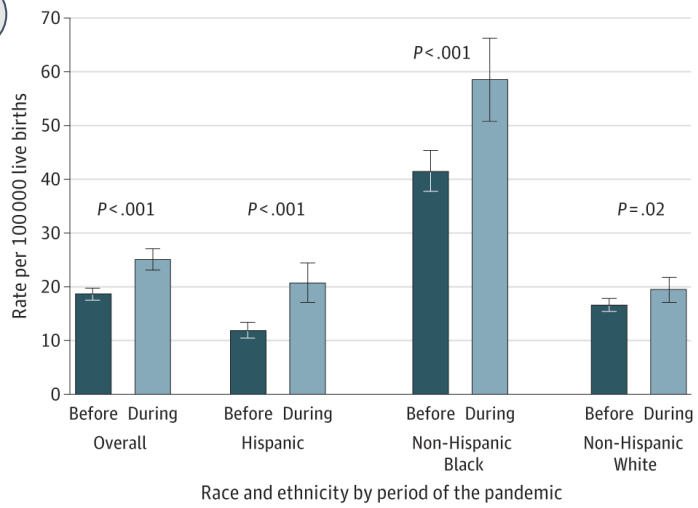

Maternal mortality rates and percentages with a secondary COVID-19 code were compared by timing, race and ethnicity, and underlying cause. Between 2019 and 2020 death during pregnancy or within 42 days of pregnancy relative increase was 44.4% among Hispanic, 25.7% among non-Hispanic Black, and 6.1% among non-Hispanic White women.
https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2793640

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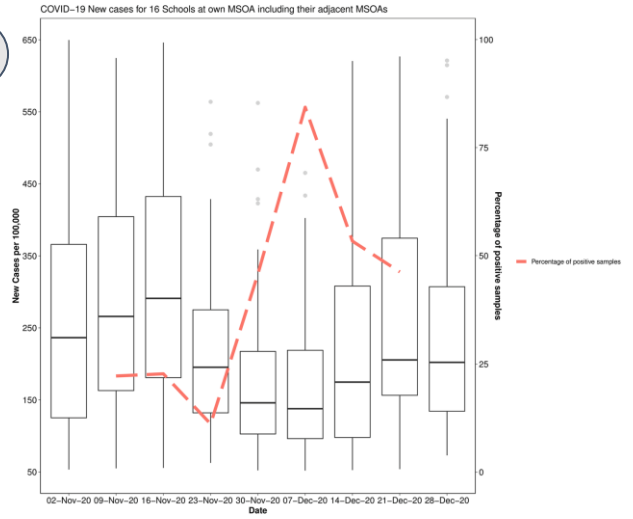

As part of a government-funded epidemiological surveillance pilot program, a wastewater-based epidemiology approach was used to monitor the occurrence of SARS-CoV-2 in Sixteen schools (10 primary, 5 secondary and 1 post-16 and further education for a total of 17 sites) in England. A lead/lag analysis was performed between the weekly positivity rates in schools and community cases to identify the maximum correlation between school and community timeseries using the Pearson's correlation coefficient. This analysis shows a maximum correlation between the two-time series when school data are shifted two weeks into the future (Pearson's correlation coefficient 0.33, p<0.01) Suggesting that the signal in school wastewater precedes the increase in the number of cases in the community.
https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0270168

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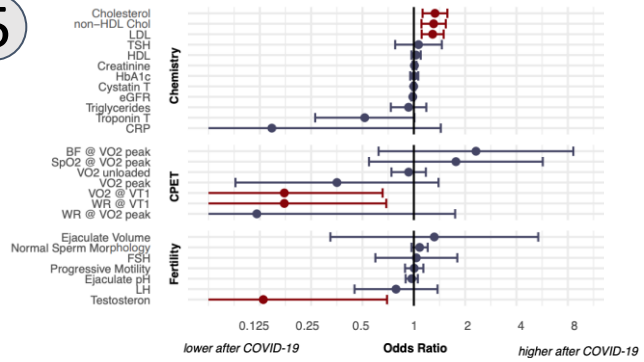

Swiss study 501 participants (5.6% females) with a median age of 21 years (range 19-29). Cases of previous COVID - 19 (>6 months (mean 10 months) since diagnosis, n=177) were compared with never infected controls (n=248). Even mild infections in young adults can lead to sequelae that persist several months post infection with significantly more fatigue, hyposomia, poorer psychological scores and a short-term, negative impact on male fertility. Other symptoms include higher body mass index, dyslipidemia and lower physical endurance 6 months post COVID-19
https://www.medrxiv.org/content/10.1101/2022.02.11.22270836v1

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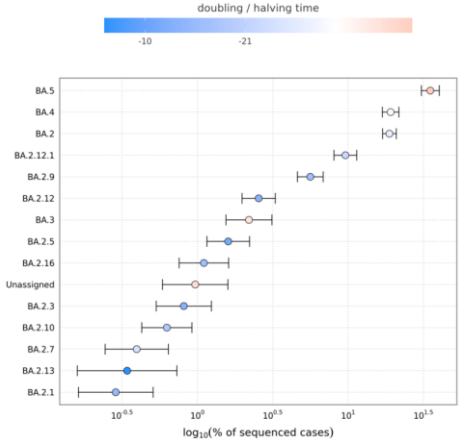

"Laboratory data from Genotype2Phenotype (G2P) Consortium (unpublished) and others suggest that there is a minimal change in fusogenicity of the spike of BA.4 and BA.5 (compared to other Omicron variants), and that the entry route is similar to that of BA.1 and BA.2. **Other data from G2P (cited when available) shows some changes in the interaction with the human host cell by BA.4 and BA.5 virus compared with earlier Omicron variants that could be associated with increased fitness. Neutralisation data has been described previously. Taken together the laboratory data suggest small changes in antigenicity and potentially small increases in fitness may both contribute to the observed growth advantage.**"
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1086494/Technical-Briefing-43-28.06.22.pdf

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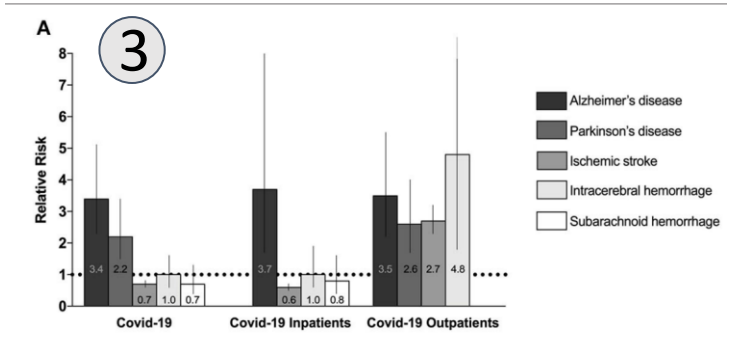

A new study which analysed the health records of more than half of the Danish population, found that those who had tested positive for COVID-19 were at an increased risk of Alzheimer's disease, Parkinson's disease, and ischaemic stroke. **Out of the 919,731 individuals that tested for COVID-19 within the study, researchers found that the 43,375 people who tested positive had a 3.5 times increased risk of being diagnosed with Alzheimer's disease, 2.6 times with Parkinson's disease, 2.7 times with ischaemic stroke and a 4.8 times increased with intracerebral haemorrhage.**
https://www.frontiersin.org/articles/10.3389/fneur.2022.904796/full

Pandemic Pubs (last week)

1. When administered as an early-stage treatment, Paxlovid might prevent COVID-19–related hospitalization among persons with mild-to-moderate COVID-19 who are at risk for progression to severe disease.
2. Reinfection adds risks of mortality, hospitalization, and adverse outcomes in the acute and post-acute phase.
3. Additional public health, regulatory, and policy efforts might help decrease barriers to oral antiviral access, particularly in communities with high social vulnerability.
4. Further evidence for dynamic polymorphic viral populations in immunocompromised patients, suggesting that a compromised immune system selects for antibody evasion in particular niches in a patient's body
5. Measurements indicate that in a healthy volunteer, the airborne mass of speech aerosol far exceeds that generated by breathing, even when accounting for faster sedimentation of the larger particles.

1

Characteristic	No. (column %) All Paxlovid recipients	COVID-19–related* hospitalization/ED encounter 5–15 days after Paxlovid dispensed†
Total, row %	**5,287**	**45 (0.9)**
Age group, yrs§		
12–17	36 (0.7)	0 (—)
18–24	81 (1.5)	0 (—)
25–44	994 (18.8)	11 (24.4)
45–64	1,929 (36.5)	12 (26.7)
≥65	2,214 (41.9)	21 (46.7)
Unknown	33 (0.6)	1 (2.2)
Median (IQR)	61 (47.0–71.0)	63 (44.5–77.0)
Sex§		
Female	3,025 (57.2)	30 (66.7)
Male	2,228 (42.1)	14 (31.1)
Unknown	34 (0.6)	1 (2.2)
Race and ethnicity§		
White, non-Hispanic	2,245 (42.5)	16 (35.6)
Hispanic	1,603 (30.3)	14 (31.1)
Asian or Pacific Islander, non-Hispanic	823 (15.6)	8 (17.8)
Black, non-Hispanic	327 (6.2)	4 (8.9)
Multiple or other	119 (2.3)	1 (2.2)
Unknown	170 (3.2)	2 (4.4)
Charlson comorbidity index¶		
0	2,288 (43.3)	10 (22.2)
1	1,321 (25.0)	13 (28.9)
2	737 (13.9)	6 (13.3)
≥3	941 (17.8)	16 (35.6)
No. of COVID-19 vaccine doses received**		
0	412 (7.8)	5 (11.1)
1	102 (1.9)	3 (6.7)
2	937 (17.7)	9 (20.0)
3	3,279 (62.0)	27 (60.0)
4	557 (10.5)	1 (2.2)

"COVID-19–related hospital admissions and emergency department (ED) encounters occurring 5–15 days after Paxlovid treatment were described using data from a large integrated health care system. Reports of such hospitalizations or ED encounters occurred infrequently, representing <1% of Paxlovid-treated patients over the study period."
https://www.cdc.gov/mmwr/volumes/71/wr/mm7125e2.htm?s_cid=mm7125e2_w

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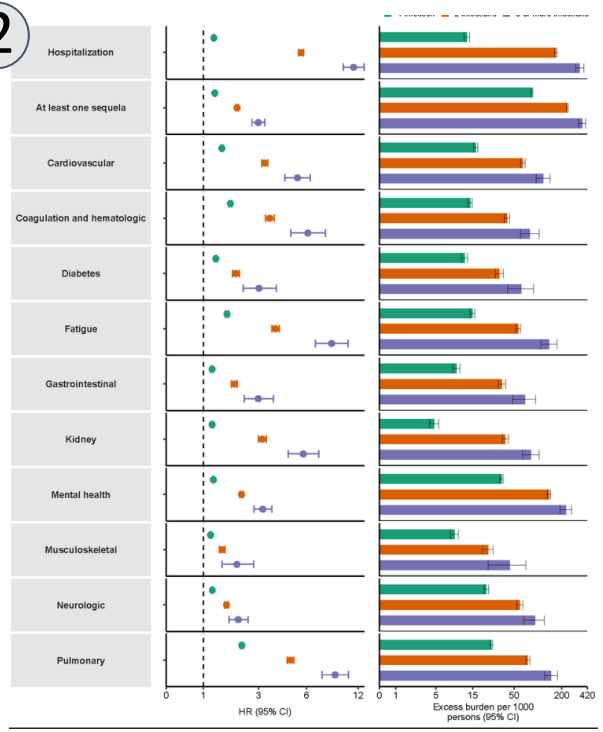

"National health care databases of the US Department of Veterans Affairs to build a cohort of people with first infection (n = 257,427), reinfection (2 or more infections, n = 38,926), and a non-infected control group (n = 5,396,855) to estimate risks and 6-month burdens of all-cause mortality, hospitalization, and a set of pre-specified incident outcomes." Found that non-trivial risk is added to adverse outcomes when compared to individuals not experiencing reinfection
https://www.researchsquare.com/article/rs-1749502/v1

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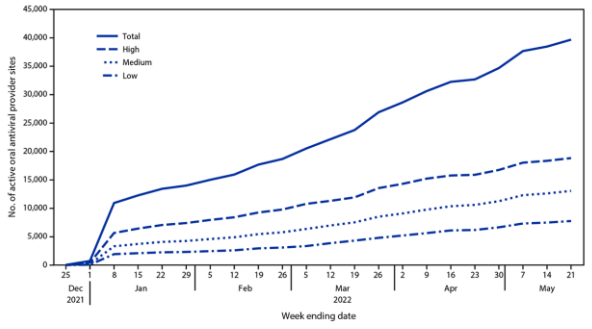

During December 23, 2021–May 21, 2022, 1,076,762 oral antiviral prescriptions were dispensed in the United States. The overall number of antivirals dispensed increased; however, by the end of the study period, dispensing rates were lowest in high vulnerability zip codes, despite these zip codes having the largest number of dispensing sites.
https://www.cdc.gov/mmwr/volumes/71/wr/mm7125e1.htm?s_cid=mm7125e1_w

4

Researchers in Israel searched for drivers of VOC-like emergence by consolidating sequencing results from a set of 27 chronic infections. Many substitutions in this set reflected lineage-defining VOC mutations; however, a subset of mutations associated with successful global transmission were absent from chronic infections. Also found association of antibody evasion mutations with patient-specific and virus-specific features and that viral rebound is strongly correlated with the emergence of antibody evasion. Highlights the need for further sequence surveillance and its study
https://www.nature.com/articles/s41591-022-01882-4

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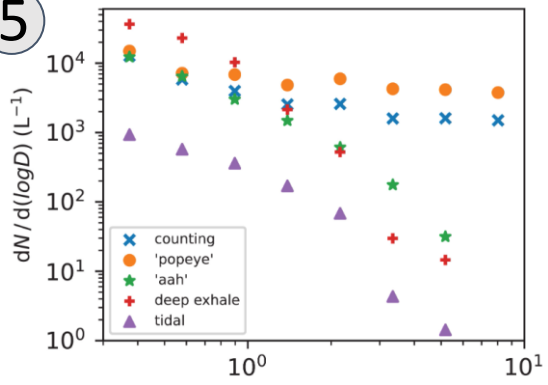


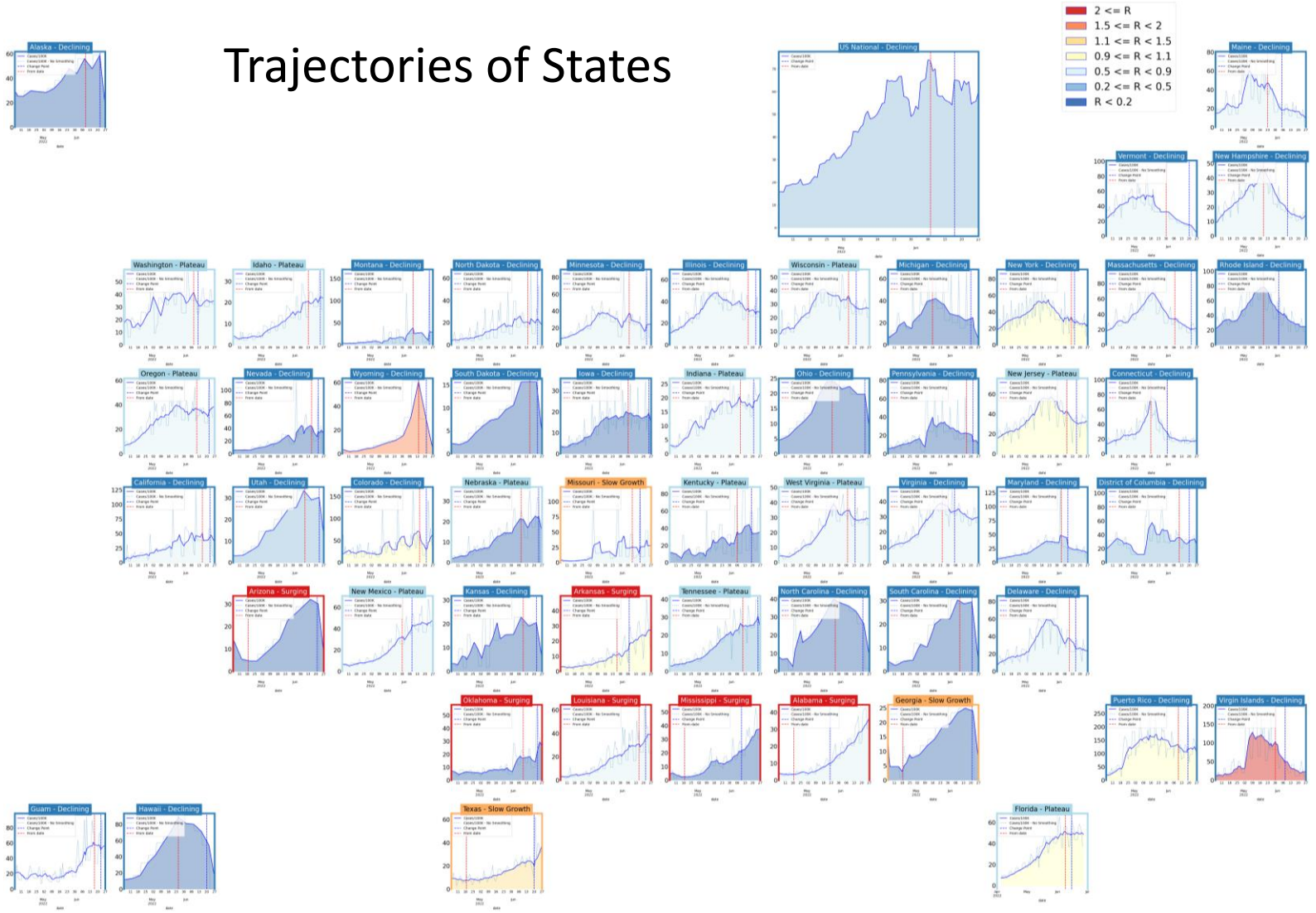
Researchers at NIH found that "Measurements suggest that in the absence of symptoms such as coughing or sneezing, the importance of speech-generated aerosol in the transmission of respiratory diseases is far greater than generally recognized."
https://www.pnas.org/doi/full/10.1073/pnas.2203086119#fig05

United States Case Rates

- Plateauing case rates nationally
- Surge observed in SouthWest

Status	# States
Declining	38 (41)
Plateau	12 (3)
Slow Growth	3 (5)
In Surge	6 (5)

Trajectories of States



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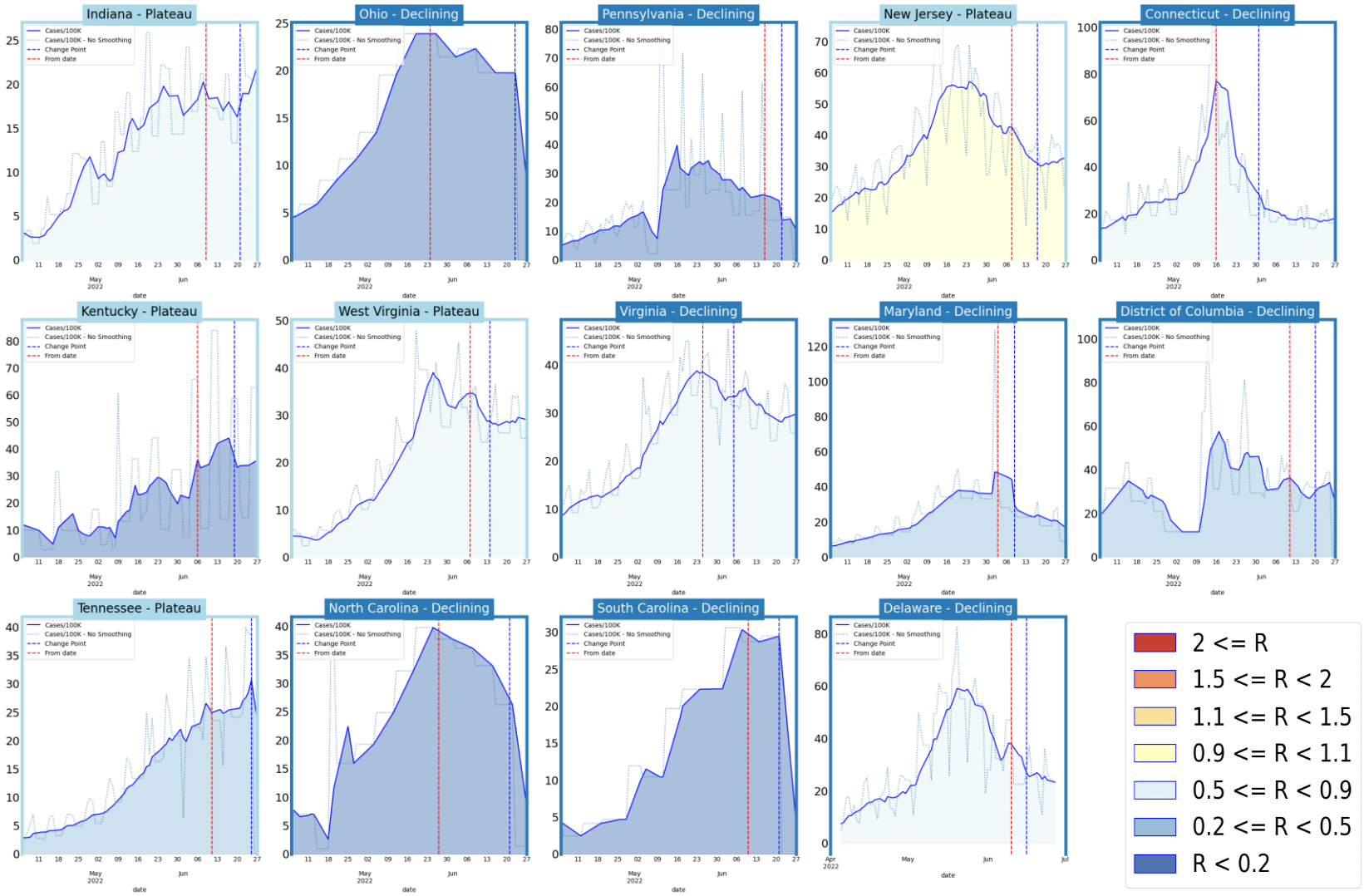
Virginia and Her Neighbors



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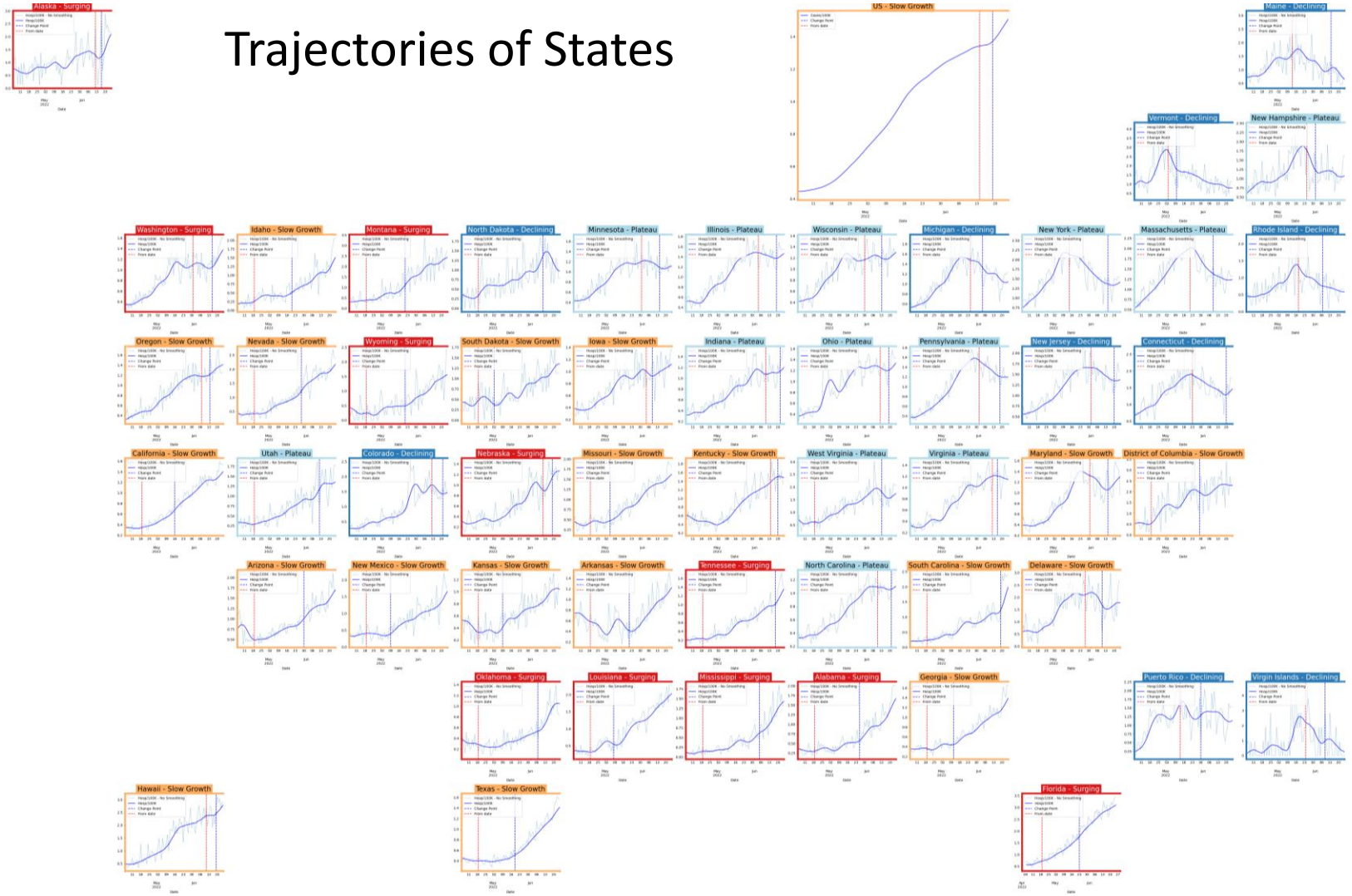
United States Hospitalizations

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

Status	# States
Declining	10 (8)
Plateau	13 (13)
Slow Growth	19 (25)
In Surge	11 (7)

Trajectories of States



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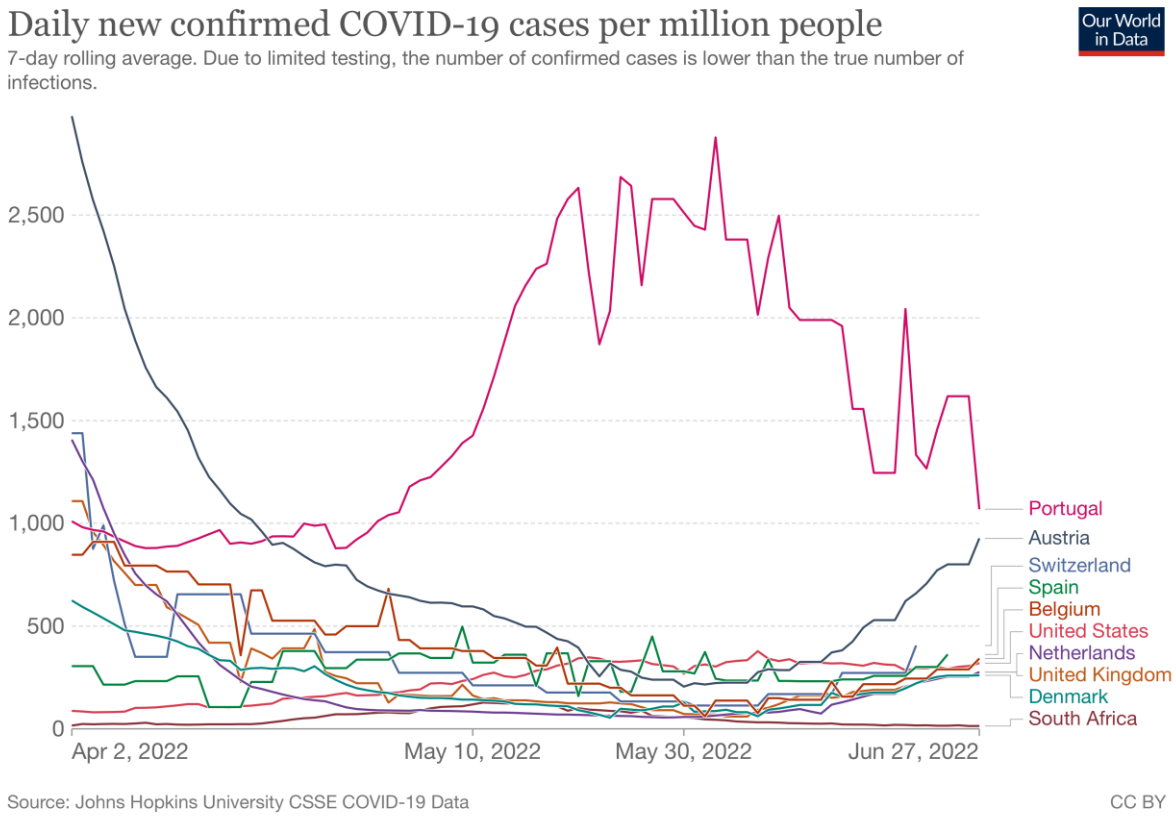
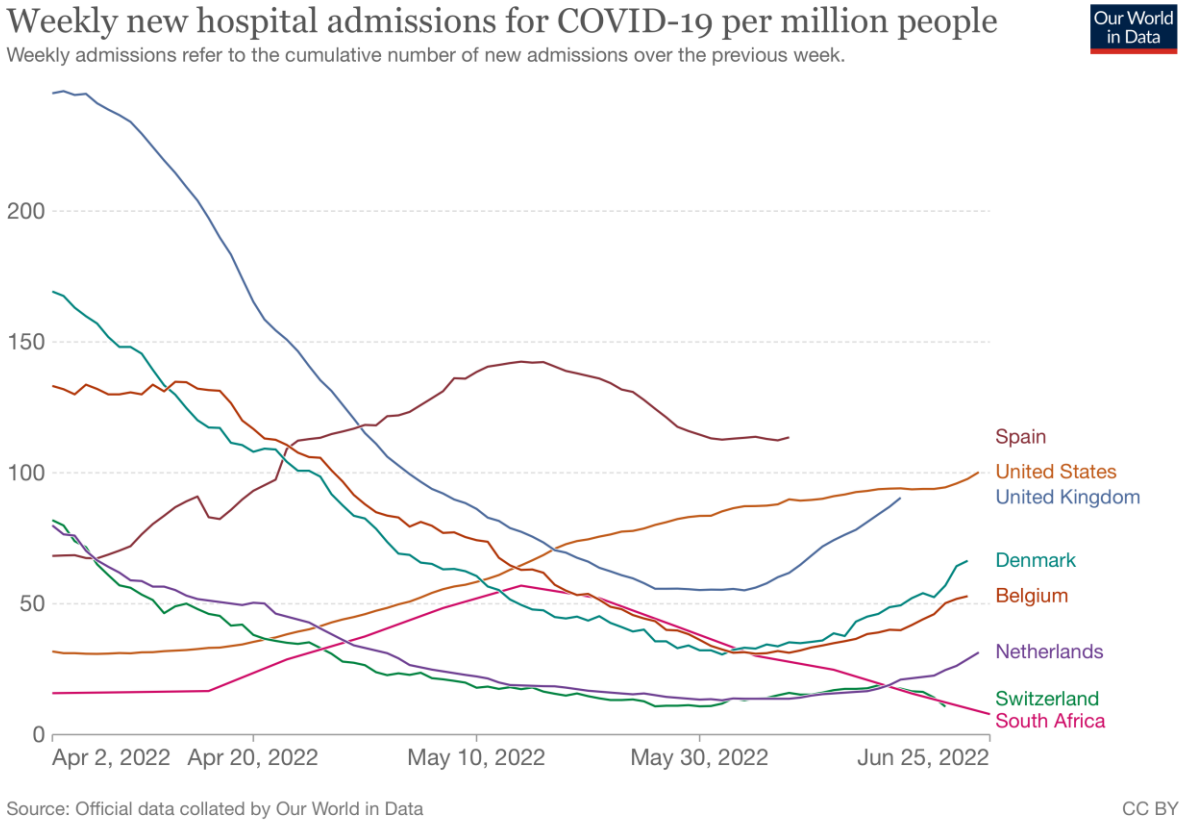
Around the World – BA.4 and BA.5 impacted countries

Confirmed cases

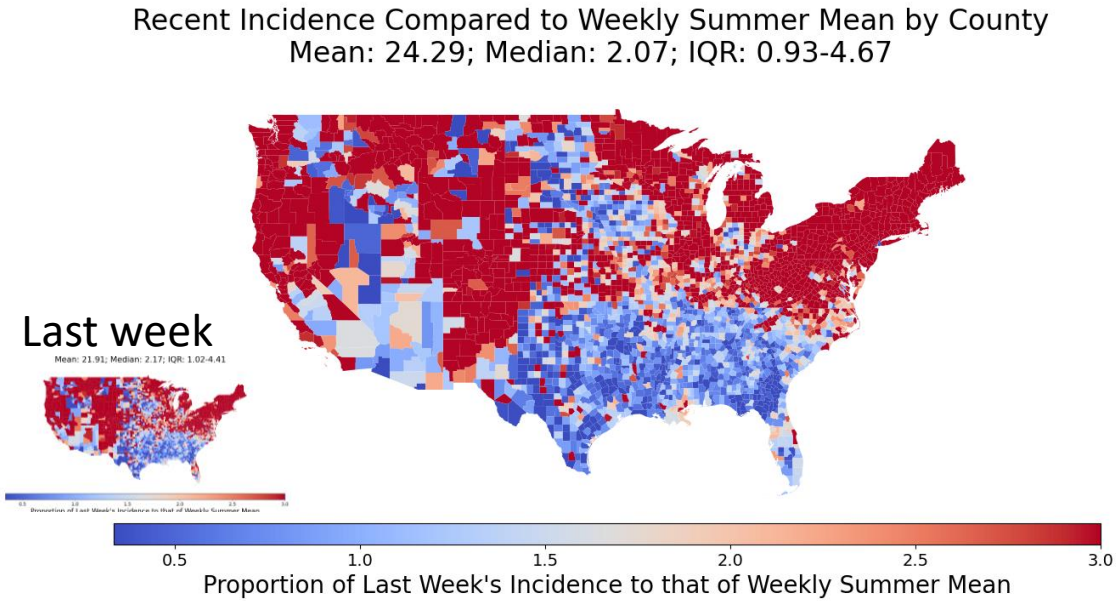


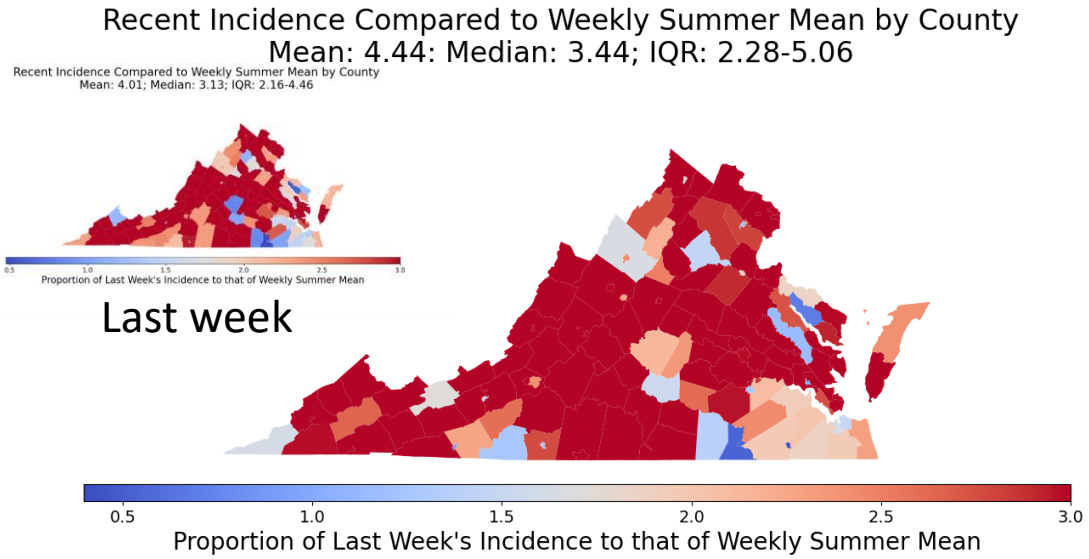
Hospitalizations



[Our World in Data]

County-level comparison to last Summer





Zip code level weekly Case Rate (per 100K)

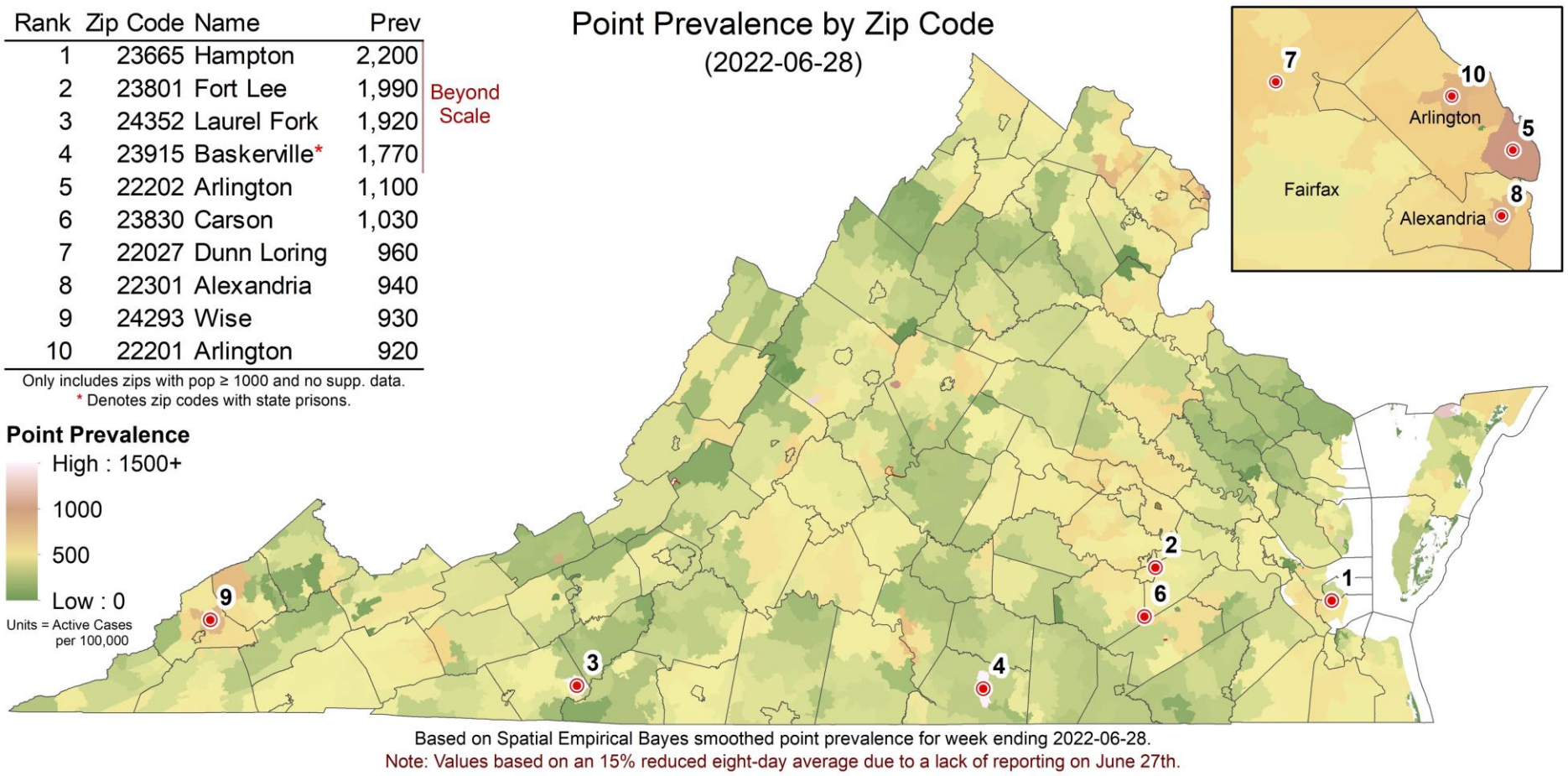
Case Rates in the last week by zip code

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

Rank	Zip Code	Name	Prev
1	23665	Hampton	2,200
2	23801	Fort Lee	1,990
3	24352	Laurel Fork	1,920
4	23915	Baskerville*	1,770
5	22202	Arlington	1,100
6	23830	Carson	1,030
7	22027	Dunn Loring	960
8	22301	Alexandria	940
9	24293	Wise	930
10	22201	Arlington	920

Beyond Scale

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 2022-06-28.
Note: Values based on an 15% reduced eight-day average due to a lack of reporting on June 27th.

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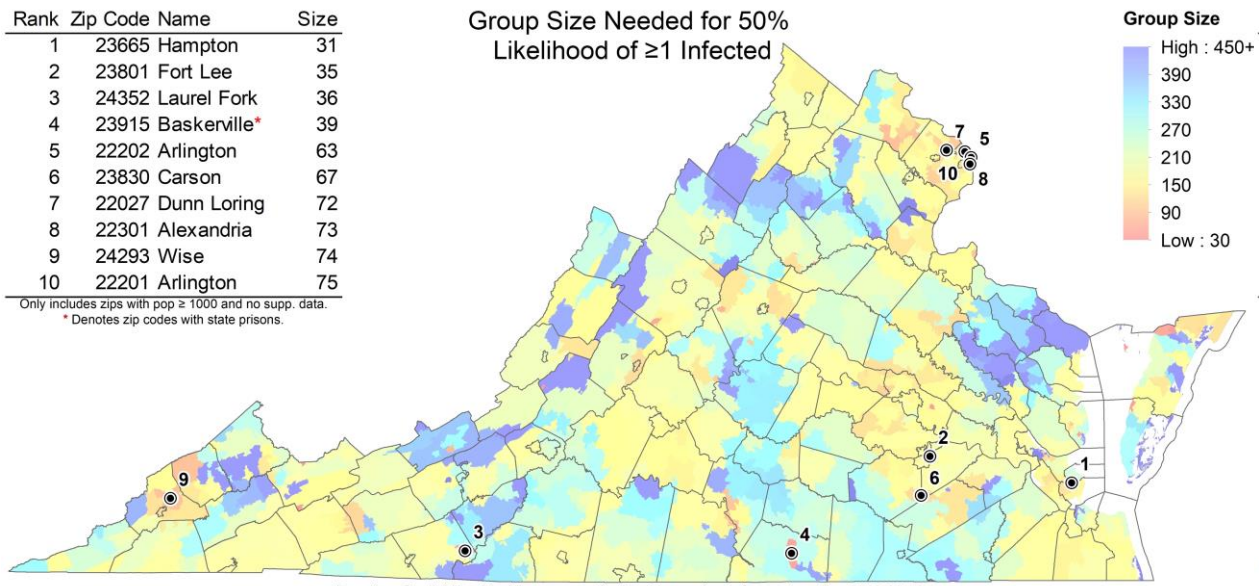
Risk of Exposure by Group Size and HCW prevalence

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)

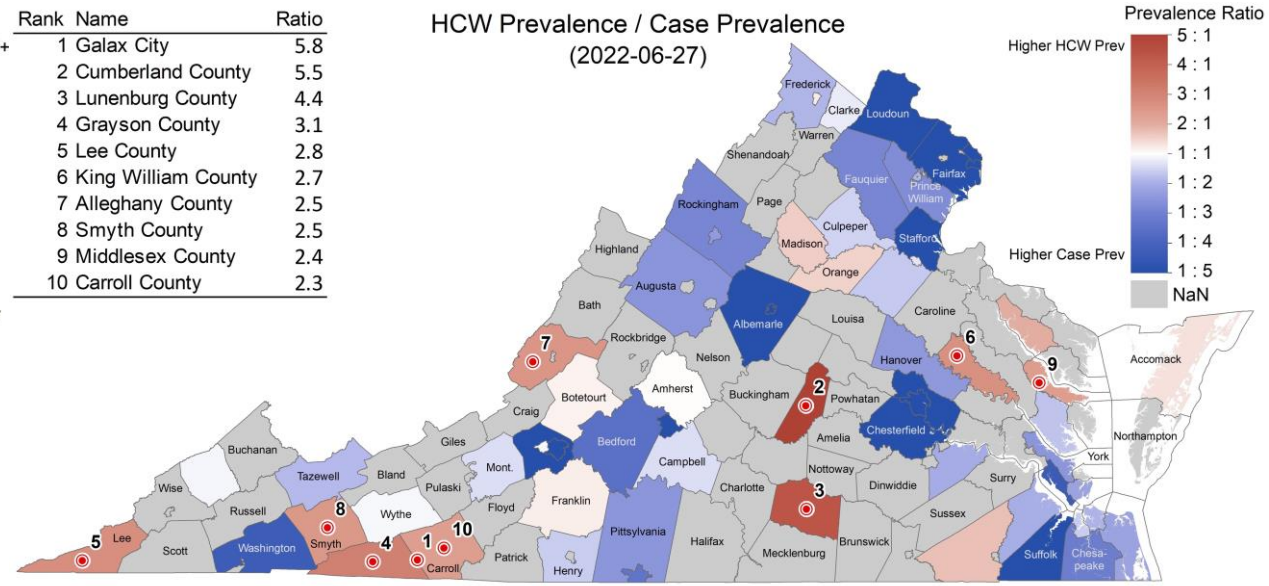
- **Group Size**: Assumes 2 undetected infections per confirmed case (ascertainment rate from recent seroprevalence survey), and shows minimum size of a group with a 50% chance an individual is infected by zip code (eg in a group of 44 in Victoria, there is a 50% chance someone will be infected)
- **HCW 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	23665	Hampton	31
2	23801	Fort Lee	35
3	24352	Laurel Fork	36
4	23915	Baskerville*	39
5	22202	Arlington	63
6	23830	Carson	67
7	22027	Dunn Loring	72
8	22301	Alexandria	73
9	24293	Wise	74
10	22201	Arlington	75

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



Rank	Name	Ratio
1	Galax City	5.8
2	Cumberland County	5.5
3	Lunenburg County	4.4
4	Grayson County	3.1
5	Lee County	2.8
6	King William County	2.7
7	Alleghany County	2.5
8	Smyth County	2.5
9	Middlesex County	2.4
10	Carroll County	2.3



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-06-28.
Note: Values based on an 15% reduced eight-day average due to a lack of reporting on June 27th.

Current Hot-Spots

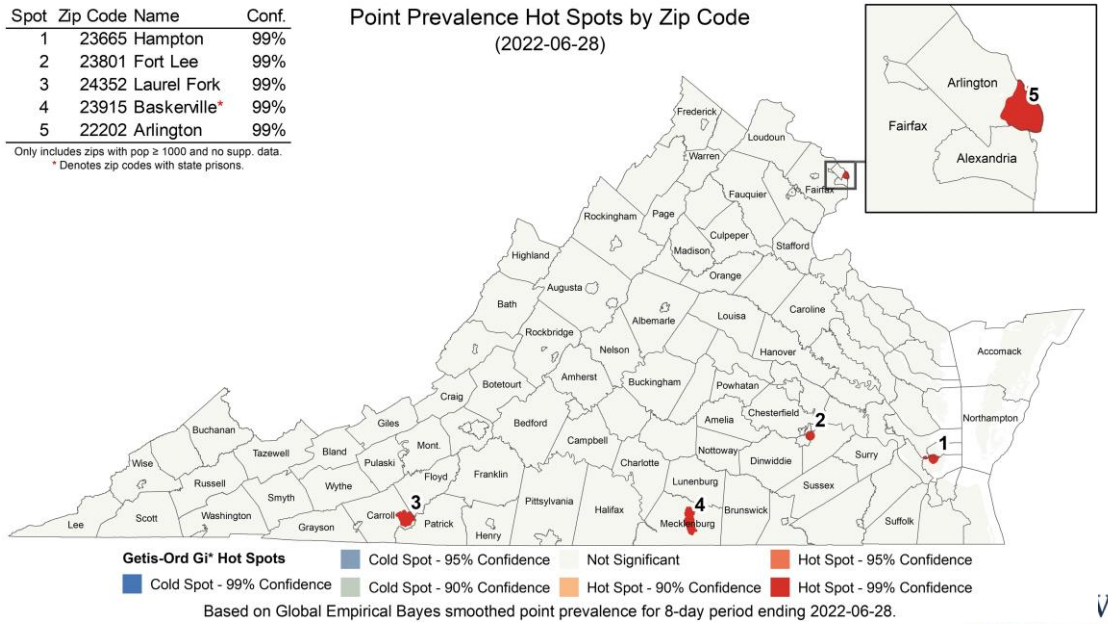
Case rates that are significantly different from neighboring areas or model projections

- **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

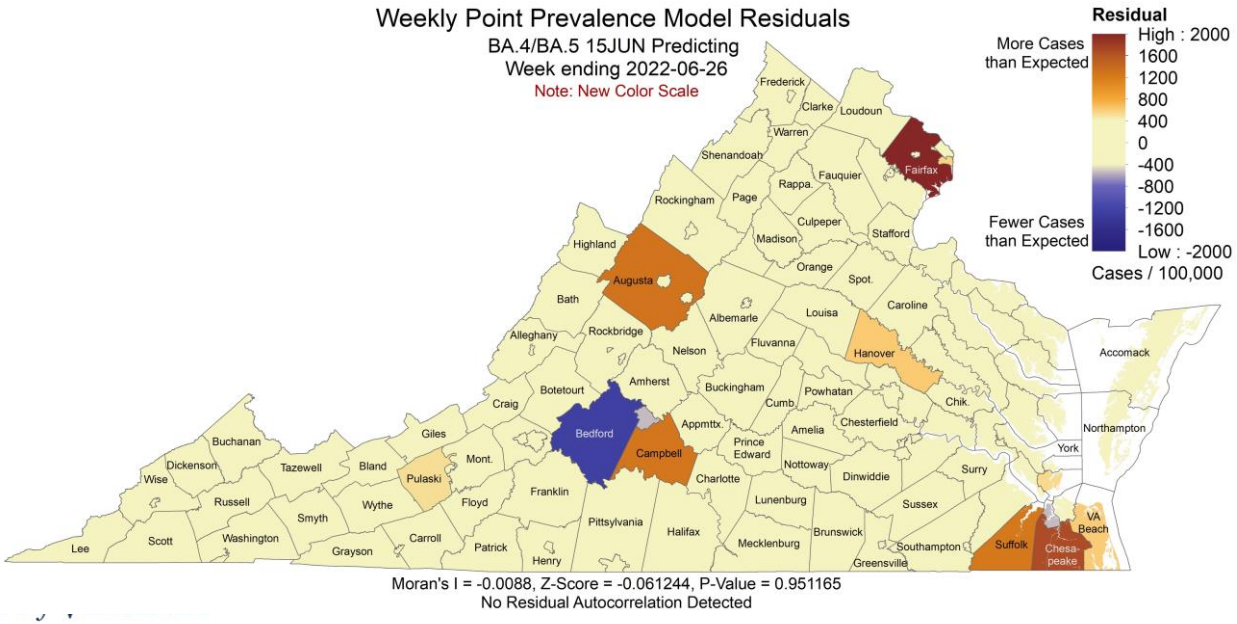
Spatial Hotspots

Spot	Zip Code	Name	Conf.
1	23665	Hampton	99%
2	23801	Fort Lee	99%
3	24352	Laurel Fork	99%
4	23915	Baskerville*	99%
5	22202	Arlington	99%

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



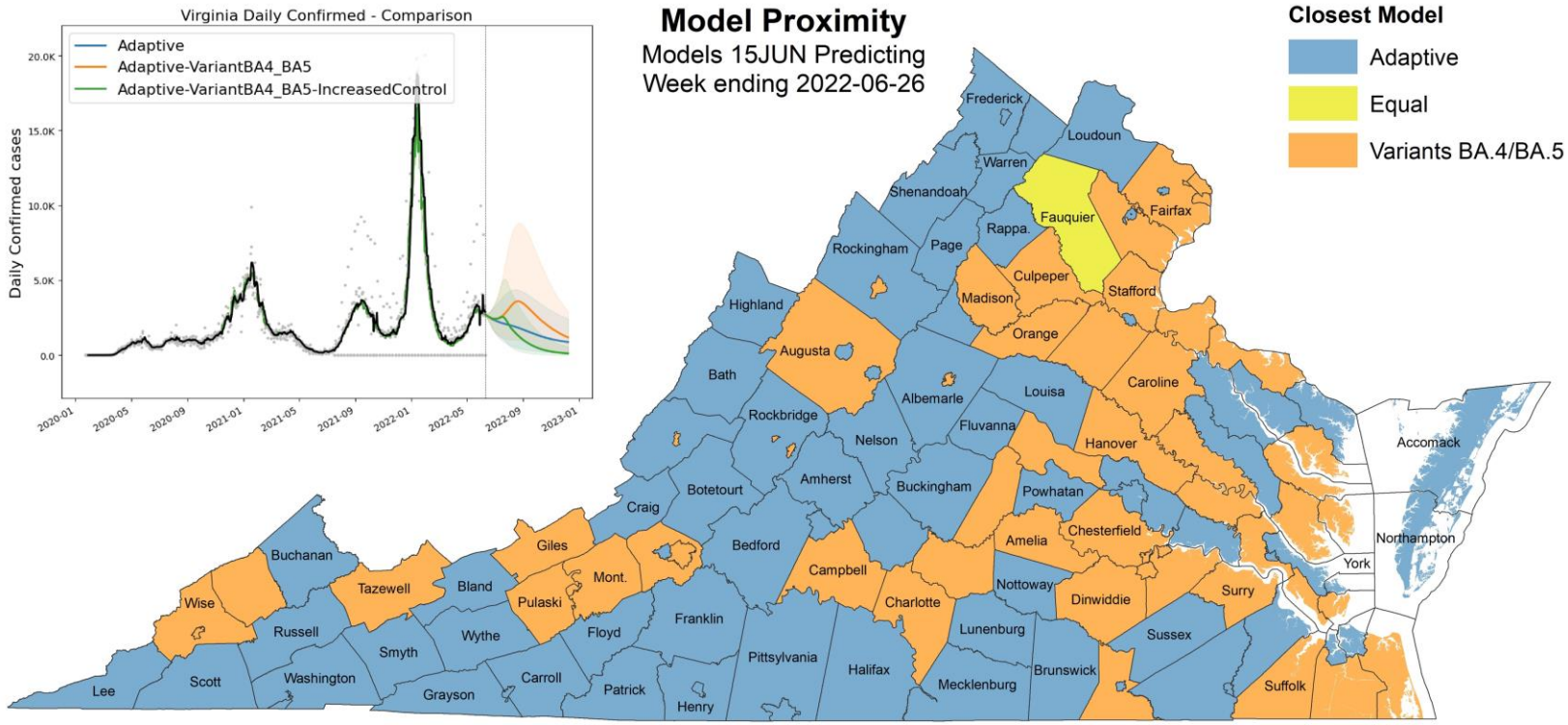
Clustered Temporal Hotspots from BA.4_BA.5



Scenario Trajectory Tracking

Which scenario from last projection did each county track closest?

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



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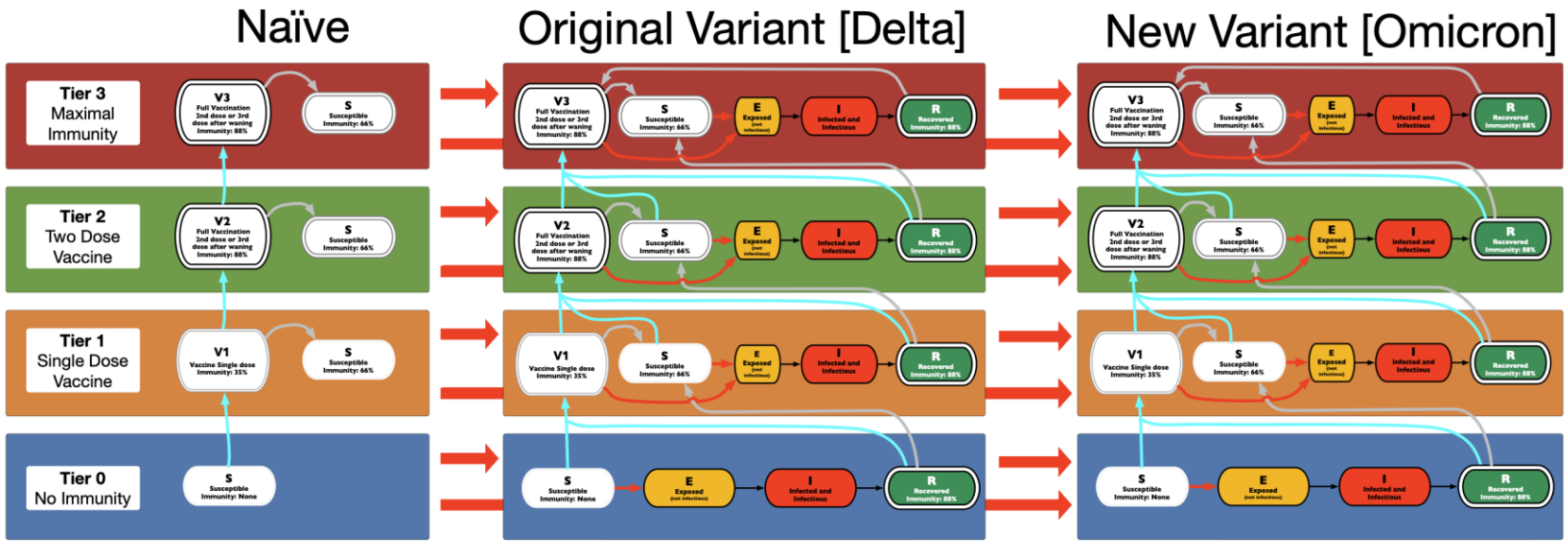
Model Update – Adaptive Fitting

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

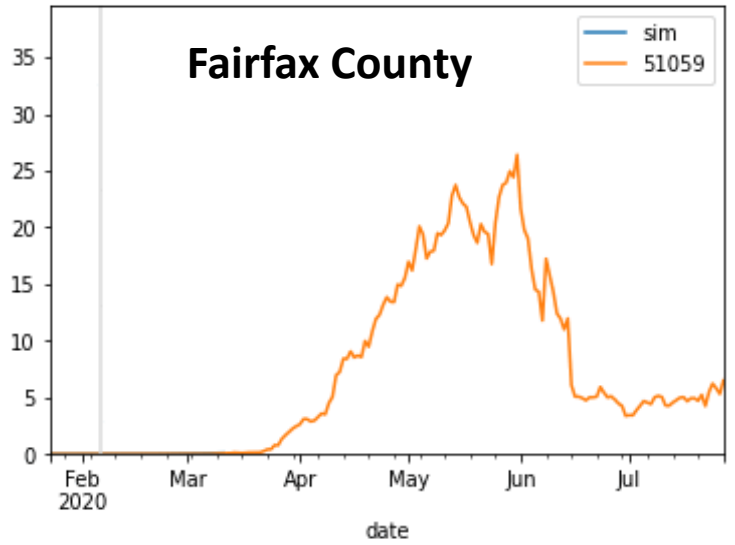
- Allows history to be precisely captured, and used to guide bounds on projections

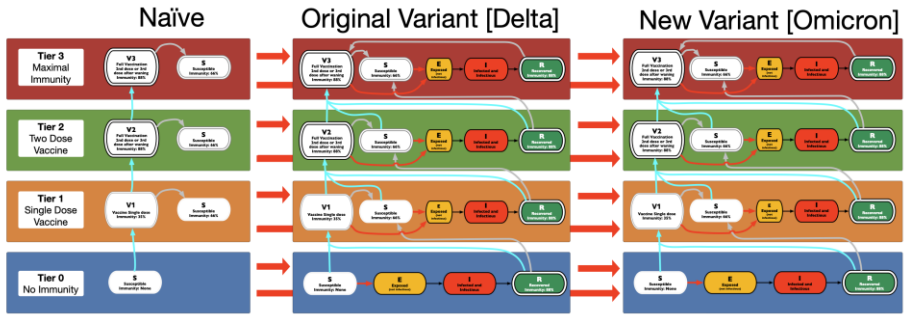
Model: An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- 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:

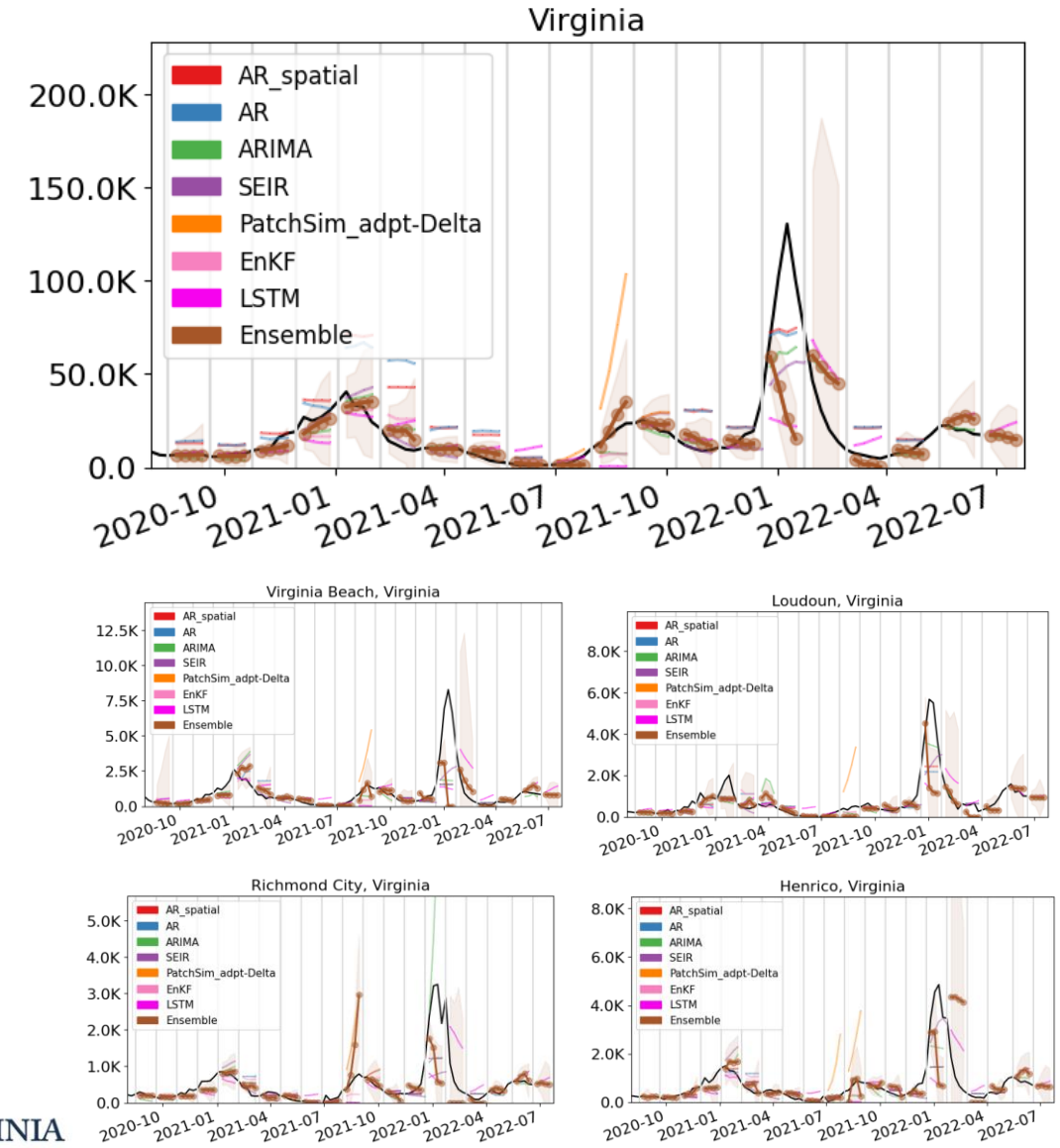
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

<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.

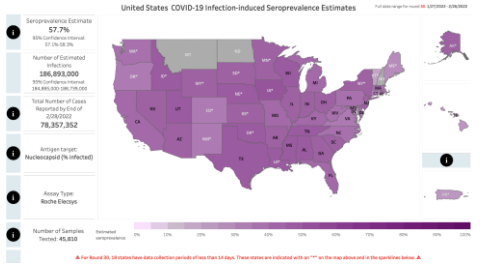


Seroprevalence updates to model design

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

- CDC Nationwide Commercial Laboratory Seroprevalence Survey, however, is no longer reporting data.

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

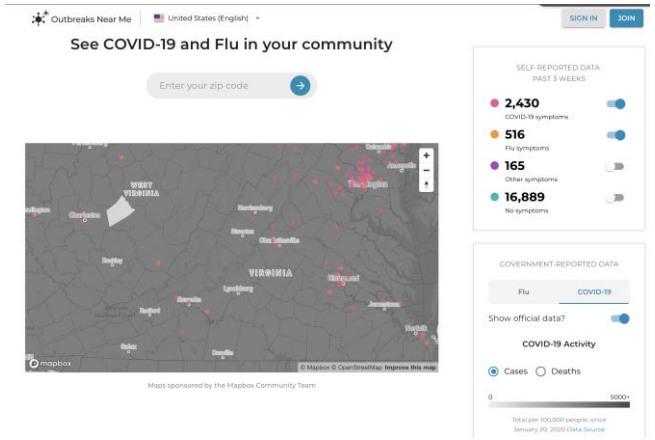


Virginia

Feb 22nd: 45% [42% - 48%];

Jan 22nd: 34% [31%-39%]

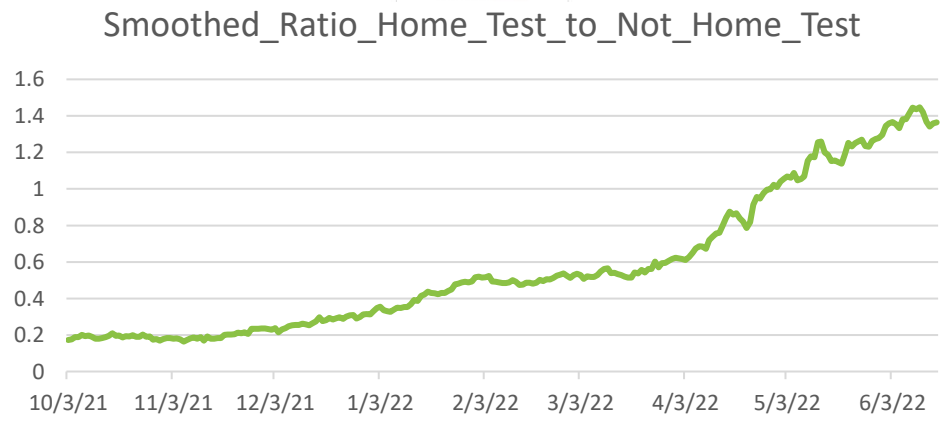
https://covid.cdc.gov/covid-data-tracker/#national-lab



OutbreaksNearMe

Testing Behavior has changed, fewer cases are reported

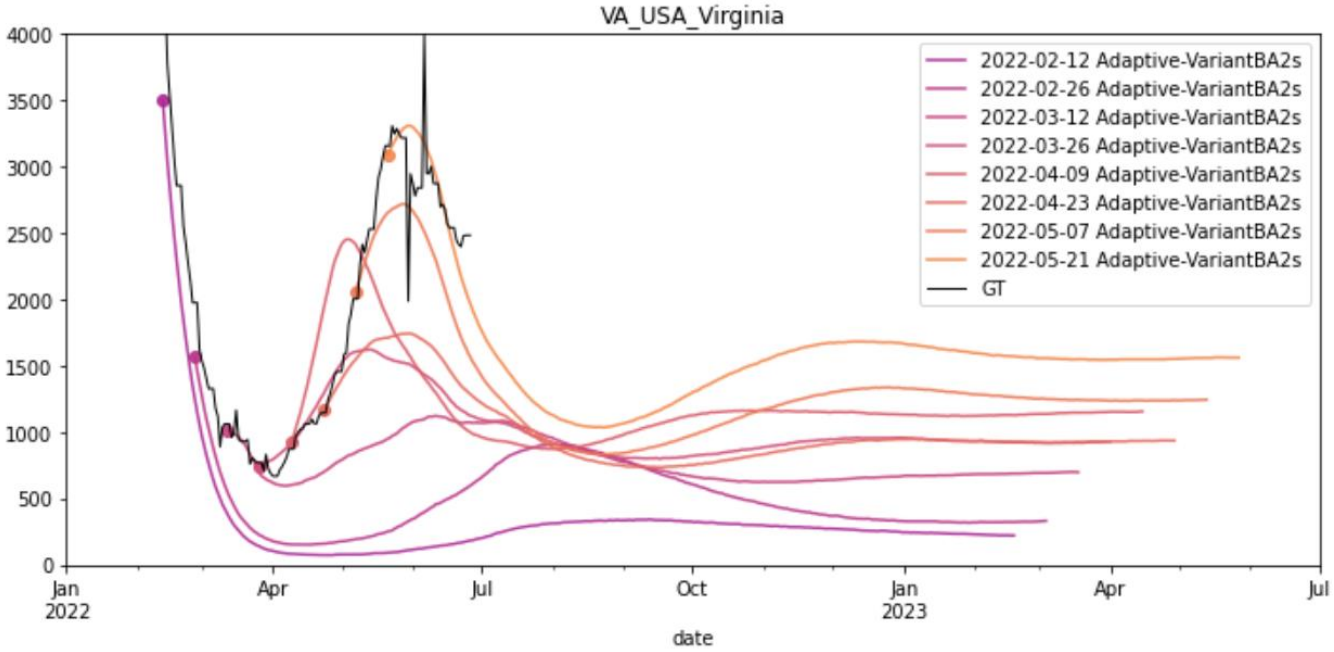
- Home testing, reduced symptoms due to breakthrough / reinfection, and elimination of public health leave (ie pay while out with COVID) limits officially reported cases
- Outbreaks Near Me from Boston Children's Hospital and Momentive collects reports of home testing and reports a general trend up
- Current models haven't included this aspect of ascertainment

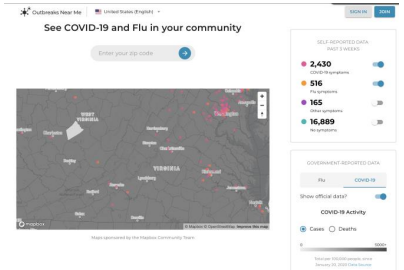


Preliminary work to incorporate home testing data

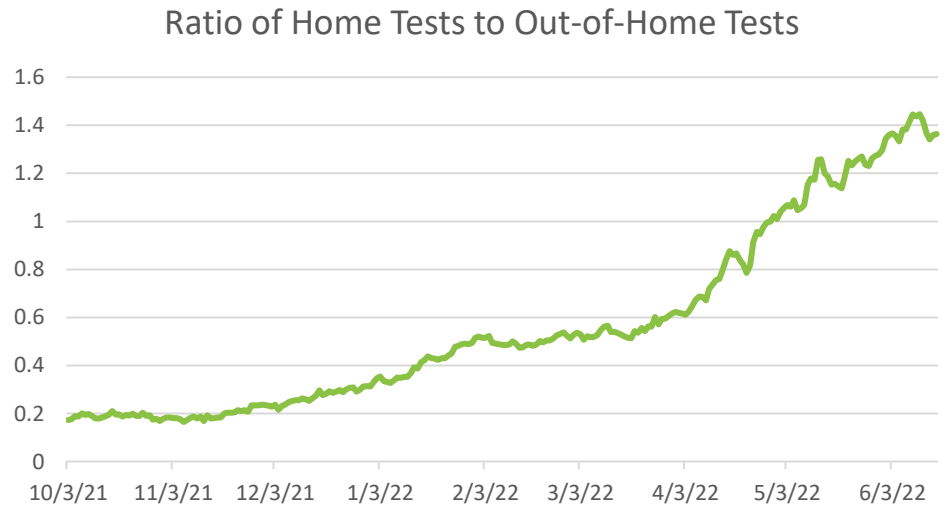
Using ratio of home-testing to out of home testing provides evidence for higher rates of infection than current surveillance indicates

- Models fit with this assumption and anticipated BA.2.12.1 growth fit much better than previous projections without this information
- With further refinement, this data source may be folded into future projections



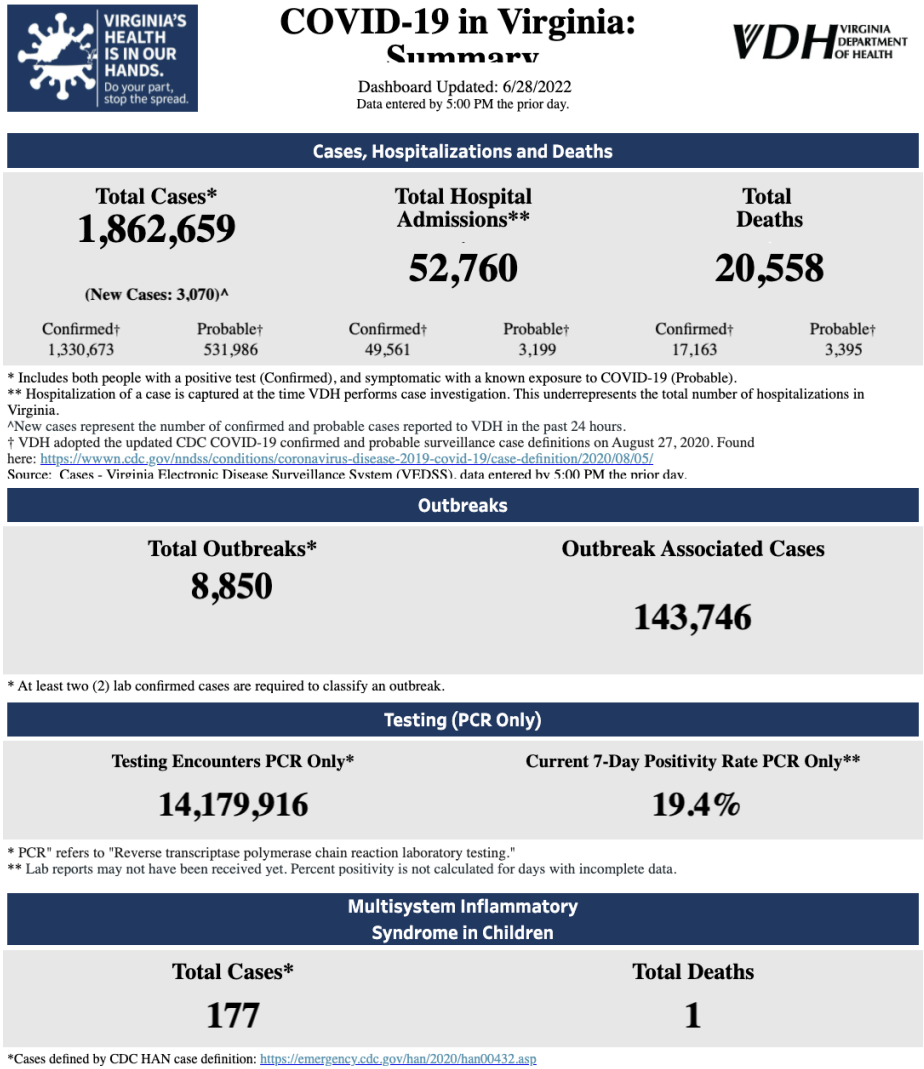


OutbreaksNearMe



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

Dashboard Updated: 6/28/2022
Data entered by 5:00 PM the prior day.

VDH VIRGINIA DEPARTMENT OF HEALTH

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospital Admissions**	Total Deaths
1,862,659	52,760	20,558
(New Cases: 3,070)^		

Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
1,330,673	531,986	49,561	3,199	17,163	3,395

* 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
8,850	143,746

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

Testing (PCR Only)

Testing Encounters PCR Only*	Current 7-Day Positivity Rate PCR Only**
14,179,916	19.4%

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

Multisystem Inflammatory Syndrome in Children

Total Cases*	Total Deaths
177	1

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

Accessed 7:00am June 29, 2022
https://www.vdh.virginia.gov/coronavirus/

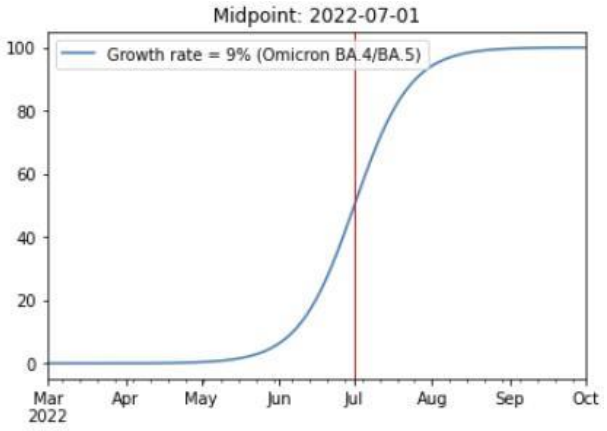
Scenarios – Transmission Conditions

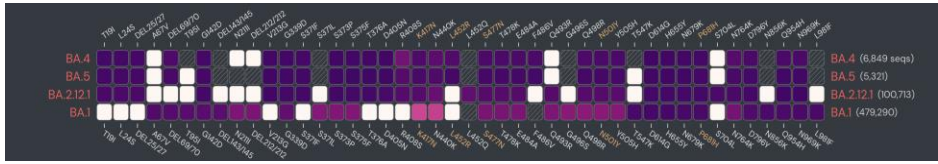
- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity**: Mean of 6 months to a year protection (rate of 0.0027) similar to Pfizer study, Omicron waning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

Scenarios – Omicron BA.4 / BA.5 Description

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

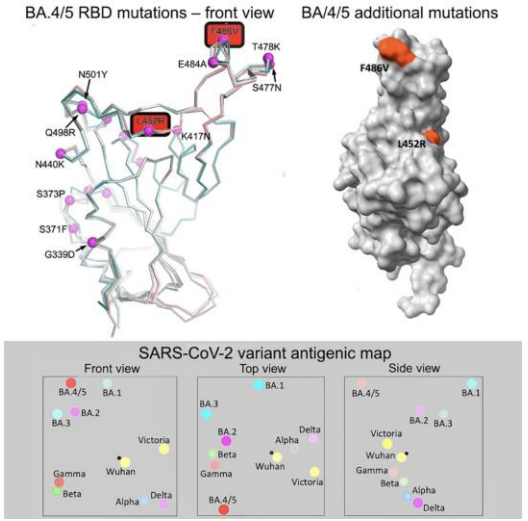
- **Immune Escape**: Lab studies demonstrate that BA.4 and BA.5 demonstrate substantial immune escape for both vaccinated and unvaccinated people who have been previously infected with BA.1 subvariants
- **Using an 80% reduction in immunity for those previously infected with Omicron (BA.1 and BA.2)**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





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

1. BA.4/5 resist neutralization by triple-dosed vaccinee serum more than BA.1/2.
2. BA.1 vaccine breakthrough serum shows reduced neutralization of BA.4/5.
3. Activity of SARS-CoV-2 therapeutic antibodies against BA.4/5 is reduced.
4. L452R and F486V mutations both make major contributions to BA.4/5 escape.



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

Projection Scenarios – Combined Conditions

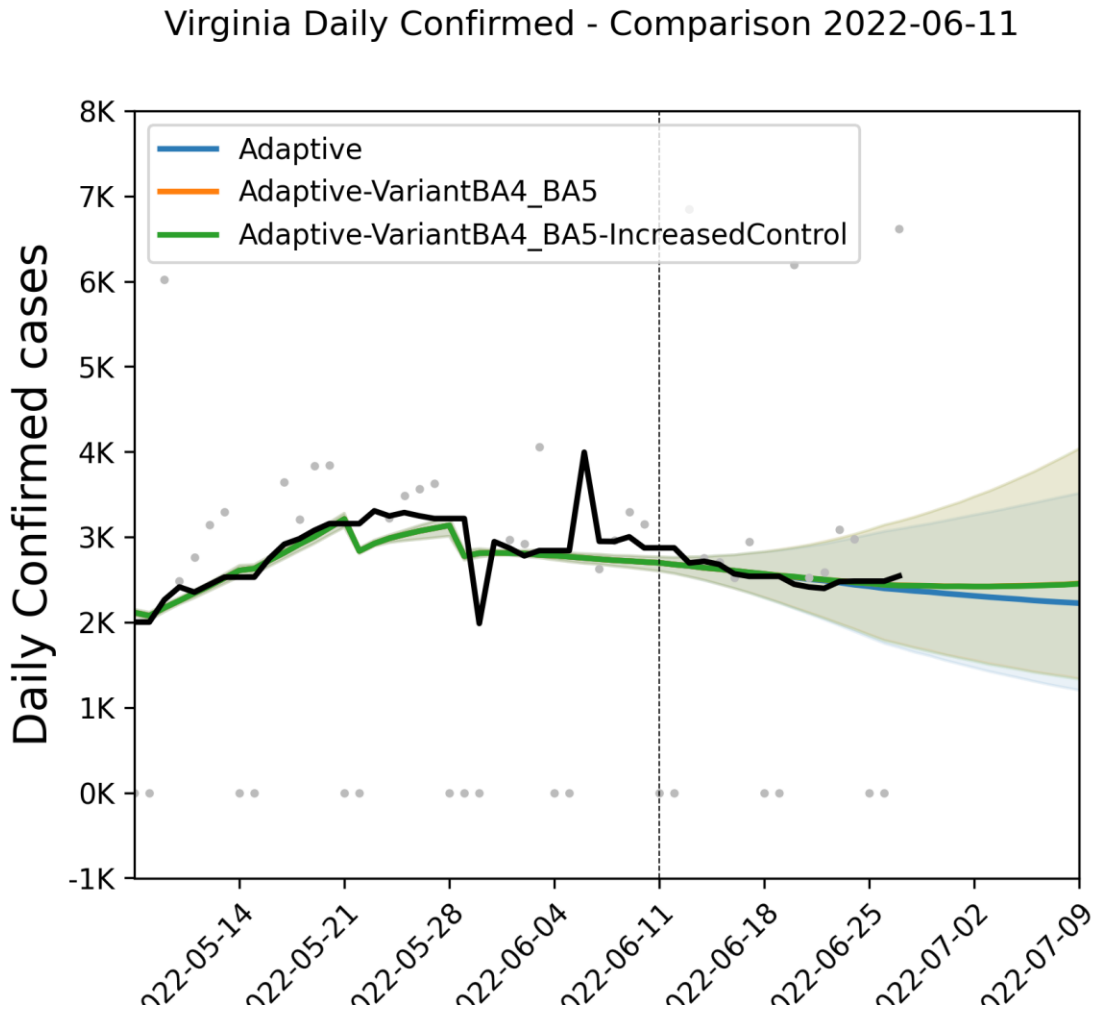
Name	Txm Controls	Vax	Description
Adaptive	C	SQ	Likely trajectory based on conditions remaining similar to the current experience, includes immune escape due to Omicron
Adaptive-VariantBA4_BA5	C	SQ	Emerging BA.4 and BA.5 subvariants have substantial immune escape from previous BA., with BA.2.12.1 prevalence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

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

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

Last projection comparison – 2 weeks ago

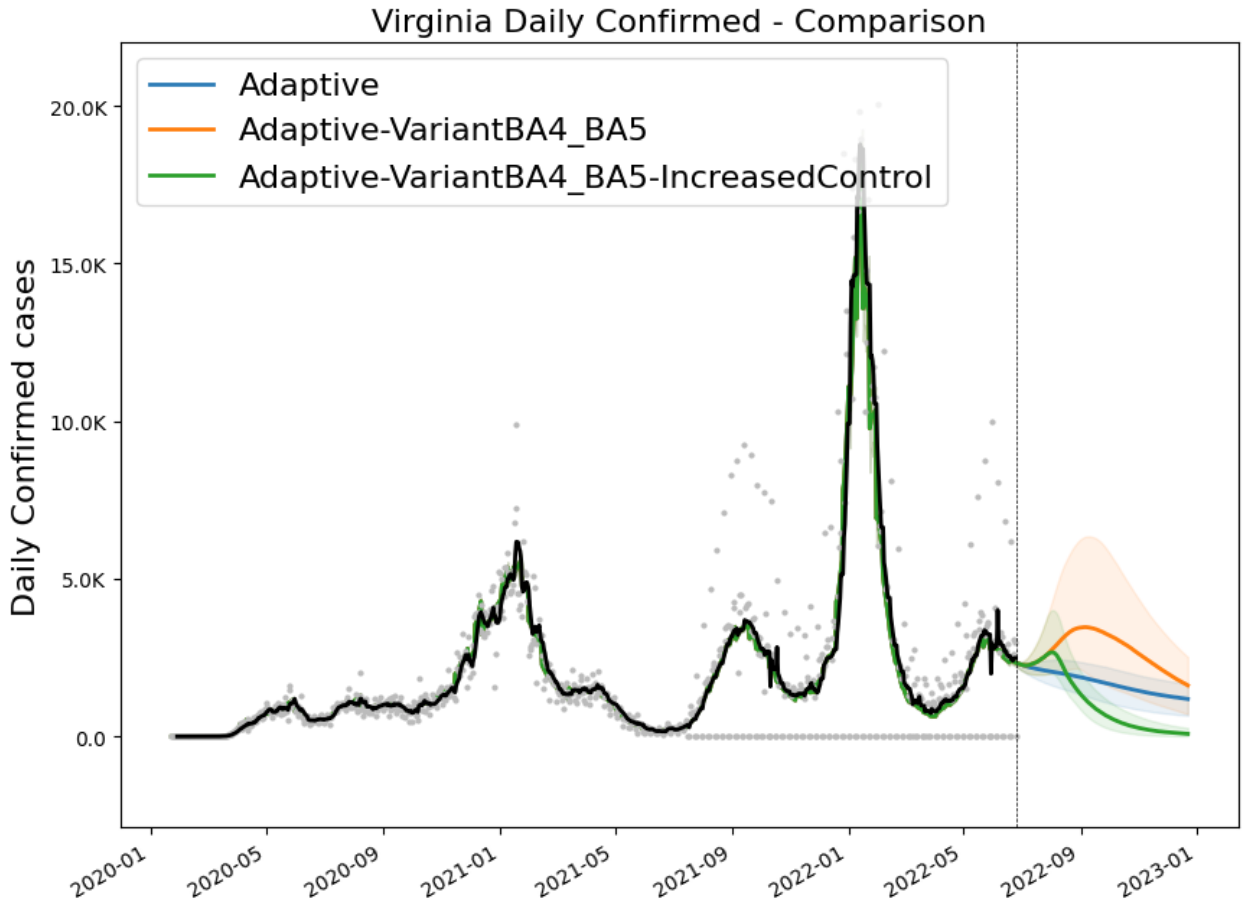
- Projection from 2 weeks ago anticipated gentle decline with BA.4 / 5 flattening leading to slight increase in early July, observations to date remain on track



Model Results

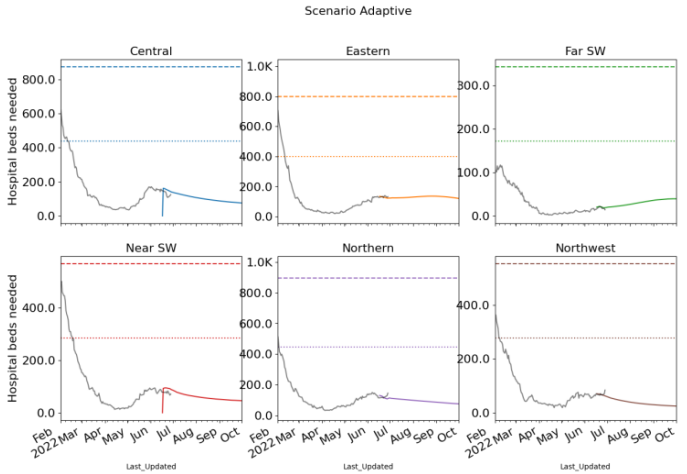
Outcome Projections

Confirmed cases

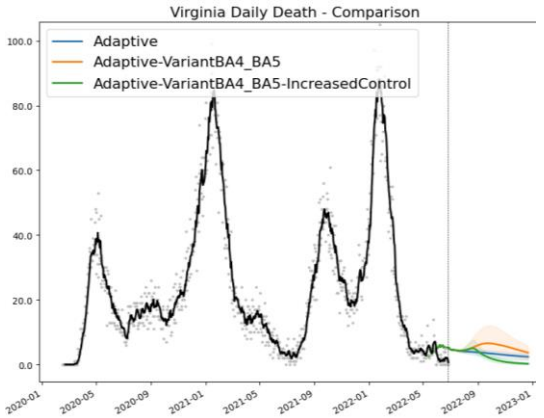


* without surveillance correction VariantBA2 peaked over 10K in July

Estimated Hospital Occupancy

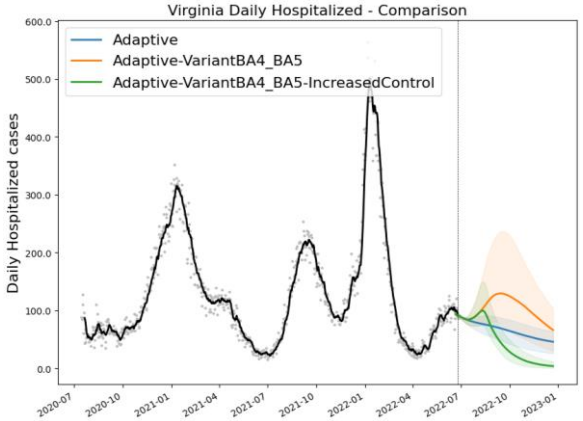


Daily Deaths



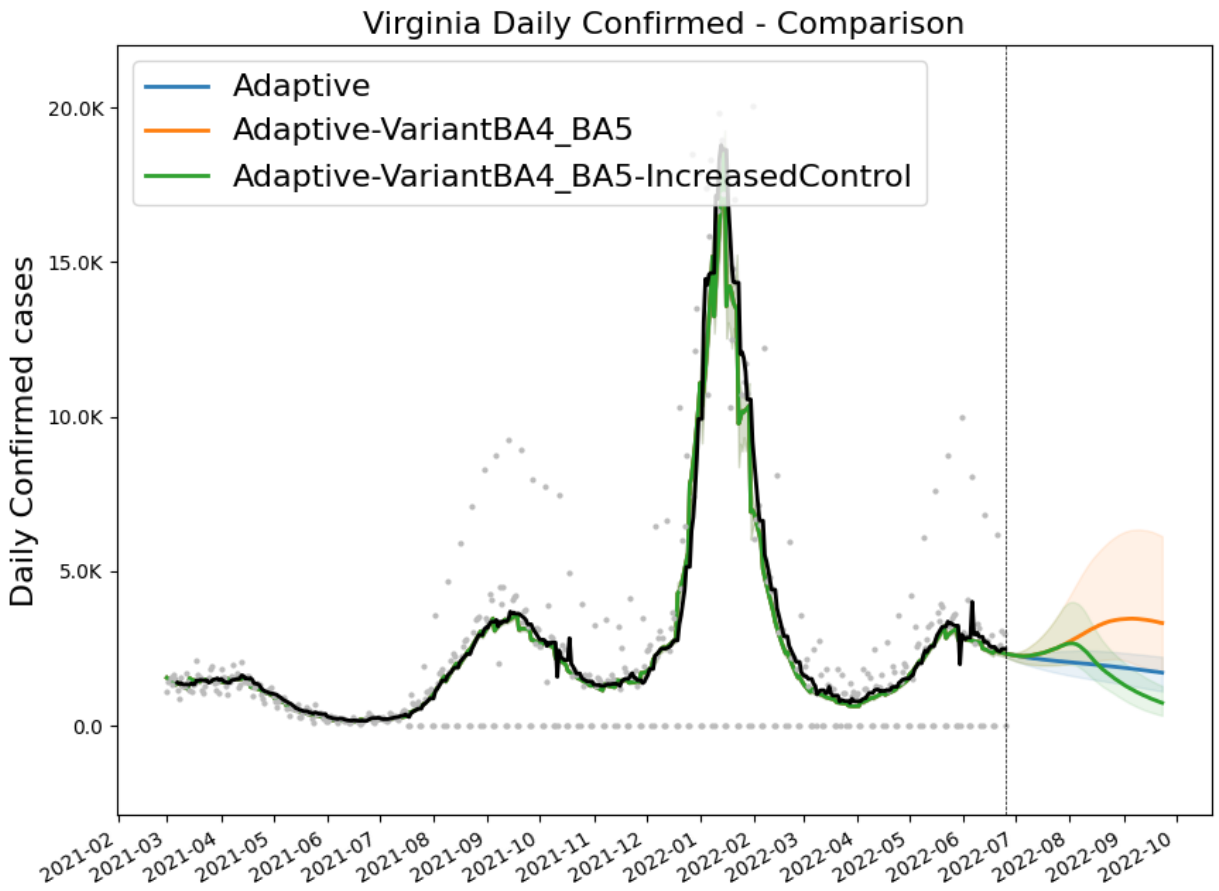
Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized



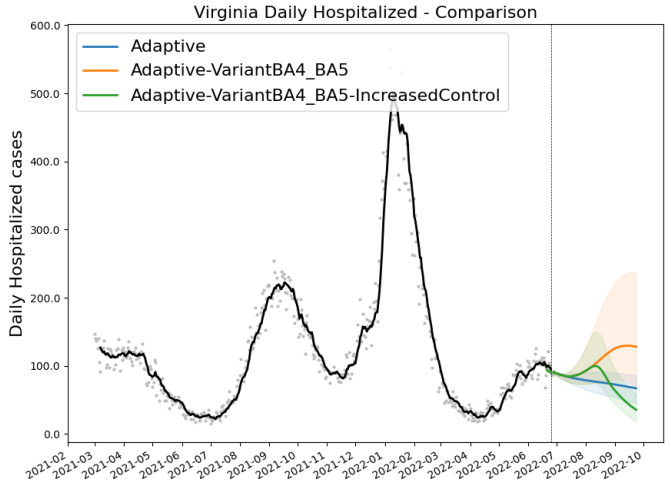
Outcome Projections – Closer Look

Confirmed cases

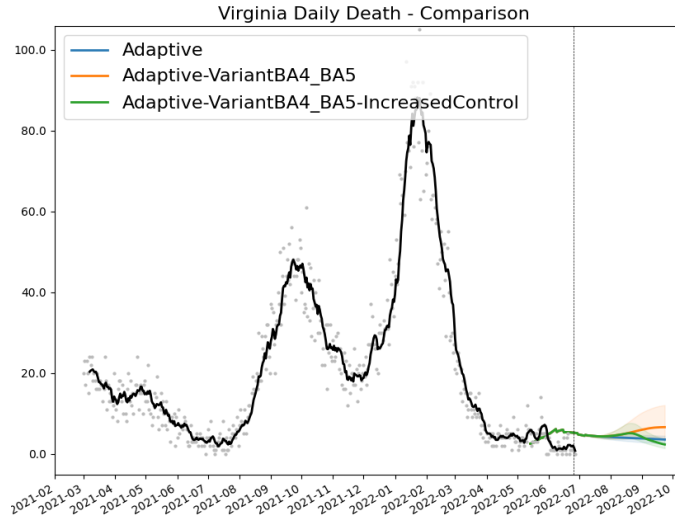


* without surveillance correction VariantBA2 peaked over 10K in July

Daily Hospitalized



Daily Deaths



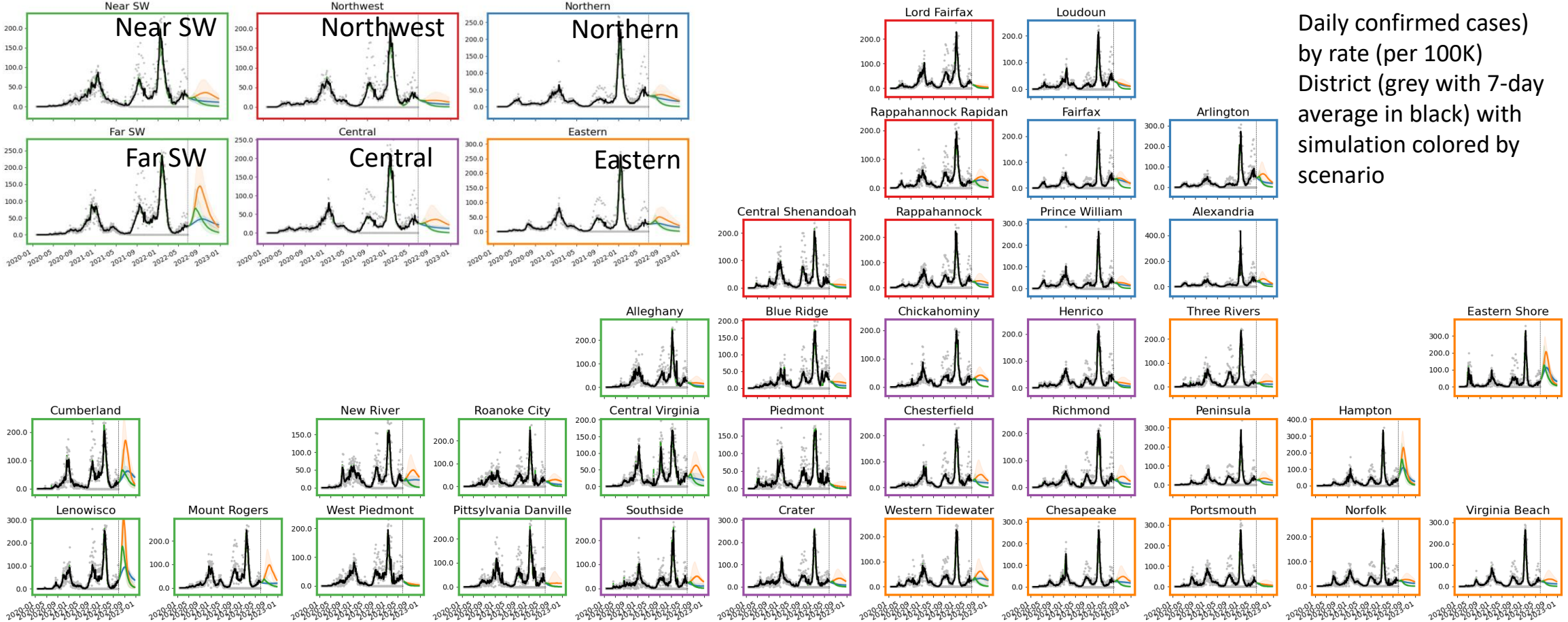
Death ground truth from VDH "Event Date" data, most recent dates are not complete

UNIVERSITY of VIRGINIA
BIOCOMPLEXITY INSTITUTE

Detailed Projections: All Scenarios

Projections by Region

Projections by District

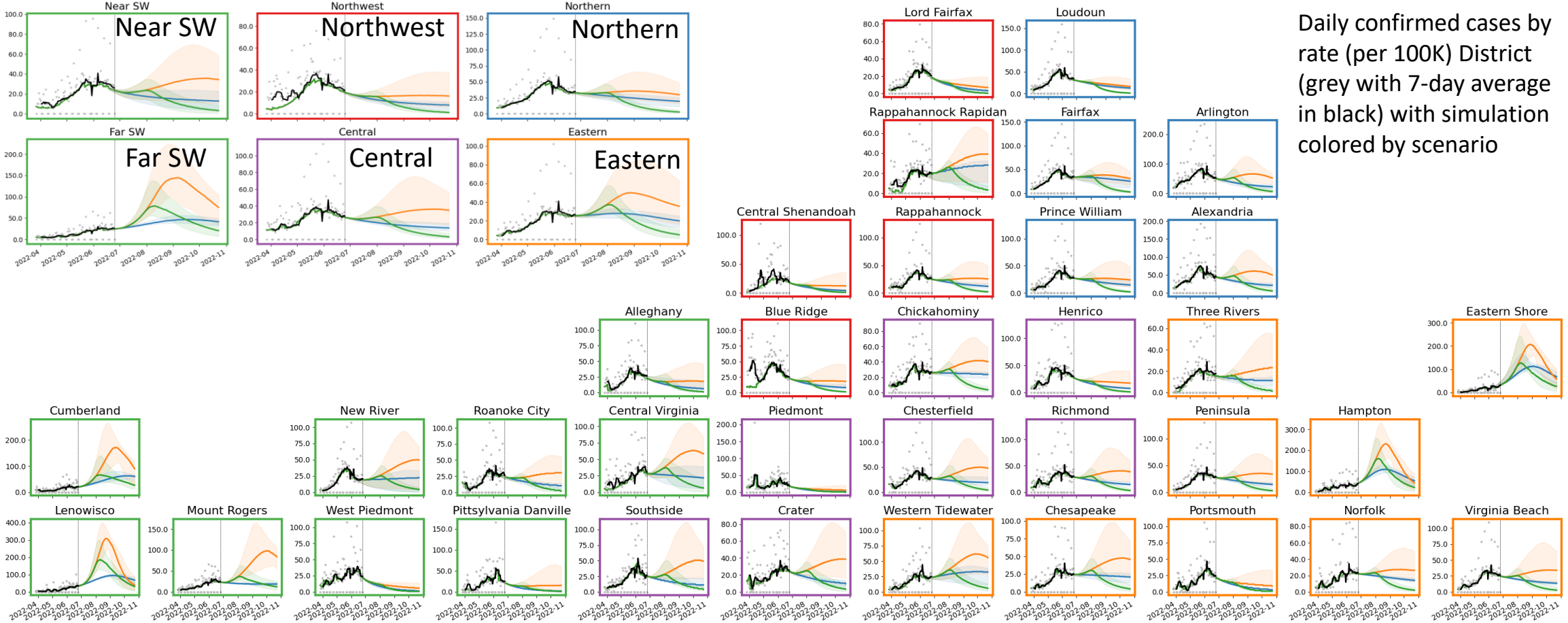


Daily confirmed cases) by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

Detailed Projections: All Scenarios - Closer Look

Projections by Region

Projections by District



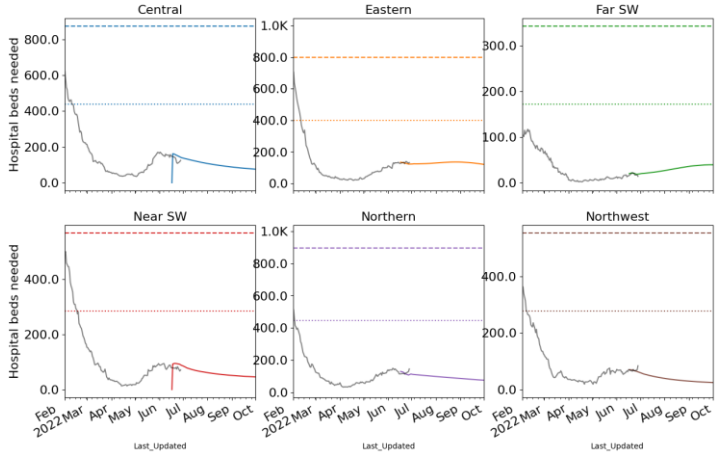
Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

Hospital Demand and Bed Capacity by Region

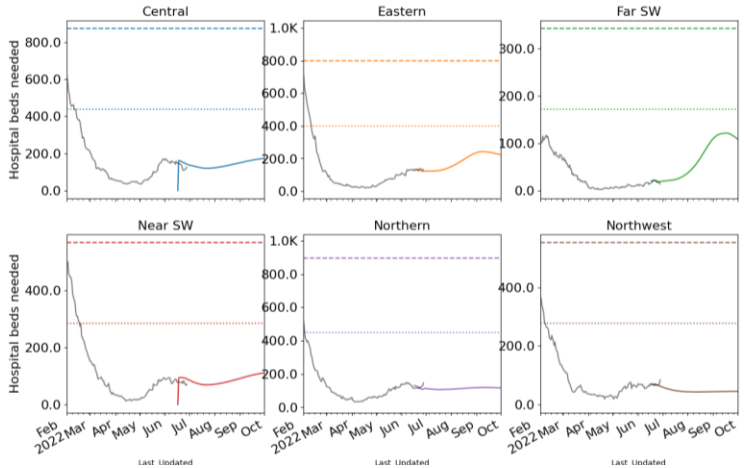
Capacities by Region

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

Adaptive



Adaptive – Variant BA4_BA5



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

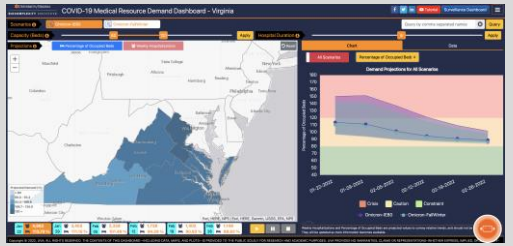
Estimated LOS lengthened slightly to better fit observed data

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

Length of Stay Estimates

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

Interactive Dashboard with regional projections



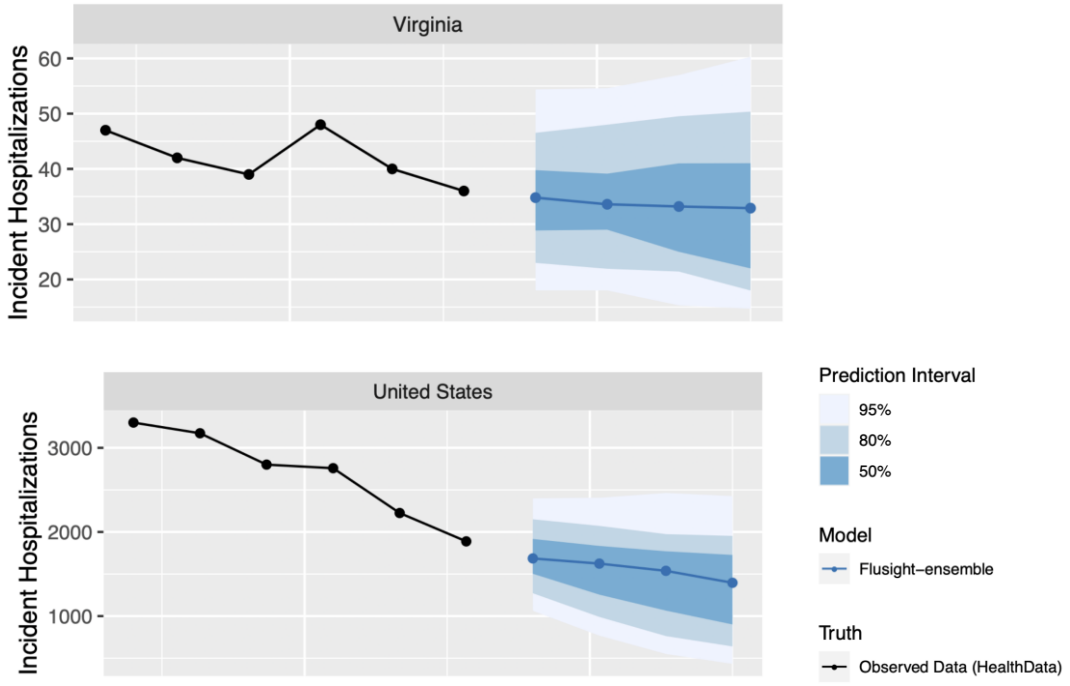
https://nssac.bii.virginia.edu/covid-19/vmrddash/

Current Influenza Hospitalization Forecast

Statistical models for submitting to CDC FluSight forecasting challenge

- Hospitalizations nationwide are slowing

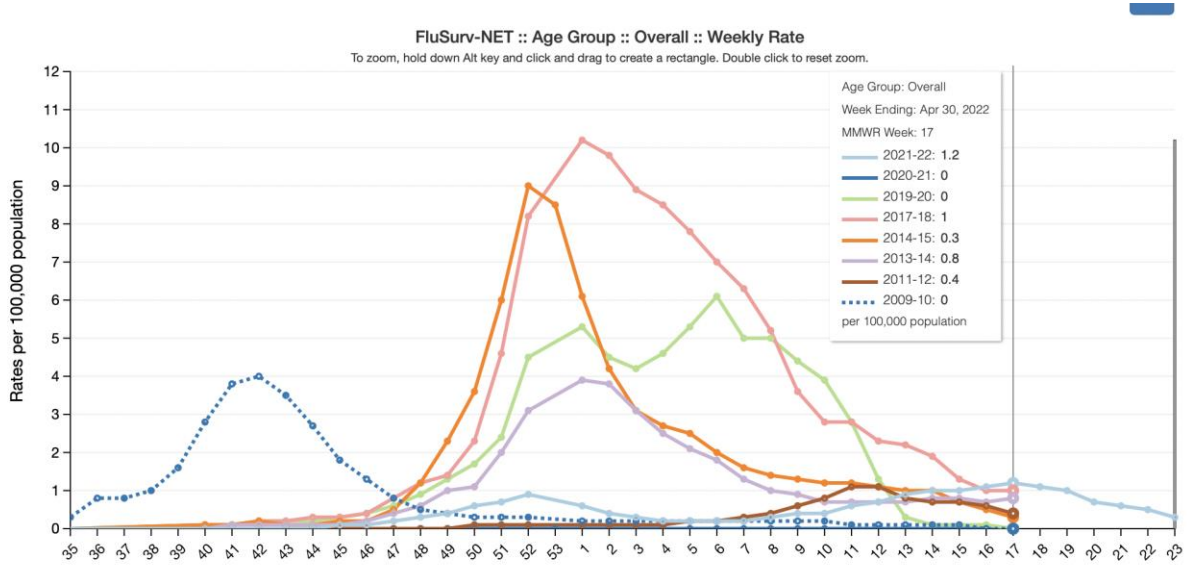
Final forecasts of season, June 20th



CDC FluSight

Ensemble Forecasts

Unusual flu season: Highest level at end of April, low levels throughout "main season"



CDC FluSurv-NET

Hospital surveillance Network

Key Takeaways

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

- **Case rates are flattening after slow declines, hospitalizations remain flat**
- VA weekly case rate slightly up to 215/100K from 203/100K
  - US also up to 233/100K from 196/100K
  - VA hospital occupancy (rolling 7 day mean of 534) is relatively flat, though shows signs of rebounding with a couple days of increase
- Projections anticipate a mix of trajectories across the districts, while remain in slow decline at state level, with near term with potential for growth due to BA4/5:
  - VA case rates may be flattening and with variant prevalence increasing BA.5 and BA.4 may drive growth
- Model updates:
  - BA.5 and BA.4 pick up the pace of growth while BA.2.12.1 has started to shrink, BA4/5 scenario seems likely to drive future dynamics
  - New data source for case ascertainment may explain more uncertainty and allow better model fits for future rounds

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

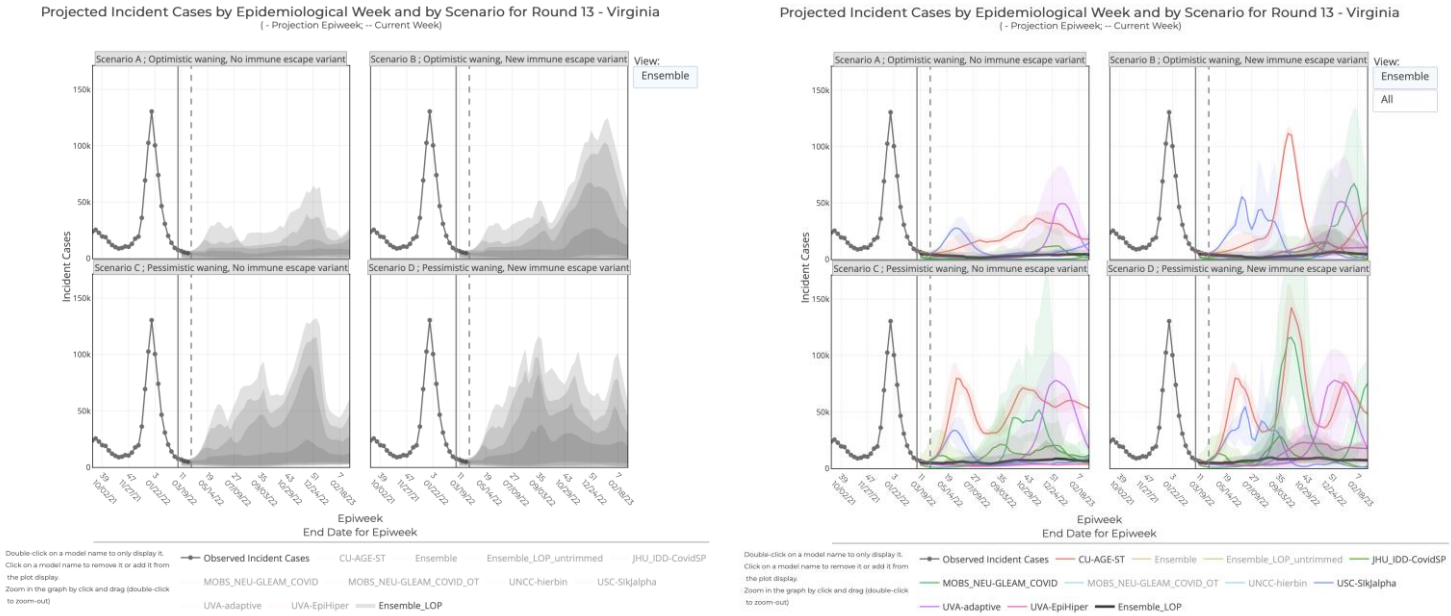
COVID-19 Scenario Modeling Hub – Round 13

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

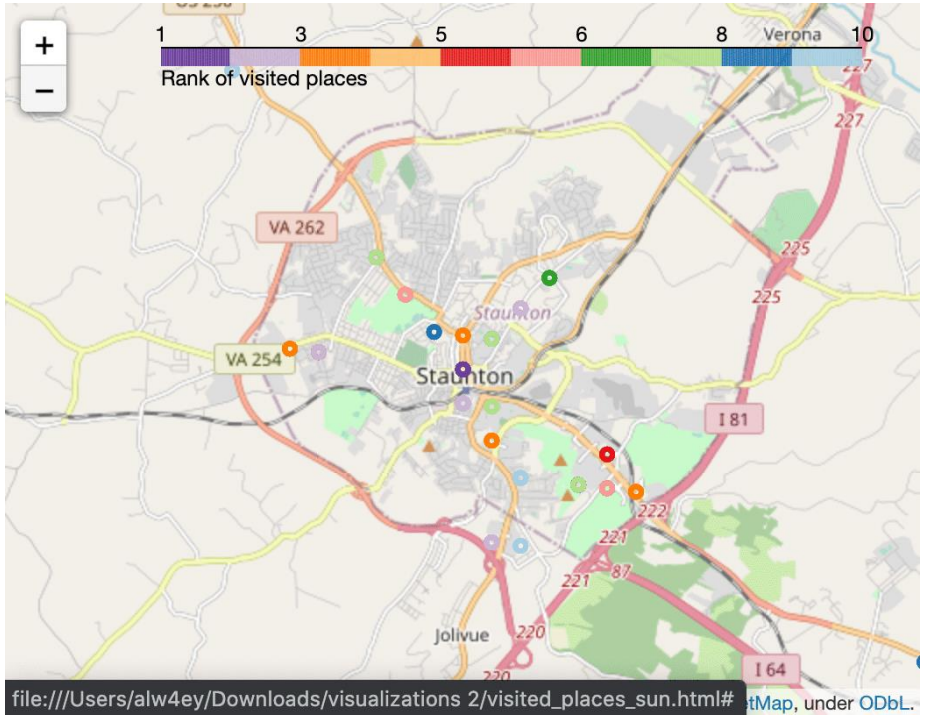
SafeGraph provides fine-grained mobility measures

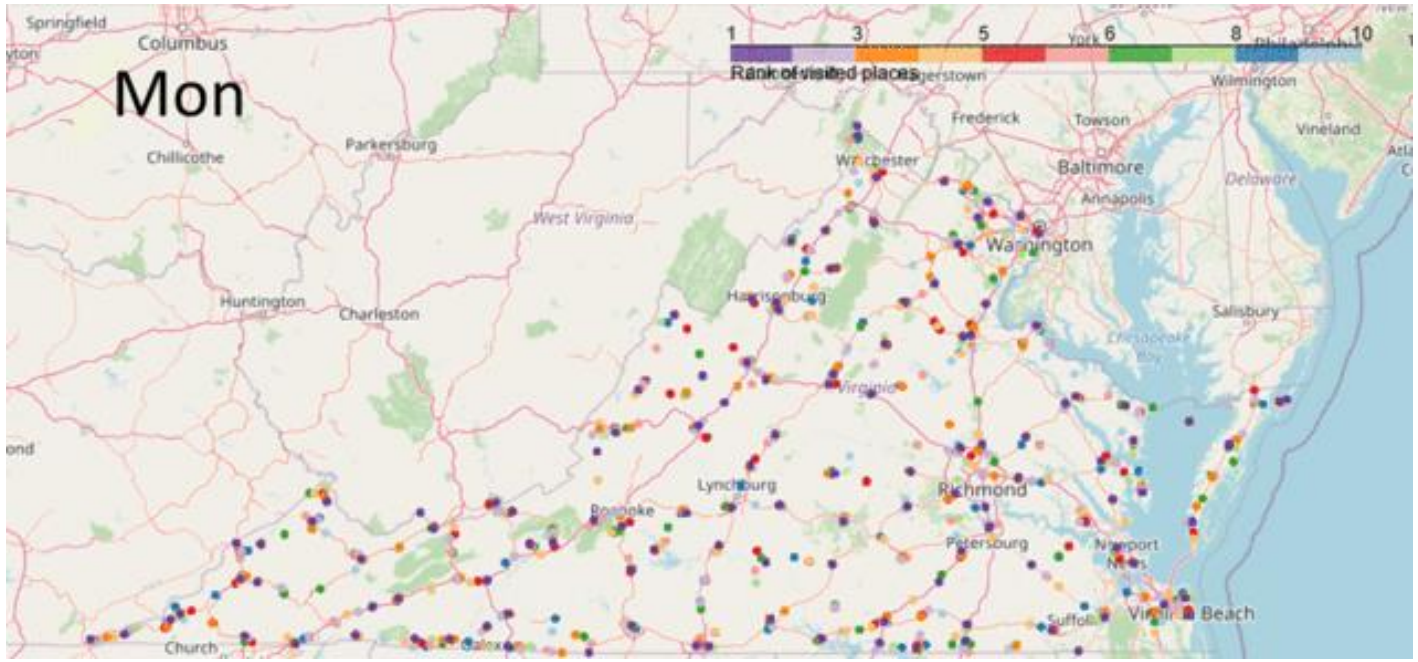
- SafeGraph: anonymized geolocation data aggregated from numerous cell phone apps
- One of the most fine-grained and high-coverage mobility data sources available: 6.4 million POIs in the US; 158,869 POIs in VA
- Has been utilized by hundreds of researchers, governments, and the CDC to aid COVID-19 efforts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

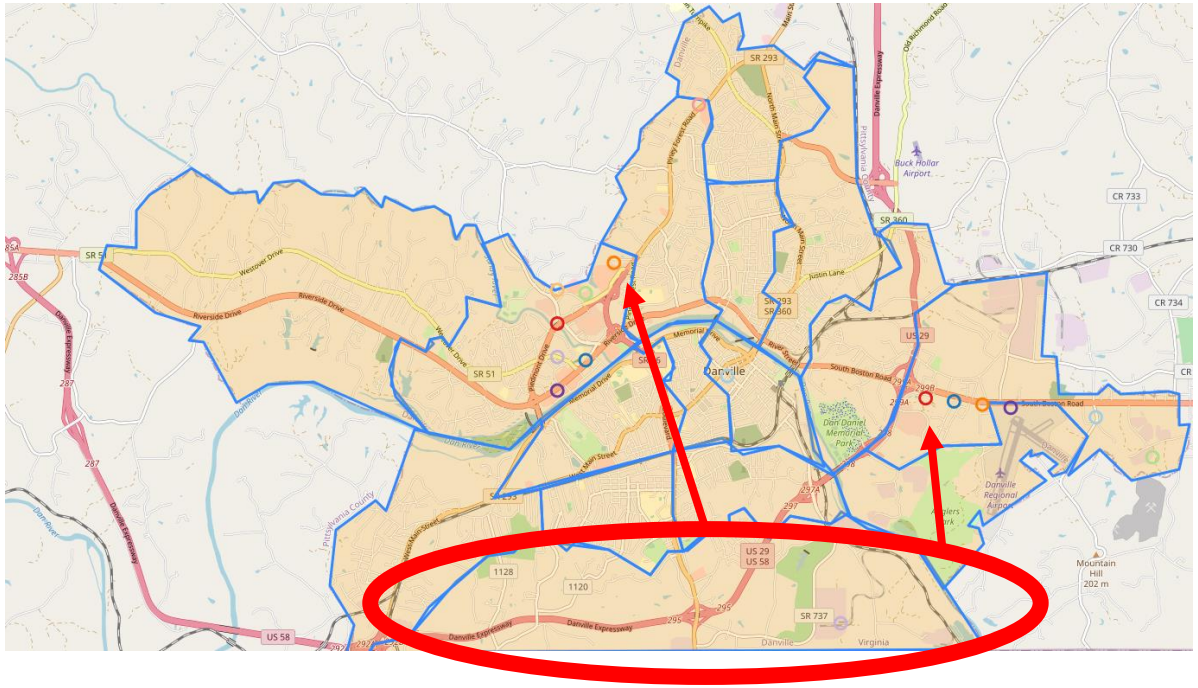




Busiest locations vary by day of week (and time of day)

Find locations visited by Population to Serve

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

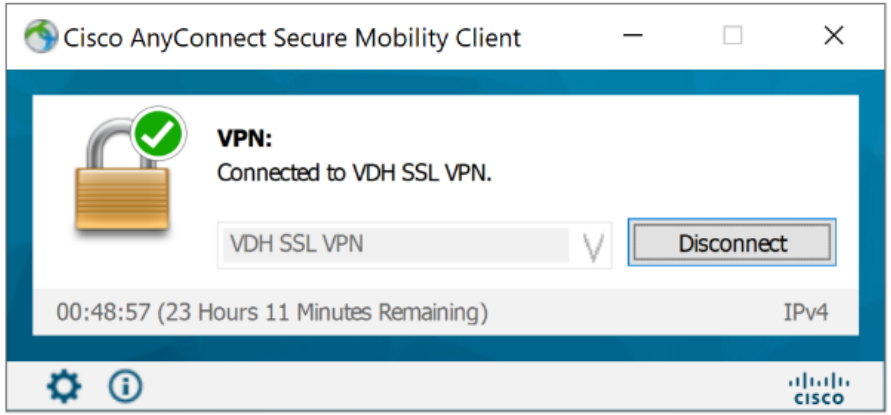
Mobility Data Updated Weekly

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

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

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

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

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

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

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

Questions?

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Biocomplexity COVID-19 Response Team

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