Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

January 19th, 2022

(data current to Jan 16th – 18th)

Biocomplexity Institute Technical report: TR 2022-004

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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:

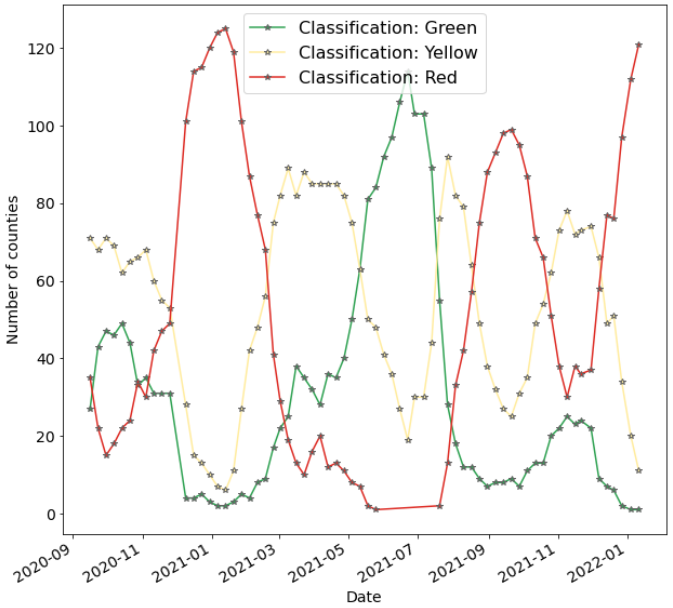
- **Case rates and hospitalizations seem to be leveling off and projections suggest we are nearing the peak**
- VA 7-day mean daily case rate up to 198/100K from 155/100K; US is up to 212/100K (from 144/100K)
- Projections anticipate near-term peak with subsequent decline:
  - Sensitivity analyses show further growth remains possible, though requires significant increase in transmission drivers
  - Decline is rapid and approach very low levels quickly, this assumes immunity to infection with Omicron protects against Omicron
- Current signs indicate case ascertainment is in flux and case counts may miss key dynamics, thus its possible the true peak will not match the observed peak and observed cases may be chaotic in near term
- Recent model updates:
  - Further refined model to be multi-variant model structure further refined to better capture different tiers of immunity and the immune evasion of the Omicron variant

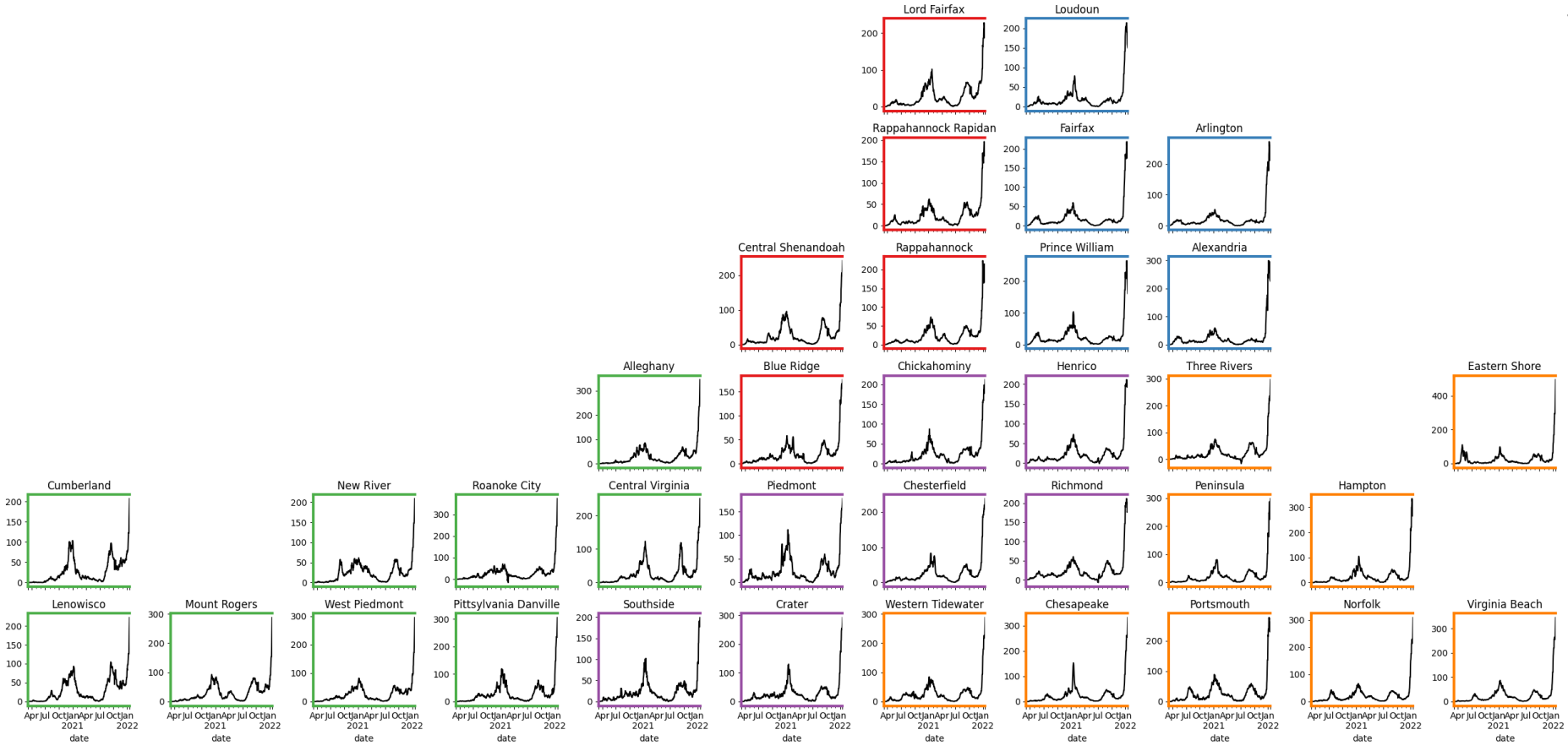
The situation continues to change. Models continue to be updated regularly.

Situation Assessment

Case Rates (per 100k) and Test Positivity

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





County level RT-PCR test positivity

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

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

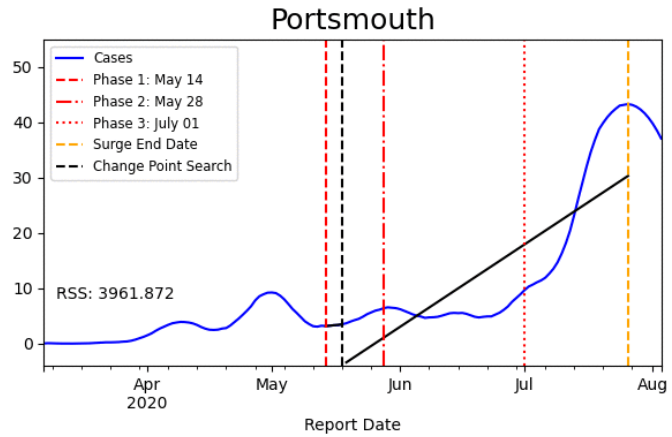
Red: >10.0% (and not "Green" or "Yellow")

District Trajectories

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

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

Hockey stick fit

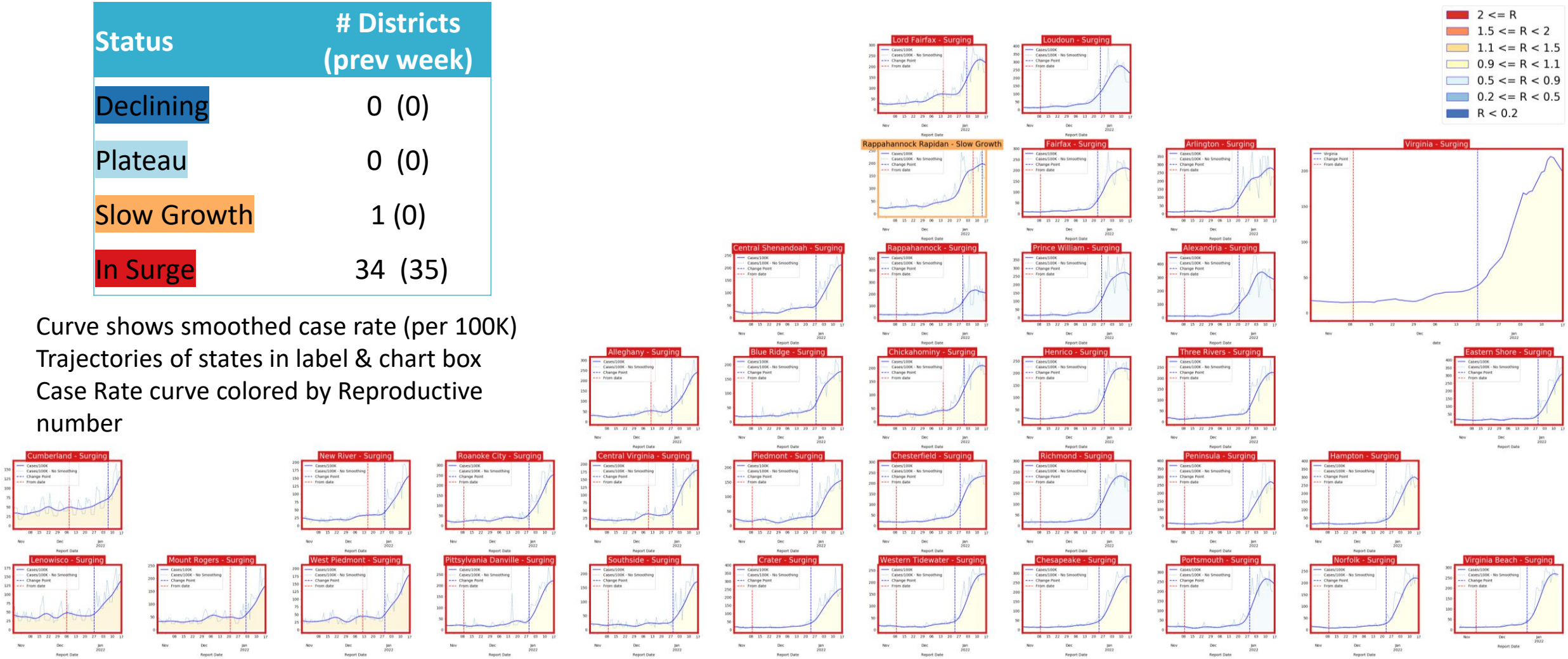


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	0 (0)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	0 (0)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	1 (0)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	34 (35)

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	0 (0)
Plateau	0 (0)
Slow Growth	1 (0)
In Surge	34 (35)

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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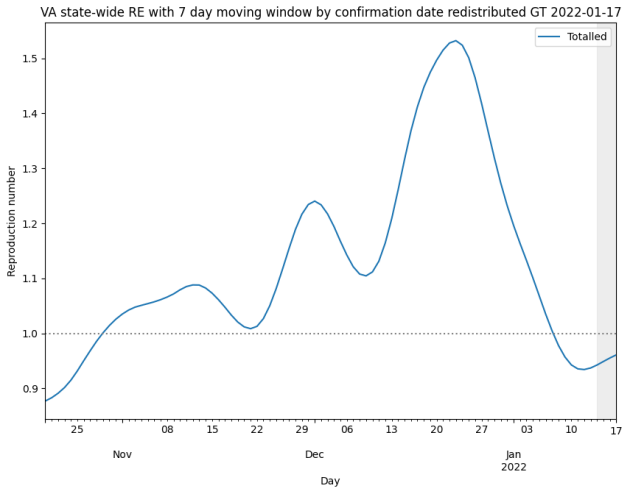
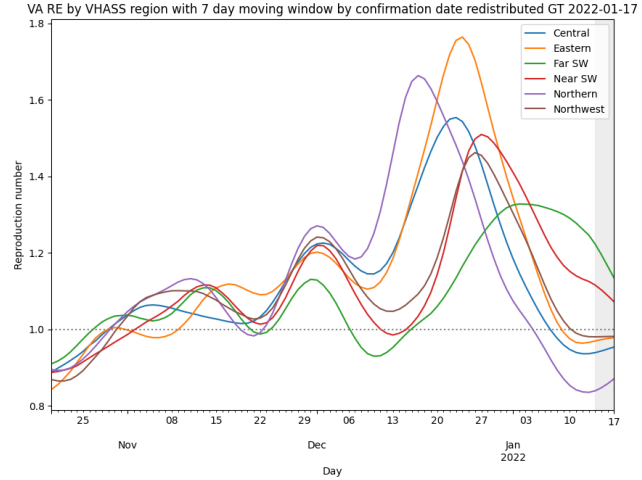
Estimating Daily Reproductive Number – Redistributed gap

Jan 17th Estimates

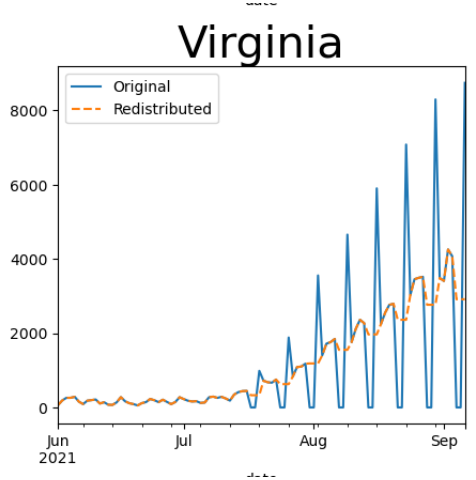
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.961	-0.121
Central	0.955	-0.093
Eastern	0.978	-0.151
Far SW	1.135	0.017
Near SW	1.072	-0.082
Northern	0.870	-0.168
Northwest	0.983	-0.127





Skipping Weekend Reports & holidays biases estimates

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



Methodology

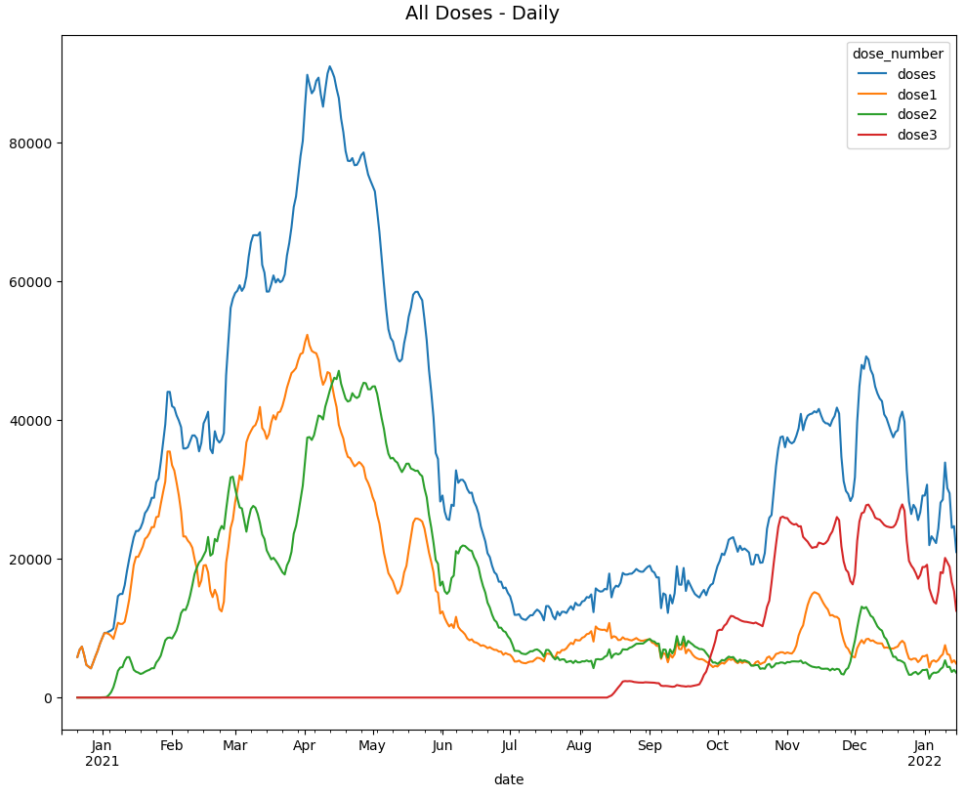
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

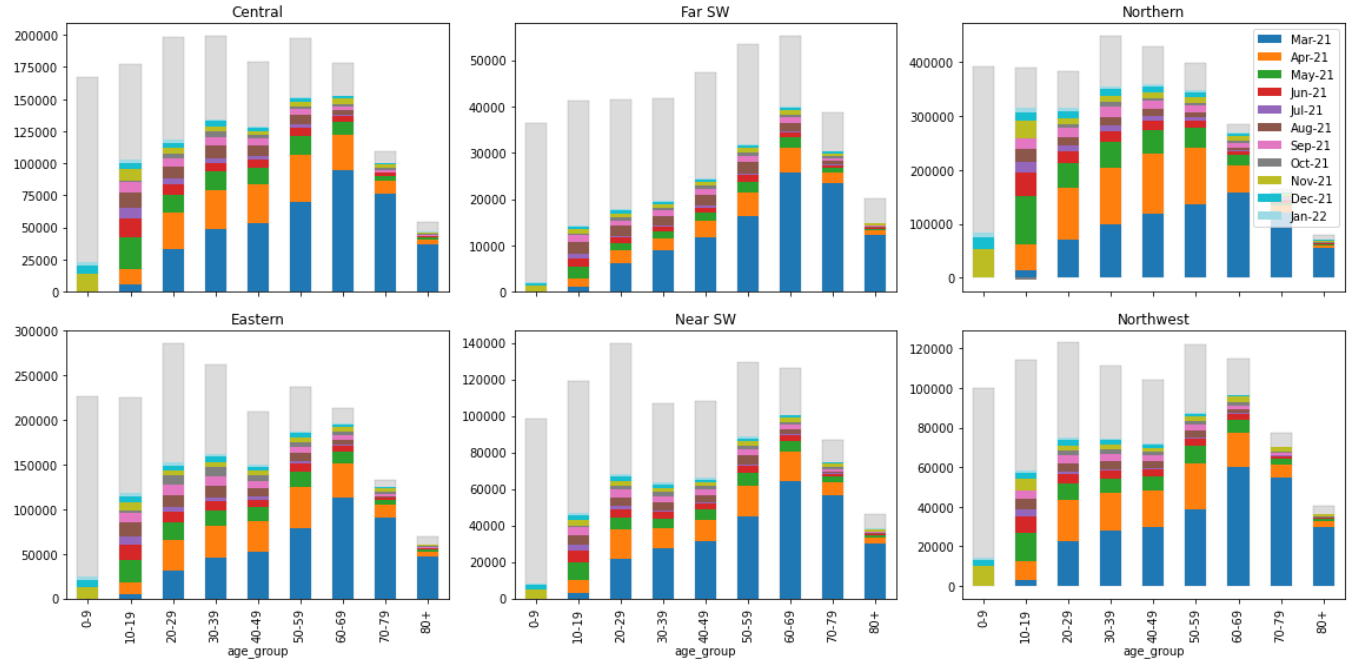
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Vaccination Administration in Virginia

Vaccine Doses administered:

- First dose administration has returned to pre 5-11 authorization levels
- Third dose administration still outpaces 1st, but has slowed in the last month
- Age-specific proportions of population vaccinated reflect slowed progress in younger ages



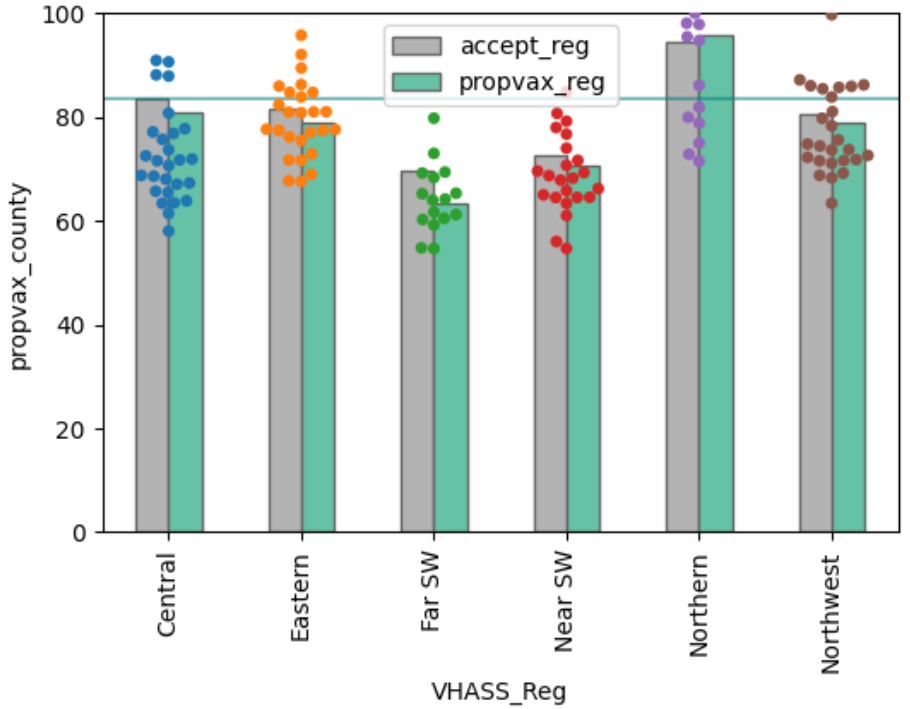


Vaccination Acceptance by Region

Corrections to surveys:

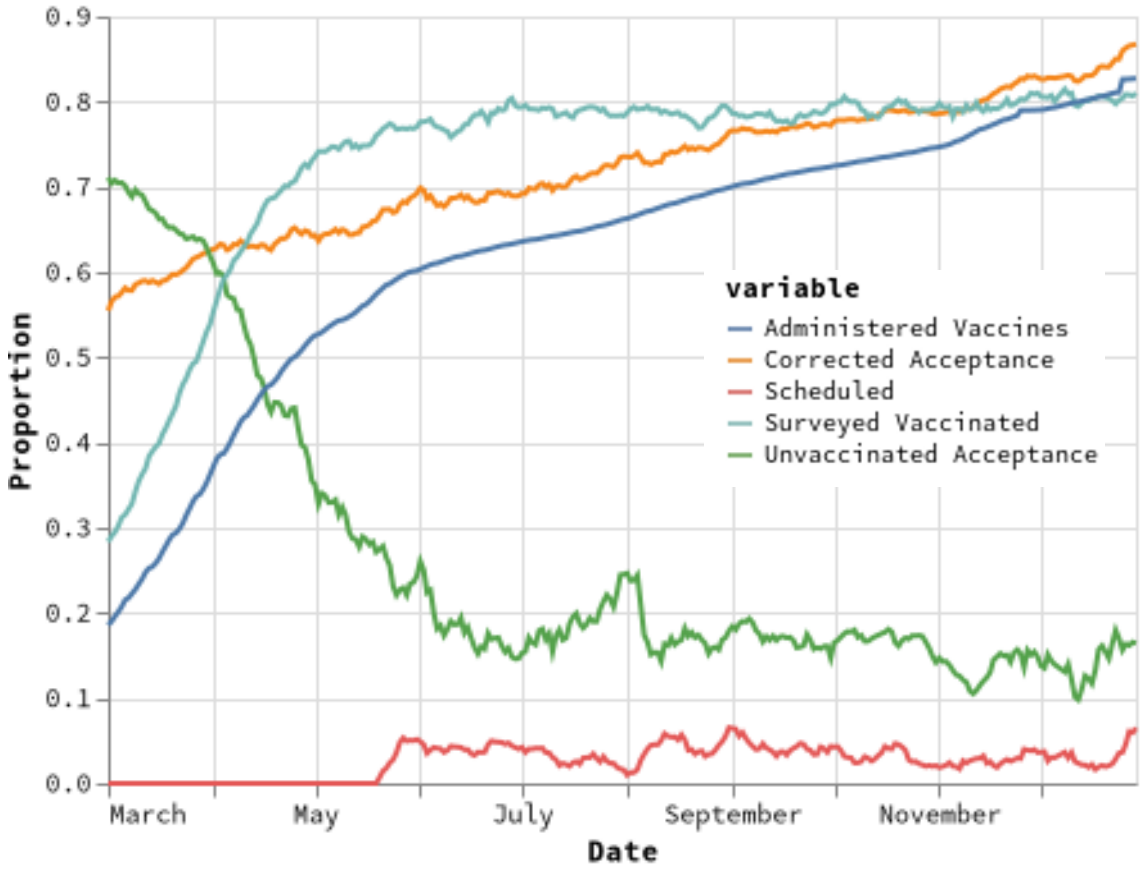
- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at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

Region	COVIDcast accepting corrected	VDH proportion pop vaccinated
Central	86%	80%
Eastern	85%	79%
Far SW	70%	63%
Near SW	74%	70%
Northern	96%	95%
Northwest	82%	78%
Virginia	**87%**	**83%**



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

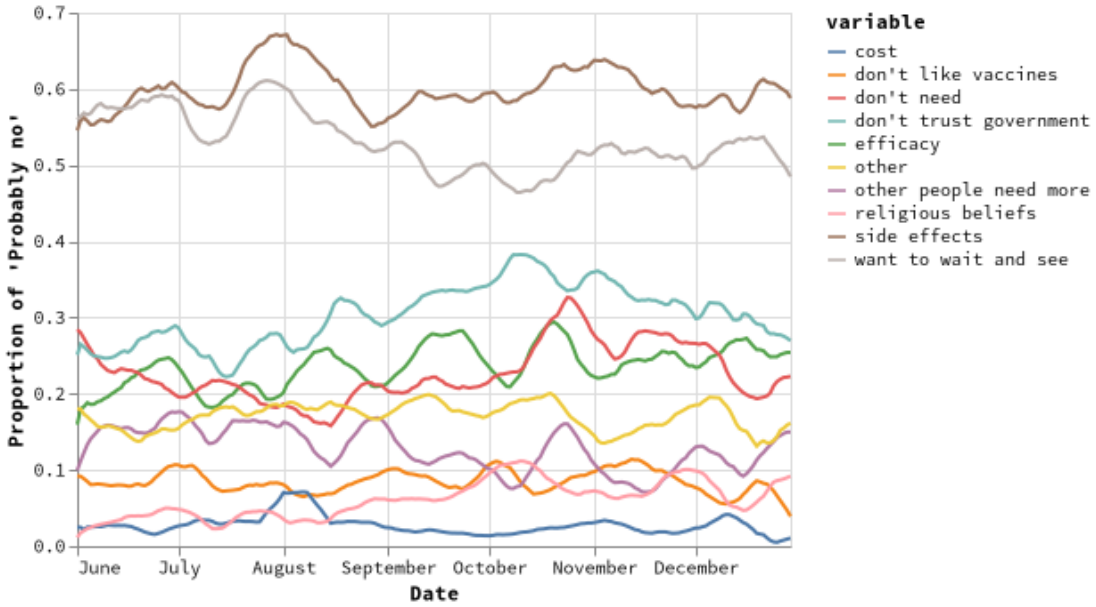
Vaccine Acceptance Components over Time



Vaccine Acceptance adjusted to include scheduled appointments

- Steady rise in acceptance over the past couple months
- Unvaccinated Acceptance shows ~20% of those who are unvaccinated are definitely or probably willing to be vaccinated
- Scheduled appointments for vaccination have increased through August but seem to be leveling off

Reasons among those that are Probably not going to Vaccinate

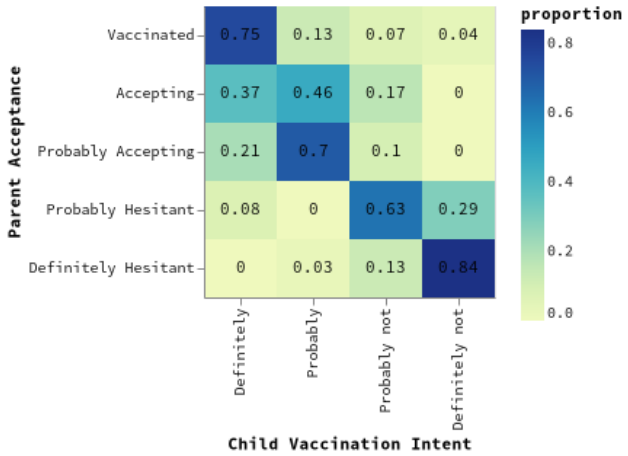


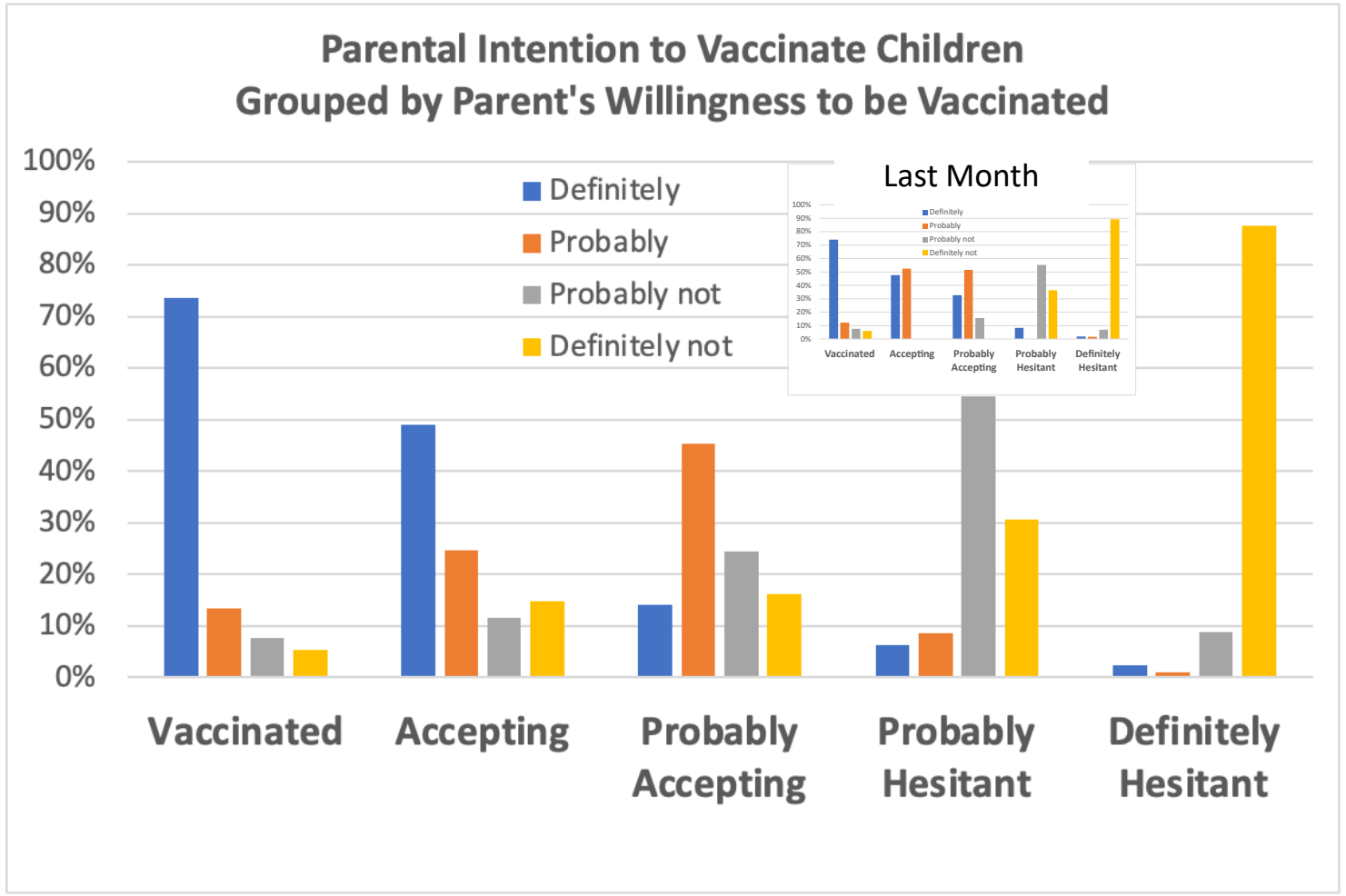
Data Source: https://covidcast.cmu.edu

Parental Intention to Vaccinate Children

Parental Intention to Vaccinate Children lower than overall Acceptance

- Most willing (vaccinated) remain at ~70% definitely intending to vaccinate kids
- Intention strongly biased by the willingness of the parent, and skews towards unwillingness to vaccinate



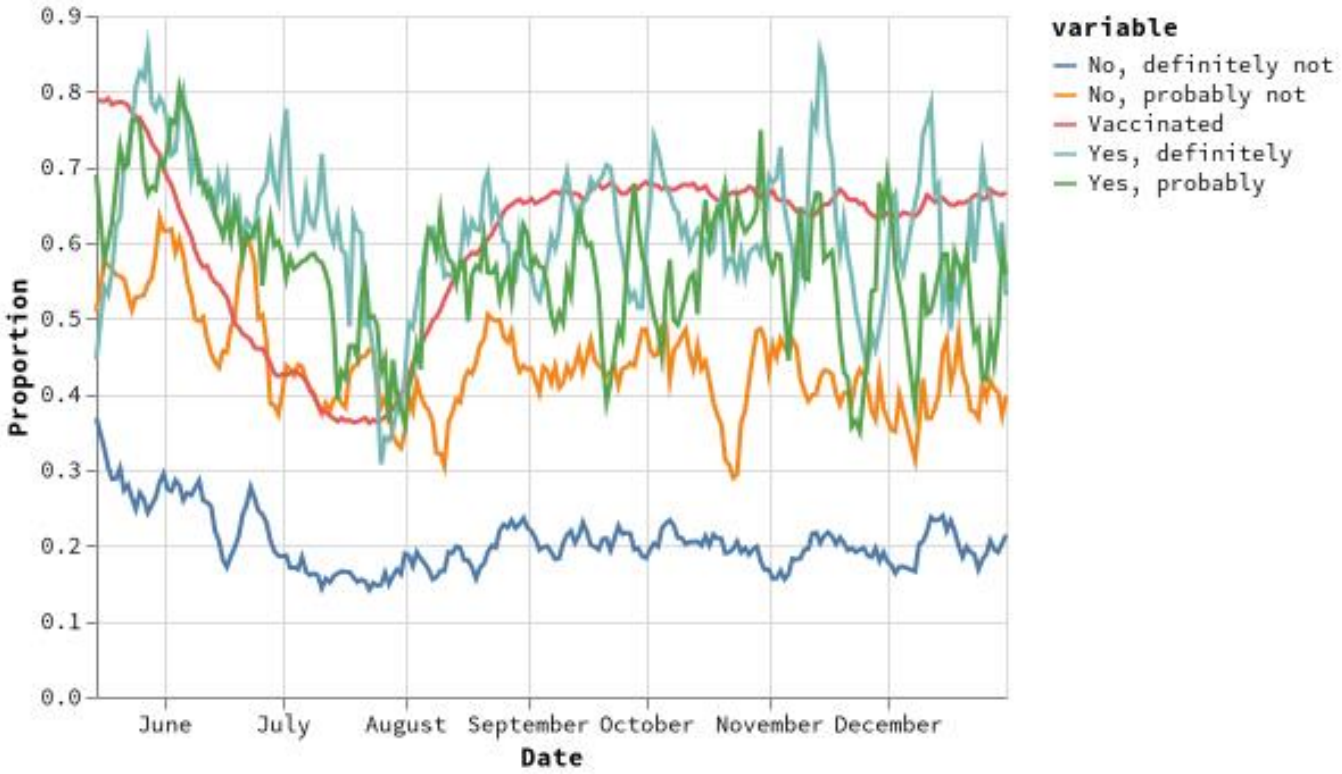


Data Source: https://covidcast.cmu.edu

Mask Usage Cpontinues to slowly Rise

Self-reported mask usage has continued to increase to 73% (mid 60s in previous months)

- US and VA experienced similar increases over the course of last month
- Mask wearing remains lower among unvaccinated especially among least willing to be vaccinated



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

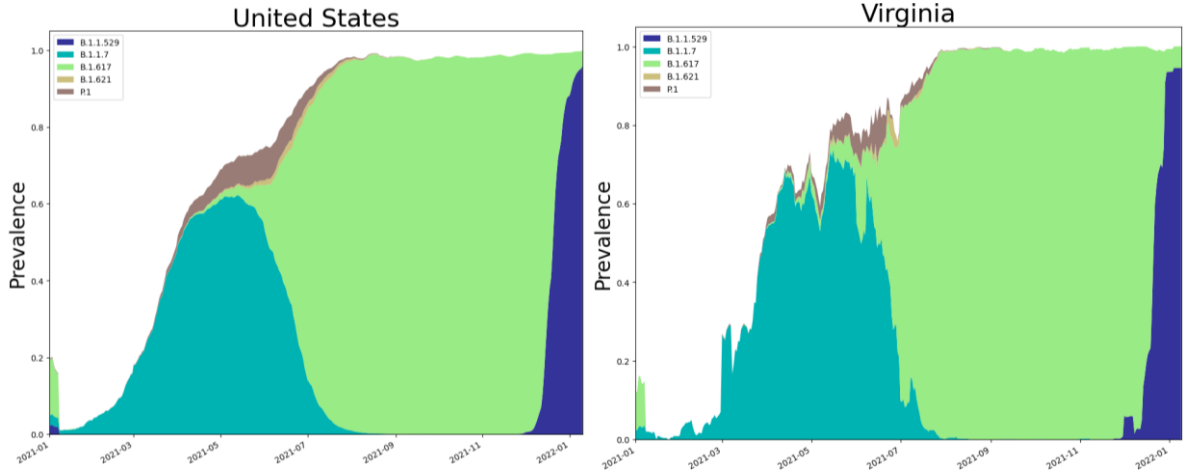
SARS-CoV2 Variants of Concern

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

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

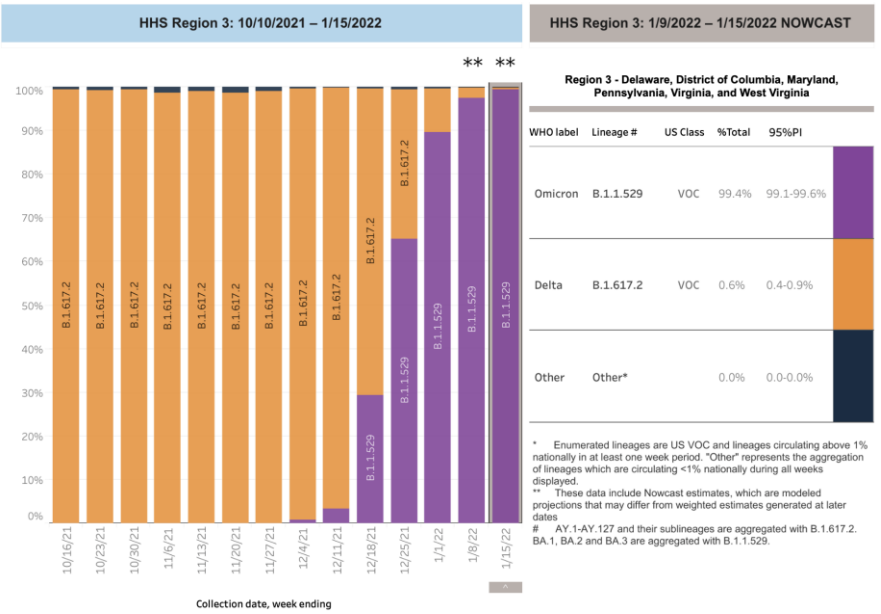
WHO label	Pango lineage*	GISAID clade	Nextstrain clade	Additional amino acid changes monitored*	Earliest documented samples	Date of designation
Alpha	B.1.1.7	GRY	20I (V1)	+S:484K +S:452R	United Kingdom, Sep-2020	18-Dec-2020
Beta	B.1.351	GH/501Y.V2	20H (V2)	+S:L18F	South Africa, May-2020	18-Dec-2020
Gamma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

World Health Organization [WHO](#)



Omicron Prevalence revised again from previous weeks

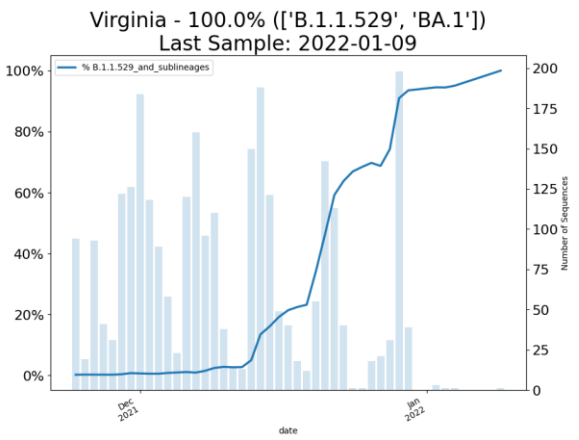
CDC nowcast calling for 99.4% in Region 3 on week ending Jan 8

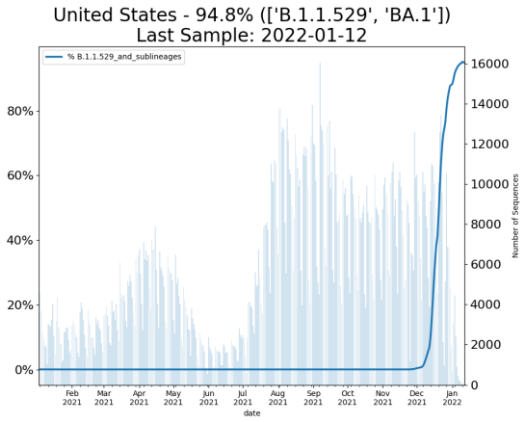


CDC [CDC Variant Tracking](#)

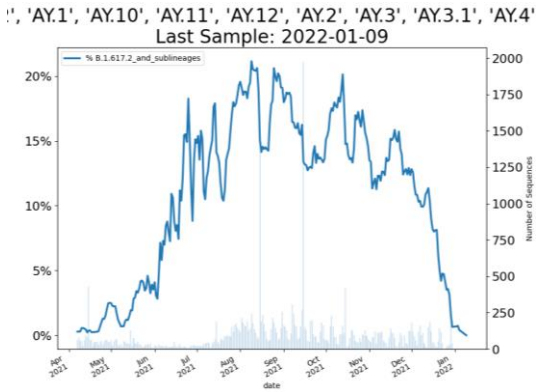
SARS-CoV2 Variants of Concern

Omicron ο - Lineage B.1.1.529



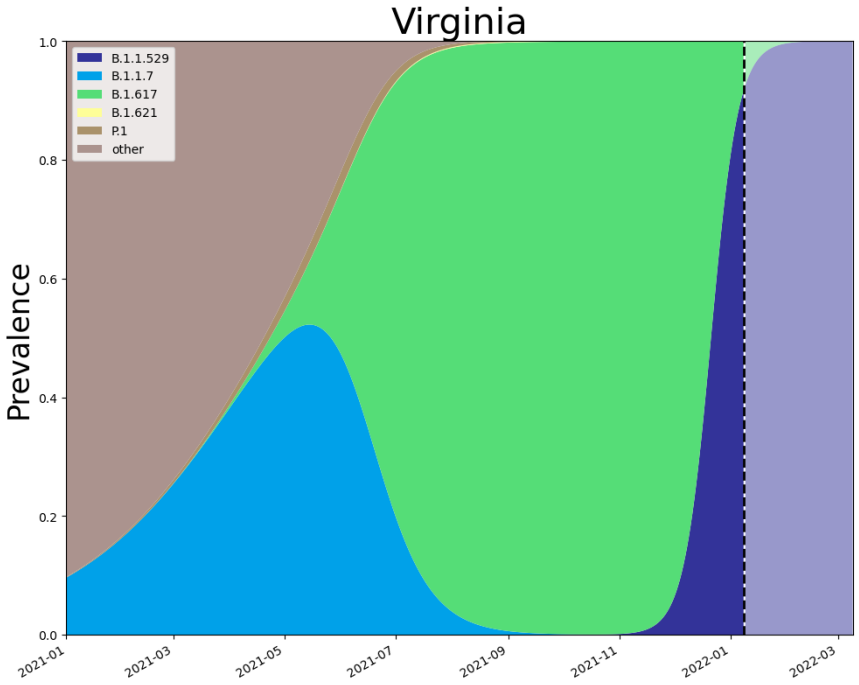


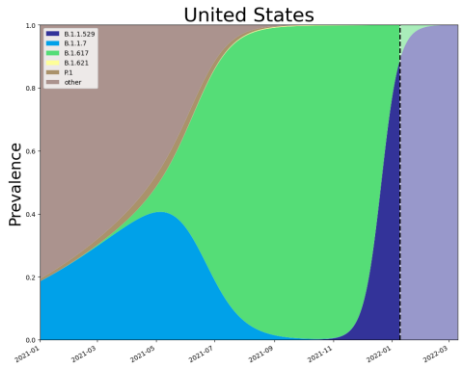
Delta δ - Lineage B.1.617.2



GISAID outbreak.info

VoC Polynomial Fit Projections

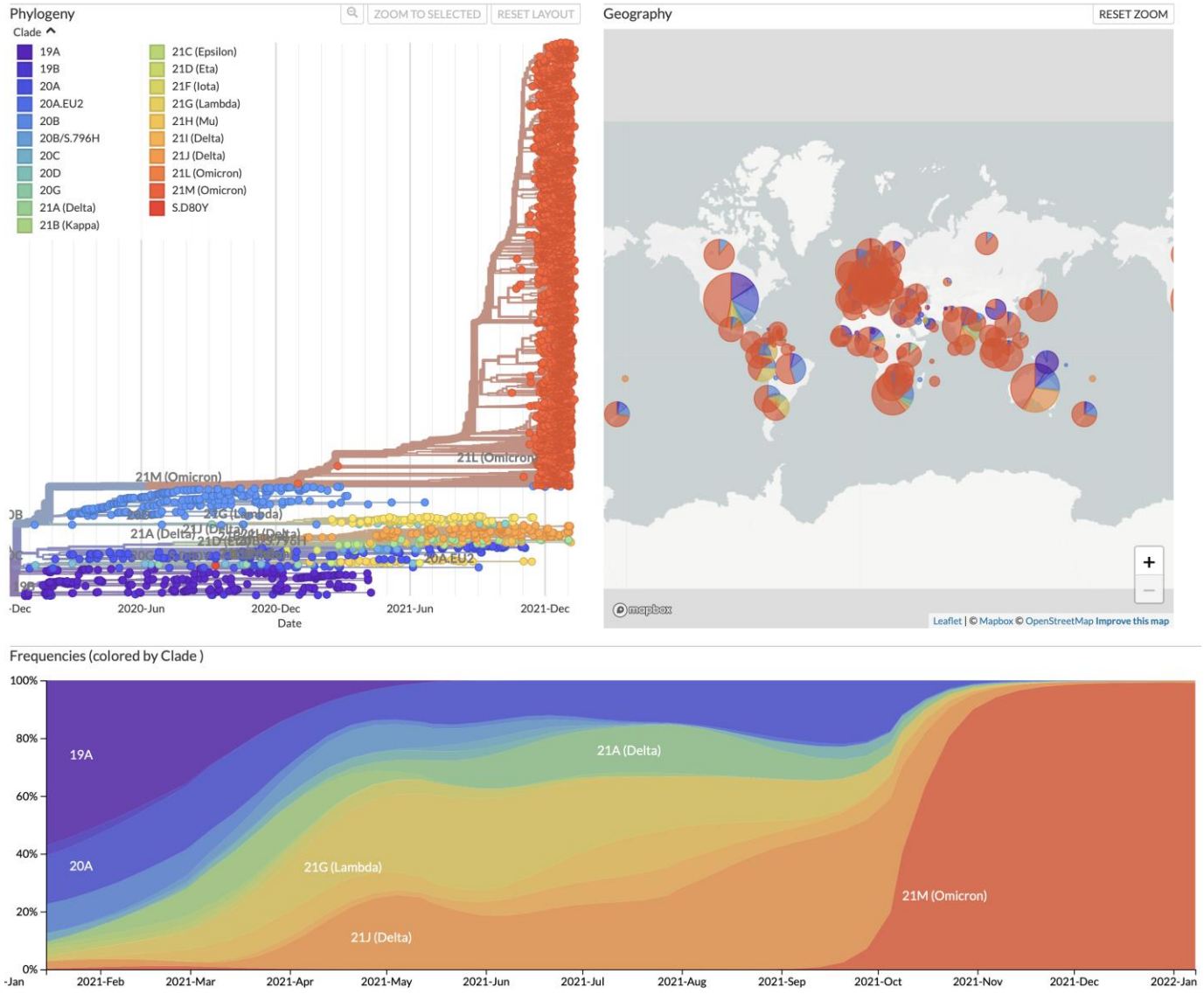




SARS-CoV2 Omicron Diversity

Significant diversity of Omicron generated in short period of time

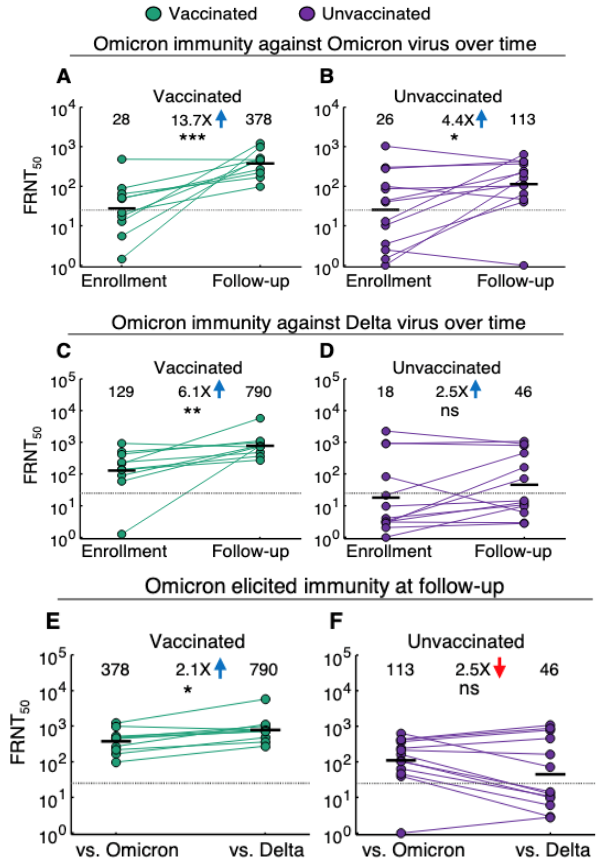
- Incredibly intense transmission has allowed significant diversification in short period time (much faster than previous variants)
- Should rapidly find subvariants with any fitness advantages (if they exist)
- Omicron remains starkly distinct from previous variants



Omicron

1. Omicron infection enhances preexisting immunity elicited by vaccines, but on its own may not induce broad, cross-neutralizing humoral immunity in unvaccinated individuals.
2. South African study indicates vaccinated individuals with Omicron breakthrough infections may have better protection against Delta than Omicron itself in a two week follow up. Both studies confirm that vaccinated breakthrough infections confer more protection than infection in unvaccinated individuals

2



Vaccinated participants were able to mount a stronger neutralization response against Delta relative to Omicron virus. This was not the case in unvaccinated individuals, some of whom continued to show low Delta neutralization, and contrasted sharply with poor cross-neutralization of Omicron in Delta infected persons. Higher Omicron neutralization in vaccinated individuals may enable a more effective immune response to Omicron, while enhancement of Delta neutralization should lead to lower Delta re-infections.
https://secureservercdn.net/50.62.198.70/1mx.c5c.myftpupload.com/wp-content/uploads/2022/01/MEDRXIV-2021-268439v2-Sigal.pdf

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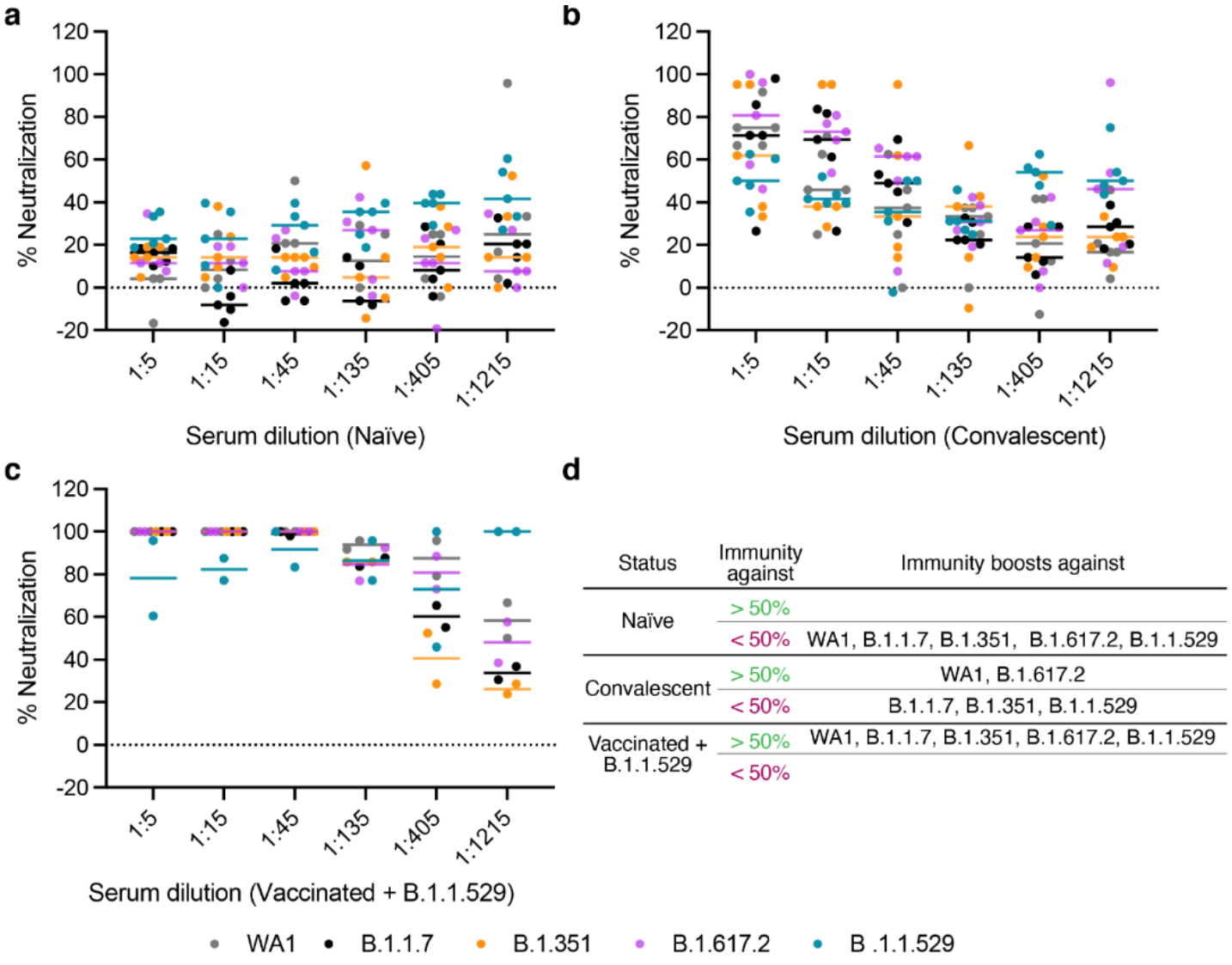

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Status	Immunity against	Immunity boosts against
Naïve	> 50%	
	< 50%	WA1, B.1.1.7, B.1.351, B.1.617.2, B.1.1.529
Convalescent	> 50%	WA1, B.1.617.2
	< 50%	B.1.1.7, B.1.351, B.1.1.529
Vaccinated + B.1.1.529	> 50%	WA1, B.1.1.7, B.1.351, B.1.617.2, B.1.1.529
	< 50%	

Sera from vaccinated individuals with confirmed Omicron breakthrough infection showed the highest level of protection (>80%) against all strains, including Omicron (Fig. 5c,d). While the Omicron virus is immunogenic, infection with this variant in unvaccinated individuals may not elicit effective cross-neutralizing antibodies against other variants. In vaccinated individuals, however, Omicron infection effectively induces immunity against itself and enhances protection against other variants
https://www.medrxiv.org/content/10.1101/2022.01.13.22269243v1.full.pdf

Omicron

1

1. Three dose regime results in much lower hospitalizations per 100k.
2. In this Arizona based study of T-cell responses, three-dose vaccinated participants had similar responses to Omicron relative to convalescent or convalescent plus two-dose vaccinated groups and exhibited responses significantly higher than those receiving two mRNA vaccine doses.
3. Updated Omicron characterization from UK Health Security Agency gives reduced risk compared to Delta and relative change of certain symptom presentation.

Age group	3 doses & hospitalized (n)	3 doses & hospitalized (rate per 100K)	2 doses & hospitalized (n)	2 doses & hospitalized (rate per 100K)	Unvaccinated & hospitalized (n)	Unvaccinated & hospitalized (rate per 100K)
Under 5 years	0	0.00	0	0.00	153	57.13
5-11 years	0	0.00	0	0.00	60	23.87
12-29 years	4	5.33	133	18.25	358	229.14
30-39 years	10	9.53	153	32.47	504	452.59
40-49 years	14	10.53	117	30.35	537	746.60
50-59 years	32	17.57	178	59.85	700	1230.49
60-69 years	46	18.96	320	163.58	757	3131.27
70-79 years	98	55.84	392	554.42	640	7115.86
80+ years	195	197.49	484	1646.99	420	4631.95
5+ years	399	39.43	1777	81.00	4129	598.42

Hospitalization rates in Alberta, Canada among boosted 80+ year-olds is lower than the hospitalization rate among unvaccinated 12-29 year-olds.
https://www.alberta.ca/stats/covid-19-alberta-statistics.htm#vaccine-outcomes

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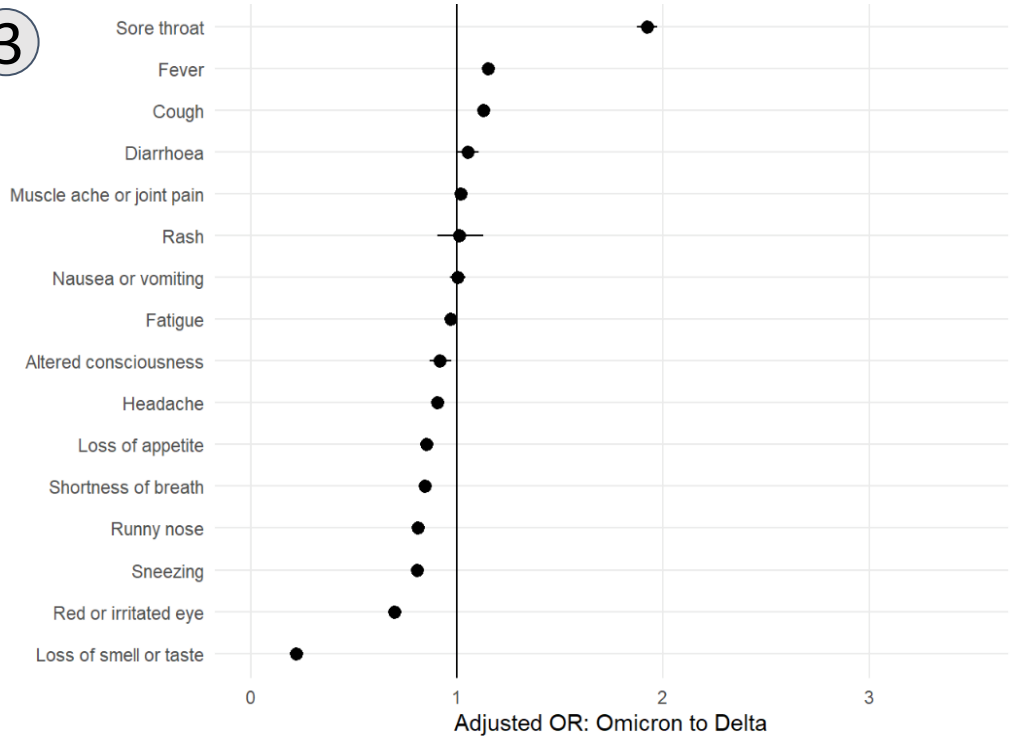

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1046853/technical-briefing-34-14-january-2022.pdf

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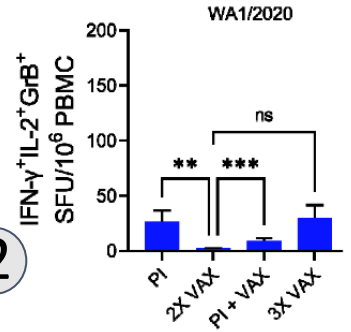
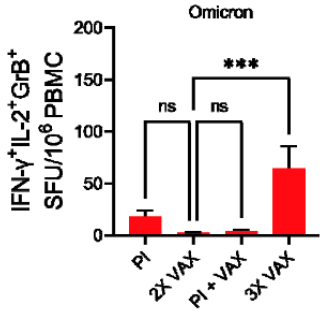




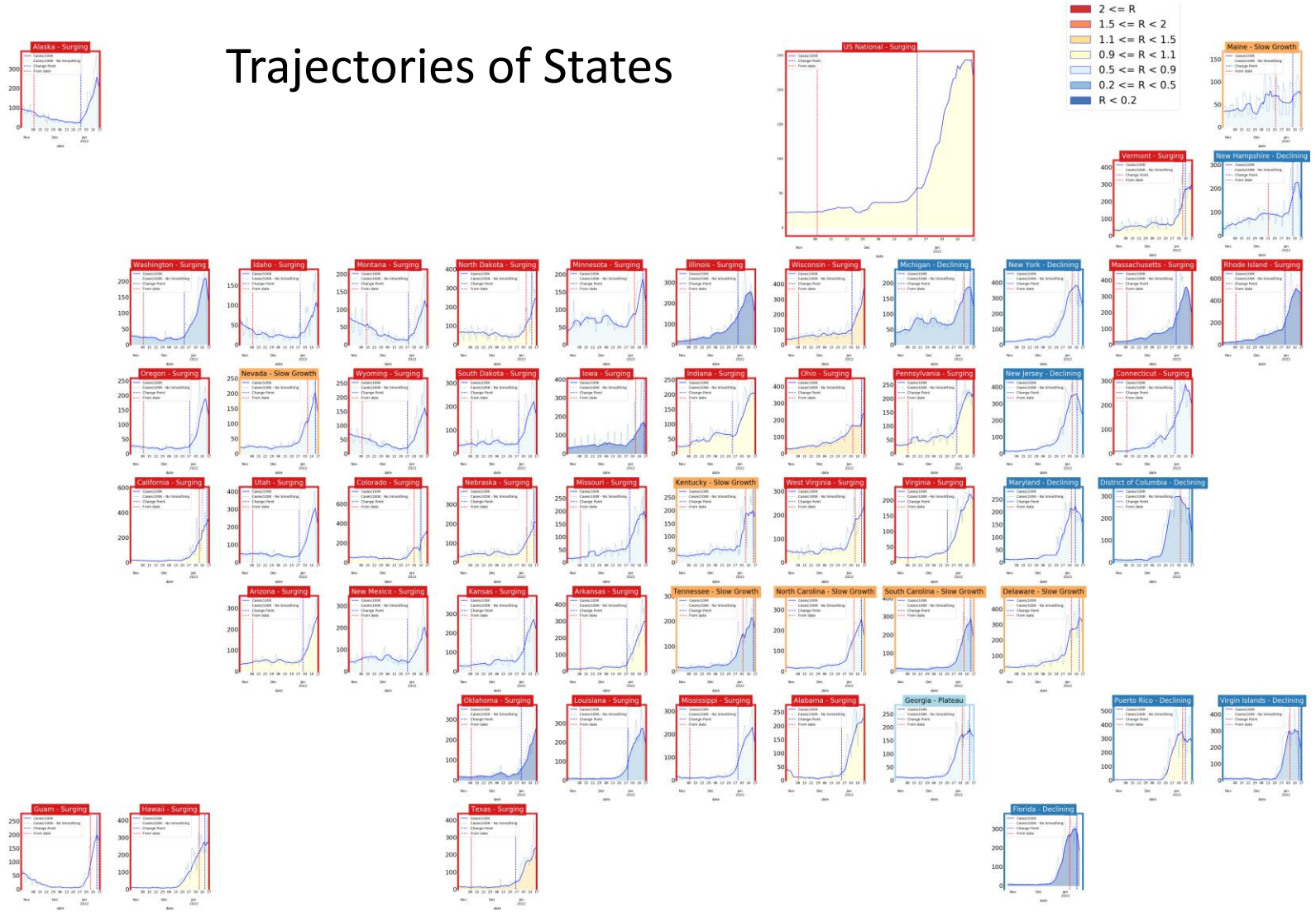
Analyzed a cohort (n=345 subjects) of two- or three- dose messenger RNA (mRNA) vaccine recipients and COVID-19 post infection subjects. Provides further evidence that a three-dose vaccine regimen benefits the induction of optimal functional T cell immune memory.
https://www.medrxiv.org/content/10.1101/2022.01.16.22269361v1.full.pdf

United States Overall

- Most of nation remains in Surge, however, significant shift towards slower growth and declines
- Surges that started in Northeast and MidAtlantic are shifting to declines

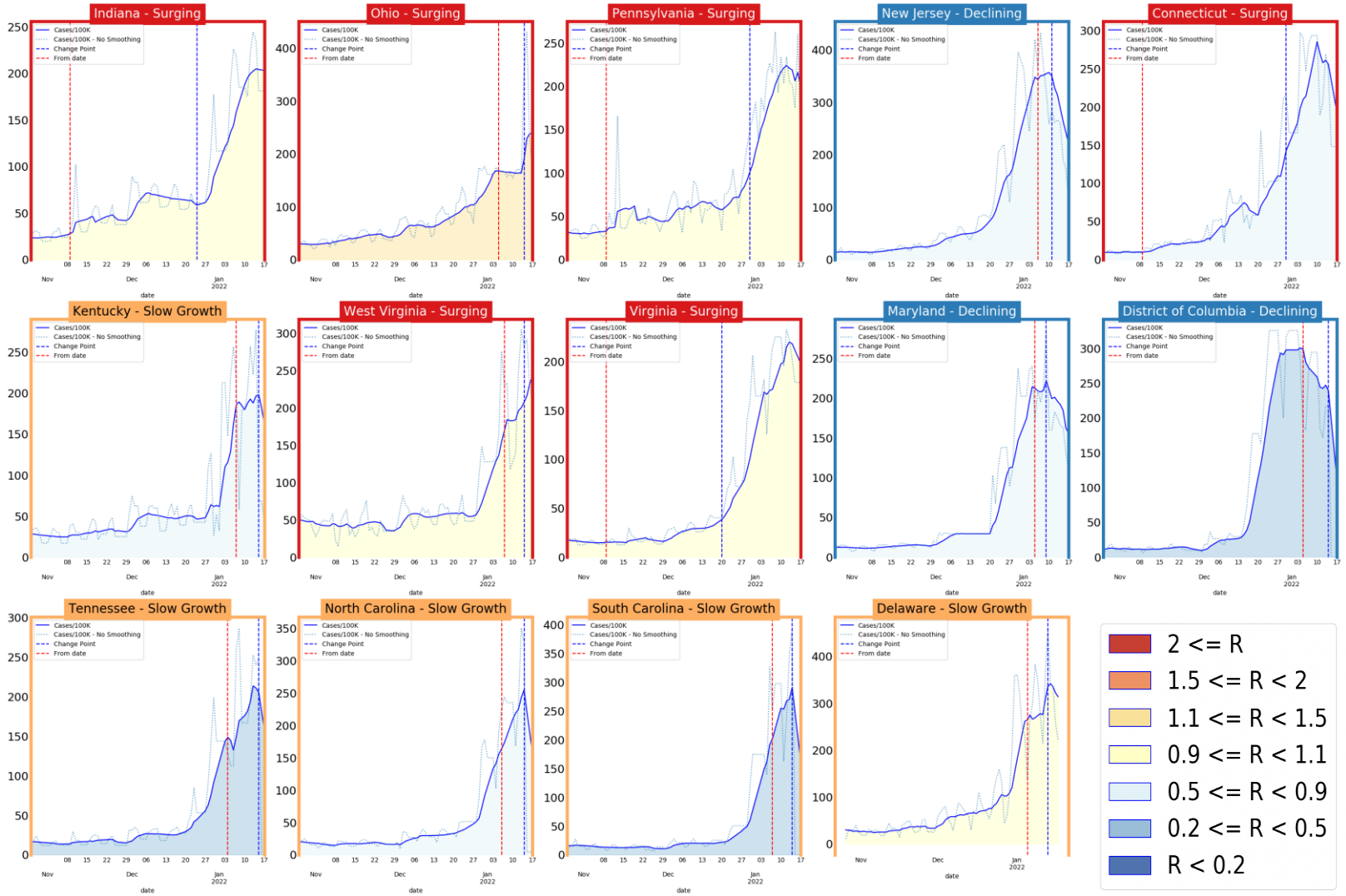
Status	# States
Declining	9 (3)
Plateau	1 (0)
Slow Growth	7 (0)
In Surge	37 (51)

Trajectories of States



Virginia and Her Neighbors

- Growth has slowed significantly for many states in the neighborhood
- All states show signs of slowing
- Rates remain high, with all experiencing more than 100/100K daily incident case rates



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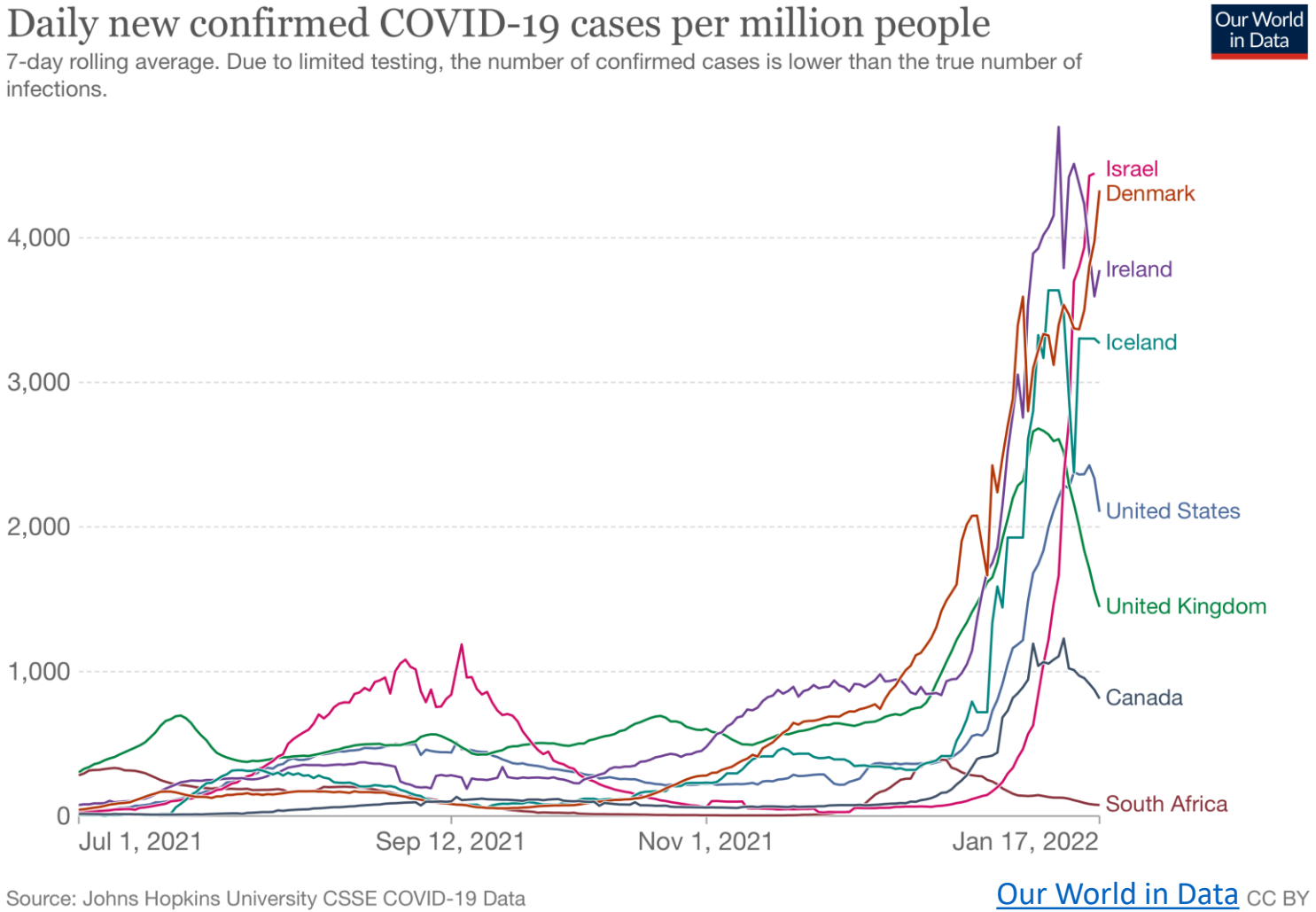
Other Countries

- Many countries that have experienced Omicron are starting to see a plateau and/or a decline
- Israel, despite very high vaccination levels, still experiencing significant case rates



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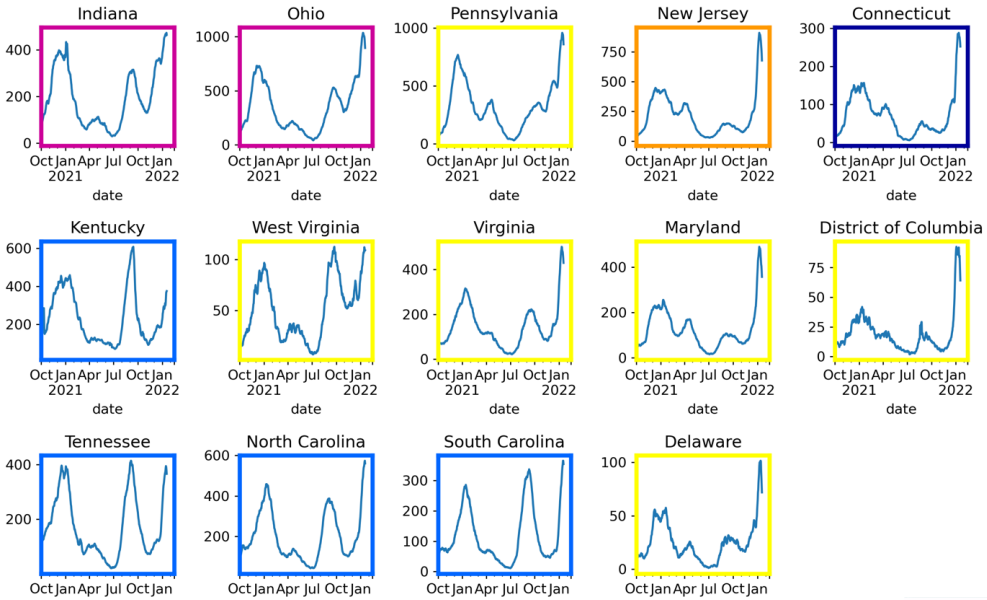
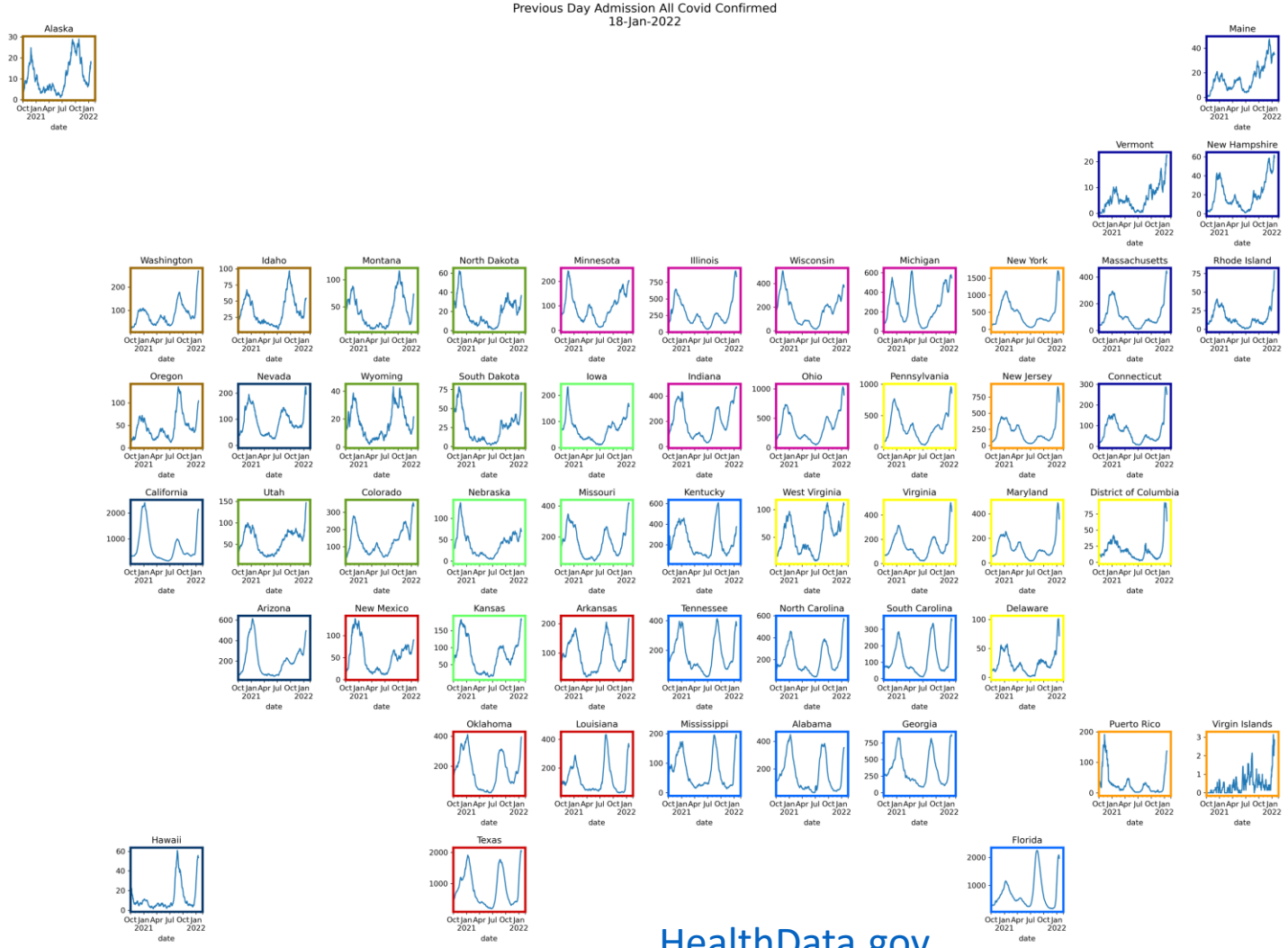
COVID-19 Hospital Admissions

- Many states show signs of slowdown in just the last several days
- VA, MD, DC, DE all have slight dip in admissions

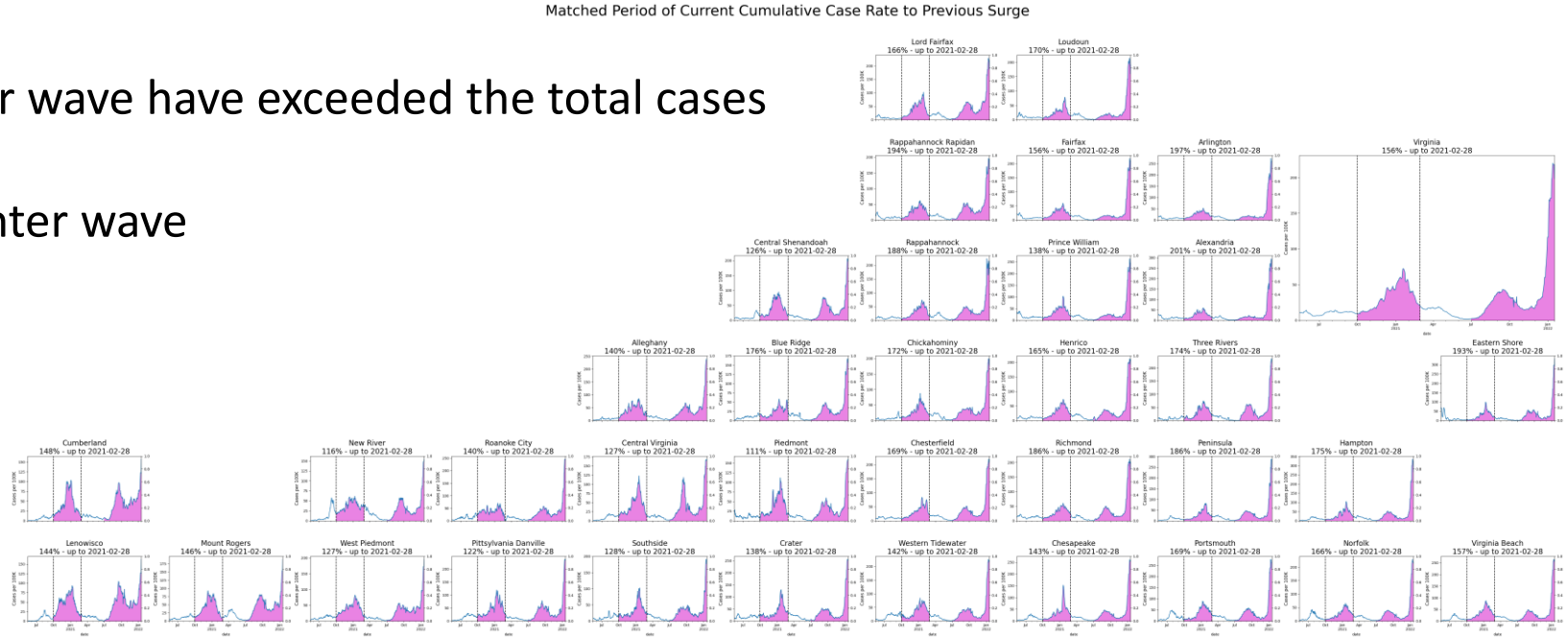


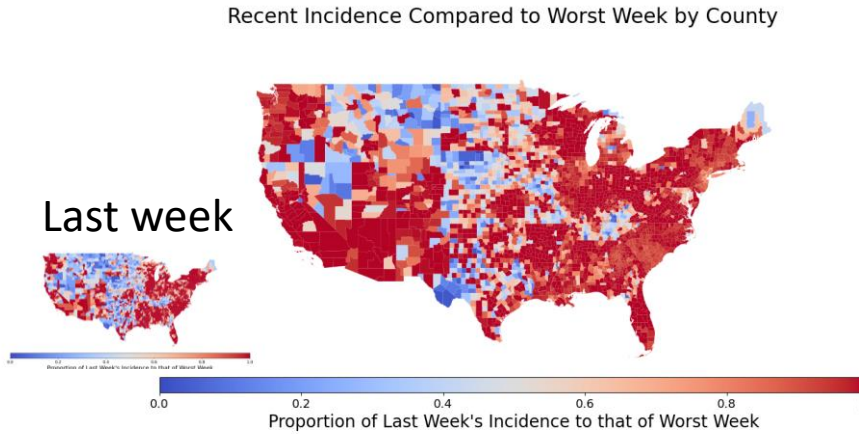


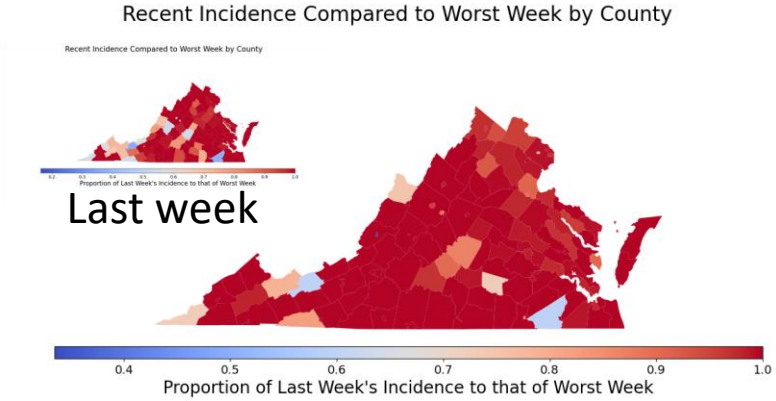
HealthData.gov

Virginia and Her Neighbors

- Current Delta and Fall-Winter wave have exceeded the total cases from last Fall-Winter wave
- Now at 150% of previous winter wave







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

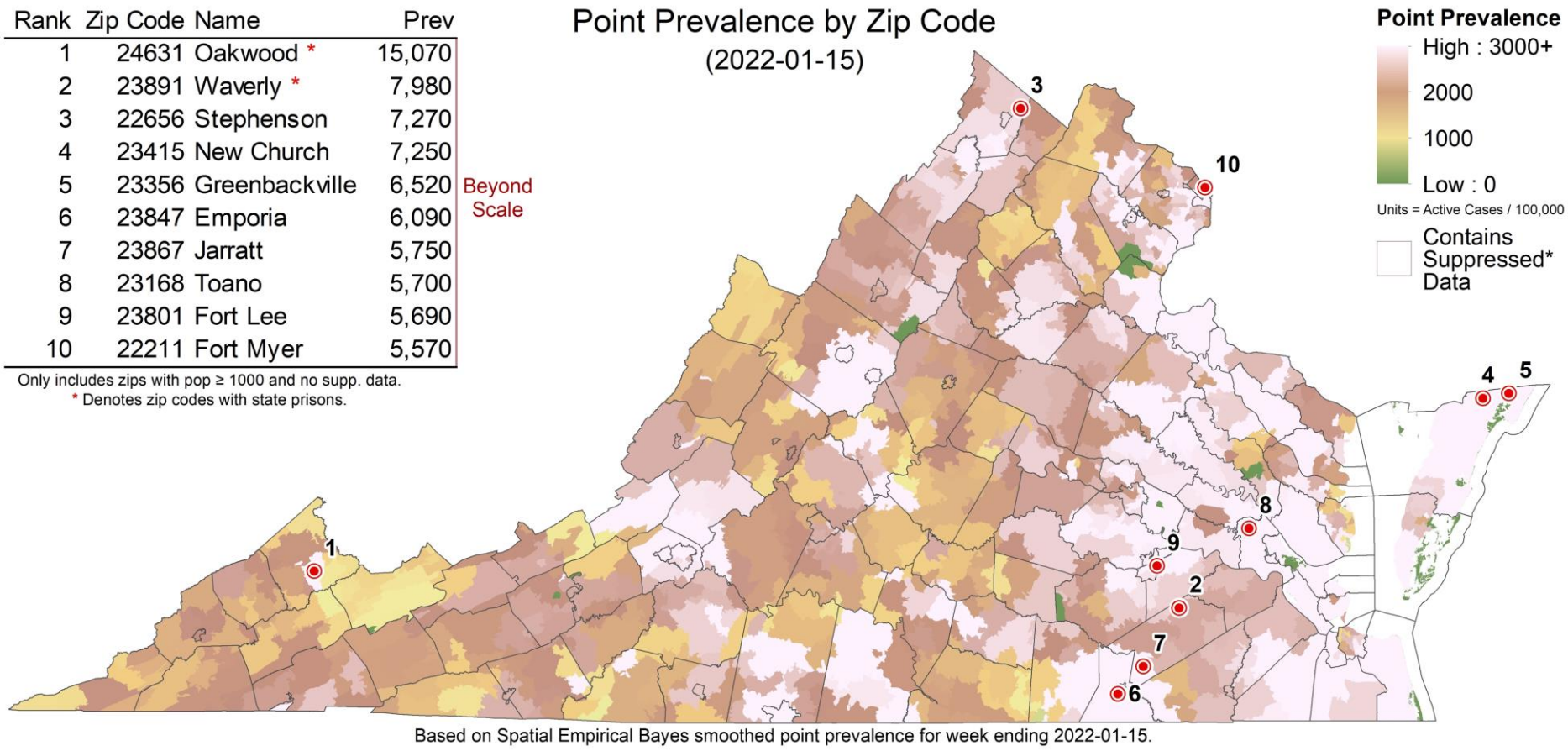
Zip code level weekly Case Rate (per 100K)

Case Rates in the last week by zip code

- Color scaled adjusted to accommodate the very high prevalence levels this week
- Clusters of high prevalence in Northeast
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prev	
1	24631	Oakwood *	15,070	
2	23891	Waverly *	7,980	
3	22656	Stephenson	7,270	
4	23415	New Church	7,250	
5	23356	Greenbackville	6,520	Beyond Scale
6	23847	Emporia	6,090	
7	23867	Jarratt	5,750	
8	23168	Toano	5,700	
9	23801	Fort Lee	5,690	
10	22211	Fort Myer	5,570	

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



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-01-15.

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Risk of Exposure by Group Size and HCW prevalence

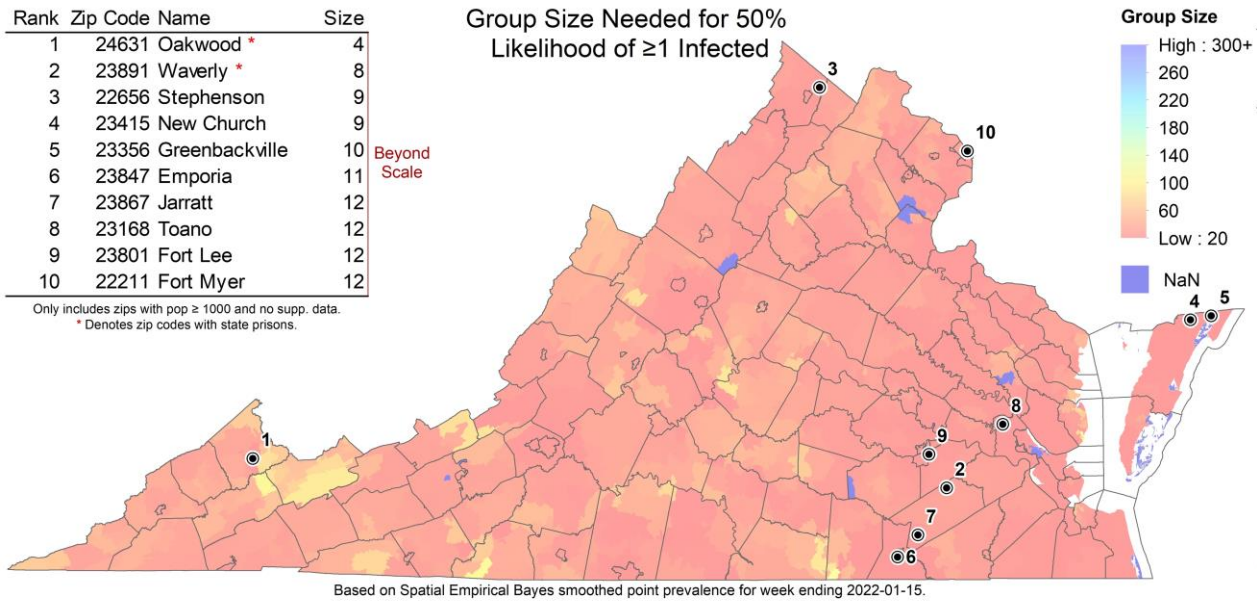
Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people (group size 25)

- **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 4 in Oakwood, there is a 50% chance someone will be infected)
- **HCW ratio**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator / general population's case prevalence

Rank	Zip Code	Name	Size
1	24631	Oakwood *	4
2	23891	Waverly *	8
3	22656	Stephenson	9
4	23415	New Church	9
5	23356	Greenbackville	10
6	23847	Emporia	11
7	23867	Jarratt	12
8	23168	Toano	12
9	23801	Fort Lee	12
10	22211	Fort Myer	12

Beyond Scale

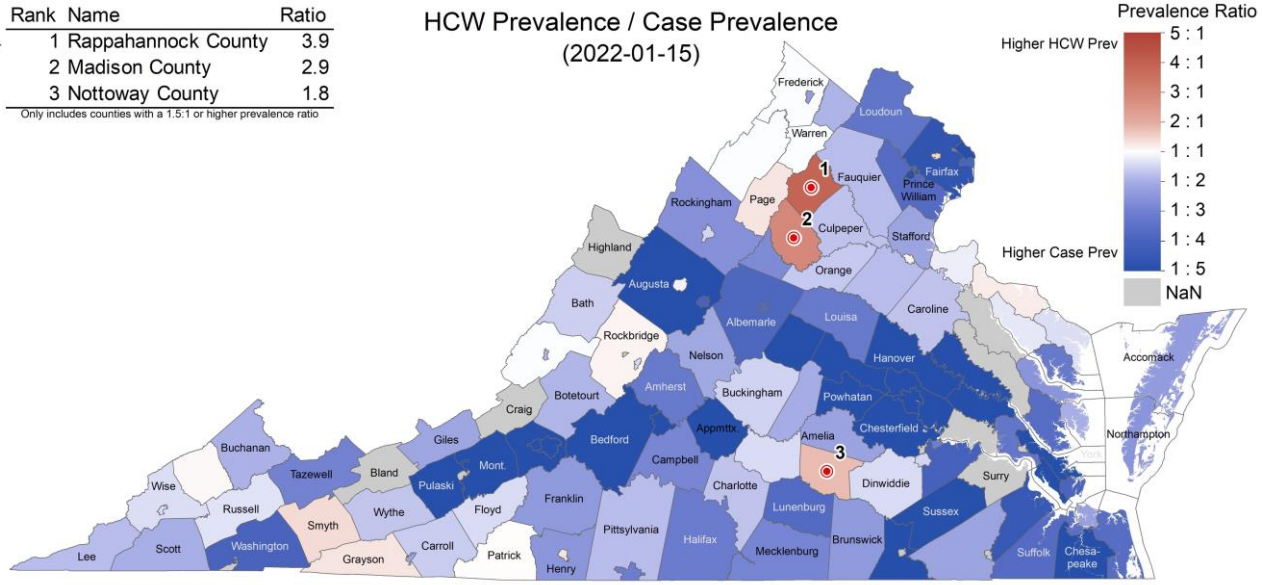
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-01-15.

Rank	Name	Ratio
1	Rappahannock County	3.9
2	Madison County	2.9
3	Nottoway County	1.8

Only includes counties with a 1.5:1 or higher prevalence ratio



Current Hot-Spots

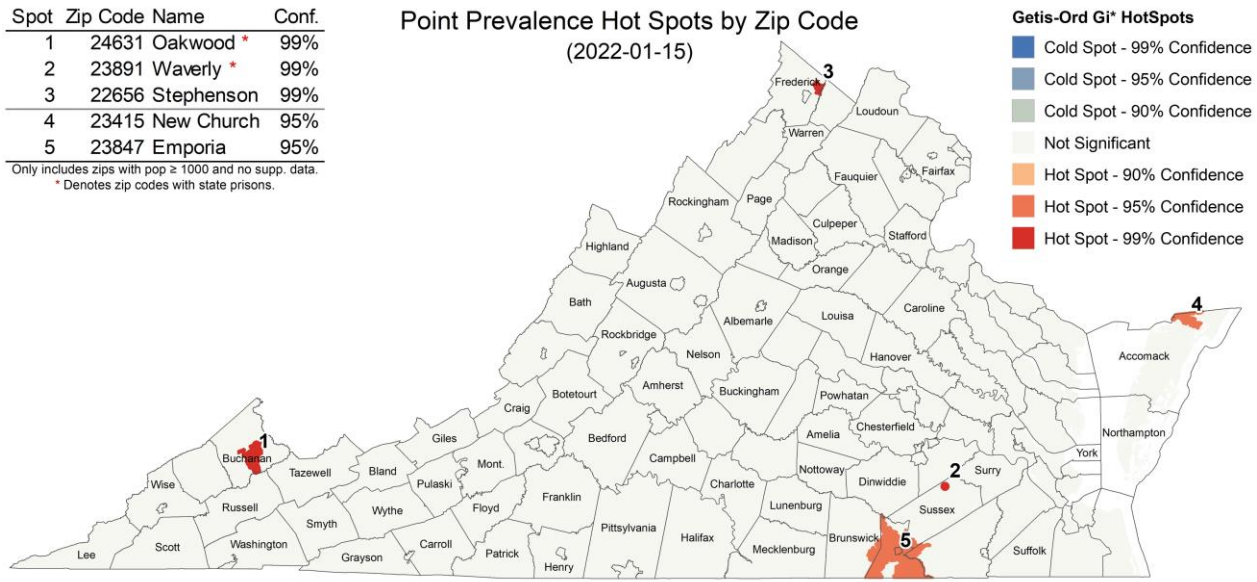
Case rates that are significantly different from neighboring areas or model projections

- **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	23891	Waverly *	99%
3	22656	Stephenson	99%
4	23415	New Church	95%
5	23847	Emporia	95%

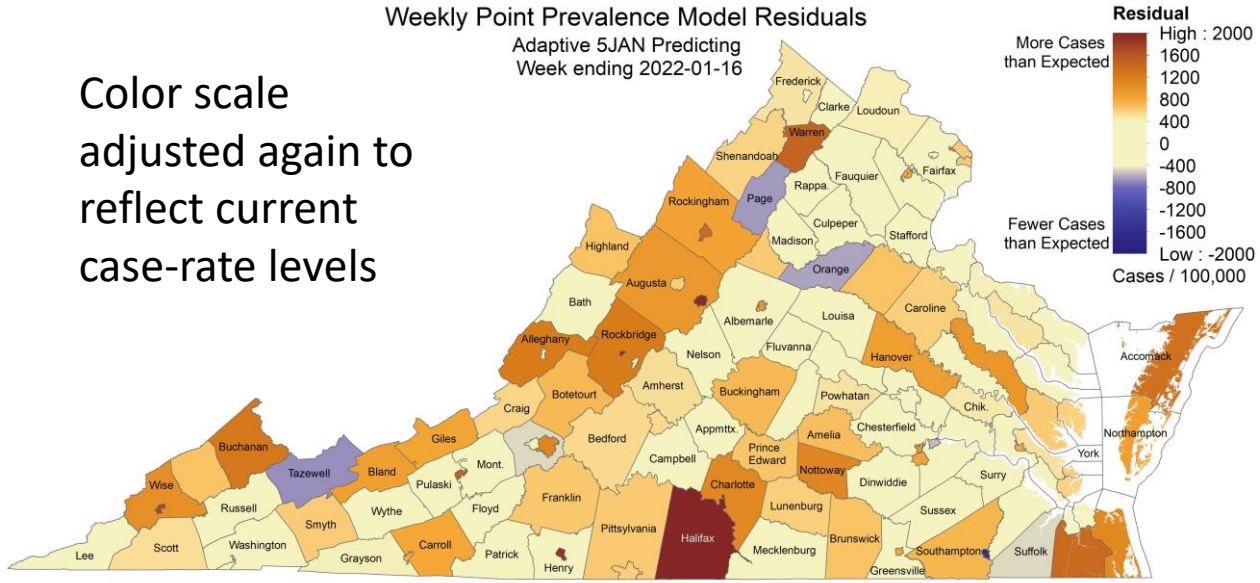
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Global Empirical Bayes smoothed point prevalence for week ending 2022-01-15.

Clustered Temporal Hotspots

Color scale adjusted again to reflect current case-rate levels

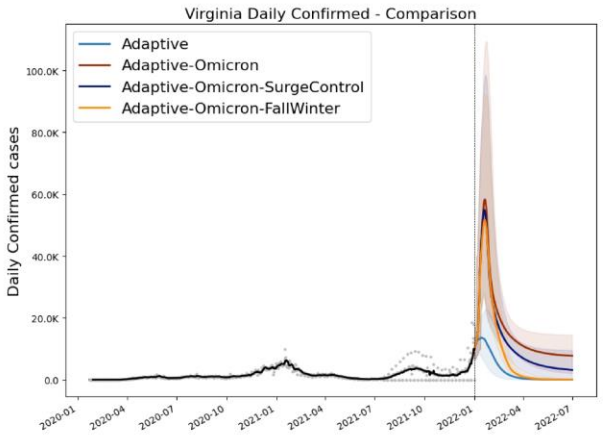


Moran's I = 0.001659, Z-Score = 0.408428, P-Value = 0.682959
No Residual Autocorrelation Detected

Scenario Trajectory Tracking

Which scenario from last projection did each county track closest?

- Adaptive-Scenario from 2 weeks ago tracked the growth from Omicron well, however, has likely significantly underestimated total infections and lack of multi-strain support
- The other Omicron scenarios were very similar two weeks ago and the western area of the state tracked its growth well.

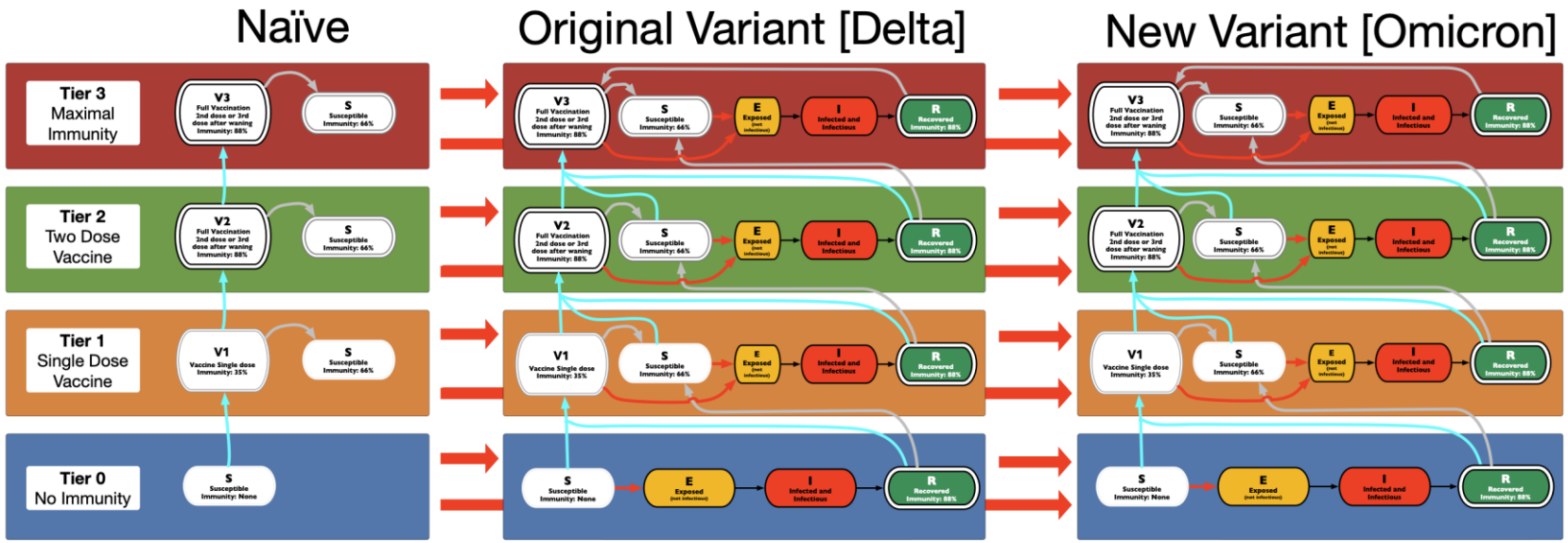


Model Update – Adaptive Fitting

Model Structure Extended for Multiple Strains

Omicron escapes immunity from vaccinated and those infected with Delta

- Multiple strain support allow representation of differential protection based on immunological history
- Severity of Outcomes varies by strain and level of immunity, thus allowing model to better capture hospitalizations and deaths from Omicron
- Adaptive fitting approach continues to use simulation to generate the full distribution of immune states across the population



Adaptive Fitting Approach

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

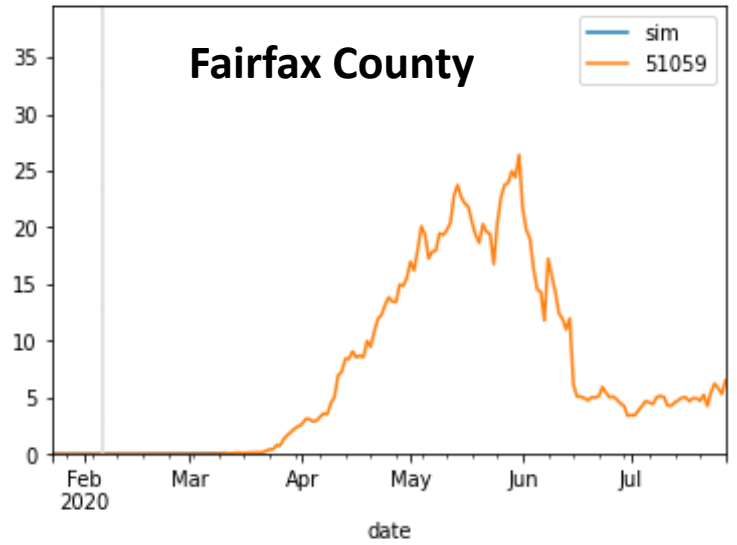
- Allows history to be precisely captured, and used to guide bounds on projections

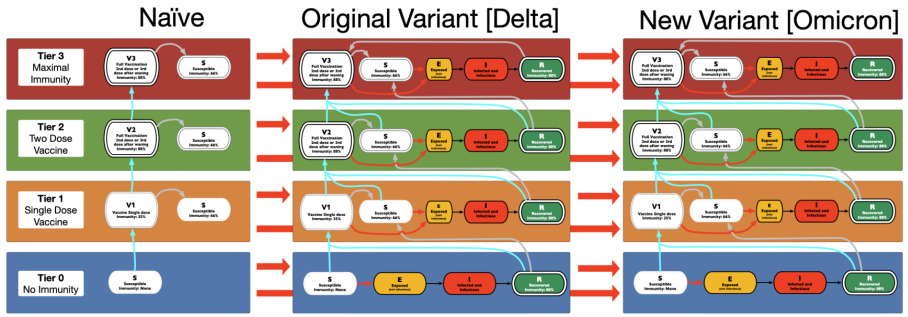
Model: An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- Allows for future "what-if" Scenarios to be layered on top of calibrated model
- Allows for waning of immunity and for partial immunity against different outcomes (eg lower protection for infection than death)

External Seeding: Steady low-level importation

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





Using Ensemble Model to Guide Projections

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

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

Weekly forecasts done at county level

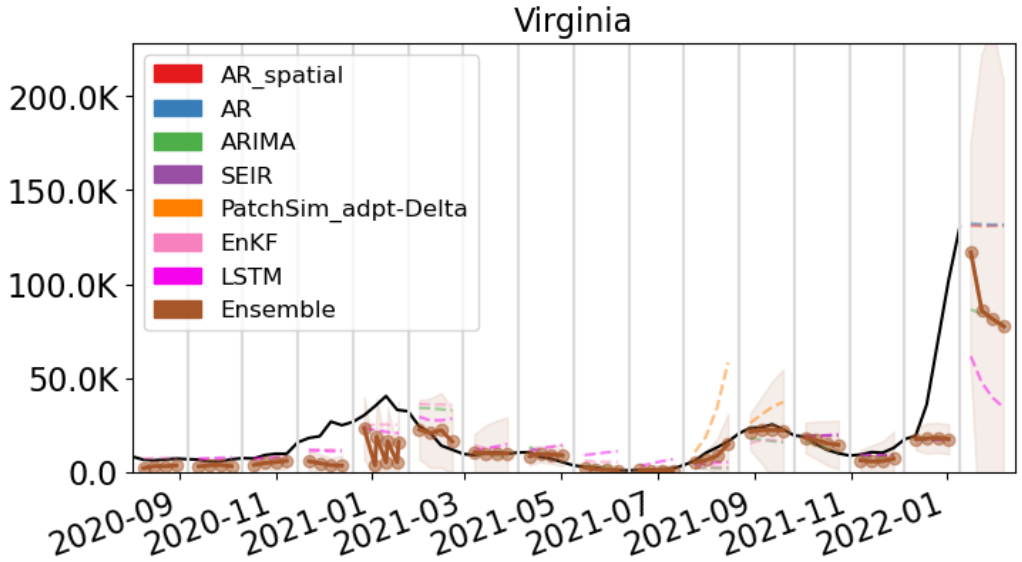
Models chosen because of [illegible] in disease forecasting and [illegible] robustness.

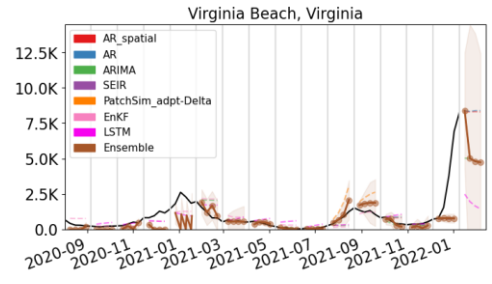
Ensem[illegible] additional 'surveillance' for [illegible] scenario-based projections.

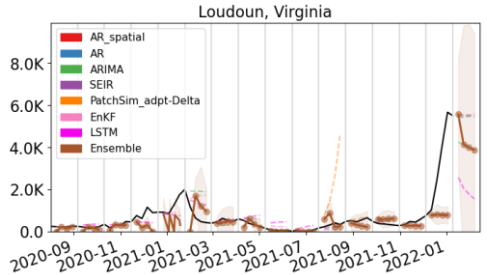
Also submitted to CDC Forecast Hub.

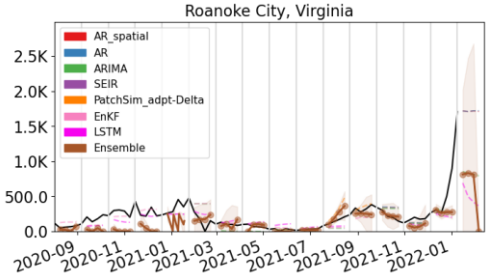
Ensemble tracking Omicron surge much better

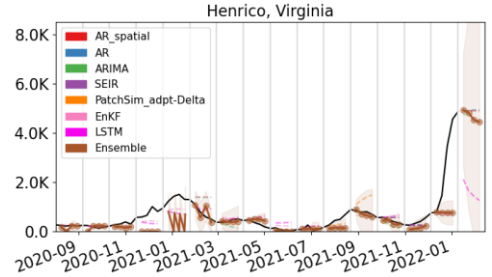
This week's projections still not scaffolded on these forecasts due to new model structure











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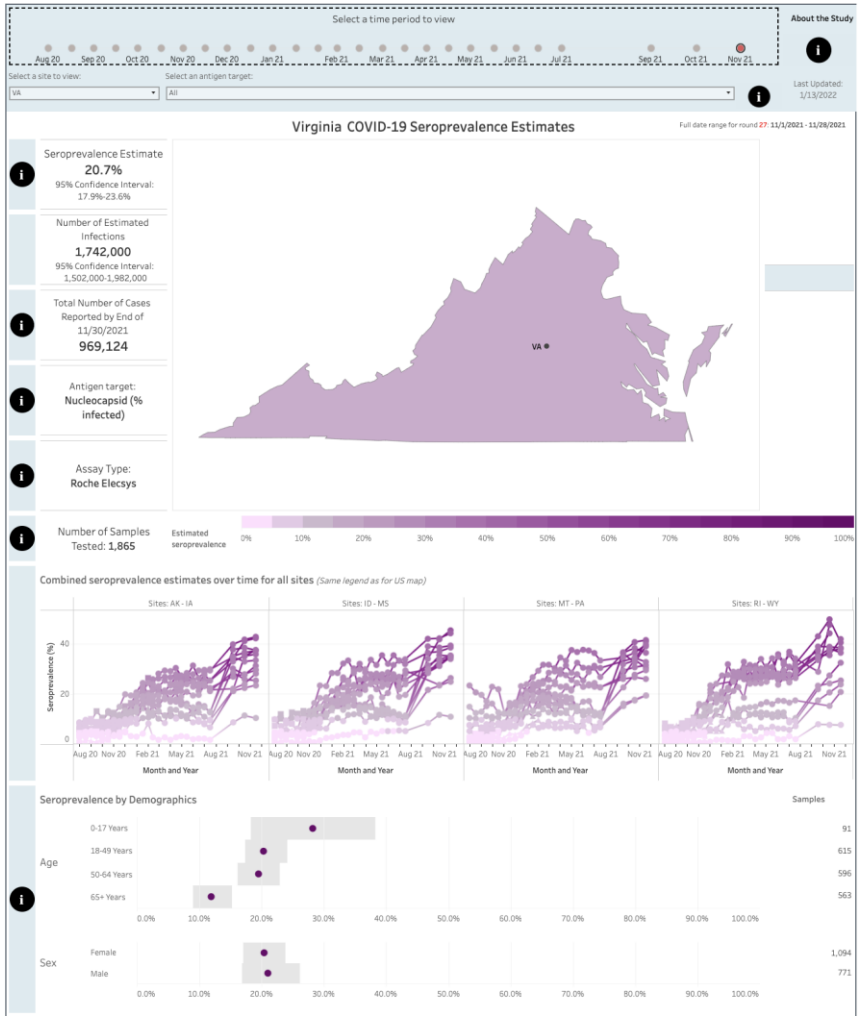
Seroprevalence updates to model design

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

- CDC Nationwide Commercial Laboratory Seroprevalence Survey

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

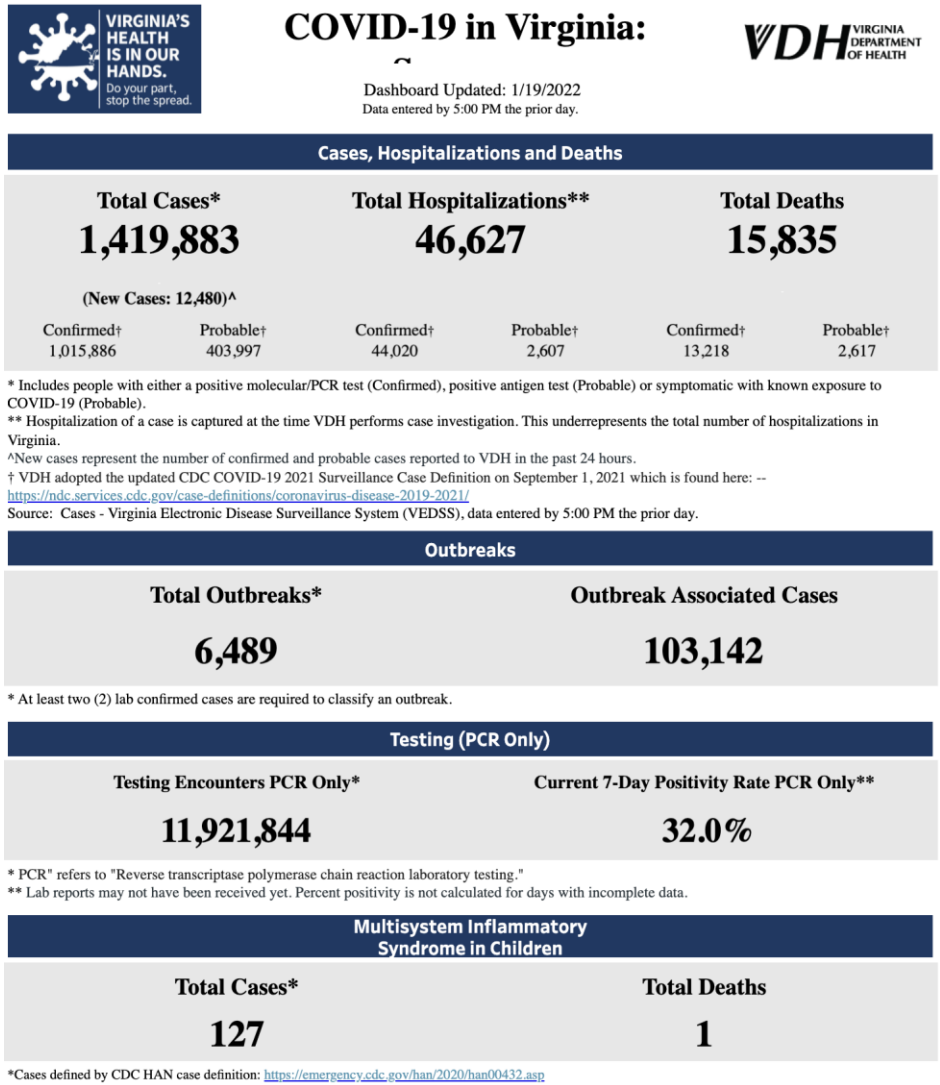
- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- **Case ascertainment is half of that for those with prior immunity**
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were 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
- **Outcomes**: Data driven by shift and ratio that has least error in last month of observations
  - Hospitalizations: 3 days from confirmation, 6.8% of cases hospitalized
  - Deaths: 11 days from confirmation, 1.45% of cases die



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

COVID-19 in Virginia:

VDH VIRGINIA DEPARTMENT OF HEALTH

Dashboard Updated: 1/19/2022
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospitalizations**	Total Deaths
1,419,883	46,627	15,835
(New Cases: 12,480)^		
Confirmed† 1,015,886 / Probable† 403,997	Confirmed† 44,020 / Probable† 2,607	Confirmed† 13,218 / Probable† 2,617

* Includes people with either a positive molecular/PCR test (Confirmed), positive antigen test (Probable) or symptomatic with 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 2021 Surveillance Case Definition on September 1, 2021 which is found here: -- https://ndc.services.cdc.gov/case-definitions/coronavirus-disease-2019-2021/
Source: Cases - Virginia Electronic Disease Surveillance System (VEDSS), data entered by 5:00 PM the prior day.

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
6,489	103,142

* 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**
11,921,844	32.0%

* 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
127	1

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

Accessed 9:30am January 19, 2022
https://www.vdh.virginia.gov/coronavirus/

Scenarios – Transmission Conditions

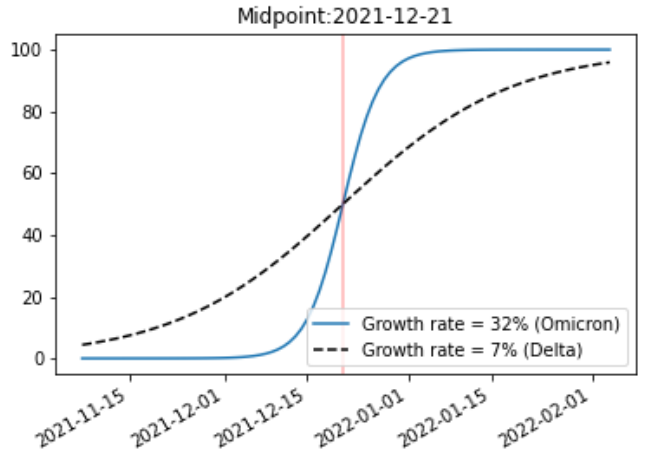
- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity**: Mean of 6 months to a re year protection (rate of 0.0027) similar to Pfizer study
- **Projection Scenarios**:
  - **Adaptive:** Control remains as is currently experienced into the future with assumption that Omicron remains as the majority strain, and that infection with Omicron provides protection against Omicron infection in the future
  - **Adaptive-Spring:** Same as Adaptive, except transmission rates are driven down by behaviors and seasonal effects by 60% over the next 2 months (as observed last Fall-Winter wave
  - **Adaptive-DecreasedControl:** Same as Adaptive, except transmission rates are driven up by 60% in the coming 2 weeks

Scenarios – Omicron Description

Omicron shown ability to evade immunity and may be more transmissible

- **Transmissibility**: New evidence suggests that Omicron has **similar transmissibility** to Delta
- **Immune Evasion**: Strong evidence demonstrates that Omicron can cause infection in those with some immunity (natural and vaccine induced). Consensus estimate of **80% immune evasion** allows Omicron to infect 80% of individuals that would have otherwise been protected against Delta. Assume that recovery from Omicron provides protection to infection with Omicron similar pre-Omicron variants
- **Prevalence**: Proportion of cases caused by Omicron variant estimated from growth rates observed in other countries with similar levels of immunity (growth of 32%, doubling in ~3 days)
- **Severity:** Several reports suggest Omicron may not cause as severe disease as Delta, we use a 50% reduction in severity for hospitalizations and deaths
- Studies: South Africa, UK, Canada

Estimated Prevalence curve for US



Predominance occurs before Jan 1, 2022

Previous conservative estimates proved to be so, as last projections underpredicted growth.
These consensus estimates may over predict as human behavior and testing may be outpaced by rapid growth

Projection Scenarios – Combined Conditions

Name	Txm Controls	Vax	Description
Adaptive	C	SQ	Likely trajectory based on conditions remaining similar to the current experience, includes immune escape due to Omicron
Adaptive-Spring	Spring	SQ	Assumes rapid decrease observed last Fall-Winter wave plays out till spring, resulting an overall decrease in transmission drivers of 60%
Adaptive-DecreaseControl	Decrease	SQ	Transmission rates in the next couple weeks are increased 60% and remain at that level demonstrate that increases in case rates remain possible despite the historically high rates, remaining vigilant has benefits

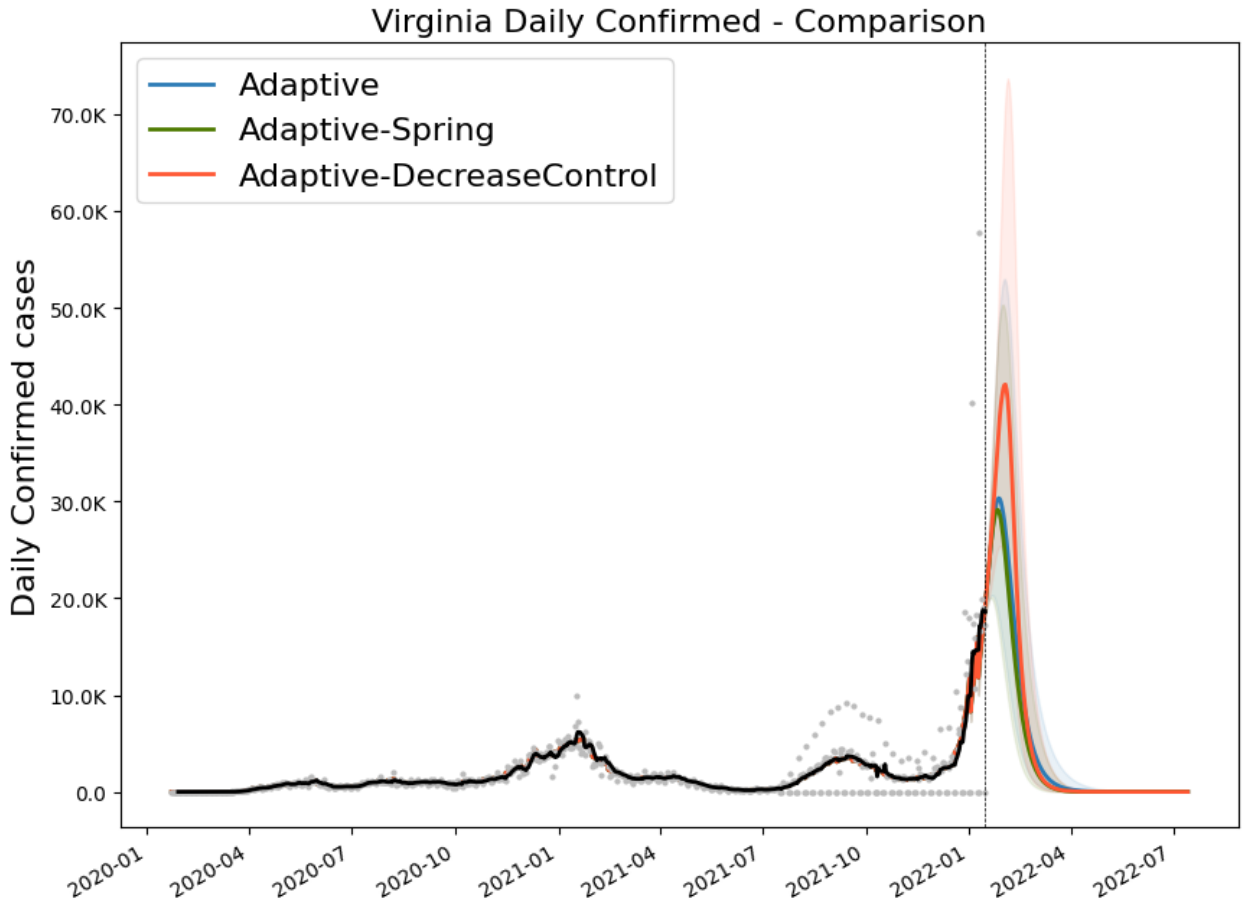
Transmission Controls:
C = Current levels persist into the future
Decrease = Transmission rates are boosted by 60% over next couple weeks and remain at that level
Spring = Transmission rates from mid-Jan 2021 through mid-March 2021 are coarsely replayed, representing a 60% reduction in transmission rate drivers, with Omicron remaining dominant

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

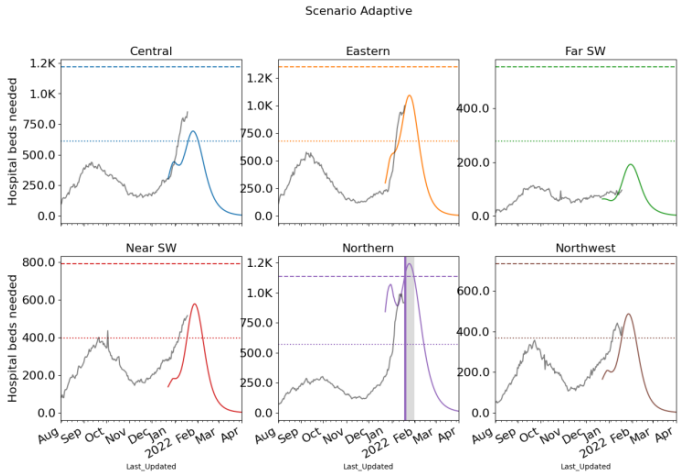
Model Results

Outcome Projections

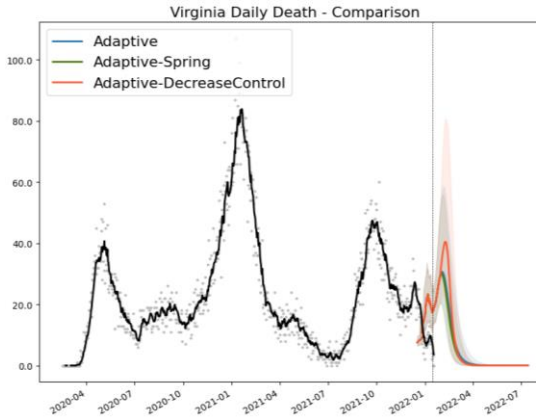
Confirmed cases



Estimated Hospital Occupancy

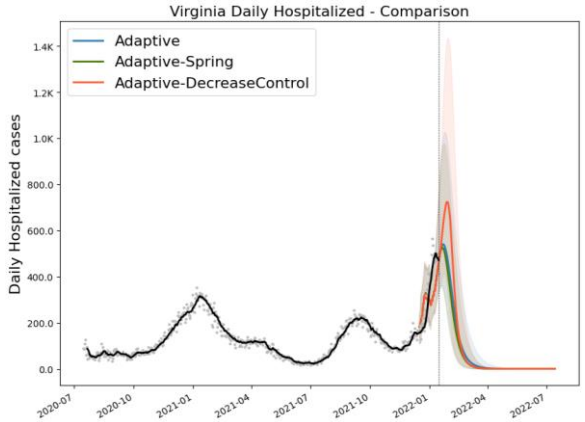


Daily Deaths



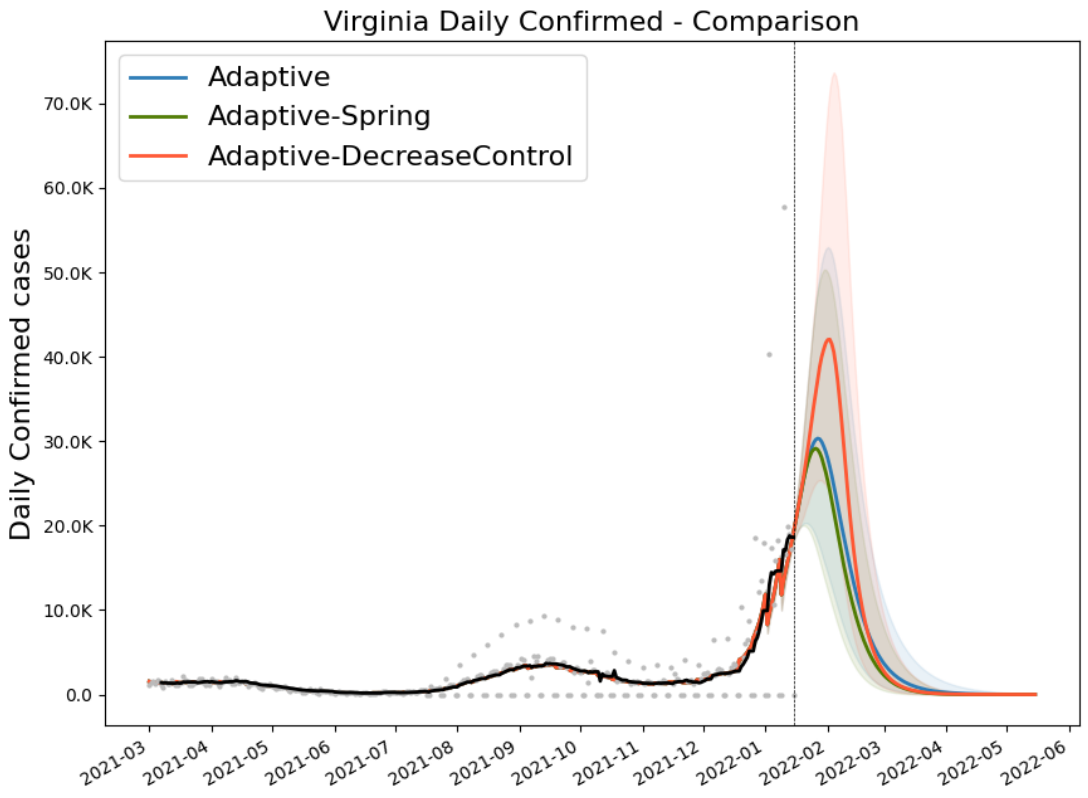
Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized

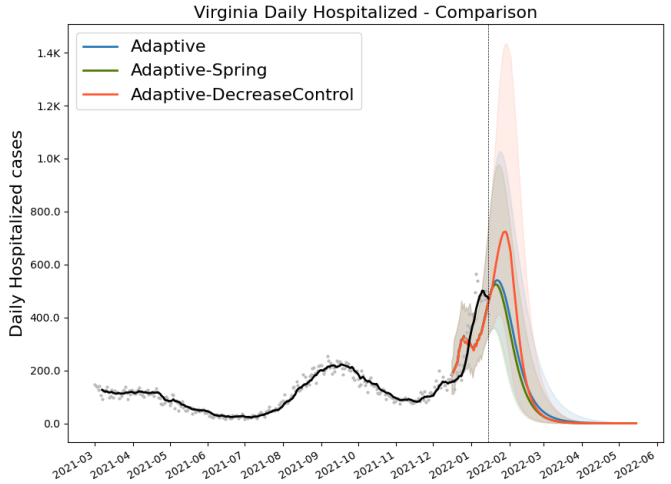


Outcome Projections – Closer Look

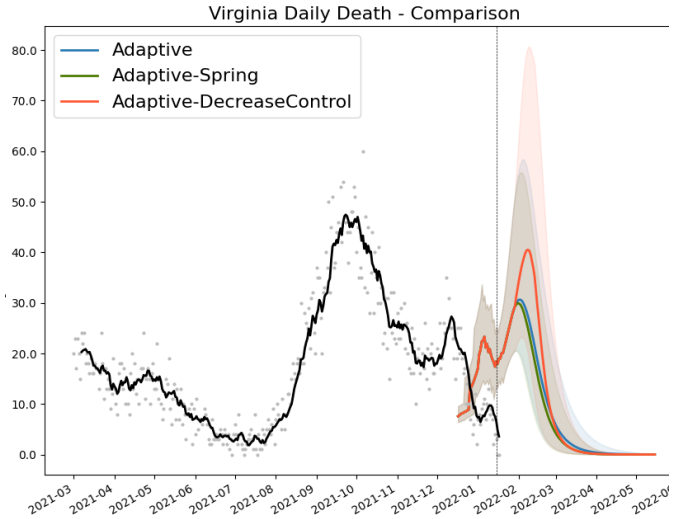
Confirmed cases



Daily Hospitalized



Daily Deaths



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

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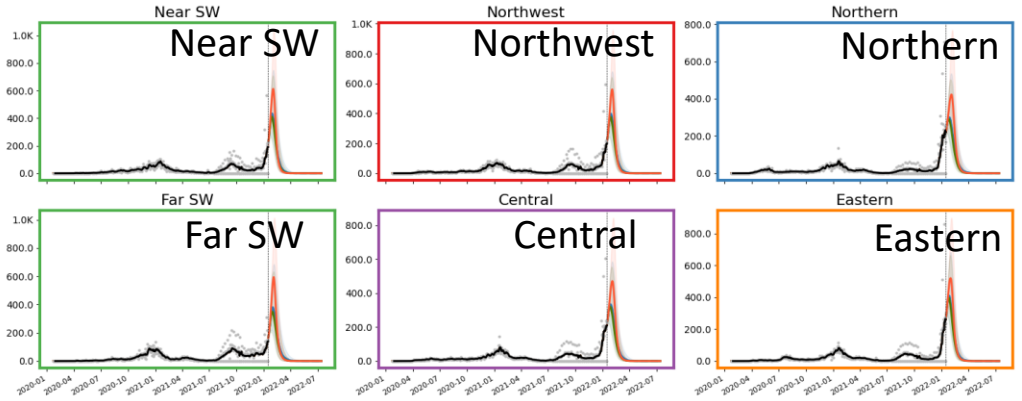
Detailed Projections: All Scenarios

Projections by Region

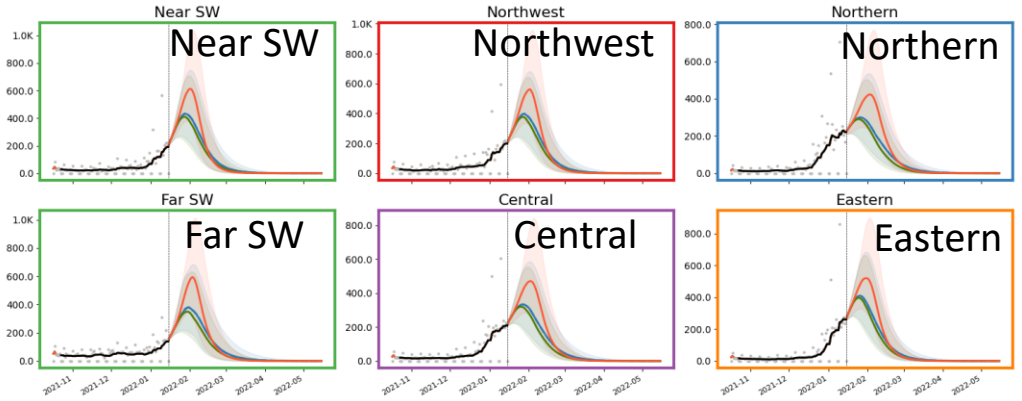


Projections by District

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

Detailed Projections: All Scenarios - Closer Look

Projections by Region



Projections by District

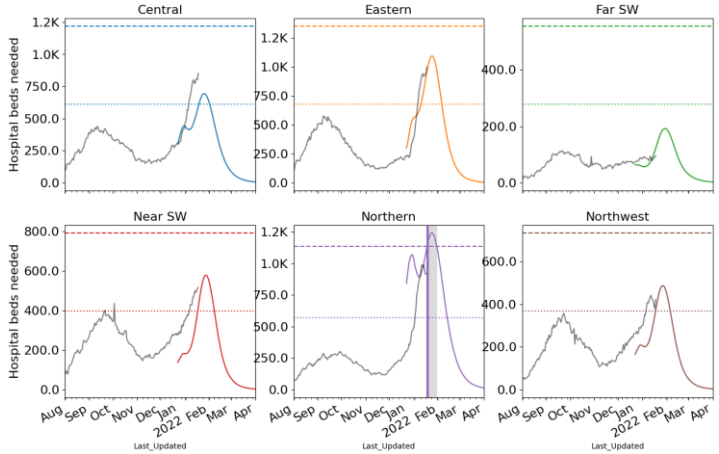
Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

Hospital Demand and Bed Capacity by Region

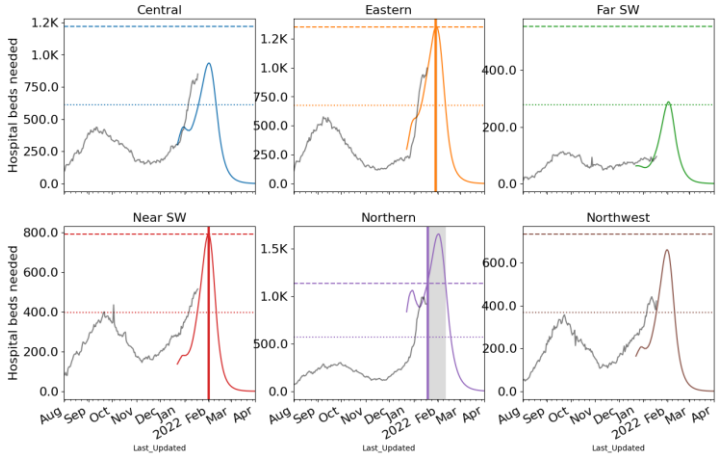
Capacities* by Region

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

Adaptive



Adaptive – Decrease Control



* Assumes average length of stay of 8 days

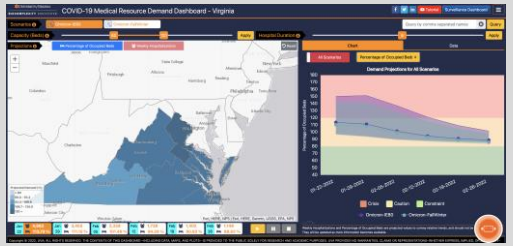
Length of Stay more variable with Omicron, occupancy projections may vary as a result

Current occupancies are pressuring initial capacities in some regions.

Projections shows several regions exceeding initial and surge capacities:

- Adaptive: Northern may reach surge capacity in coming weeks
- Adaptive-DecreaseControl: Northern may exceed surge capacities while Eastern and Near SW may approach it

Interactive Dashboard with regional projections

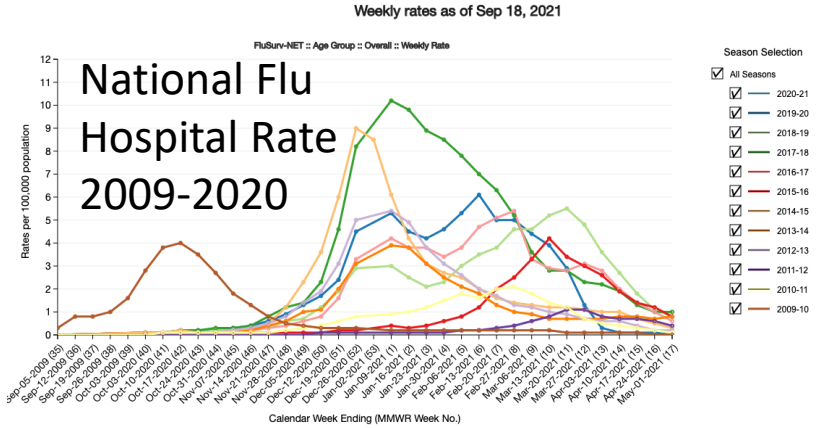


https://nssac.bii.virginia.edu/covid-19/vmrddash/

Impact of Influenza based on Previous Intense Flu Seasons

Augment COVID-19 daily hospitalizations with that of past Influenza seasons

- Include hybrid seasons that use timing of one season but are scaled by severity of another
- Due to limited historical data on Virginia flu hospitalizations currently using national rates applied to VA population



https://gis.cdc.gov/GRASP/Fluview/FluHospRates.html

2009-10 – Pandemic 2009 H1N1 season

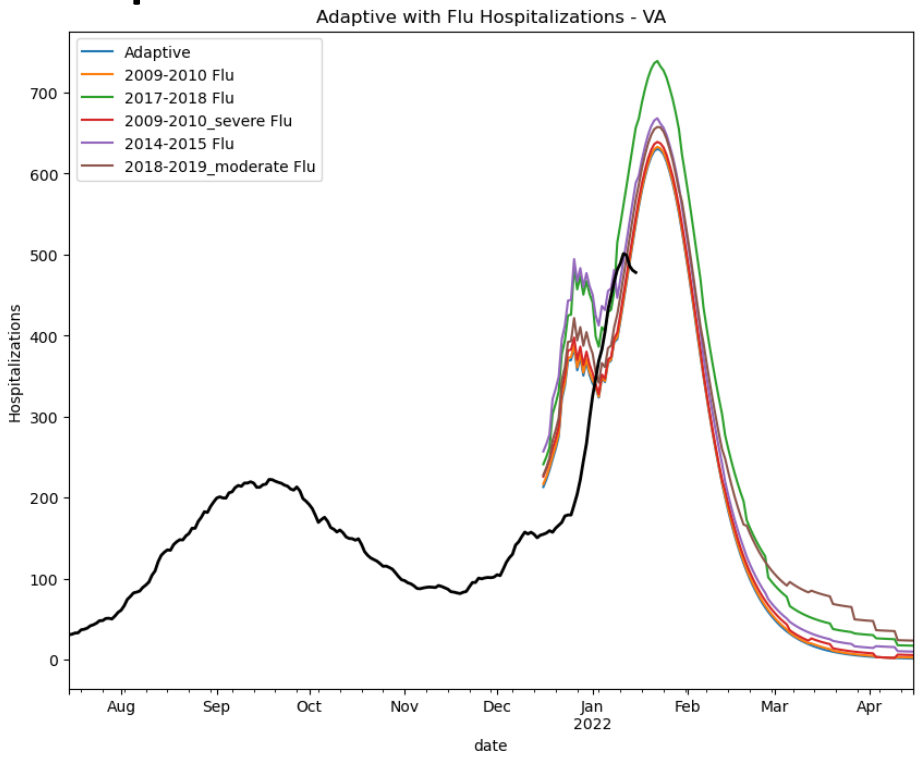
2017-18 – Timing and severity of 2017-18 season

2009-10_severe – Timing of 2009 pandemic (early) with the severity of the 2017-18 season

2014-15 – Timing and severity of 2014-15 season

2018-19_moderate – Timing of 2018-19 (late) season with severity of 2014-15

COVID Hospitalizations from Adaptive + Flu Hospitalizations from historical scenarios



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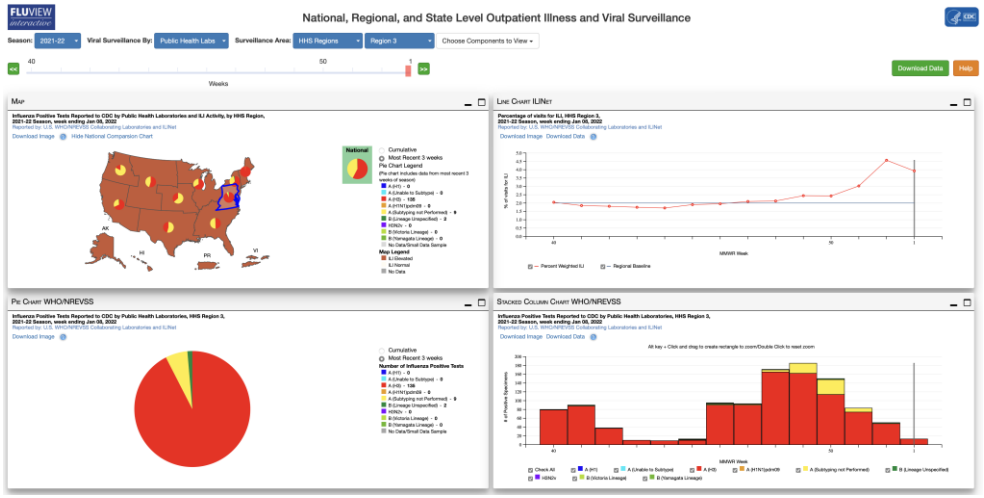
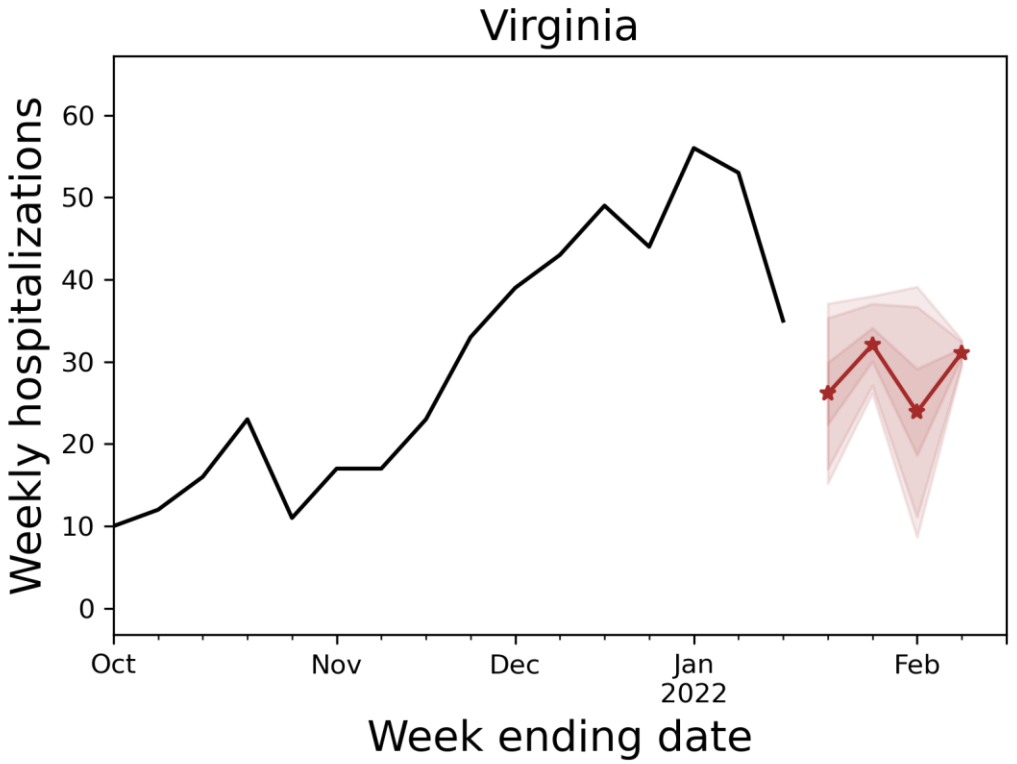
Current Influenza Hospitalization Forecast

Augment COVID-19 daily hospitalizations with that of past Influenza seasons

- Include hybrid seasons that use timing of one season but are scaled by severity of another
- Due to limited historical data on Virginia flu hospitalizations currently using national rates applied to VA population



Influenza A activity high in our region but leveled off in first week of Jan
Labs show high levels of H3 this season
(Influenza A H3N2 is more severe)



Key Takeaways

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

- **Case rates and hospitalizations seem to be leveling off and projections suggest we are nearing the peak**
- VA 7-day mean daily case rate up to 198/100K from 155/100K; US is up to 212/100K (from 144/100K)
- Projections anticipate near-term peak with subsequent decline:
  - Sensitivity analyses show further growth remains possible, though requires significant increase in transmission drivers
  - Decline is rapid and approach very low levels quickly, this assumes immunity to infection with Omicron protects against Omicron
- Current signs indicate case ascertainment is in flux and case counts may miss key dynamics, thus its possible the true peak will not match the observed peak and observed cases may be chaotic in near term
- Recent model updates:
  - Further refined model to be multi-variant model structure further refined to better capture different tiers of immunity and the immune evasion of the Omicron variant

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

Additional Analyses

Weekly Cases and Hospitalizations

Weekly confirmed cases

Week Ending	Adaptive	Adaptive-Spring	Adaptive-DecreaseControl
1/9/22	86721	86700	86700
1/16/22	118218	118188	118188
1/23/22	177027	176438	181864
1/30/22	209088	199739	259242
2/6/22	180230	159716	283759
2/13/22	122744	99618	186691
2/20/22	72764	54566	84578
2/27/22	40078	27336	35878
3/6/22	21671	12906	15216
3/13/22	11678	5820	6544
3/20/22	6334	2482	2851
3/27/22	3418	1003	1228
4/3/22	1848	322	521
4/10/22	996	88	220

Weekly Hospitalizations

Week Ending	Adaptive	Adaptive-Spring	Adaptive-DecreaseControl
1/9/22	2536	2537	2537
1/16/22	3425	3424	3427
1/23/22	4294	4222	4684
1/30/22	4079	3761	5813
2/6/22	2993	2550	4823
2/13/22	1815	1435	2414
2/20/22	1005	734	990
2/27/22	544	357	415
3/6/22	294	167	180
3/13/22	160	75	80
3/20/22	87	32	36
3/27/22	48	13	16
4/3/22	27	5	7
4/10/22	15	2	3

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

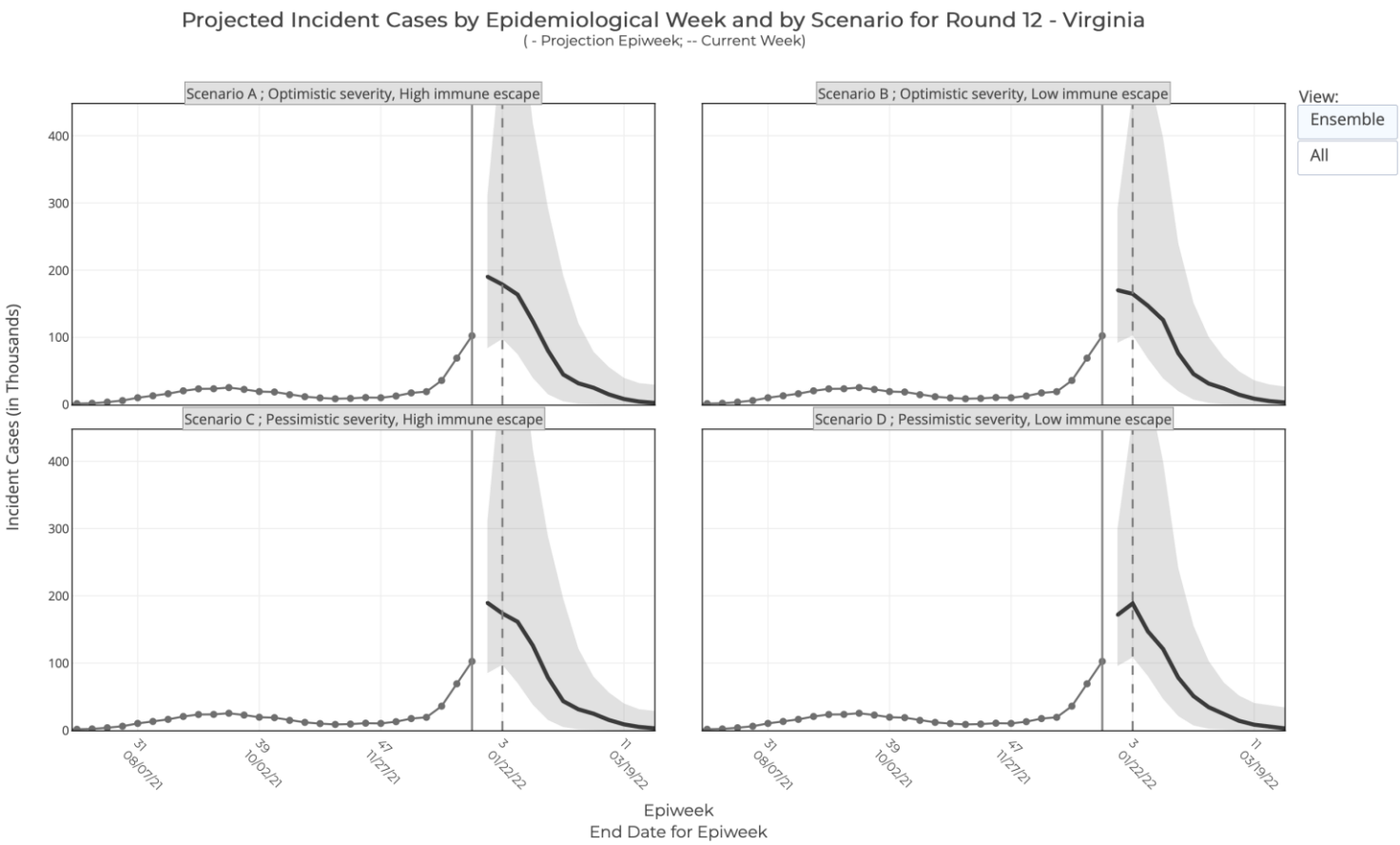
COVID-19 Scenario Modeling Hub

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 12 recently released to assist in federal response to Omicron wave
- Only national consortium tracking Omicron wave well
- Rounds 4-11 now available

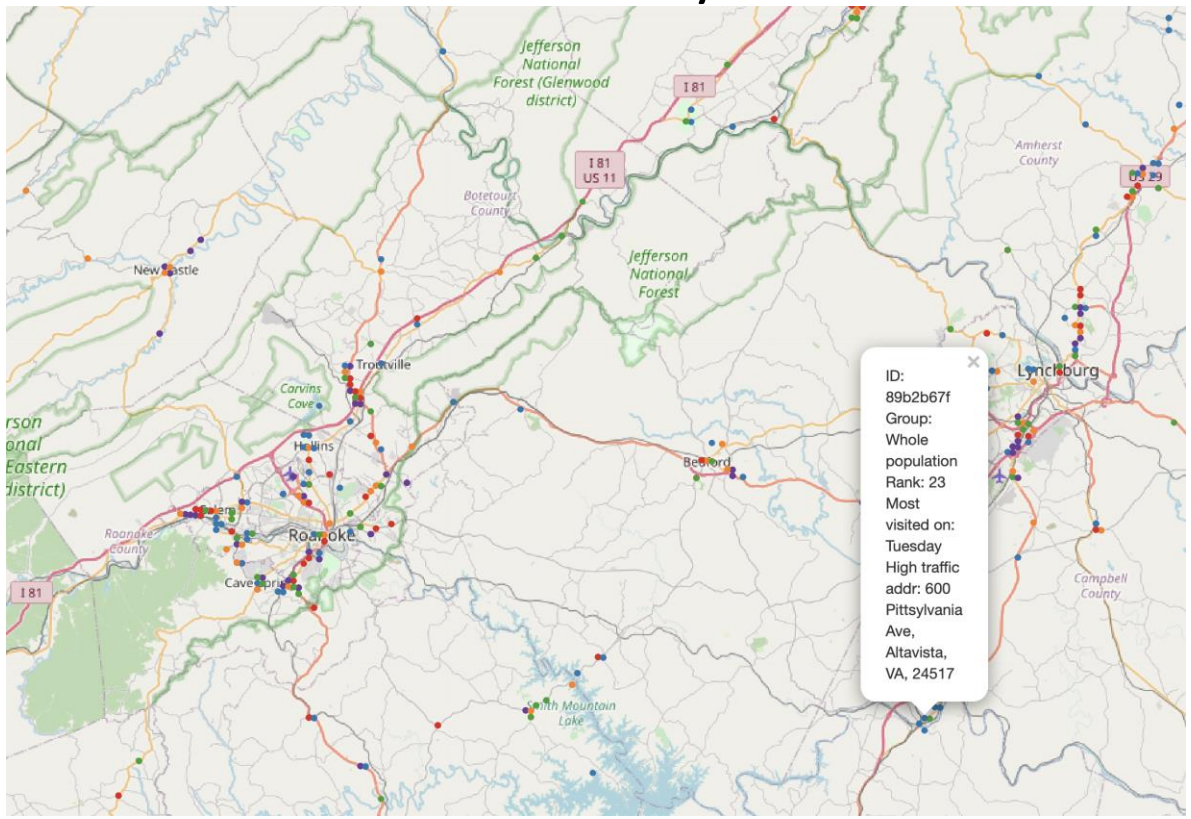
Round 4 Results were published May 5th, 2021 in MMWR

https://covid19scenariomodelinghub.org/viz.html



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

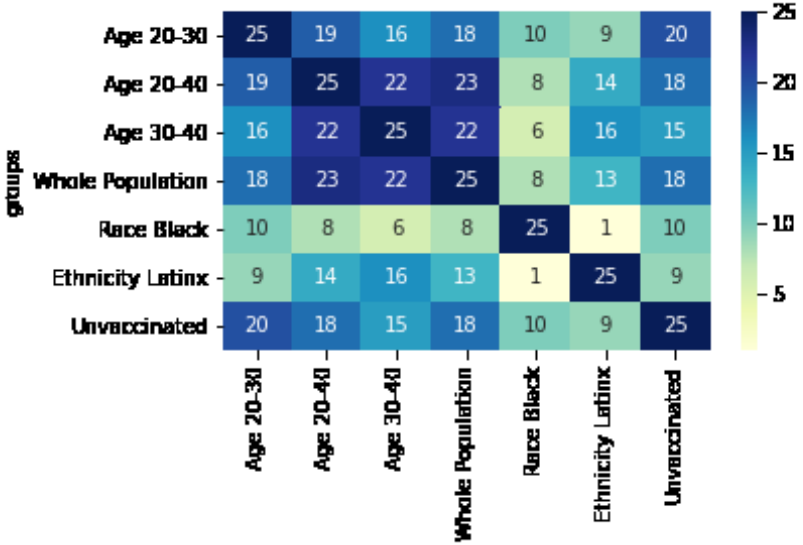
Goal: Provide frequently visited locations based on populations and vaccination levels one desires to reach

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

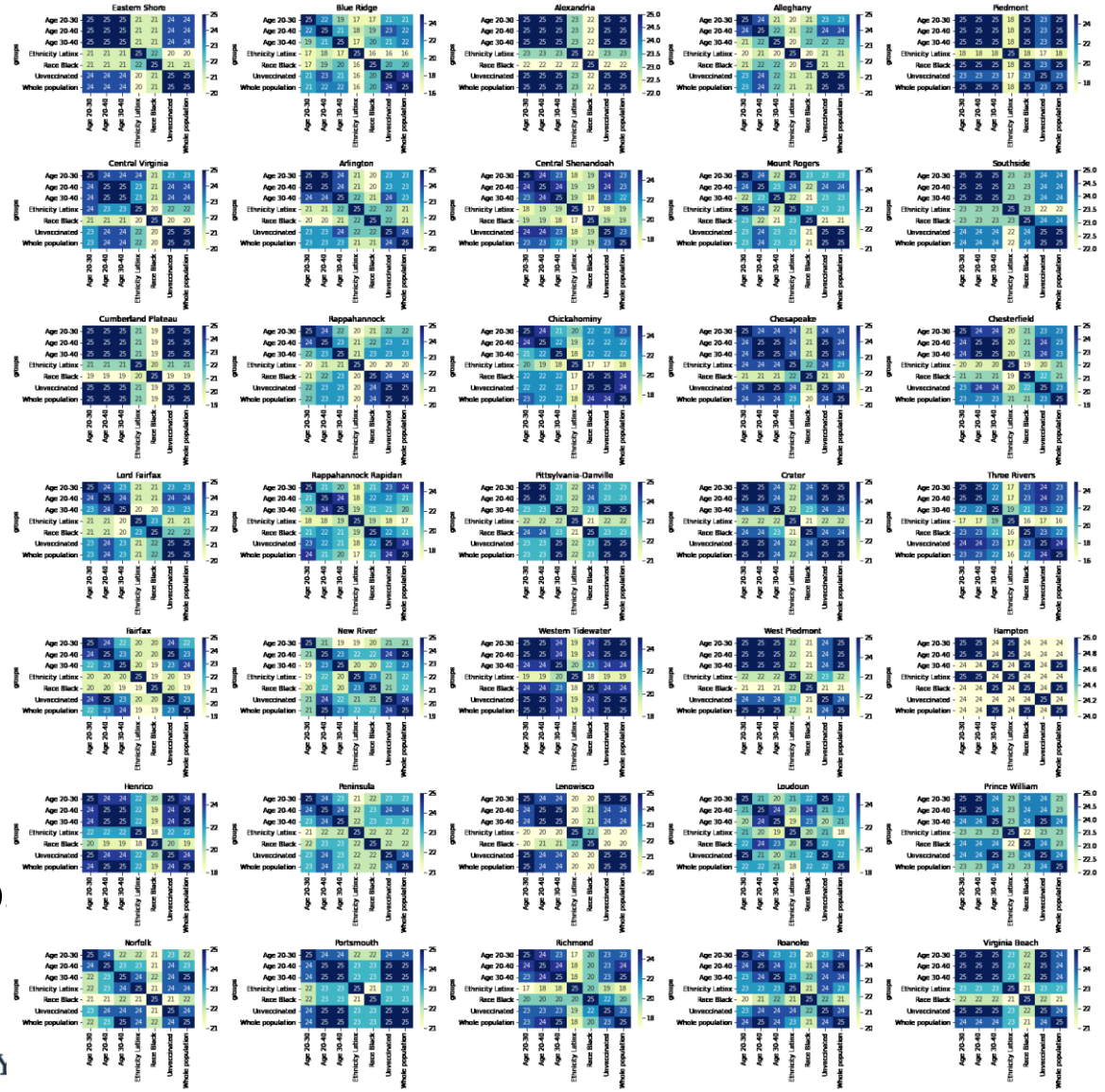
Data Recommended Mobile Vax Clinic Sites

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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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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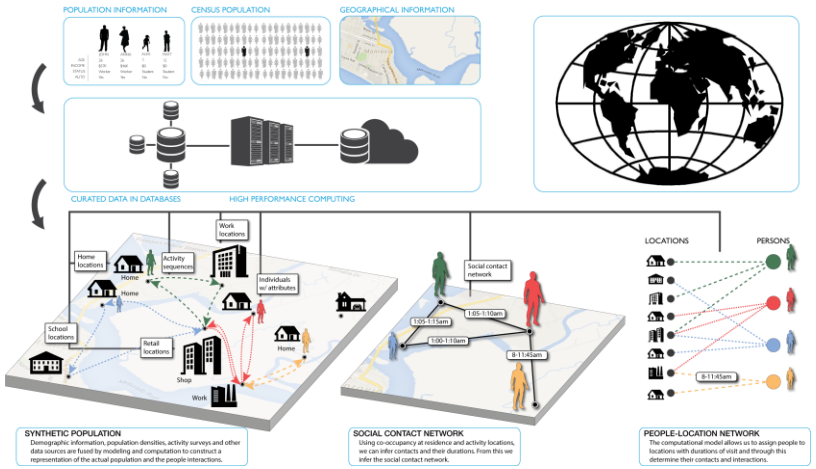
Supplemental Slides

Agent-based Model (ABM)

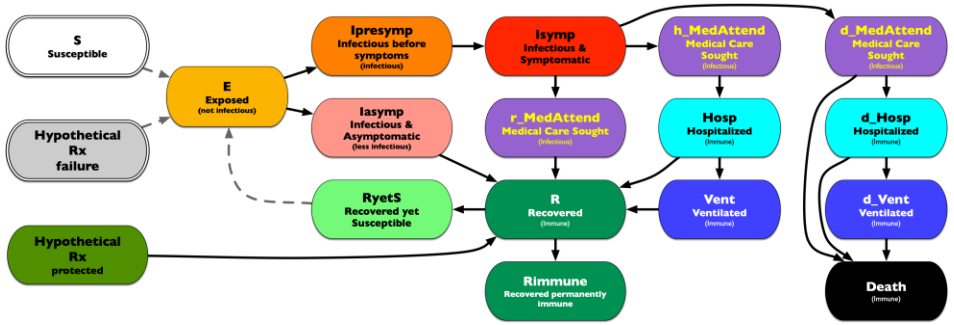
EpiHiper: Distributed network-based stochastic disease transmission simulations

- 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