Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

September 1st, 2021

(data current to August 28th – 31st)

Biocomplexity Institute Technical report: TR 2021-098

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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:

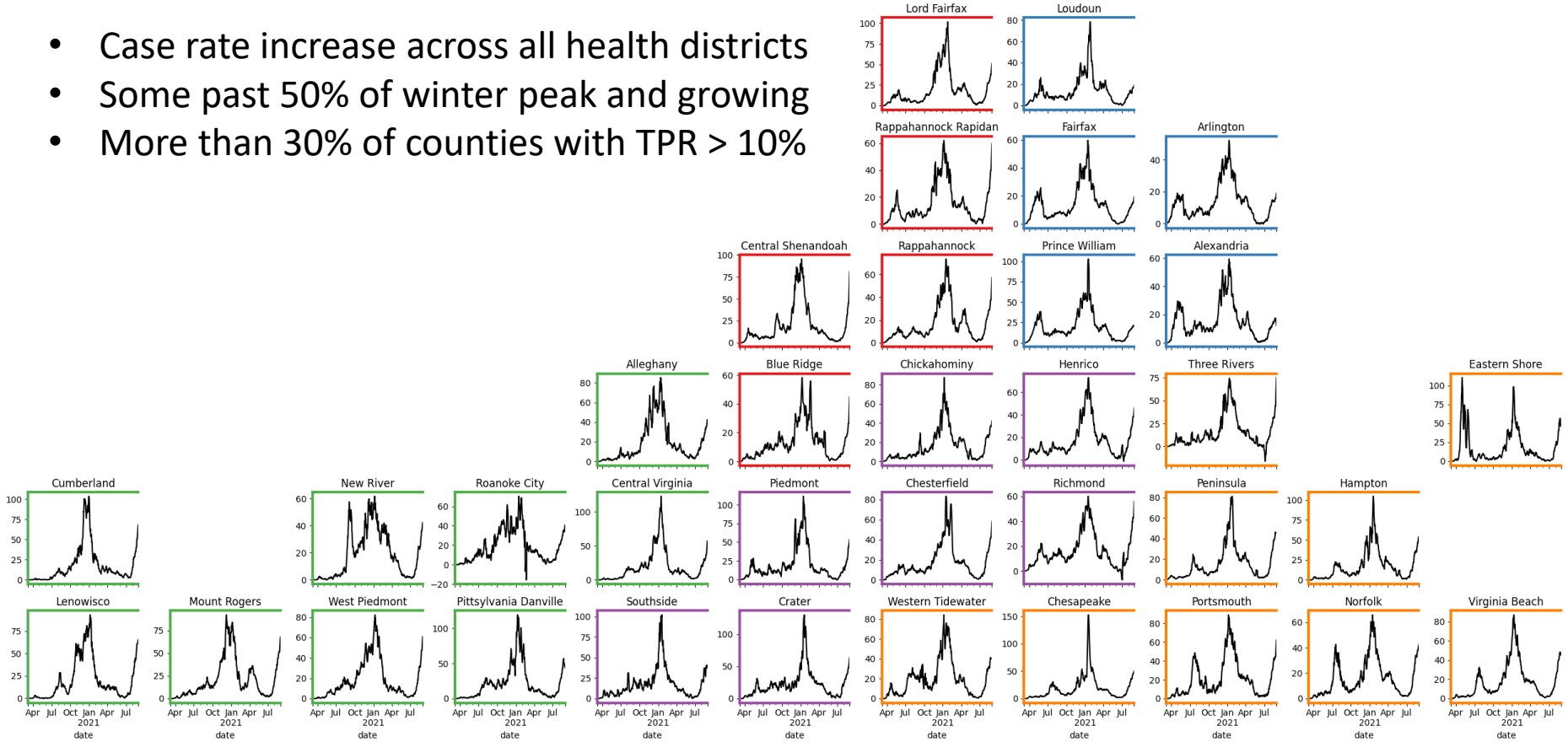
- **Case rates in Virginia continue to rise though the pace remains steady while initial surge states have peaked, case rates remain very high**
- VA mean weekly incidence up to 37/100K from 30/100K, US up to 48/100K (from 44/100K)
- Growth in vaccination rates remain higher than June and July with slight uptick
- Projections continue to show significant uptick in activity, however, the reduced pace has decreased the overall impact
- Recent updates:
  - Added Fall surge scenario to capture potential rebounds and further test immunity from expanded vaccination
  - Updated Optimistic Vaccination to include potential inclusion of 5-11 year olds this Fall

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

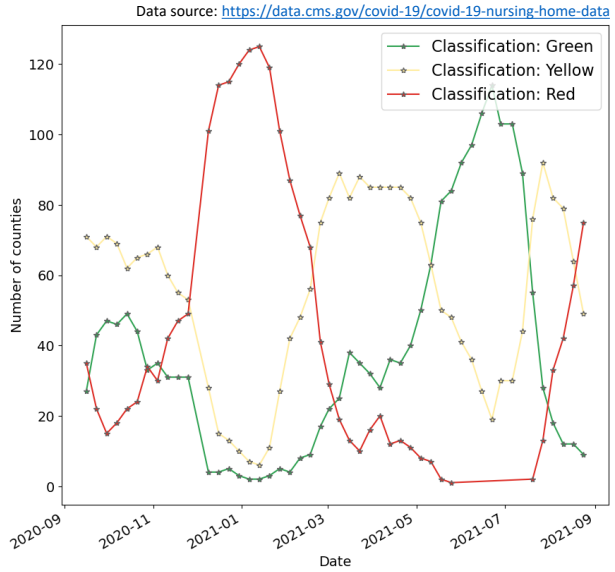
Situation Assessment

Case Rates (per 100k) and Test Positivity

- Case rate increase across all health districts
- Some past 50% of winter peak and growing
- More than 30% of counties with TPR > 10%



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



County level RT-PCR test positivity

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

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

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

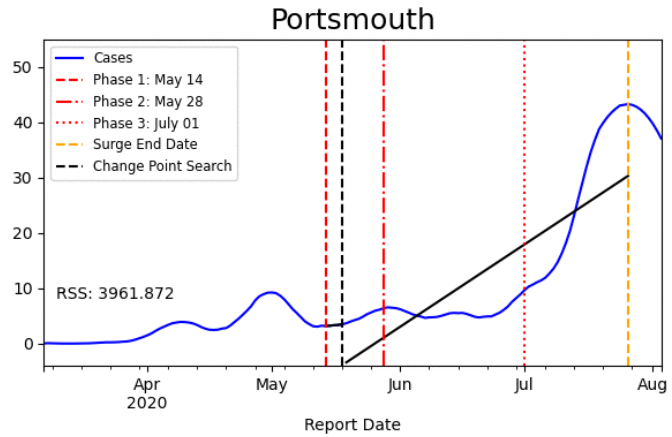
Classification date	Green	Red	Yellow
2021-07-20	55.0	2.0	76.0
2021-07-27	28.0	13.0	92.0
2021-08-03	18.0	33.0	82.0
2021-08-10	12.0	42.0	79.0

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

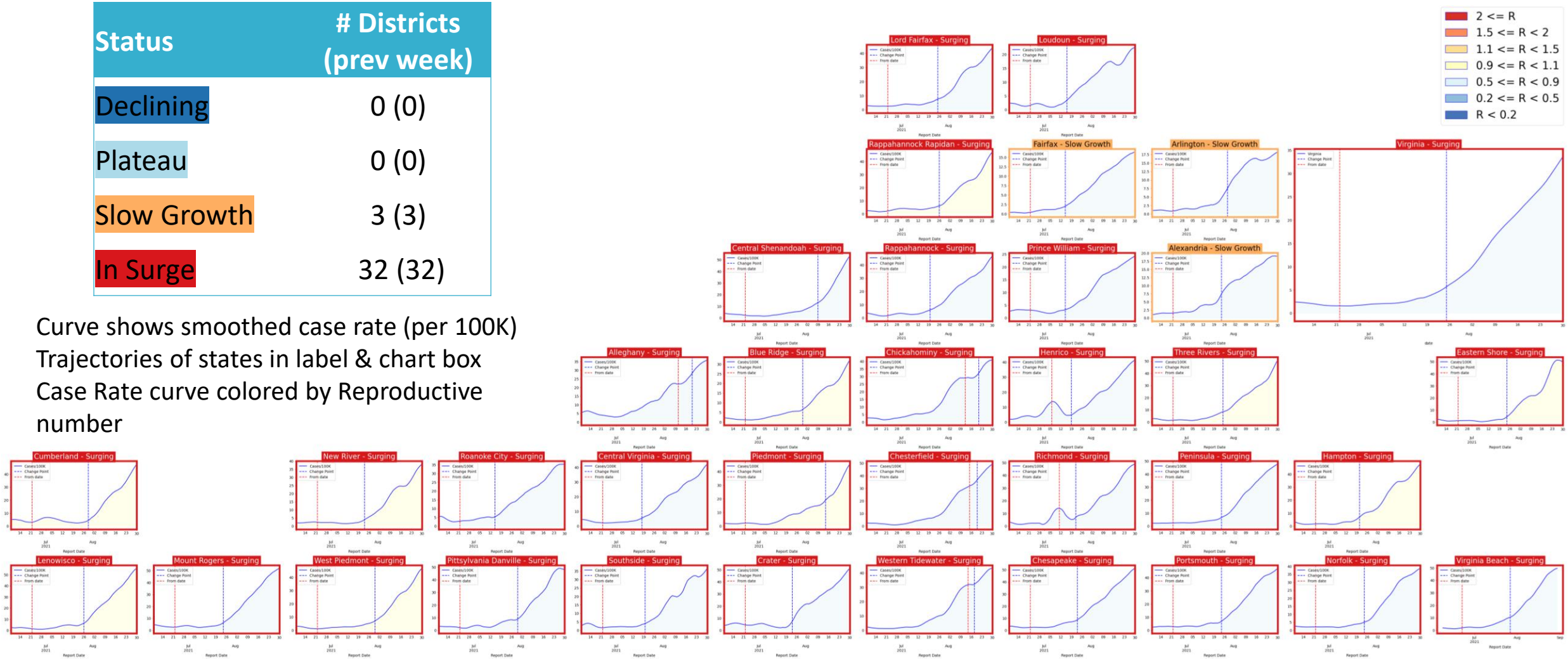


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	0 (0)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	0 (0)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	3 (2)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	32 (33)

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	0 (0)
Plateau	0 (0)
Slow Growth	3 (3)
In Surge	32 (32)

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



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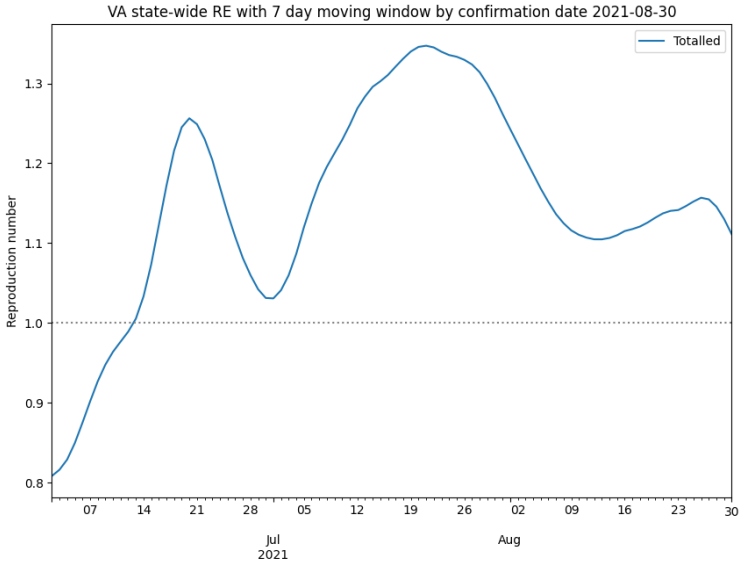
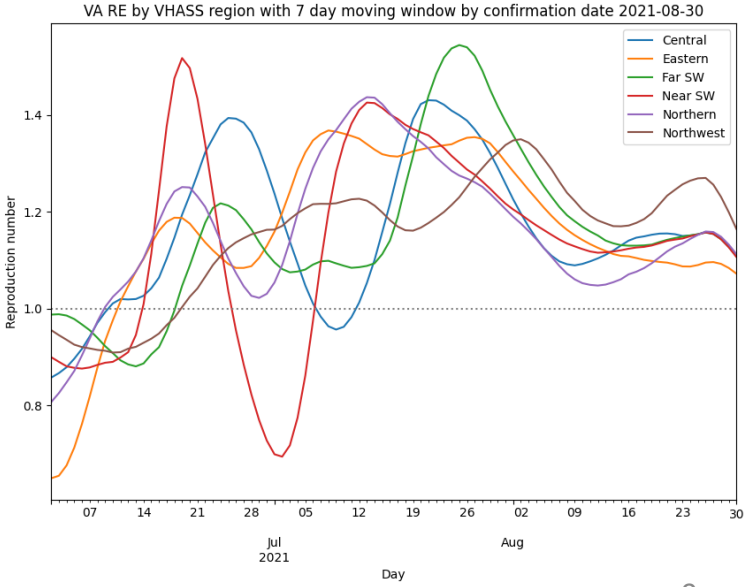
Estimating Daily Reproductive Number

August 30th Estimates

Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	1.111	-0.007
Central	1.109	-0.028
Eastern	1.071	-0.021
Far SW	1.107	-0.010
Near SW	1.107	-0.017
Northern	1.113	0.023
Northwest	1.164	0.027





Methodology

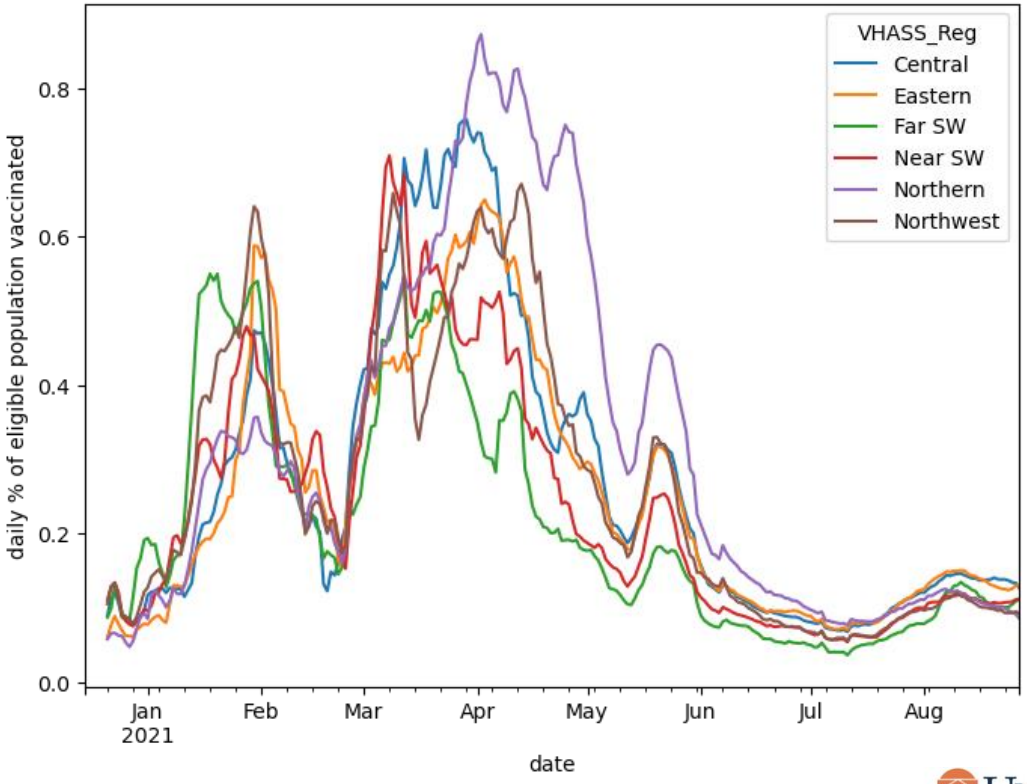
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

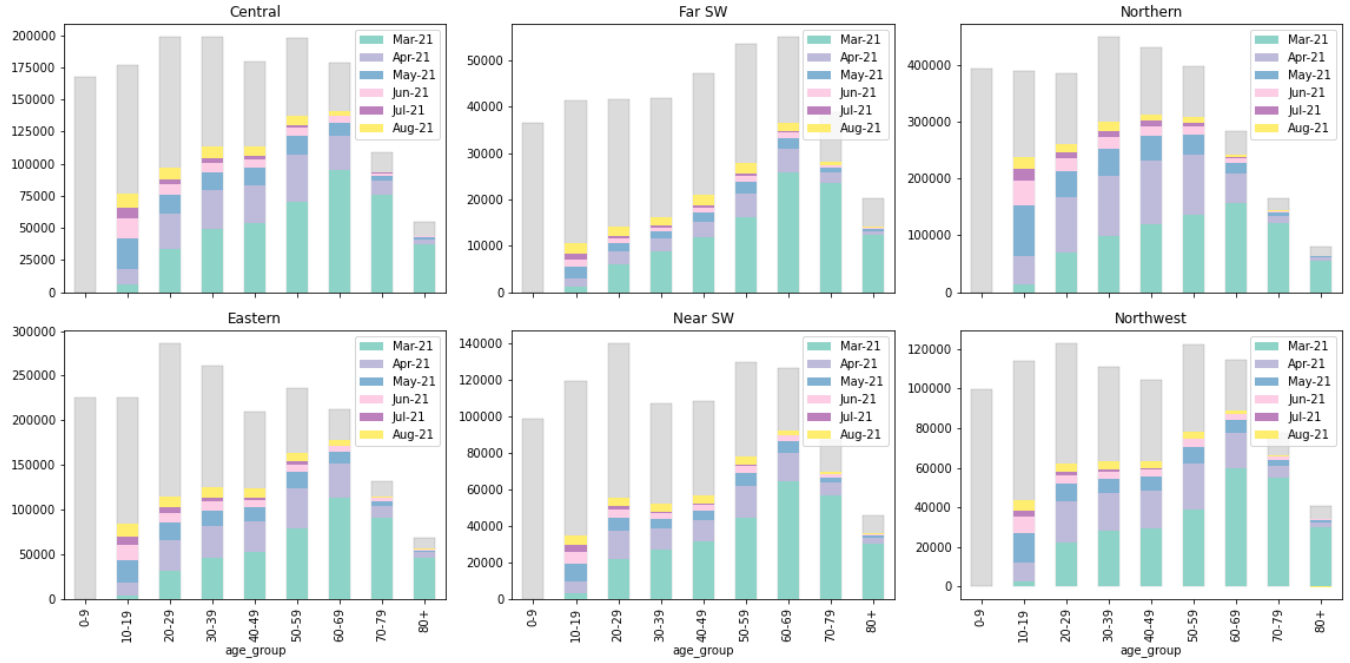
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Vaccination Administration Slows

Regional Vaccine courses initiated per day:

- Total counts of first dose of vaccines across regions
- Age-specific proportions of population vaccinated



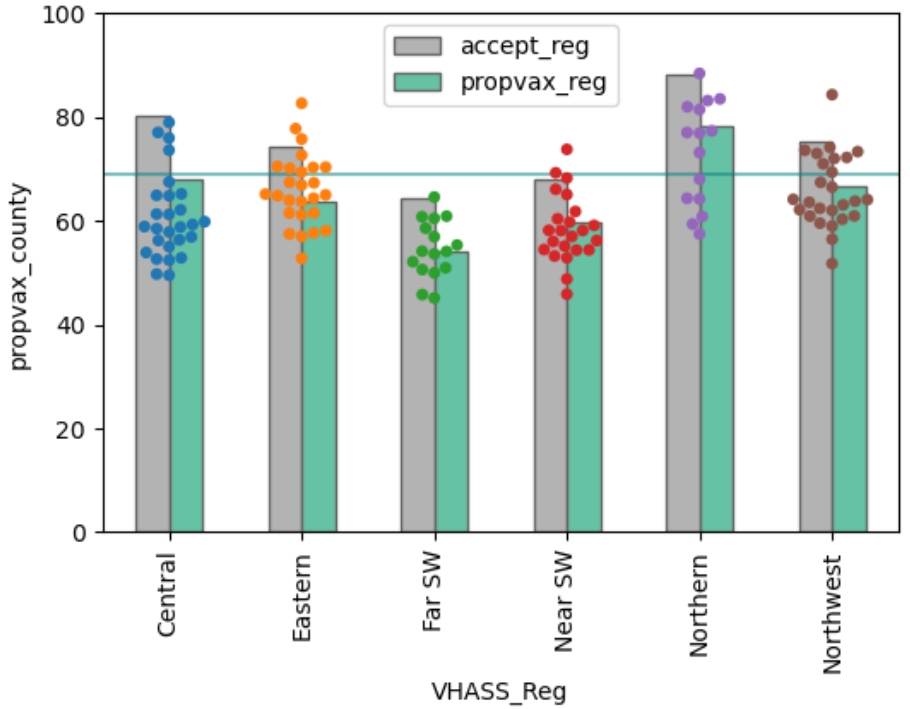


Vaccination Acceptance by Region

Corrections to surveys:

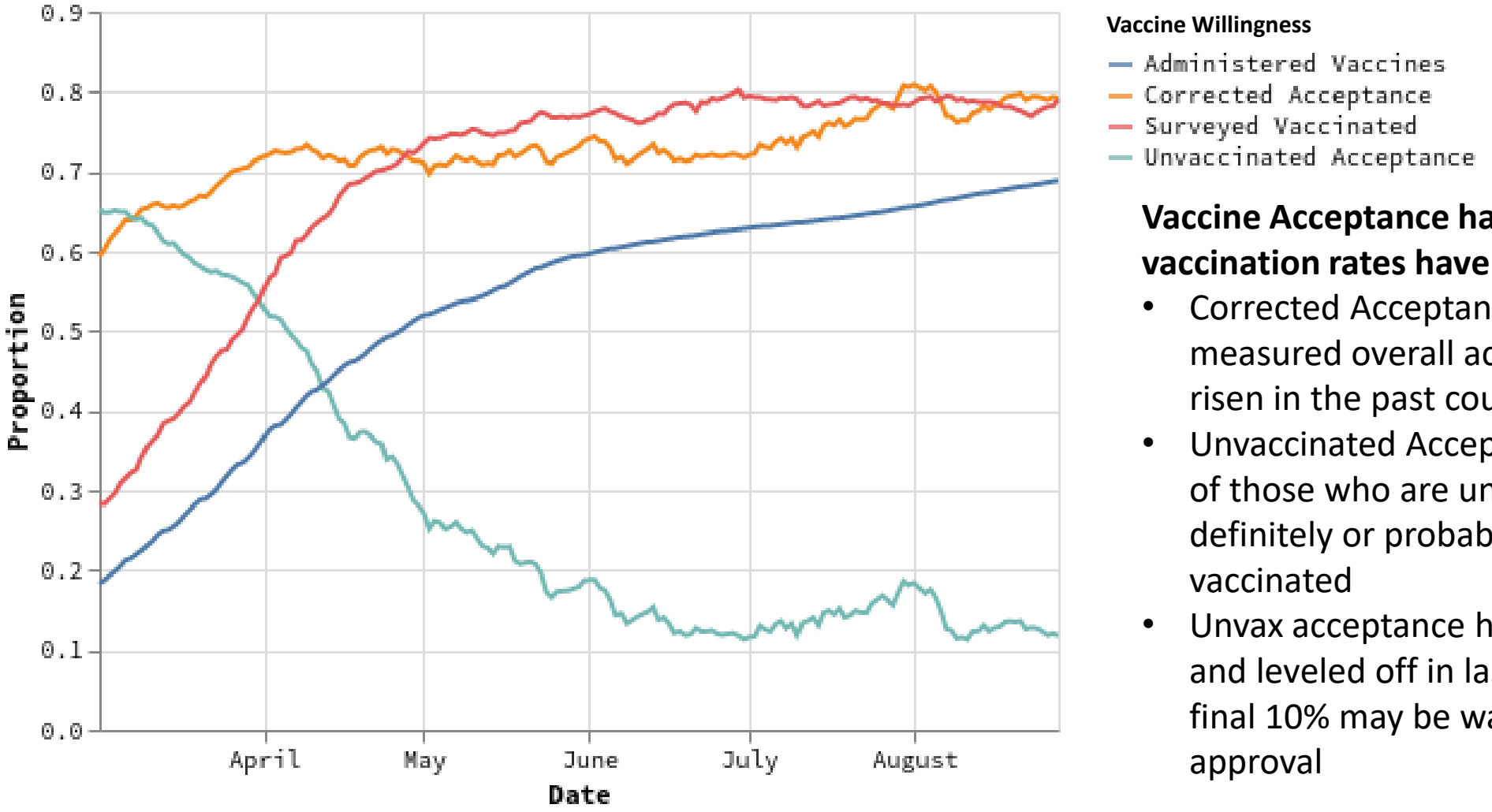
- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at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

Region	COVIDcast accepting corrected	VDH proportion pop vaccinated
Central	78%	68%
Eastern	75%	64%
Far SW	64%	54%
Near SW	68%	60%
Northern	89%	78%
Northwest	75%	67%
Virginia	**79%**	**69%**



Grey Bar: Survey measured and corrected acceptance
Green Bar: Proportion of eligible population administered a vaccine
Dots: Proportion administered at least one dose for each county

Vaccine Acceptance Components over Time



Vaccine Acceptance has risen as vaccination rates have climbed

- Corrected Acceptance reflects the daily measured overall acceptance and has risen in the past couple days
- Unvaccinated Acceptance shows ~10% of those who are unvaccinated are definitely or probably willing to be vaccinated
- Unvax acceptance has declined a bit and leveled off in last couple of weeks, final 10% may be waiting for FDA approval

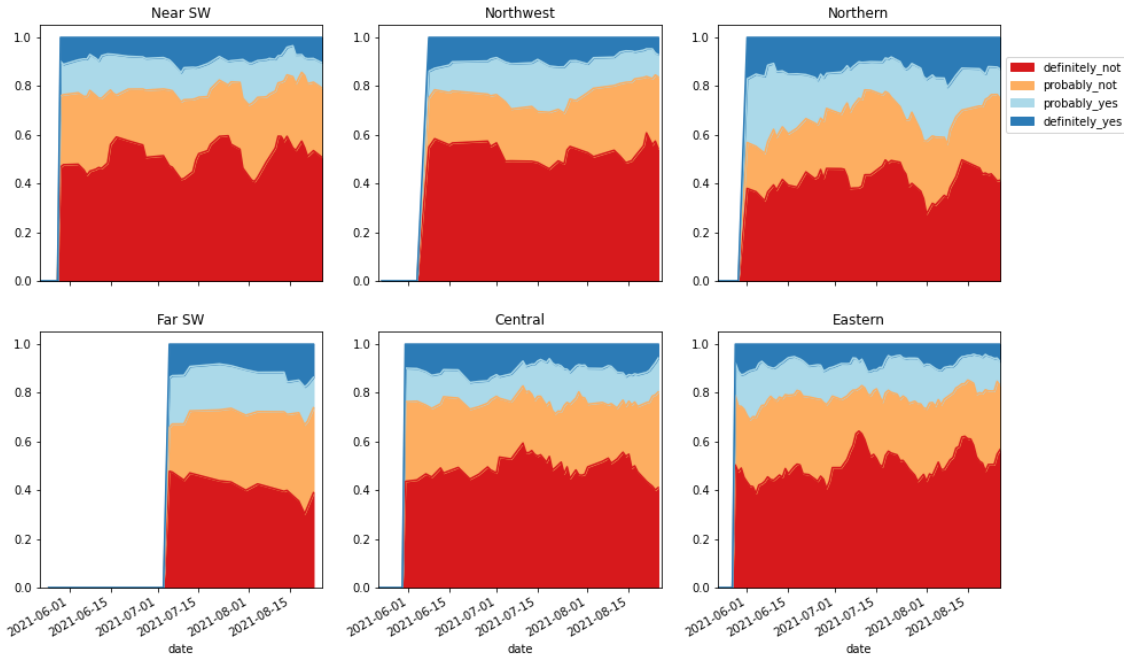
Data Source: https://covidcast.cmu.edu

Vaccine Acceptance by Region- COVIDcast

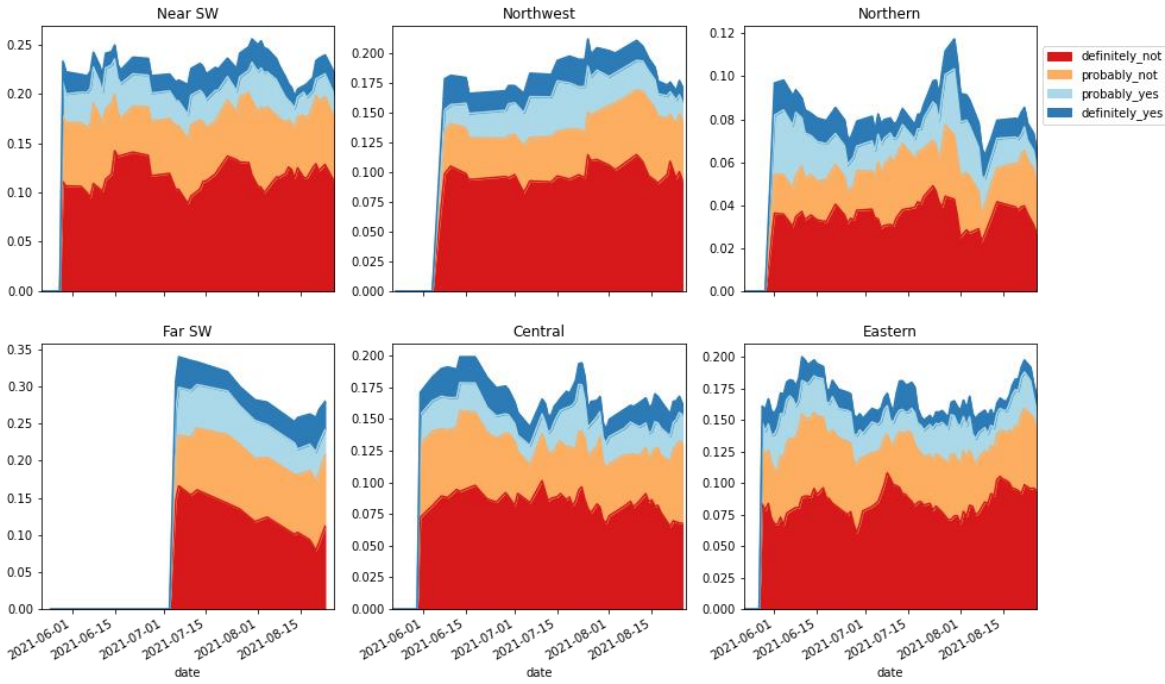
Levels of Acceptance and potential acceptance in flux:

- Most regions (except Central and Far SW) see vaccine uptake in the “Definitely Yes”.
- Among the unvaccinated, about 20-30% remain in the Definitely/Probably “Yes” categories.
- About 50% of the Unvaccinated seem to be in the “Definitely Not” category.

Unvaccinated Only



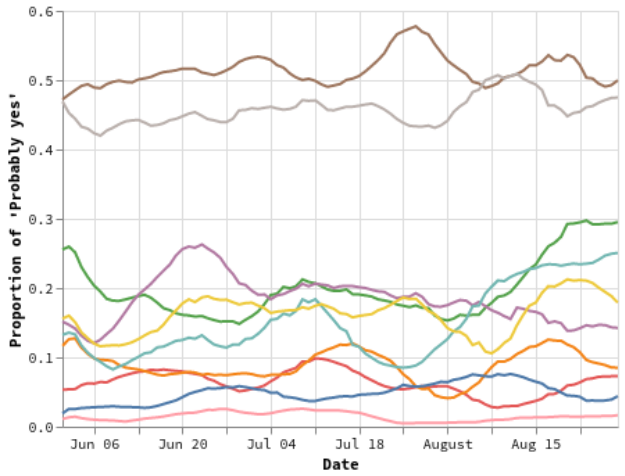
All Respondents



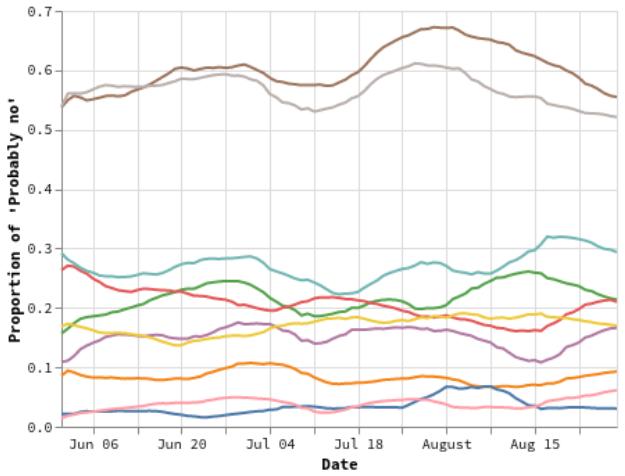
Data Source: https://covidcast.cmu.edu

Reasons for Hesitancy by Likeliness to Accept

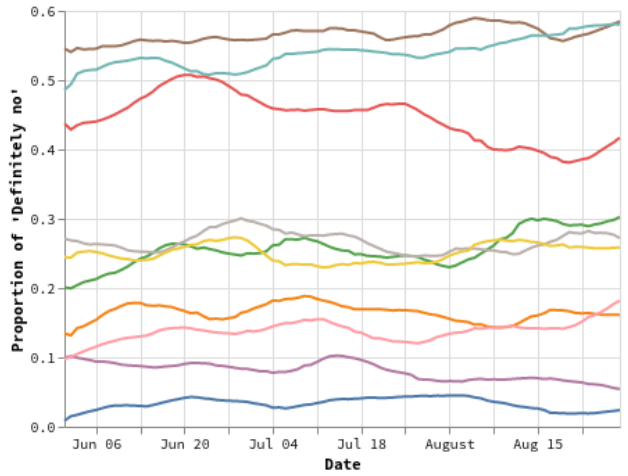
Probably Yes

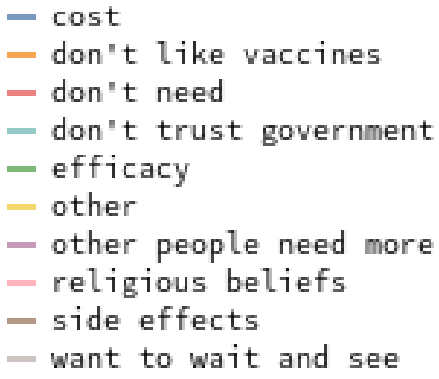


Probably No



Definitely No





Reasons for Hesitancy vary across tiers of likeliness to accept the vaccine

- Probably Yes and Probably No most concerned about side effects & are waiting to see
- Definitely No are concerned about side effects but also don't think they need the vaccine and don't trust the government, though don't need is declining
- Most other reasons are below 30% within these tiers of likeliness

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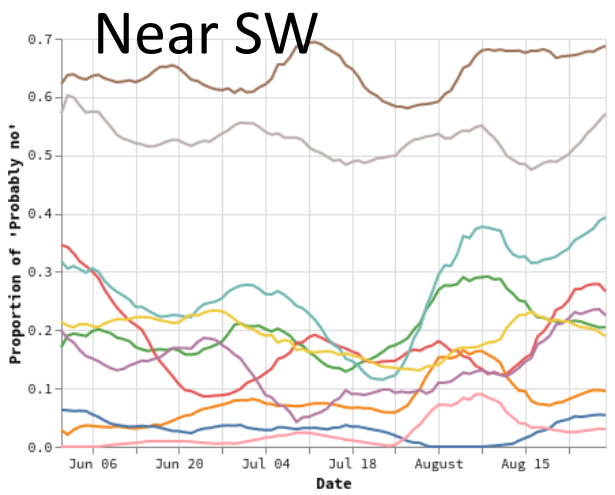
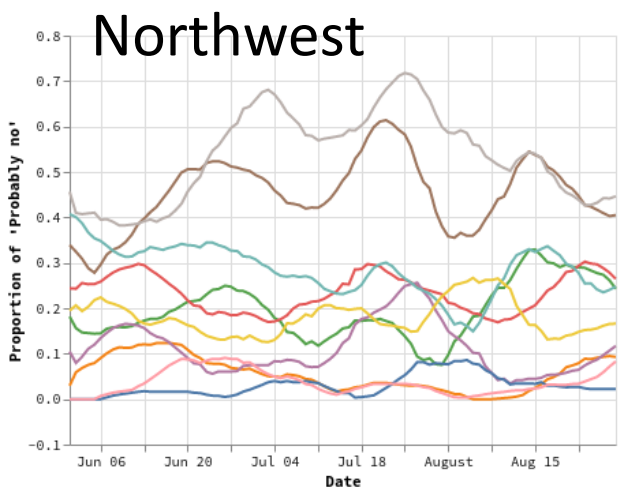
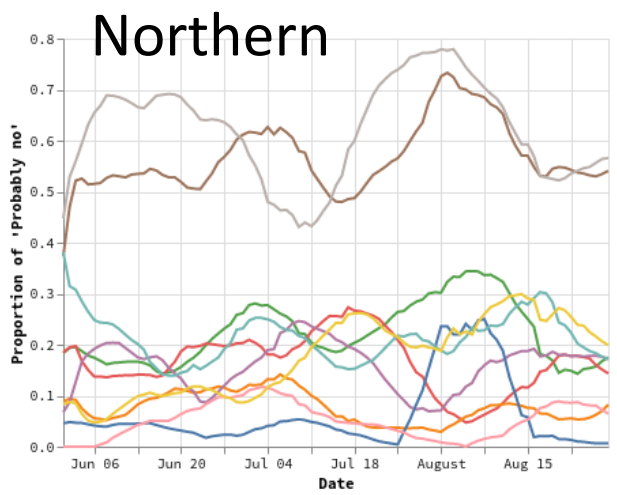
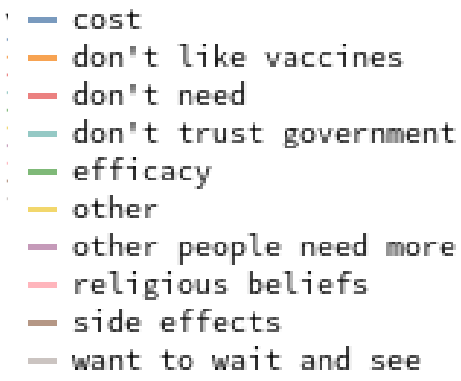
Data Source: https://covidcast.cmu.edu

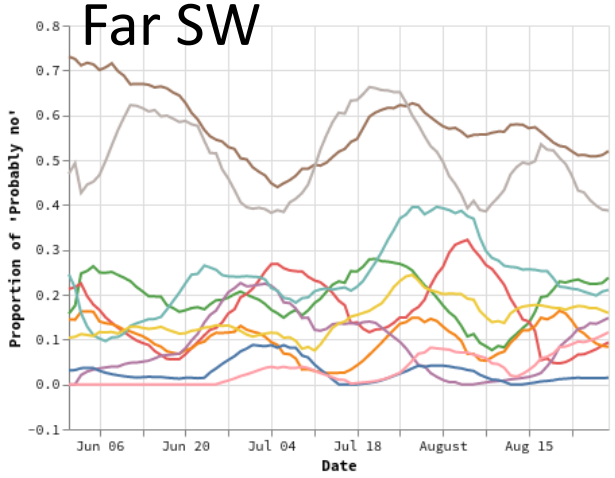
Reasons for Hesitancy of Probably No by Region

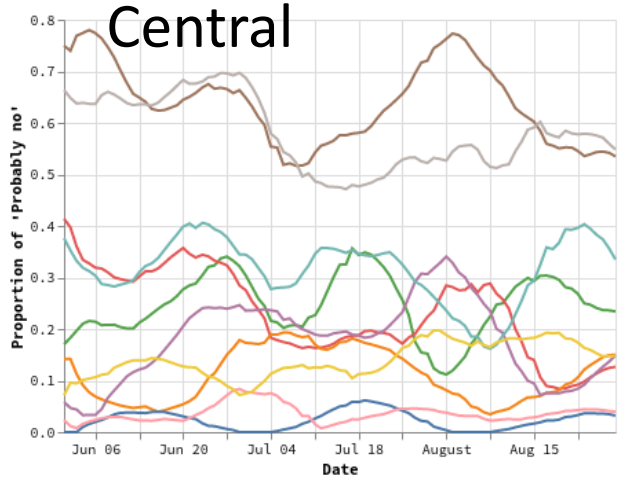


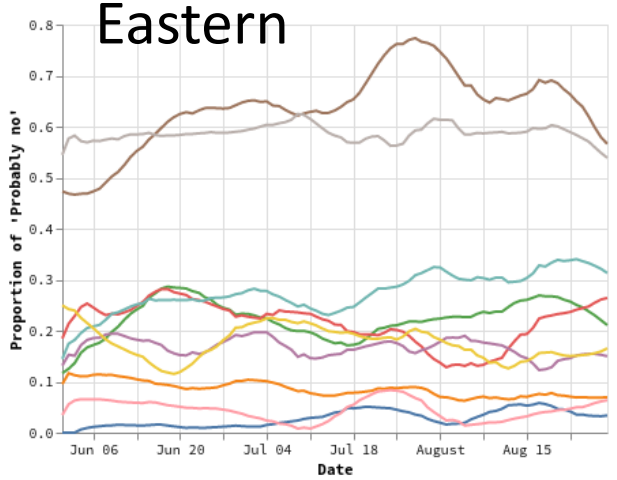












Reasons for Hesitancy vary across Regions

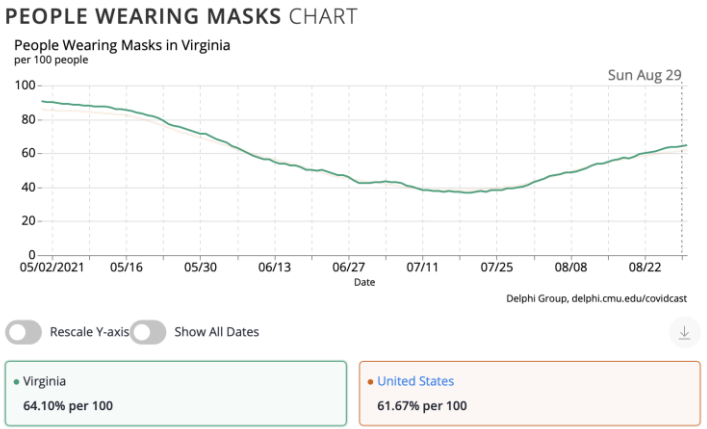
- Side effects and waiting to see safety are primary
- Most movement in last couple weeks seen in trust of govt and efficacy

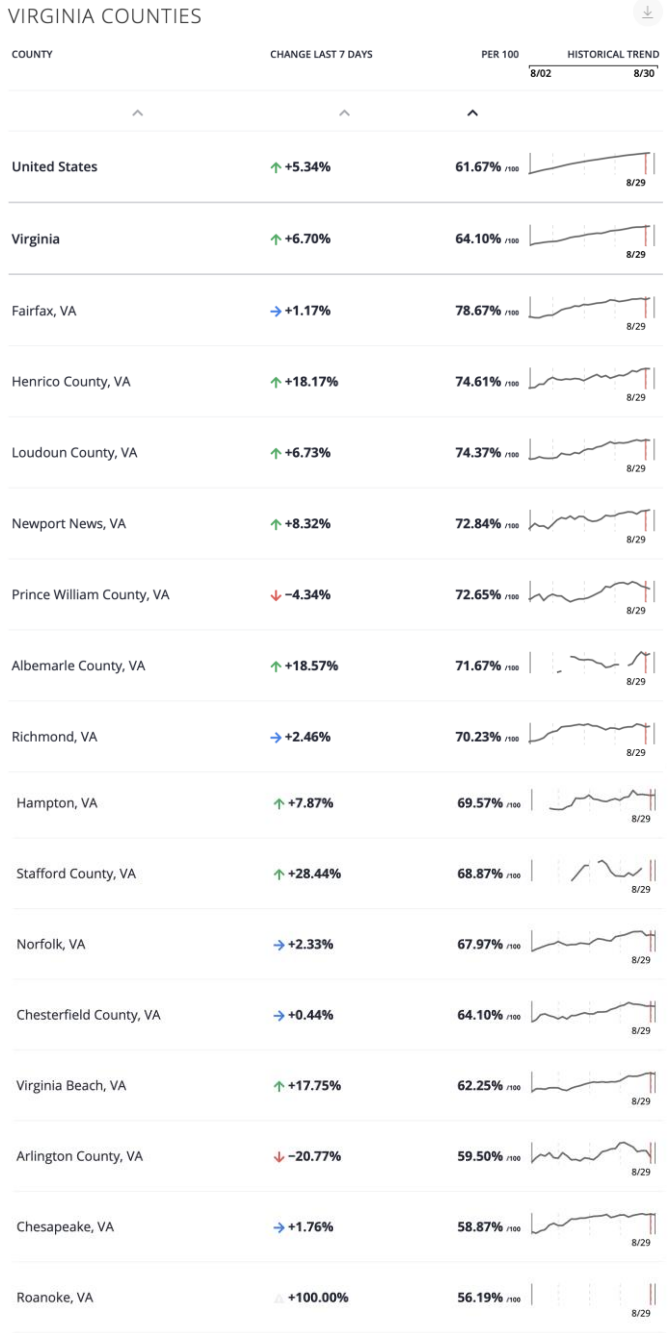
Data Source: https://covidcast.cmu.edu

Mask Usage Increases

Self-reported mask usage has declined for months, but rebounded

- State-wide continues to rise, now outpaces US (64% vs. 62%)
- Progress in some counties has stalled or declined





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

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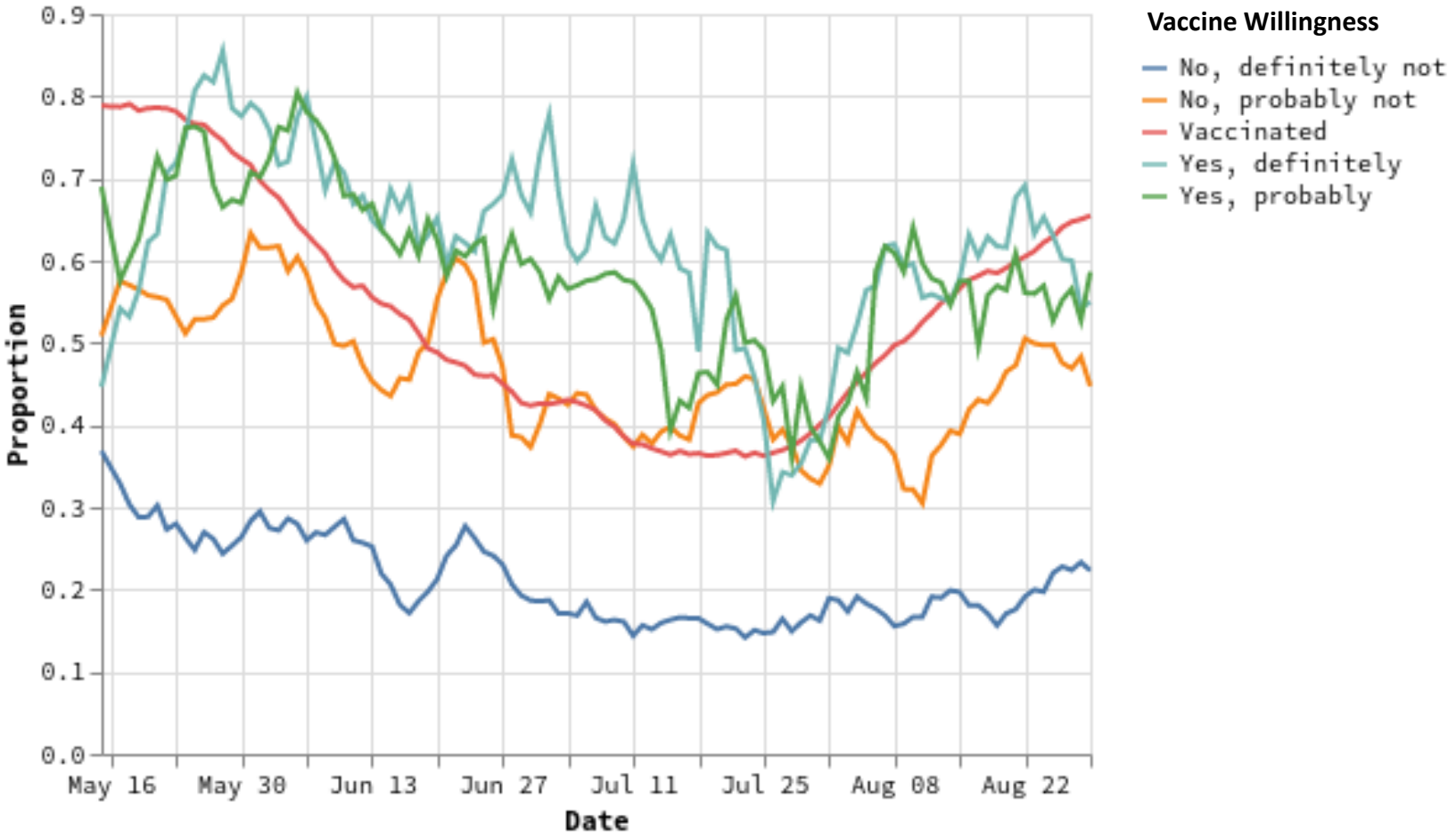
Mask Wearing by Vaccine Willingness

Among the different tiers of vaccine acceptance, mask wearing increasing

- Only those who would "definitely not" take the vaccine if offered have a low level of mask usage
- Slight decline for Definitely Yes, Probably Yes, and Probably No
- Vaccinated slightly higher in mask wearing than unvaccinated



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

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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

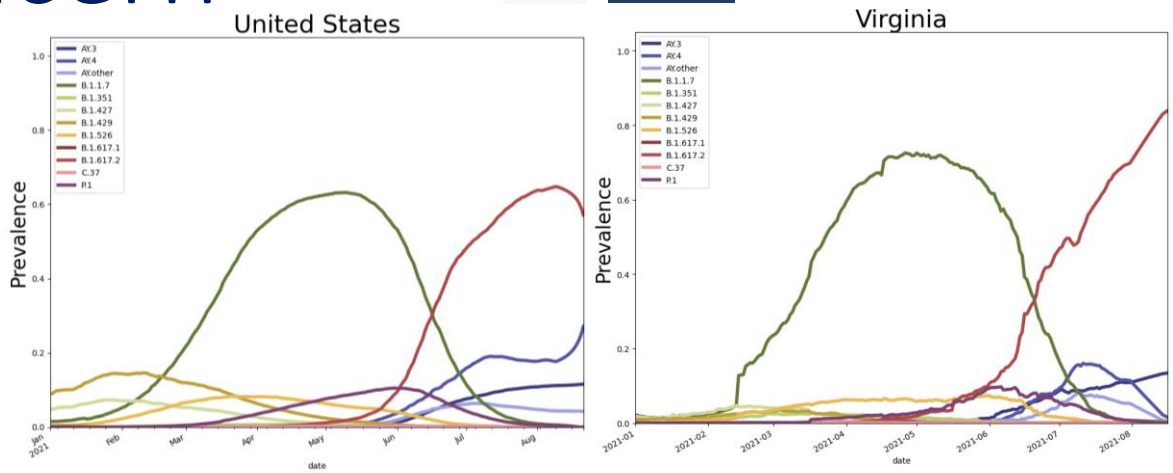
	New WHO Name	Transmissibility	Immune Evasiveness	Vaccine Effectiveness^
Ancestral		—	—	✓
D614G		+	—	✓
B.1.1.7	Alpha	+++	—	✓
B.1.351	Beta	+	++++	✓
P.1	Gamma	++	++	✓
B.1.429	Epsilon	+	+	✓
B.1.526	Iota	+	+	✓
B.1.617.2	Delta	++++*	++#	✓

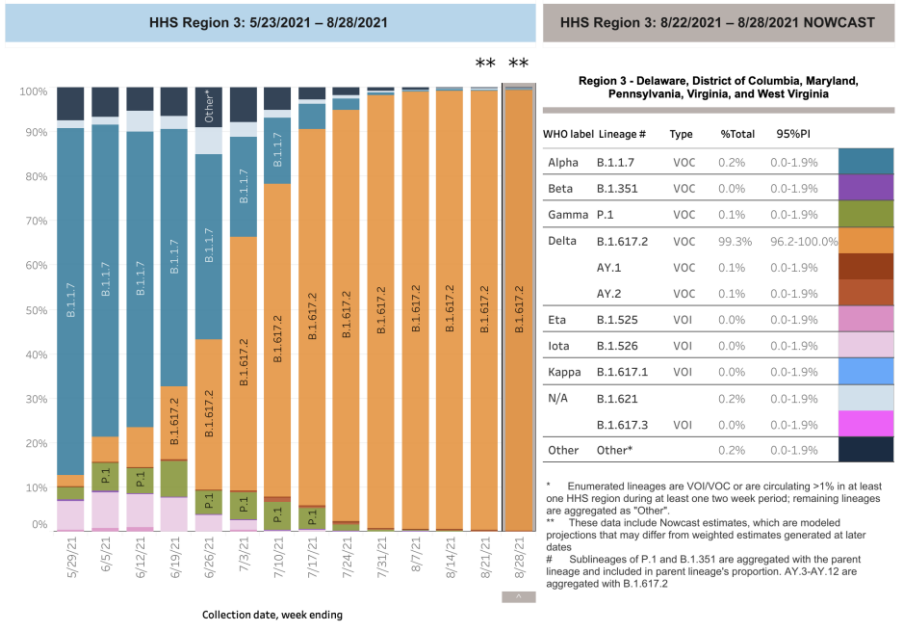
*Relative transmissibility to B.1.1.7 yet to be fully defined
^Effectiveness from real world evidence vs. severe illness, not all vaccines are effective vs all variants, and importance of 2-doses, especially for B.1.617.2 for which 1 dose of mRNA or AZ is only ~30% effective # May carry more immune escape than P.1, to be determined

World Health Organization

WHO and Eric Topol

GISAID outbreak.info





CDC Variant Tracking

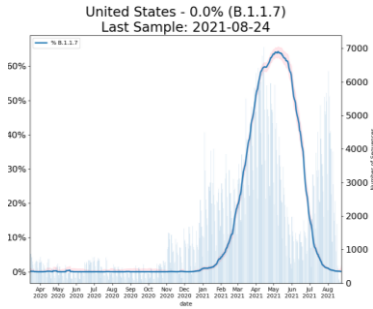
SARS-CoV2 Variants of Concern

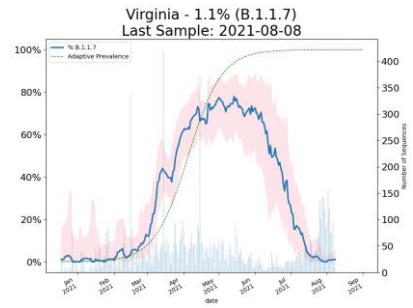
Alpha α - Lineage B.1.1.7

Prevalence: Nationally low, decline from a high of 60% (VA reached about 80%)

Transmissibility: Estimated increase of 50% compared to previous variants. B.1.1.7's mutations boost 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

Severity: Increased 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 estimates 60% higher mortality

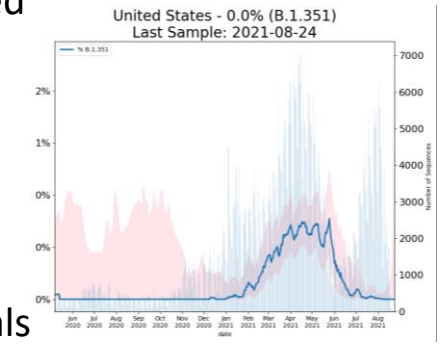


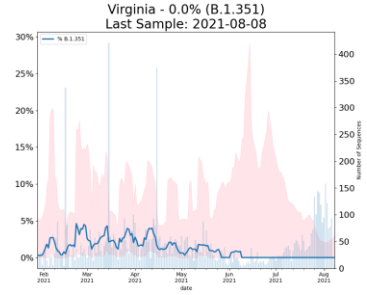


Beta β - Lineage B.1.351

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

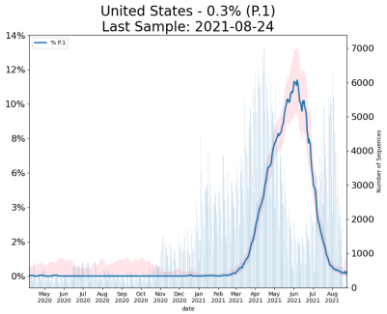


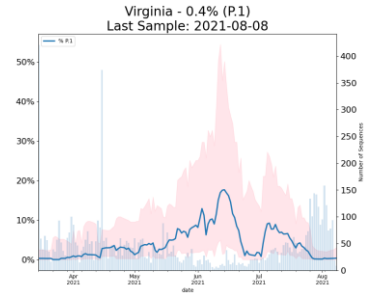


Gamma γ - Lineage P.1

Prevalence: Nationally low, declining from a high of 12%

Study estimates 17-32% of all infections in Manaus in 2021 were reinfections, which helps explain data from Brazil demonstrating P.1's continued dominance in Rio despite presence of B.1.1.7

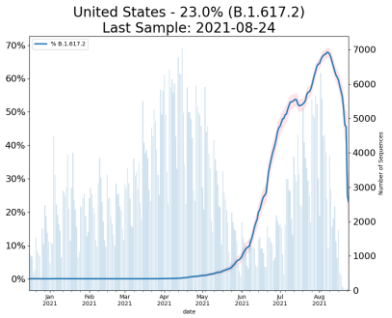


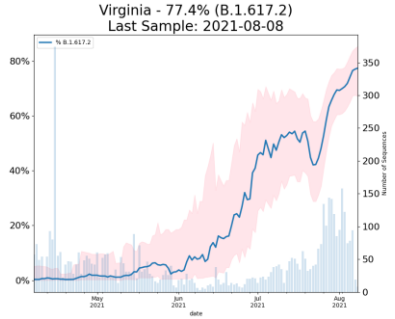


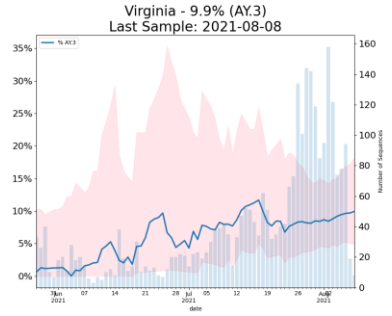
SARS-CoV2 Variants of Concern

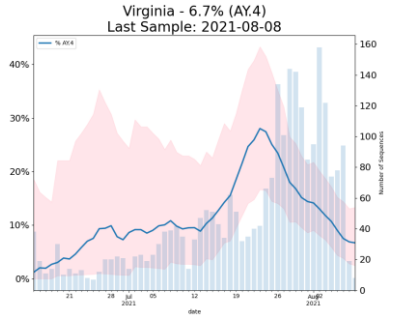
Delta δ - Lineage B.1.617.2 and related subvariants

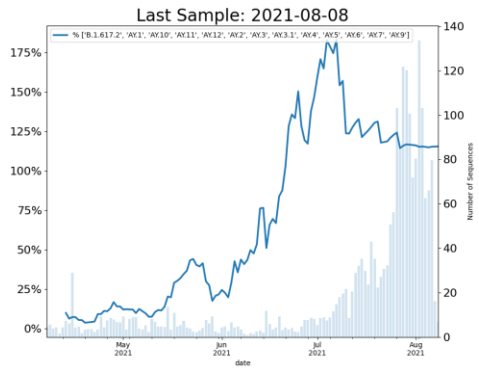
- Delta plus δ+ lineage which contains the K417N mutation is emerging as a sub-variant that is even more transmissible; declared a VoC in India
- Delta variant now dominates most of Europe and US
- CDC recommends resumption of mask wearing indoors due to reports of breakthrough infections of the vaccinated possibly being transmissible
- Recent study from Mayo clinic shows Delta reducing the efficacy of mRNA vaccines (Pfizer more so than Moderna) along with other reports. Israeli study showed 64% efficacy against infection, however, a 3rd dose may counteract this reduction
- Public Health Scotland study in Lancet suggests Delta is 2x more likely to cause hospitalization than Alpha
- Subvariants AY.3 (9%) and AY.4 (4%) of Delta are more prevalent, these subvariants are mainly
  may be more transmissible than Delta itself











All other subvariants

Variants & Vaccines

August 31, 2021

1. Israeli study shows that natural immunity provides stronger protection (13x) against the Delta variant and potentially wanes less rapidly
2. School study in France demonstrates the benefits of weekly screening of students compared to symptom based testing
3. Scotland's return to school following their large delta wave seems to be driving another surge, significant number of cases in the 15-19 range
4. Analysis of household transmission pairs in Singapore suggest that the serial interval for delta variant is similar to other Variants, thus transmission boost is mainly from increased infectivity

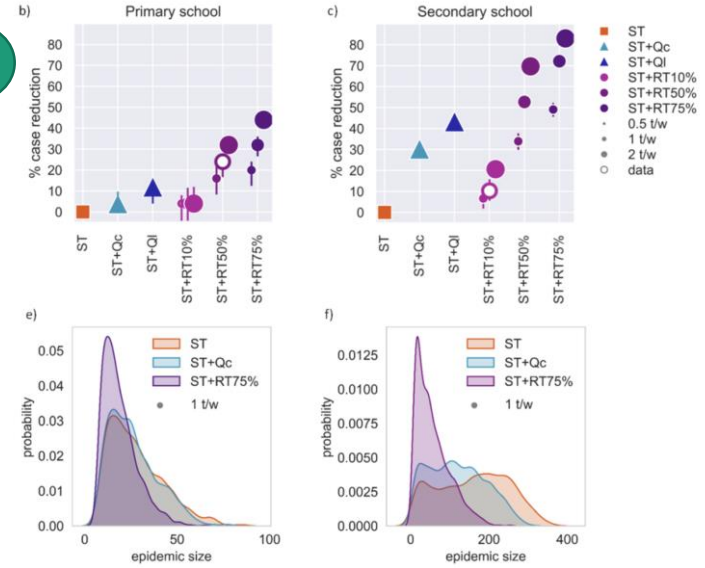
1

Table 2a. OR for SARS-CoV-2 infection, model 1, previously infected vs. vaccinated

Variable	Category	ß	OR	95%CI	P-value
Induced Immunity					
	Previously infected	Ref			
	Vaccinated	2.57	13.06	8.08 – 21.11	<0.001

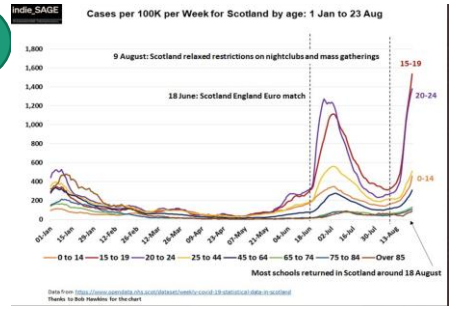
Recent Israel based study found vaccinees with no prior infection had a 13.06-fold (95% CI, 8.08 to 21.11) increased risk for breakthrough infection with the Delta variant compared to those previously infected, when the first event (infection or vaccination) occurred during January and February of 2021. The increased risk was significant (P<0.001) for symptomatic disease as well.
https://www.medrxiv.org/content/10.1101/2021.08.24.21262415v1

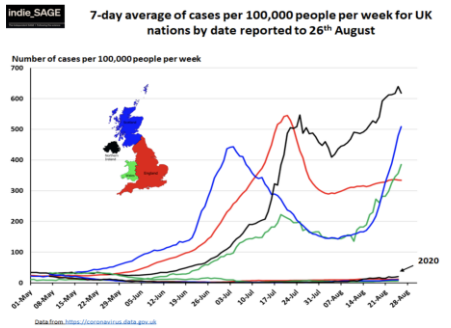
2



Using empirical contact data measured in a primary and a secondary school in France, and field estimates for adherence to screening from 683 schools during the spring 2021 wave, this France based study examines different screening protocols, using a cost-benefit analysis for varying epidemic conditions and vaccination scenarios. In a partially immunized school population, weekly screening would reduce the number of cases on average by 24% in the primary and 53% in the secondary school compared to symptom-based testing alone, if R=1.3 and 50% adhered to screening.
https://www.medrxiv.org/content/10.1101/2021.08.15.21261243v1.full.pdf

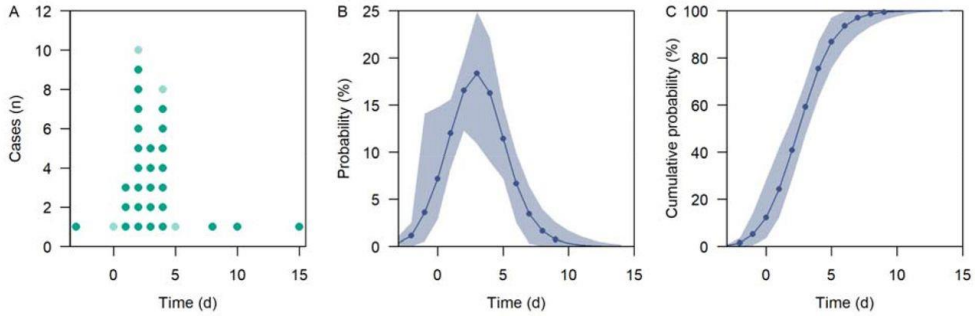
3





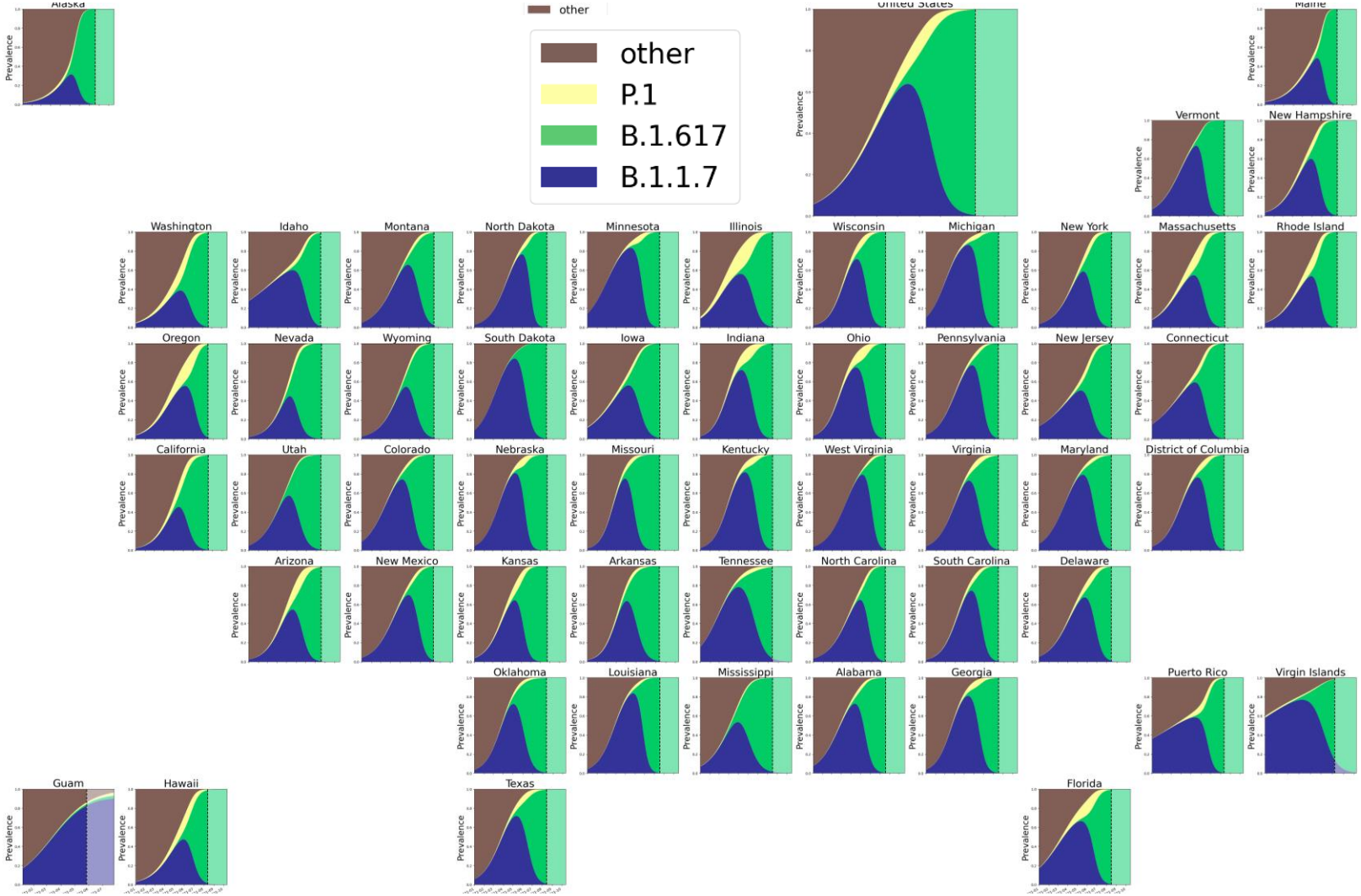
Scottish return to school potentially contributing to increase in cases. Overall in worse shape than 2020 heading into Fall.
https://twitter.com/chrischirp/status/1431312408631410691

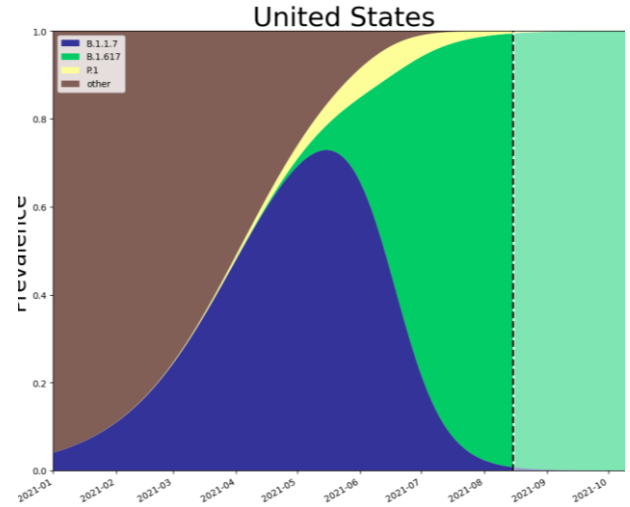
4

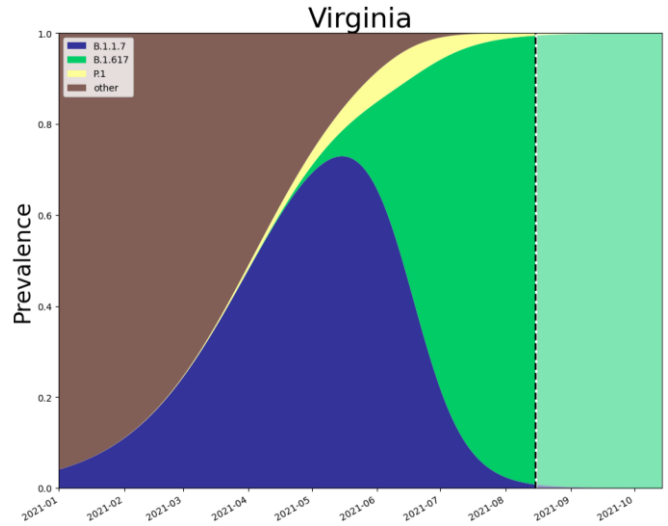


After controlling for confounding factors, our findings suggest no significant changes in the serial intervals for SARS-CoV-2 cases infected with the B.1.617.2 variant. This, in turn, lends support for the hypothesis of a higher R in B.1.617.2 cases.
https://www.medrxiv.org/content/10.1101/2021.06.04.21258205v1.full-text

Variant of Concern Trajectories







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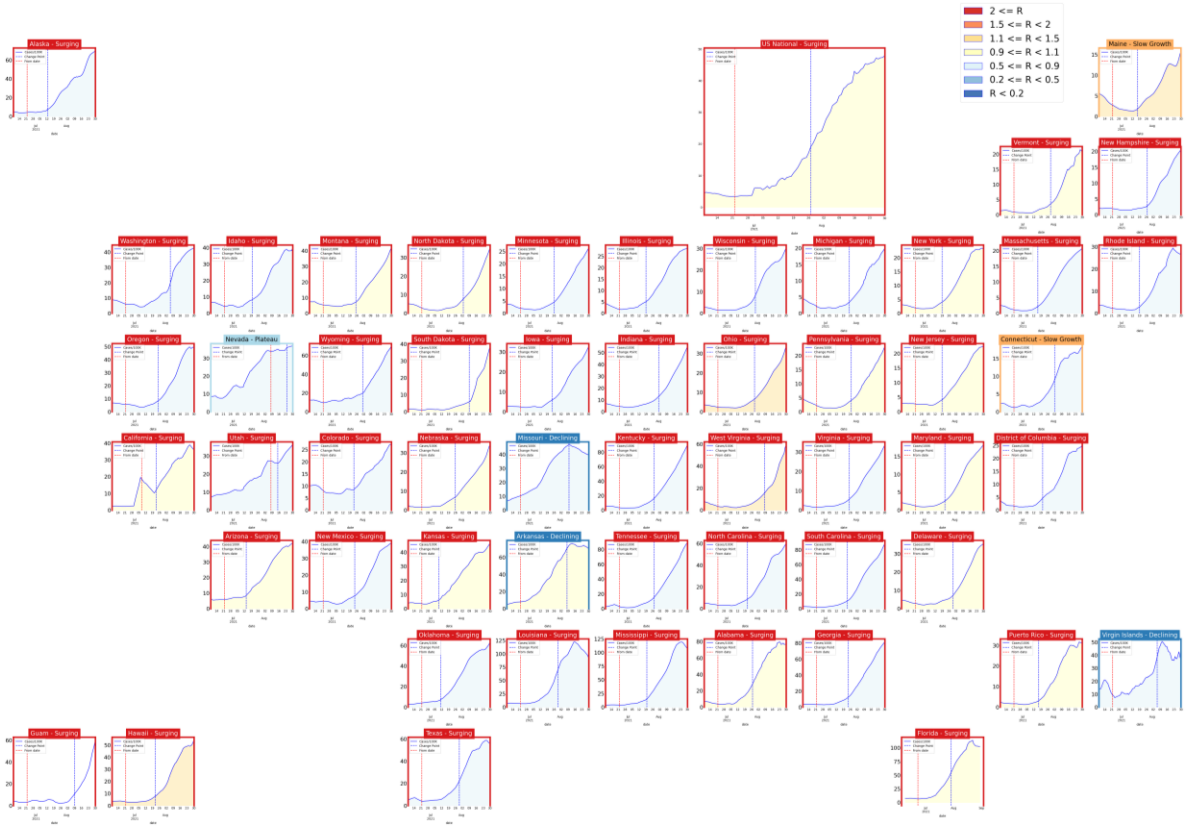
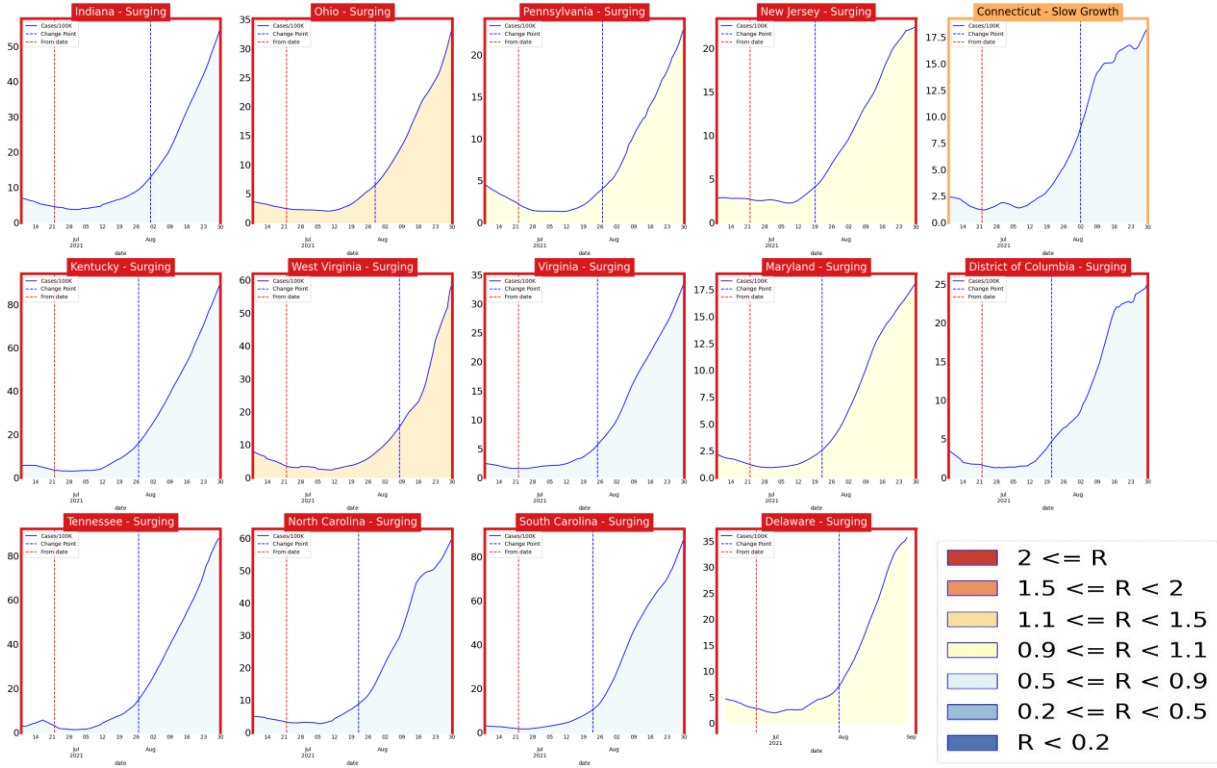
Other State Comparisons

Trajectories of States



- Most of the country remains in Surge, but several states have peaked and are now in decline
- Case rates remain high, but pace of growth has slowed

Virginia and her neighbors

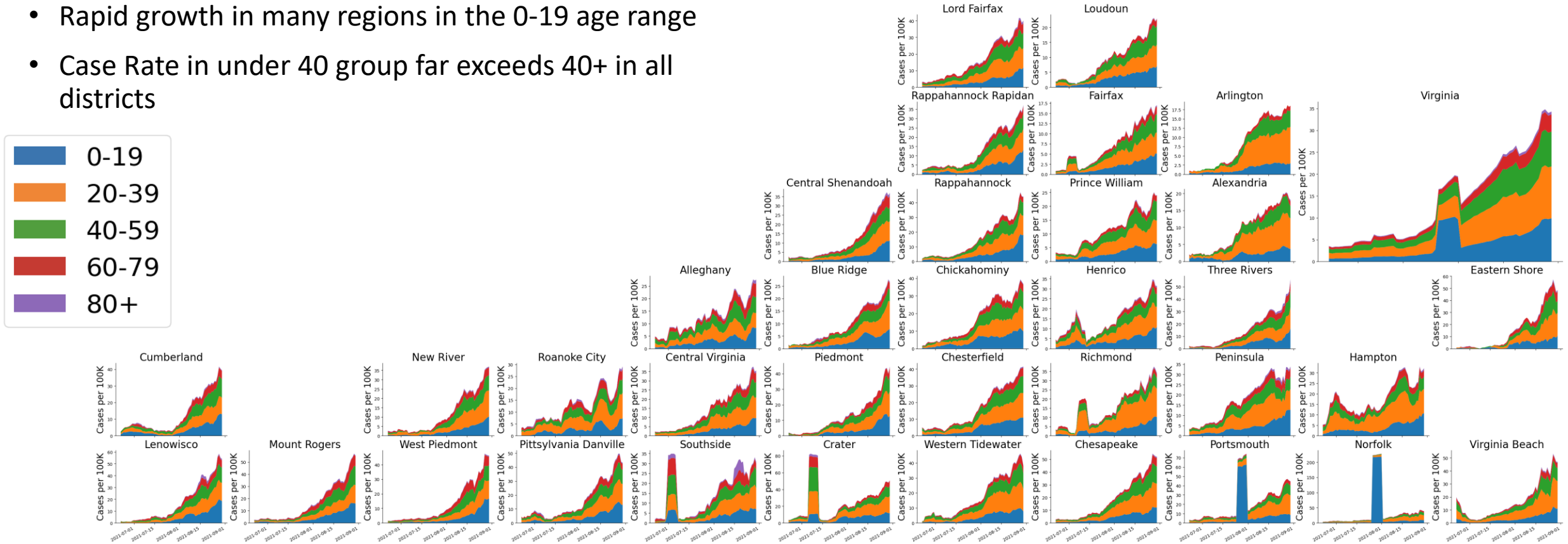


- VA and many neighbors continue to surge
- Many neighbors are in surge and have reached very high case rates

Age-Specific Case Rates

Case Rates (per 100K) by Age Groups

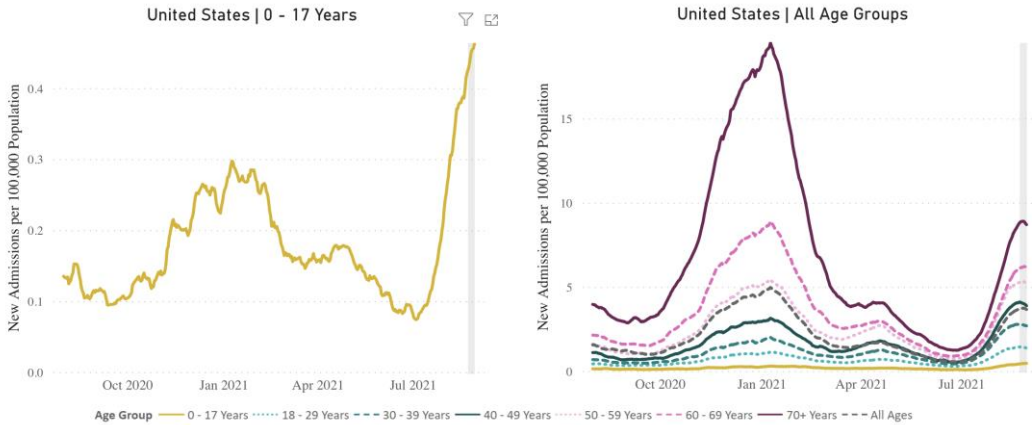
- Rapid growth in many regions in the 0-19 age range
- Case Rate in under 40 group far exceeds 40+ in all districts



Hospitalizations across the US

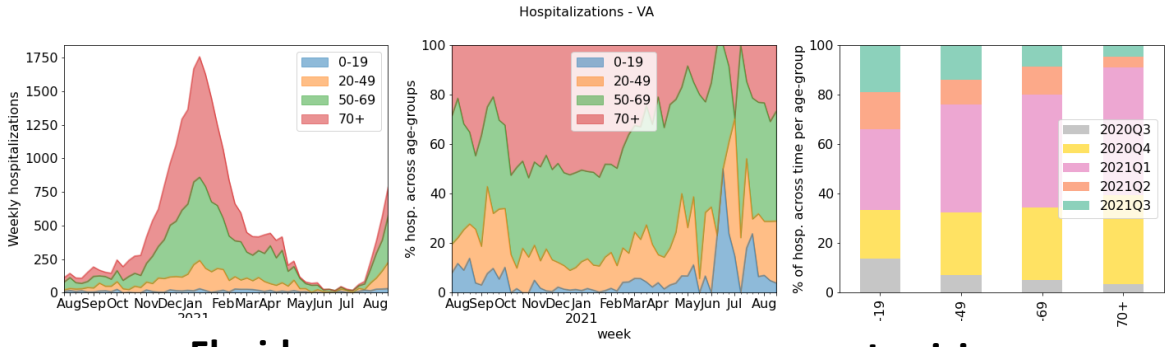
Hospitalization rates remain low in VA, but rapid change is possible as seen in other states

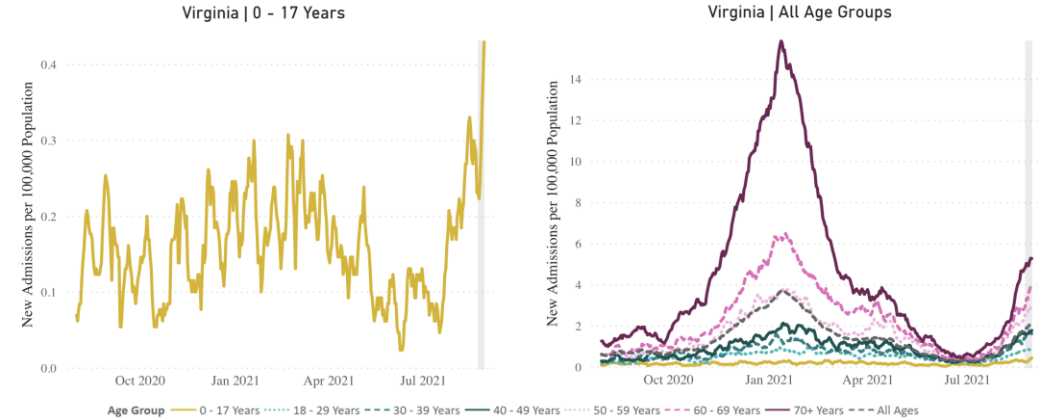
- Hotspot states see rapid rise in hospitalizations especially among the younger age groups
- Nationally pediatric hospitalizations are at an all time high since the pandemic began



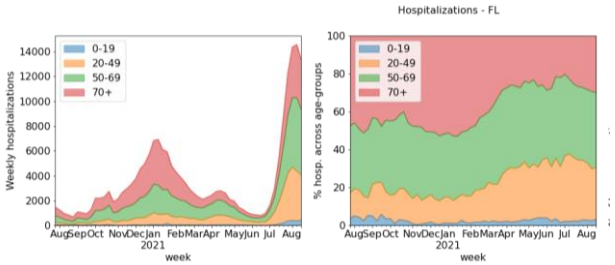
Source: https://covid.cdc.gov/covid-data-tracker/#new-hospital-admissions

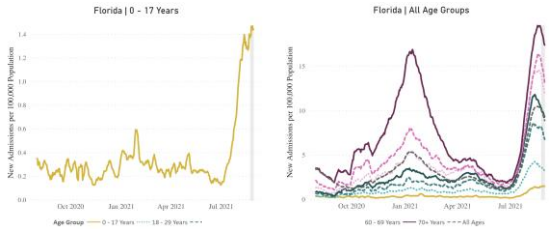
Virginia



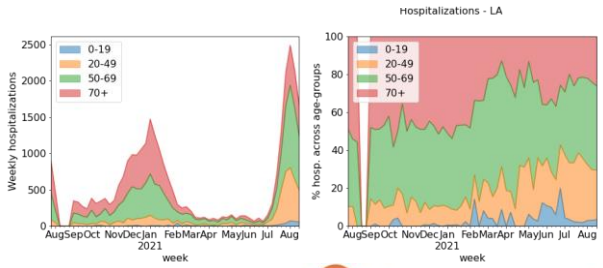


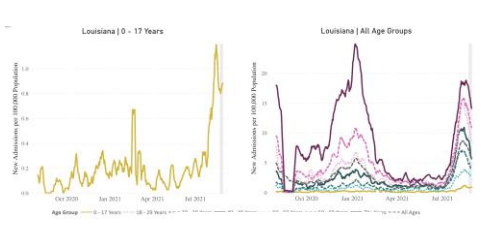
Florida





Louisiana





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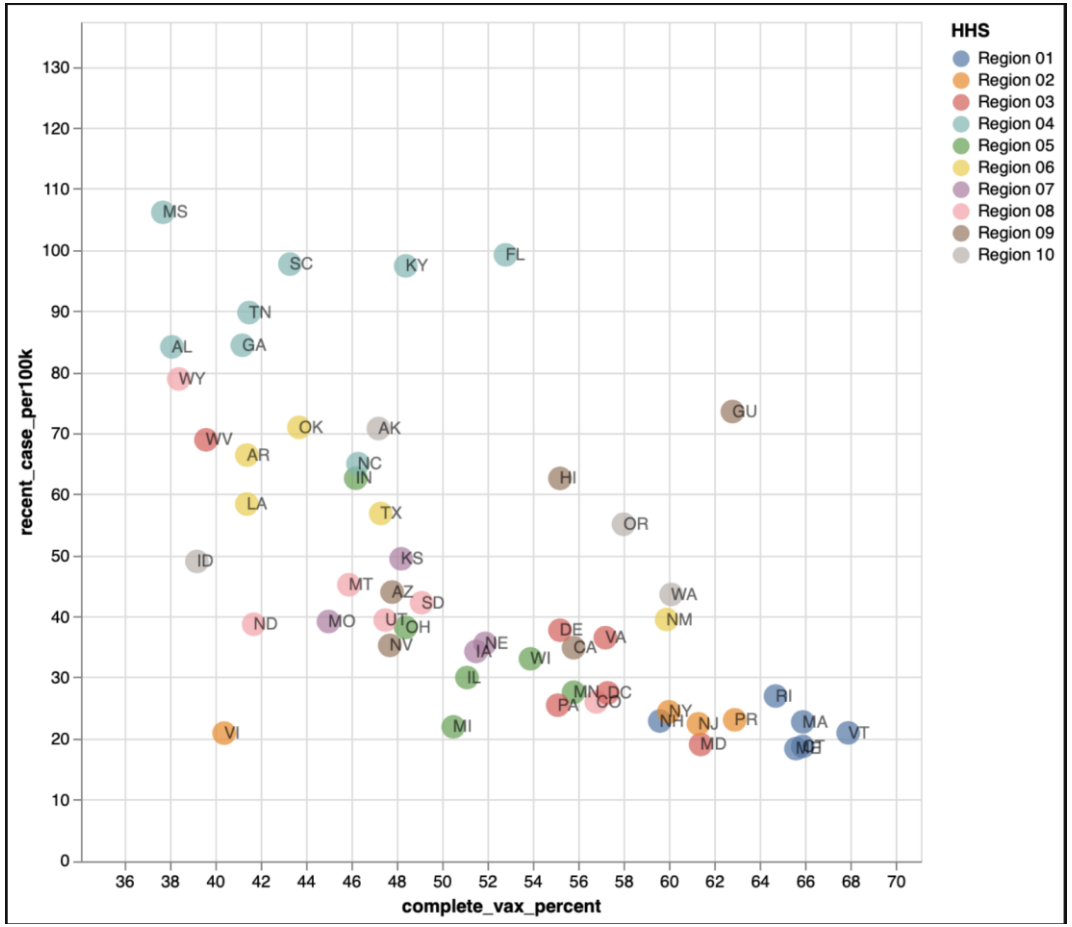
Recent Cases Correlate with Vax Coverage

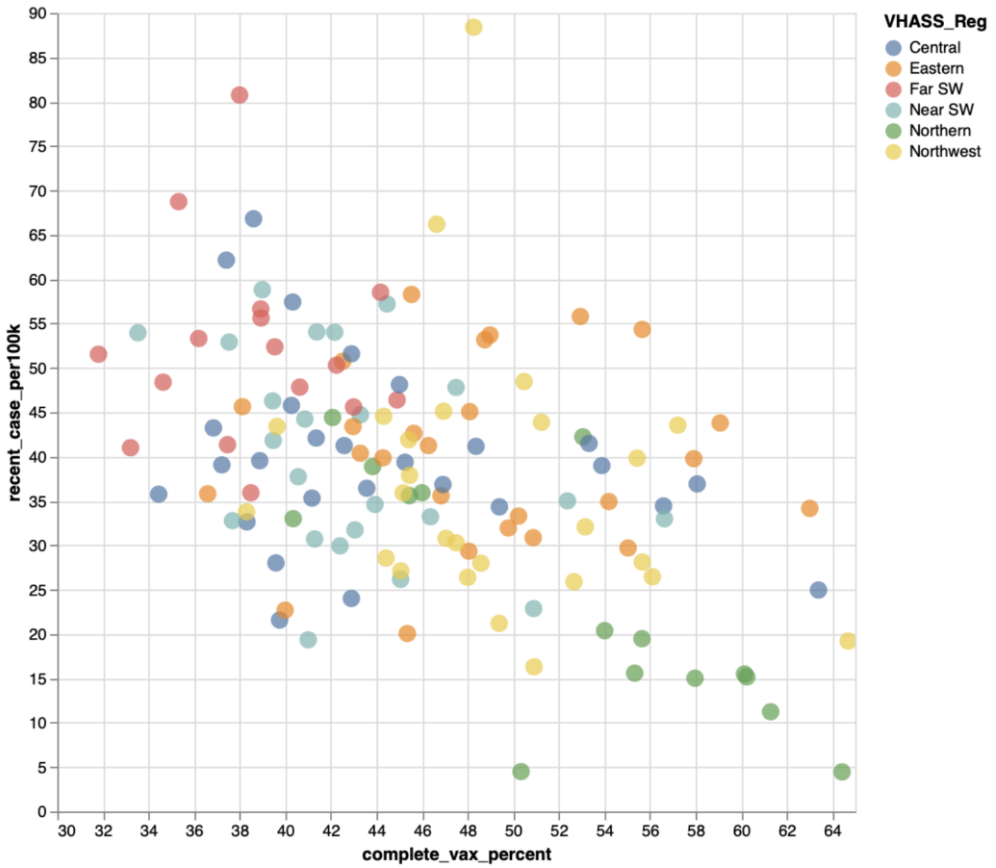
Mean cases per 100K vs. vaccine coverage

- States with lower vax coverage have had the worst case spikes
- Virginia 14th out of 51 states in fully vaccinated coverage



Virginia Counties

- Counties with higher vax coverage are maintaining lower case rates (e.g., Albemarle, Fairfax city)
- Many counties with low vax coverage starting to rise as Delta surge reaches more remote areas of state



Zip code level weekly Case Rate (per 100K)

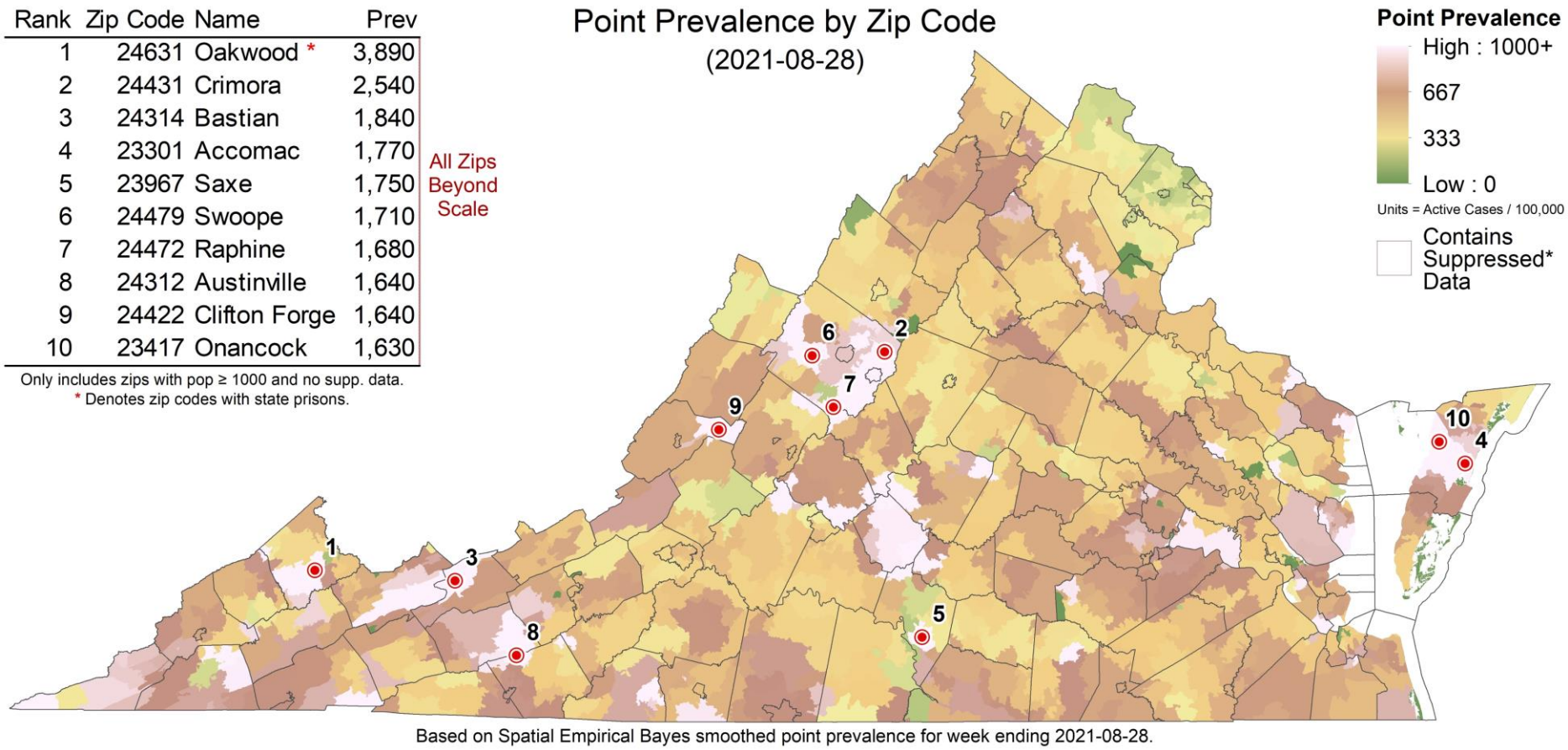
Case Rates in the last week by zip code

- Clusters of high prevalence in Southwest and Eastern
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prev
1	24631	Oakwood *	3,890
2	24431	Crimora	2,540
3	24314	Bastian	1,840
4	23301	Accomac	1,770
5	23967	Saxe	1,750
6	24479	Swoope	1,710
7	24472	Raphine	1,680
8	24312	Austinville	1,640
9	24422	Clifton Forge	1,640
10	23417	Onancock	1,630

All Zips 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 2021-08-28.

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Risk of Exposure by Group Size

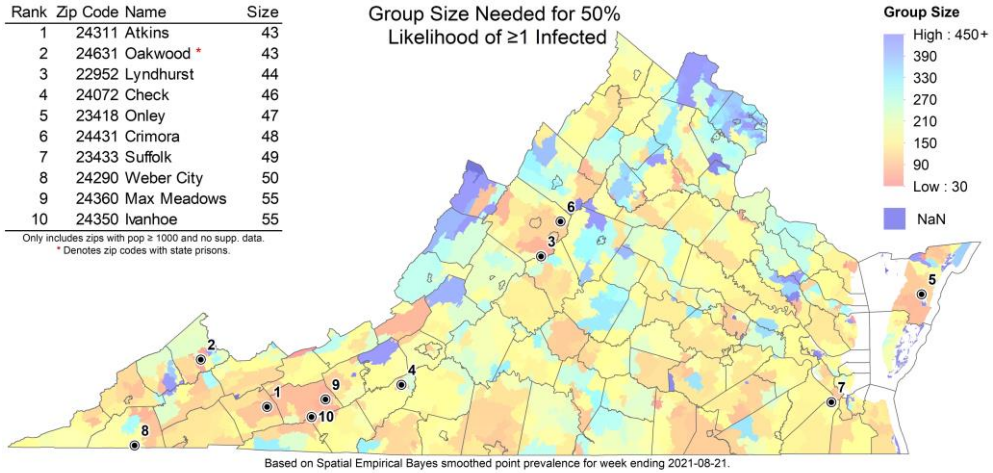
Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people (group size 25)

- **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 17 in Oakwood, there is a 50% chance someone will be infected)

From Last Week

Rank	Zip Code	Name	Size
1	24311	Atkins	43
2	24631	Oakwood *	43
3	22952	Lyndhurst	44
4	24072	Check	46
5	23418	Onley	47
6	24431	Crimora	48
7	23433	Suffolk	49
8	24290	Weber City	50
9	24360	Max Meadows	55
10	24350	Ivanhoe	55

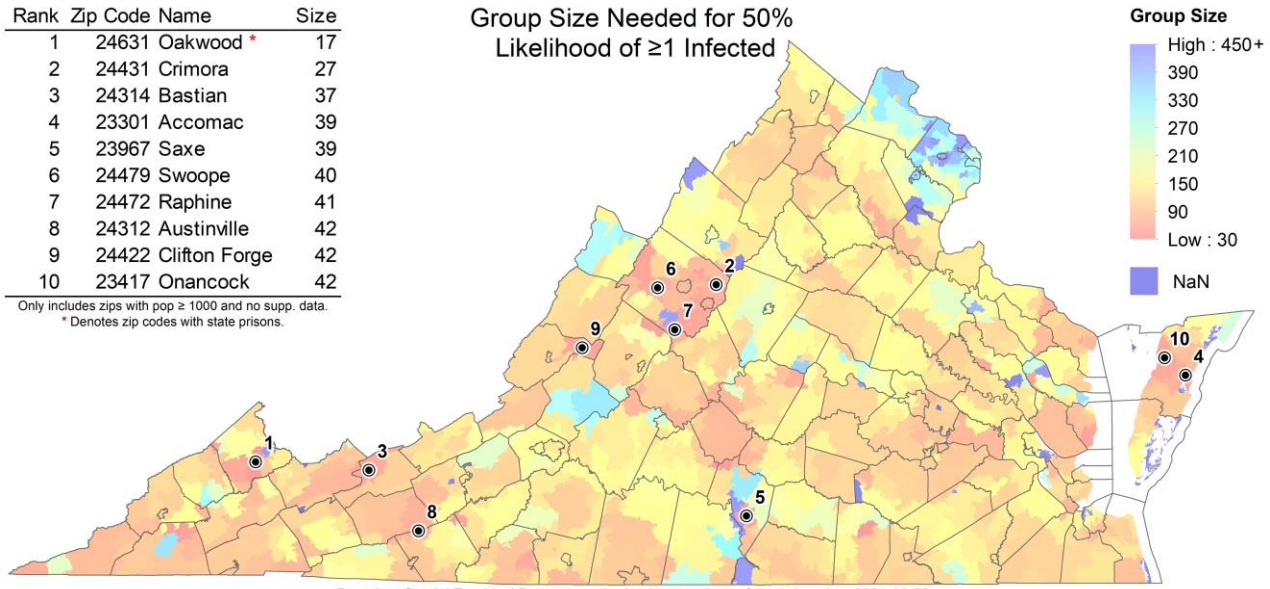
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2021-08-21.

Rank	Zip Code	Name	Size
1	24631	Oakwood *	17
2	24431	Crimora	27
3	24314	Bastian	37
4	23301	Accomac	39
5	23967	Saxe	39
6	24479	Swoope	40
7	24472	Raphine	41
8	24312	Austinville	42
9	24422	Clifton Forge	42
10	23417	Onancock	42

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 2021-08-28.

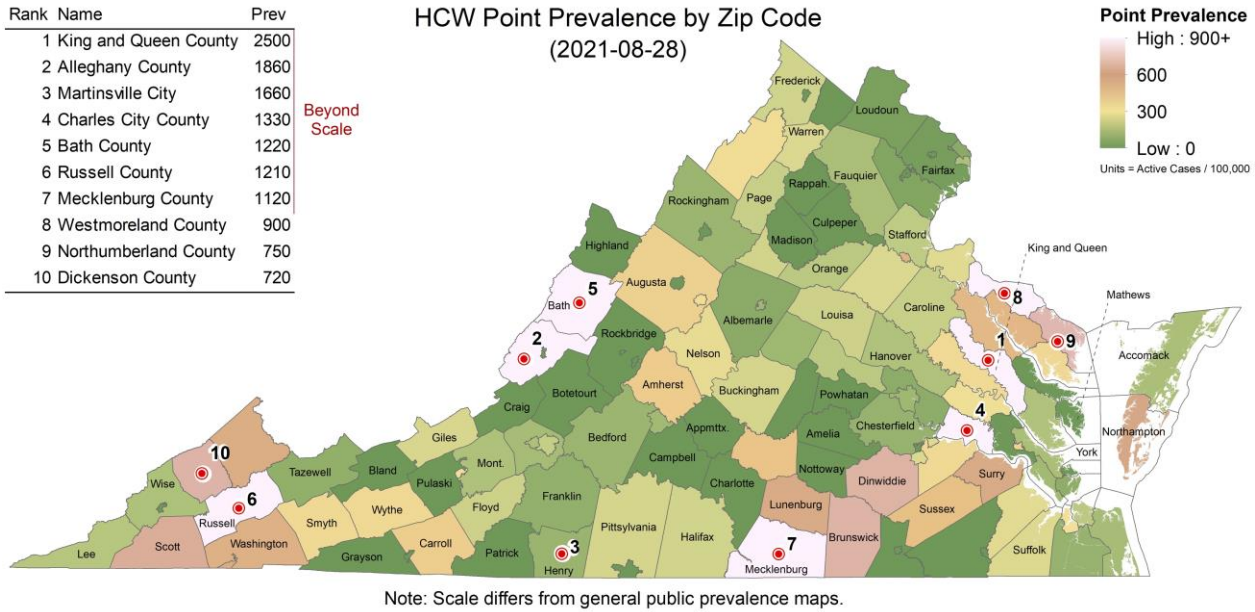
HCW Prevalence

- **HCW prevalence**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator
  - Clusters of high HCW point prevalence in far southwest (Wise & Dickinson Counties) and south of Richmond (Lunenburg and Prince Edward to Surry Counties)
- **HCW Ratio**: HCW Prevalence / Total Case Prevalence
  - (blue = higher case rate among public, red = higher case rate among HCW)

HCW Prevalence

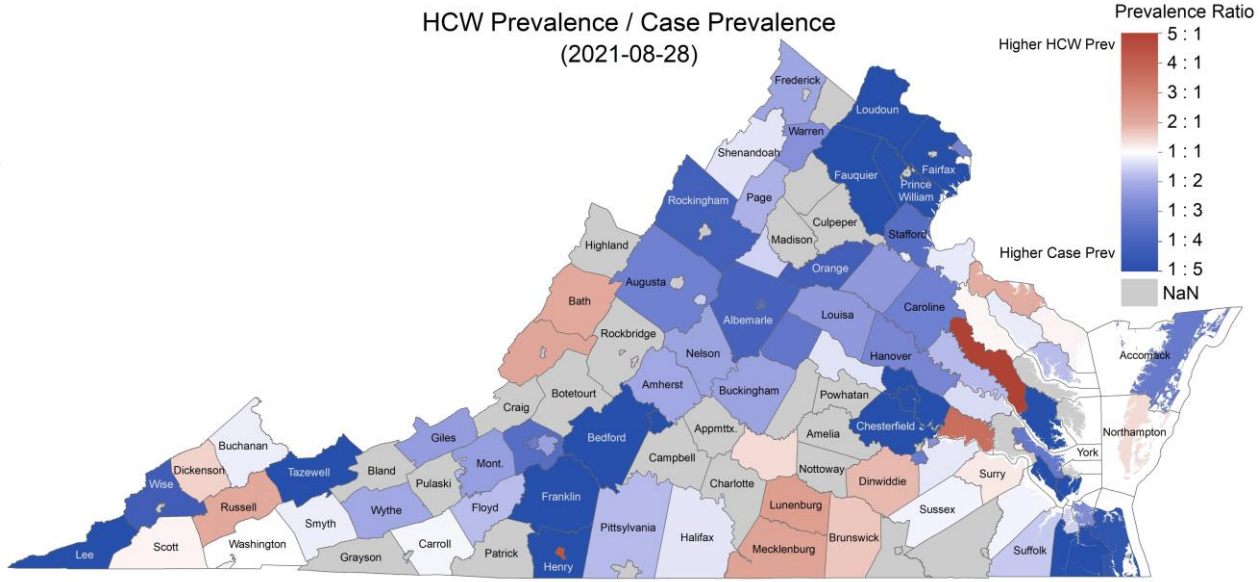
Rank	Name	Prev
1	King and Queen County	2500
2	Alleghany County	1860
3	Martinsville City	1660
4	Charles City County	1330
5	Bath County	1220
6	Russell County	1210
7	Mecklenburg County	1120
8	Westmoreland County	900
9	Northumberland County	750
10	Dickenson County	720

Beyond Scale



Note: Scale differs from general public prevalence maps.

HCW to Public Prevalence Ratio



Current Hot-Spots

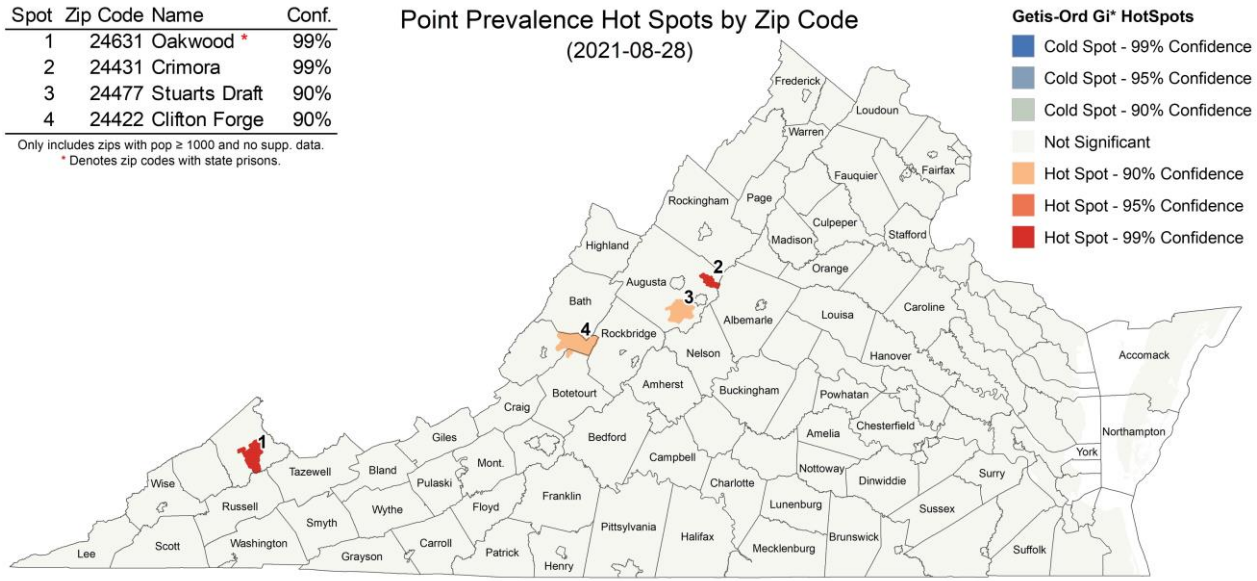
Case rates that are significantly different from neighboring areas or model projections

- **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

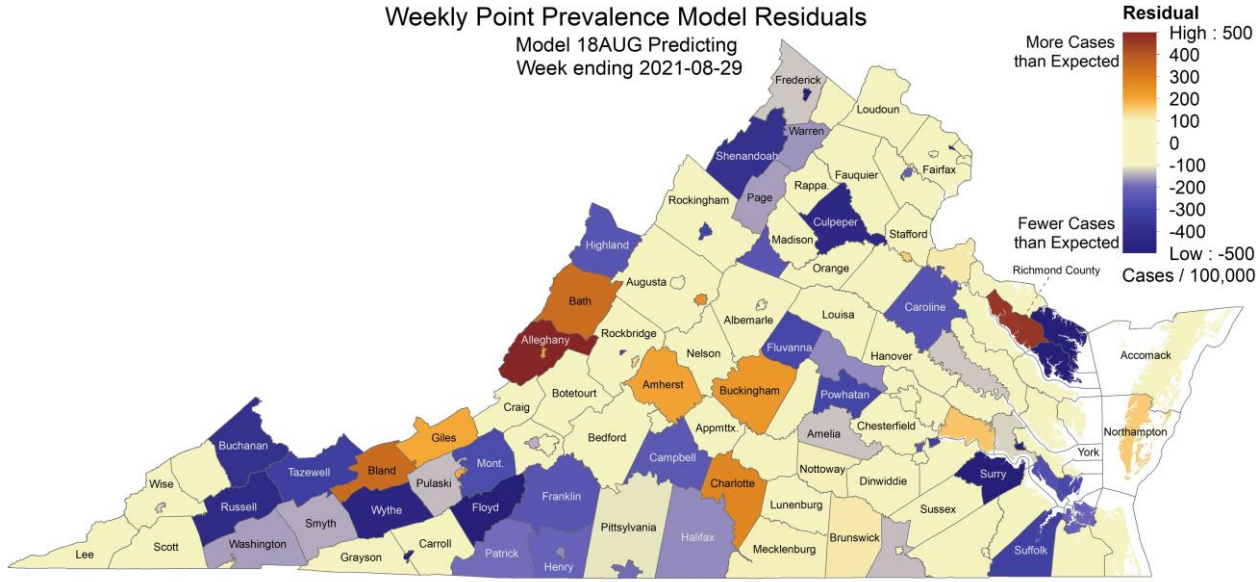
Spot	Zip Code	Name	Conf.
1	24631	Oakwood *	99%
2	24431	Crimora	99%
3	24477	Stuarts Draft	90%
4	24422	Clifton Forge	90%

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



Based on Global Empirical Bayes smoothed point prevalence for week ending 2021-08-28.

Clustered Temporal Hotspots



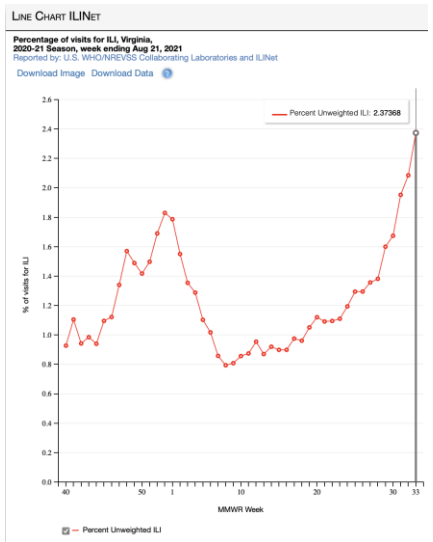
Moran's I = 0.011897, Z-Score = 0.9135, P-Value = 0.36098
No Residual Autocorrelation Detected

Non-COVID Respiratory Illness Update

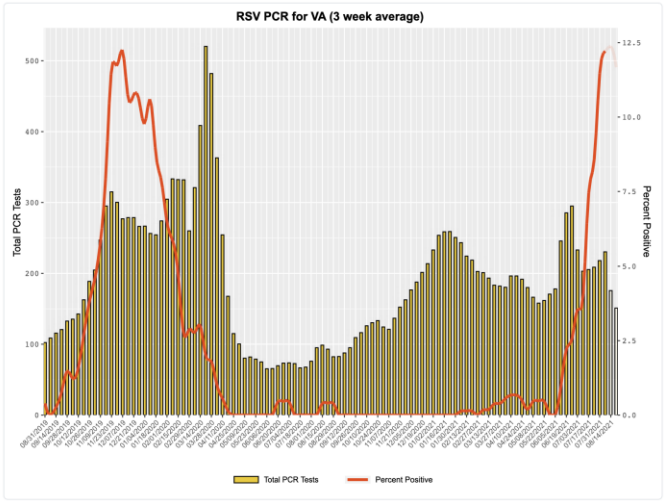
Other Respiratory Viruses on the rise and are on way towards a much earlier than usual flu and cold season

- Very little true Influenza detected still, mostly other respiratory viruses
- Much higher non-COVID ILI activity now compared to previous decade
- Southeast is already above ILI season threshold, driven by RSV
- Virginia is currently at ~2.4% ILI activity which is similar to early Nov 2017 (last very strong influenza season)

Virginia ILI 2020-21

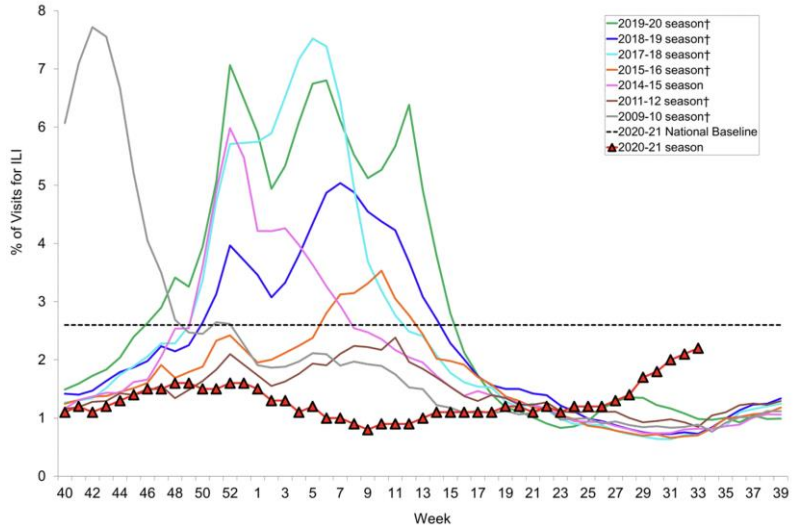


Virginia RSV 2019-21

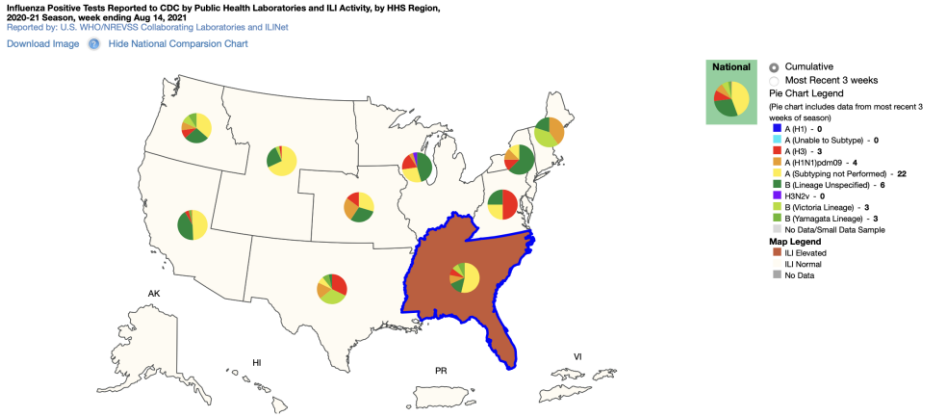


[CDC RSV surveillance](#)

Percentage of Visits for Influenza-like Illness (ILI) Reported by the U.S. Outpatient Influenza-like Illness Surveillance Network (ILINet), Weekly National Summary, 2020-2021 and Selected Previous Seasons



†These seasons did not have a week 53, so the week 53 value is an average of week 52 and week 1.



Data & Images: [CDC FluView](#)

Model Update – Adaptive Fitting

Adaptive Fitting Approach

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

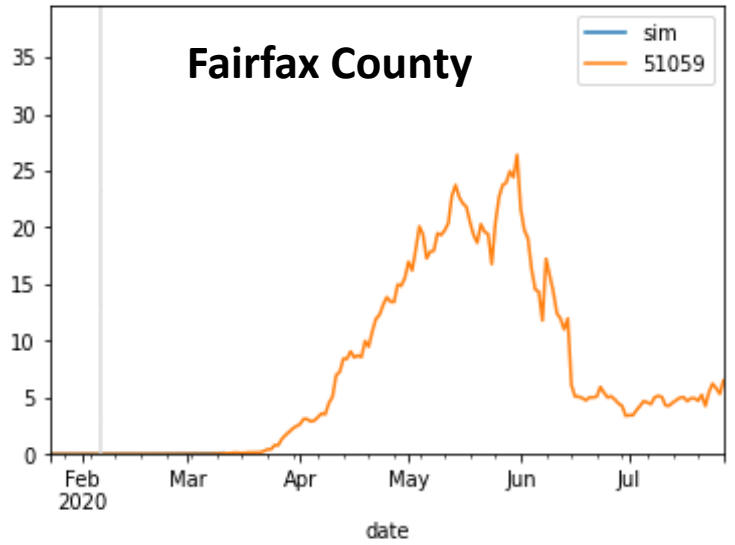
- Allows history to be precisely captured, and used to guide bounds on projections

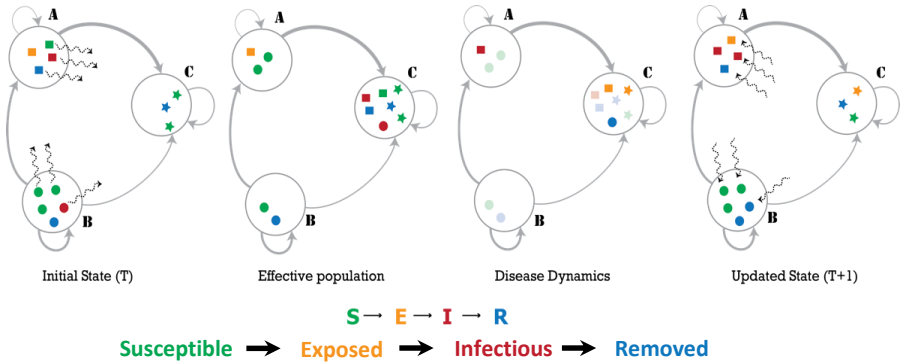
Model: An alternative use of the same meta-population model, PatchSim

- 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:

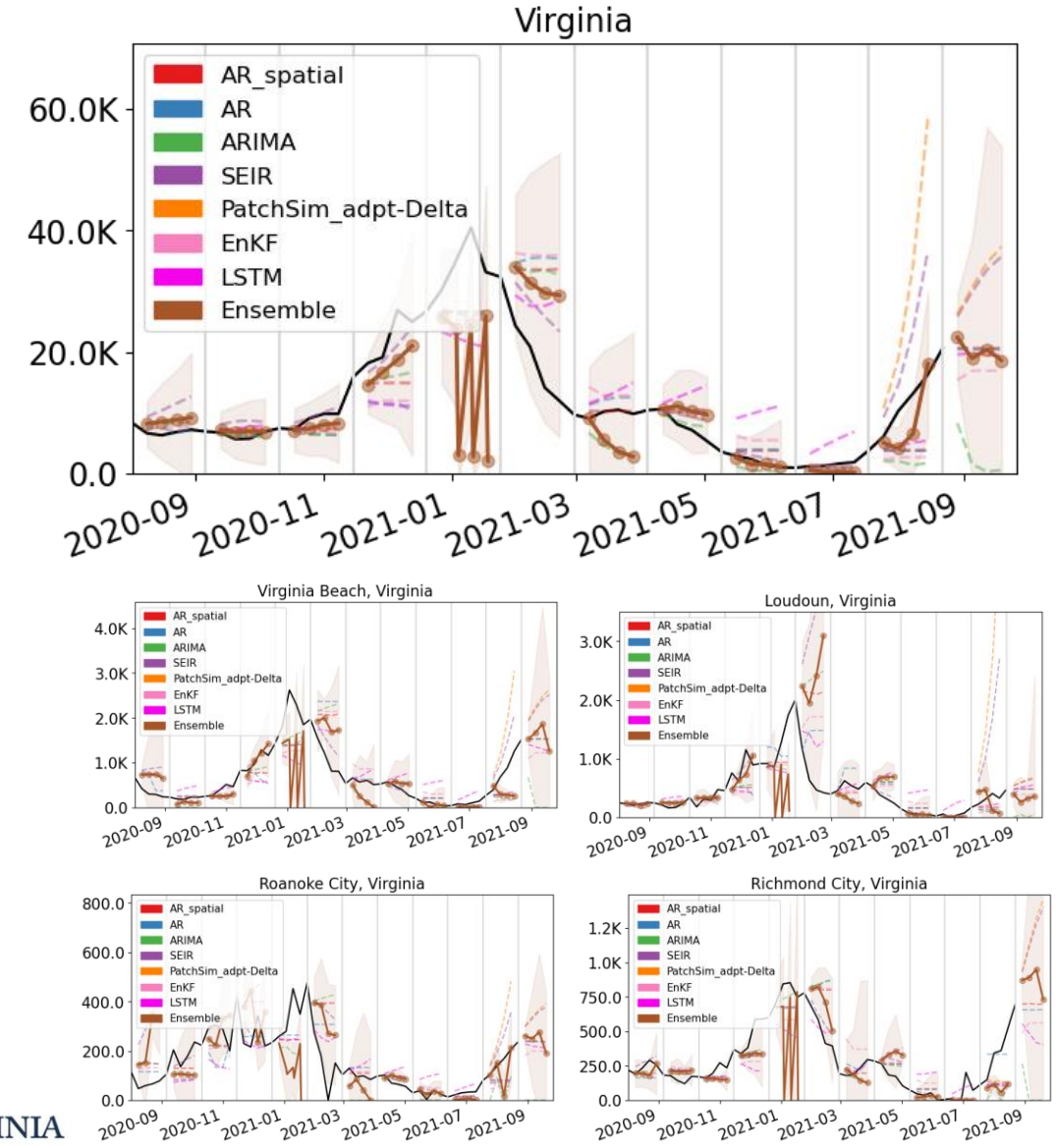
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

<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.



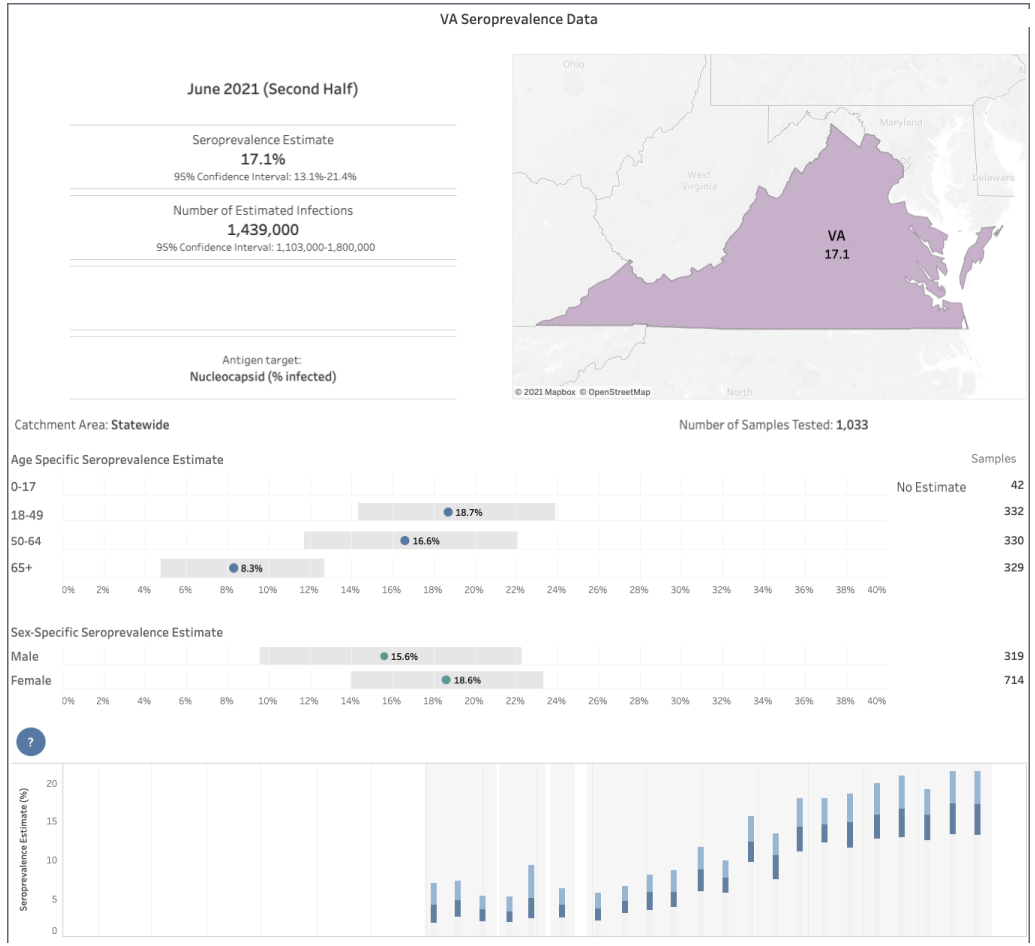
Seroprevalence updates to model design

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

- CDC Nationwide Commercial Laboratory Seroprevalence Survey estimated 17.1% [13.1% – 21.4%] seroprevalence as of June 15th – 30th up from 15.8% a month earlier

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

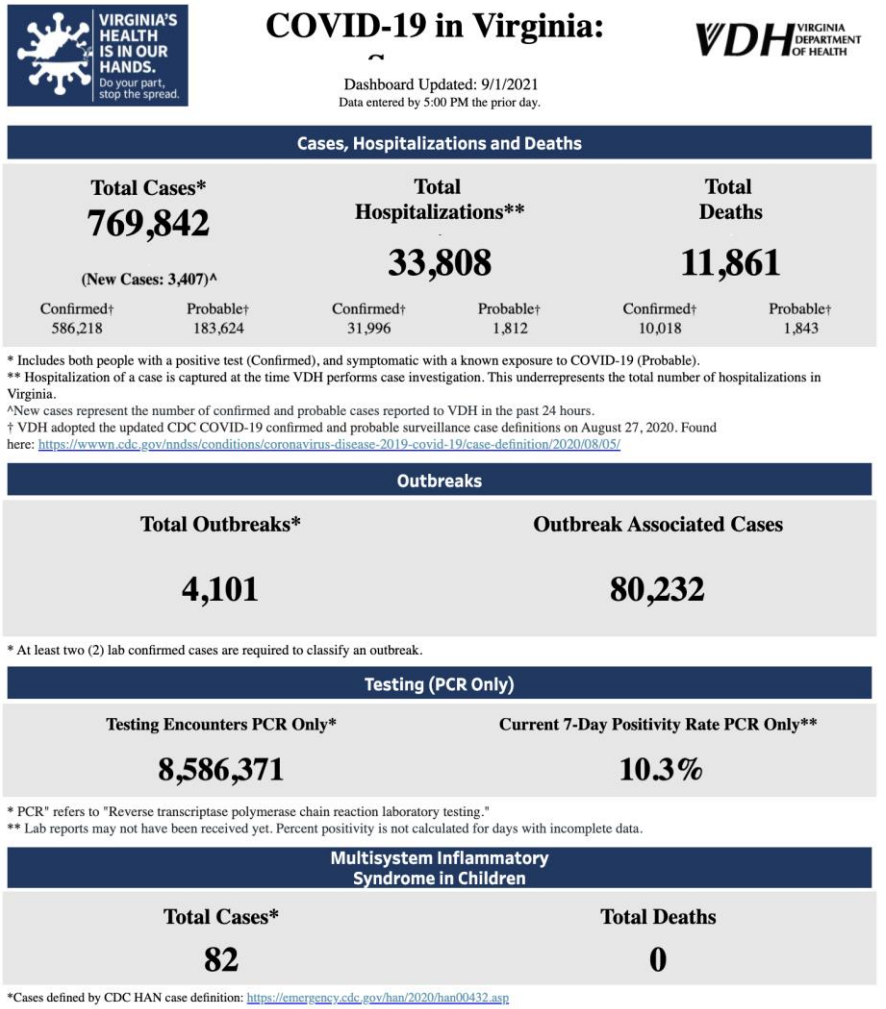
- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- This measure now fully tracks the estimated ascertainment over time
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were being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



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

COVID-19 in Virginia:

VDH VIRGINIA DEPARTMENT OF HEALTH

Dashboard Updated: 9/1/2021
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*		Total Hospitalizations**		Total Deaths	
769,842		33,808		11,861	
(New Cases: 3,407)^					
Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
586,218	183,624	31,996	1,812	10,018	1,843

* 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
4,101	80,232

* 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**
8,586,371	10.3%

* 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
82	0

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

Accessed 8:45am September 1, 2021
https://www.vdh.virginia.gov/coronavirus/

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Scenarios – Transmission Conditions

- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- Projection Scenario:
  - **Adaptive:** Control remains as is currently experienced into the future with assumption that Delta remains as the majority strain
  - **Adaptive-Fall:** Control remains as is currently experienced into the future, with an increase in transmission that is 20% stronger than the highest experienced in Fall-Winter of 2020-21 starting on Nov 1st
  - **Adaptive-Surge Control:** Starting in one week behaviors and mitigation efforts ramp up over a 2-week period culminating in a 25% reduction in transmission
  - **Adaptive-SpringControl:** Immediate return to the mean levels of transmission experienced in May 2021

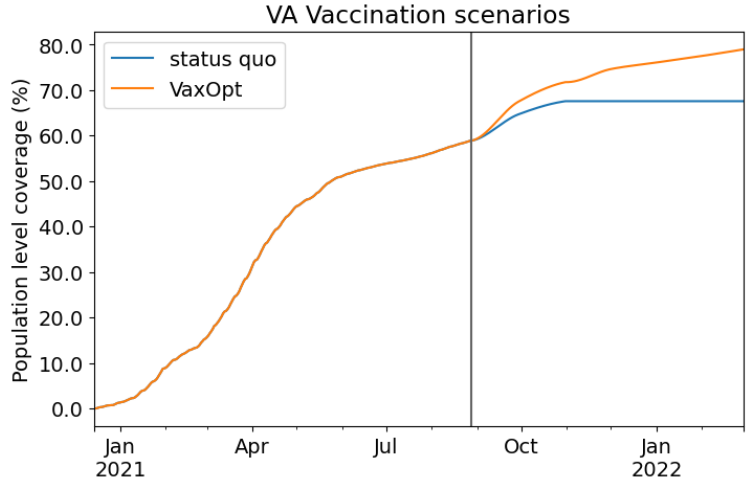
Scenarios – Vaccination Conditions

Vaccine Characteristics

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

Vaccine Administration Scenarios

- **Status quo (no label):** COVIDcast corrected acceptance estimates (statewide mean is ~80% adults, 65% of population) reached by end of October.
- **Optimistic (VaxOpt):** Expand VA mean acceptance to include ”probably not” (~85% adults) with addition of childhood rollout starting in November further boosting 10% of population by end of January. Also, all counties reaching a minimum of 65%, max of 95%) by end of October
- Acceptance at county level = regional acceptance +/- relative current vax
- Front-loaded rollout (two-thirds of the remaining in half the time)



Monthly first doses

Date	status quo	VaxOpt
2020-12-31	108.9K	108.9K
2021-01-31	753.7K	753.7K
2021-02-28	1.3M	1.3M
2021-03-31	2.6M	2.6M
2021-04-30	3.8M	3.8M
2021-05-31	4.3M	4.3M
2021-06-30	4.6M	4.6M
2021-07-31	4.8M	4.8M
2021-08-31	5.0M	5.1M
2021-09-30	5.5M	5.8M
2021-10-31	5.8M	6.1M
2021-11-30	5.8M	6.4M
2021-12-31	5.8M	6.5M
2022-01-31	5.8M	6.6M
2022-02-28	5.8M	6.7M
2022-03-31	5.8M	6.7M

Cumulative

Date	status quo	VaxOpt
2020-12-31	108.9K	108.9K
2021-01-31	644.8K	644.8K
2021-02-28	557.6K	557.6K
2021-03-31	1.3M	1.3M
2021-04-30	1.2M	1.2M
2021-05-31	573.6K	573.6K
2021-06-30	242.1K	242.1K
2021-07-31	196.7K	196.7K
2021-08-31	261.0K	266.1K
2021-09-30	483.5K	721.8K
2021-10-31	237.0K	351.3K
2021-11-30	0.0	239.9K
2021-12-31	0.0	124.8K
2022-01-31	0.0	122.6K
2022-02-28	0.0	122.4K
2022-03-31	0.0	4.6K

Scenarios – Delta δ Variant Condition

Variant Delta δ has exhibited ability to outcompete other variants and now is nearly the sole variant in the US and most states

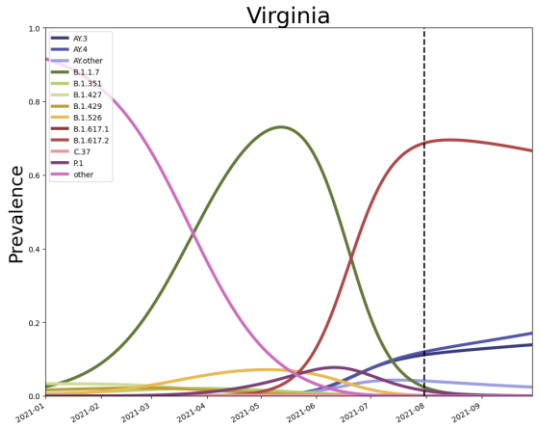
Transmissibility: Delta's relative transmissibility compared to Alpha is better understood (60% more transmissible) and its weighted growth fits a 60% growth advantage well

Immune Escape: Delta has been observed to evade immunity, both natural and vaccine-induced, however, uncertainty remains high thus this is **NOT** factored into the model

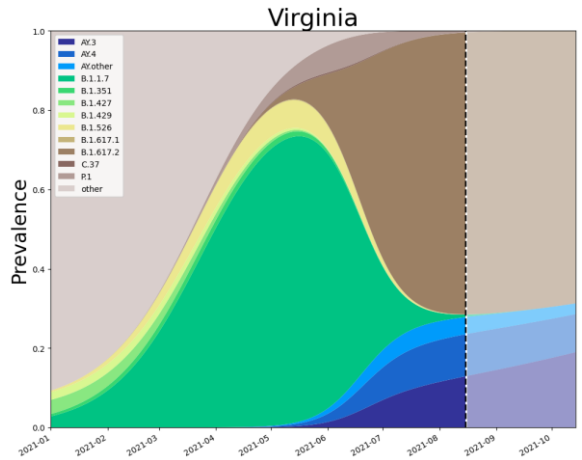
Severity: Delta, similar to Alpha, appears to cause more severe disease (estimates range from 50-200%), model assesses severity in last month and assumes this remains constant into the future

Variant is stable, thus captured by Adaptive Scenario:

- Delta now accounts for nearly all sequenced variants, subvariants AY.3 and AY.4 are growing



outbreak.info GISAID



Projection Scenarios – Combined Conditions

Name	Txm Controls	Fall Boosted Txm	Vax	Description
Adaptive	C	No	SQ	Likely trajectory based on conditions remaining similar to the current experience
Adaptive-VaxOpt	C	No	VO	Vaccination through October reaches an optimistically high level of expanded coverage (85%)
Adaptive-Fall	C	Yes	SQ	Same as Adaptive, with increased transmissibility driven by seasonality and/or another variant starting Nov 1st
Adaptive-Fall-VaxOpt	C	Yes	VO	Optimistically expand vaccination with increased transmissibility driven by seasonality and/or another variant starting Nov 1st
Adaptive-SurgeControl	25%	No	SQ	Transmission rates in the next month reduced through increased control from non-pharmaceutical interventions, with status quo vax and Delta
Adaptive-SpringControl	Spring	No	SQ	Transmission rates return to rates experienced in May 2021 with status quo vaccination and increasing prevalence of Delta

Transmission Controls: C = Current levels persist into the future
25% = Transmission rates are reduced by 25% with a gradual introduction, concluding in 4 weeks
Spring = Transmission rates return to May 2021 levels

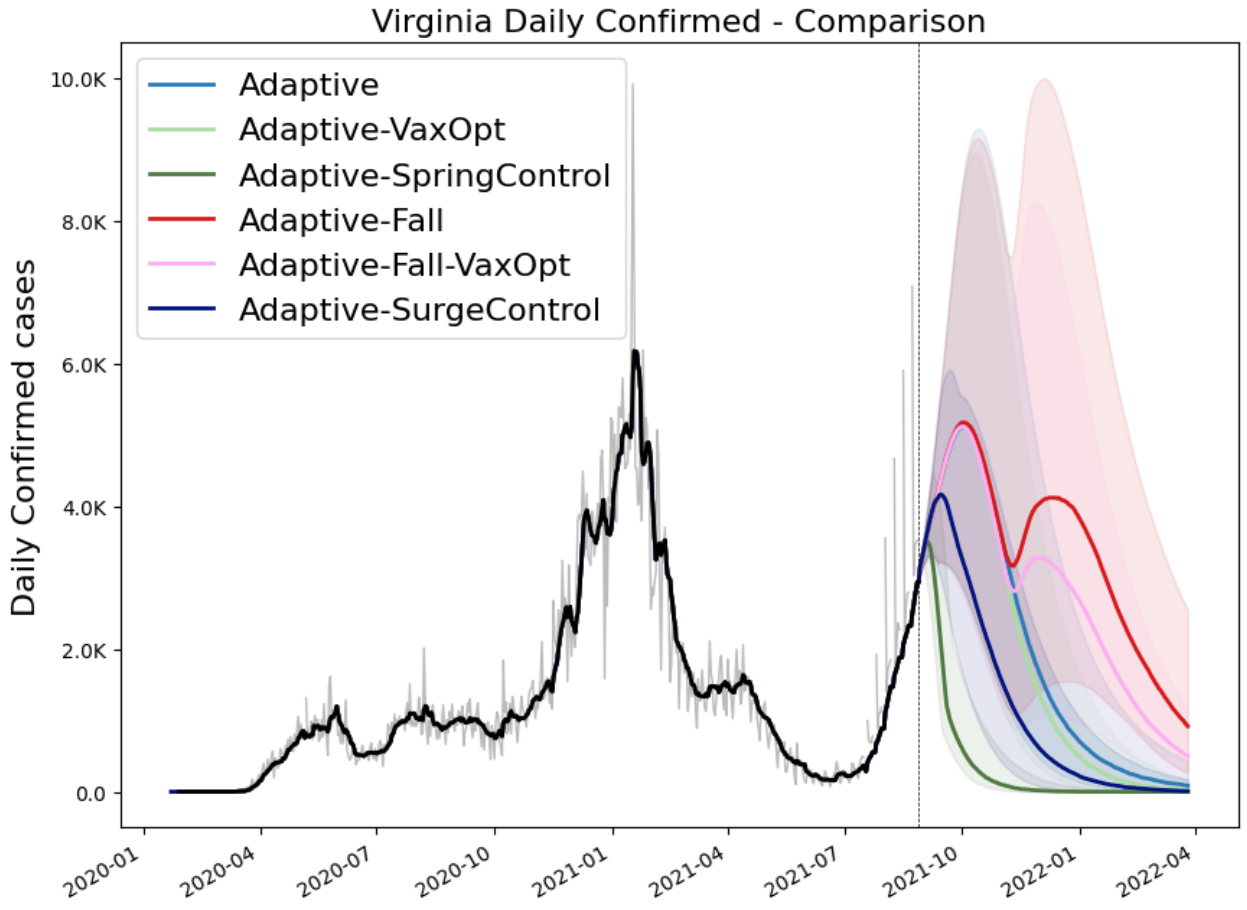
Fall Boosted Txm: No = No boosting of transmission later in the Fall or Winter
Yes = Transmission rate increases to 20% more than the worst of Fall-Winter 2020-21 on Nov 1st

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

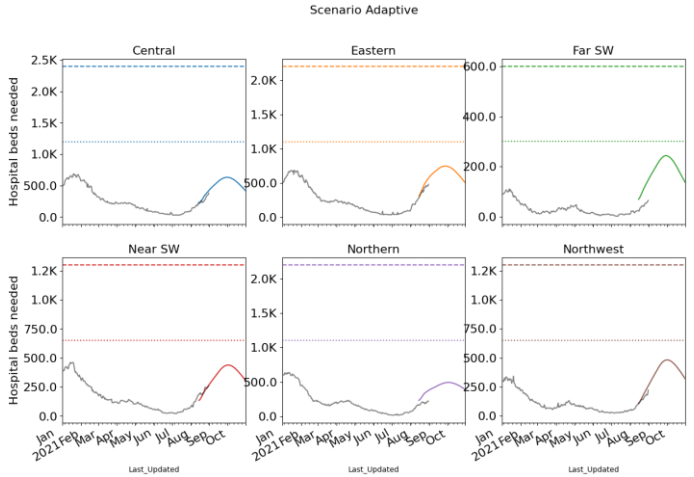
Model Results

Outcome Projections

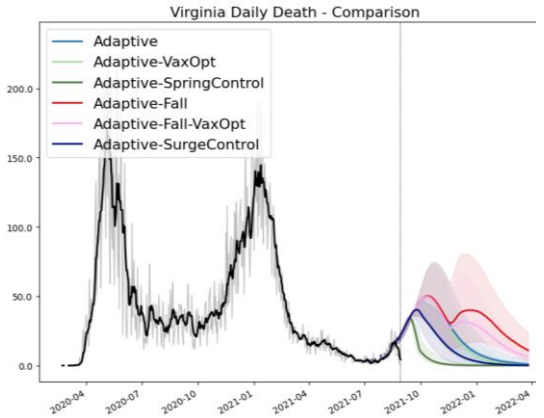
Confirmed cases



Estimated Hospital Occupancy

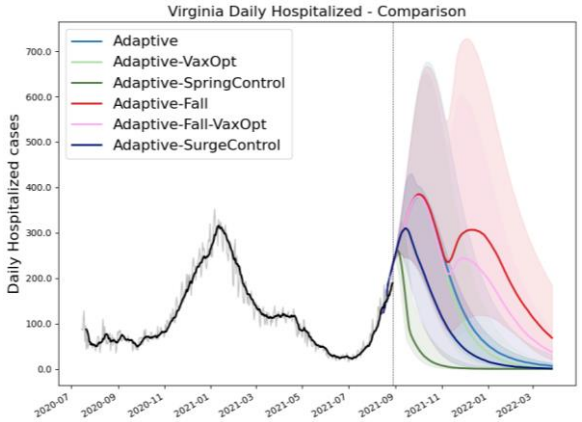


Daily Deaths



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

Daily Hospitalized



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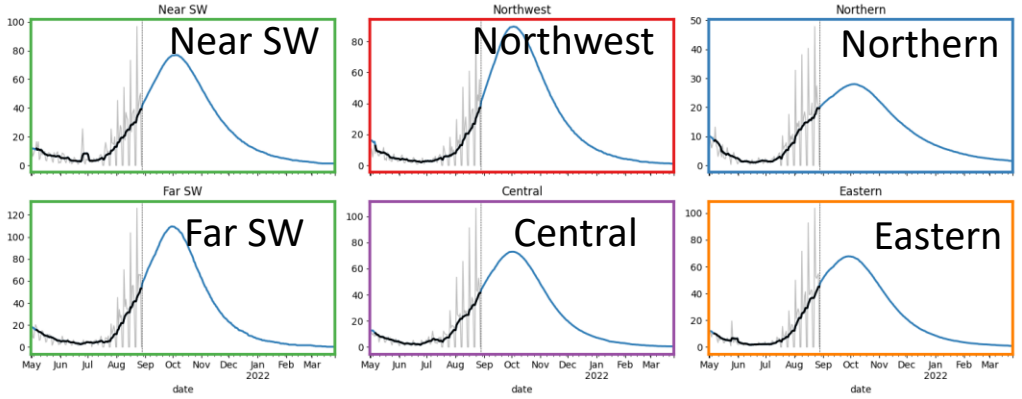
District Level Projections: Adaptive

Projections by Region

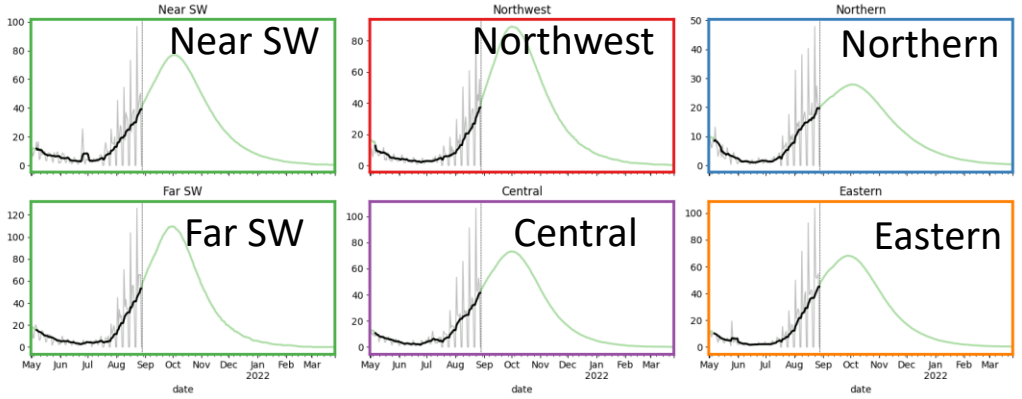


Projections by District

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

District Level Projections: Adaptive-VaxOpt

Projections by Region

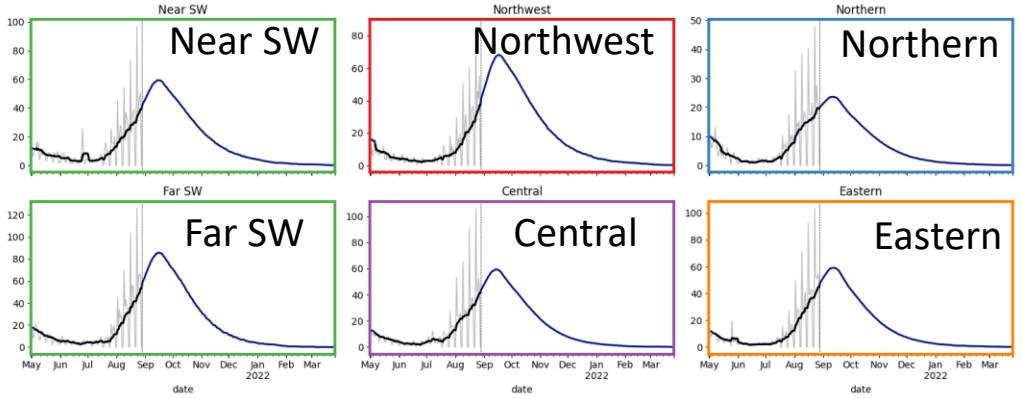


Projections by District

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

District Level Projections: SurgeControl

Projections by Region

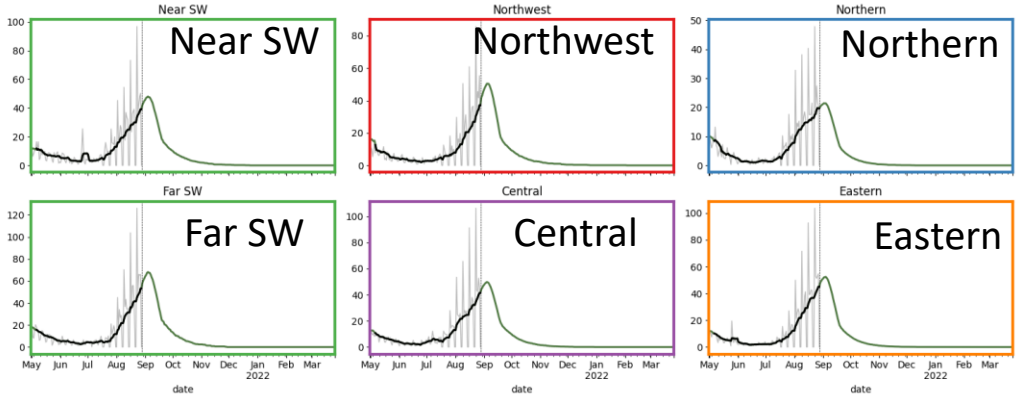


Projections by District

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

District Level Projections: SpringControl

Projections by Region

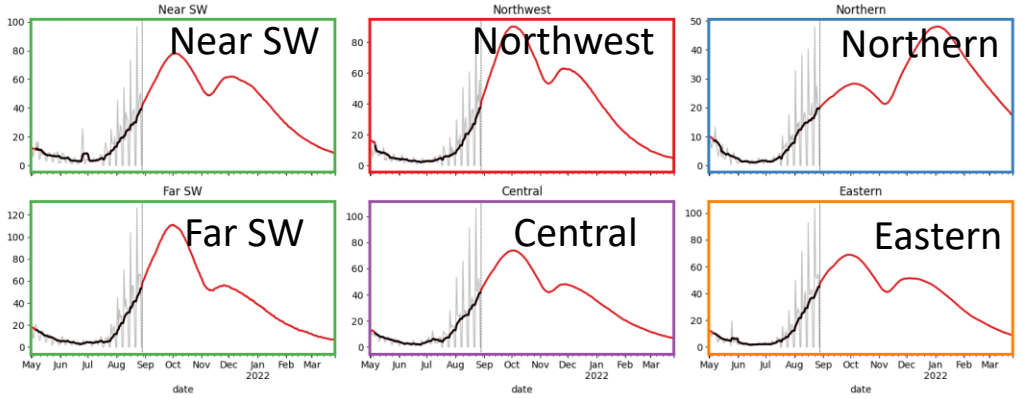


Projections by District

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

District Level Projections: Adaptive-Fall

Projections by Region

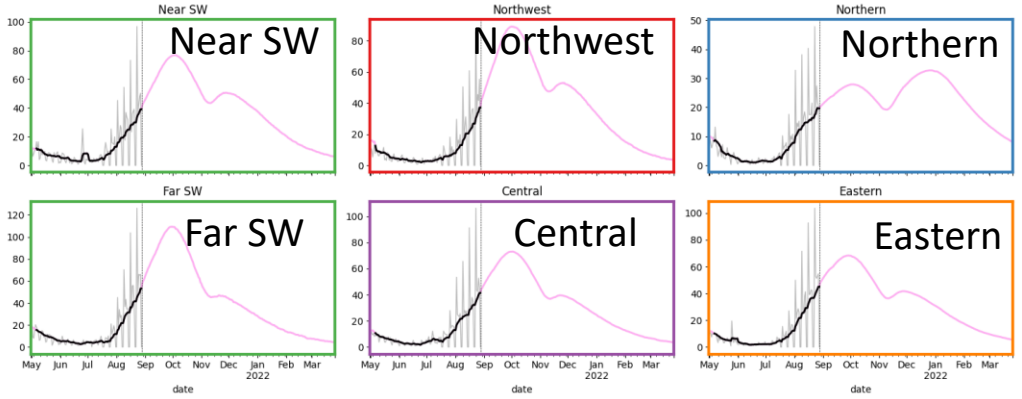


Projections by District

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

District Level Projections: Adaptive-Fall-VaxOpt

Projections by Region



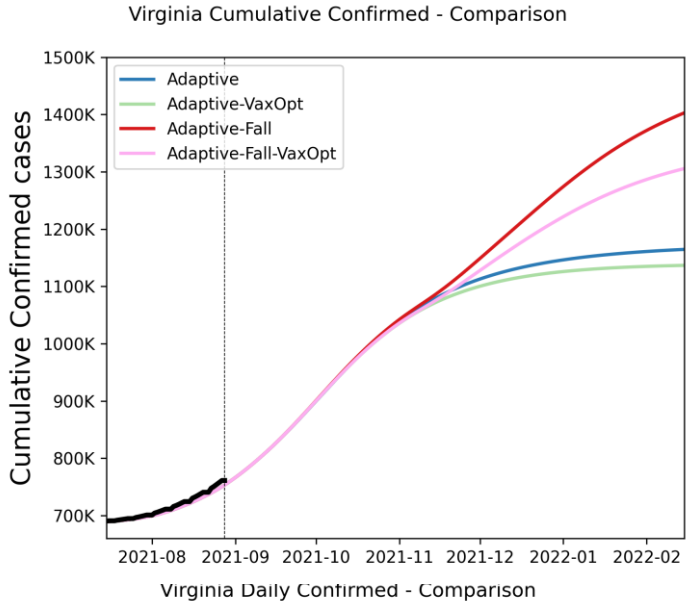
Projections by District

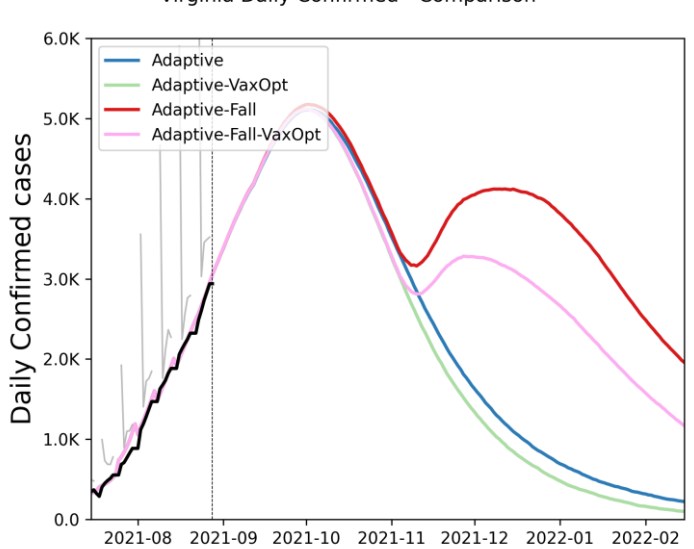
Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario

Impact of expanded vaccine acceptance

Expanded Vax coverage to higher overall adult coverage and with 5-11 rollout in November

- Even if transmission rates decline after a Delta wave, expanded vax coverage can reduce case counts by ~30K, in addition to providing further resilience to future waves
- A Fall Surge can rebound declining rates following the Delta wave
- Expanded vaccination coverage including children can further curtail the impact of a Fall Surge by up to 120K cases

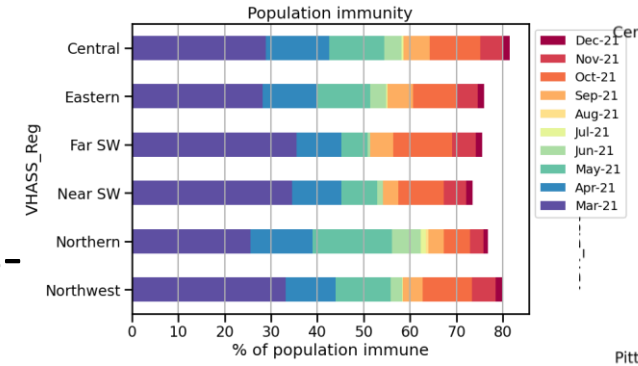


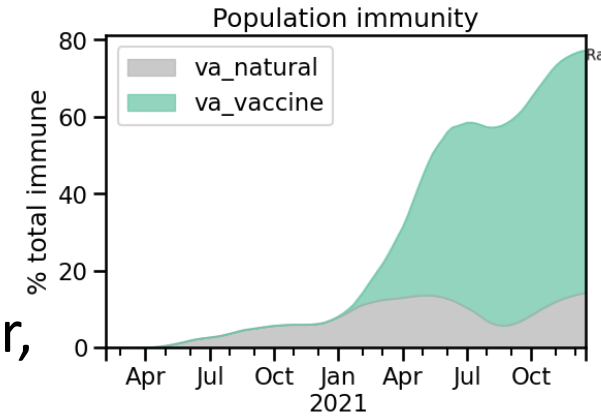


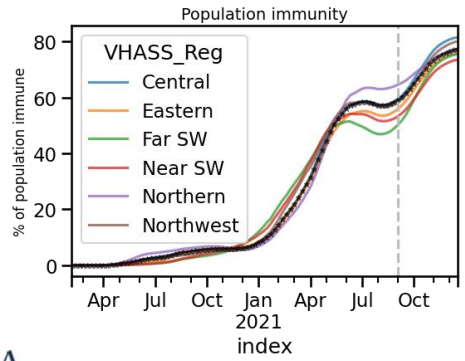
Virginia's Progress on Population Immunity

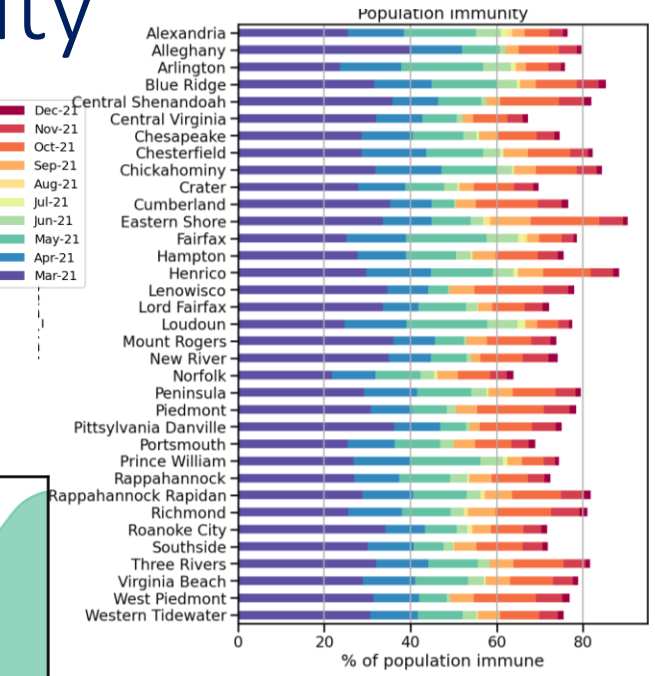
Natural Immunity and Vaccines combine to produce a population level of immunity

- Duration of immunity from infection with SARS-CoV2 still not well understood
  - We assume a conservative 6 month period of protection for these calculations
  - Do **not** factor in variant immune escape
  - 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 variants
- Population immunity depends on a very high proportion of the population getting vaccinated
  - Current models track measured seroprevalence









Region	% pop immune (est.)*
Central	58%
Eastern	55%
Far SW	49%
Near SW	52%
Northern	64%
Northwest	57%
Virginia	58%

* As of August 29, 2021 (updated to account for entire population)

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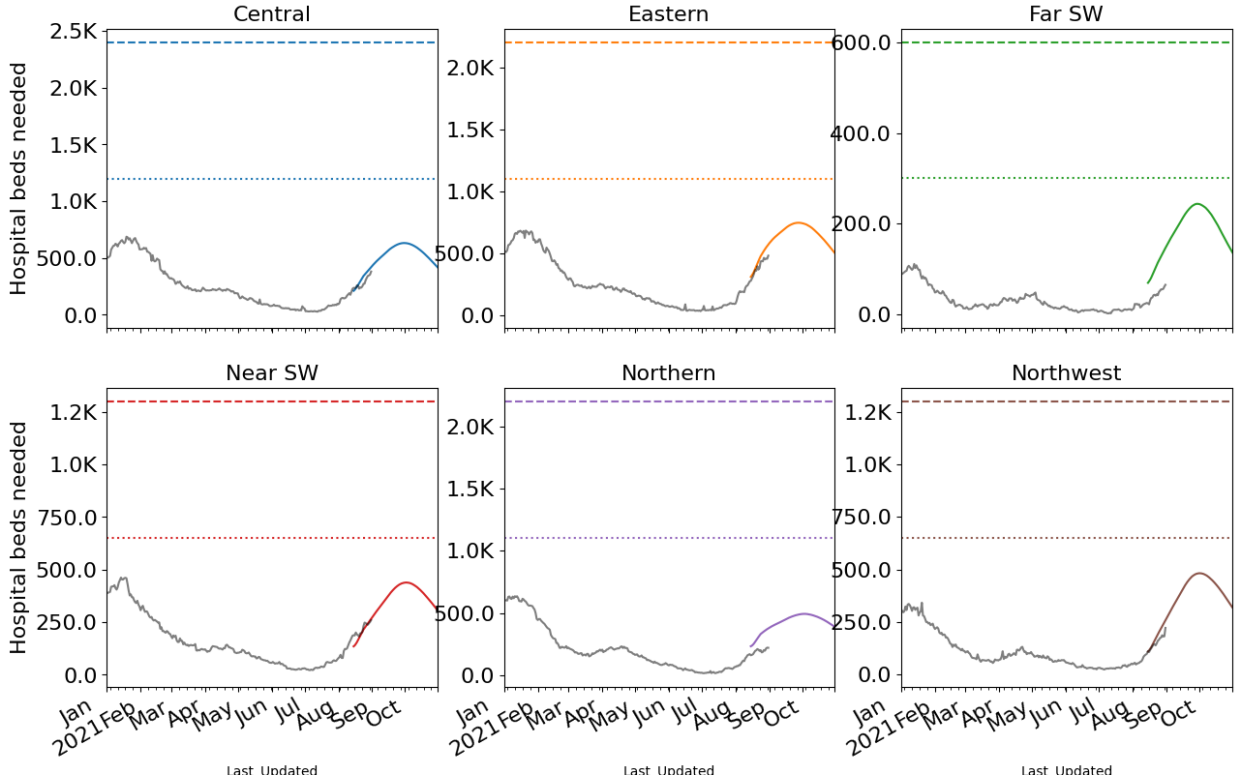
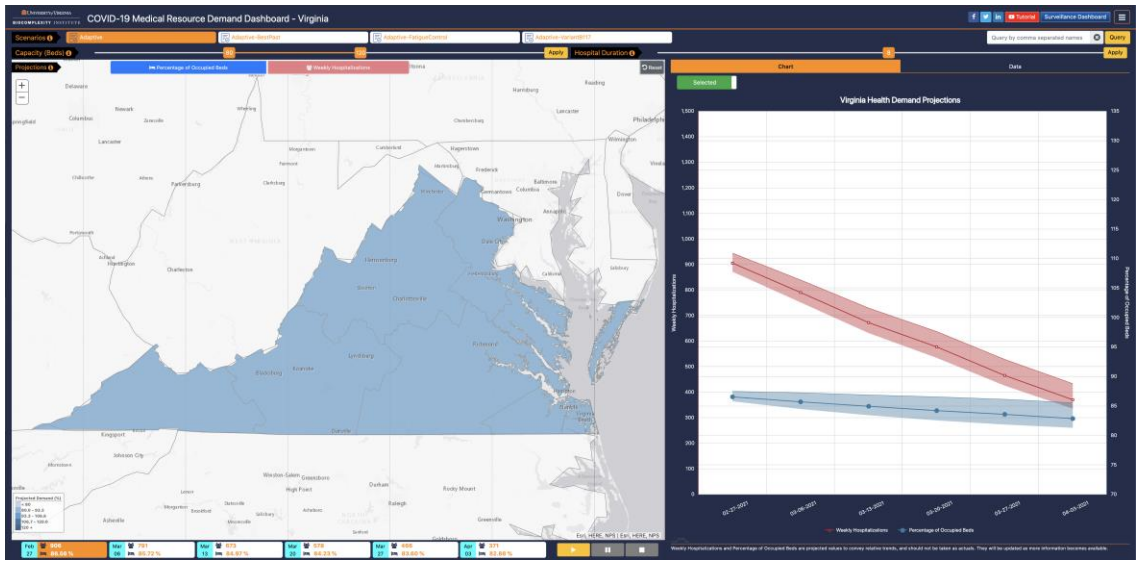
Hospital Demand and Bed Capacity by Region

Capacities* by Region – Adaptive

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





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

Adaptive scenario shows that even with Delta enhanced severity:

- No regions should exceed their initial capacities

* Assumes average length of stay of 8 days

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 rise though the pace remains steady while initial surge states have peaked, case rates remain very high**
- VA mean weekly incidence up to 37/100K from 30/100K, US up to 48/100K (from 44/100K)
- Growth in vaccination rates remain higher than June and July with slight uptick
- Projections continue to show significant uptick in activity, however, the reduced pace has decreased the overall impact
- Recent updates:
  - Added Fall surge scenario to capture potential rebounds and further test immunity from expanded vaccination
  - Updated Optimistic Vaccination to include potential inclusion of 5-11 year olds this Fall
- 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 Mobile Vaccine Clinic Site Selection:** Collaboration with VDH state and local, Stanford, and SafeGraph to leverage anonymized cell data to help identify

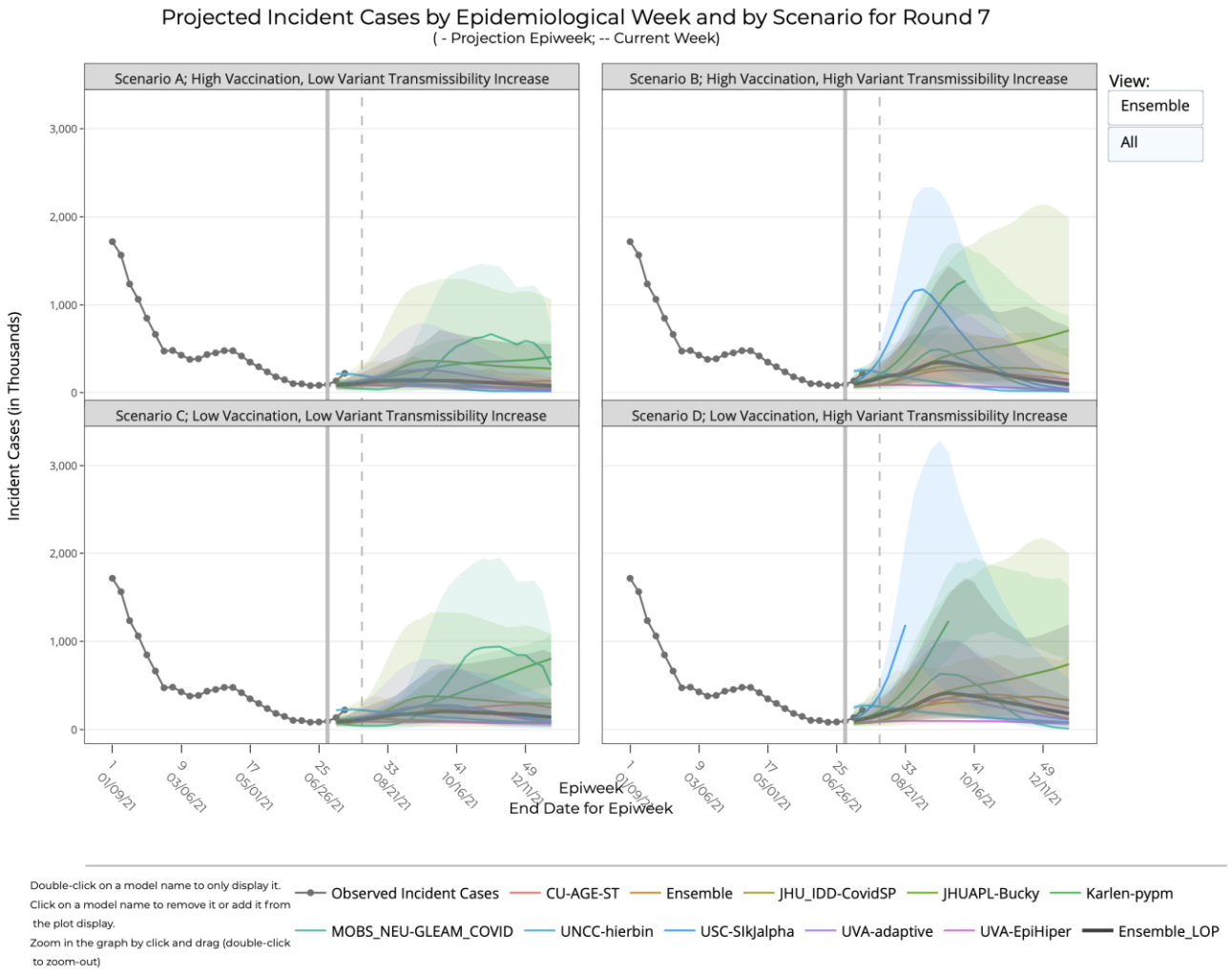
COVID-19 Scenario Modeling Hub

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 impact of the Delta variant (high and low)

- Round 8 in planning
- Round 7 now available

Round 4 Results were published May 5th, 2021 in MMWR

https://covid19scenariomodelinghub.org/viz.html



COVID-19 Scenario Modeling Hub – Round 7

Round 7 scenarios explore the effects of a variant similar to Delta (B.1.617.2) against different backgrounds of vaccination. Includes some vax escape

Vaccinations by Nov 30

- LowVacc – 70% overall coverage
- HighVacc – 80% overall coverage

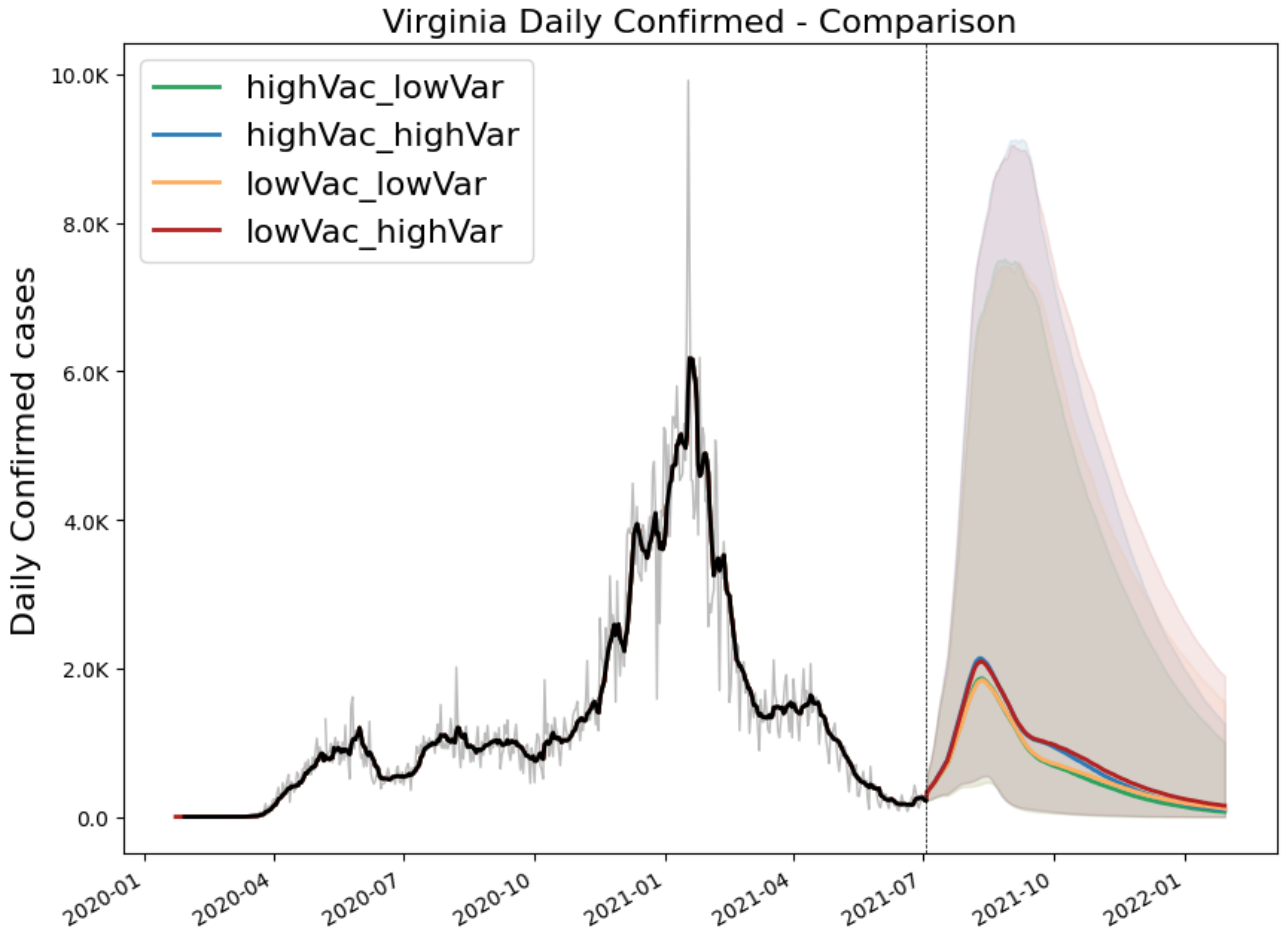
Emerging Variant Impact (5% prevalence on May 29th)

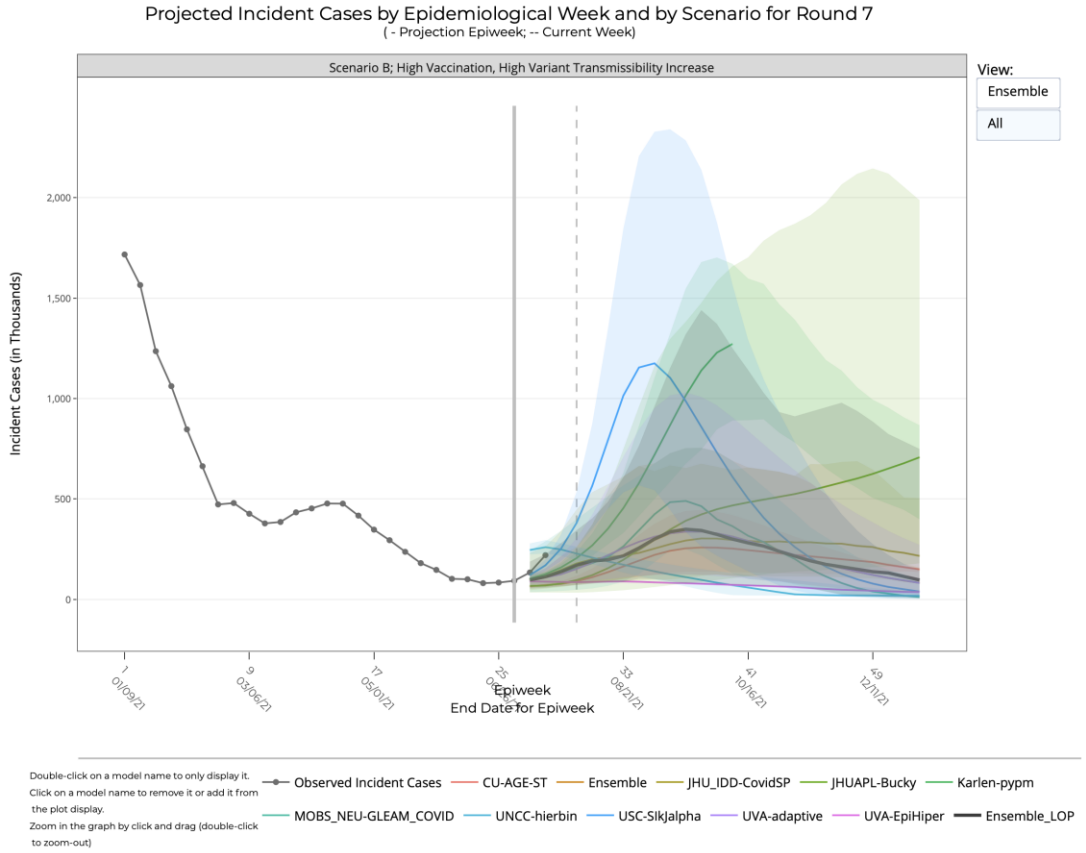
- LowVar – 40% more transmissible
- HighVar – 60% more transmissible

https://covid19scenariomodelinghub.org/viz.html

	LowVar	**HighVar**
See more detailed notes for each scenario below	**Low Impact Variant** *(low transmissibility increase, no immune escape)*	**High Impact Variant** *(high transmissibility increase, no immune escape)*
High Vaccination *(Low hesitancy)* **HighVacc**	***Scenario A*** Vaccination: - Coverage saturates at **80% nationally** among the vaccine-eligible population* by December 31, 2021** - VE is **50%/90%** for Pfizer/Moderna against the Delta variant, against symptoms (1st /2nd dose) - J&J no longer used Variant: - **40% increased transmissibility** as compared with Alpha for Delta variant. Initial prevalence estimated at state-level by teams.	***Scenario B*** Vaccination: - Coverage saturates at **80% nationally** among the vaccine-eligible population* by December 31, 2021** - VE is **35%/85%** for Pfizer/Moderna against the Delta variant, against symptoms (1st /2nd dose) - J&J no longer used Variant: **60% increased transmissibility** as compared with Alpha for Delta variant. Initial prevalence estimated at state-level by teams.
Low Vaccination *(High hesitancy)* **LowVacc**	***Scenario C*** Vaccination: - Coverage saturates at **70% nationally** among the vaccine-eligible population* by December 31, 2021** - VE is **50%/90%** for Pfizer/Moderna against the Delta variant, against symptoms (1st /2nd dose) - J&J no longer used Variant: - **40% increased transmissibility** as compared with Alpha for Delta variant. Initial prevalence estimated at state-level by teams.	***Scenario D*** Vaccination: - Coverage saturates at **70% nationally** among the vaccine-eligible population* by December 31, 2021** - VE is **35%/85%** for Pfizer/Moderna against the Delta variant, against symptoms (1st /2nd dose) - J&J no longer used Variant: **60% increased transmissibility** as compared with Alpha for Delta variant. Initial prevalence estimated at state-level by teams.

Modeling Hub – Round 7 Prelim Results





https://covid19scenariomodelinghub.org/viz.html

COVID-19 Scenario Modeling Hub – Round 8 (ongoing)

Round 8 scenarios targeted at exploring the effect of waning immunity (natural and vaccine-induced) and varying levels of protection after waning

Waning Rates

- Slow – exp. waning with mean=3yrs
- Fast – exp. waning with mean=1yr
- No waning (Sc A) as baseline

Protection after Waning

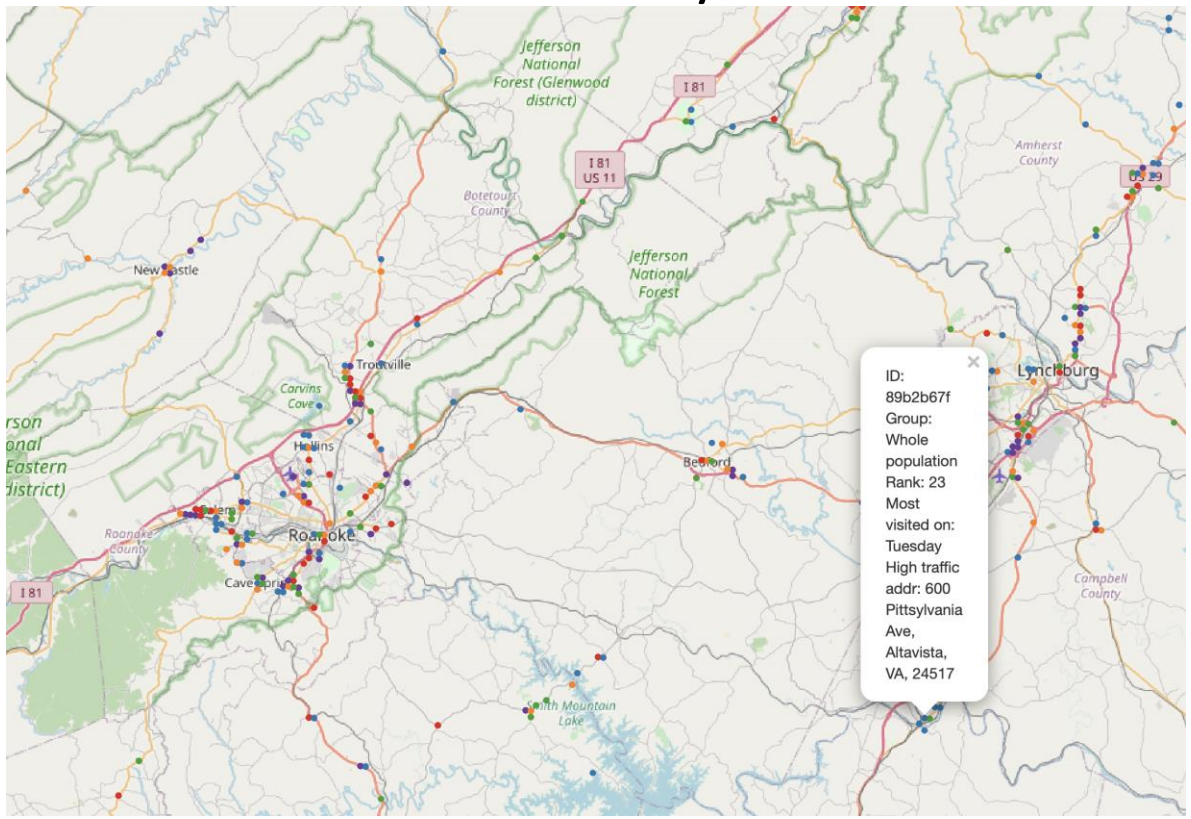
- Age stratified protection from infection
- 80% or 90% protection from hosp/death

		Slow Waning	**Fast Waning**
See detailed notes on each scenario below		**Slow waning of natural and vaccine-induced immunity** *(from no waning to exponential waning with mean of 3 yrs)*	**Fast waning of natural and vaccine-induced immunity** *(exponential waning with mean of 1 year)*
High protection against infection and severe disease after waning	**High Protection**	***Scenario A*** No Waning: - Vaccine-induced and natural immunity retain their initial protection throughout the simulation period	***Scenario B*** Waning: - **Exponentially distributed immune waning with mean of 1 year** (time to transition to partially immune state) In partially immune state: - Protection from infection is: **- 70% ≤ 65yrs** **- 35% > 65yrs** - Protection from hospitalization and death is **90%**
Low protection against infection and severe disease after waning	**Low Protection**	***Scenario C*** Waning: - **Exponentially distributed immune waning with mean of 3 years** (time to transition to partially immune state) In partially immune state: - Protection from infection is: **- 50% ≤ 65yrs** **- 25% > 65yrs** - Protection from hospitalization and death is **80%**	***Scenario D*** Waning: - **Exponentially distributed immune waning with mean of 1 year** (time to transition to partially immune state) In partially immune state: - Protection from infection is: **- 50% ≤ 65yrs** **- 25% > 65yrs** - Protection from hospitalization and death is **80%**

https://covid19scenariomodelinghub.org/

Data Recommended Mobile Vax Clinic Sites

Detailed and Timely Locations



Data Delivered and Disseminated to Locals

Provides a list of areas most visited by a given demographic group based on SafeGraph mobility data that links visits to specific sites and the home Census Block Group of the anonymized visitors

Demographic Groups: Black, Lantinx, Young Adults (20-40), Unvaccinated, and Whole Population

Data Included: Rank, Weight, most visited Day of Week, Highly Visited Address, and Lat-Long of area

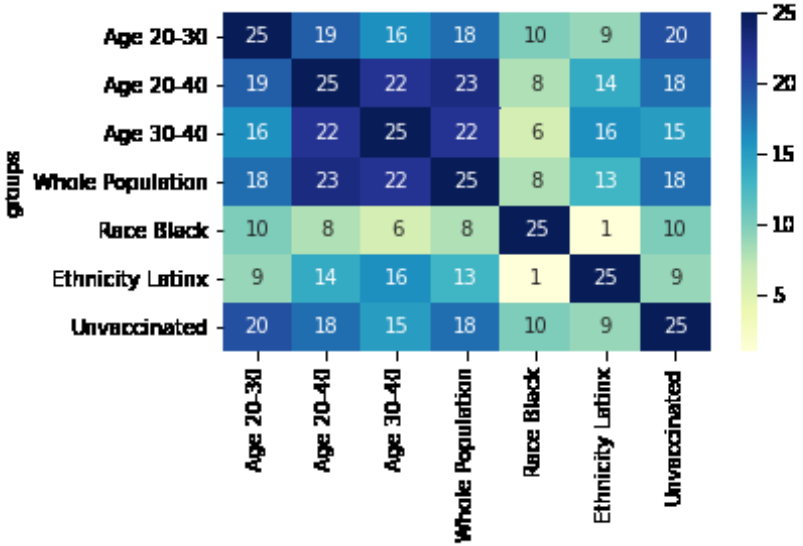
Goal: Provide frequently visited locations based on populations and vaccination levels one desires to reach

Example: List of location in the Southside frequented by 20-40 year olds

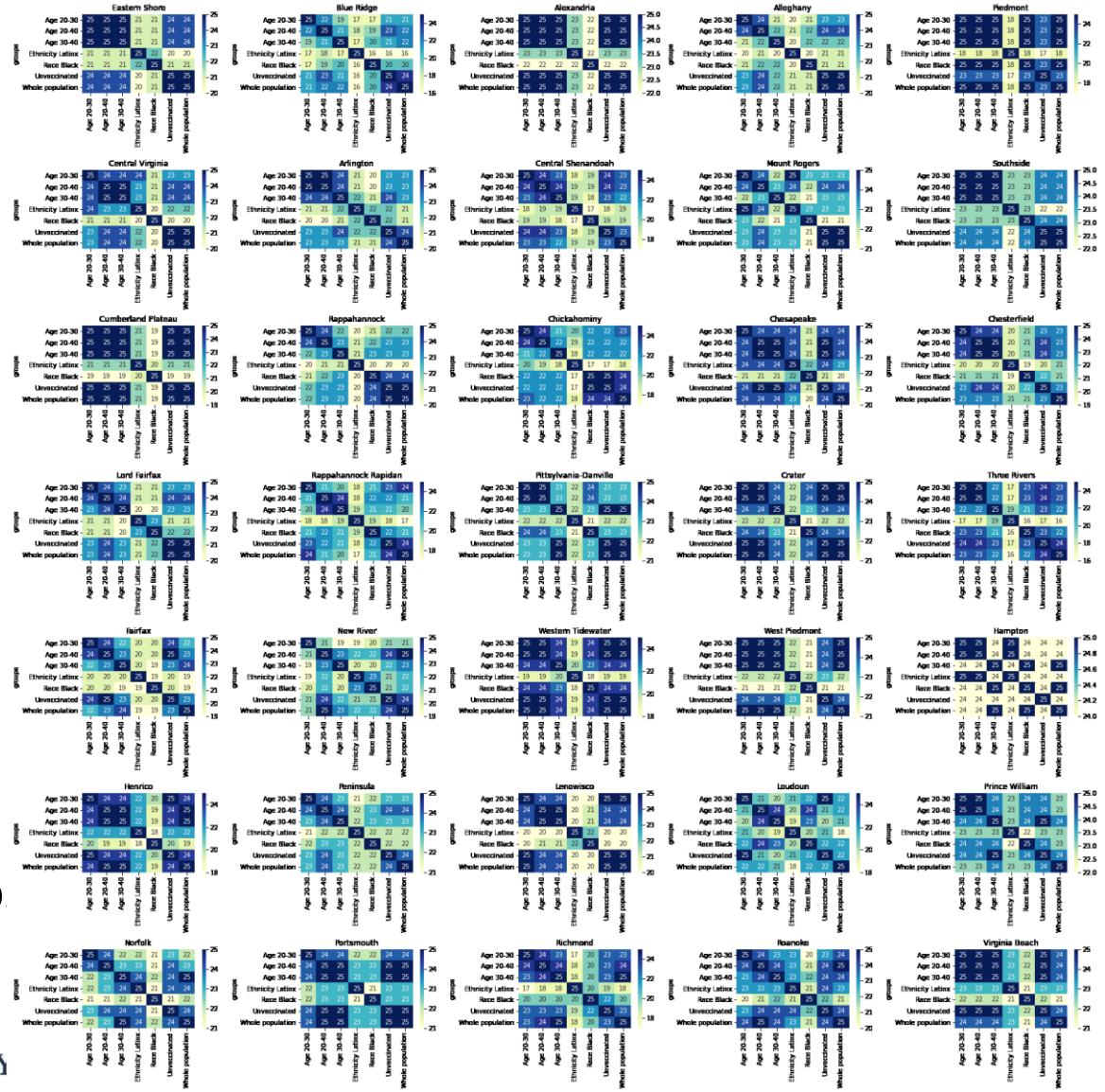
Data Recommended Mobile Vax Clinic Sites

Overlap of locations between groups

State Level



Within VDH Health Districts



Different groups visit different areas

- Least overlap between Black and Latinx
- Overlap in ages highest, but drops with large gap
- Districts have different overlap patterns

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Questions?

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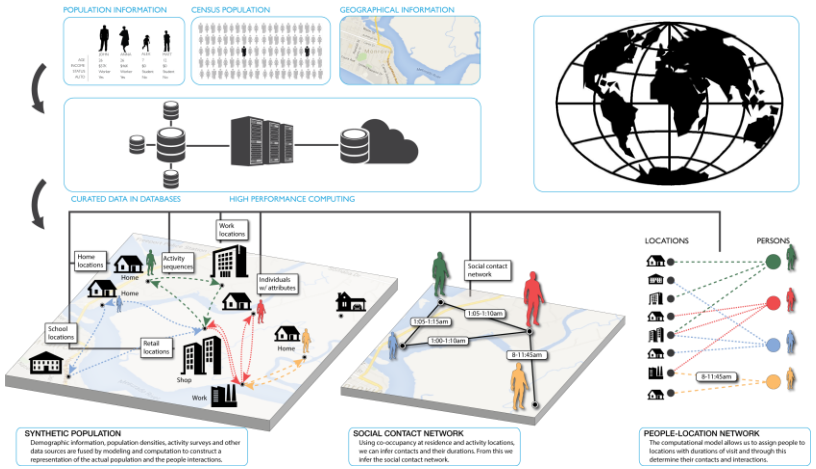
Supplemental Slides

Agent-based Model (ABM)

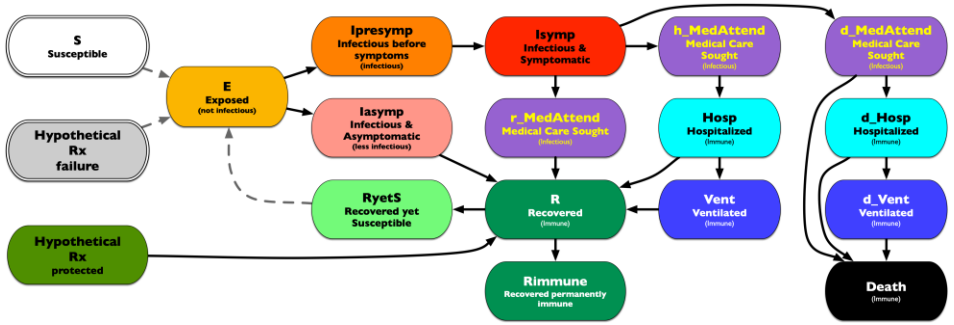
EpiHiper: Distributed network-based stochastic disease transmission simulations

- 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