Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

May 12th, 2021

(data current to May 8th – May 11th)

Biocomplexity Institute Technical report: TR 2021-055

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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

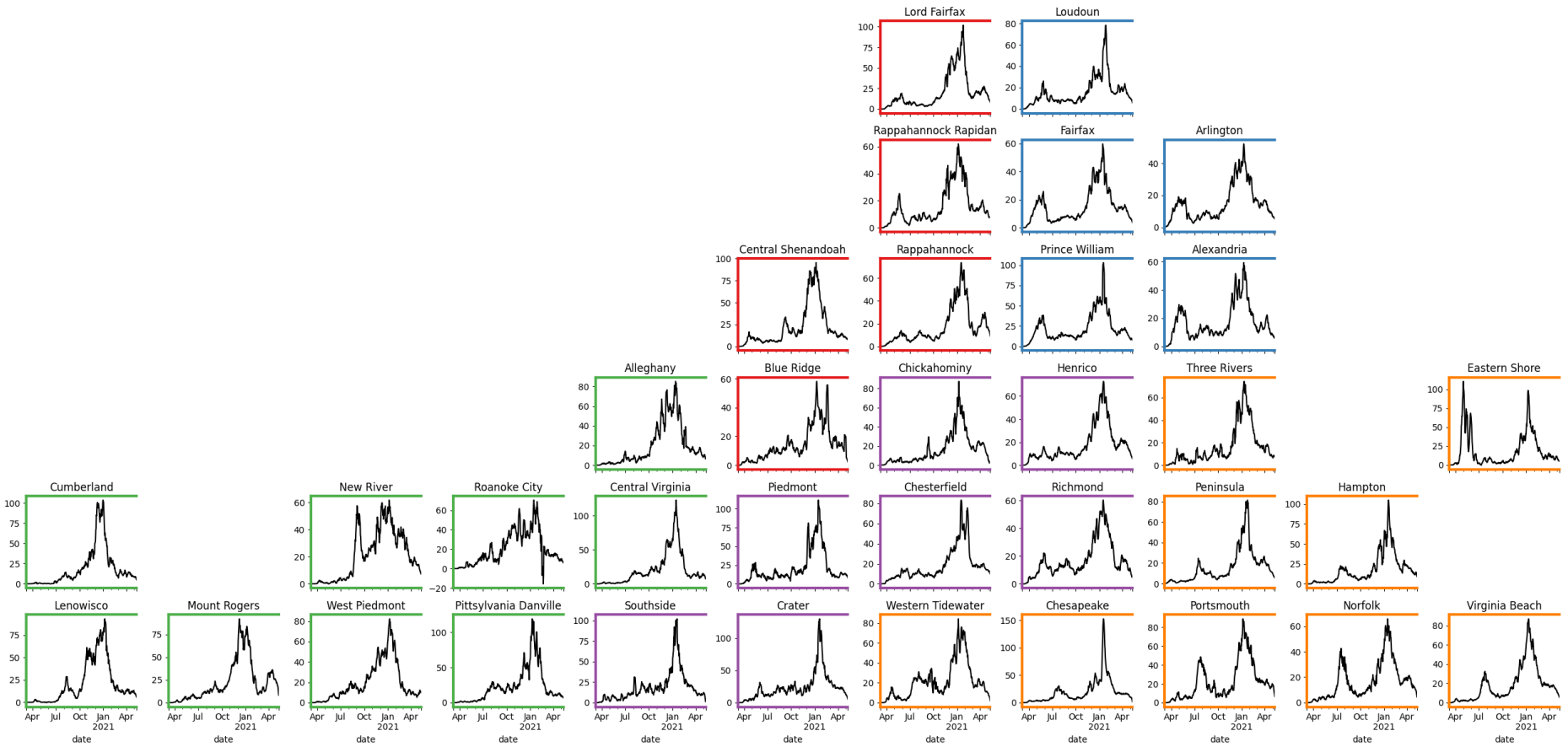
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

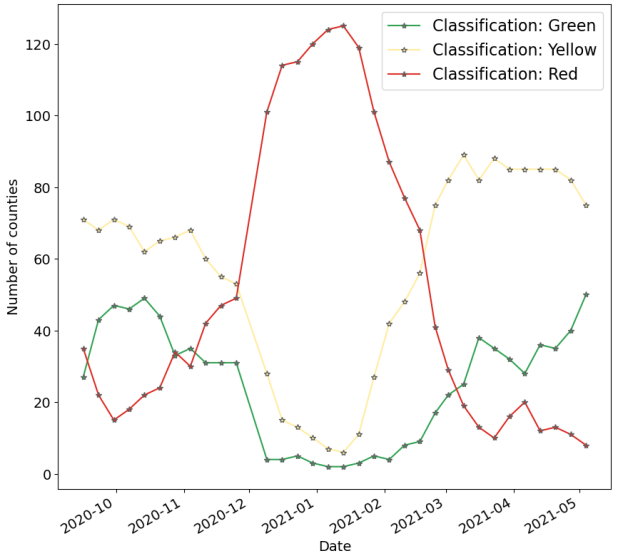
- **Case rates in Virginia continue to decline with pace accelerating in some districts**
- VA mean weekly incidence down to 8/100K from 11/100K, US down (12 from 15 per 100K)
- Vaccination rates have slowed considerably, but overall population immunity remains over 50%
- Projections show declining rate overall across Commonwealth,
- Recent updates:
  - Significant update to current measured acceptance levels to lower levels, validated with additional national survey
  - Added vaccination scenarios to compare status quo acceptance levels against expanded optimistic levels
  - Added a Fall surge resiliency study to test vaccination levels vs. increased activity in the Fall

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

Situation Assessment

Case Rates (per 100k) and Test Positivity





https://data.cms.gov/stories/s/q5r5-gjyu

County level test positivity from RT-PCR tests.

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

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

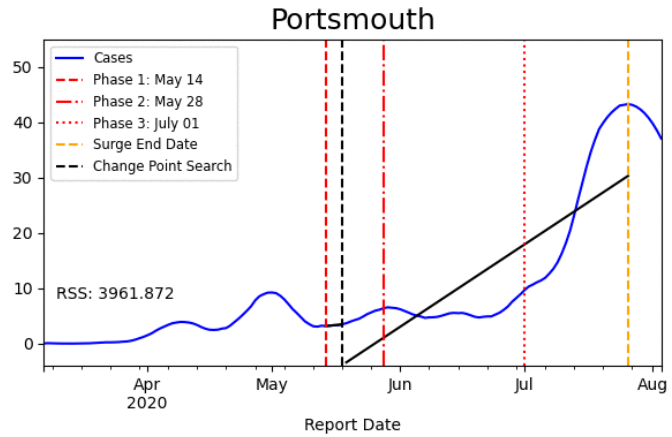
Red: >10.0%
(and not "Green" or "Yellow")

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

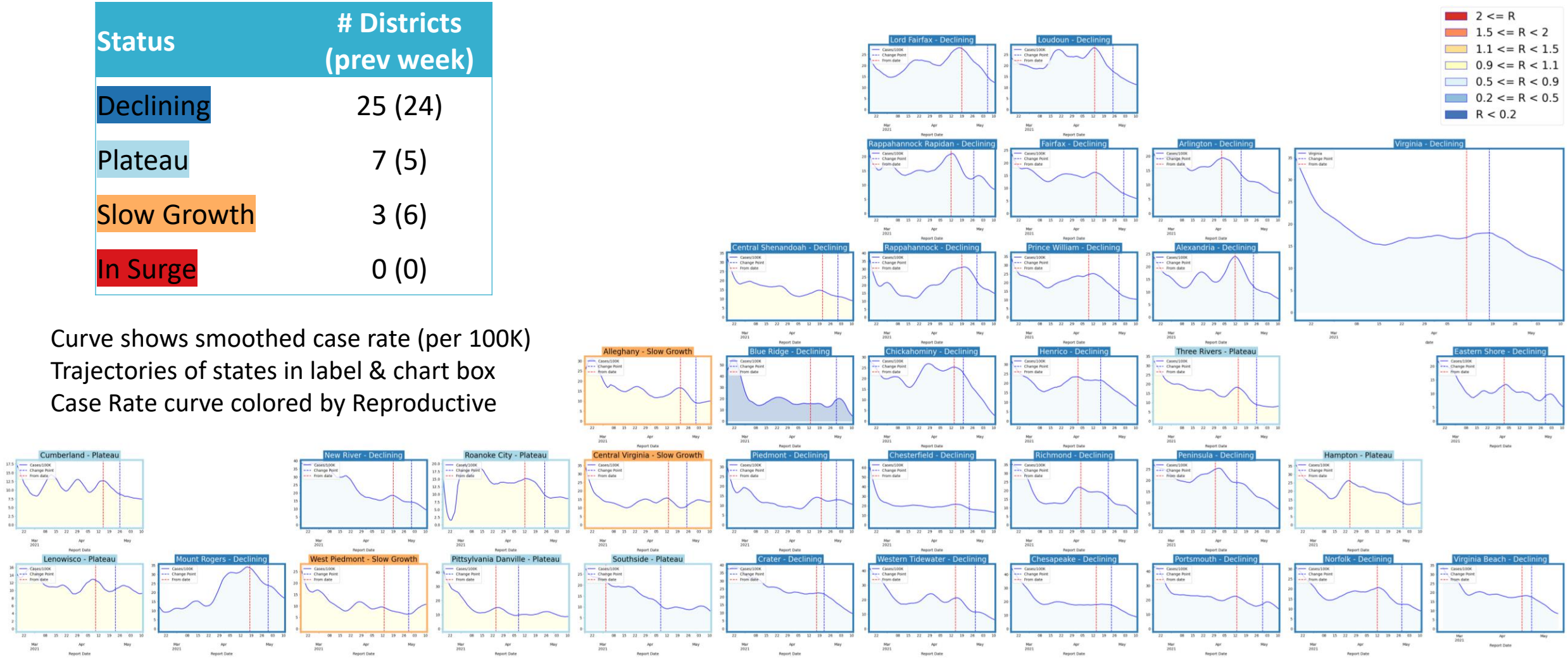


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	25 (24)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	7 (5)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	3 (6)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	0 (0)

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	25 (24)
Plateau	7 (5)
Slow Growth	3 (6)
In Surge	0 (0)

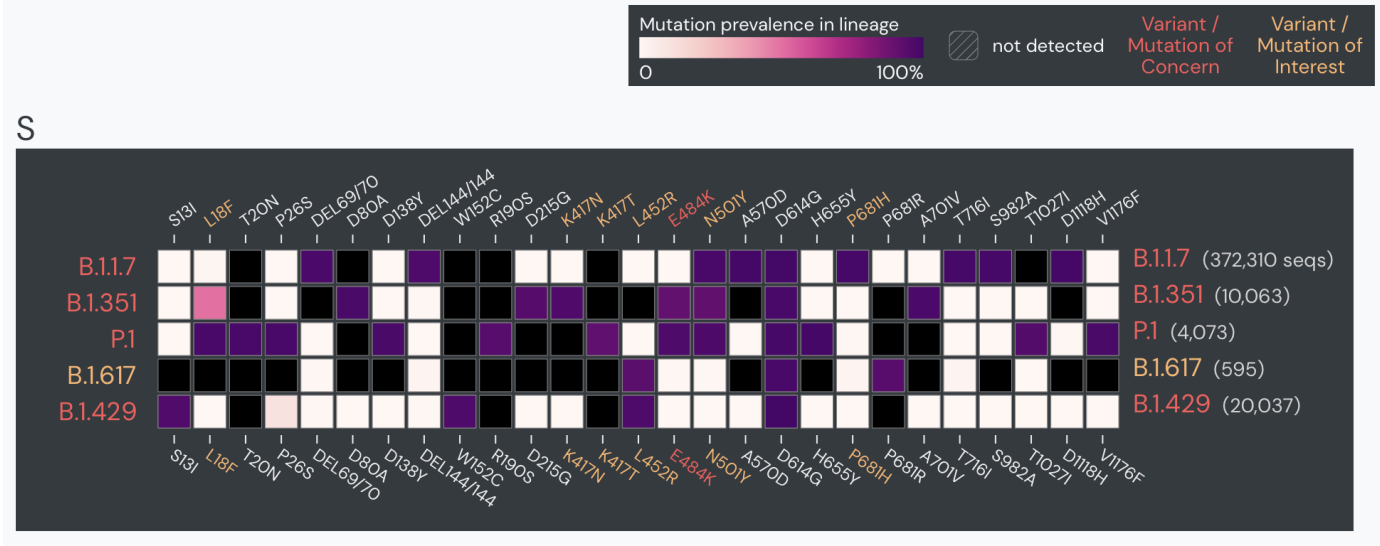
Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive

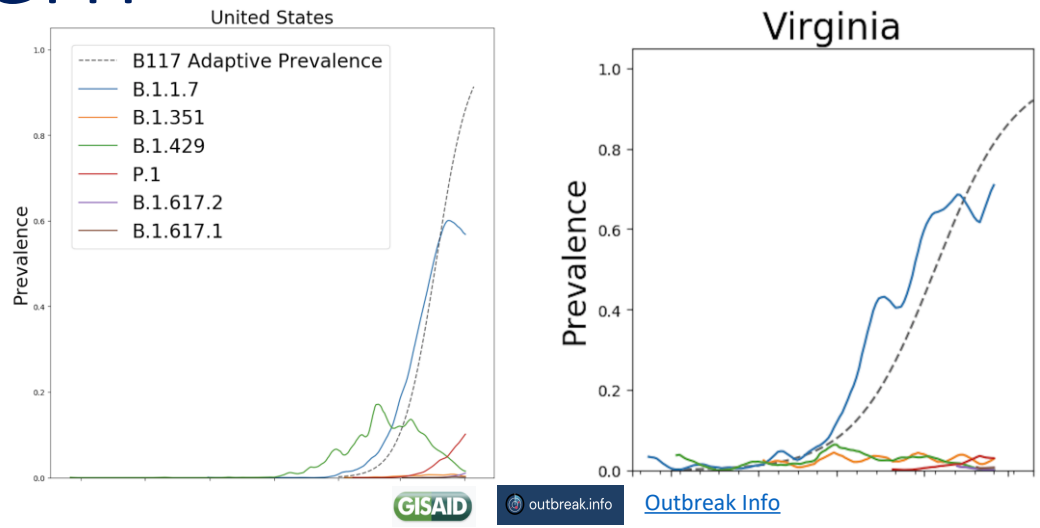


SARS-CoV2 Variants of Concern

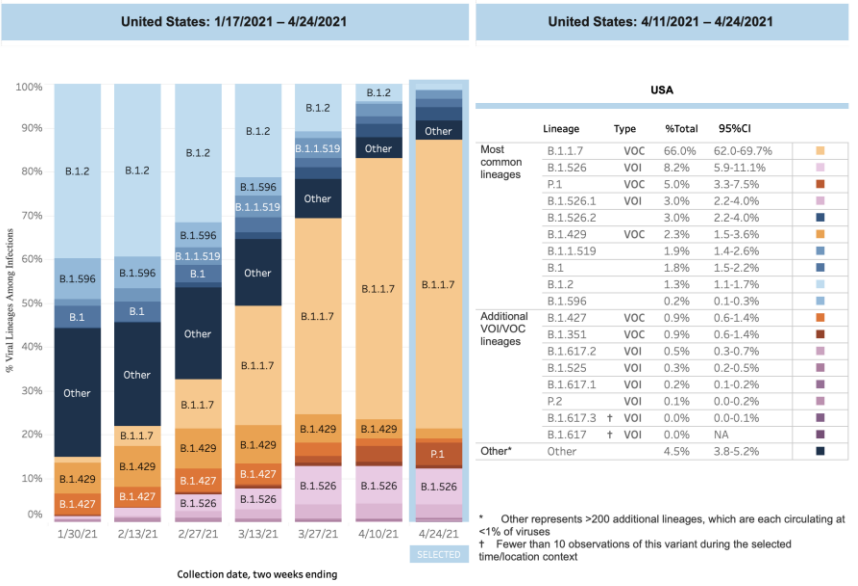
Emerging new variants will alter the future trajectories of pandemic and have implications for future control

- 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





Outbreak Info

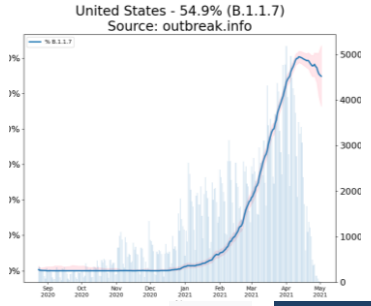


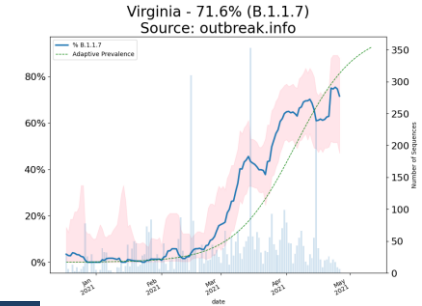
CDC Variant Tracking

outbreak.info Outbreak Info

SARS-CoV2 Variants of Concern

Lineage B.1.1.7





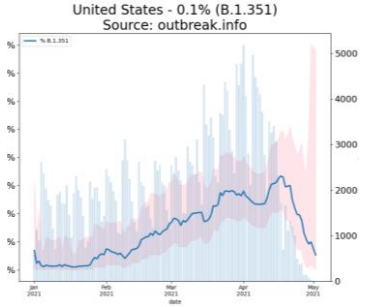
GISAID outbreak.info [Outbreak Info](#)

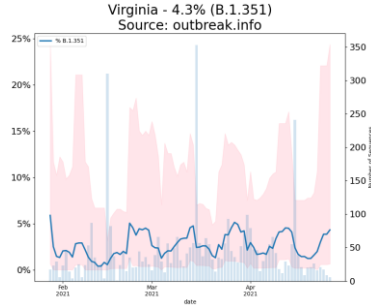
Prevalence: Levels have rapidly risen, as anticipated, and now are plateauing at national level, many states, and seemingly in VA as well.

Transmissibility: Estimated increase of 50% compared to previous variants. B.1.1.7's mutations aids its infection efficiency, and thus boosts its overall levels of viremia; study from Public Health England shows contacts of B.1.1.7 cases are more likely (50%) to test positive than contacts of non-B.1.1.7 patients

Severity: Increased viremia also appears to increase the risk of hospitalization (60%) and mortality (60%). Danish study shows B.1.1.7 to have a 64% higher risk of hospitalization, while Public Health Scotland studies showed a range of 40% to 60%; Study in Nature based on UK data estimates B.1.1.7 cases have 60% higher mortality

Lineage B.1.351





Prevalence: Levels have remained low, as this variant's transmissibility can't compete with B.1.1.7, however, as more of the population becomes immune it may gain an advantage

Immune Escape: Many studies show that convalescent sera from previously infected individuals does not neutralize B.1.351 virus well which is predictive of protection, however, vaccine induced immunity shows signs of effectiveness

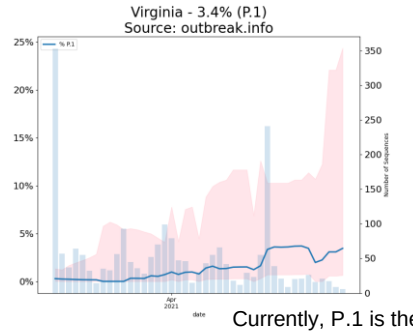
Lineage B.1.429/427 and B.1.526 and subvariants

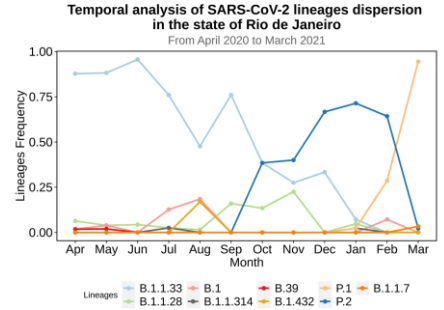
- Combined account for around 20% of circulating virus, share may be shrinking as B.1.1.7 outcompetes

SARS-CoV2 Variants of Concern

Lineage P.1

- **Prevalence:** Nationally at 13.2% (up from 9.9%), though a bit lower in VA (3.4% up from 2.8%)
- Data from Brazil shows that P1 has maintained dominance in Rio despite B.1.1.7 being identified Jan 1st, and has remained at low levels

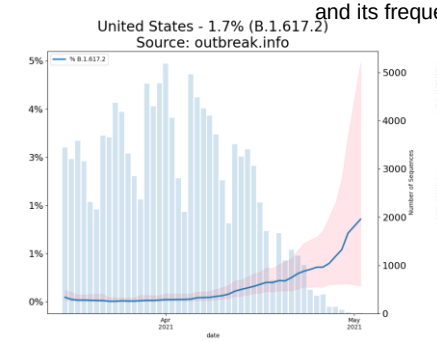


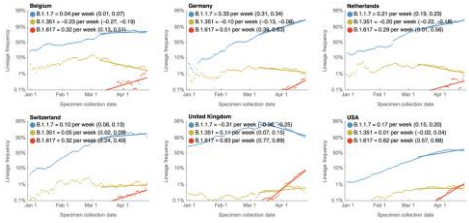


Currently, P.1 is the dominant lineage widespread across all regions in the State. B.1.1.7 lineage was first identified on January, 1st, 2021 and its frequency has remained low (total n=8) virological.org

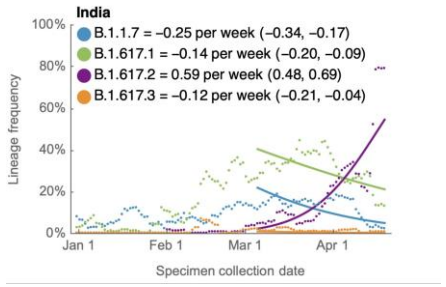
Lineage B.1.617 and subvariants B.1.671.2 & B.1.617.1

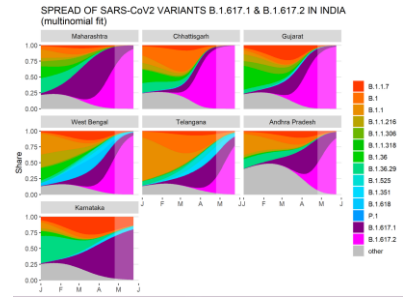
- Categorized as VoC by Public Health England, WHO, expect CDC to follow
- Continues to drive outbreak in India and neighbors, with immeasurable numbers of cases surpassing healthcare capacities in many regions
- Strain shows rapid growth in UK, Europe and lesser extent so far in US
- Some studies estimate B.1.617.2 to have 60% transmission advantage over B.1.1.7 with immune escape similar to B.1.351, however, even with some level of immune escape, protection remained for most sera tested



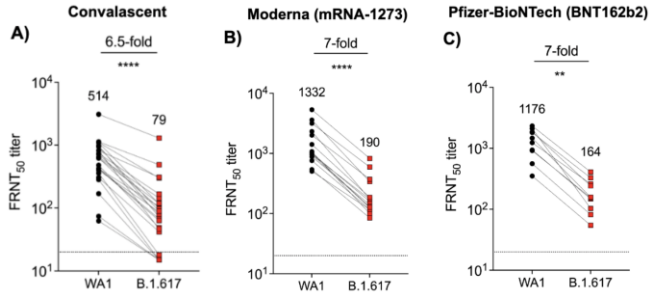


Initial growth seen in many countries across Europe **Twitter**





Rapid dominance in India [Twiter], specifically, B.1.617.2 also seen across most large states within Indiaa **Twitter**

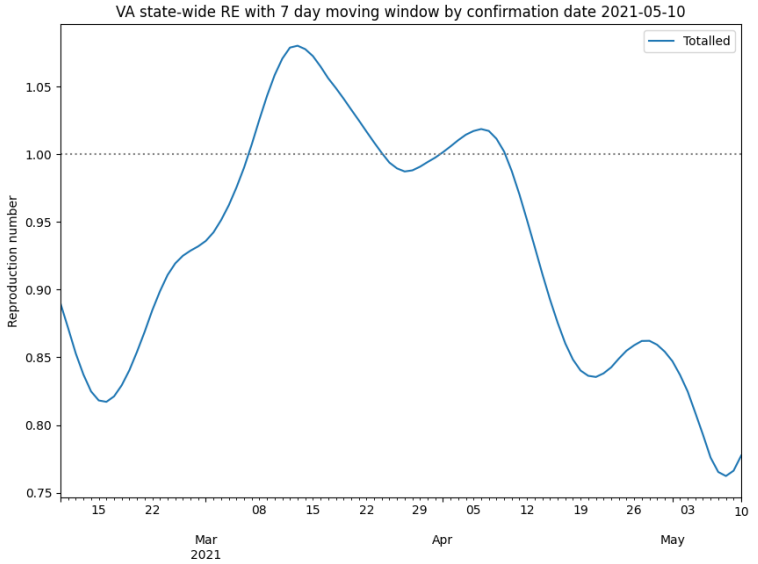


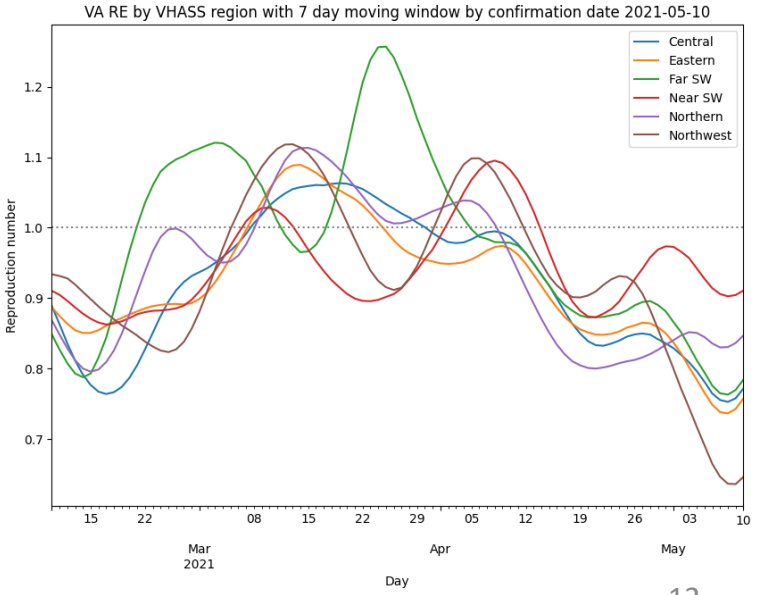
Found that the B.1.617.1 variant is 6.8-fold more resistant to neutralization by sera from COVID-19 convalescent and Moderna and Pfizer vaccinated individuals. Despite this, a majority of the sera from convalescent individuals and all sera from vaccinated individuals were still able to neutralize the B.1.617.1 variant. BioRxiv

Estimating Daily Reproductive Number

May 10th Estimates

Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.777	-0.095
Central	0.772	-0.131
Eastern	0.758	-0.133
Far SW	0.785	-0.094
Near SW	0.911	-0.031
Northern	0.847	0.076
Northwest	0.647	-0.311





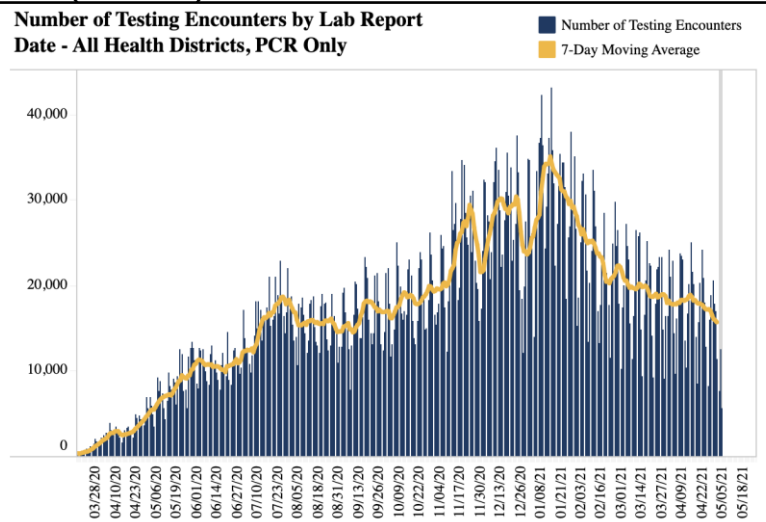
Methodology

- 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

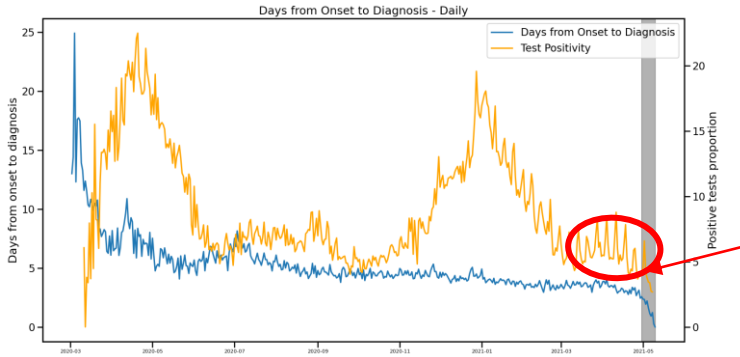
Changes in Case Detection

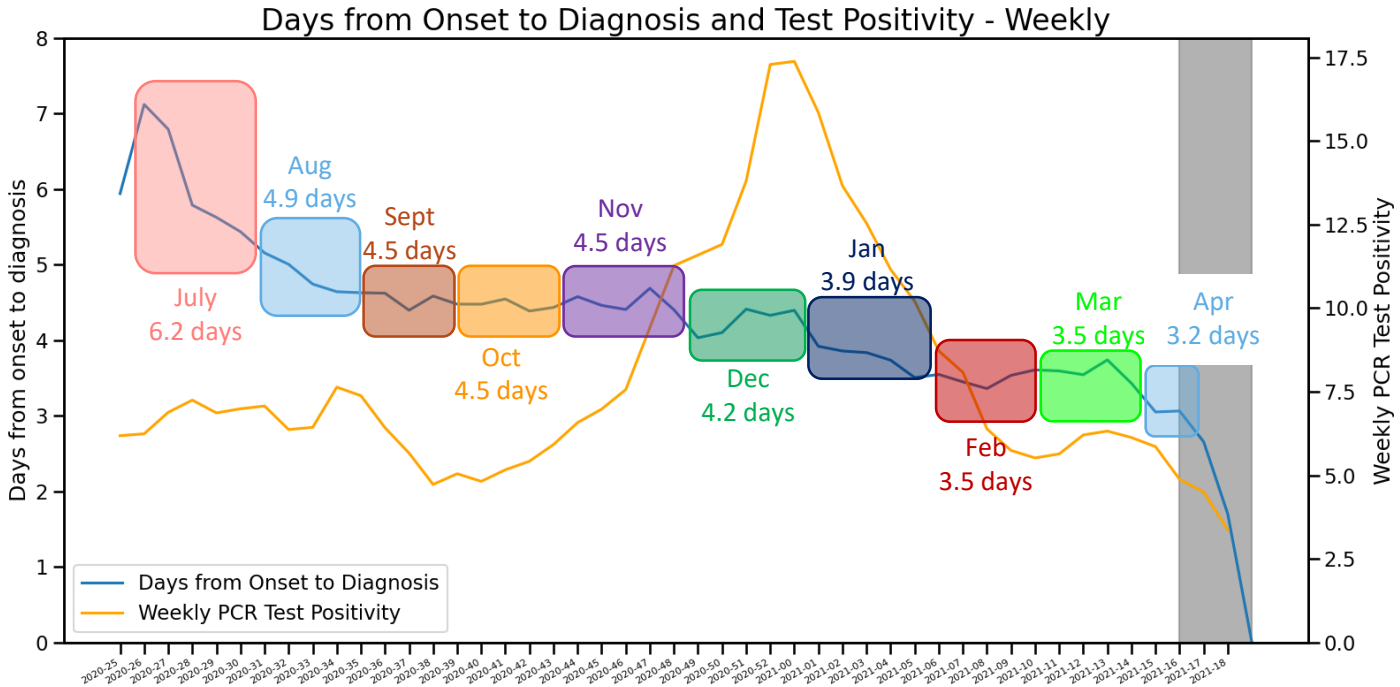
Timeframe (weeks)	Mean days	% difference from overall mean
July (26-30)	6.2	-3%
Aug (31-34)	4.9	-23%
Sept (35-38)	4.6	-28%
Oct (39-43)	4.5	-30%
Nov (44-47)	4.5	-29%
Dec (48-49)	4.3	-33%
Jan (00-04)	4.0	-38%
Feb (05-08)	3.5	-46%
Mar (09-13)	3.6	-43%
Apr (14-16)	3.2	-50%
Overall (13 - 16)	6.4	--



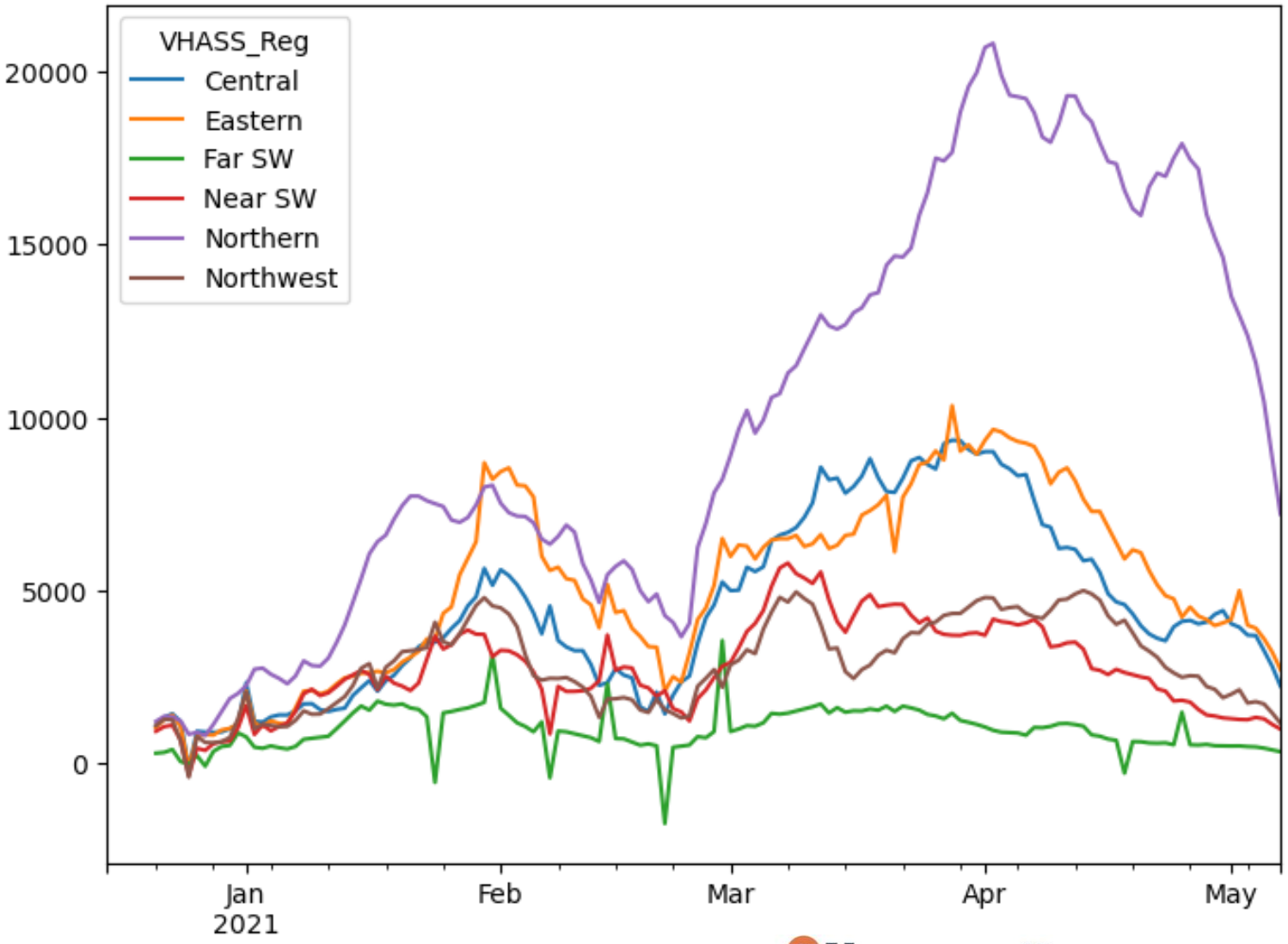
Accessed 9:30am May 12, 2021
https://www.vdh.virginia.gov/coronavirus/

Test positivity vs. Onset to Diagnosis



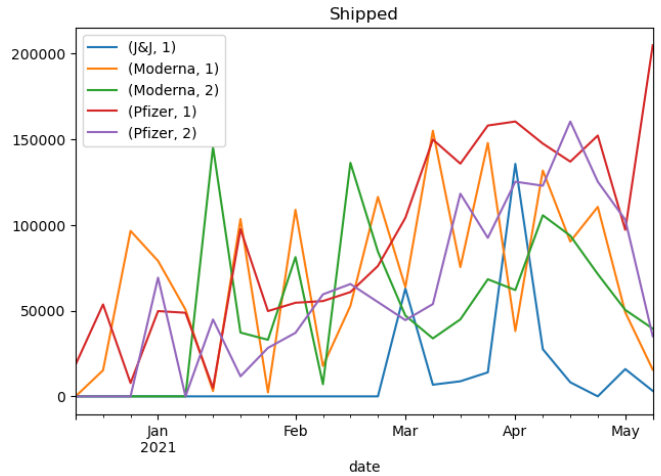


Vaccination Administration Slows



Regional Vaccine courses initiated per day:

- Total counts of first dose of vaccines across regions
- Significant declines starting at the end of April



Shipments remain relatively high across the state

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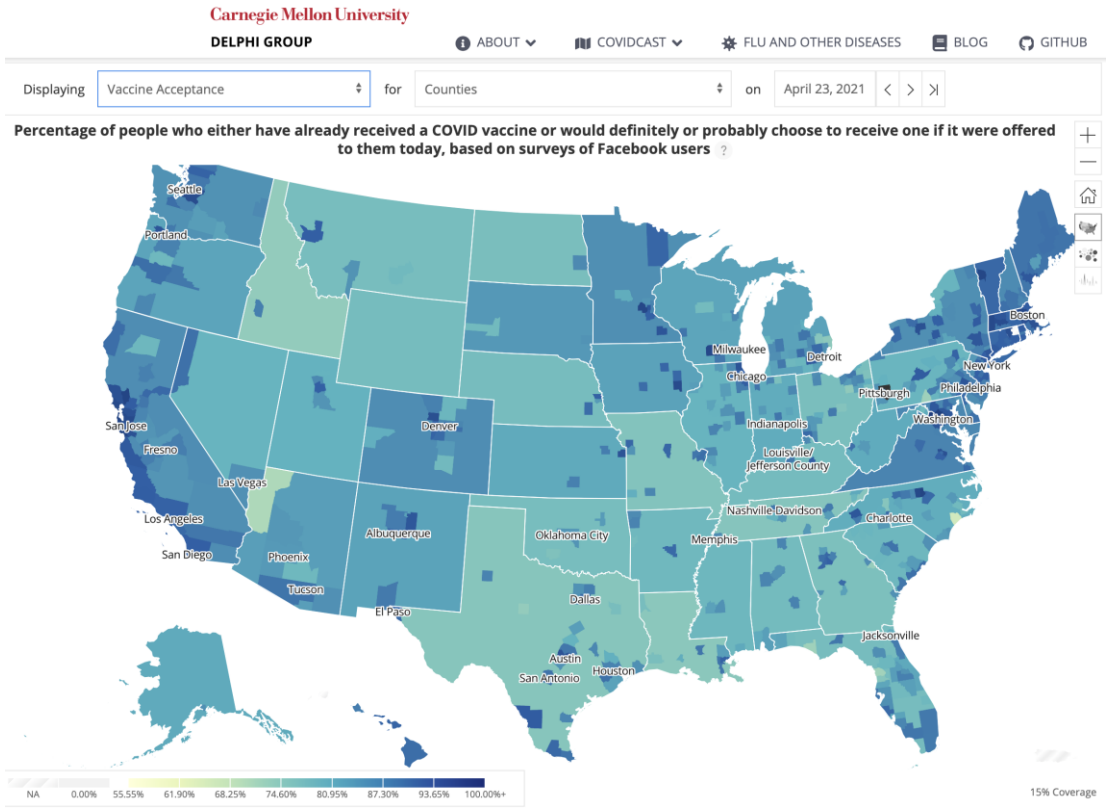
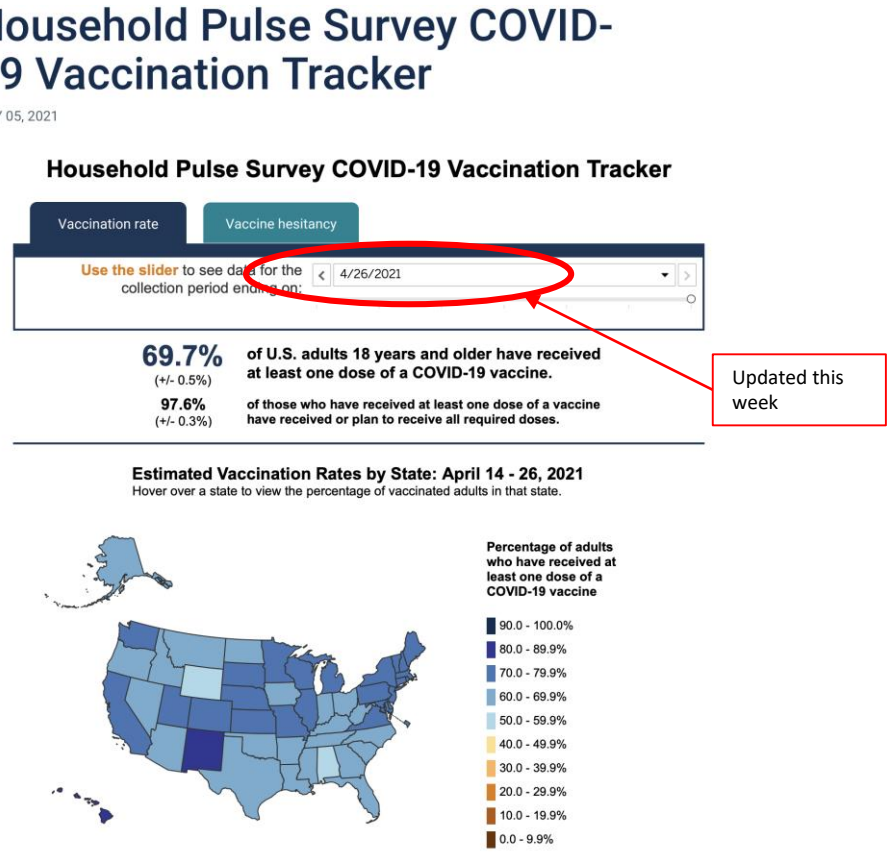
Vaccine Acceptance Data Sources





COVIDcast / Facebook Survey

https://covidcast.cmu.edu

Census Household Pulse Surveys (HPS)

https://www.census.gov/library/visualizations/interactive/household-pulse-survey-covid-19-vaccination-tracker.html

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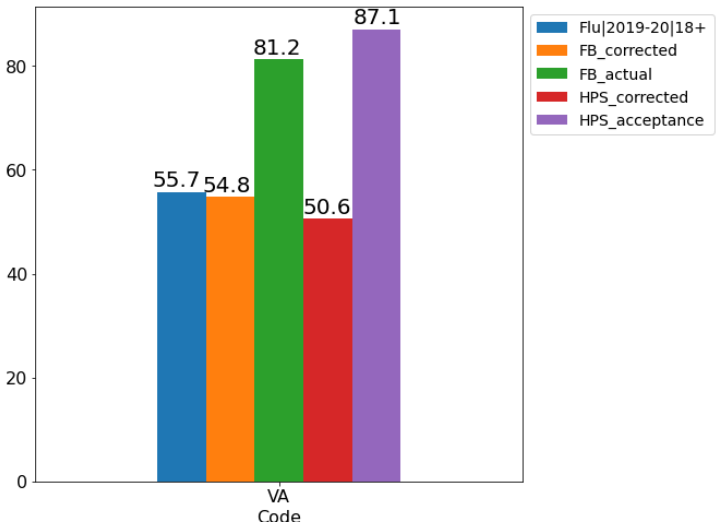
Vaccination Acceptance – Comparison of Sources

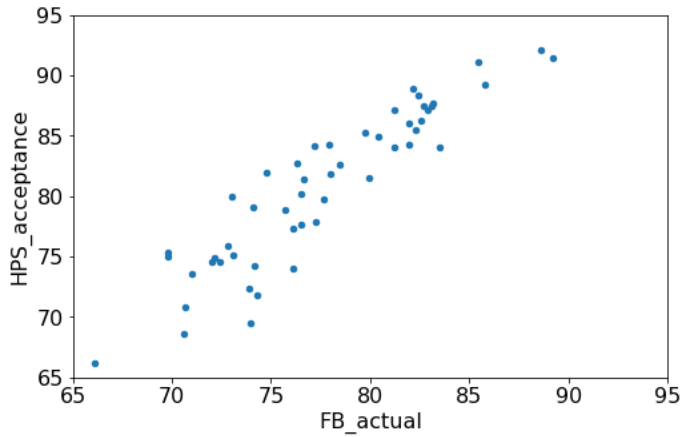
Measured acceptance varies across sources:

- **COVIDcast / Facebook (FB):** Both corrected and actual measurement
- **FluVax:** Acceptance levels in VA for influenza vaccine during 2019-20 flu season
- **Household Pulse (HPS):** Census administered survey, but with some time delay till release (most recent for fortnight ending April 29th, 2021)
- HPS has highest overall, while FluVax is expectedly the lowest
- Corrected HPS and COVIDcast are very similar for VA at the state level

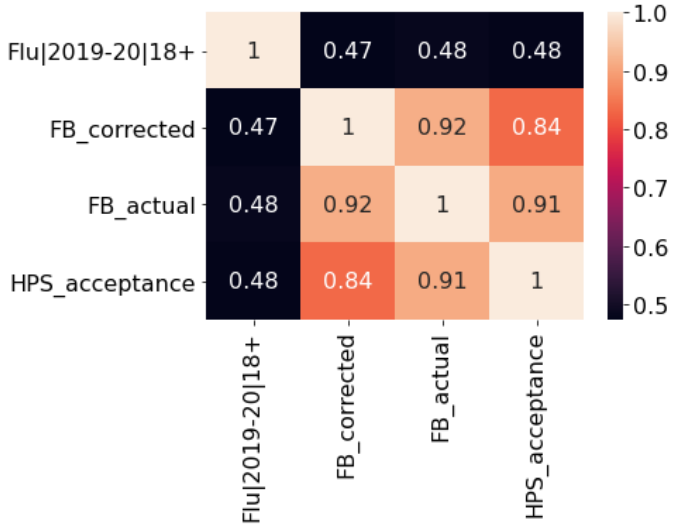
Virginia Vaccine Acceptance levels



State by State correlation COVIDcast and HPS



State level correlation between all four



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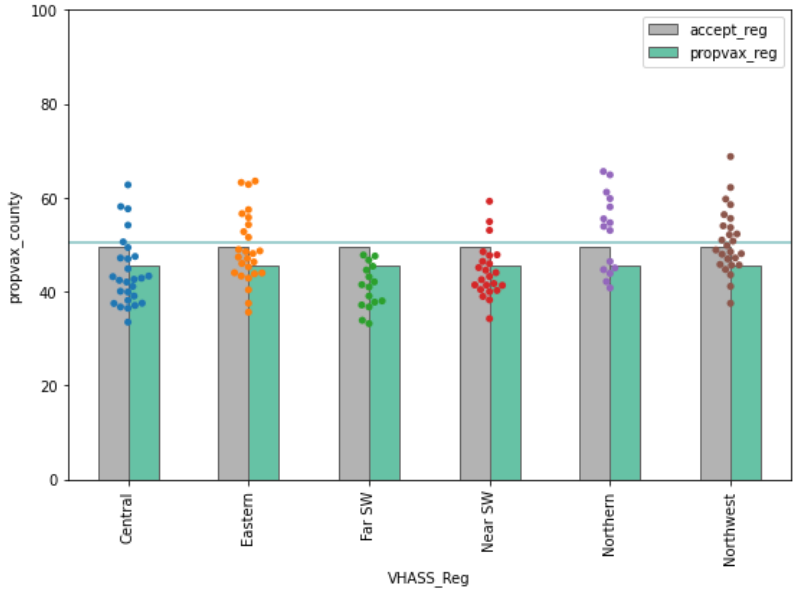
Vaccination Acceptance by Region

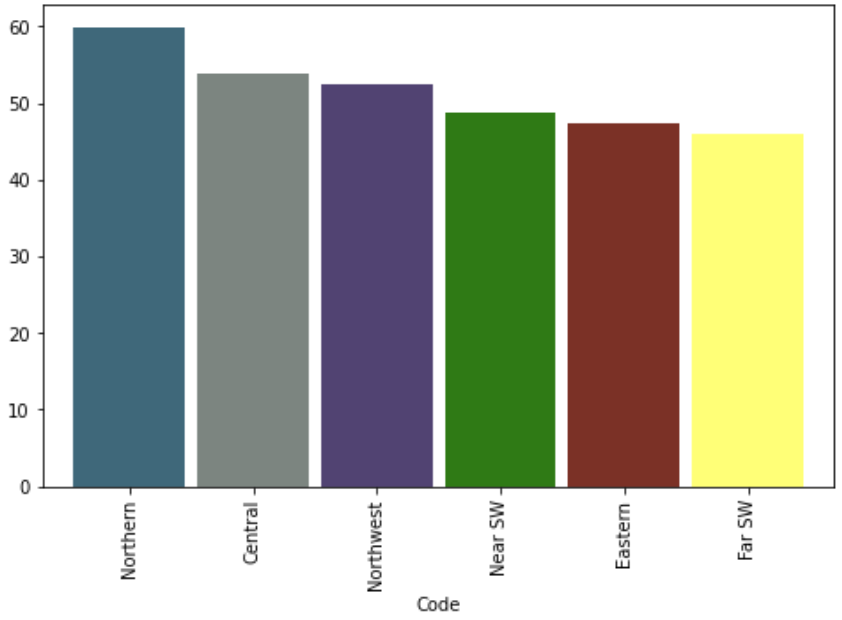
Corrections to COVIDcast survey:

- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at the state level

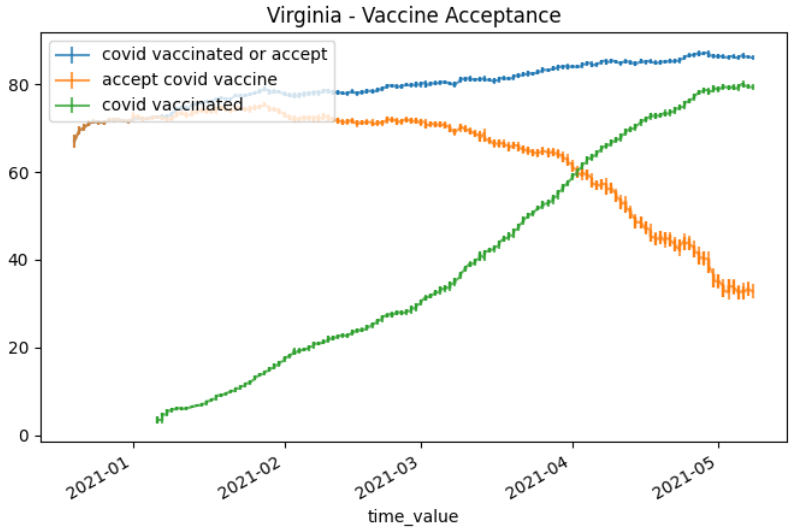
Region	COVIDcast corrected	COVIDcast uncorrected	VDH measured proportion vaccinated	COVIDcast reported vaccinated
Northern	59.9%	86.3%	56.5%	81.3%
Central	53.9%	76.9%	50.2%	71.5%
Northwest	52.6%	77.1%	51.1%	74.8%
Near SW	48.6%	75.6%	45.5%	70.7%
Eastern	47.4%	77.2%	45.5%	74.0%
Far SW	45.9%	69.8%	40.7%	62.4%

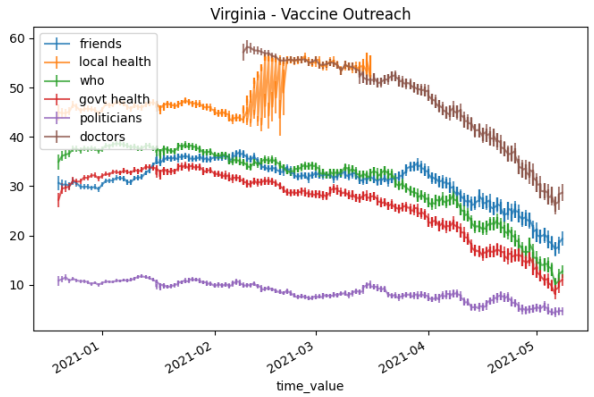


Bars: Survey measured and corrected acceptance by region & proportion of eligible population administered a vaccine
Dots: Proportion administered at least one dose for each county



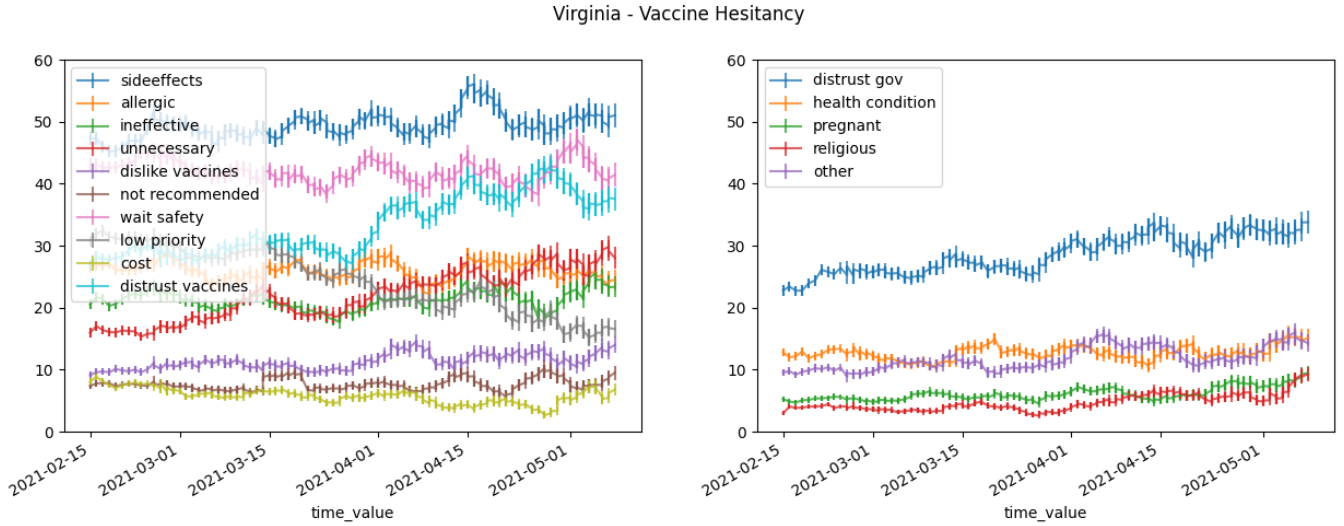
Vaccine Acceptance in Virginia - COVIDcast





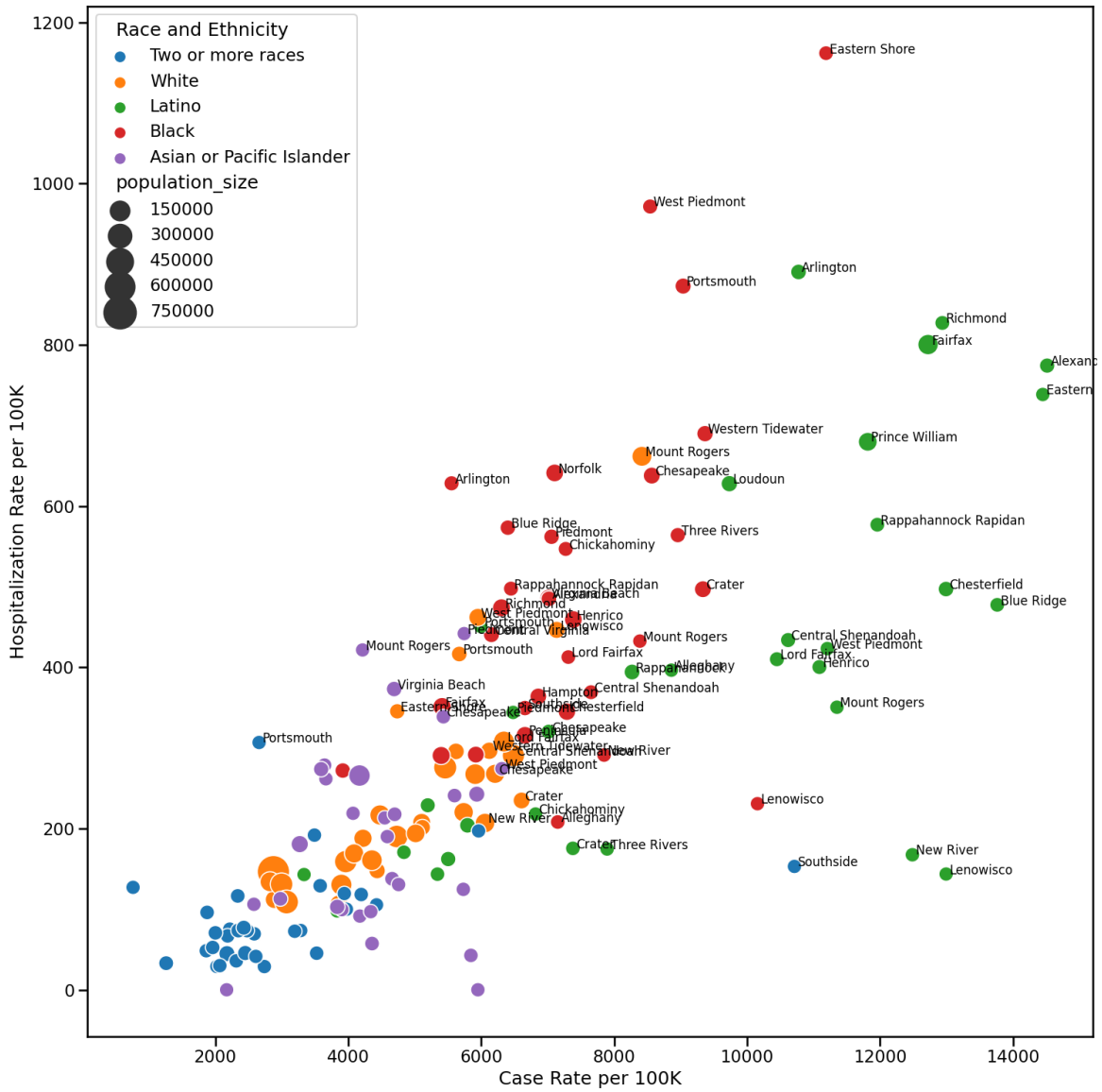
Acceptance remains high:

- Proportion of Virginians that have already or would definitely or probably accept vaccination if offered today
- *Survey respondents are reporting high levels of vaccination of ~70% reflecting some bias of the mechanism*
- Over 80% of Virginians have already or will choose to be vaccinated
- **Top reasons for hesitancy**: side effects, safety, distrust (increasing)
- **More likely to take if recommended by** doctors and friends



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

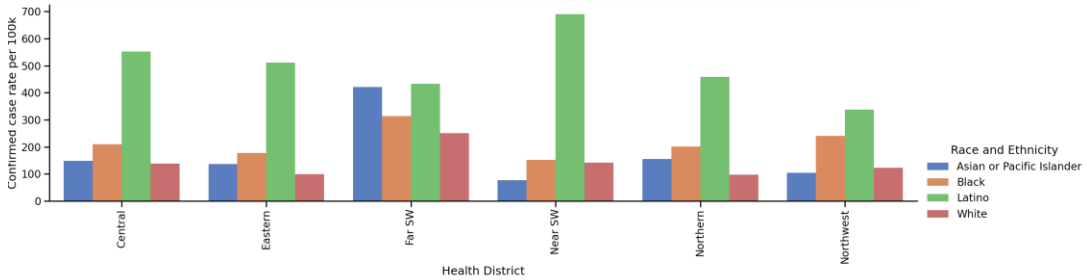
Race and Ethnicity cases per 100K



Rates per 100K of each Racial-Ethnic population by Health District

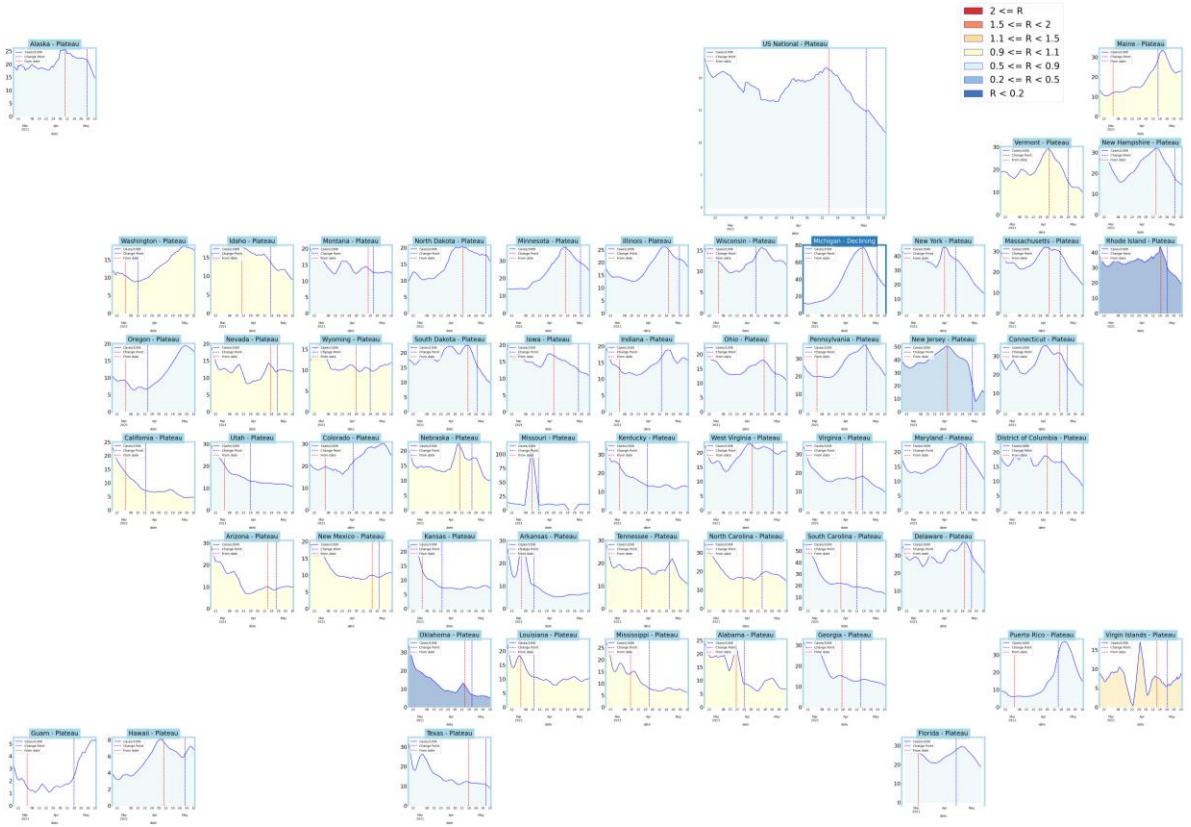
- Each Health District's Racial-Ethnic population is plotted by their Hospitalization and Case Rate
- Points are sized based on their overall population size (overlapping labels removed)
- Change in rates over the last 2 weeks

Case Rate Change in last 14 days



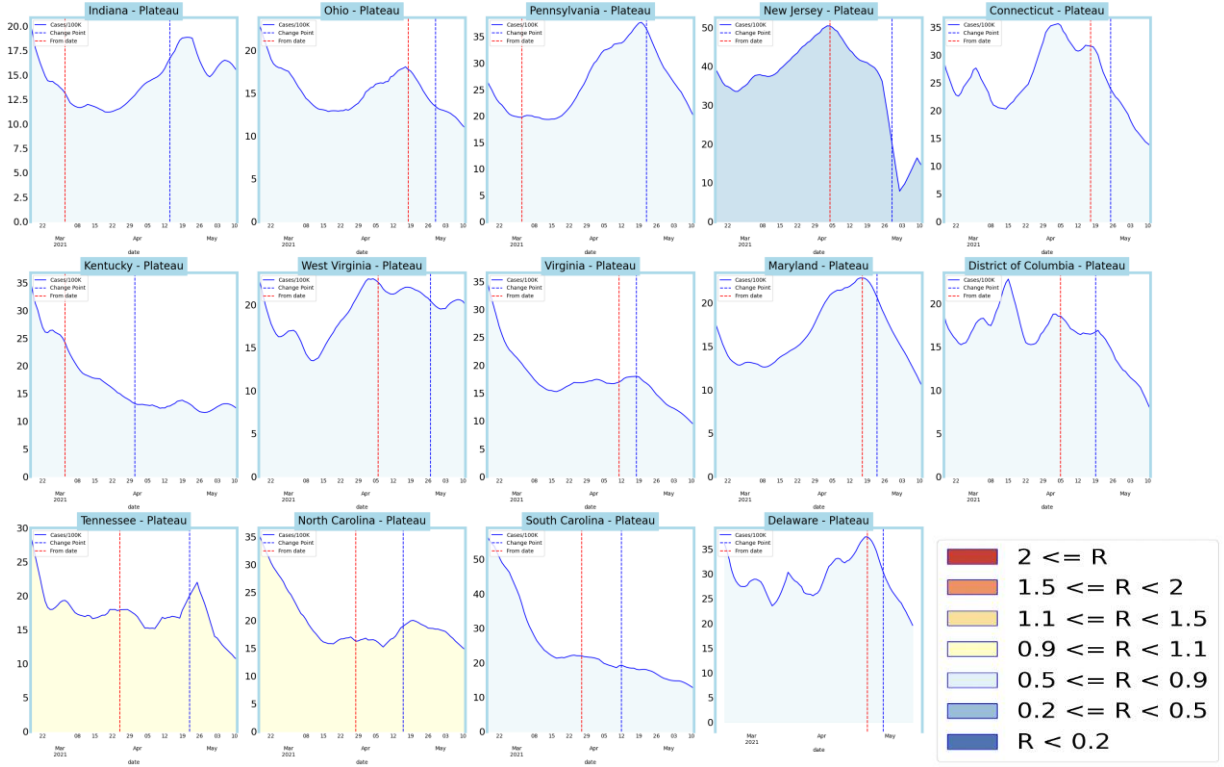
Other State Comparisons

Trajectories of States



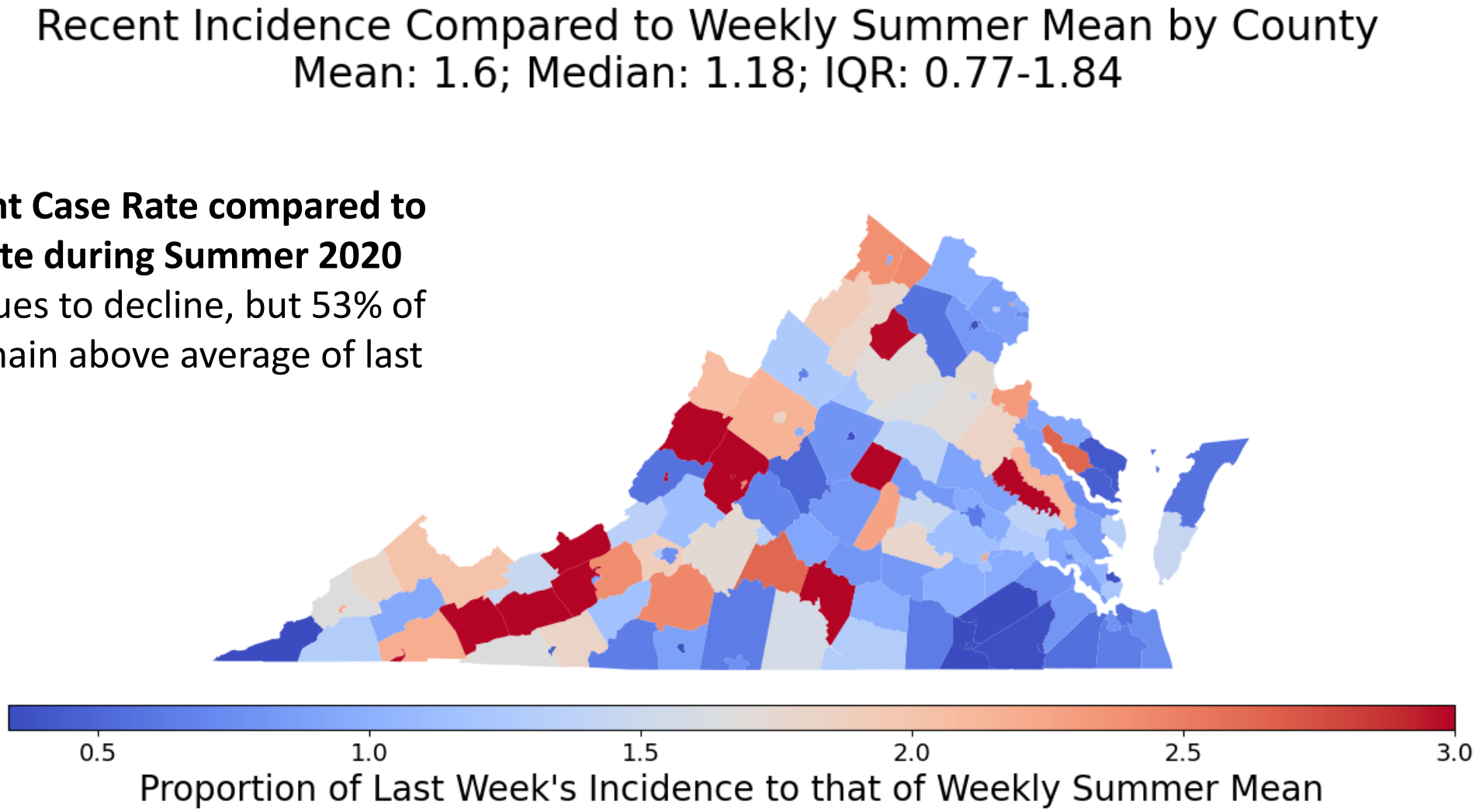
- Nearly all states are plateaued, several now in significant decline
- Some states in West are growing but may be leveling off

Virginia and her neighbors



- VA and neighbors remain in plateau, with declines increasing their pace
- Levels remain high but many are approaching 10/100K level

Recent Incidence Compared to Summer 2020

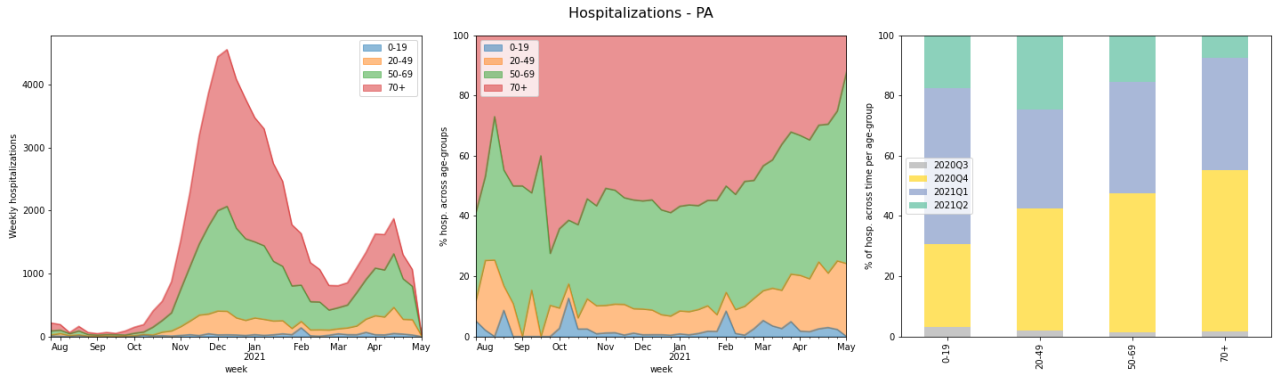


Ratio of Recent Case Rate compared to mean Case Rate during Summer 2020

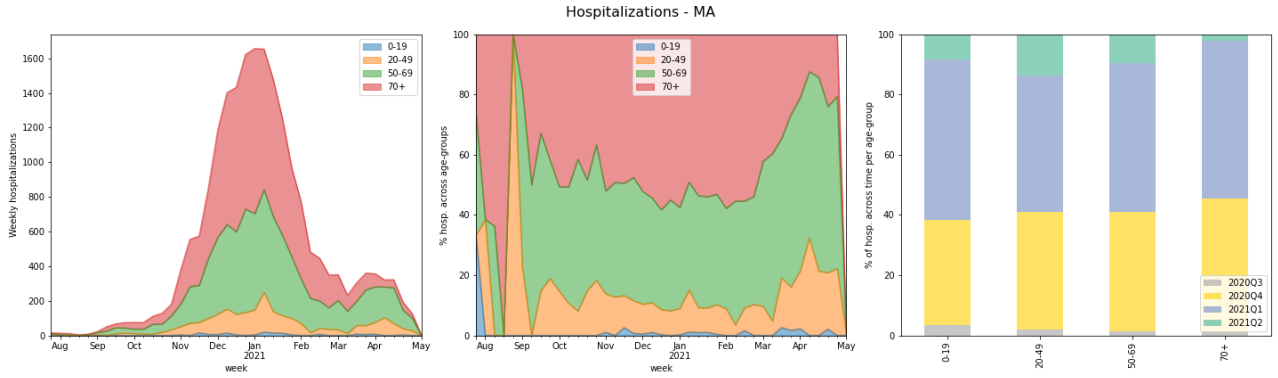
- Ratio continues to decline, but 53% of counties remain above average of last summer

Shifting Age-Distributions - Hospitalizations

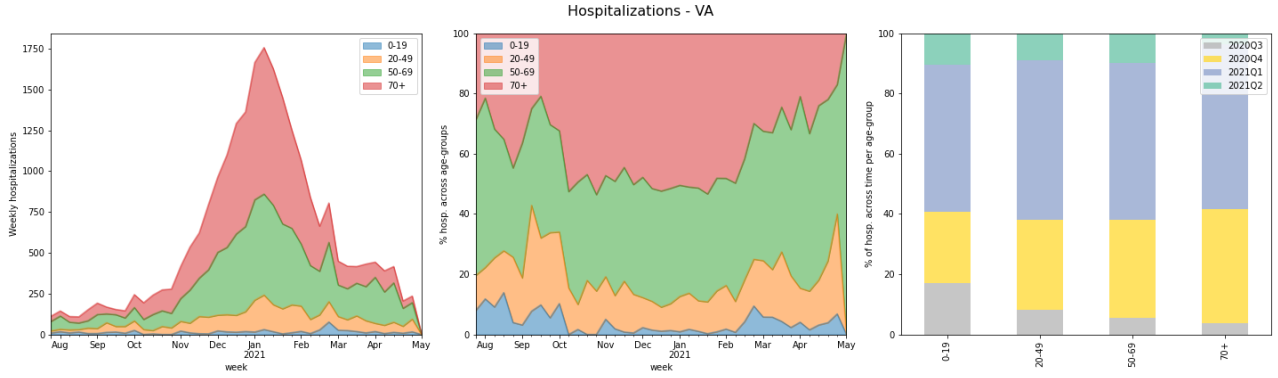
Pennsylvania



Massachusetts



Virginia



Shifting Age Distribution of cases being hospitalized

- Dual forces of vaccinations in older groups and severity of B.1.1.7 are shifting the age distribution of hospitalized patients
- Pennsylvania continues to make progress shrinking the share of 70+ hospitalized
- Massachusetts, with high levels of vaccinations, has almost eliminated hospitalizations, and the share of 70+ has stalled but at very low levels
- Virginia has made significant progress agains 70+ hospitalizations and driven its rates down significantly

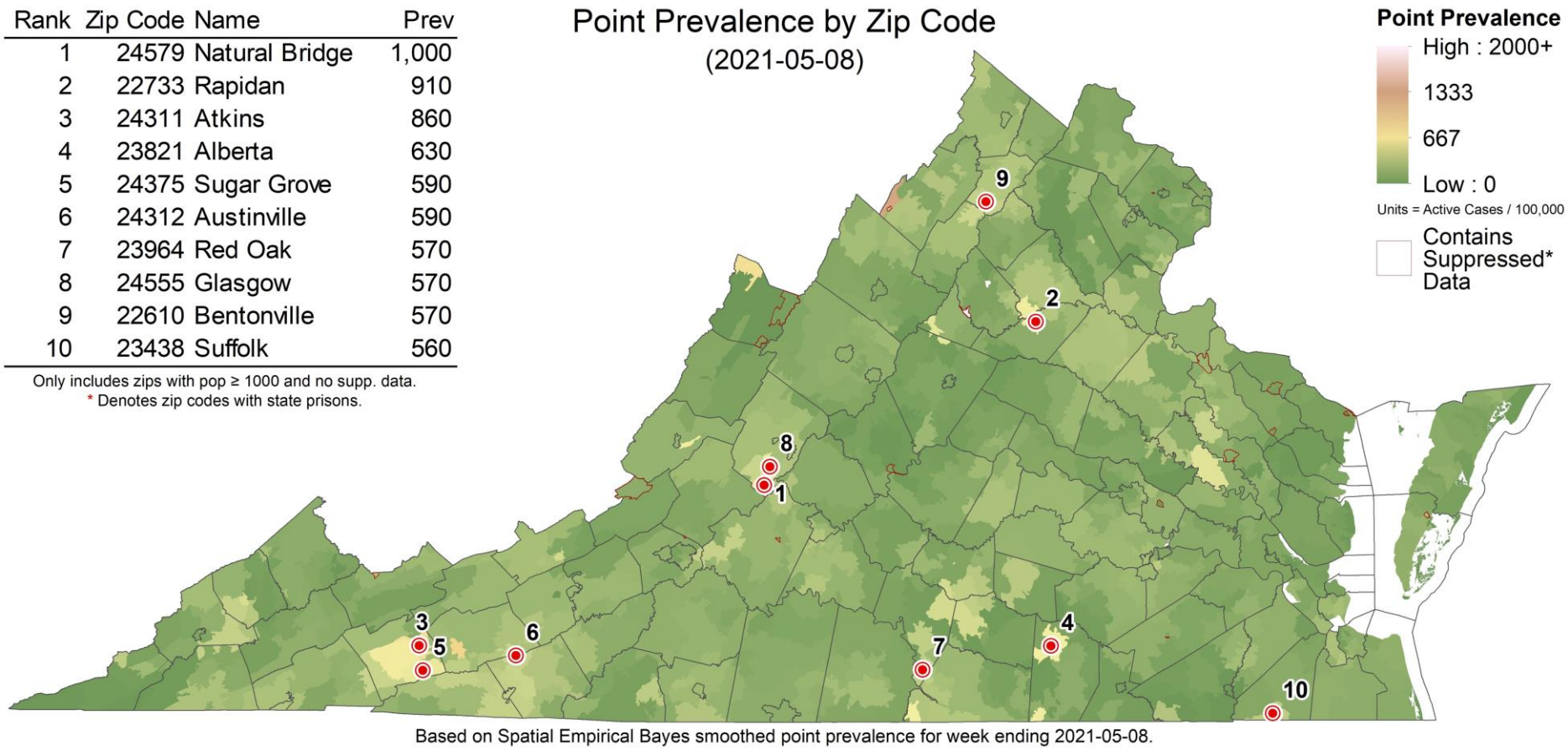
Zip code level weekly Case Rate (per 100K)

Case Rates in the last week by zip code

- Concentrations in Southwest, which was preceded by cluster of increased HCW rates last week
- Still some universities in top 10
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prev
1	24579	Natural Bridge	1,000
2	22733	Rapidan	910
3	24311	Atkins	860
4	23821	Alberta	630
5	24375	Sugar Grove	590
6	24312	Austinville	590
7	23964	Red Oak	570
8	24555	Glasgow	570
9	22610	Bentonville	570
10	23438	Suffolk	560

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 2021-05-08.

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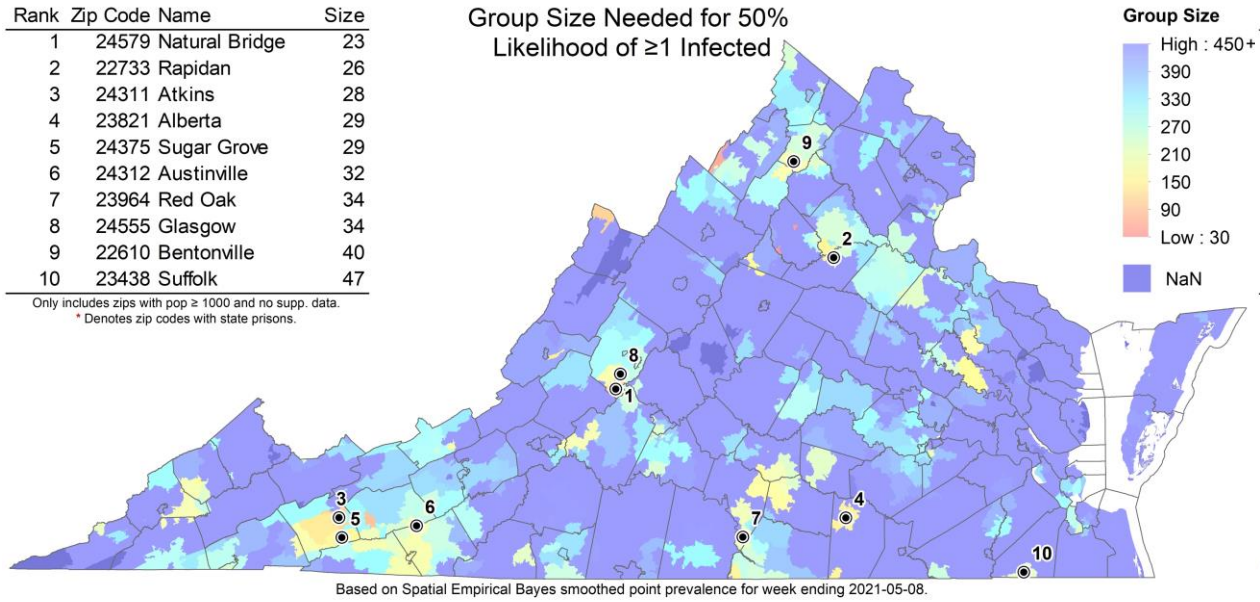
Risk of Exposure by Group Size and HCW prevalence

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 23 in Natural Bridge, there is a 50% chance someone will be infected)
- **HCW prevalence**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator

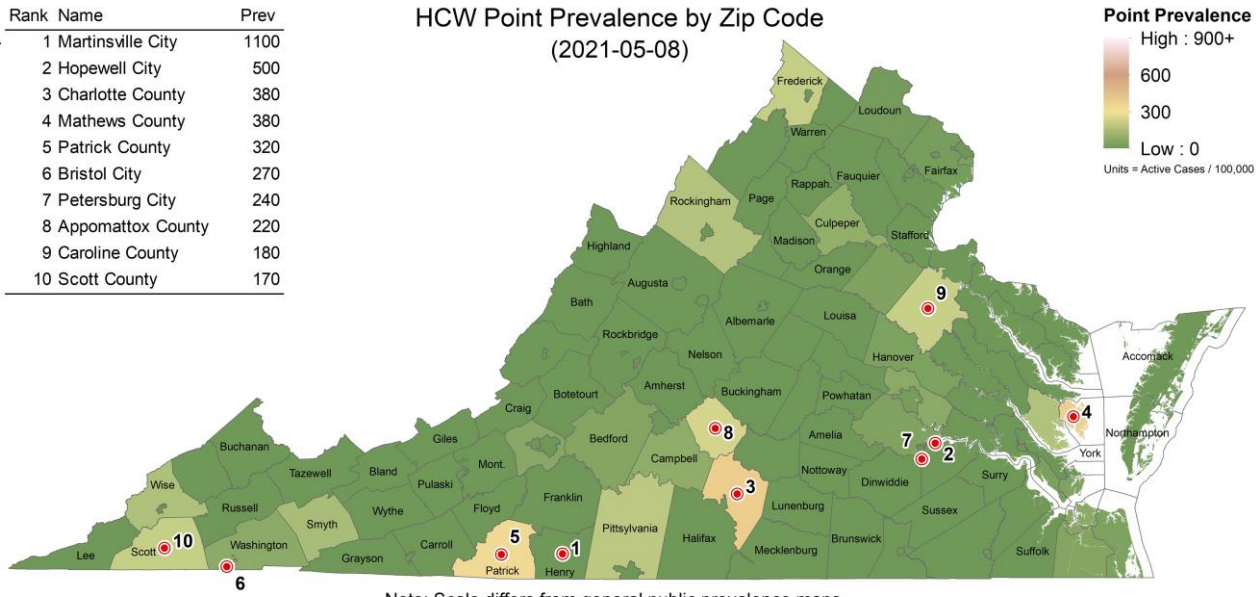
Rank	Zip Code	Name	Size
1	24579	Natural Bridge	23
2	22733	Rapidan	26
3	24311	Atkins	28
4	23821	Alberta	29
5	24375	Sugar Grove	29
6	24312	Austinville	32
7	23964	Red Oak	34
8	24555	Glasgow	34
9	22610	Bentonville	40
10	23438	Suffolk	47

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 2021-05-08.

Rank	Name	Prev
1	Martinsville City	1100
2	Hopewell City	500
3	Charlotte County	380
4	Mathews County	380
5	Patrick County	320
6	Bristol City	270
7	Petersburg City	240
8	Appomattox County	220
9	Caroline County	180
10	Scott County	170



Note: Scale differs from general public prevalence maps.

Current Hot-Spots

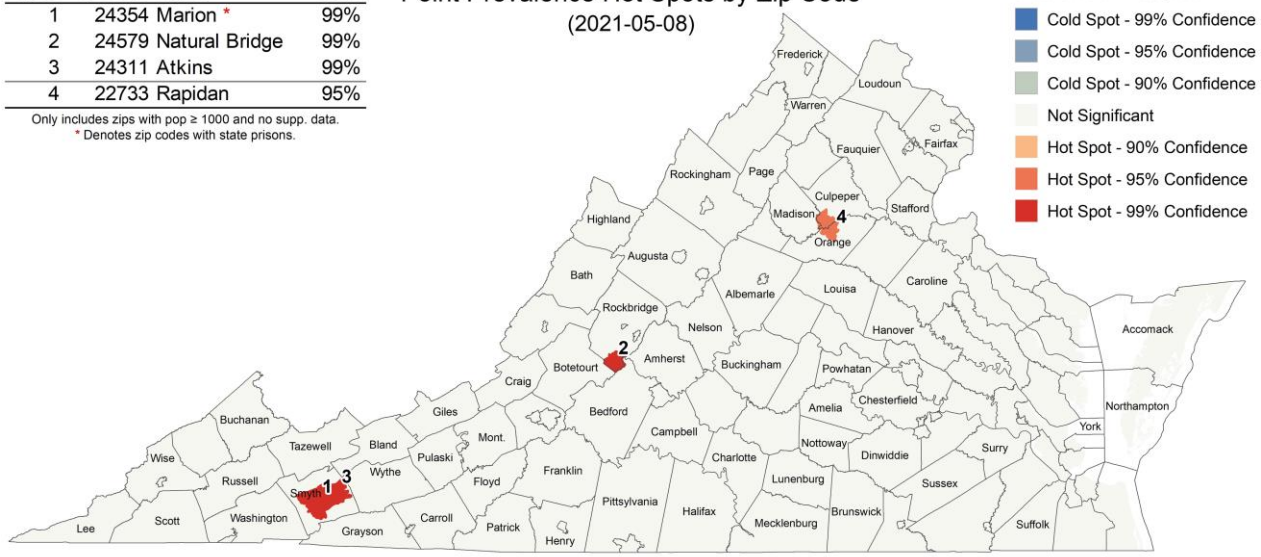
Case rates that are significantly different from neighboring areas or model projections

- **Spatial**: SaTScan 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

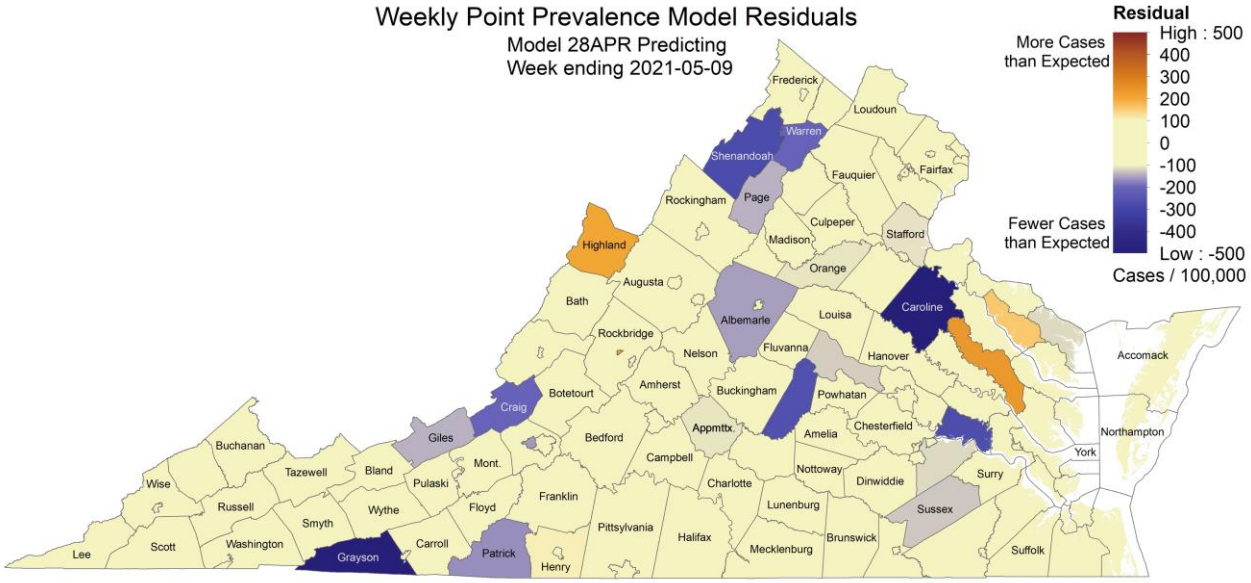
Spot	Zip Code	Name	Conf.
1	24354	Marion *	99%
2	24579	Natural Bridge	99%
3	24311	Atkins	99%
4	22733	Rapidan	95%

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 2021-05-08.

Temporal Hotspots

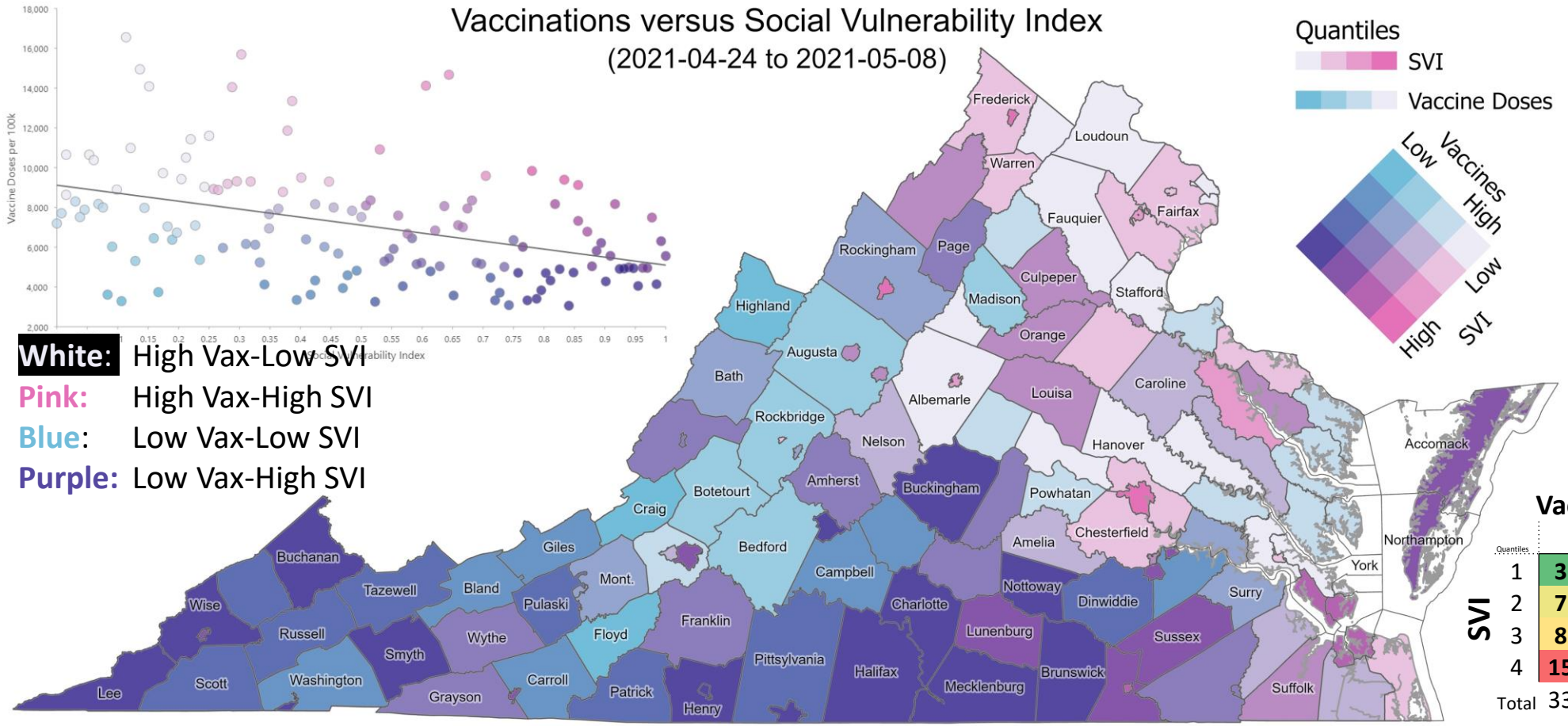


Moran's I = 0.025366, Z-Score = 0.599962, P-Value = 0.548532
No Residual Autocorrelation Detected

Social Vulnerability and Recent Vaccination Rates

Comparison of social vulnerability and vaccination rate in last 2 weeks by county

- **Social Vulnerability:** Each county's Social Vulnerability Index (CDC) compared with the level of vaccination



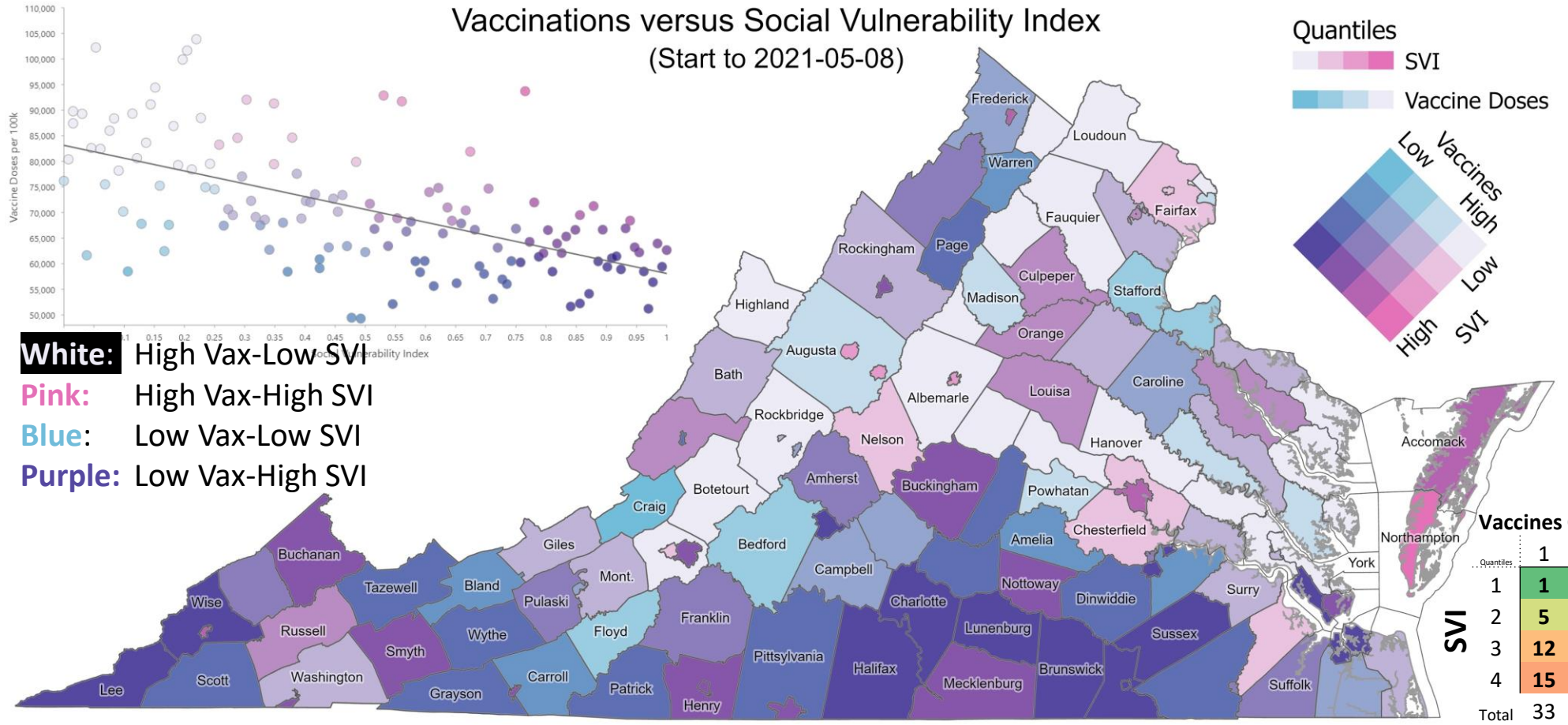
Vaccines Given

SVI Quantiles	1	2	3	4	Total
1	3	5	12	13	33
2	7	7	6	13	33
3	8	11	11	4	34
4	15	10	5	3	33
Total	33	33	33	34	133

Social Vulnerability and Total Vaccination Rates

Comparison of social vulnerability and total vaccination rate since the start of vaccination

- **Social Vulnerability:** Each county's Social Vulnerability Index (CDC) compared with the level of vaccination



Model Update – Adaptive Fitting

Adaptive Fitting Approach

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

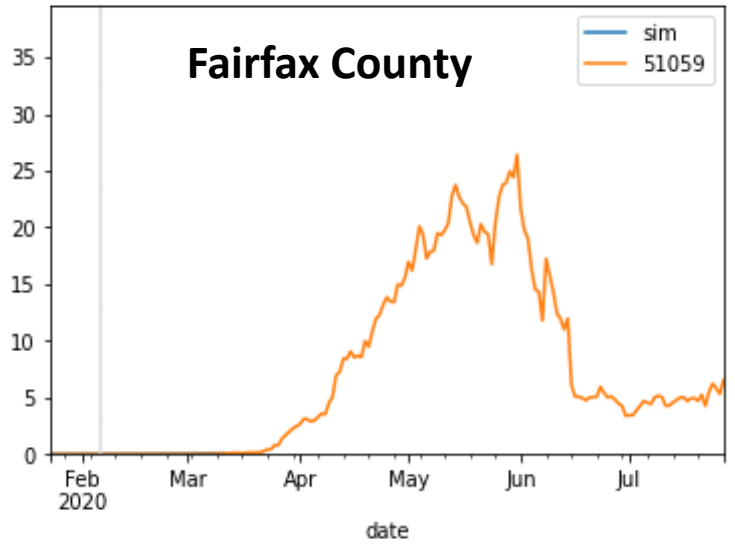
- Allows history to be precisely captured, and used to guide bounds on projections

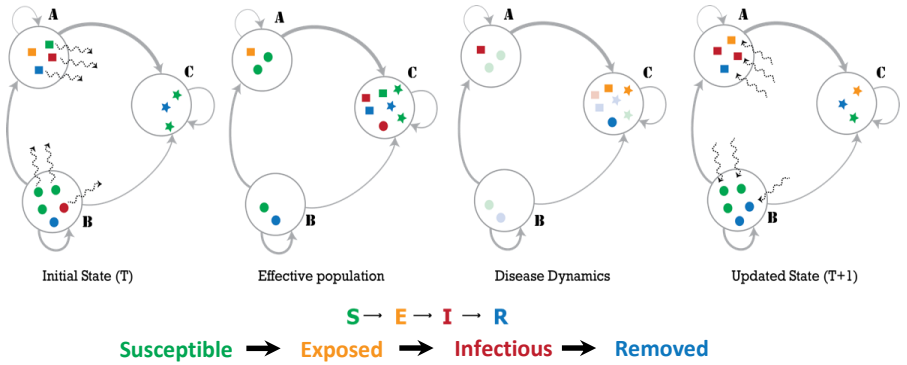
Model: An alternative use of the same meta-population model, PatchSim

- Allows for future "what-if" Scenarios to be layered on top of calibrated model
- Eliminates connectivity between patches, to allow calibration to capture the increasingly unsynchronized epidemic

External Seeding: Steady low-level importation

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





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Using Ensemble Model to Guide Projections

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

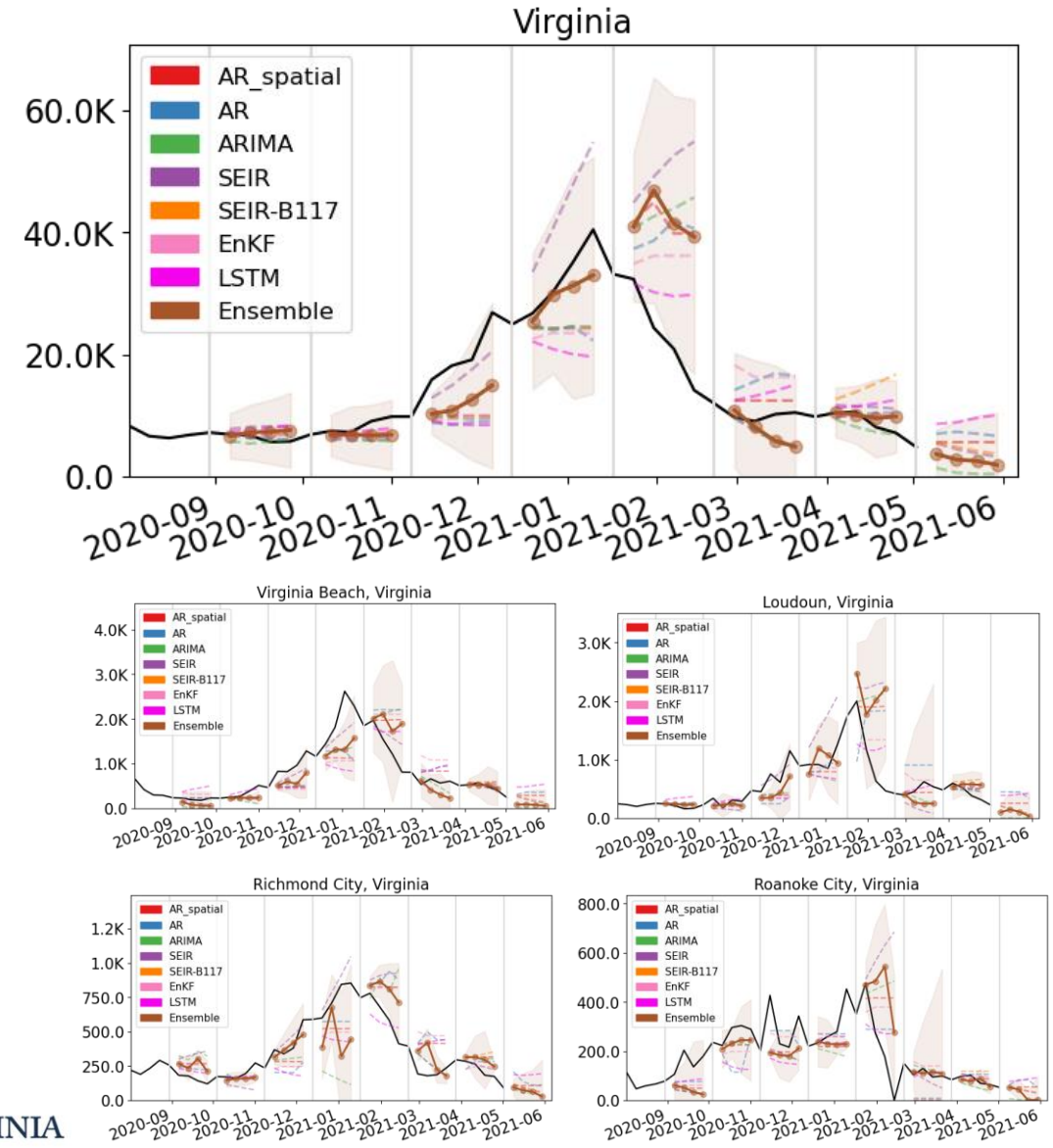
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

<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.



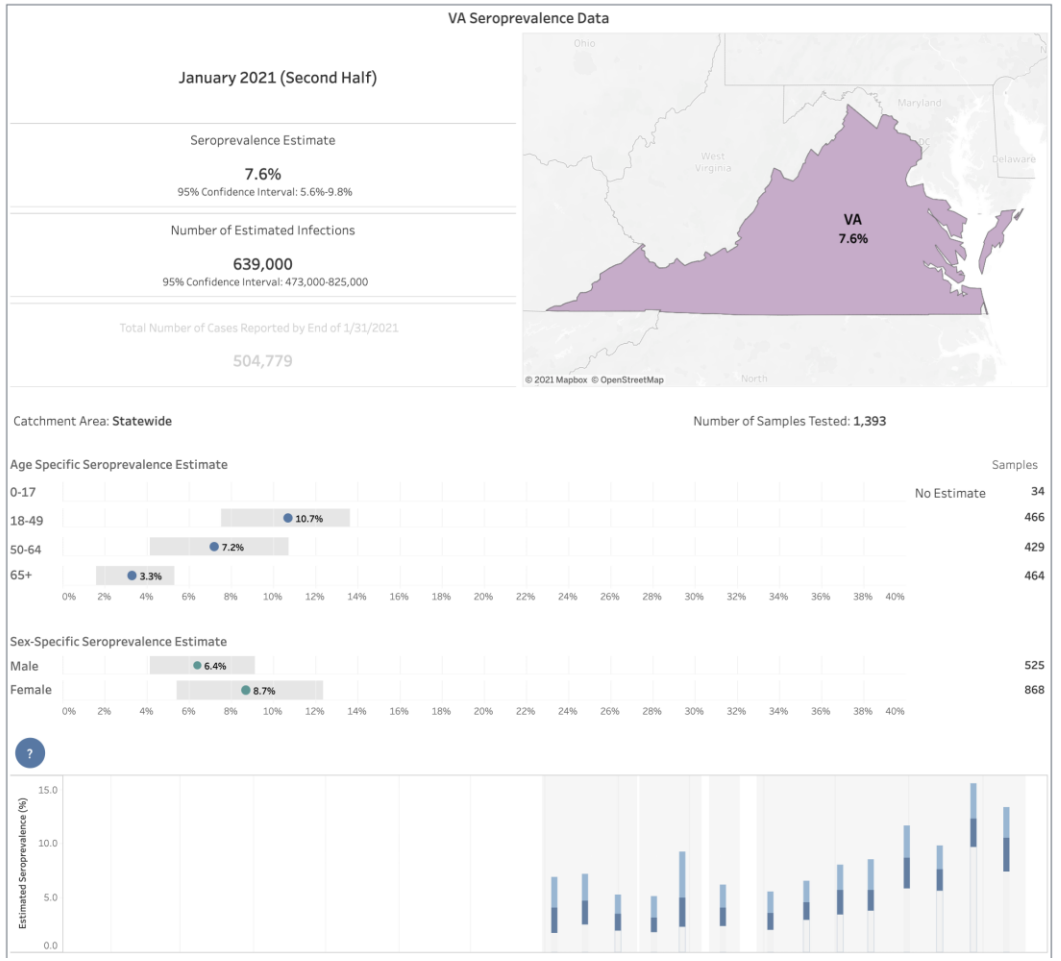
Seroprevalence updates to model design

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

- CDC Nationwide Commercial Laboratory Seroprevalence Survey estimated 7.6% [5.6% – 9.8%] seroprevalence as of Jan 7th – 21st up from 5.7% a month earlier

These findings are equivalent to an ascertainment ratio of ~2x in the future, with bounds of (1.3x to 3x)

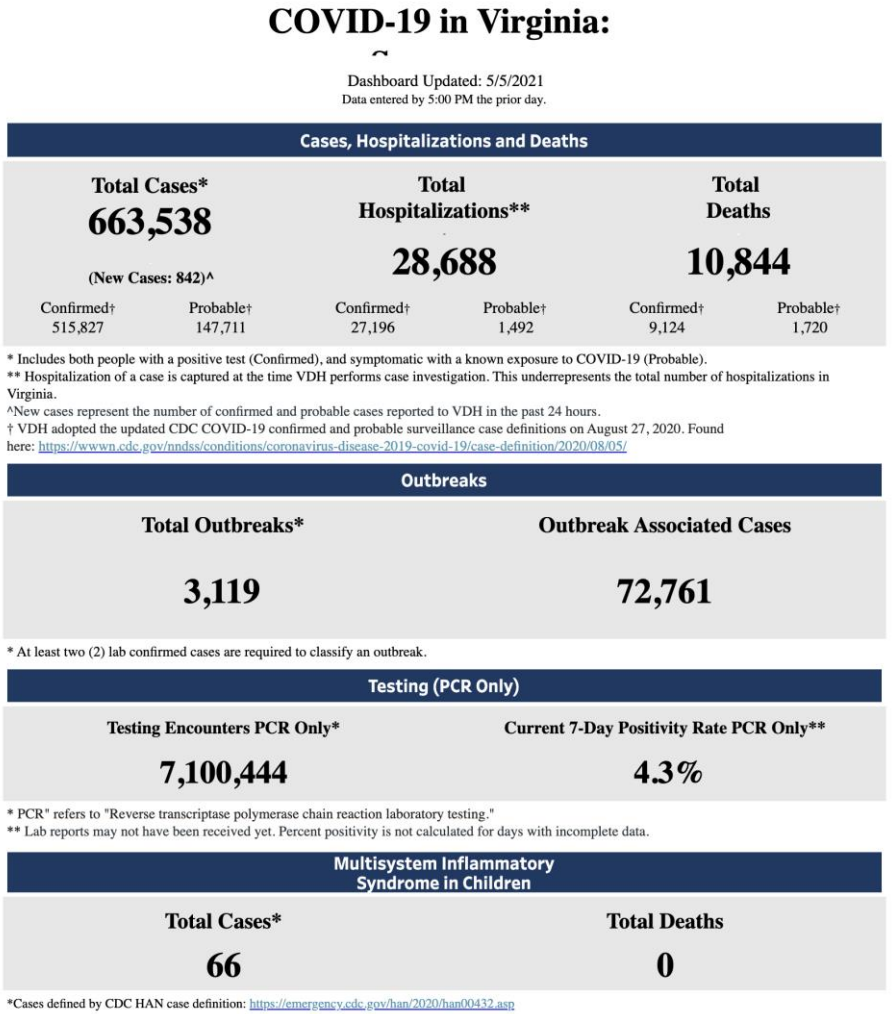
- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- This measure now fully tracks the estimated ascertainment over time
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were being used)



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



COVID-19 in Virginia:

Dashboard Updated: 5/5/2021
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospitalizations**	Total Deaths
663,538	28,688	10,844
(New Cases: 842)^		
Confirmed† 515,827 / Probable† 147,711	Confirmed† 27,196 / Probable† 1,492	Confirmed† 9,124 / Probable† 1,720

* 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/

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
3,119	72,761

* 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**
7,100,444	4.3%

* 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
66	0

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

Accessed 9:30am May 12, 2021

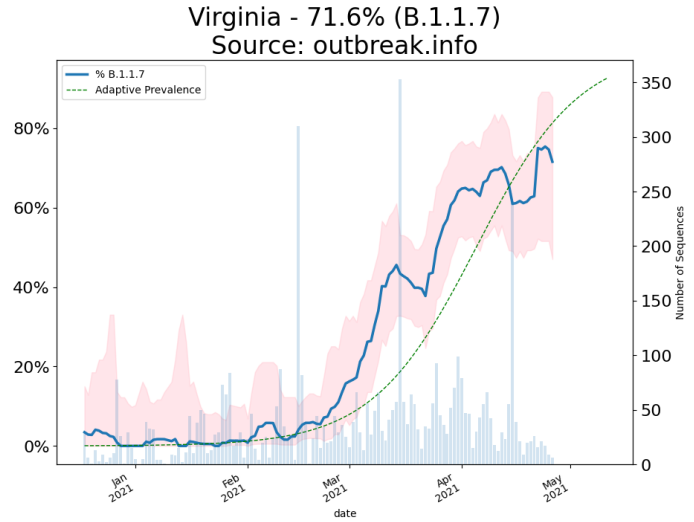
https://www.vdh.virginia.gov/coronavirus/

Scenarios – Transmission Control

- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- Plausible levels of transmission can be bounded by past experience
  - Assess transmission levels at the county level from May 1, 2020 – Sept 1, 2020 or current whichever is highest.
  - Use the highest levels experienced (excluding outliers) as plausible bounds for levels of control achievable
  - Transition from current levels of projection to the new levels over 2 months
- Projection Scenario:
  - **Adaptive:** Control remains as is currently experienced into the future
  - **Fatigued Control**: Highest level of transmission (95th percentile) increased by additional 5%

Scenarios – Variant B.1.17

- Variant B.1.1.7 has reached dominance in Virginia
  - **Transmission increase**: 50% increase from the current baseline projection based on estimated prevalence in past and future
  - **Increased Severity**: 60% increase in likelihood of hospitalization and a 60% increase in mortality Nature
  - **Emergence timing:** Gradual frequency increase reaching 50% frequency on April 5th, a couple weeks after the national estimate in MMWR report from CDC and refined by Andersen et al.
- Variant planning Scenario:
  - **DominantB117**: Current projected transmissibility continues to increase through June to a level 50% more transmissible



Estimated frequency from public genome repository with added analysis: 72%
Current frequency used in model: 91%

outbreak.info
Outbreak Info

GISAID

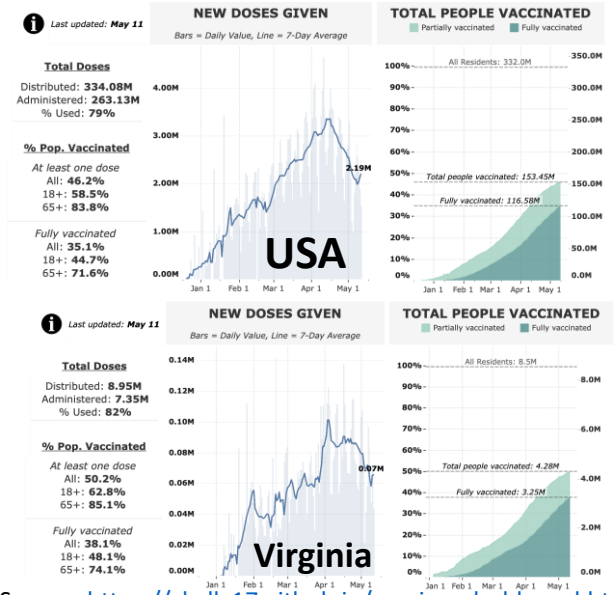
Scenarios – Vaccines

Assumed vaccine efficacies

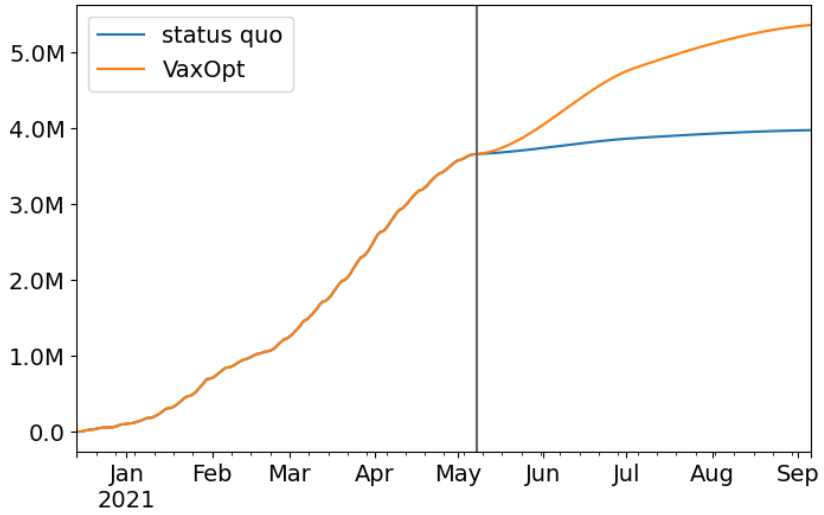
- **Pfizer/Moderna**: 50% after first dose, 95% after second dose (3.5 week gap)
- **J &J** : 67% efficacy after first (and only) dose
- Delay to efficacy from doses is 14 days, immunity lasts at least 7m (NEJM study)

Two Vaccine Administration Scenarios

- Acceptance at county level = regional acceptance +/- relative current vax
- **Status quo (no label):** Slowly reach COVIDcast estimated acceptance level [statewide 55%] by end of Summer (Labor Day)
- **Optimistic (VaxOpt):** Expand acceptance to 75% by Labor day [66.7% by July 4th]



Source: https://ckelly17.github.io/vaccine_dashboard.html



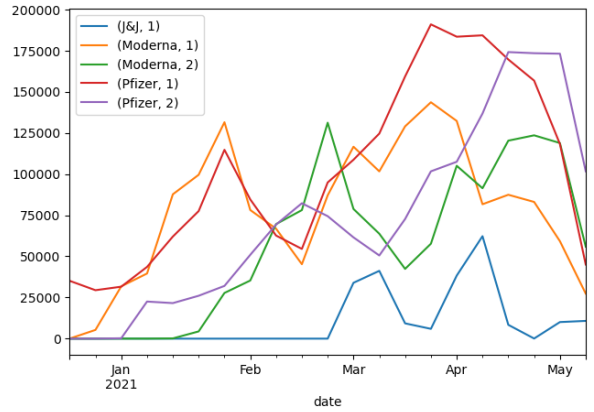
Monthly first doses

Date	status quo	VaxOpt
2020-12-31	99.3K	99.3K
2021-01-31	598.6K	598.6K
2021-02-28	531.6K	531.6K
2021-03-31	1.2M	1.2M
2021-04-30	1.1M	1.1M
2021-05-31	181.0K	470.2K
2021-06-30	123.6K	712.3K
2021-07-31	67.6K	367.3K
2021-08-31	43.5K	235.5K
2021-09-30	4.3K	22.8K

Cumulative

Date	status quo	VaxOpt
2020-12-31	99.3K	99.3K
2021-01-31	697.9K	697.9K
2021-02-28	1.2M	1.2M
2021-03-31	2.5M	2.5M
2021-04-30	3.6M	3.6M
2021-05-31	3.7M	4.0M
2021-06-30	3.9M	4.7M
2021-07-31	3.9M	5.1M
2021-08-31	4.0M	5.3M
2021-09-30	4.0M	5.4M

Weekly VA doses administered by manufacturer



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Scenarios – Seasonal Effects and Vaccines

Three scenarios combine these control effects and use the current vaccine schedule

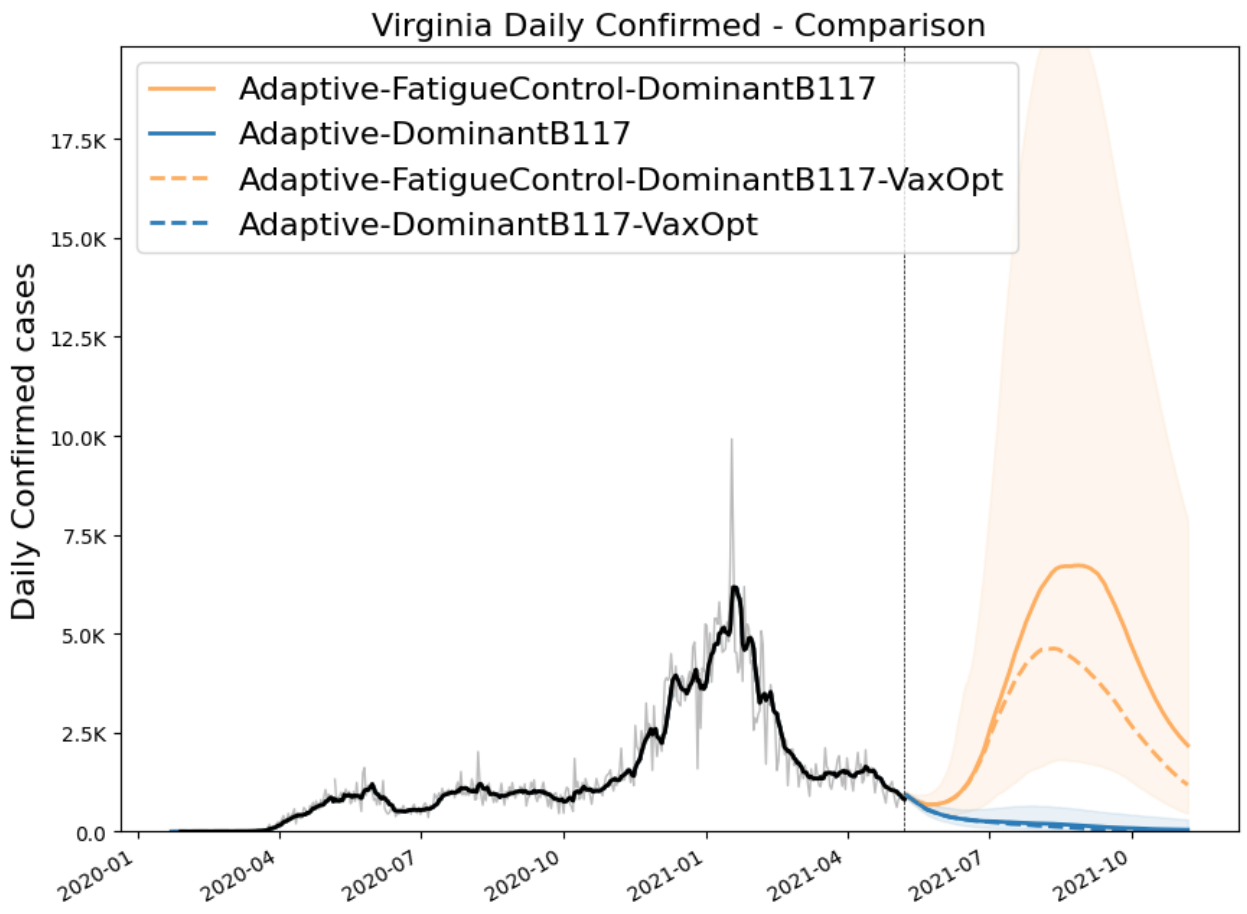
- **Adaptive-DominantB117**: Controls remain as they currently are, with layered in boosting of transmissibility from the dominance of B.1.1.7, with status quo
- **Adaptive-FatigueControl-DominantB117:** Fatigued controls and transmission boost from B.1.1.7
- **Adaptive-DominantB117-VaxOpt:** Controls remain as they currently are, with layered in boosting of transmissibility from the dominance of B.1.1.7, with optimistic levels of acceptance
- **Adaptive-FatigueControl-DominantB117-VaxOpt:** Fatigued controls and transmission boost from B.1.1.7, with optimistic levels of acceptance

Counterfactuals with no vaccine (“NoVax”) are provided for comparison purposes

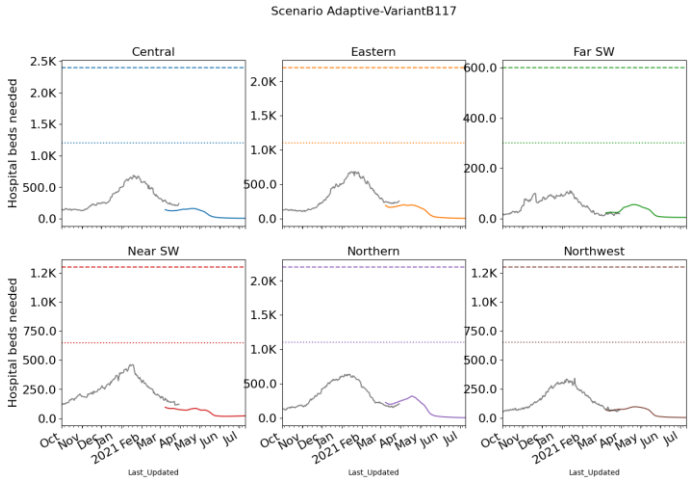
Model Results

Outcome Projections

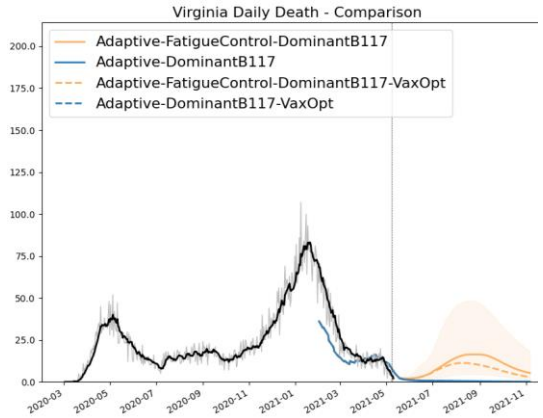
Confirmed cases



Estimated Hospital Occupancy

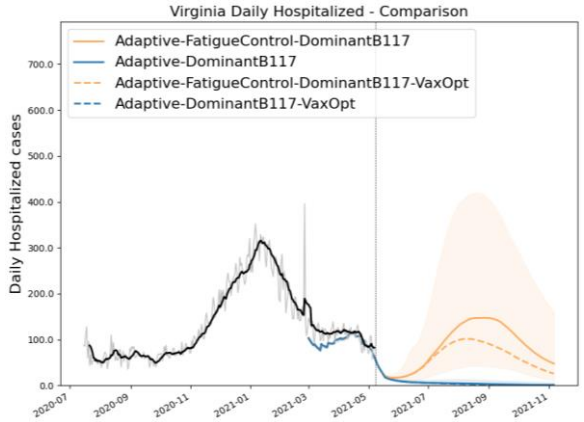


Daily Deaths



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

Daily Hospitalized



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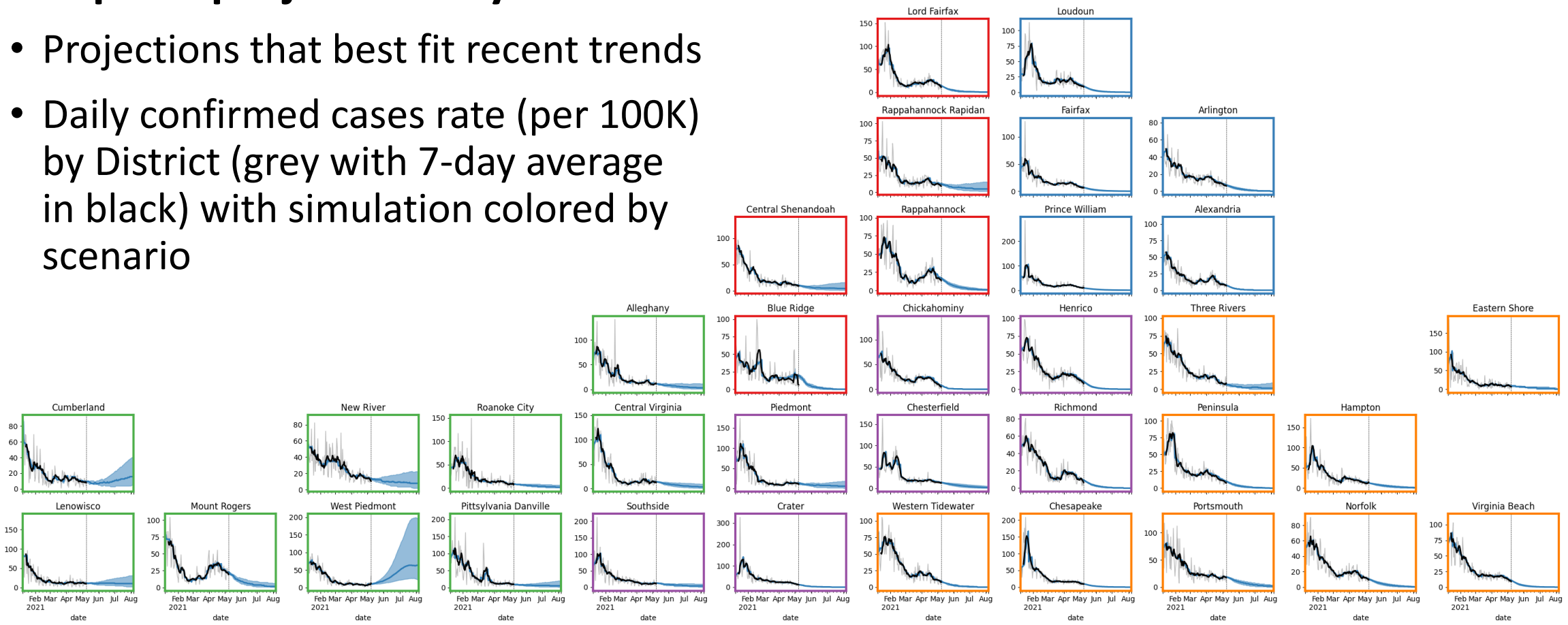
District Level Projections: Adaptive-DominantB117

Adaptive projections by District

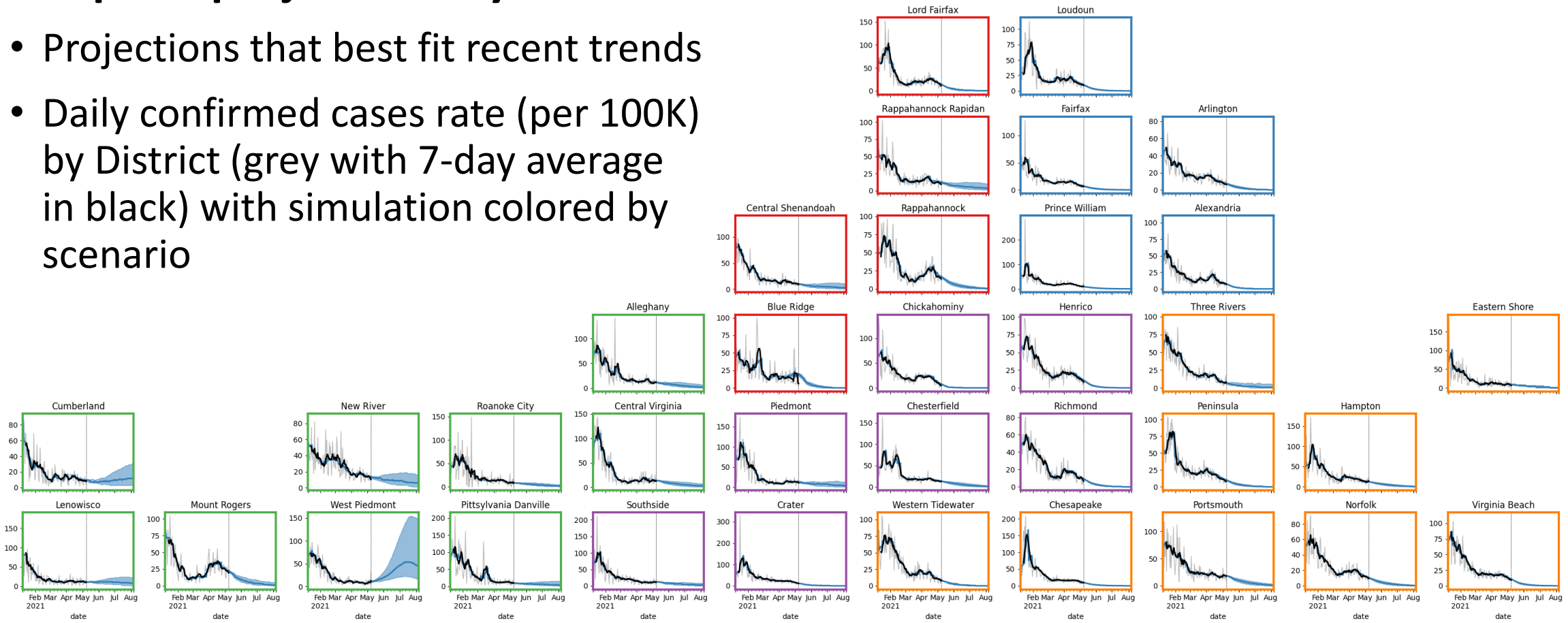
- Projections that best fit recent trends
- Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario



District Level Projections: Adaptive-DominantB117-VaxOpt

Adaptive projections by District

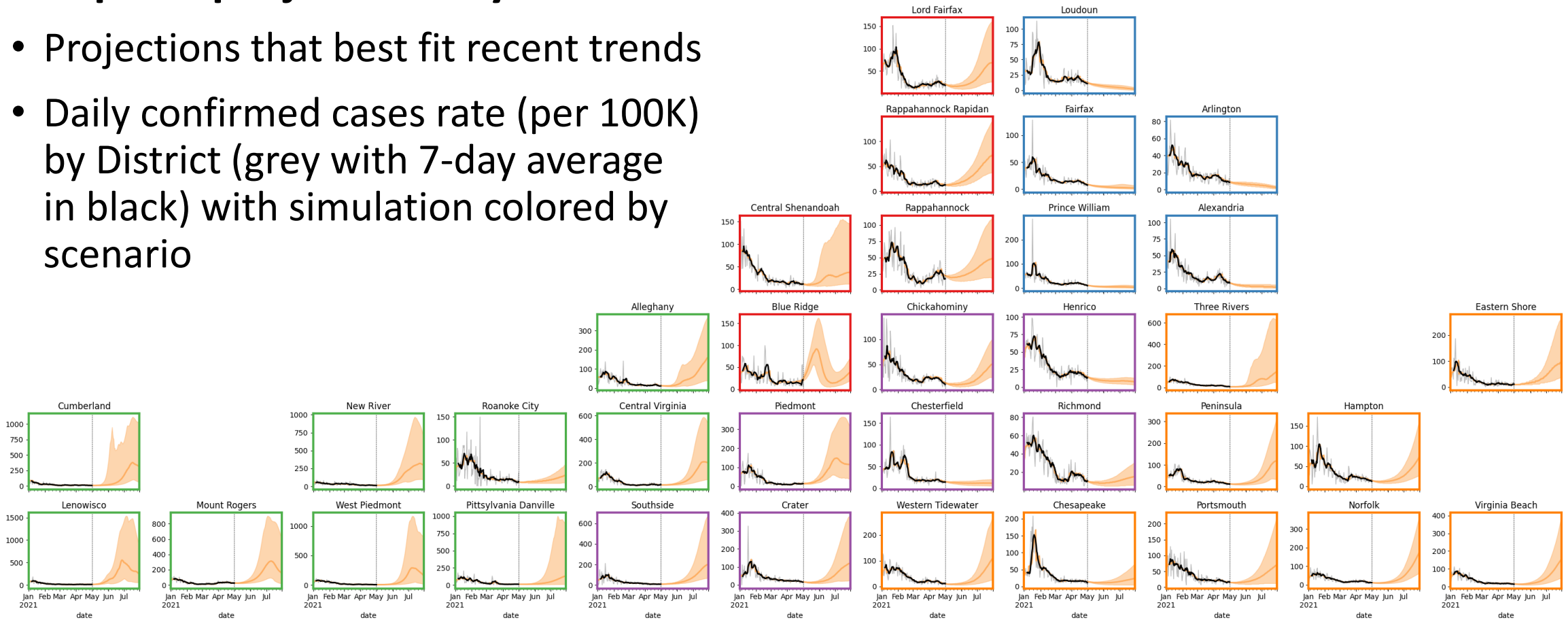
- Projections that best fit recent trends
- Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario



District Level Projections: Adaptive-FatigueControl-DominantB117

Adaptive projections by District

- Projections that best fit recent trends
- Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario



District Level Projections: Adaptive-FatigueControl-DominantB117-VaxOpt

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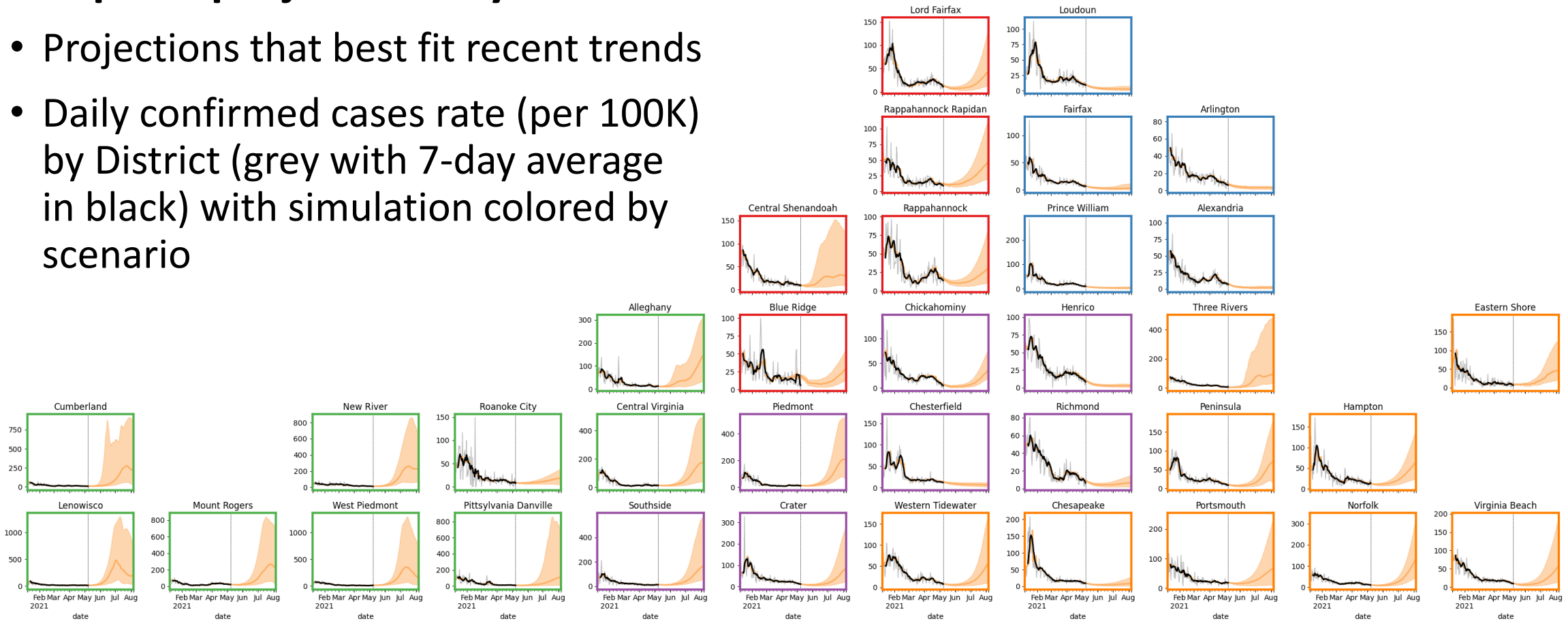
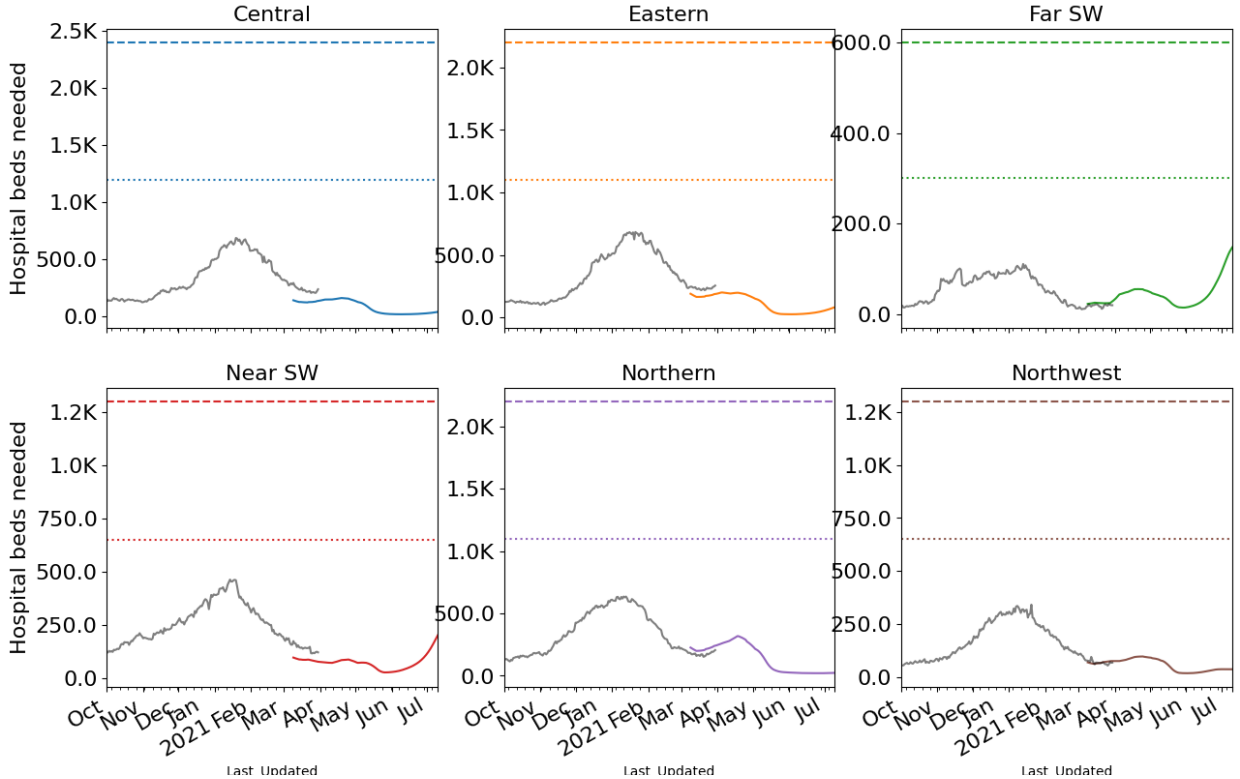
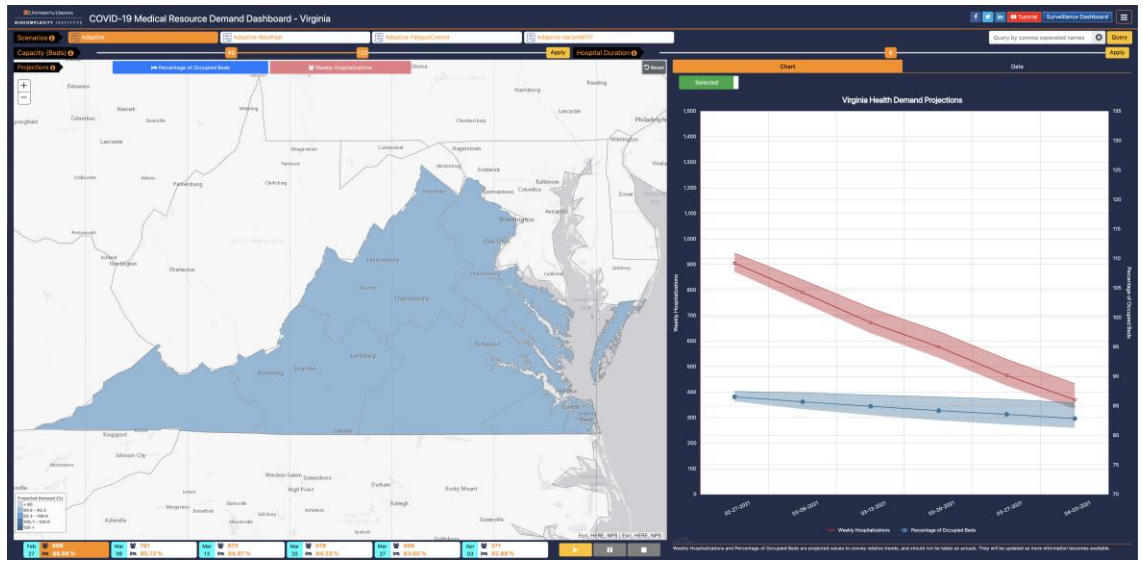


Hospital Demand and Bed Capacity by Region

Capacities* by Region – Adaptive-FatigueControl-DominantB117

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





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

If Adaptive-FatigueControl-DominantB117 scenario persists:

- No capacity challenges for hospital beds in near-term

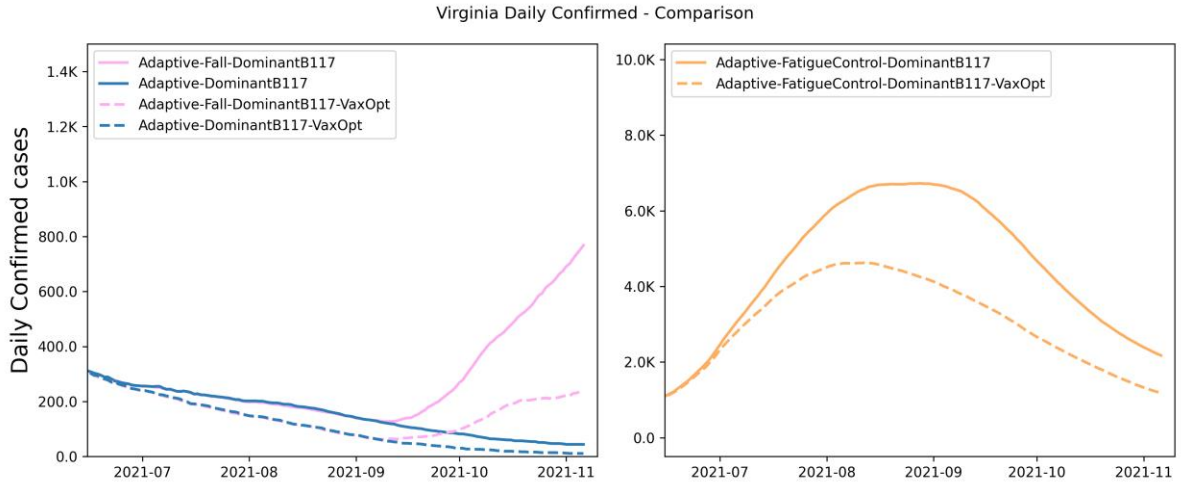
* Assumes average length of stay of 8 days

Resilience to Fall Surge

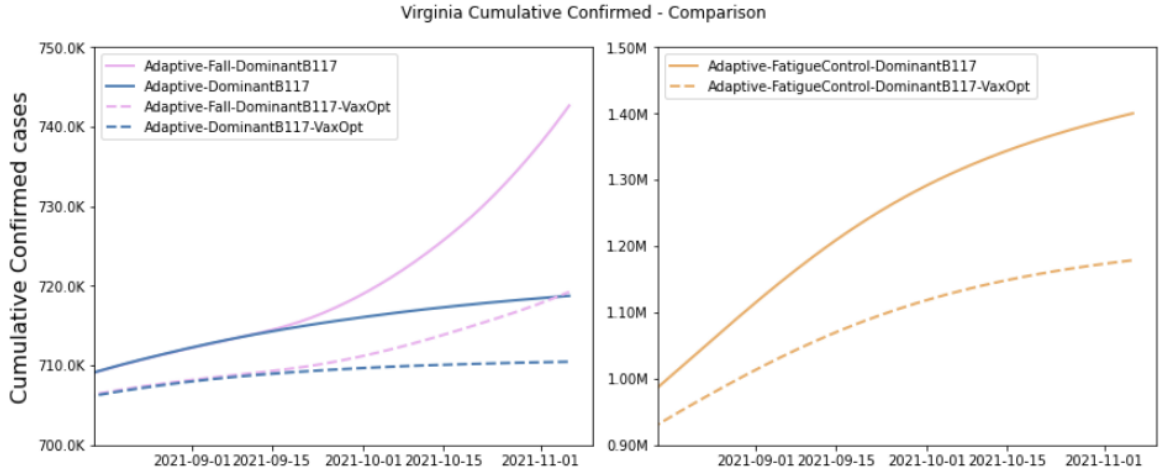
Impact of expanded vaccine acceptance against a Fall Surge

- To further test Virginia's resilience to new transmission surges, implement a Fall Surge
  - Highest rate from Fall 2020, with a 2 week ramp up starting on Sept 1st 2021
- Population more resilient to Fall Surge (5-6 times fewer cases produced)
- In worst case of sustained Fatigue Control 250K cases averted
- In more realistic case Adaptive-DominantB117 scenario several thousand cases averted

Daily Infections



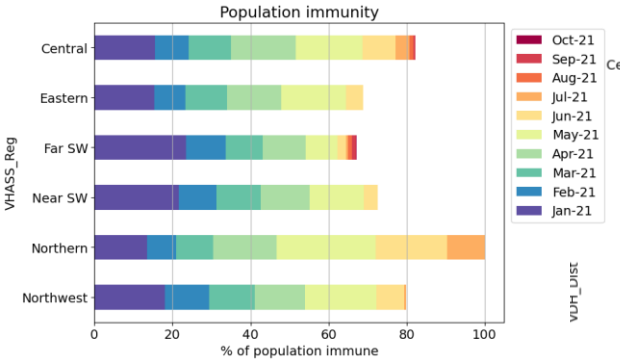
Cumulative Infections

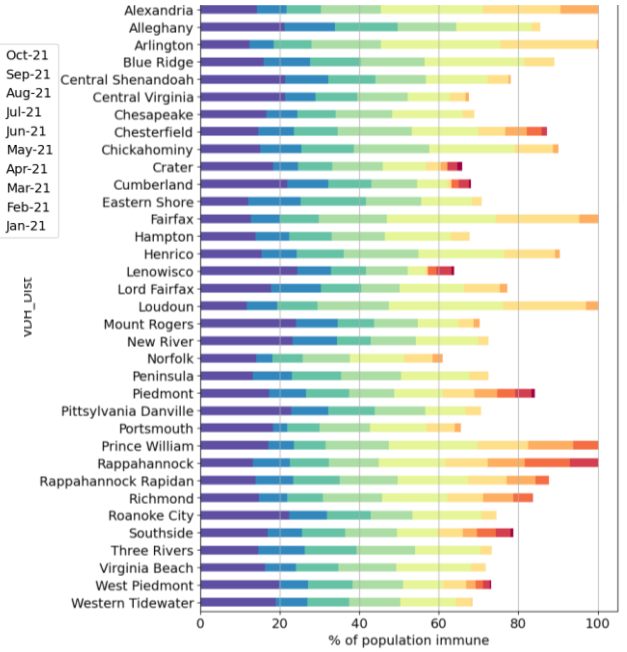


Virginia's Progress on Population Immunity

Natural Immunity and Vaccines combine to produce a population level of immunity

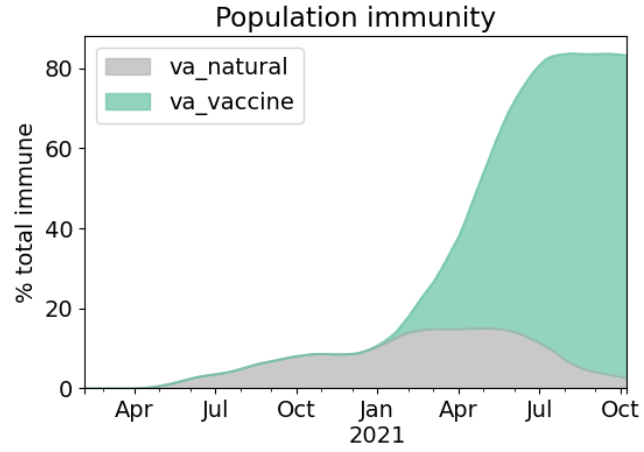
- Duration of immunity from infection with SARS-CoV2 still not well understood
  - We assume a conservative 6 month period of protection for these calculations
  - Natural immunity is well calibrated to recent seroprevalence surveys
- Vaccine induced immunity is likely to last longer, we assume indefinite protection
  - This also assumes that all administered vaccines remain protective against current and future novel variants
- Population immunity depends on a very high proportion of the population getting vaccinated
  - Using regional vaccine acceptance





Region	% immune (est.)*
Central	59%
Eastern	55%
Far SW	58%
Near SW	61%
Northern	57%
Northwest	62%
Virginia	**58%**

* As of May 9, 2021



UNIVERSITY of VIRGINIA
BIOCOMPLEXITY INSTITUTE

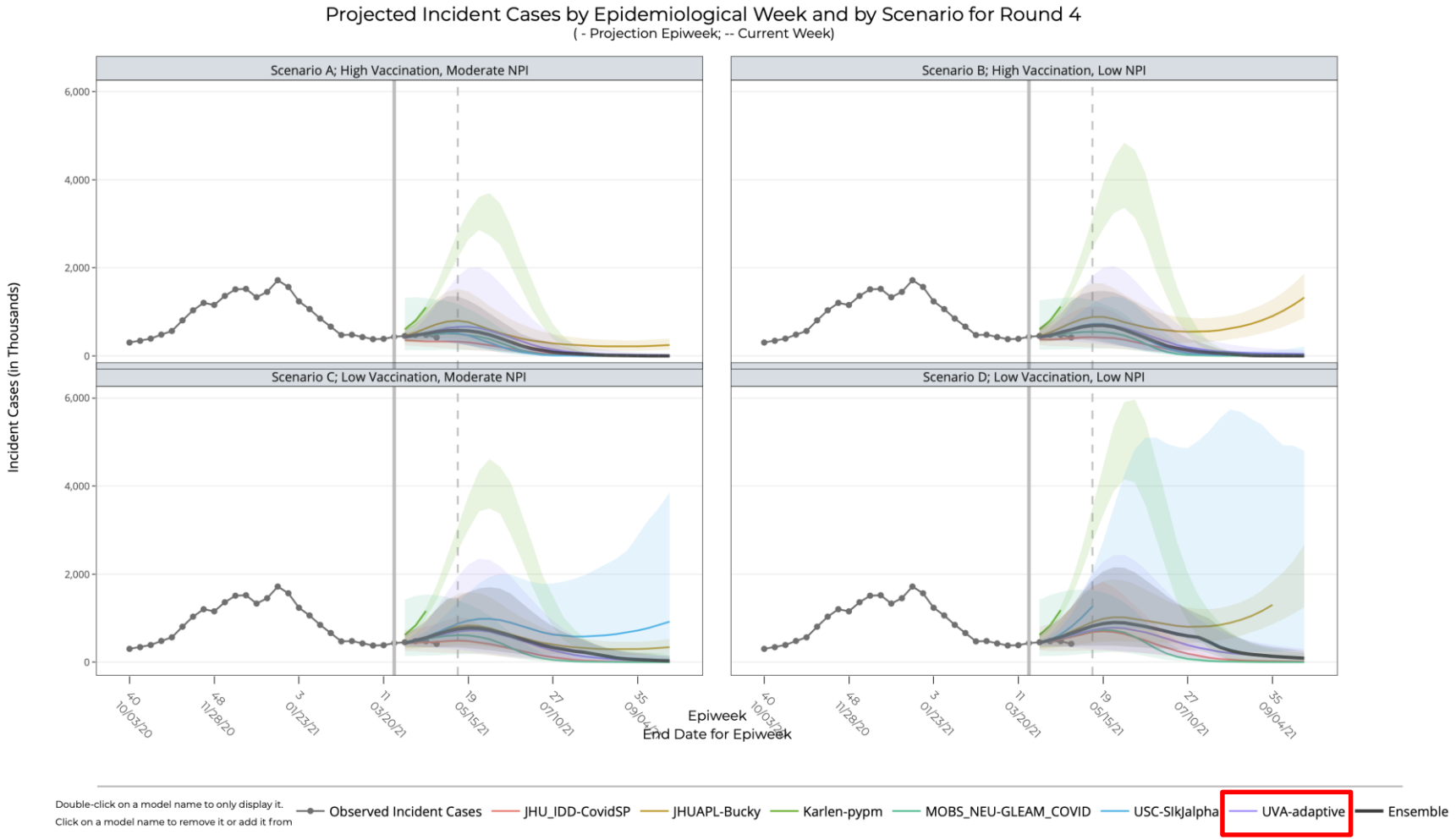
COVID-19 Scenario Modeling Hub

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios that vary vaccine rates (high – low) and levels of control (moderate and low)

- Similar to our current scenarios with regular updates, round 5 should be done in 1st week in May

Published May 5th, 2021 in MMWR

https://covid19scenariomodelinghub.org/viz.html



Key Takeaways

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

- **Case rates in Virginia continue to decline with pace accelerating in some districts**
- VA mean weekly incidence down to 8/100K from 11/100K, US down (12 from 15 per 100K)
- Vaccination rates have slowed considerably, but overall population immunity remains over 50%
- Projections show declining rate overall across Commonwealth,
- Recent updates:
  - Significant update to current measured acceptance levels to lower levels, validated with additional national survey
  - Added vaccination scenarios to compare status quo acceptance levels against expanded optimistic levels
  - Added a Fall surge resiliency study to test vaccination levels vs. increased activity in the Fall
- The situation continues to change. Models continue to be updated regularly.

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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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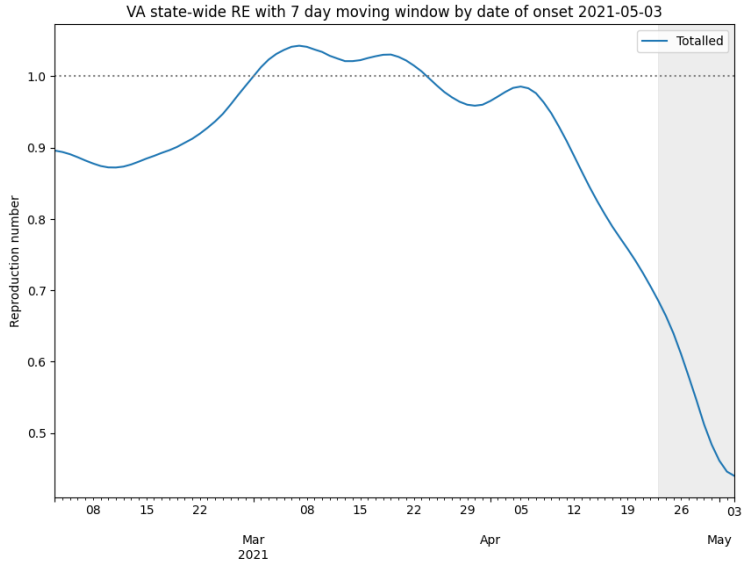
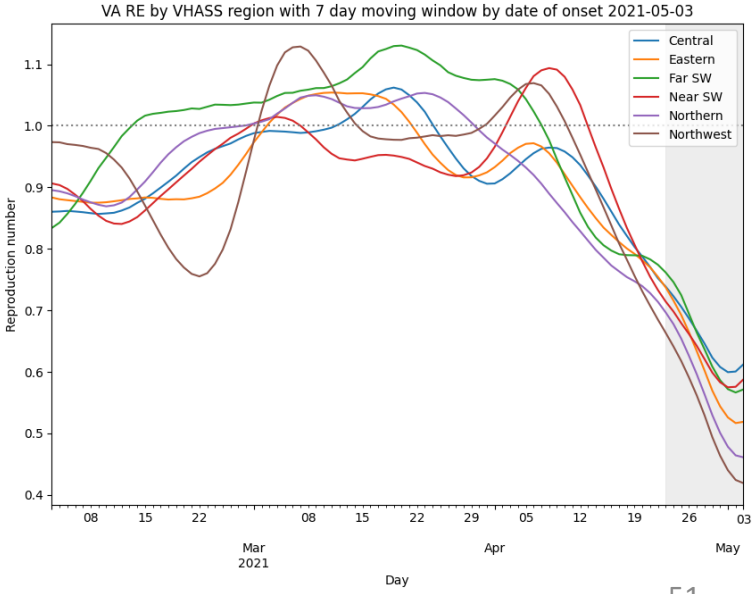
Supplemental Slides

Estimating Daily Reproductive Number

April 24th Estimates

Region	Date of Onset R_e	Date Onset Diff Last Week
State-wide	0.662	0.019
Central	0.722	-0.031
Eastern	0.718	0.018
Far SW	0.749	0.087
Near SW	0.690	-0.065
Northern	0.678	0.062
Northwest	0.647	-0.039





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

Weekly Cases and Hospitalizations

Weekly confirmed cases

Week Ending	Adaptive-DominantB117	Adaptive-BestPast-Dominant B117	Adaptive-Fatigued Control -DominantB117
4/25/21	9,598	9,599	9,597
5/2/21	9,747	9,767	9,850
5/9/21	8,858	8,894	9,683
5/16/21	8,048	8,086	10,150
5/23/21	7,392	7,428	11,250
5/30/21	6,713	6,561	13,152
6/6/21	5,994	5,553	16,388
6/13/21	5,365	4,521	21,163
6/20/21	4,746	3,508	27,038
6/27/21	4,201	2,575	32,380
7/4/21	3,647	1,808	38,477
7/11/21	3,131	1,204	42,721

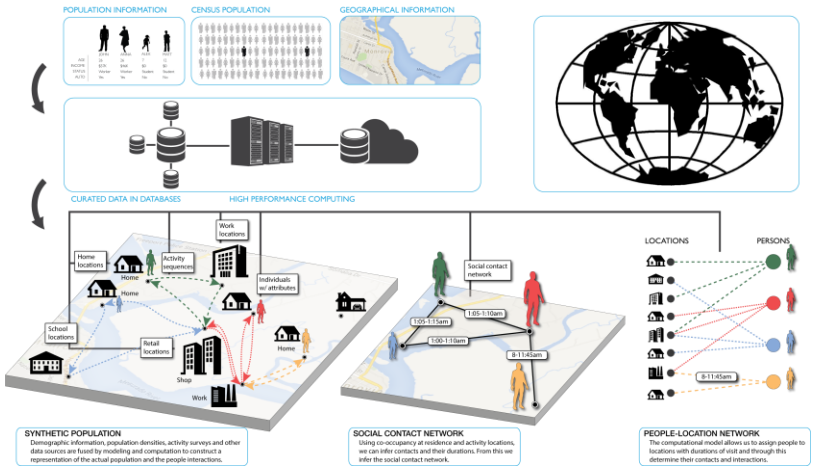
Weekly Hospitalizations

Week Ending	Adaptive-DominantB117	Adaptive-BestPast-Dominant B117	Adaptive-Fatigued Control -DominantB117
4/25/21	750	750	750
5/2/21	659	659	666
5/9/21	548	548	601
5/16/21	451	452	575
5/23/21	373	372	580
5/30/21	302	292	609
6/6/21	241	219	654
6/13/21	196	159	707
6/20/21	161	112	771
6/27/21	131	74	784
7/4/21	103	48	748
7/11/21	81	29	659

Agent-based Model (ABM)

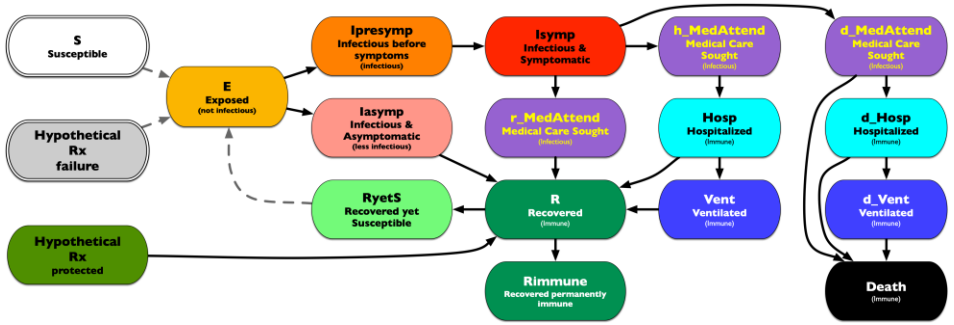
EpiHiper: Distributed network-based stochastic disease transmission simulations

- Assess the impact on transmission under different conditions
- Assess the impacts of contact tracing



Synthetic Population

- Census derived age and household structure
- Time-Use survey driven activities at appropriate locations



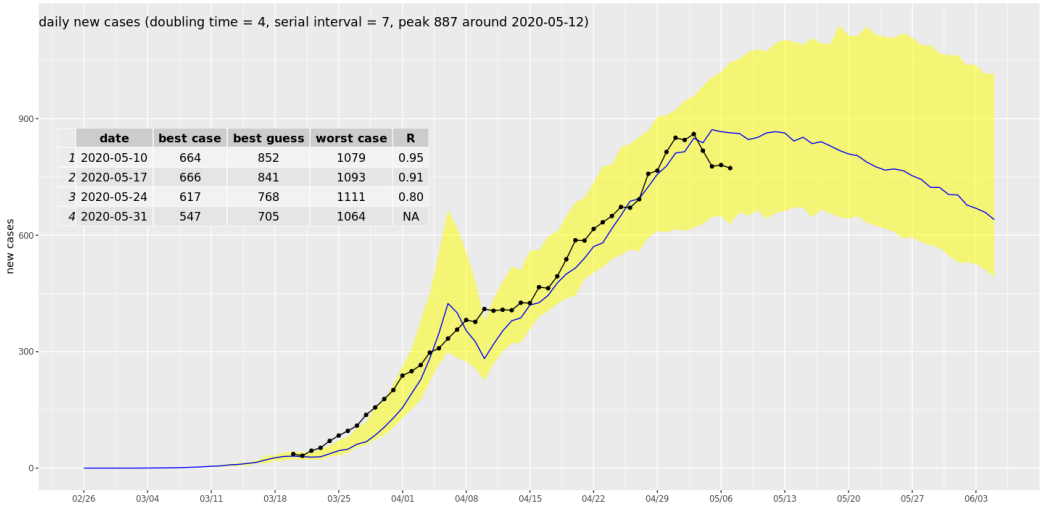
Detailed Disease Course of COVID-19

- Literature based probabilities of outcomes with appropriate delays
- Varying levels of infectiousness
- Hypothetical treatments for future developments

ABM Social Distancing Rebound Study Design

Study of ”Stay Home” policy adherence

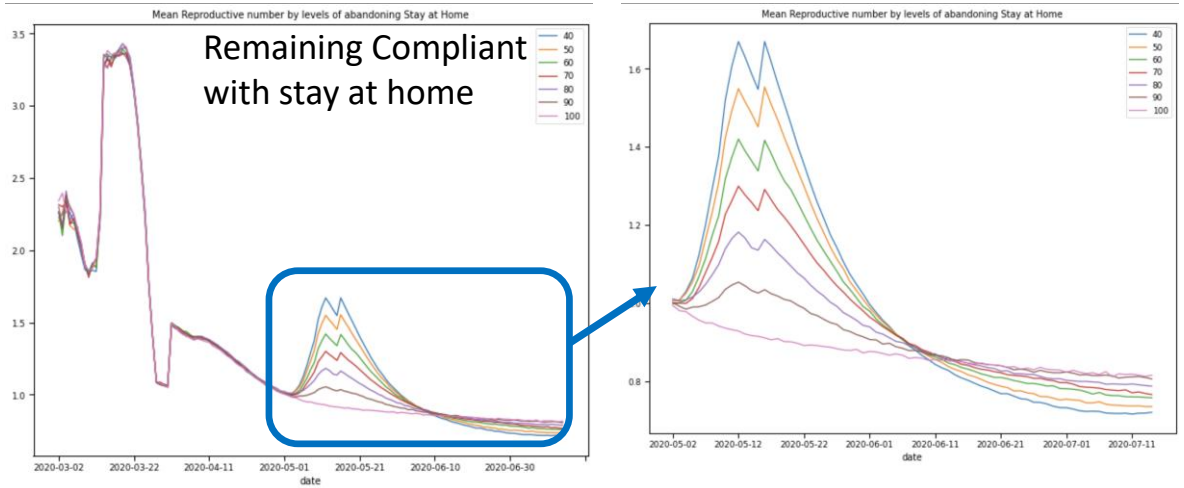
- Calibration to current state in epidemic
- Implement “release” of different proportions of people from ”staying at home”



	date	best case	best guess	worst case	R
1	2020-05-10	664	852	1079	0.95
2	2020-05-17	666	841	1093	0.91
3	2020-05-24	617	768	1111	0.80
4	2020-05-31	547	705	1064	NA

Calibration to Current State

- Adjust transmission and adherence to current policies to current observations
- For Virginia, with same seeding approach as PatchSim



Impacts on Reproductive number with release

- After release, spike in transmission driven by additional interactions at work, retail, and other
- At 25% release (70-80% remain compliant)
- Translates to 15% increase in transmission, which represents a 1/6th return to pre-pandemic levels