Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

# Estimation of COVID-19 Impact in Virginia

November 17th, 2021

(data current to November 13th – 16th)

Biocomplexity Institute Technical report: TR 2021-118

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# 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:

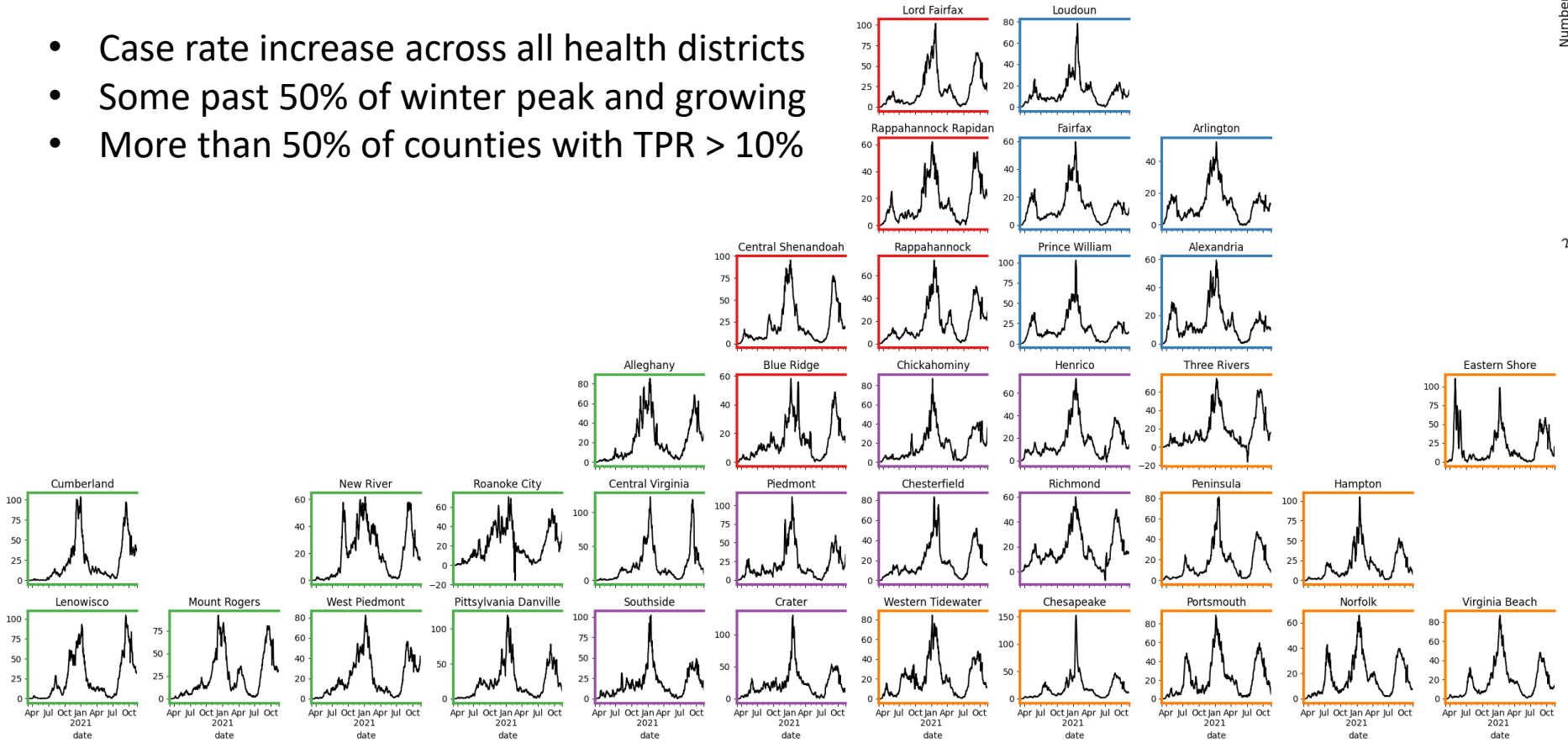
- **Case rates in Virginia has levelled off with a mix of activity across the commonwealth**
- VA 7-day mean daily incidence is flat at 15.3/100K from 15/100K; US is up to 26/100K (from 22/100K)
- Projections show a flattening with eventual decline should current low transmission drivers persist
- As seasonal factors mount trajectories should shift towards the FallWinter2020 scenario with near-term growth;  this scenario shows considerable growth is still possible.
- Recent updates:
  - Preliminary analysis of the effects of immune waning, based on overhauled model structure
  - Added 3rd doses to status quo vaccination schedule, with estimated coverage of 40%
  - Analysis to show potential impact of Influenza based on past seasons

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

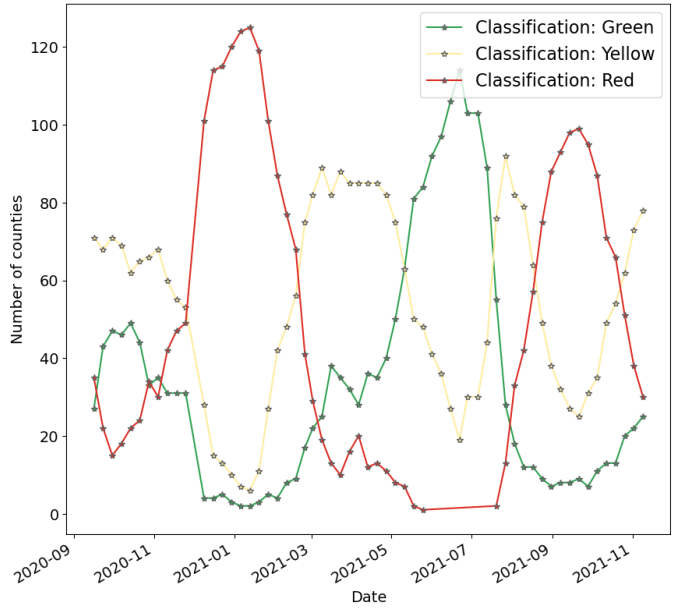
# Situation Assessment

# Case Rates (per 100k) and Test Positivity

- Case rate increase across all health districts
- Some past 50% of winter peak and growing
- More than 50% 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)

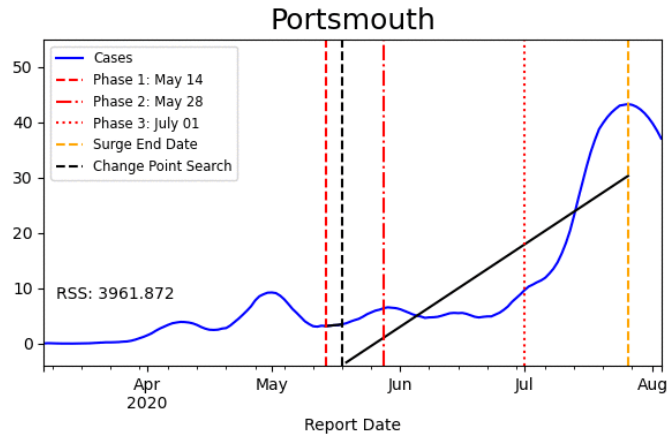
Red: >10.0% (and not "Green" or "Yellow")

# 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

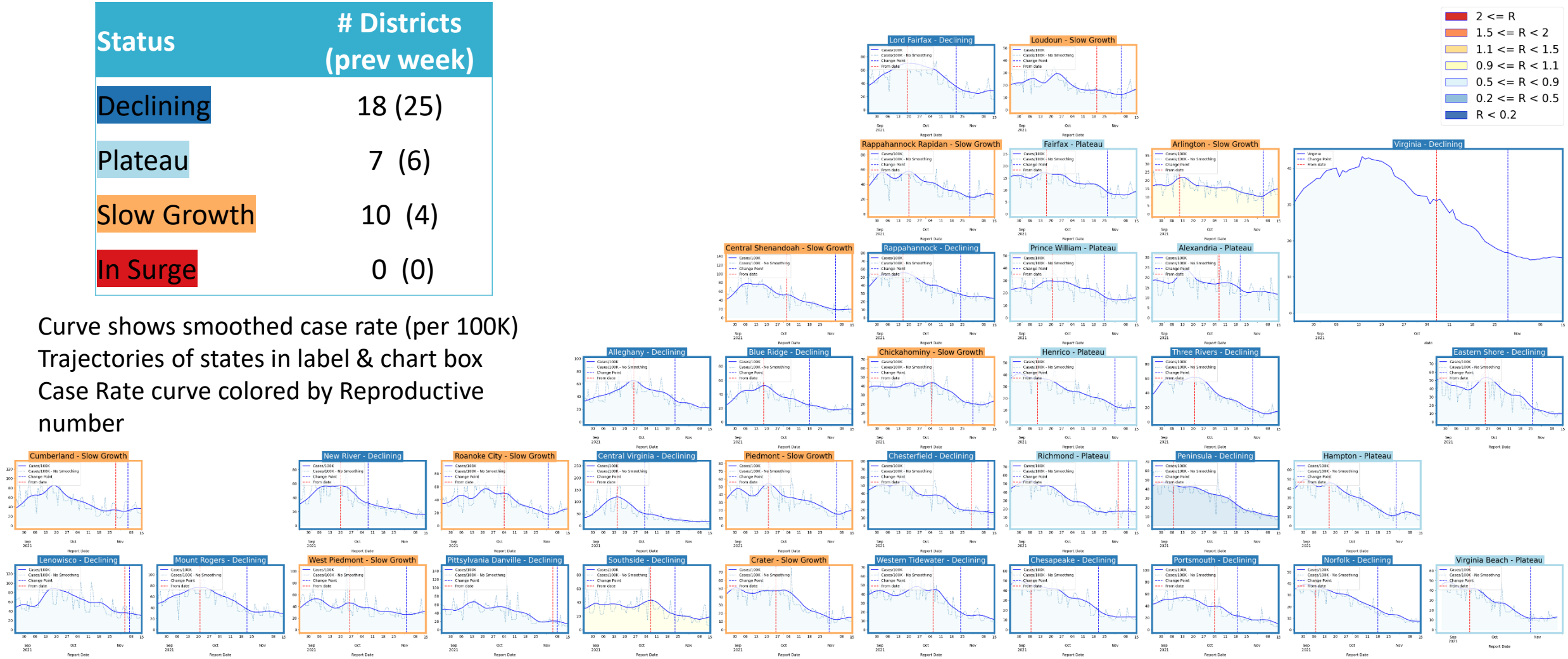



| Trajectory | Description | Weekly Case Rate (per 100K) bounds | # Districts (prev week) |
|---|---|---|---|
| **Declining** | Sustained decreases following a recent peak | below -0.9 | 18 (25) |
| **Plateau** | Steady level with minimal trend up or down | above -0.9 and below 0.5 | 7 (6) |
| **Slow Growth** | Sustained growth not rapid enough to be considered a Surge | above 0.5 and below 2.5 | 10 (4) |
| **In Surge** | Currently experiencing sustained rapid and significant growth | 2.5 or greater | 0 (0) |

# District Trajectories – last 10 weeks

| Status | # Districts (prev week) |
|---|---|
| Declining | 18 (25) |
| Plateau | 7 (6) |
| Slow Growth | 10 (4) |
| In Surge | 0 (0) |

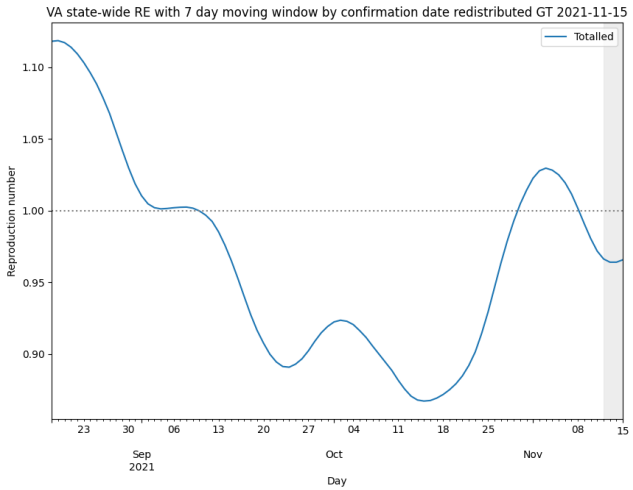
Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive number

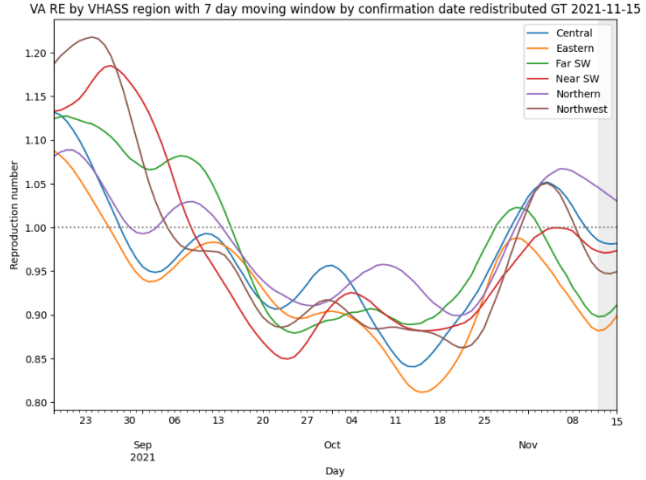


# Estimating Daily Reproductive Number –
## Redistributed gap

### Nov 15th Estimates

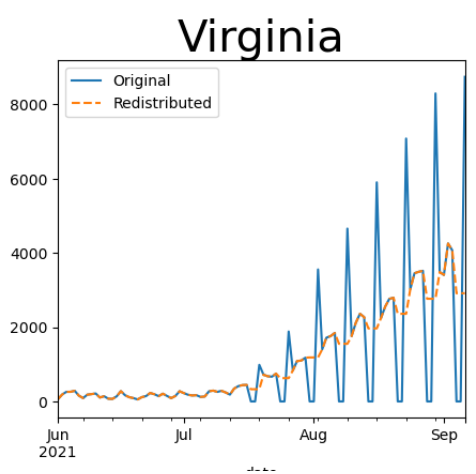
| Region | Date Confirmed $R_e$ | Date Confirmed Diff Last Week |
|---|---|---|
| State-wide | 1.001 | 0.007 |
| Central | 0.982 | -0.032 |
| Eastern | 0.899 | -0.039 |
| Far SW | 0.911 | -0.060 |
| Near SW | 0.974 | 0.025 |
| Northern | 1.030 | 0.043 |
| Northwest | 0.949 | -0.059 |




### Skipping Weekend Reports & holidays biases estimates

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




**Methodology**

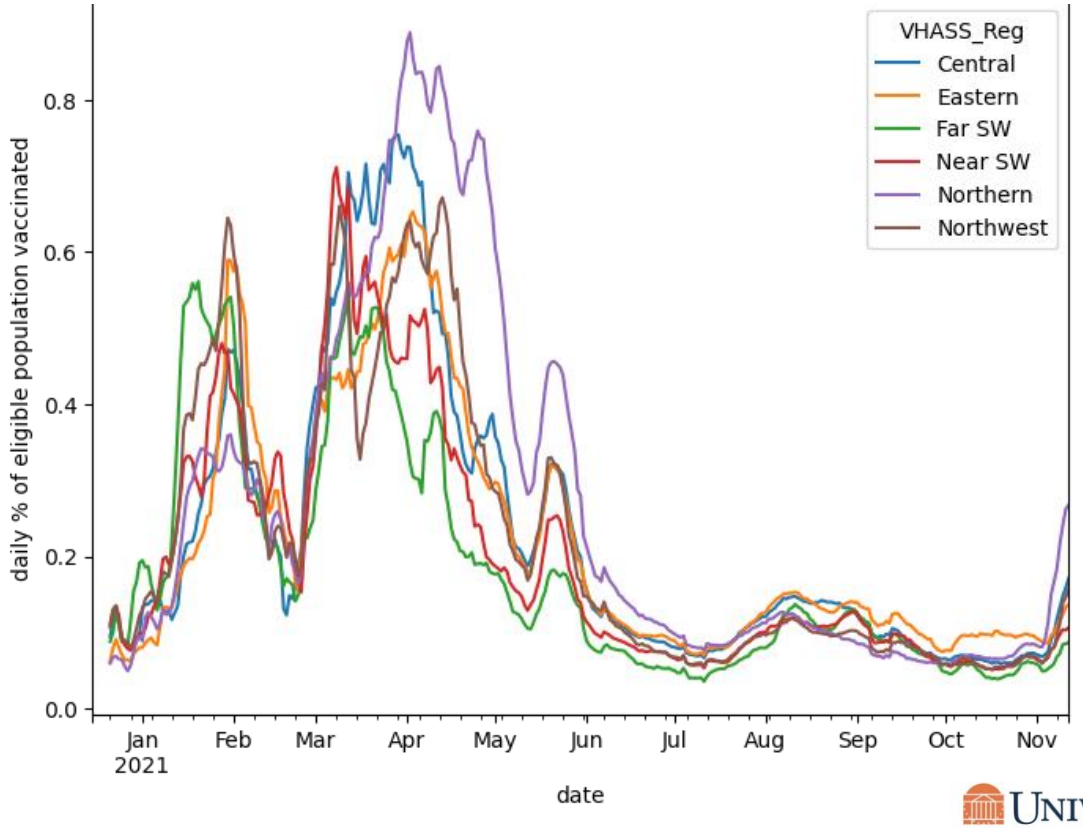
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

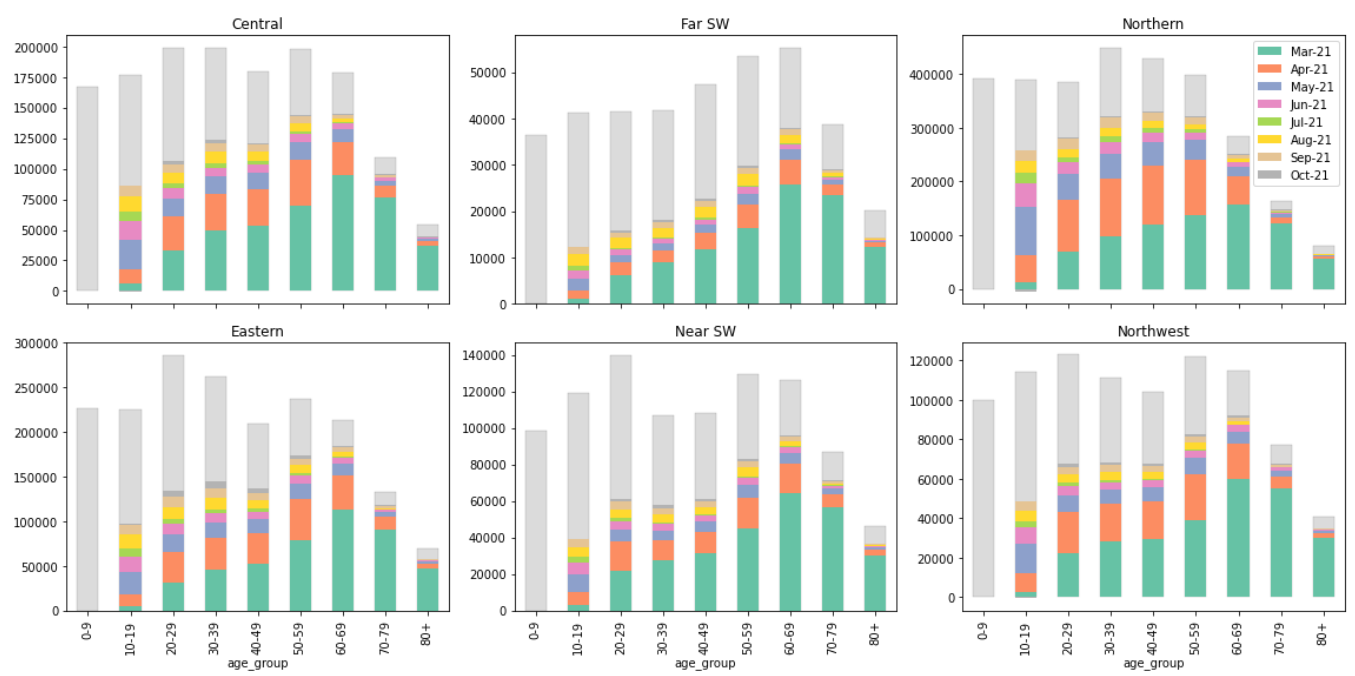

1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

# Vaccination Administration Slow

**Regional Vaccine courses initiated per day (% eligible):**

- Proportion eligible for first dose of vaccines across regions (in the ~0.1% or 100 per 100K a day)
- Age-specific proportions of population vaccinated show recent progress in younger ages

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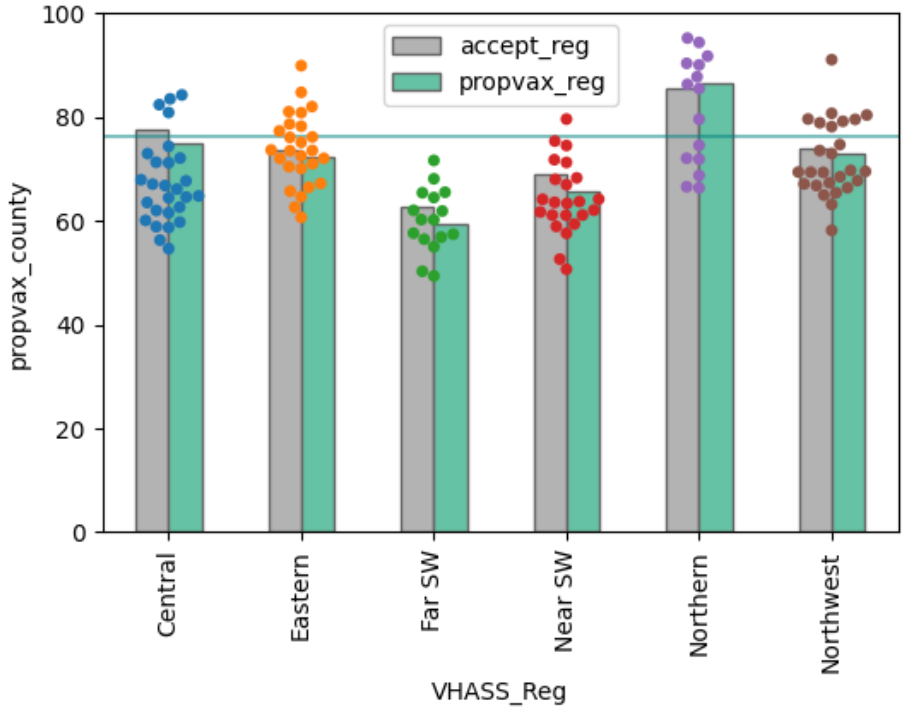
# Vaccination Acceptance by Region

**Corrections to surveys:**

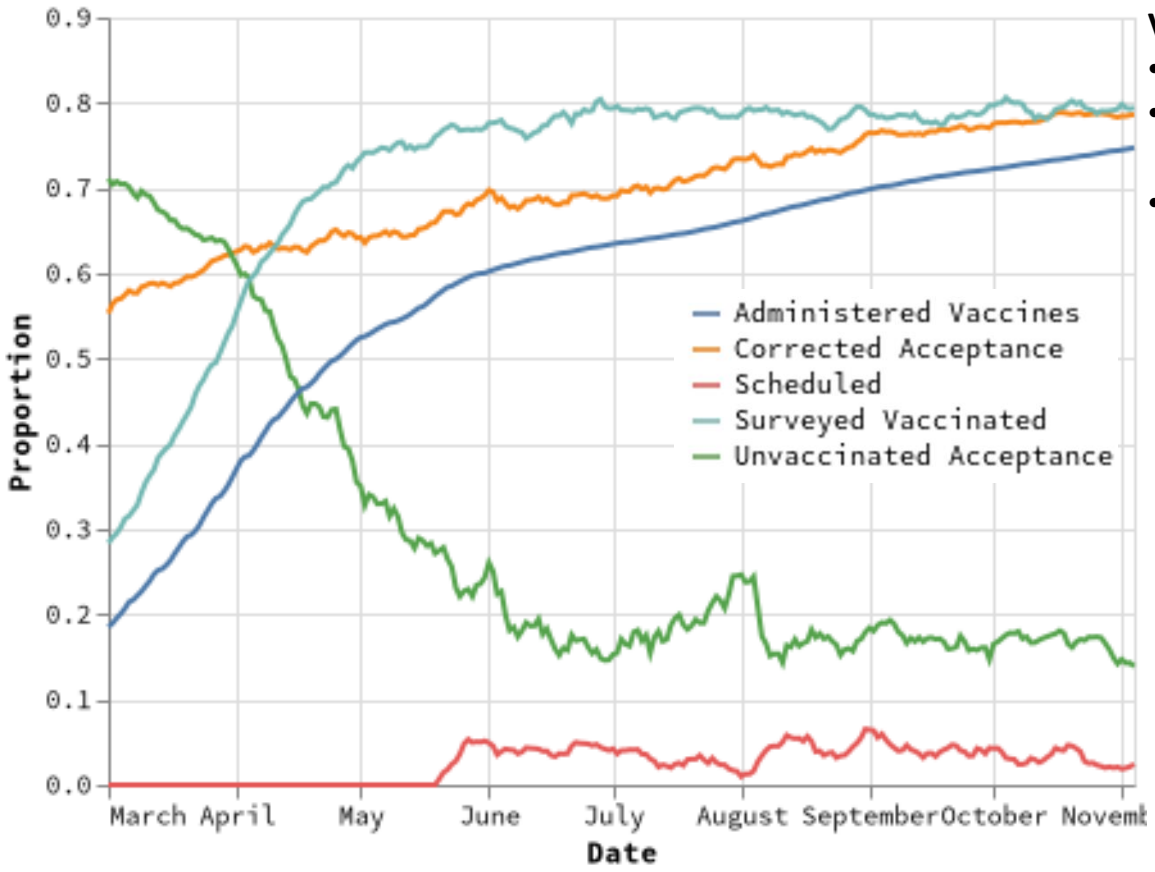
- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at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

| Region | COVIDcast accepting corrected | VDH proportion pop vaccinated |
|---|---|---|
| Central | 79% | 75% |
| Eastern | 76% | 72% |
| Far SW | 63% | 59% |
| Near SW | 69% | 66% |
| Northern | 89% | 87% |
| Northwest | 76% | 73% |
| **Virginia** | **80%** | **76%** |




**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

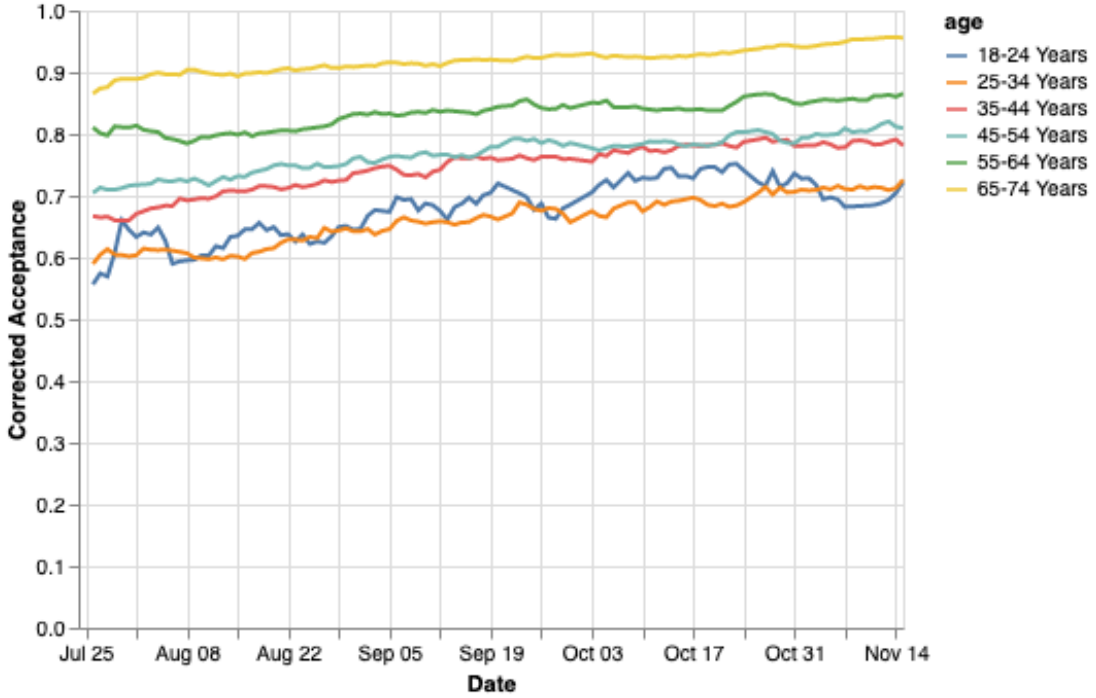
# Vaccine Acceptance Components over Time




**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

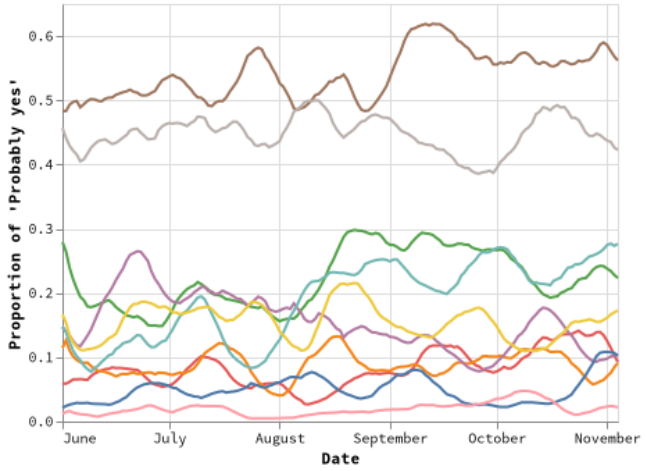
**Acceptance Across Age groups**



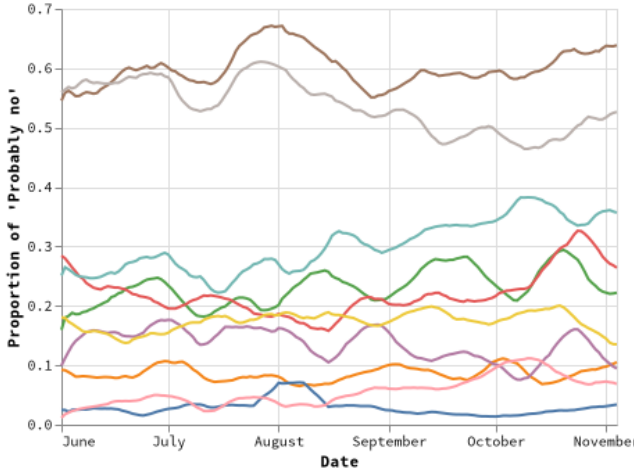

Data Source: [https://covidcast.cmu.edu](https://covidcast.cmu.edu)

# Reasons for Hesitancy by Likeliness to Accept

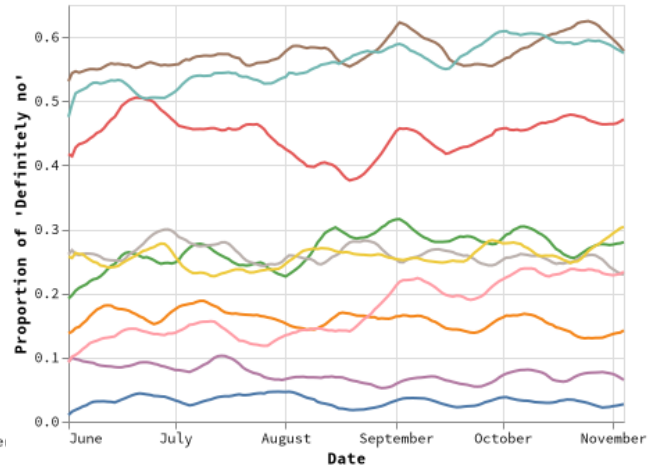
Probably Yes

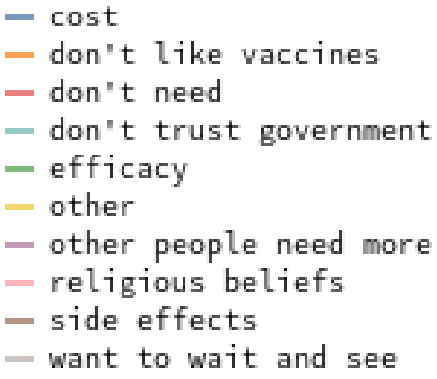



Probably No




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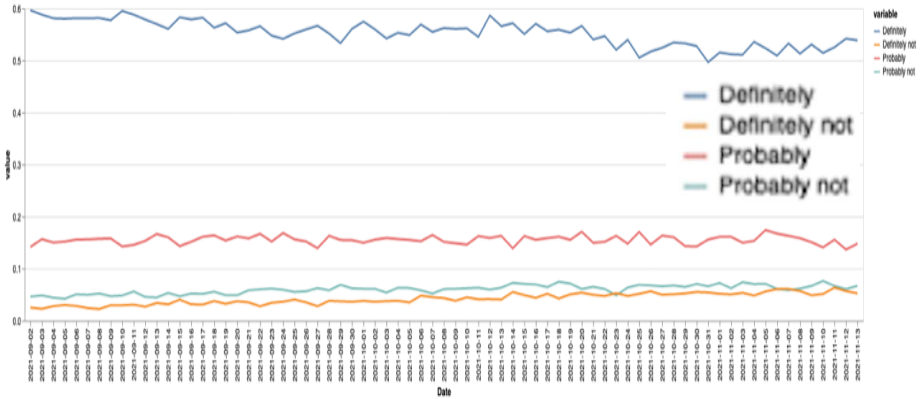
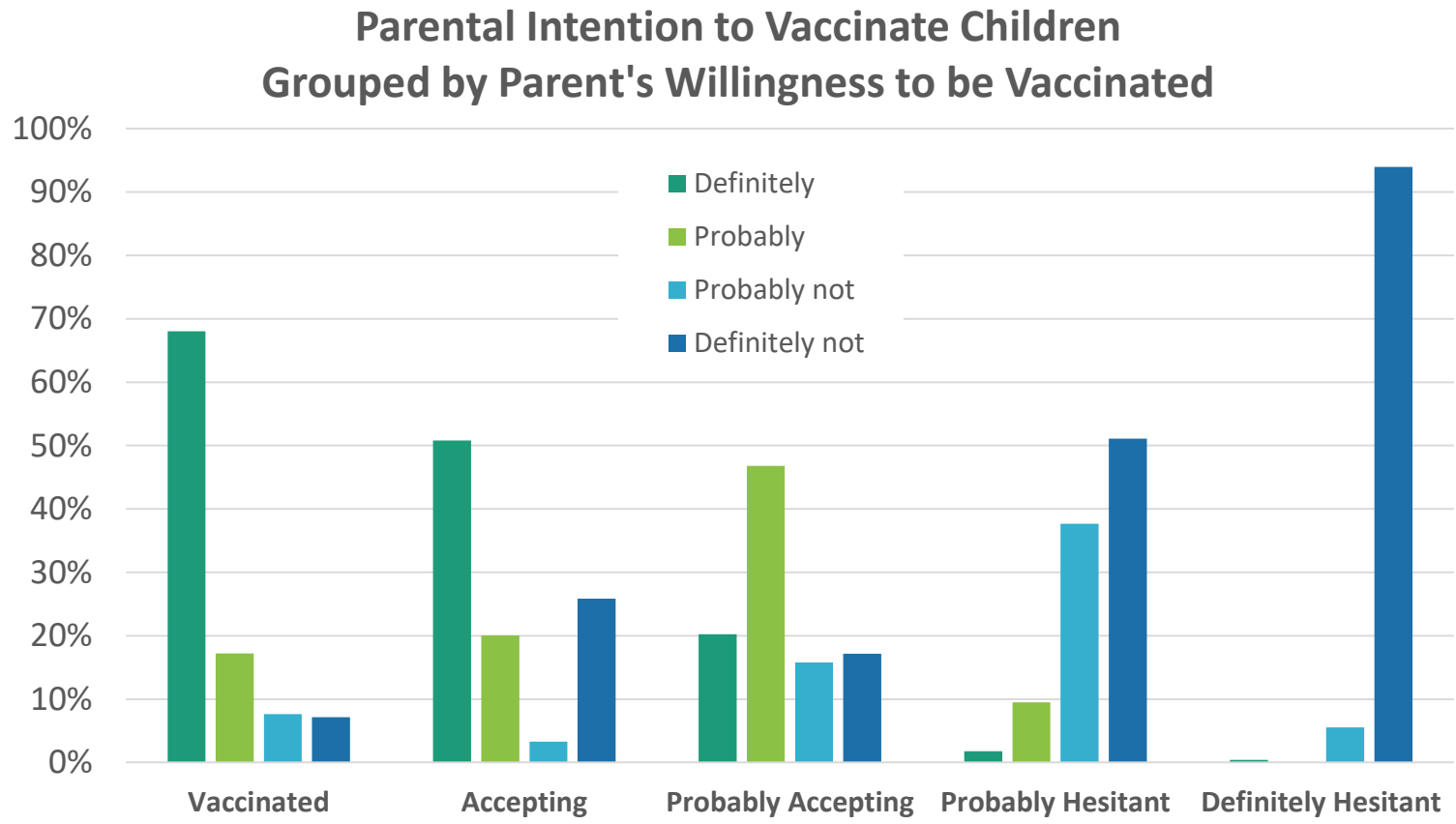
Data Source: https://covidcast.cmu.edu

# Parental Intention to Vaccinate Children

**Parental Intention to Vaccinate Children lower than overall Acceptance**

- Steady decline from the beginning of the Summer to present, from ~72% to ~64%
- Intention strongly biased by the willingness of the parent



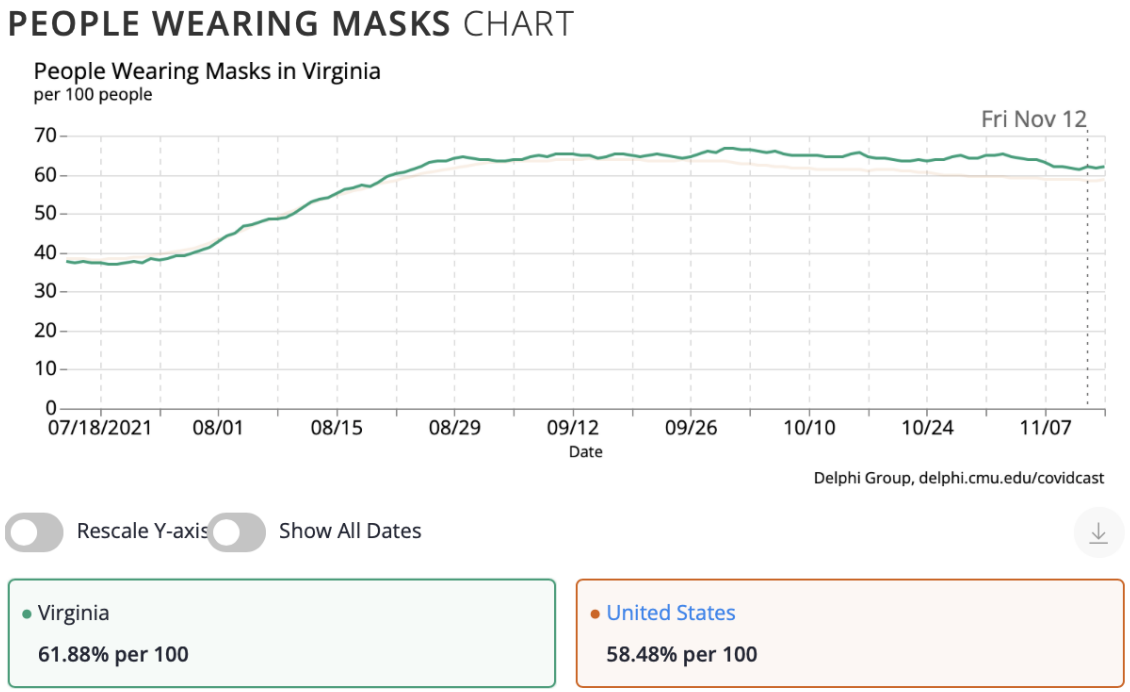



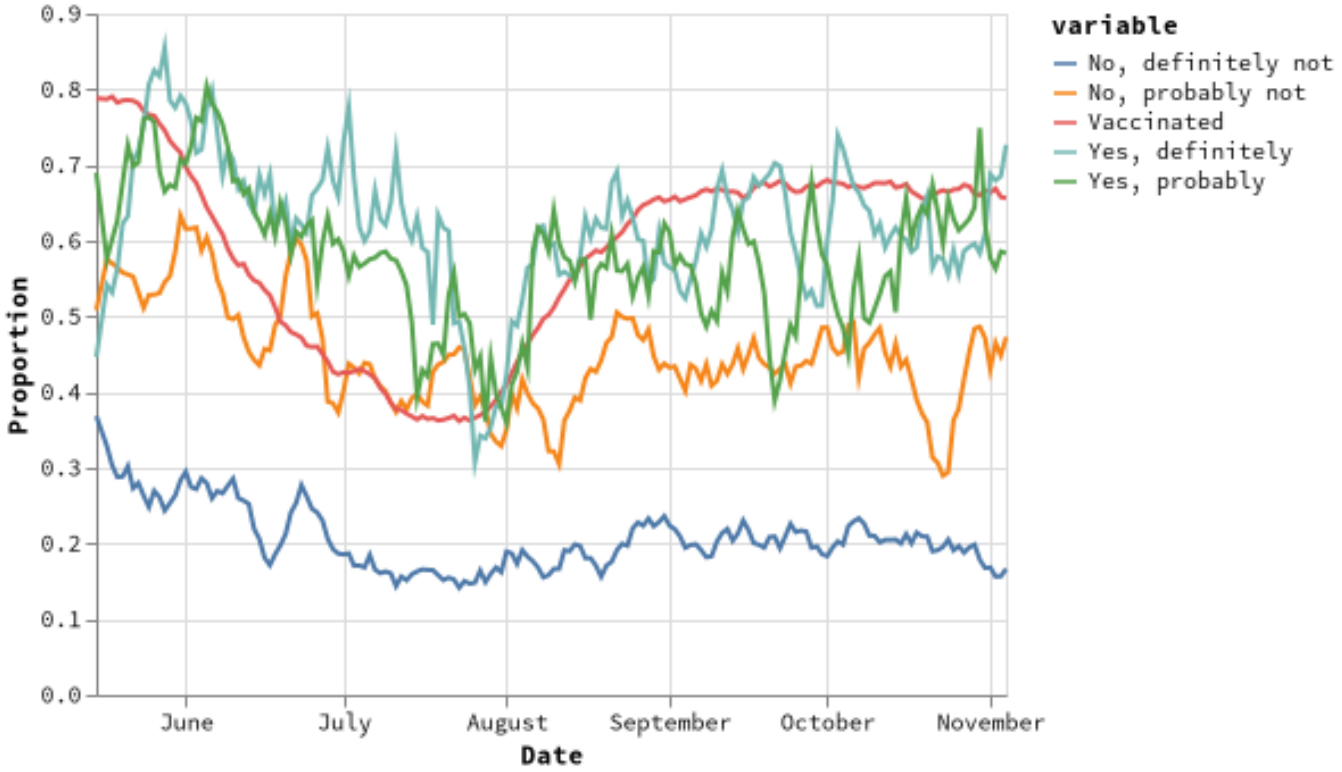

Data Source: https://covidcast.cmu.edu

# Mask Usage Stalls

**Self-reported mask usage has decline slightly to ~62% (mid 60s in previous months)**

- US and VA similar, though US is down a little more in past month
- Mask wearing remains lower amongst unvaccinated especially among least willing to be vaccinated




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

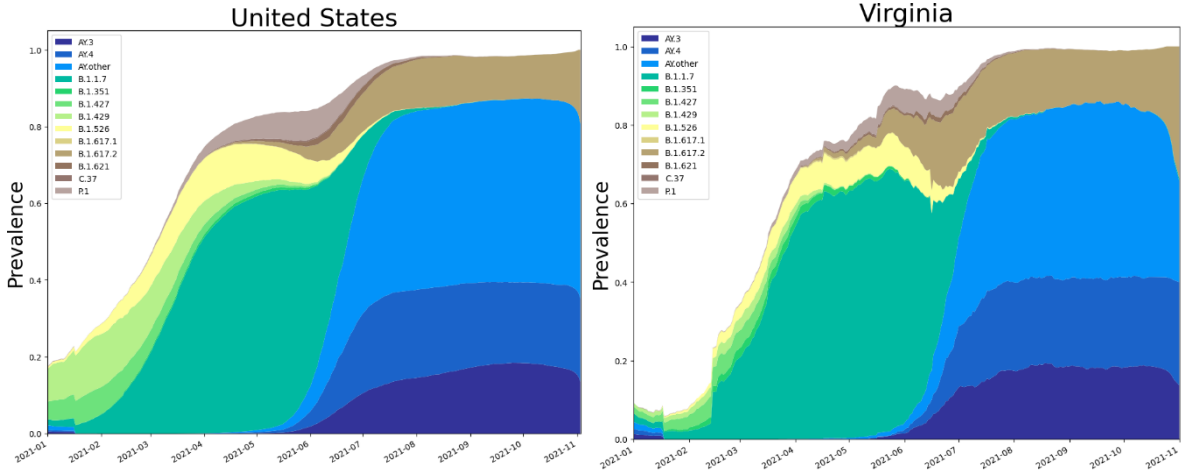
| | New WHO Name | Transmissibility | Immune Evasiveness | Vaccine Effectiveness^ |
|---|---|---|---|---|
| Ancestral | | — | — | ✓ |
| D614G | | + | — | ✓ |
| B.1.1.7 | Alpha | +++ | — | ✓ |
| B.1.351 | Beta | + | ++++ | ✓ |
| P.1 | Gamma | ++ | ++ | ✓ |
| B.1.429 | Epsilon | + | + | ✓ |
| B.1.526 |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

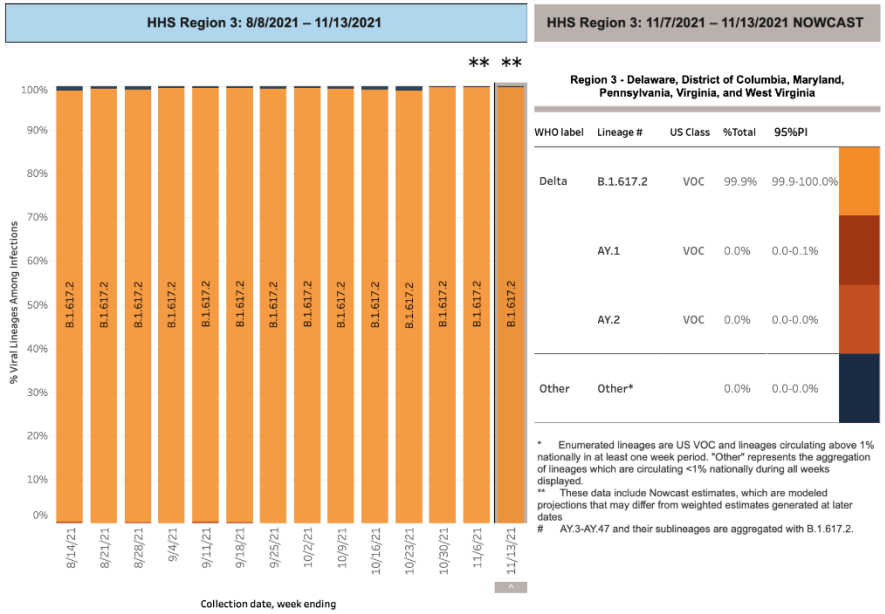
*Relative transmissibility to B.1.1.7 yet to be fully defined
^Effectiveness from real world evidence vs. severe illness, not all vaccines are effective vs all variants, and importance of 2-doses, especially for B.1.617.2 for which 1 dose of mRNA or AZ is only ~30% effective # May carry more immune escape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

World Health Organization

WHO and Eric Topol

GISAID outbreak.info



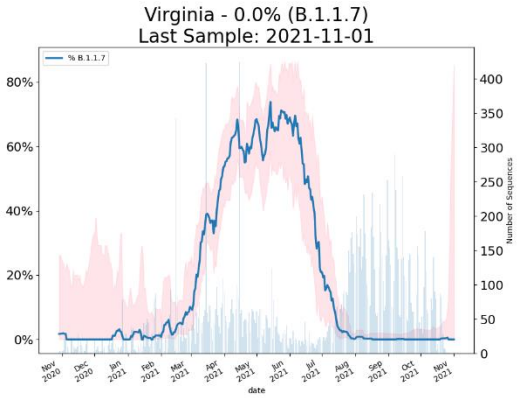




CDC

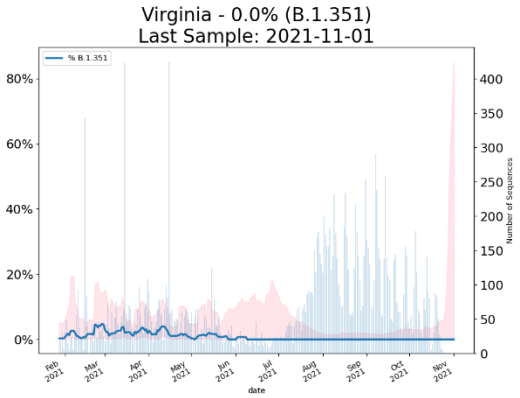
CDC Variant Tracking

# SARS-CoV2 Variants of Concern

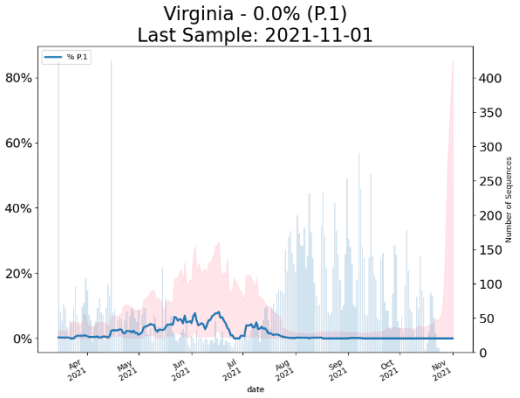
## Alpha α - Lineage B.1.1.7



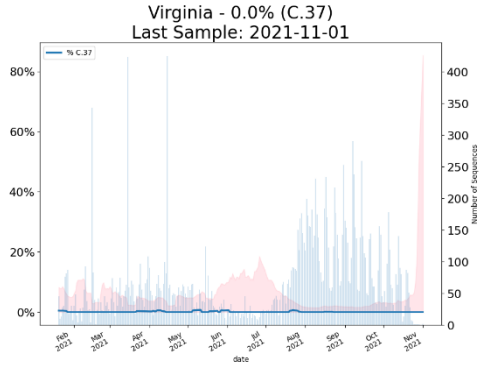

## Beta β - Lineage B.1.351



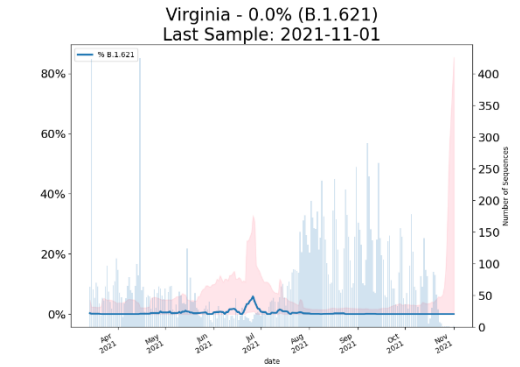

## Gamma γ - Lineage P.1



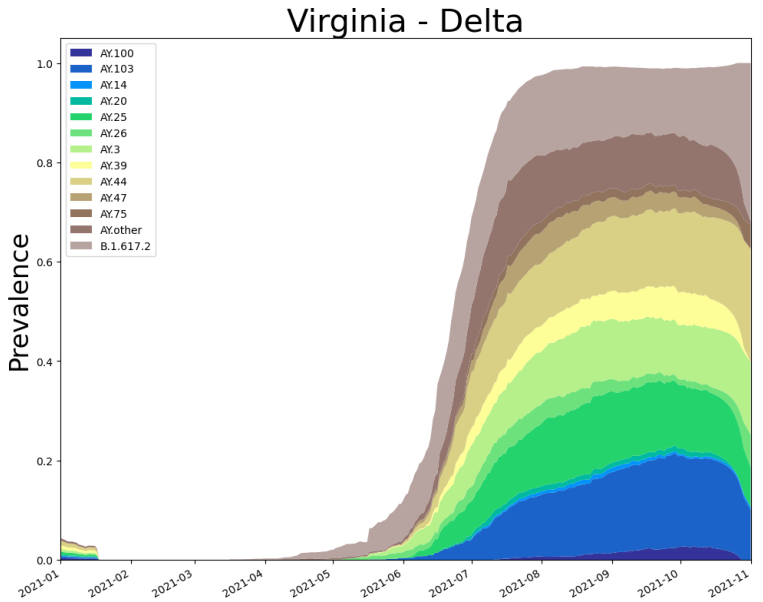

## Lambda λ - Lineage C.37

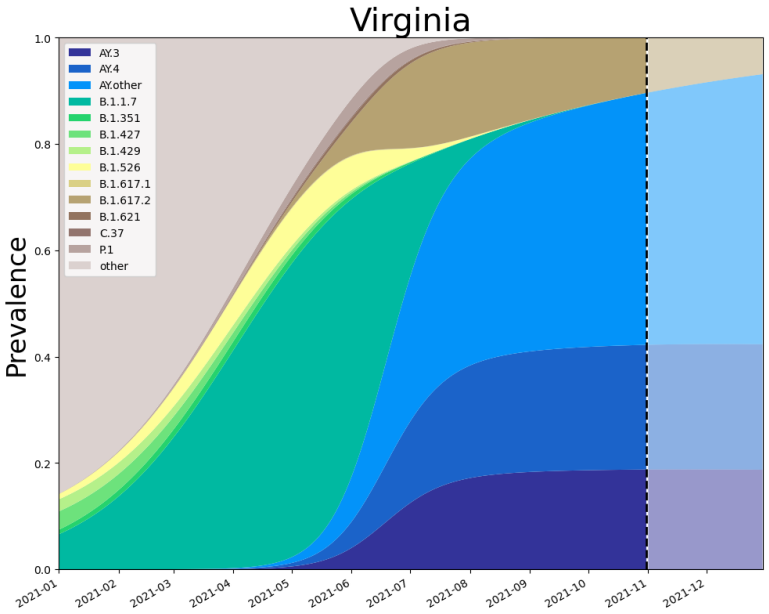



## Mu μ - Lineage B.1.621




## Delta δ - Lineage B.1.617.2




**Delta Subvariant Activity**
Current fits suggest slow shifts among subvariants in the future, no major movement

# News, Variants & Vaccines

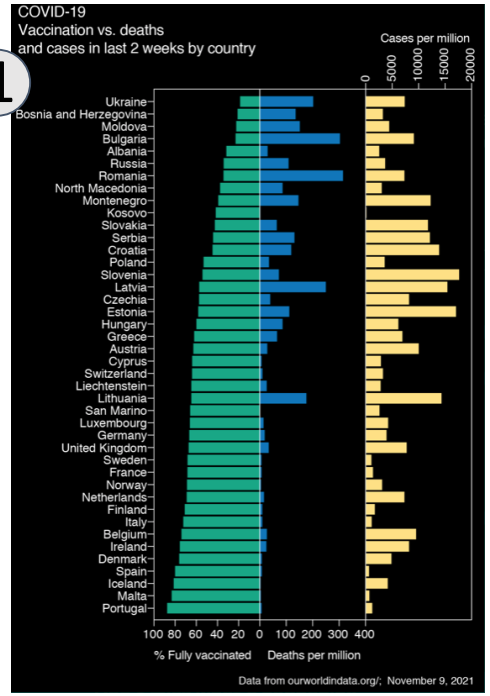
**1.** In Germany and other Eastern European countries the recent uptick in cases is primarily among the unvaccinated. In Germany this has greatly reduced the number of critical care beds.

**2.** VA off to strong start in children 5-11 vax

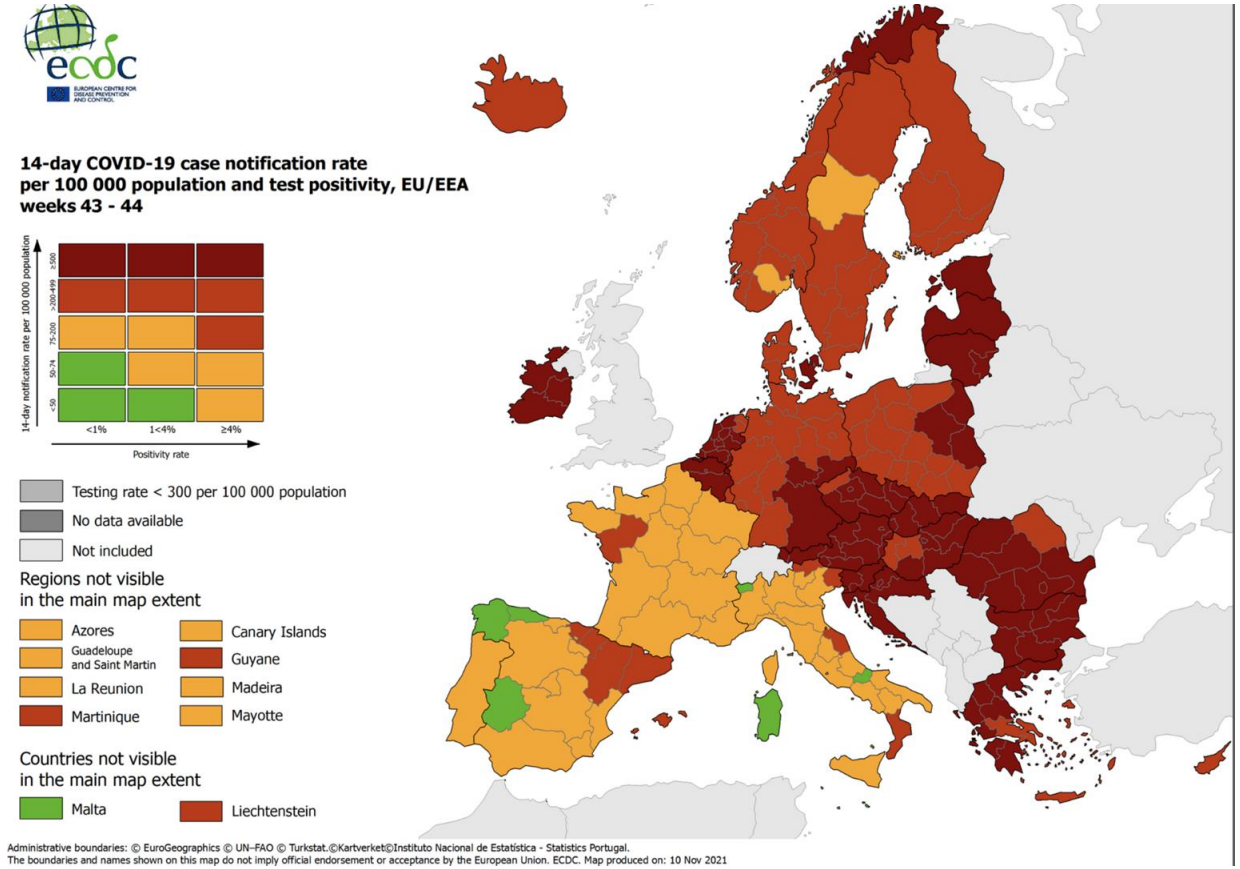
**3.** The Delta sublineage AY.4.2 (VUI-21OCT-01) accounts for an increasing proportion of cases in the UK, does NOT show signs of immune escape

**4.** A recent UK based contact tracing study highlights immune waning contribution to breakthrough transmission in Delta

1




https://twitter.com/LukaMesin/status/1458504379372392453

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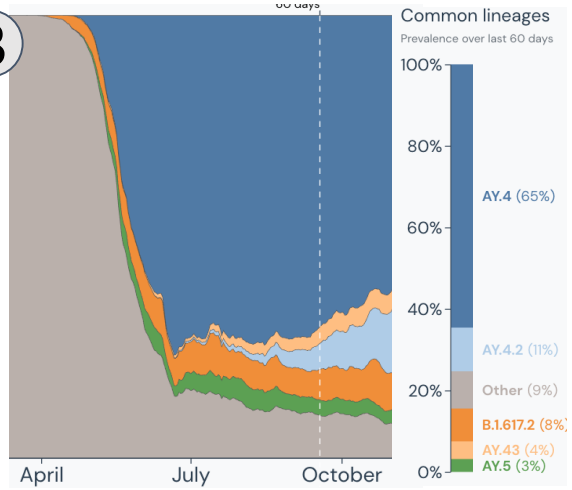
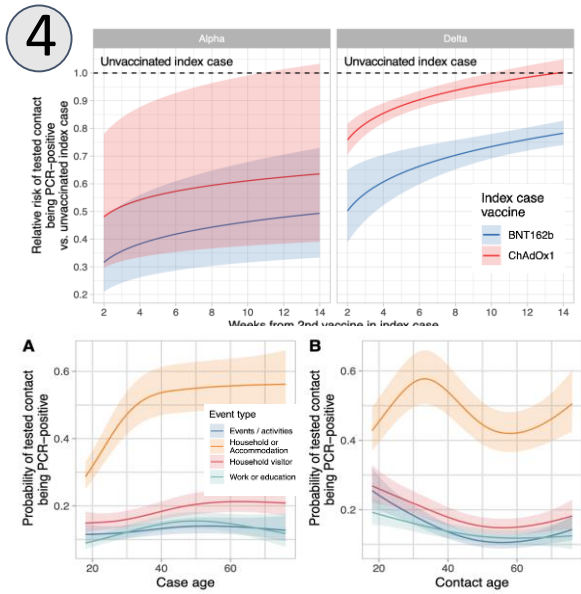



Eastern Europe is being hit particularly hard in recent weeks. Perhaps demonstrating early seasonal trends for those states with low vaccination levels https://www.ecdc.europa.eu/en/covid-19/situation-updates/weekly-maps-coordinated-restriction-free-movement

4




https://www.medrxiv.org/content/10.1101/2021.09.28.21264260v2.full.pdf

The Delta sublineage AY.4.2 was designated VUI-21OCT-01 on 20 October 2021 has shown an increase in the number of cases in UK surveillance. For all the AstraZeneca, Pfizer and Moderna vaccines, vaccine effectiveness against AY.4.2 symptomatic disease is very similar to that seen for Delta not AY.4.2. Preliminary neutralisation (live virus and pseudo virus) assays from the Genotype to Phenotype Consortium UK suggests AY.4.2 is equally, or even more easily neutralised by both post-vaccination antisera.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033101/Technical_Briefing_28_12_Nov_2021.pdf

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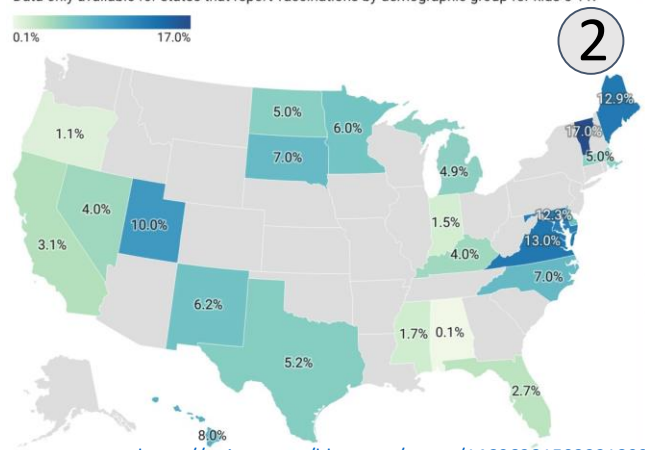


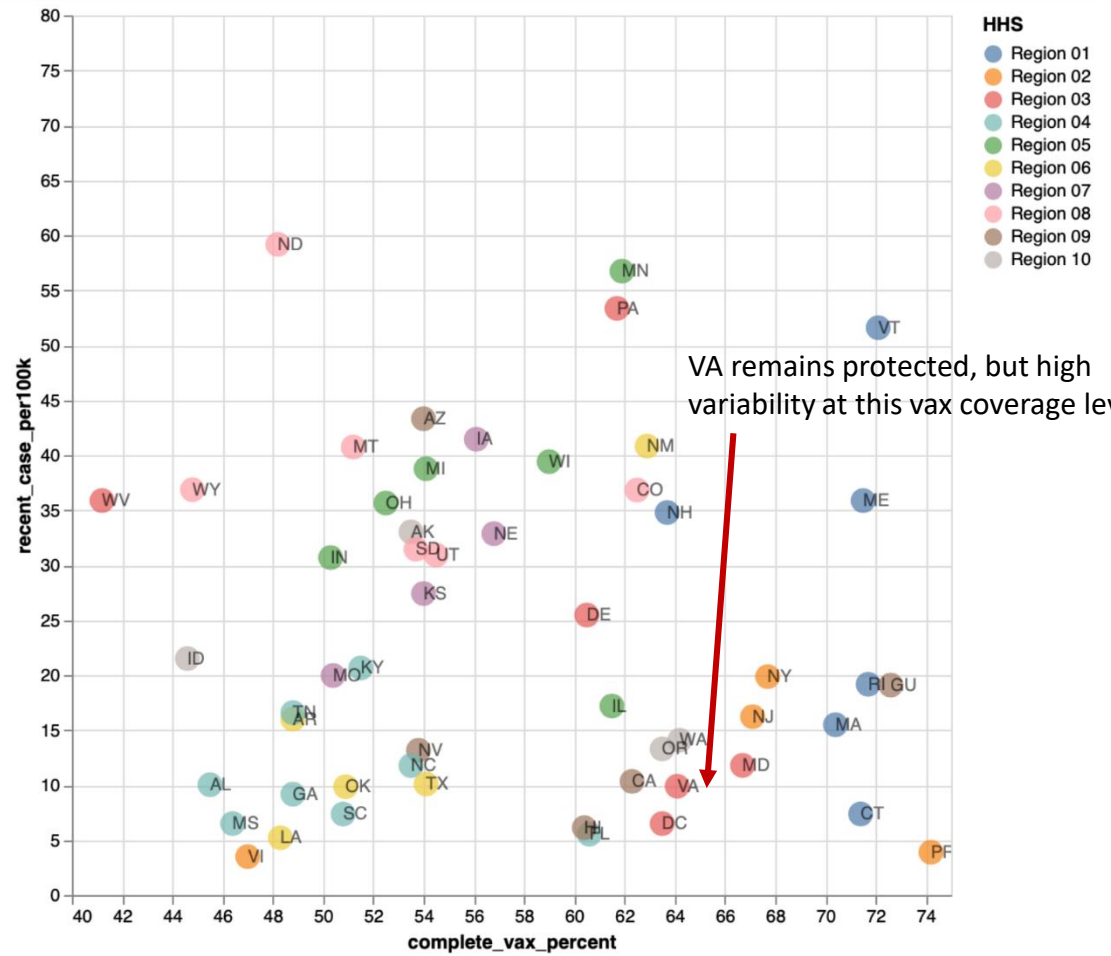

https://twitter.com/bhrenton/status/1460638150322180098

Early collection of state-level child vaccination progress shows Virginia off to a strong start. The CDC will start reporting this data later this week.

# Recent Cases Correlate with Vax Coverage

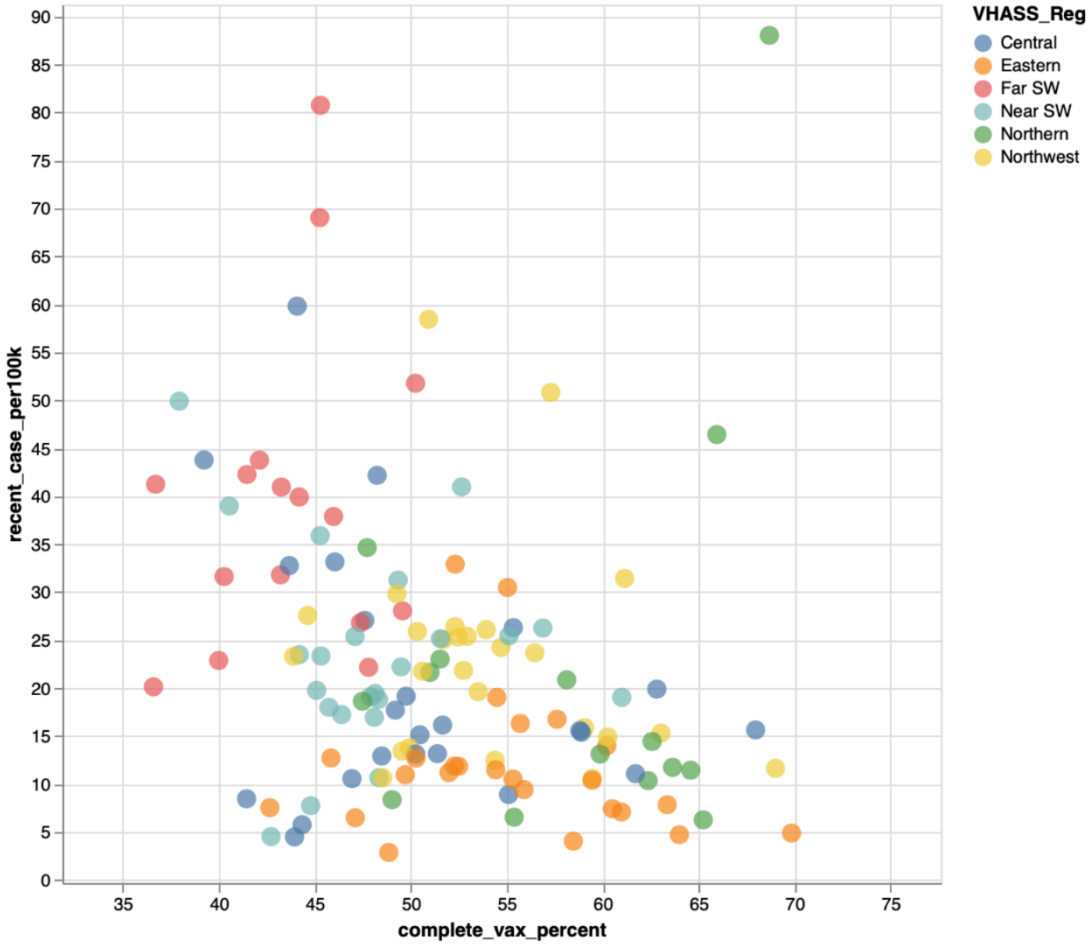
**Mean cases per 100K vs. vaccine coverage**

- States with lower vax coverage have had the worst case spikes



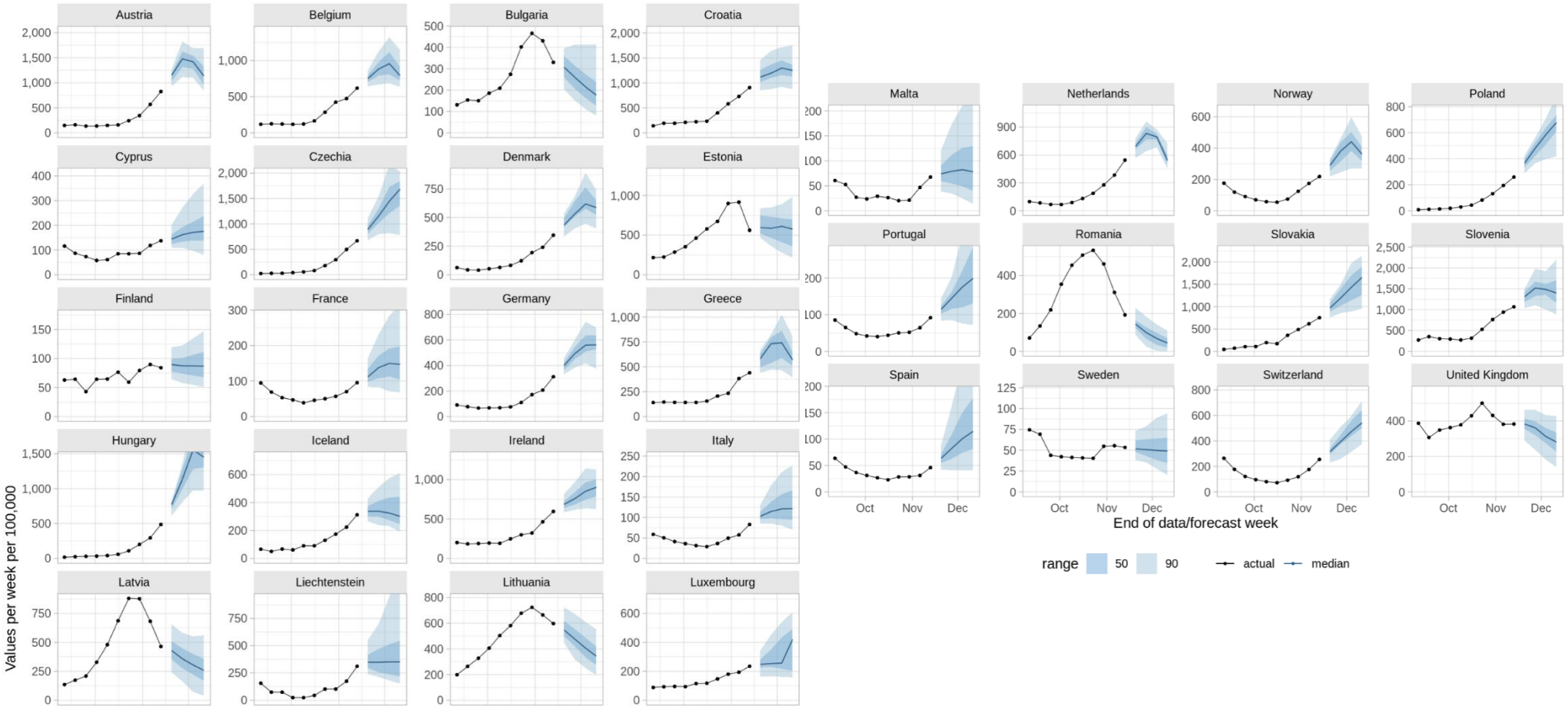

**Virginia Counties**

- Counties with higher vax coverage are maintaining lower case rates



# European Nations

- Cases continue to climb in most European nations
- Short term forecasts calling for increased cases or plateaus in most nations
- Some are renewing control measures



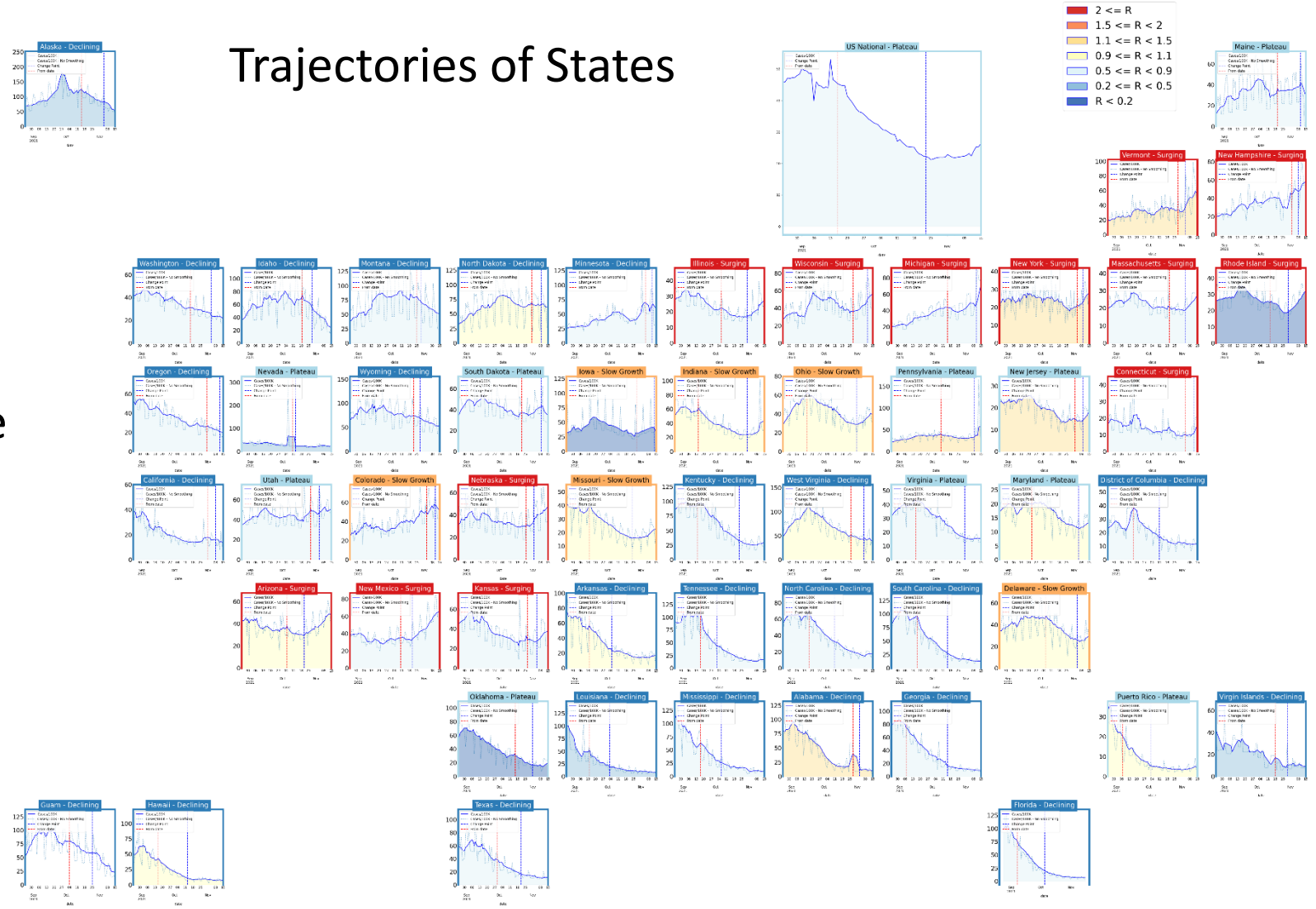

UVA-Ensemble model contributes to forecasts
https://covid19forecasthub.eu/reports.html

# United States Overall

- Declines still outnumber growth but the gap has closed
- Significant number of states in growth
- Case rates remain moderate to high in most states

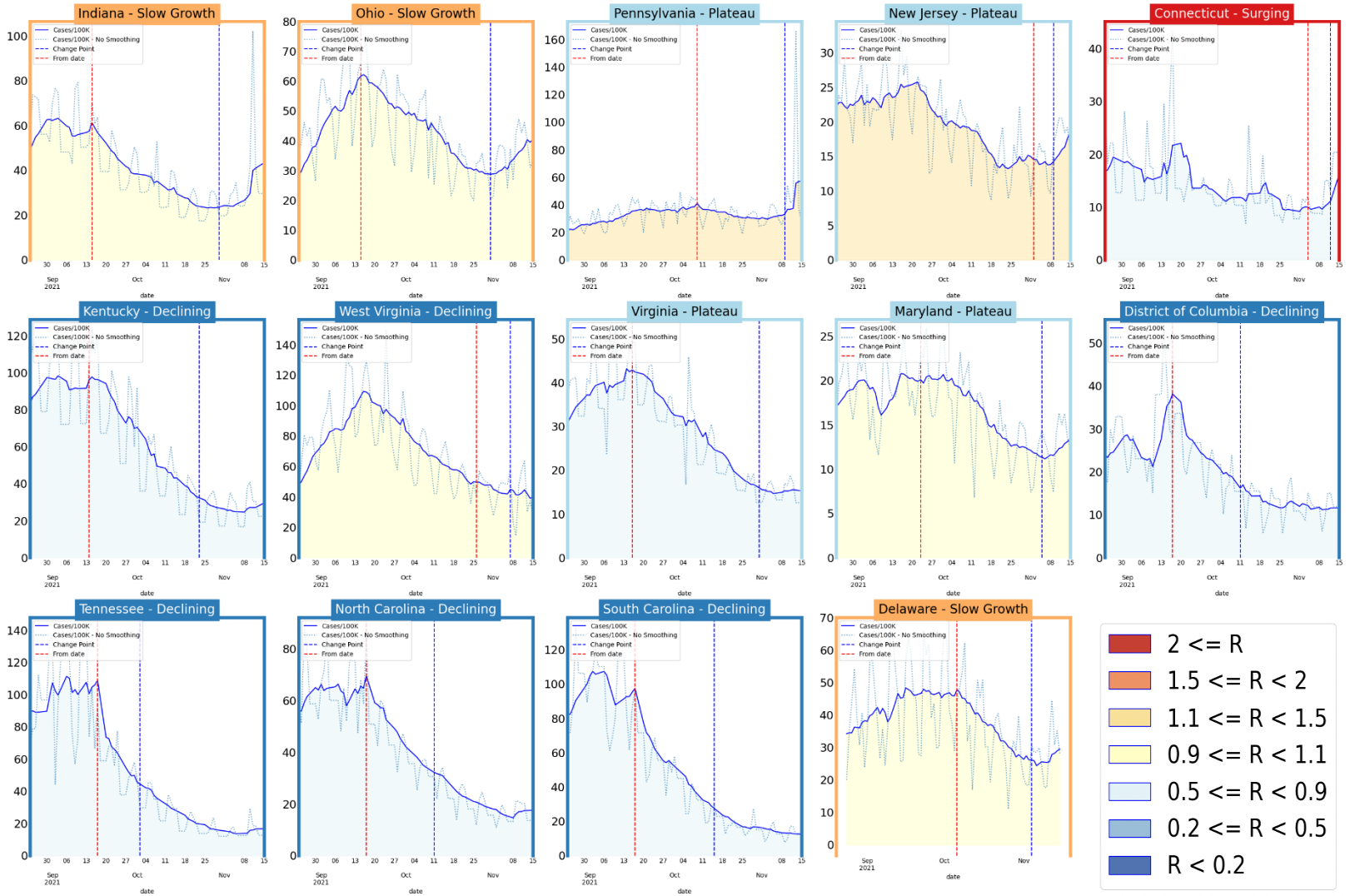
| Status | # States |
|---|---|
| Declining | 25 |
| Plateau | 10 |
| Slow Growth | 6 |
| In Surge | 13 |

Trajectories of States



# Virginia and Her Neighbors

- Neighbors now shifting to growth
- Declines remain in neighbors to the south
- Case rates have mostly moderated but some remain high
- Signs of slowing declines and plateaus emerging

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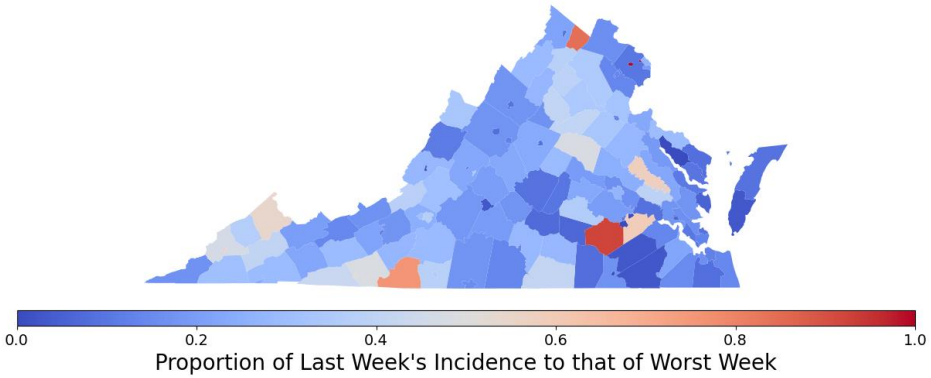
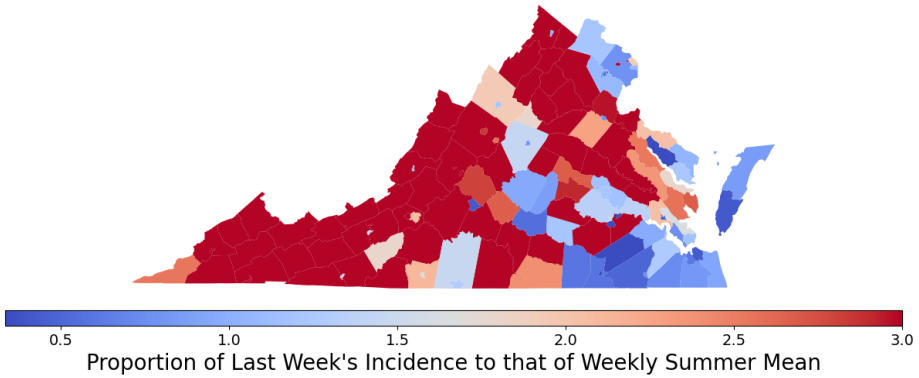
# Last Week compared to the worst and the best

**County level Case Rates (per 100K) proportion when comparing this most recent week to:**

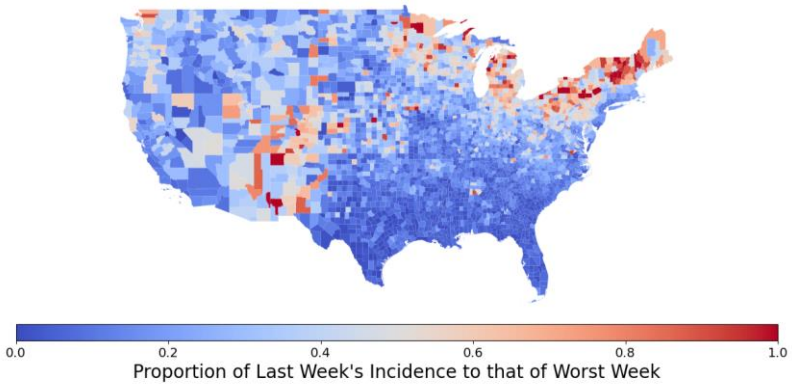
**Worst Week of the Pandemic**



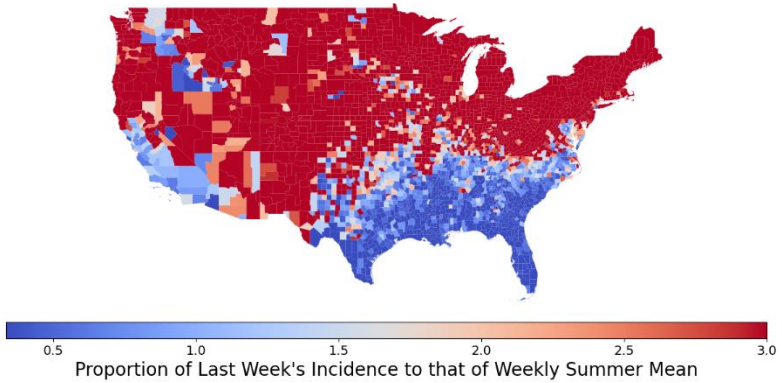

**Summer 2020 mean**




Recent Incidence Compared to Worst Week by County




Recent Incidence Compared to Weekly Summer Mean by County
Mean: 74.31; Median: 3.13; IQR: 0.85-8.76



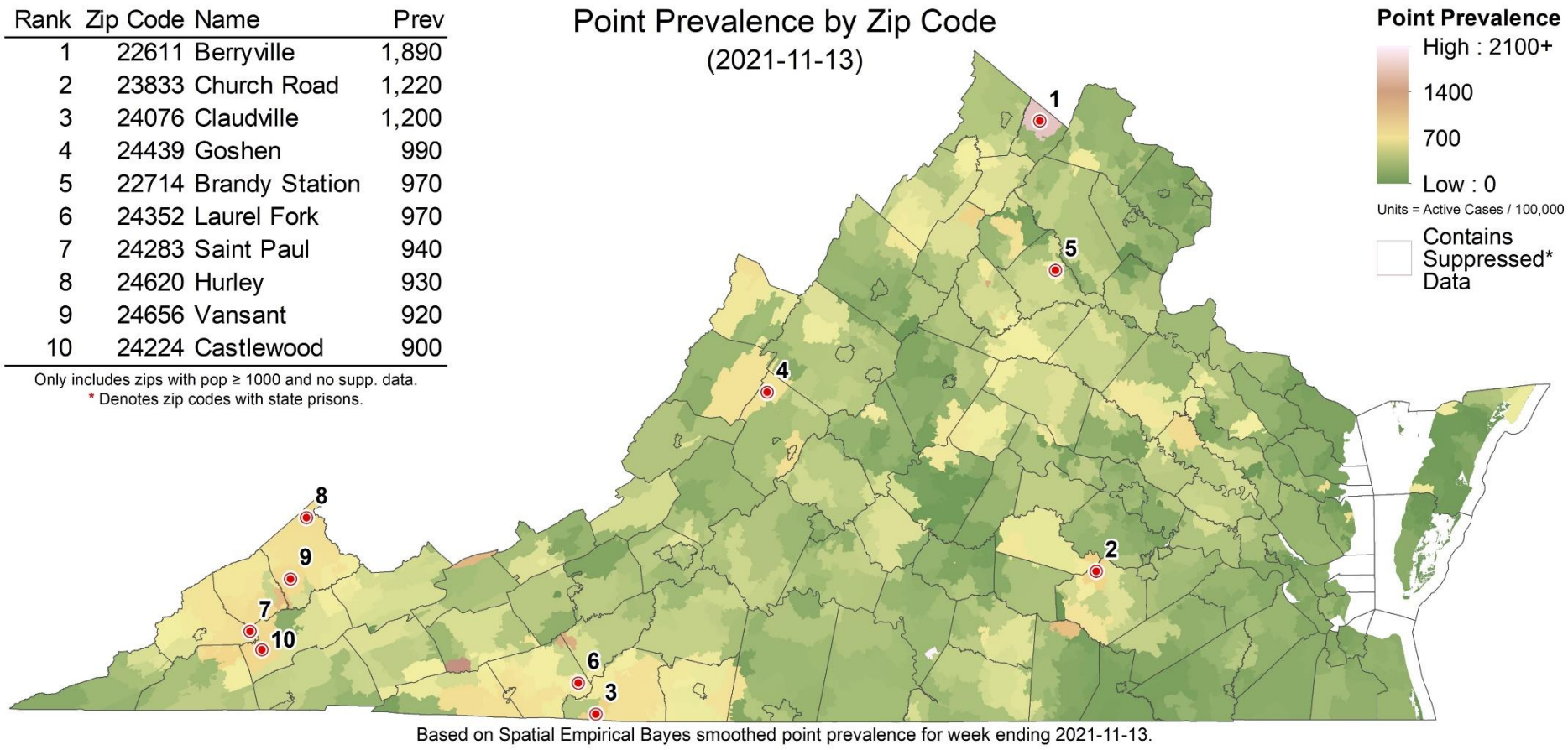
# Zip code level weekly Case Rate (per 100K)

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

| Rank | Zip Code | Name | Prev |
|---|---|---|---|
| 1 | 22611 | Berryville | 1,890 |
| 2 | 23833 | Church Road | 1,220 |
| 3 | 24076 | Claudville | 1,200 |
| 4 | 24439 | Goshen | 990 |
| 5 | 22714 | Brandy Station | 970 |
| 6 | 24352 | Laurel Fork | 970 |
| 7 | 24283 | Saint Paul | 940 |
| 8 | 24620 | Hurley | 930 |
| 9 | 24656 | Vansant | 920 |
| 10 | 24224 | Castlewood | 900 |

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 2021-11-13.

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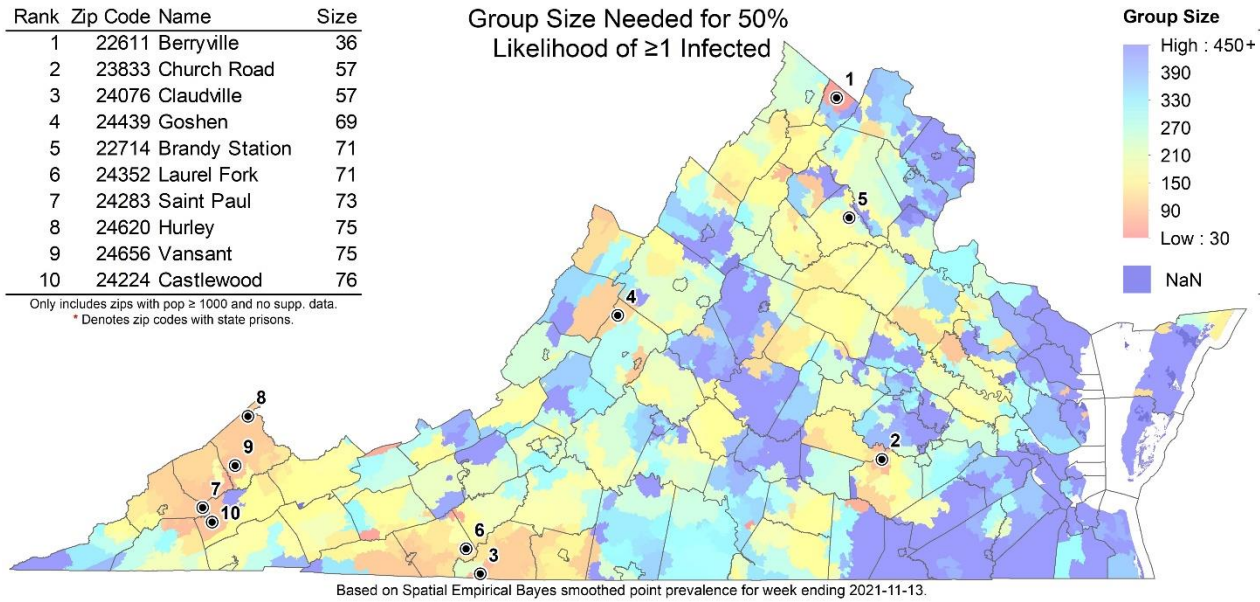
# Risk of Exposure by Group Size and HCW prevalence

**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 36 in Berryville, 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

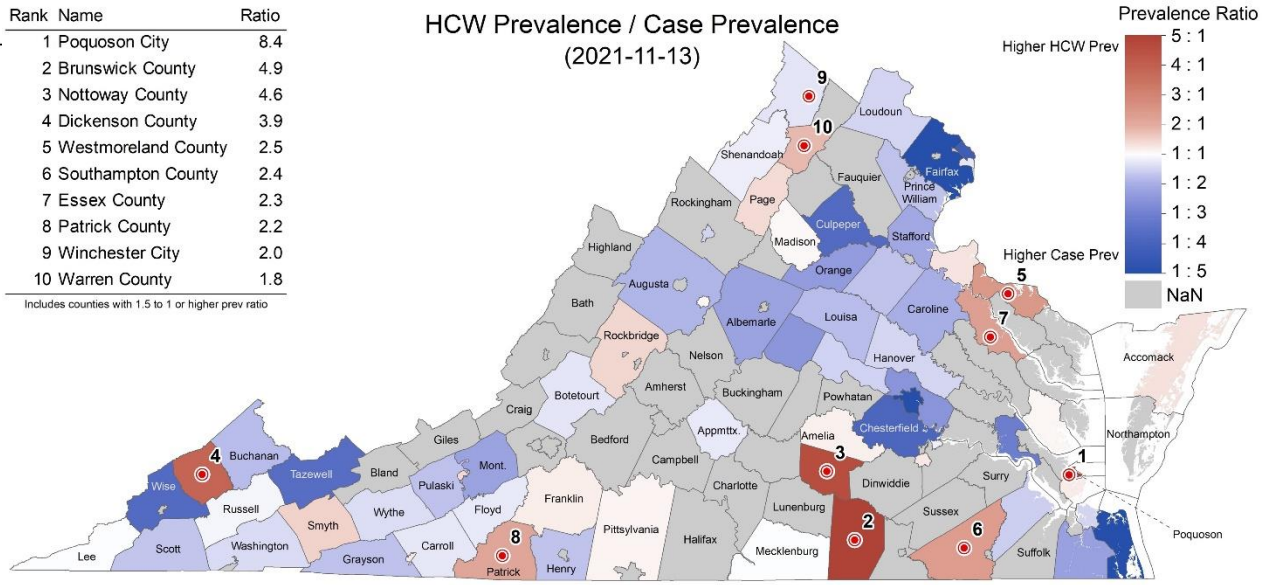
| Rank | Zip Code | Name | Size |
|---|---|---|---|
| 1 | 22611 | Berryville | 36 |
| 2 | 23833 | Church Road | 57 |
| 3 | 24076 | Claudville | 57 |
| 4 | 24439 | Goshen | 69 |
| 5 | 22714 | Brandy Station | 71 |
| 6 | 24352 | Laurel Fork | 71 |
| 7 | 24283 | Saint Paul | 73 |
| 8 | 24620 | Hurley | 75 |
| 9 | 24656 | Vansant | 75 |
| 10 | 24224 | Castlewood | 76 |

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




| Rank | Name | Ratio |
|---|---|---|
| 1 | Poquoson City | 8.4 |
| 2 | Brunswick County | 4.9 |
| 3 | Nottoway County | 4.6 |
| 4 | Dickenson County | 3.9 |
| 5 | Westmoreland County | 2.5 |
| 6 | Southampton County | 2.4 |
| 7 | Essex County | 2.3 |
| 8 | Patrick County | 2.2 |
| 9 | Winchester City | 2.0 |
| 10 | Warren County | 1.8 |

Includes counties with 1.5 to 1 or higher prev ratio



# Current Hot-Spots

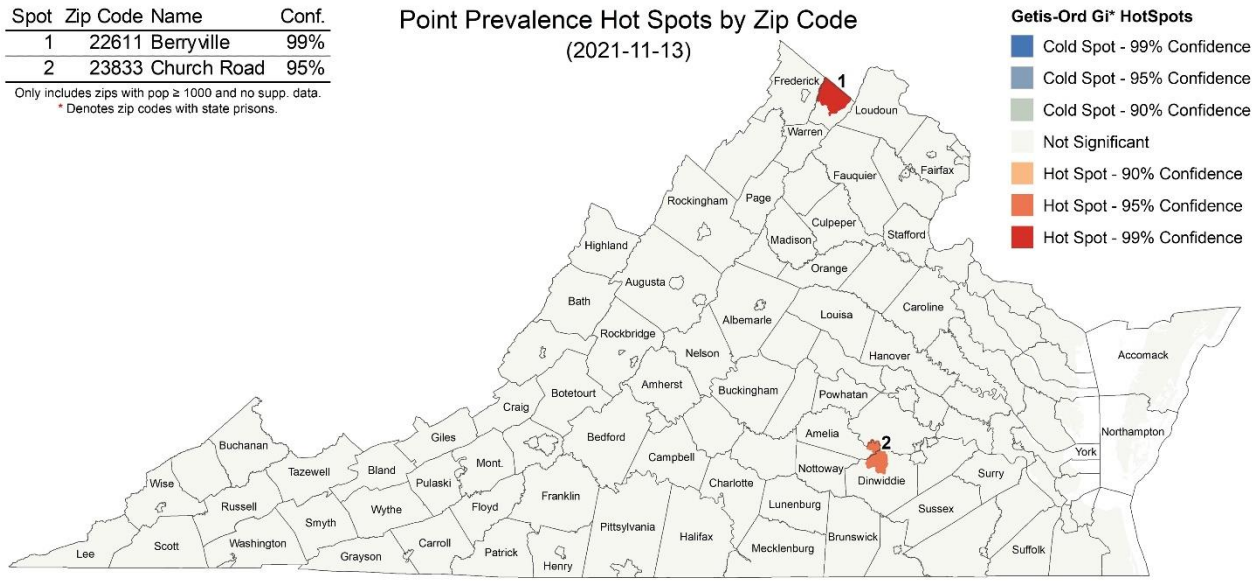
**Case rates that are significantly different from neighboring areas or model projections**

- **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

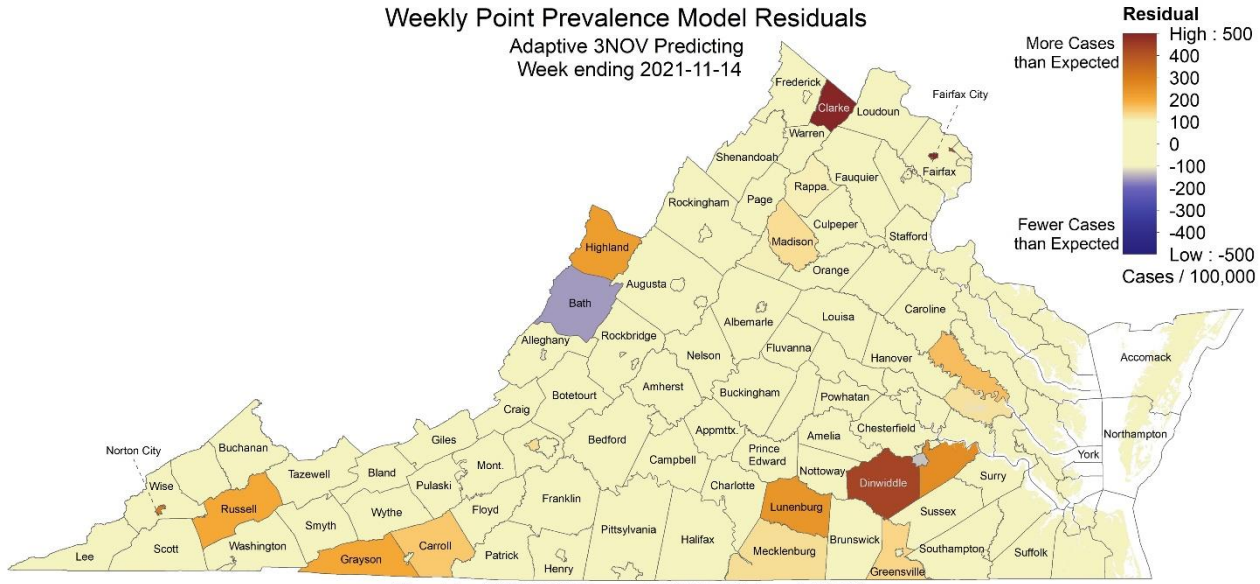
| Spot | Zip Code | Name | Conf. |
|---|---|---|---|
| 1 | 22611 | Berryville | 99% |
| 2 | 23833 | Church Road | 95% |

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




Based on Global Empirical Bayes smoothed point prevalence for week ending 2021-11-13.

## Clustered Temporal Hotspots

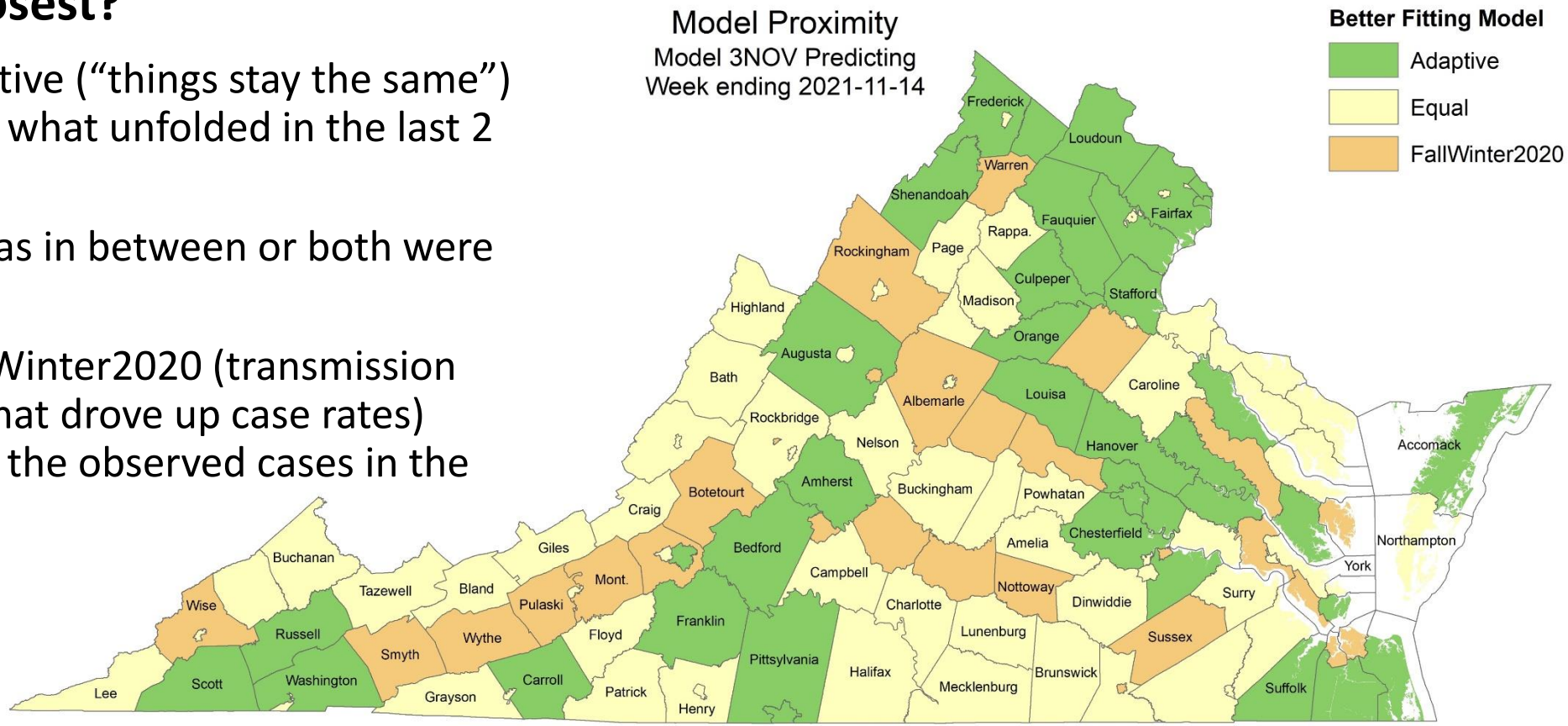



Moran's I = -0.002786, Z-Score = 0.220007, P-Value = 0.825866
No Residual Autocorrelation Detected

# Scenario Trajectory Tracking

**Which scenario from last projection did each county track closest?**

- Green means the Adaptive (“things stay the same”) scenario was closest to what unfolded in the last 2 weeks
- Yellow means reality was in between or both were very similar
- Orange means the FallWinter2020 (transmission drivers from last year that drove up case rates) scenario was closest to the observed cases in the last 2 weeks



# Model Update – Adaptive Fitting

# Adaptive Fitting Approach

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

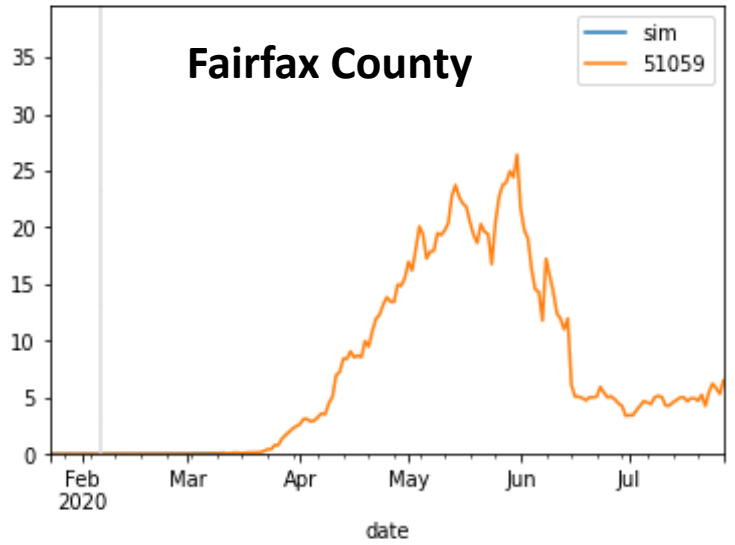
- Allows history to be precisely captured, and used to guide bounds on projections

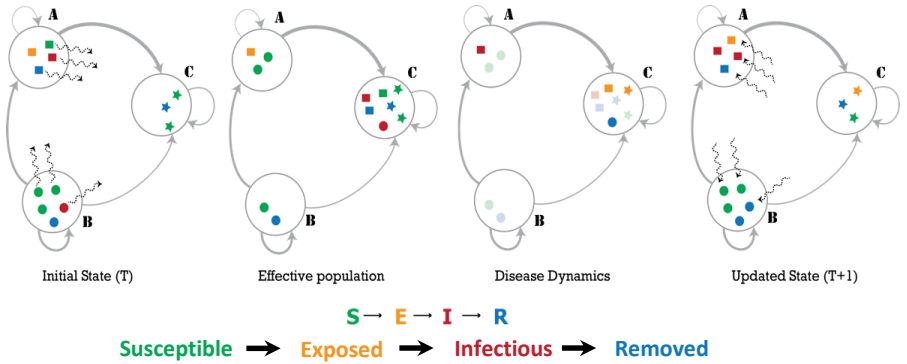
**Model:** An alternative use of the same meta-population model, PatchSim

- 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:

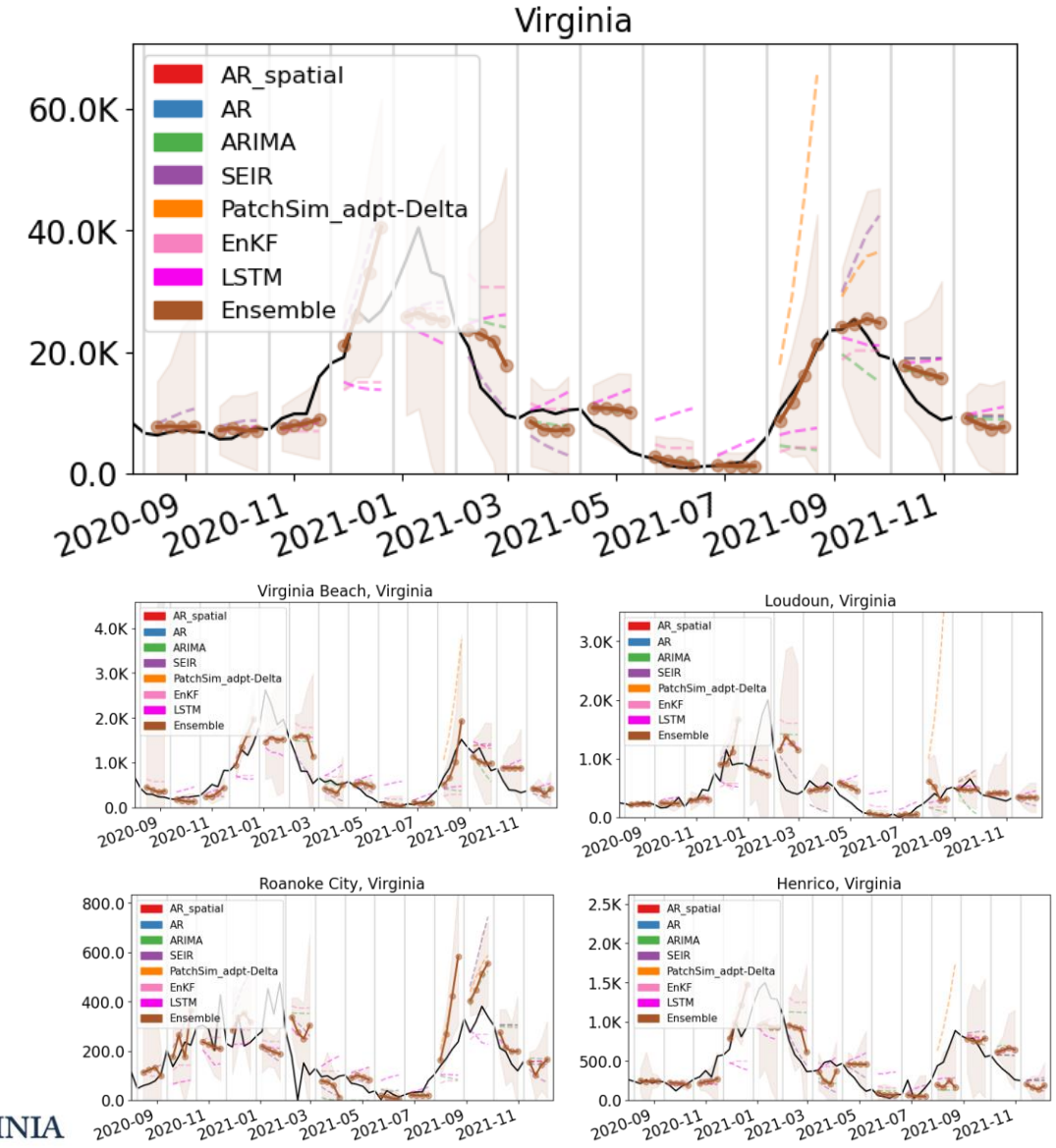
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

<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.



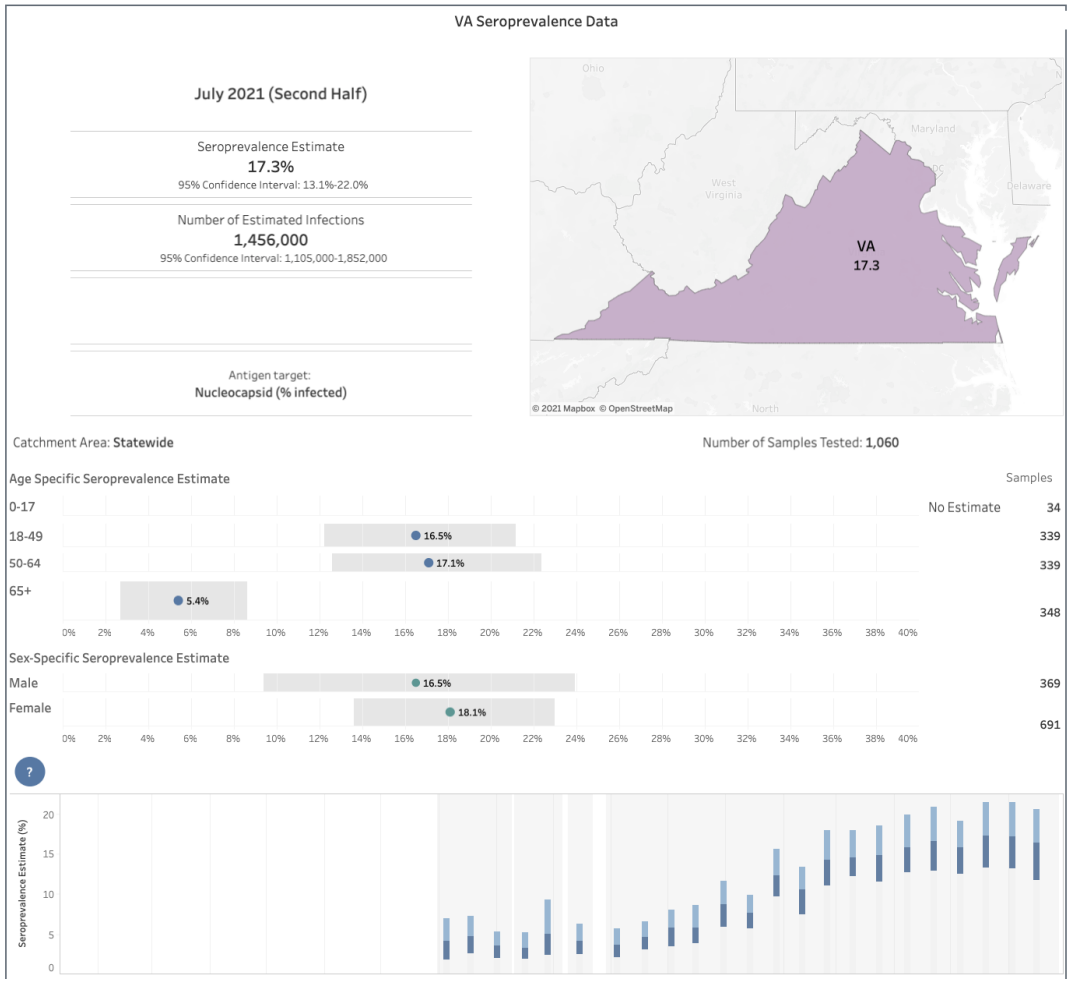
# Seroprevalence updates to model design

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

- CDC Nationwide Commercial Laboratory Seroprevalence Survey

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

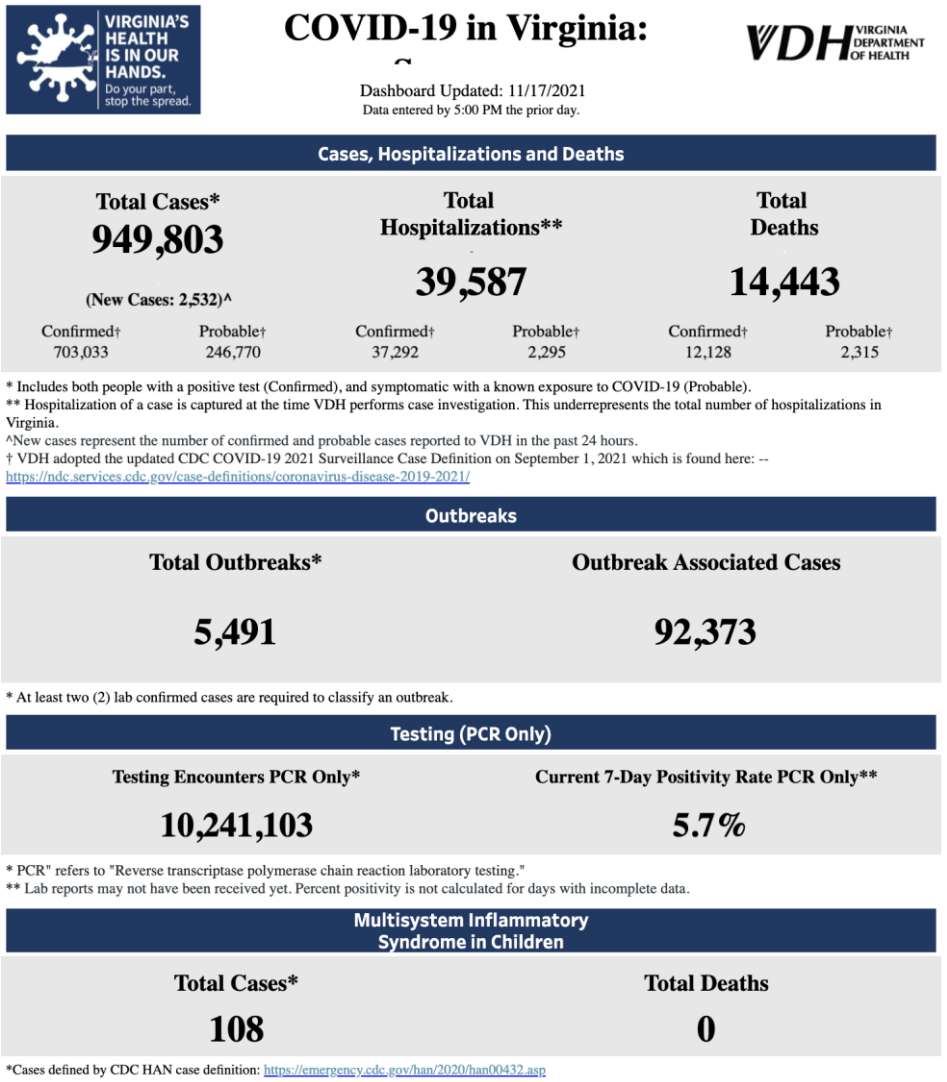
- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- This measure now fully tracks the estimated ascertainment over time
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were being 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
- **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: 11/17/2021
Data entered by 5:00 PM the prior day.

**Cases, Hospitalizations and Deaths**

| Total Cases* | Total Hospitalizations** | Total Deaths |
|---|---|---|
| 949,803 | 39,587 | 14,443 |
| (New Cases: 2,532)^ | | |

| Confirmed† | Probable† | Confirmed† | Probable† | Confirmed† | Probable† |
|---|---|---|---|---|---|
| 703,033 | 246,770 | 37,292 | 2,295 | 12,128 | 2,315 |

* 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 2021 Surveillance Case Definition on September 1, 2021 which is found here: -- https://ndc.services.cdc.gov/case-definitions/coronavirus-disease-2019-2021/

**Outbreaks**

| Total Outbreaks* | Outbreak Associated Cases |
|---|---|
| 5,491 | 92,373 |

* 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** |
|---|---|
| 10,241,103 | 5.7% |

* 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 |
|---|---|
| 108 | 0 |

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

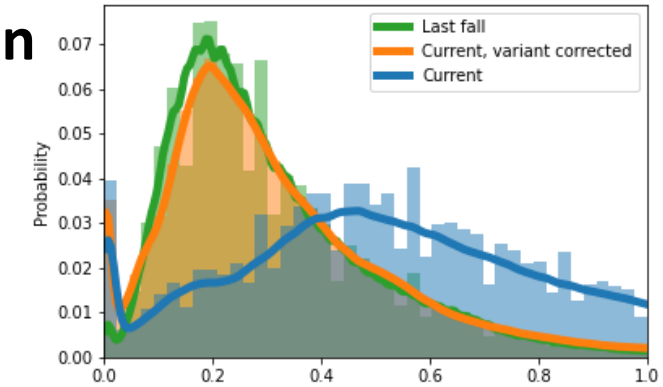
Accessed 9:30am November 17, 2021
https://www.vdh.virginia.gov/coronavirus/

# 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 one 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 Delta remains as the majority strain
  - **Adaptive-FallWinter2020:** Starting this week the core drivers of transmission from Sept 2020 – Feb 2021 are coarsely replayed but boosted to account for Delta's increased transmissibility
  - **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

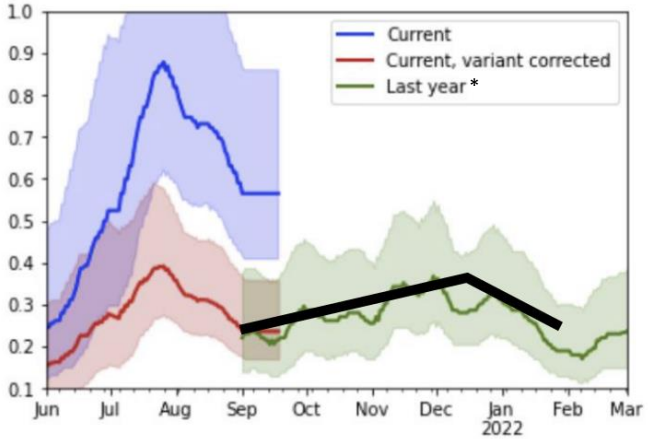
# Scenarios – FallWinter2020 Description

**September 2020 – February 2021 saw a strong wave of transmission**

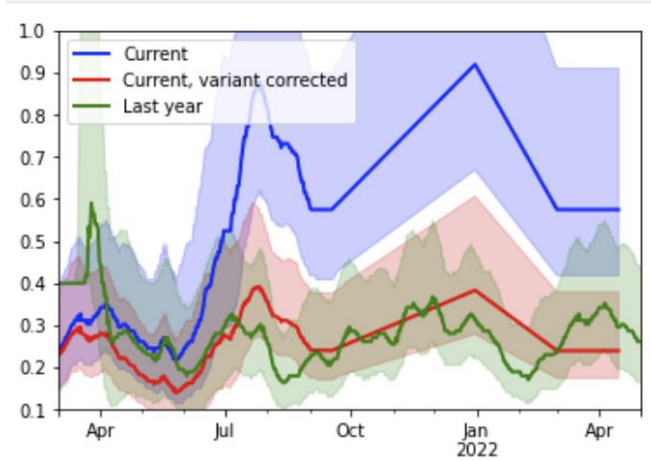



- We analyze previous Fall-Winter's wave vs. current Delta driven wave and observe surprising similarities
  - The distribution of fitted model transmissibility is nearly identical between these periods when corrected for Delta's increased transmissibility
- **FallWinter2020** tries to capture the "transmission drivers" from the past and use them as if they were to occur again this season but with Delta variant (compared to ancestral)
  - Use the above analysis of fitted model transmissibilities from Sept 2020 – Feb 2021 to guide the future transmissibility from Sept 2021 through Feb 2022, but add the enhanced transmissibility of Delta back in

**Fitting:**
Black line represents the coarsely fitted base transmissibility




* "Last year" is transplanted into 2021-22




**Delta enhanced:**
Blue trajectory represents current fitted and then projected transmissibility in FallWinter2020

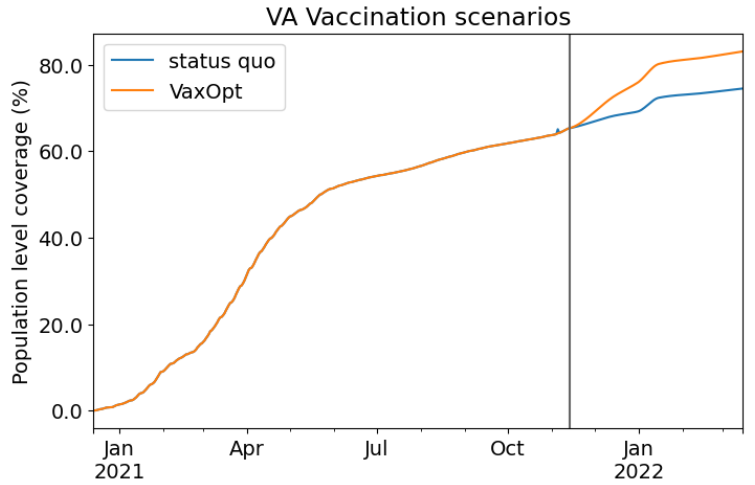
# Scenarios – Vaccination Conditions

## 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. 3rd doses continue with total coverage of 40%
- **Optimistic (VaxOpt):** Expand VA mean acceptance to include "probably not" (~85% adults) with addition of childhood (5-11 yo) rollout starting in Nov 8th. This follows the same rates as observed of adolescents and results in a net increase of ~10% of population by end of February. Additionally, all counties guaranteed to reach a minimum of 65%, max of 95% by end of December. 3rd doses continue with total coverage of 60%
- Acceptance at county level = regional acceptance +/- relative current vax
- Front-loaded rollout (two-thirds of the remaining in half the time)




| | Monthly | | Cumulative | |
|---|---|---|---|---|
| Date | status quo | VaxOpt | status quo | VaxOpt |
| 12/31/20 | 110.2K | 110.2K | 110.2K | 110.2K |
| 1/31/21 | 649.8K | 649.8K | 760.0K | 760.0K |
| 2/28/21 | 561.7K | 561.7K | 1.3M | 1.3M |
| 3/31/21 | 1.3M | 1.3M | 2.6M | 2.6M |
| 4/30/21 | 1.2M | 1.2M | 3.8M | 3.8M |
| 5/31/21 | 575.8K | 575.8K | 4.4M | 4.4M |
| 6/30/21 | 243.0K | 243.0K | 4.6M | 4.6M |
| 7/31/21 | 198.2K | 198.2K | 4.8M | 4.8M |
| 8/31/21 | 271.6K | 271.6K | 5.1M | 5.1M |
| 9/30/21 | 177.4K | 177.4K | 5.3M | 5.3M |
| 10/31/21 | 145.0K | 249.9K | 5.4M | 5.5M |
| 11/30/21 | 110.5K | 432.3K | 5.5M | 6.0M |
| 12/31/21 | 122.3K | 507.6K | 5.7M | 6.5M |
| 1/31/22 | 0 | 446.2K | 5.7M | 6.9M |
| 2/28/22 | 0 | 103.2K | 5.7M | 7.0M |
| 3/31/22 | 0 | 67.6K | 5.7M | 7.1M |

# Projection Scenarios – Combined Conditions

| Name | Txm Controls | Vax | Description |
|---|---|---|---|
| Adaptive | C | SQ | Likely trajectory based on conditions remaining similar to the current experience |
| Adaptive-VaxOpt | C | VO | Vaccination through October reaches an optimistically high level of expanded coverage (85%) |
| Adaptive-SurgeControl | 25% | SQ | Transmission rates in the next month reduced through increased control from non-pharmaceutical interventions, with status quo vax and Delta |
| Adaptive-FallWinter2020 | FallWinter 2020 | SQ | Transmission rates coarsely follow the rates from last September through this February but are boosted by Delta's enhanced transmissibility |
| Adaptive-FallWinter2020-VaxOpt | FallWinter 2020 | VO | Transmission rates coarsely follow the rates from last September through this February but are boosted by Delta's enhanced transmissibility, with optimistic vax |

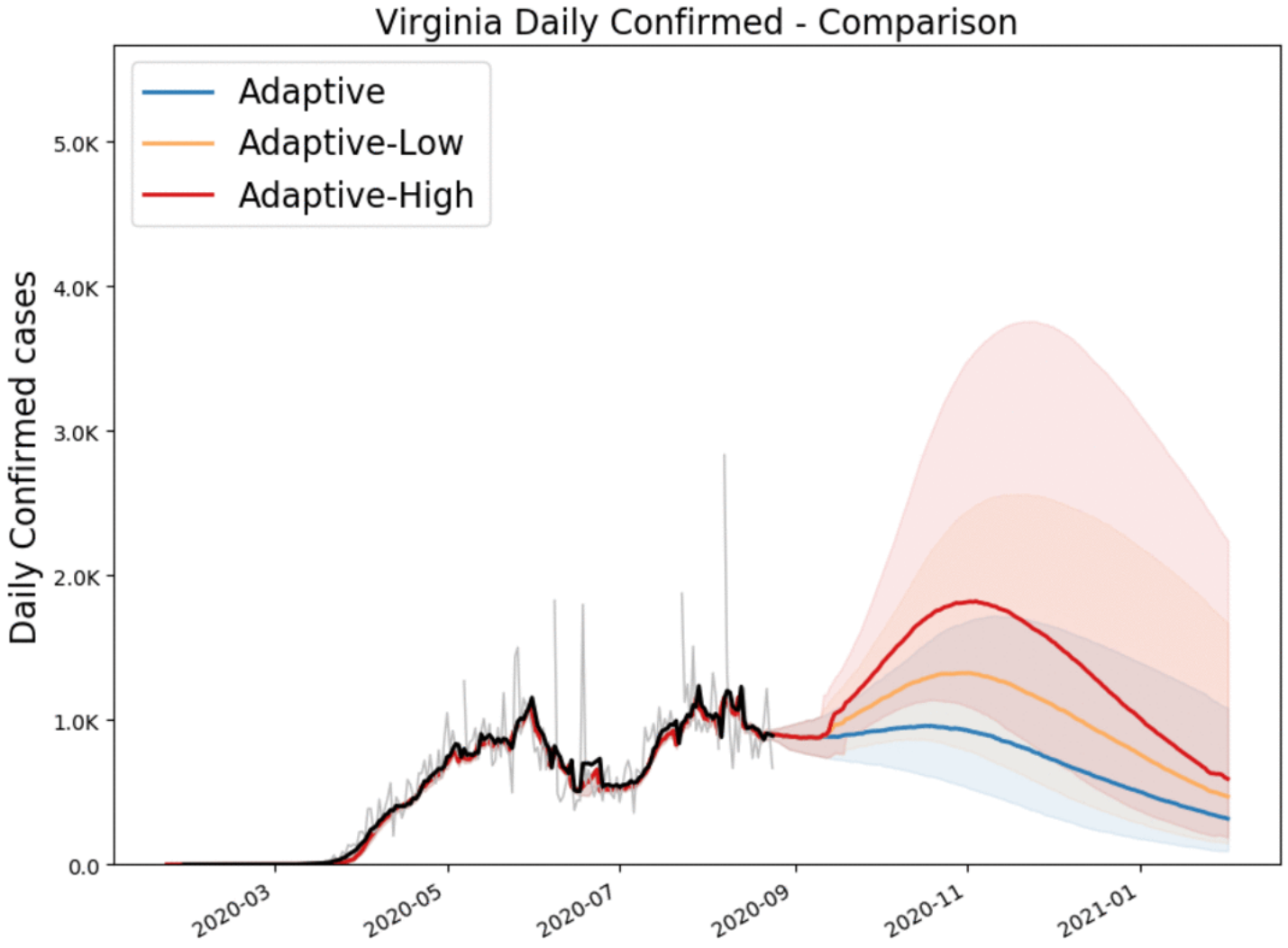
**Transmission Controls:**
C = Current levels persist into the future
25% = Transmission rates are reduced by 25% with a gradual introduction, concluding in 4 weeks
FallWinter2020 = Transmission rates from Sept 2020 – Feb 2021 are coarsely replayed but boosted by Delta's increased transmissibility

**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

# Review of “A Year of Projections”

**Confirmed case Projections**
Adaptive Approach with associated other projections

Sept 30th, 2020 to
Nov 3rd, 2021

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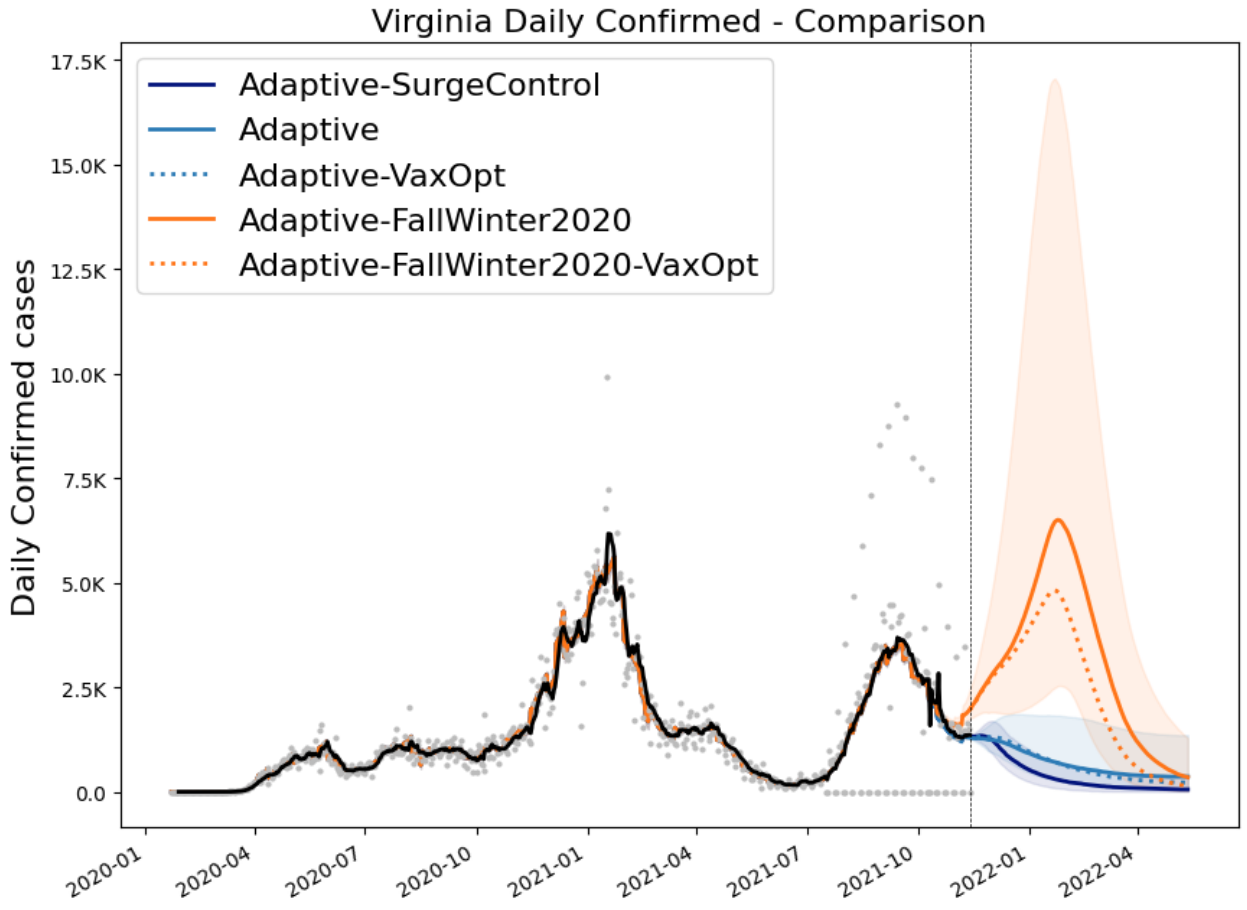
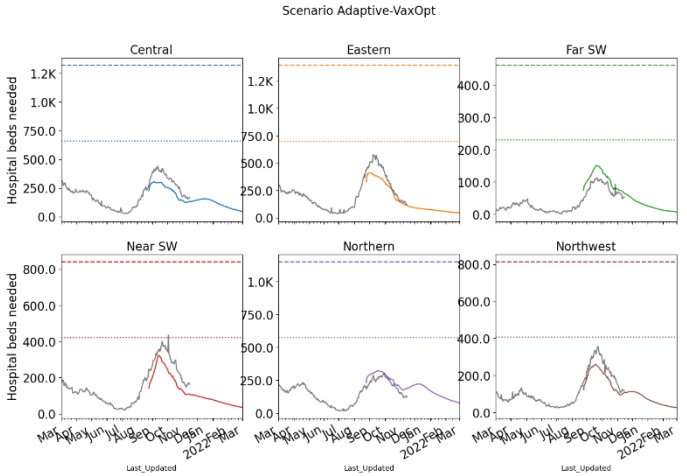
# Model Results

# Outcome Projections

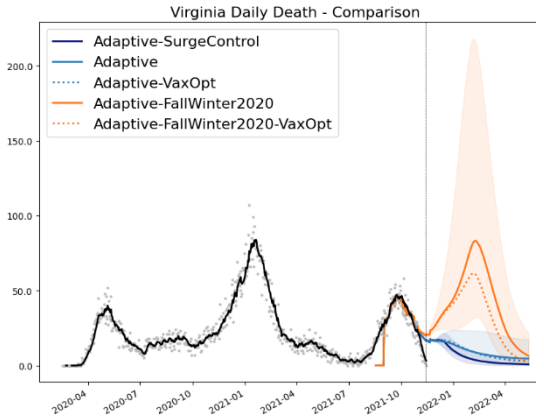
## Confirmed cases




## Estimated Hospital Occupancy

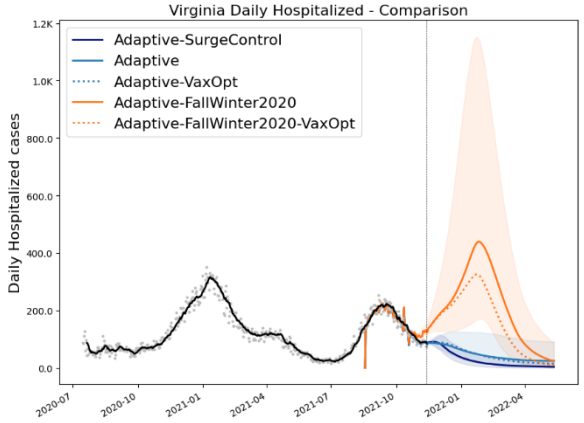



## Daily Deaths



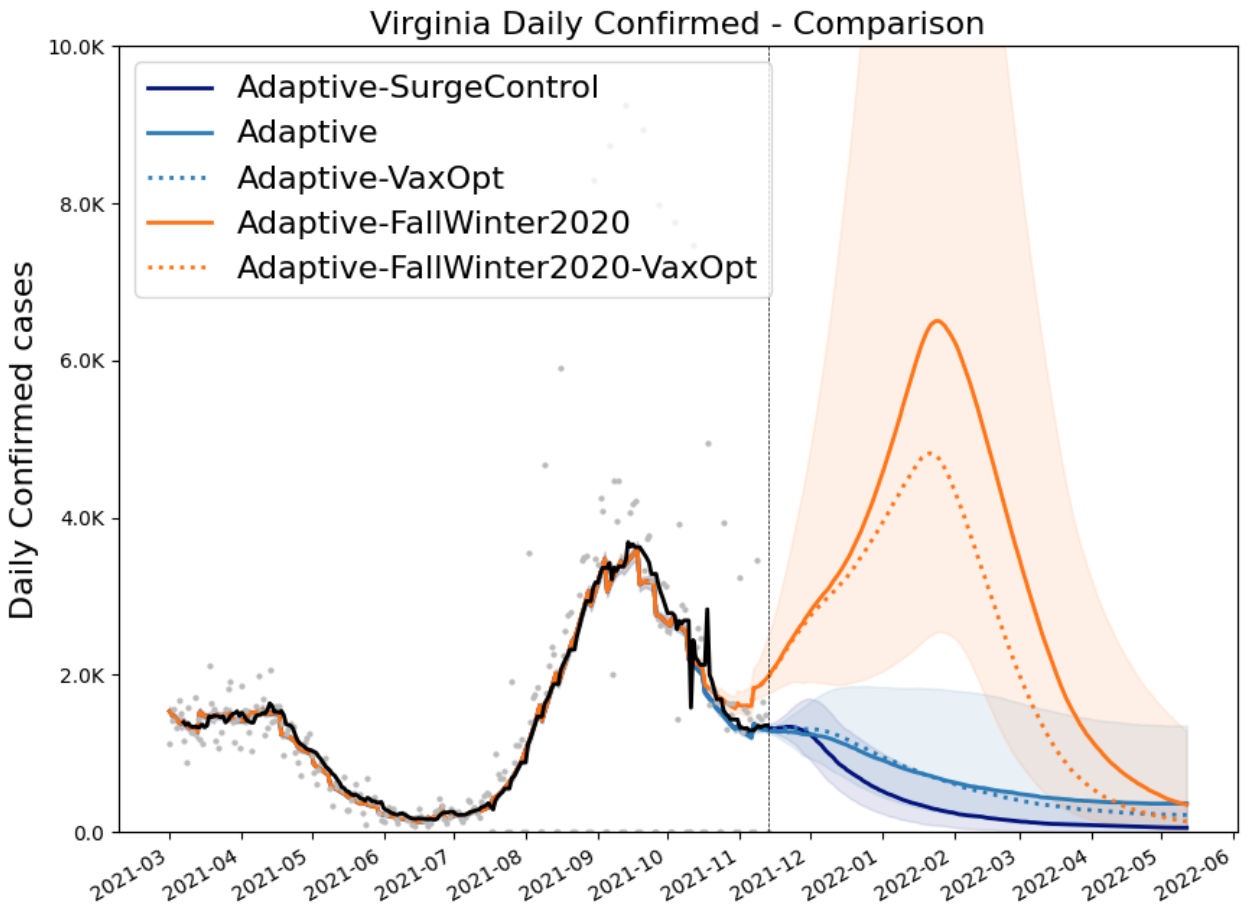

Death ground truth from VDH "Event Date" data, most recent dates are not complete

## Daily Hospitalized

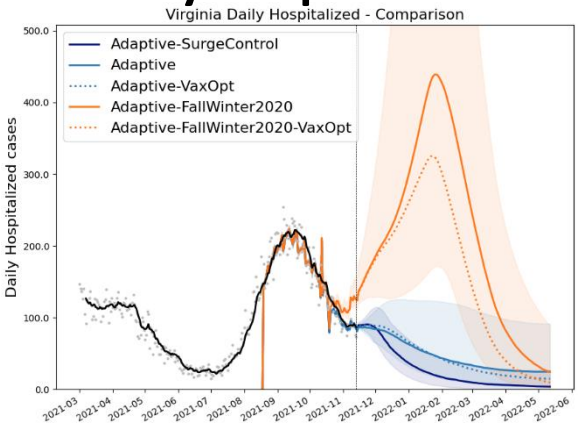


# Outcome Projections – Closer Look

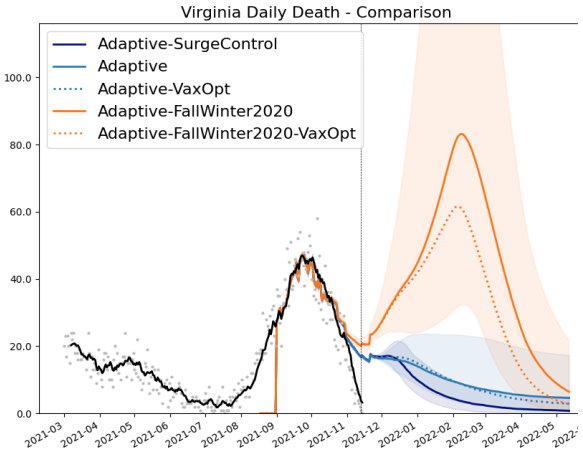
## Confirmed cases




## Daily Hospitalized




## Daily Deaths




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

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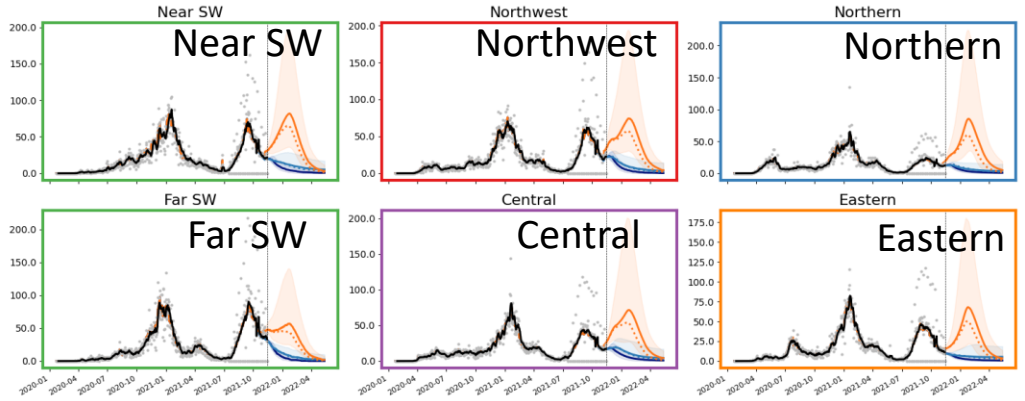
# Detailed Projections: All Scenarios

## Projections by Region



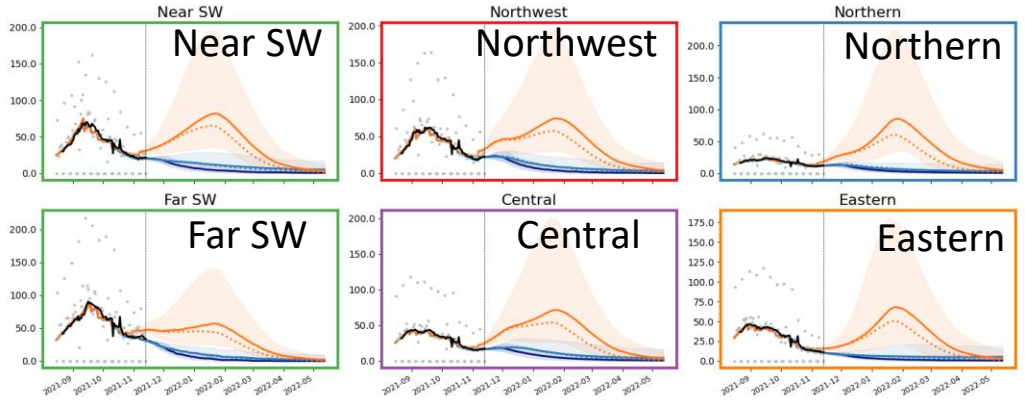

## Projections by District




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

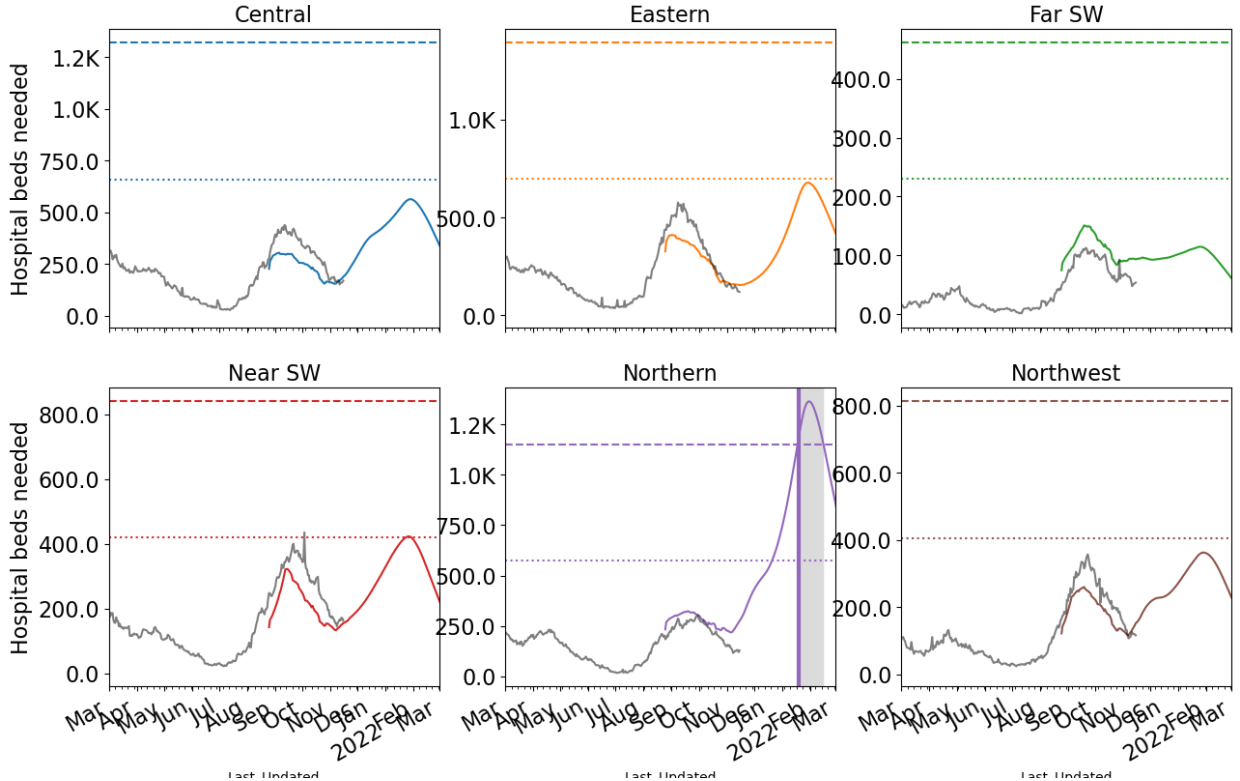


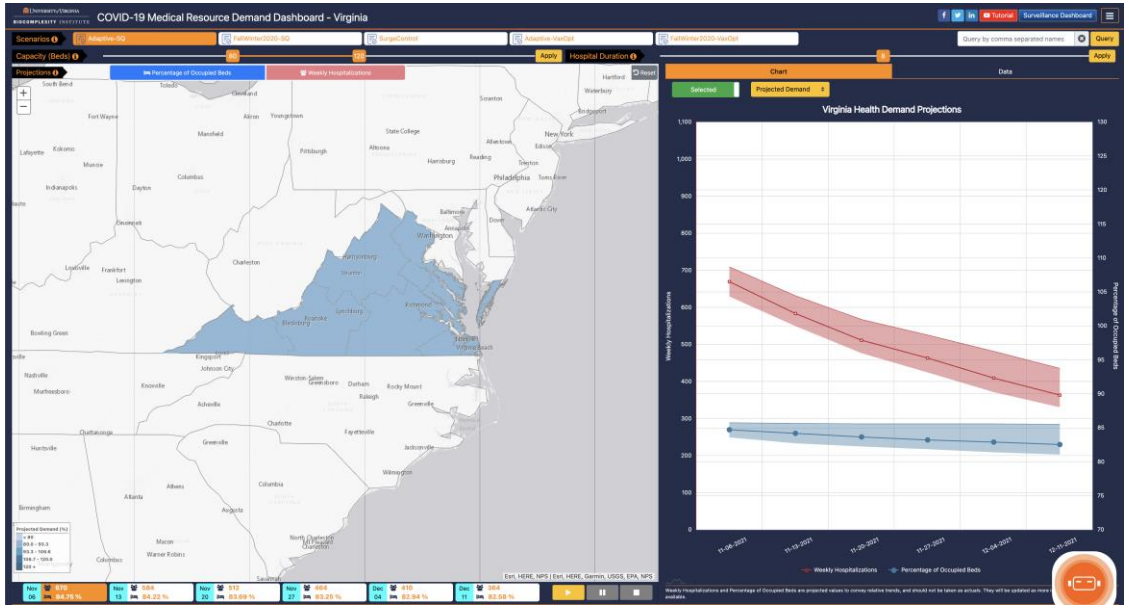

Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

# Hospital Demand and Bed Capacity by Region

**Capacities* by Region – Adaptive FallWinter2020**

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




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

**Adaptive FallWinter2020 scenario shows that even with Delta enhanced severity:**

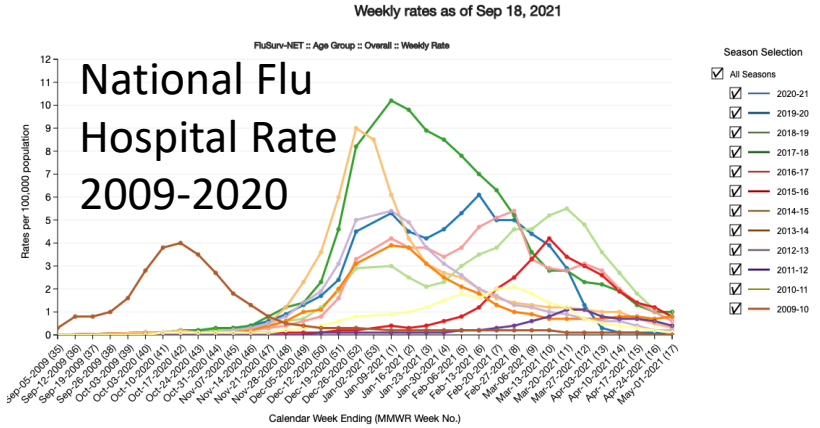
- No regions should exceed their current capacities

* Assumes average length of stay of 8 days

# 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

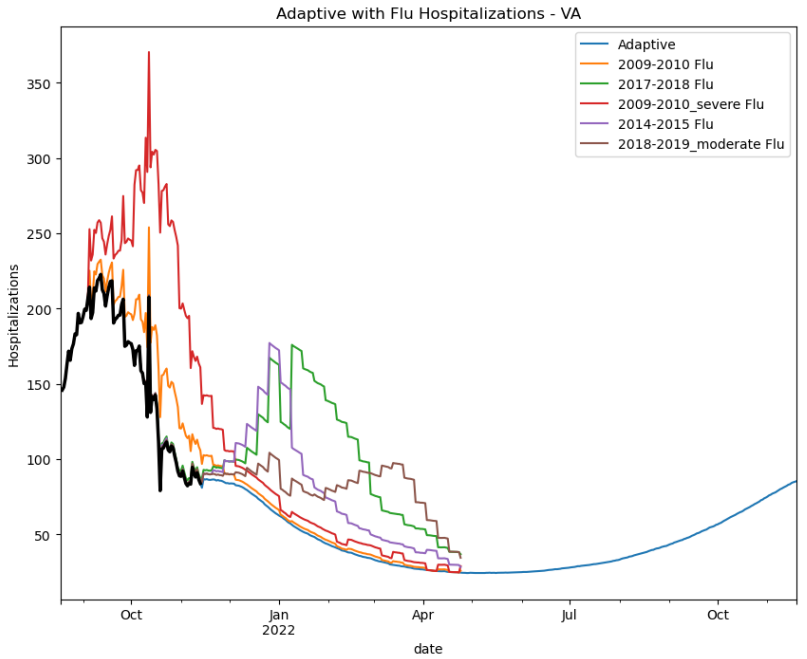
**2017-18** – Timing and severity of 2017-18 season

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

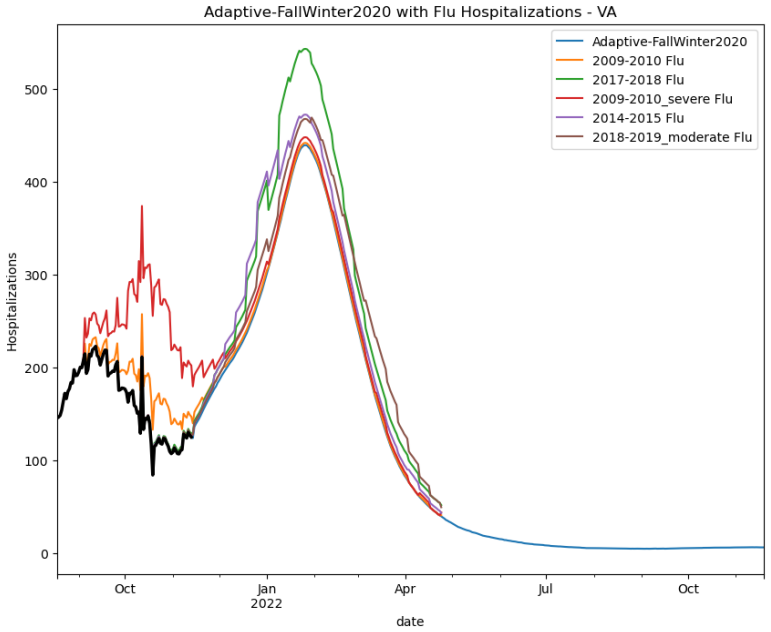
**2014-15** – Timing and severity of 2014-15 season

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

### Adaptive




### Adaptive – FallWinter2020

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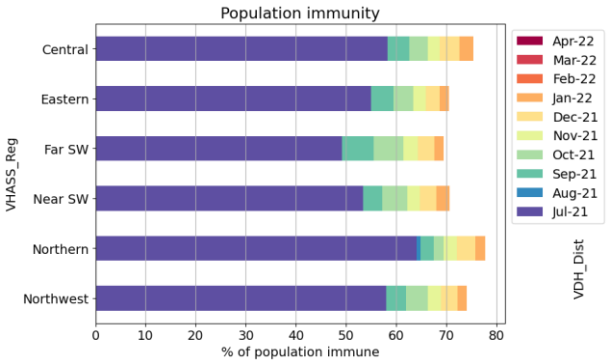
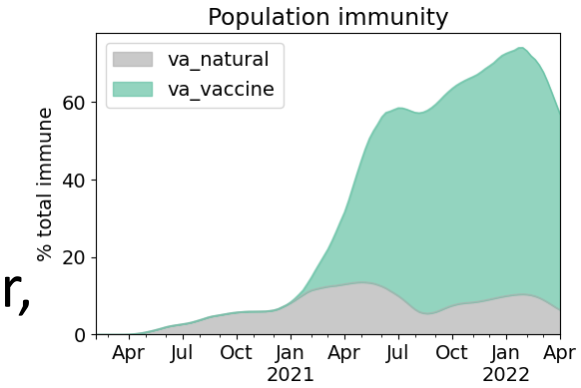
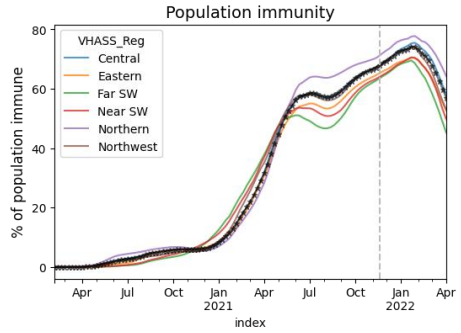
# Virginia's Progress on Population Immunity

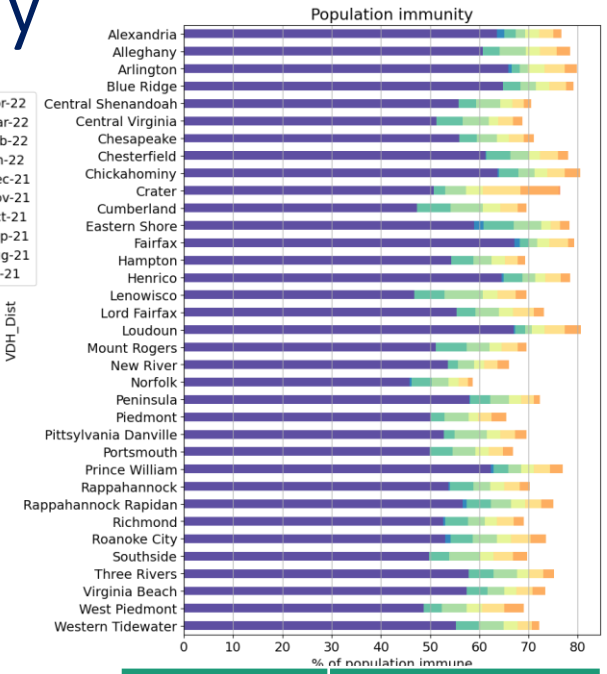
**Natural Immunity and Vaccines combine to produce a population level of immunity**

- 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 | 67% |
| Eastern | 65% |
| Far SW | 63% |
| Near SW | 63% |
| Northern | 70% |
| Northwest | 67% |
| Virginia | 67% |

* As of Nov 14, 2021 for entire population

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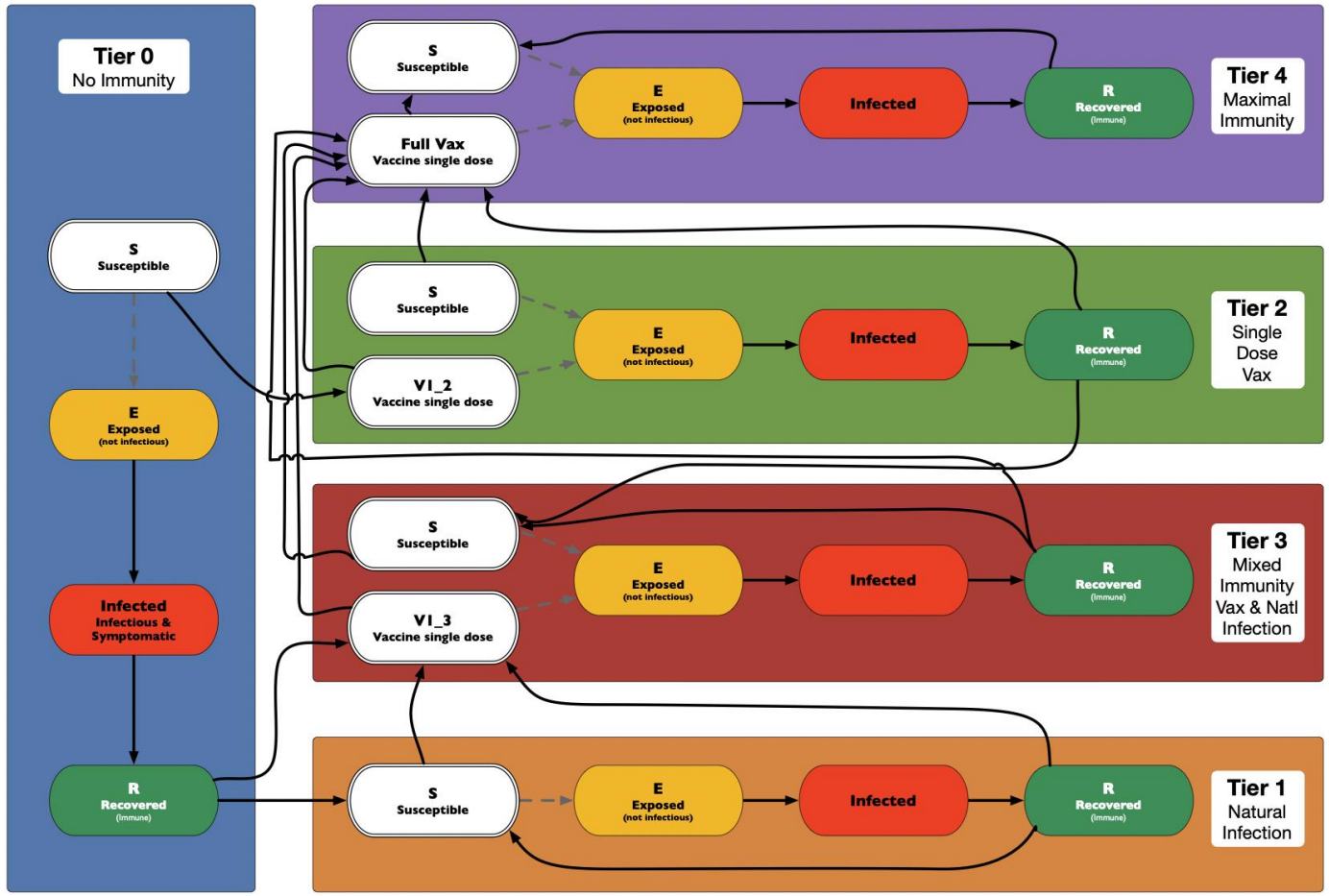
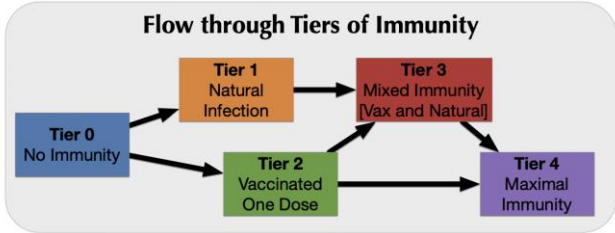
# Preliminary Analysis of Impact of Waning and 3rd doses

**Uncertainty surrounds the rate of waning immunity**

- New model structure built to better track levels and timing of waning
- Outcomes vary based on age and immune history, for partial immunity protection against hospitalization and death is stronger than No Immunity but weaker than Maximal Immunity
- Use same Adaptive fitting approach with vaccine schedules and simulated infections driving movement across the tiers
- Different Scenarios can also be applied



# Preliminary Analysis of Impact of Waning and 3rd doses

**Study to assess impact of waning rate and 3rd dose coverage levels**

**Waning rate**: Duration population remains in an immune state (Vax or Recovered) until becoming susceptible

- Pessimistic: Mean duration 6 months
- Optimistic: Mean duration 1 year

**3rd Dose Coverage**: Proportion of Fully Vaccinated that receive a 3rd dose and return to full protection

- High: 70% coverage
- Low: 40% coverage

| Scenario | Waning Rate | 3rd Dose Coverage |
|---|---|---|
| A: optWan_highBoo | 1 year | 70% |
| B: optWan_lowBoo | 1 year | 40% |
| C: pessWan_highBoo | 6 months | 70% |
| D: pessWan_lowBoo | 6 months | 40% |

**Partial Protection for:**

Optimistic Waning

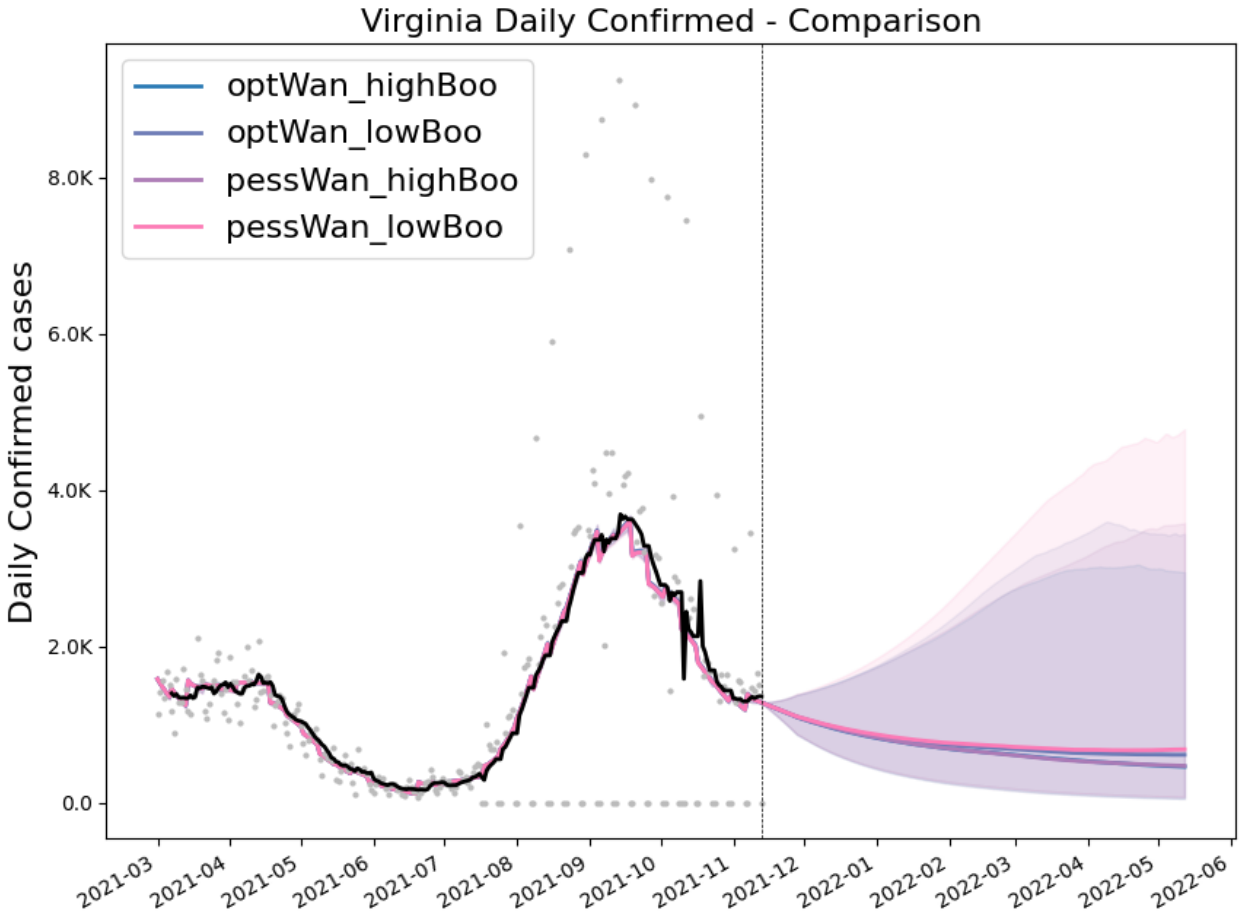
| Protection against | Less than 65 | 65 + |
|---|---|---|
| Infection | 60% | 40% |
| Hospitalization | 90% | 80% |
| Death | 95% | 90% |

Pessimistic Waning

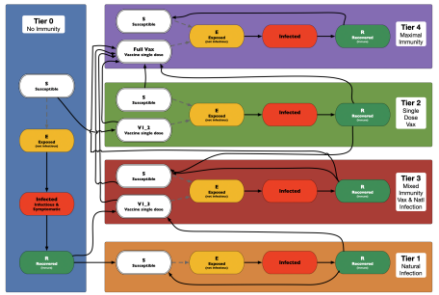
| Protection against | Less than 65 | 65 + |
|---|---|---|
| Infection | 50% | 30% |
| Hospitalization | 80% | 70% |
| Death | 90% | 85% |

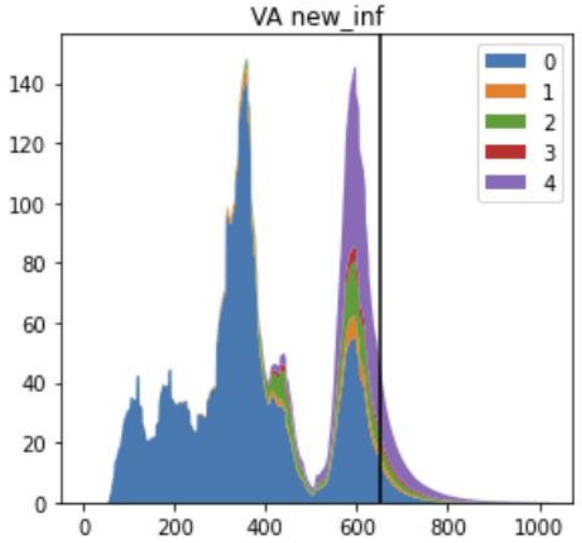
# Preliminary Analysis of Impact of Waning and Boosters

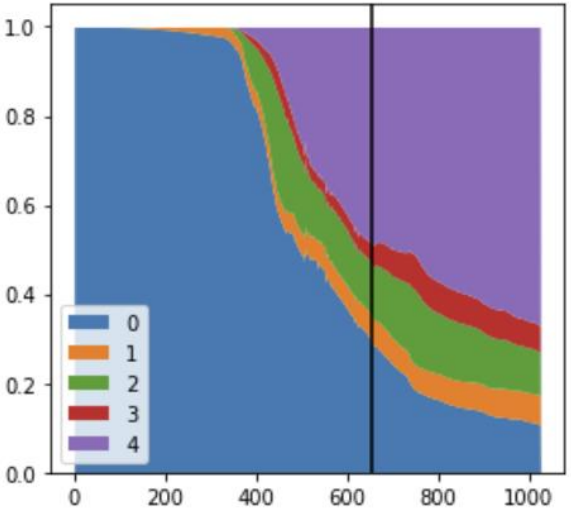
**Confirmed cases**




0: No Immunity
1: Natl Infection
2: Vax 1 dose
3: Vax & Natl Inf
4: Max Immunity





# Key Takeaways

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

- **Case rates in Virginia has levelled off with a mix of activity across the commonwealth**
- VA 7-day mean daily incidence is flat at 15.3/100K from 15/100K; US is up to 26/100K (from 22/100K)
- Projections show a flattening with eventual decline should current low transmission drivers persist
- As seasonal factors mount trajectories should shift towards the FallWinter2020 scenario with near-term growth;  this scenario shows considerable growth is still possible.
- Recent updates:
  - Preliminary analysis of the effects of immune waning, based on overhauled model structure
  - Added 3rd doses to status quo vaccination schedule, with estimated coverage of 40%
  - Analysis to show potential impact of Influenza based on past seasons

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

# Additional Analyses

# Weekly Cases and Hospitalizations

**Weekly confirmed cases**

| Week Ending | Adaptive | Adaptive-VaxOpt | Adaptive-SurgeControl | Adaptive-FallWinter 2020 | Adaptive-FallWinter 2020-VaxOpt |
|---|---|---|---|---|---|
| 11/14/21 | 8866 | 8959 | 8962 | 11482 | 11470 |
| 11/21/21 | 9142 | 9300 | 9334 | 13406 | 13360 |
| 11/28/21 | 8964 | 9210 | 9296 | 15390 | 15246 |
| 12/5/21 | 8848 | 9216 | 9267 | 17717 | 17482 |
| 12/12/21 | 8658 | 9164 | 8510 | 19860 | 19400 |
| 12/19/21 | 8370 | 8908 | 7072 | 21741 | 20937 |
| 12/26/21 | 7824 | 8348 | 5716 | 23901 | 22504 |
| 1/2/2022 | 7186 | 7646 | 4728 | 26836 | 24492 |
| 1/9/2022 | 6570 | 6914 | 3876 | 30612 | 26768 |
| 1/16/2022 | 6015 | 6276 | 3226 | 35079 | 29250 |
| 1/23/2022 | 5498 | 5676 | 2684 | 40000 | 31730 |
| 1/30/2022 | 5110 | 5113 | 2270 | 44242 | 33500 |
| 2/6/2022 | 4694 | 4634 | 1914 | 45168 | 32704 |
| 2/13/2022 | 4340 | 4136 | 1626 | 42762 | 29448 |

**Weekly Hospitalizations**

| Week Ending | Adaptive | Adaptive-VaxOpt | Adaptive-SurgeControl | Adaptive-FallWinter 2020 | Adaptive-FallWinter 2020-VaxOpt |
|---|---|---|---|---|---|
| 11/14/21 | 616 | 626 | 628 | 884 | 881 |
| 11/21/21 | 606 | 622 | 626 | 1017 | 1008 |
| 11/28/21 | 600 | 623 | 629 | 1175 | 1160 |
| 12/5/21 | 586 | 619 | 586 | 1321 | 1293 |
| 12/12/21 | 569 | 605 | 492 | 1449 | 1400 |
| 12/19/21 | 534 | 570 | 397 | 1590 | 1503 |
| 12/26/21 | 492 | 523 | 328 | 1780 | 1633 |
| 1/2/2022 | 449 | 473 | 269 | 2027 | 526 |
| 1/9/2022 | 412 | 430 | 224 | 2323 | 1950 |
| 1/16/2022 | 376 | 388 | 186 | 2653 | 2120 |
| 1/23/2022 | 349 | 351 | 157 | 2956 | 2253 |
| 1/30/2022 | 321 | 317 | 132 | 3058 | 2228 |
| 2/6/2022 | 296 | 284 | 112 | 2919 | 2025 |
| 2/13/2022 | 275 | 255 | 98 | 2648 | 1748 |

# 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

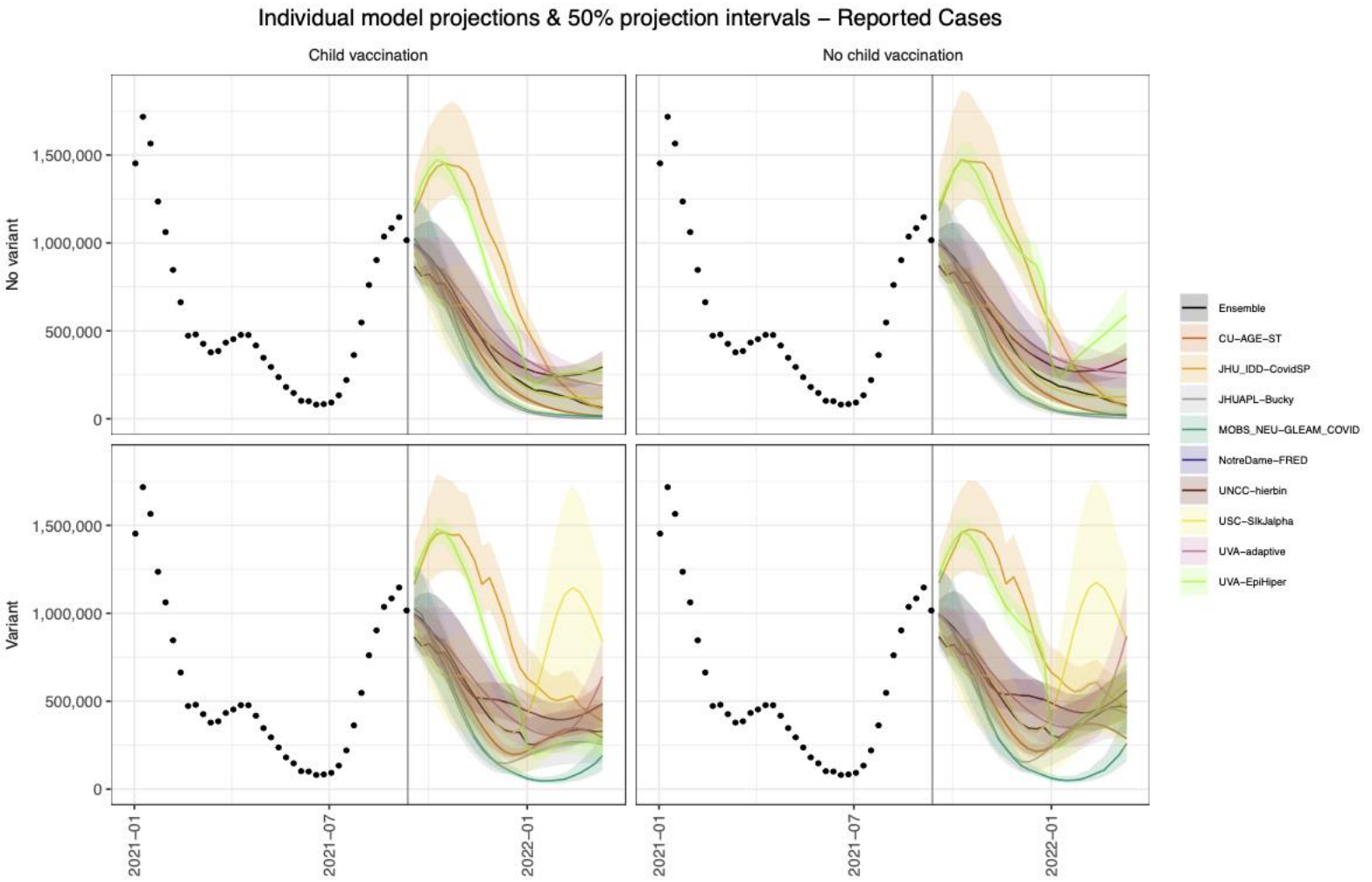
# COVID-19 Scenario Modeling Hub

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 9 released to assist in support of 5-11 vax consideration (ACIP meeting Sept 22-23)
- Rounds 4-8 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 in 5-11 start in Nov**

- Follows same rates as adolescents

**Emerging Variant Impact** (5% prevalence on Nov 15)

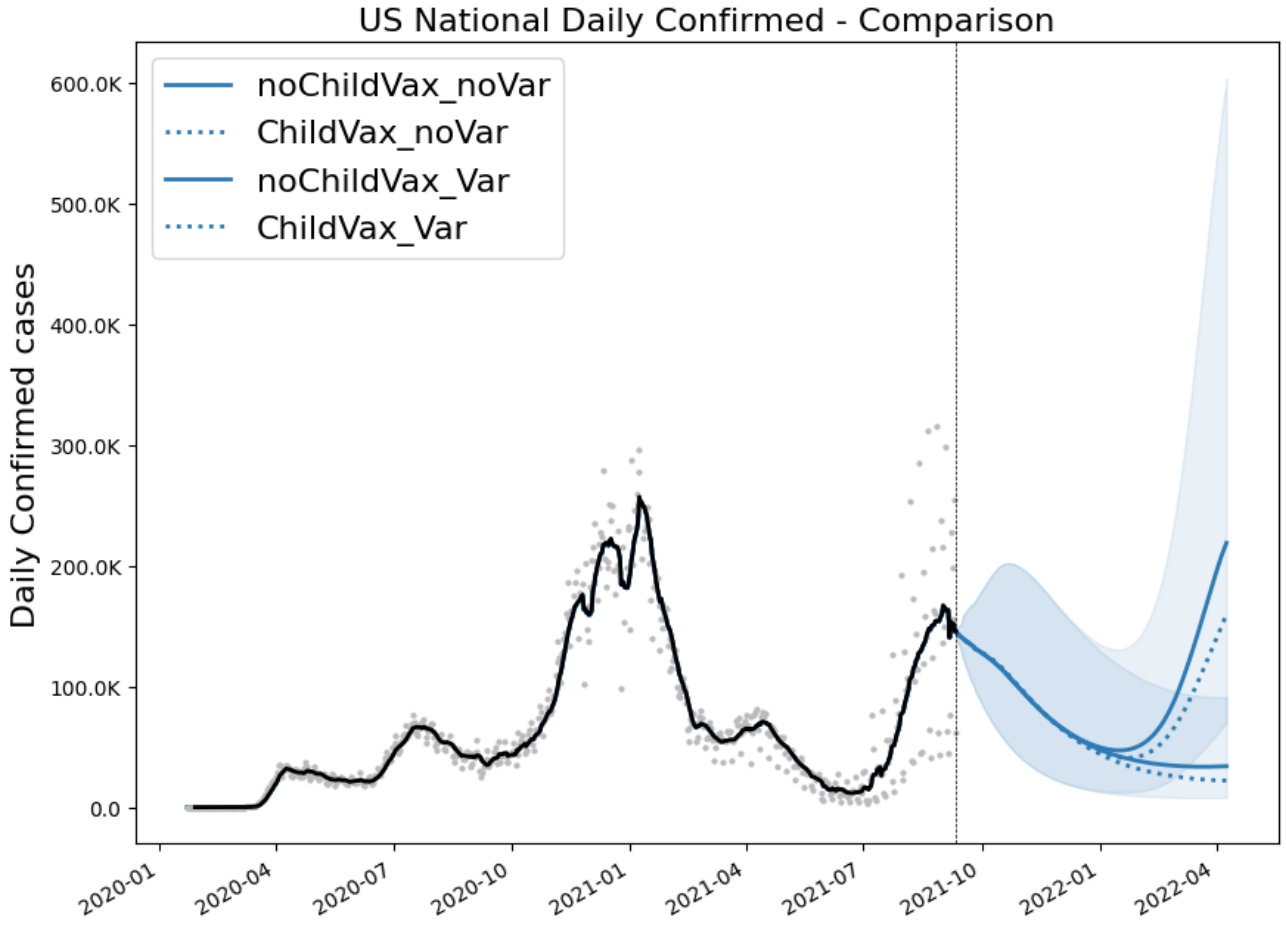
- 50% boost as it eventually predominates

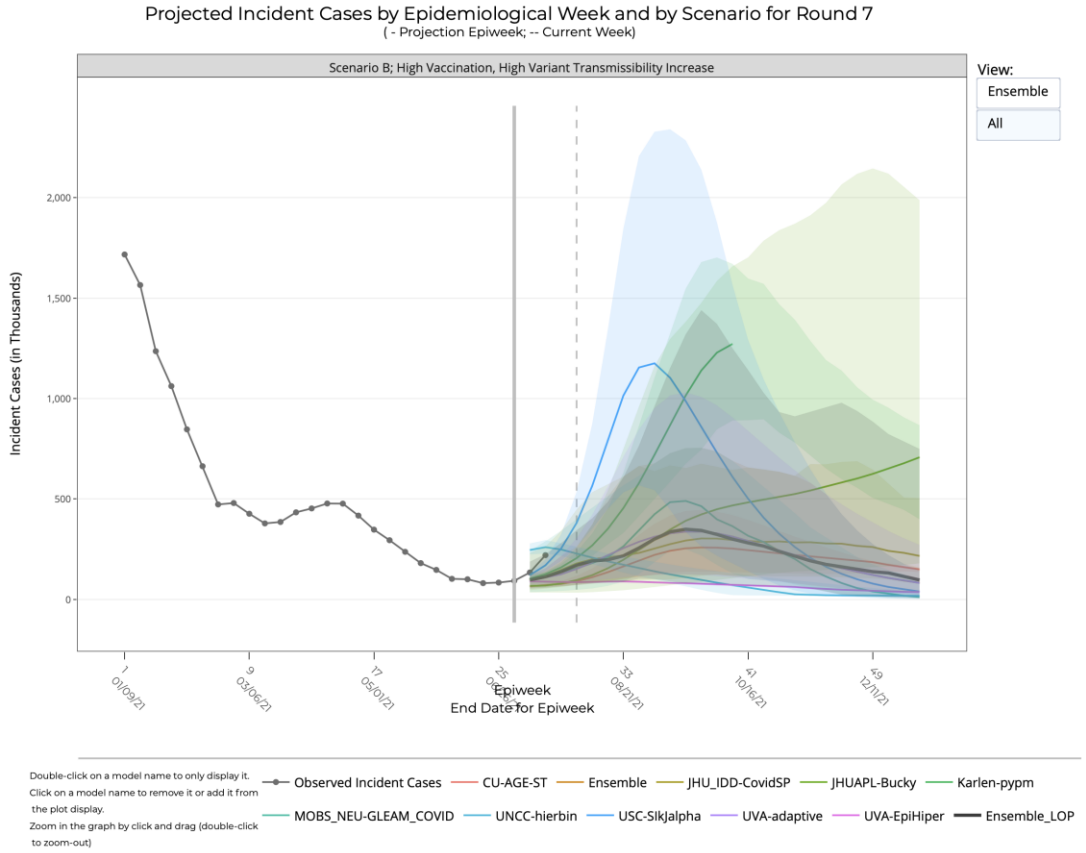
We consider a 2x2 scenario design, where childhood vaccination (5-11 years) is on the first axis, and a change in virus transmissibility is on the second axis. The second axis reflects a stress test, illustrating the potential impact of a new variant arising during the projection period:

| | The same mix of variants circulate throughout the projection period. No change in virus transmissibility. | A more transmissible variant emerges, comprising 1% of circulating viruses on **Nov 15**. The new variant is **1.5X** as transmissible as viruses circulating at the beginning of the projection period. |
|---|---|---|
| Vaccination among 5-11yrs is approved and immunization begins on Nov 1. Each state's uptake rate reflects the percent coverage increases observed for 12-17-year-olds since distribution began on May 13. | A | C |
| No vaccination for children under 12 | B | D |

https://covid19scenariomodelinghub.org/viz.html

# Modeling Hub – Round 9 Prelim Results

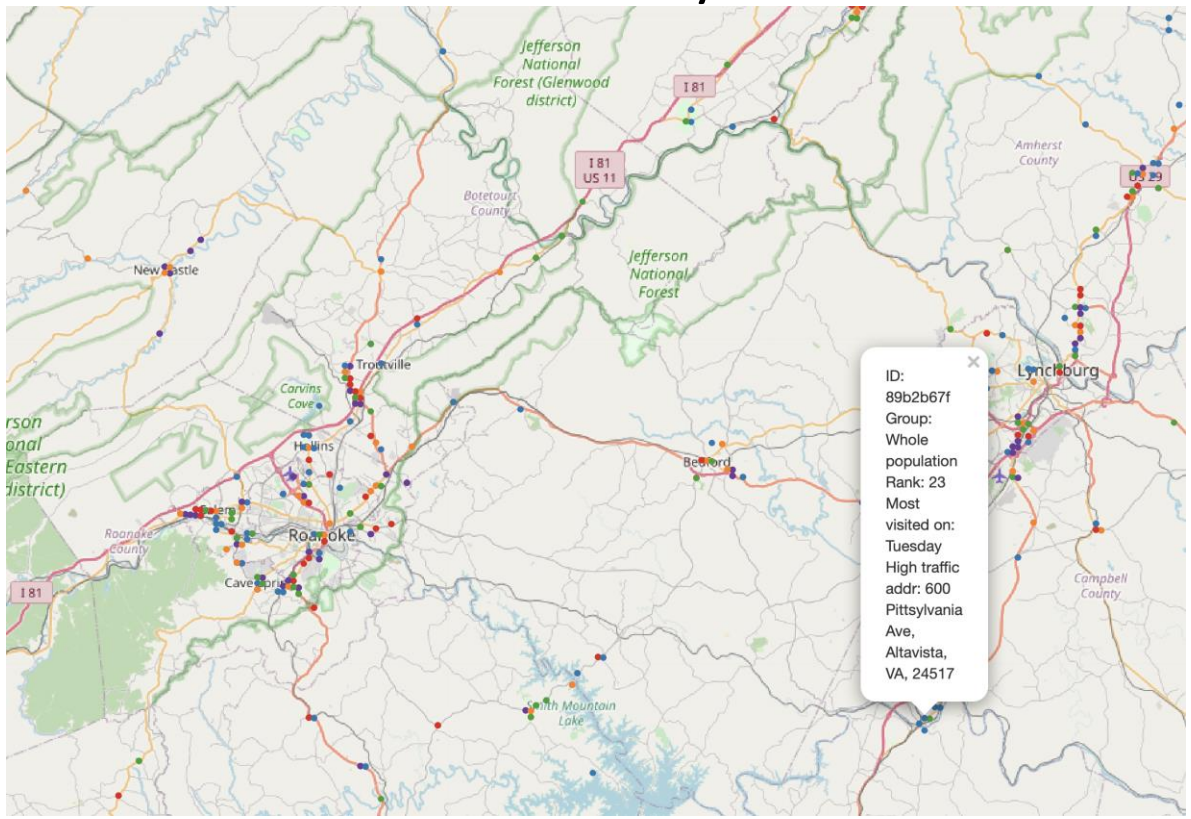



https://covid19scenariomodelinghub.org/viz.html

# 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

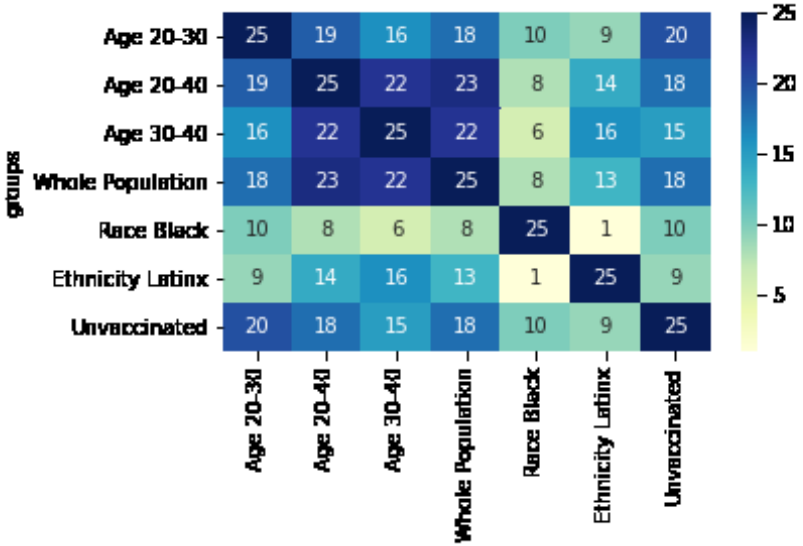
**Goal:** Provide frequently visited locations based on populations and vaccination levels one desires to reach

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

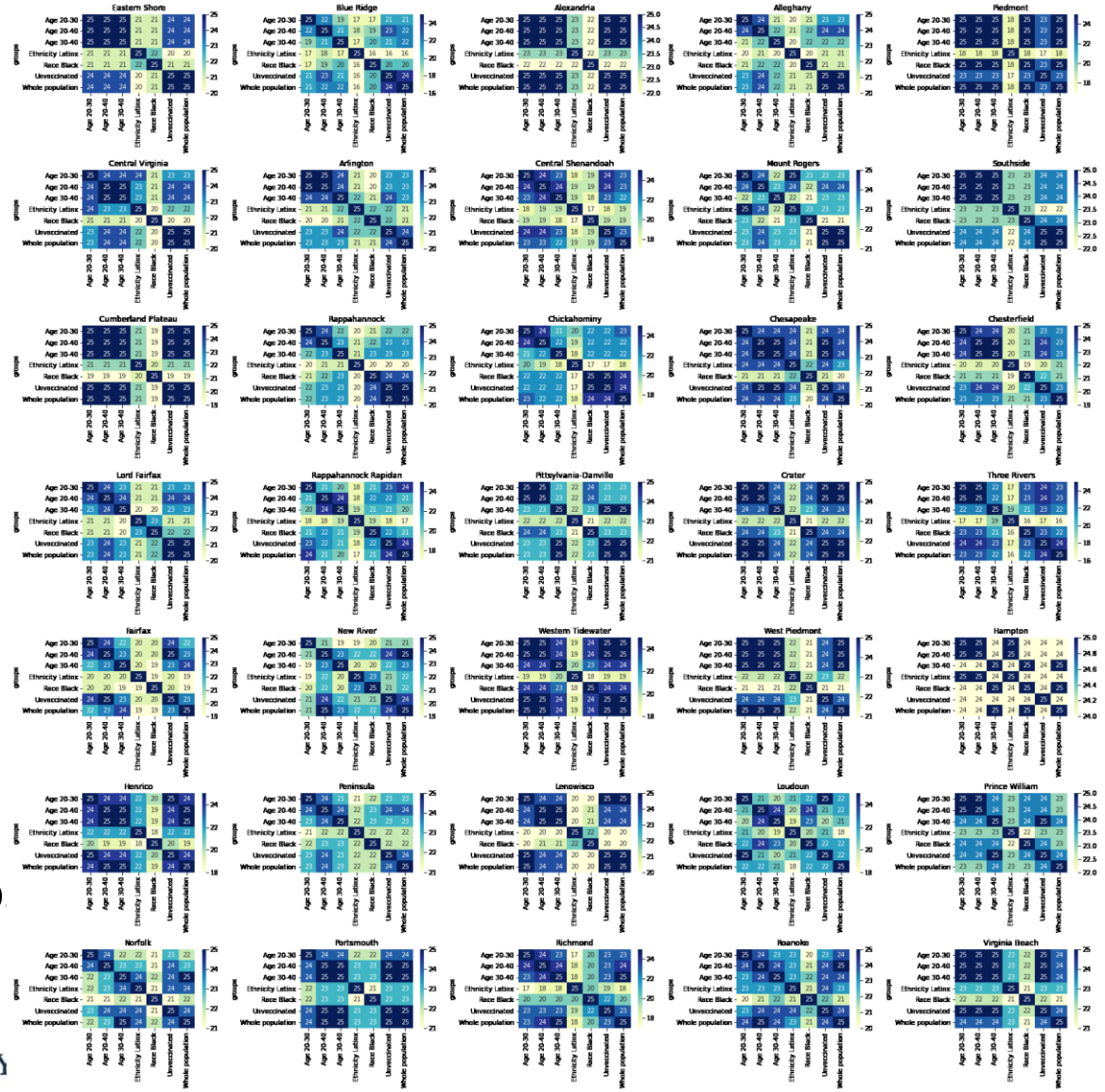
# Data Recommended Mobile Vax Clinic Sites

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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# References


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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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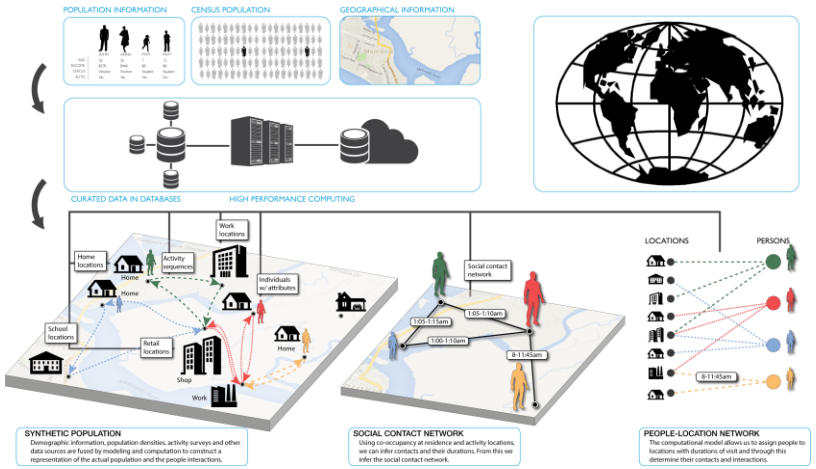
# Supplemental Slides

# Agent-based Model (ABM )

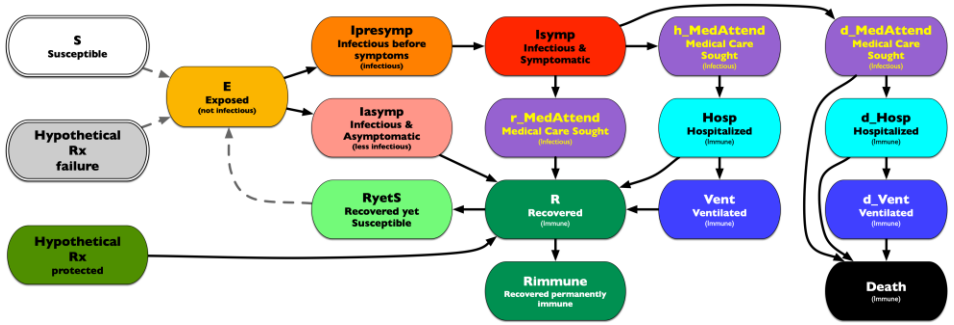
**EpiHiper: Distributed network-based stochastic disease transmission simulations**

- 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