Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

February 3rd, 2021

(data current to February 1st-2nd)

Biocomplexity Institute Technical report: TR 2021-015

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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:

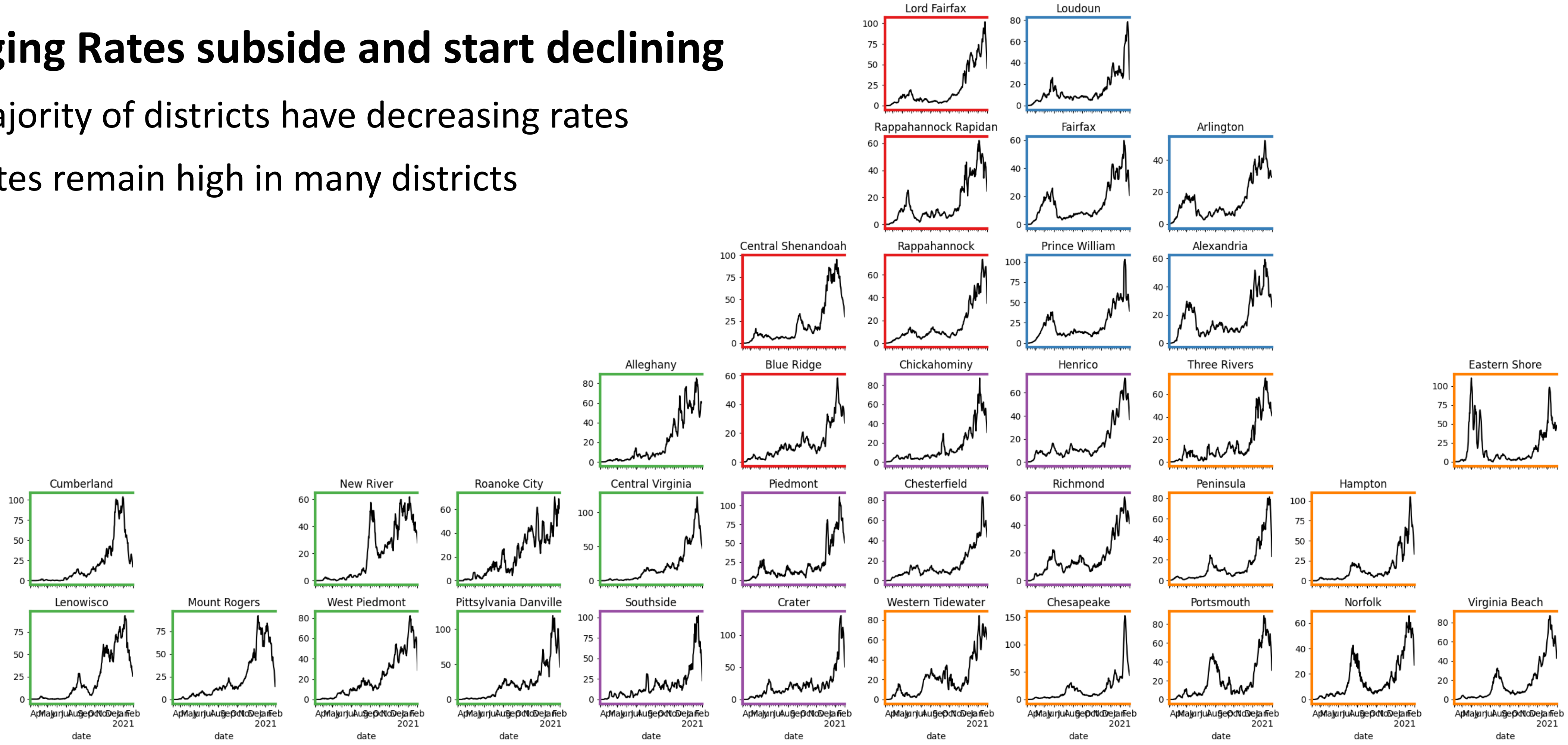
- **Case rate growth in Virginia continues to decline**
- VA mean weekly incidence down sharply 45/100K from 54/100K, as national levels continued to decline (to 37/100K from 45/100K)
- Projections are mixed across commonwealth with declines far outpacing growth
- Recent updates:
  - Scenarios expanded to add impact of transmission boosting from Variant B.1.1.7 to control-based (best of past and fatigued) scenarios
  - Further updates to vaccination schedules, with fitting now down on partially vaccinated population and future vaccinations based on current levels instead of goals
- The situation is changing rapidly. Models will be updated regularly.

Situation Assessment

Case Rate (per 100k) by VDH District

Surging Rates subside and start declining

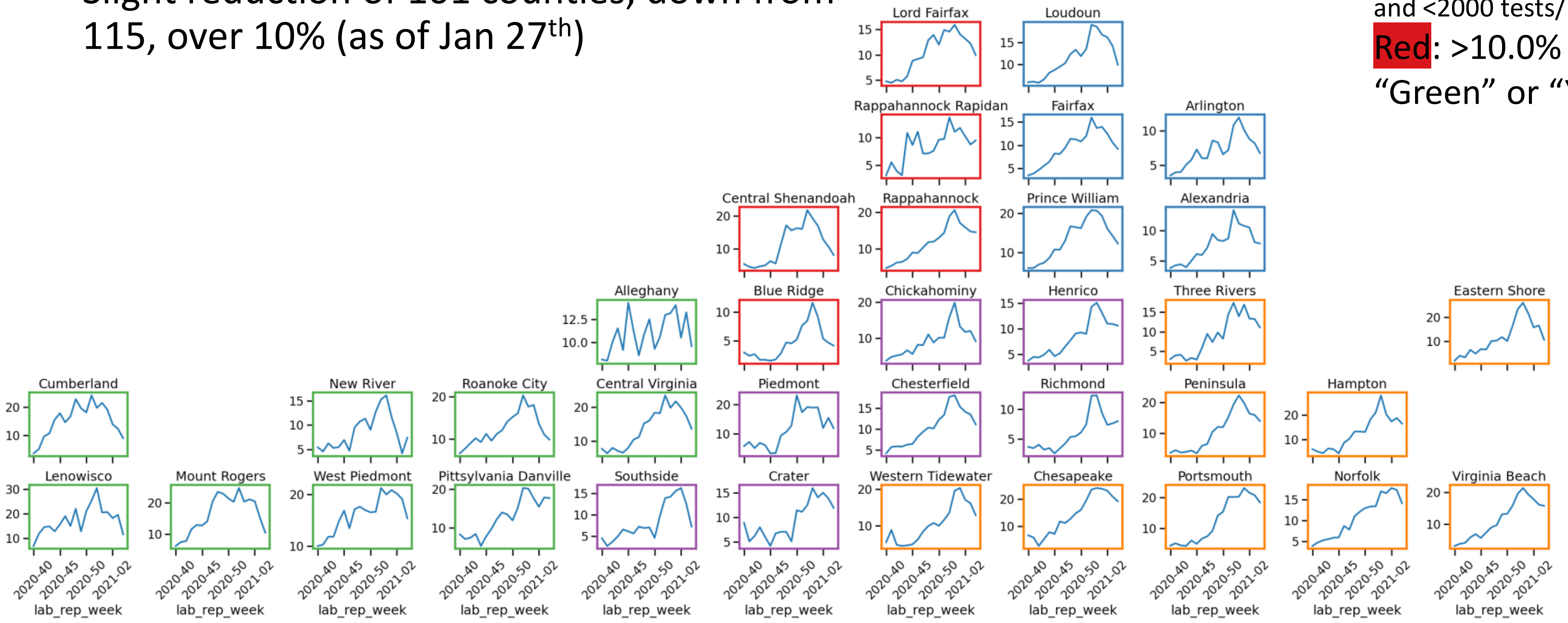
- Majority of districts have decreasing rates
- Rates remain high in many districts



Test Positivity by VDH District

Weekly changes in test positivity by district

- Increasing levels in many districts throughout the commonwealth with many districts above 10% for several weeks
- Slight reduction of 101 counties, down from 115, over 10% (as of Jan 27th)

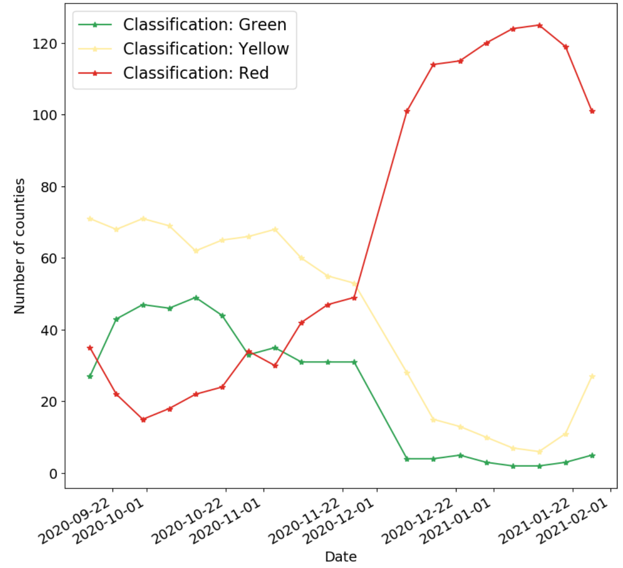


County level test positivity rates for RT-PCR tests.

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

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

Red: >10.0% and not meeting the criteria for "Green" or "Yellow"



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

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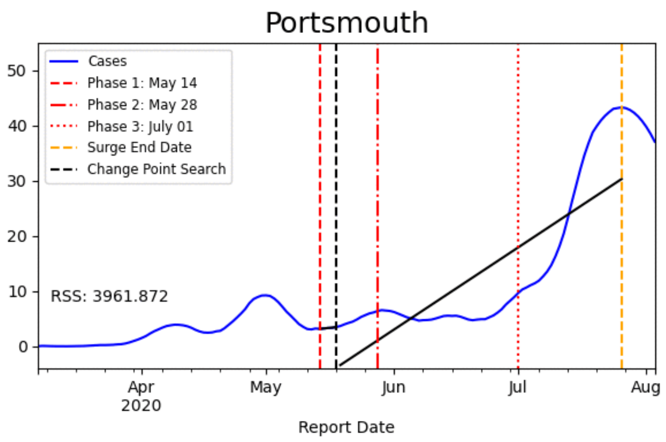
District Trajectories

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

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

Hockey stick fit



Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	29 (20)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	1 (2)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	4 (7)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	1 (6)

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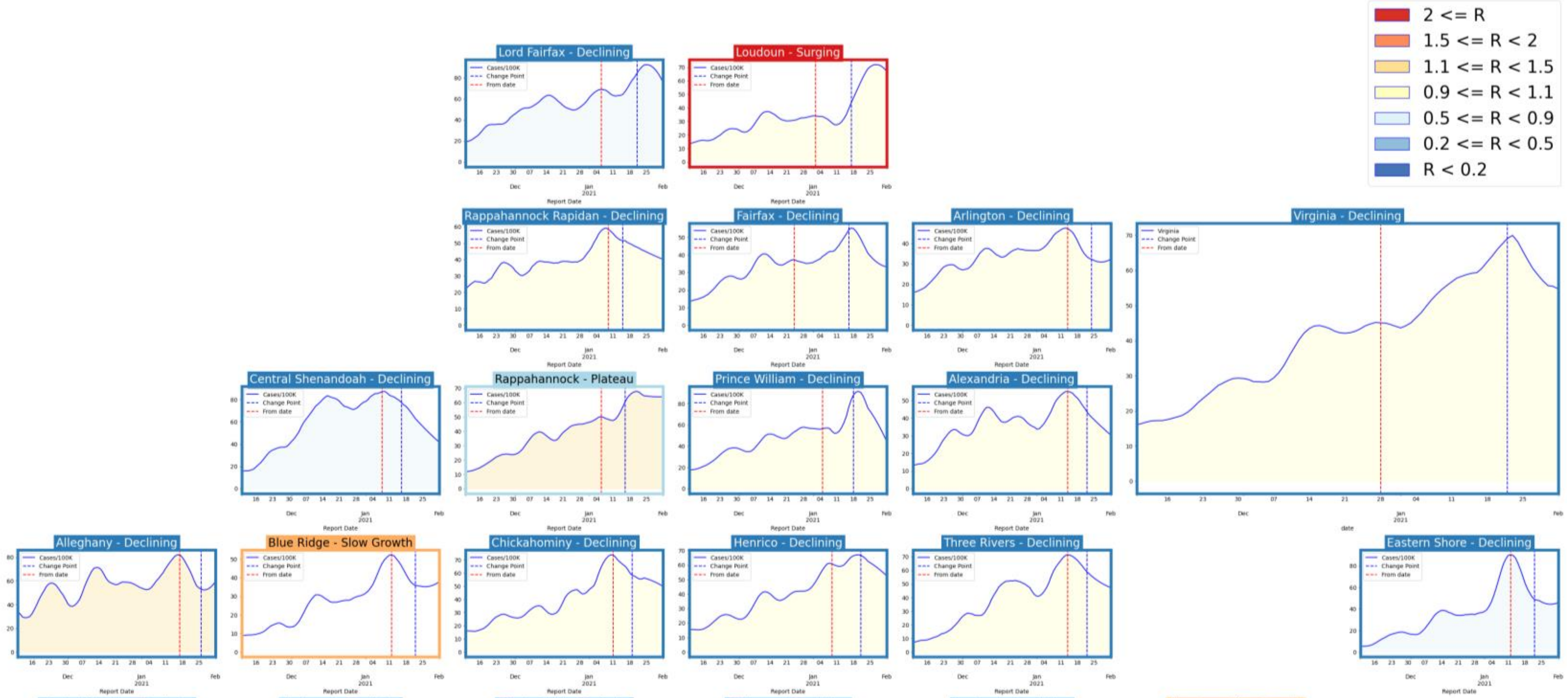
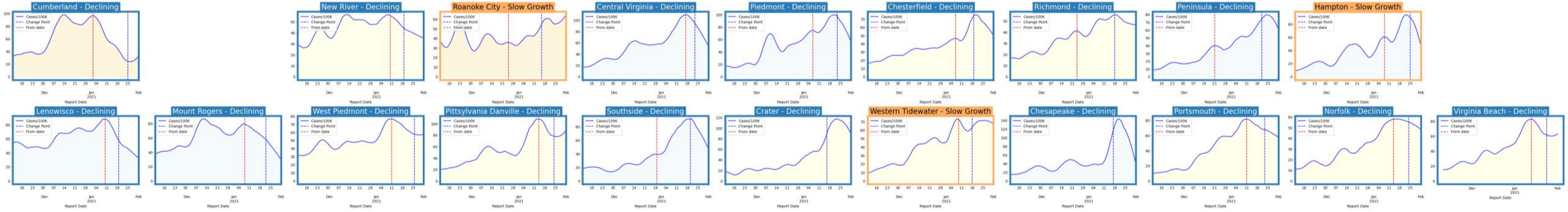
District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	29 (20)
Plateau	1 (2)
Slow Growth	4 (7)
In Surge	1 (6)

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





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Estimating Daily Reproductive Number

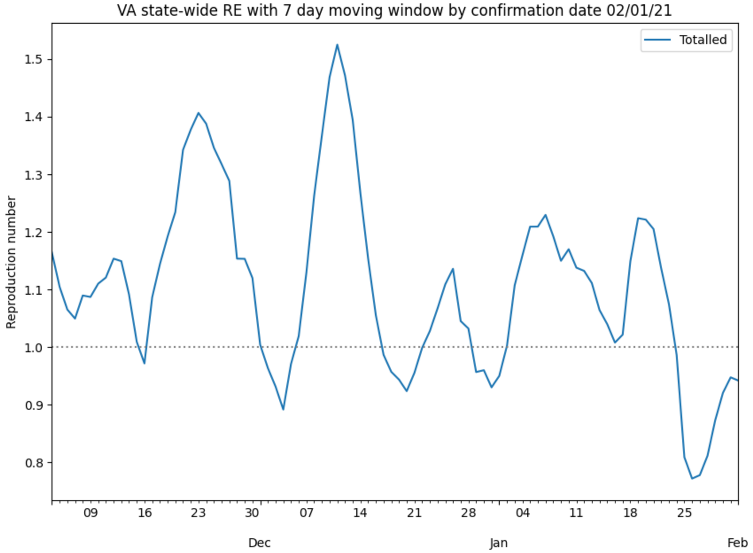
Feb 1st Estimates

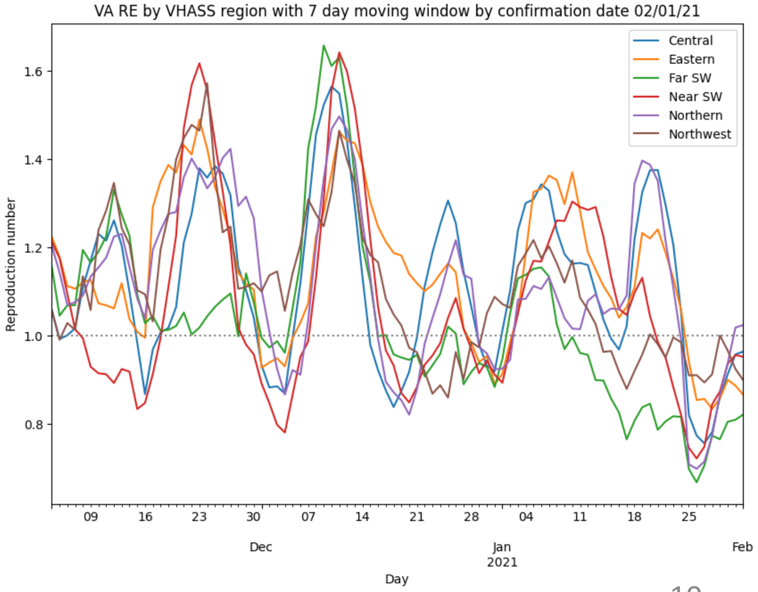
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.942	0.133
Central	0.964	0.144
Eastern	0.866	-0.076
Far SW	0.821	0.123
Near SW	0.952	0.206
Northern	1.024	0.315
Northwest	0.899	-0.011

Methodology

- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: 6 days (2 day std dev)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

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

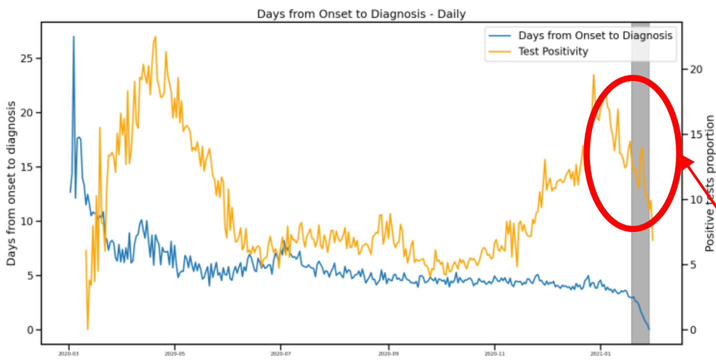




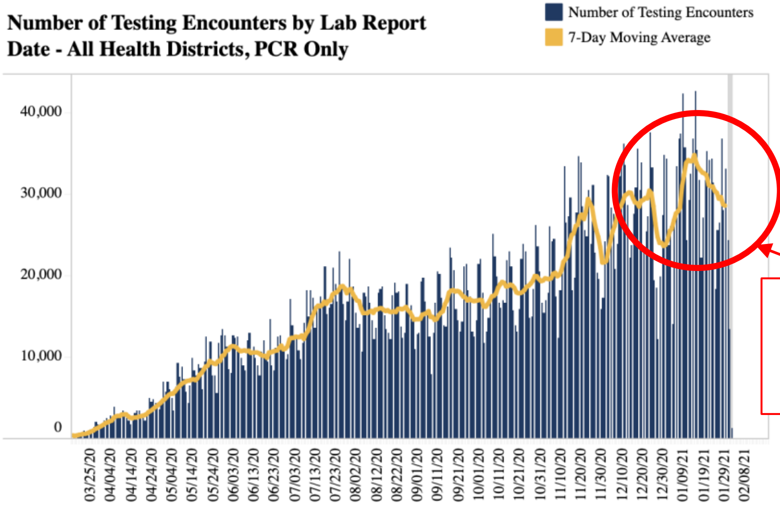
Changes in Case Detection

Timeframe (weeks)	Mean days	% difference from overall mean
May (17-21)	5.7	-20%
June (22-25)	5.8	-19%
July (26-30)	6.2	-13%
Aug (31-34)	5.0	-31%
Sept (35-38)	4.6	-36%
Oct (39-43)	4.5	-37%
Nov (44-47)	4.5	-37%
Dec (48-49)	4.1	-42%
Jan (00-02)	3.8	-47%
Overall (13-01)	7.1	--

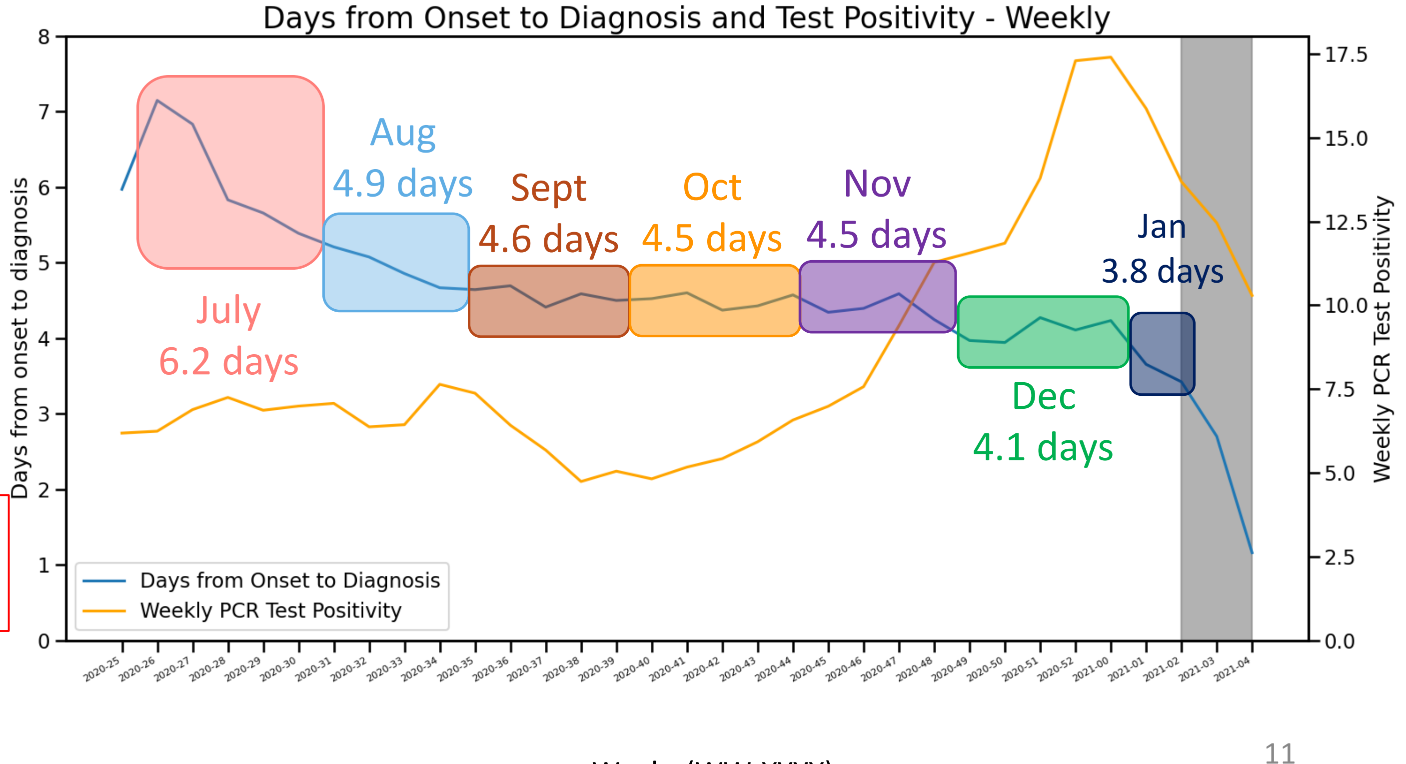
Test positivity vs. Onset to Diagnosis



Positivity remains high but is down overall

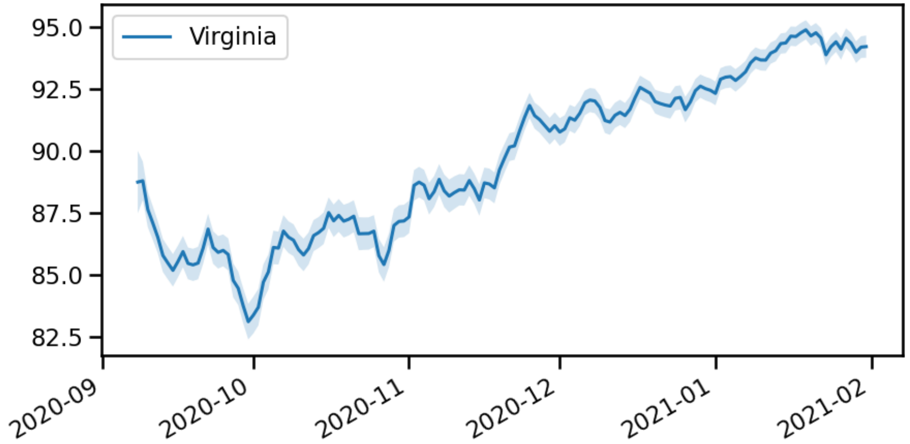


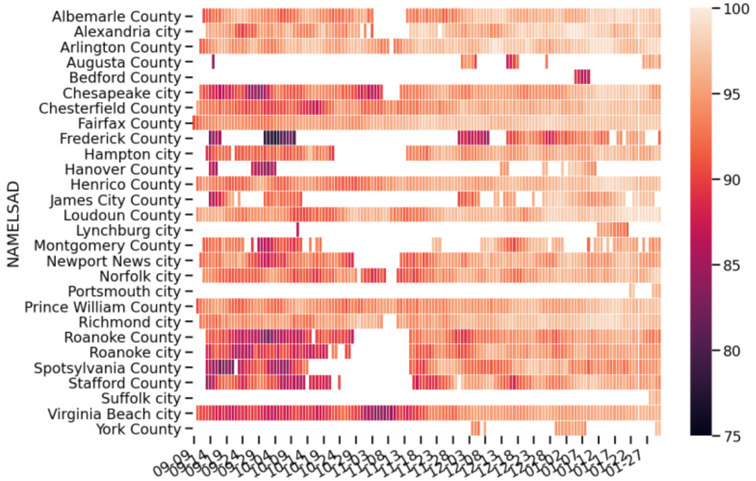
Testing levels continue to slow



Accessed 8:00am February 3, 2021
https://www.vdh.virginia.gov/coronavirus/

Mask usage in Virginia



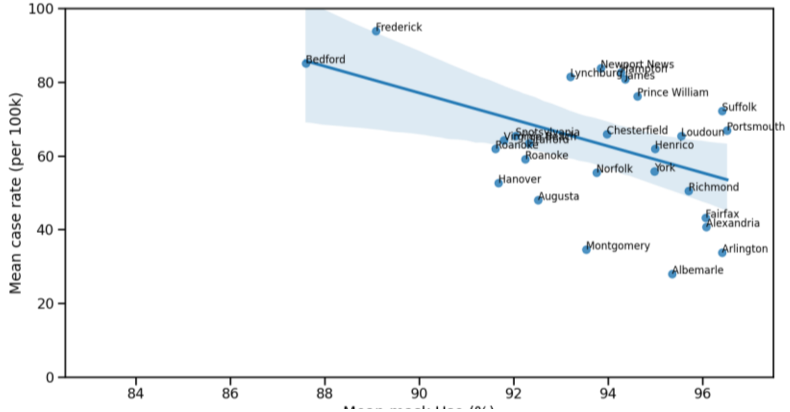


Some county level fluctuations since beginning of Sept., though data quality may be affected by sample sizes

State level mask usage as reported via Facebook surveys has shown steady increase over past three months

- ~88% (early Nov) to ~94% (mid Jan)
- Some variance across the commonwealth
- ~3000 daily responses from VA

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



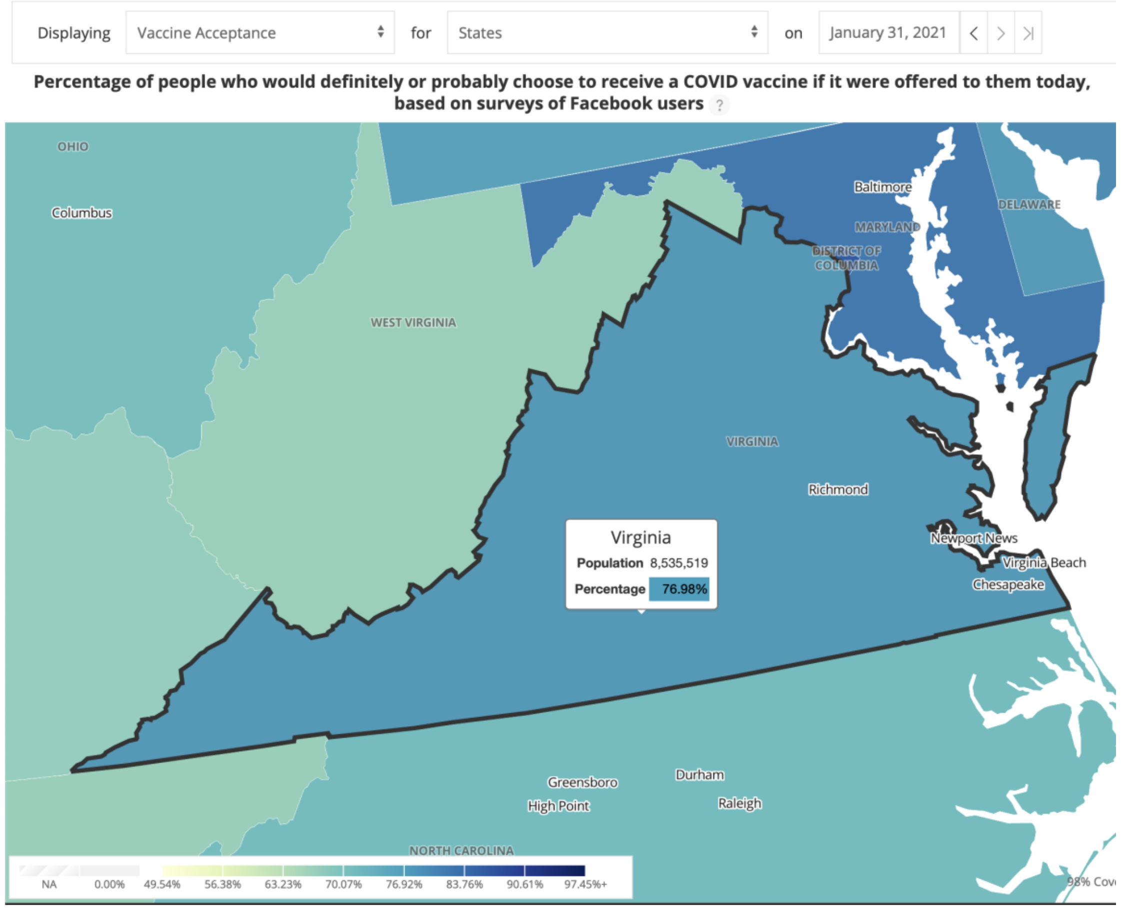
Correlations seen among VA counties between mask use and case rate are now stronger due to surging growth

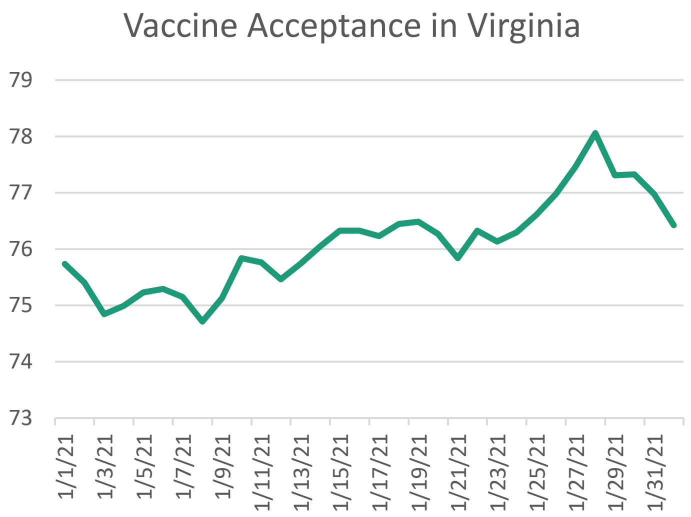
Slope: - 3.6; for every % we see a ~3.5/100K case rate difference

Vaccine Acceptance

Facebook administered survey: Percent of people who would definitely or probably choose to receive a COVID vaccine if offered today

VA typically achieves 50-60% coverage with seasonal influenza vaccine (typically over the course of 3 months)





Acceptance slightly up over the course of January:
Over ¾ of Virginians are likely to choose to be vaccinated

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

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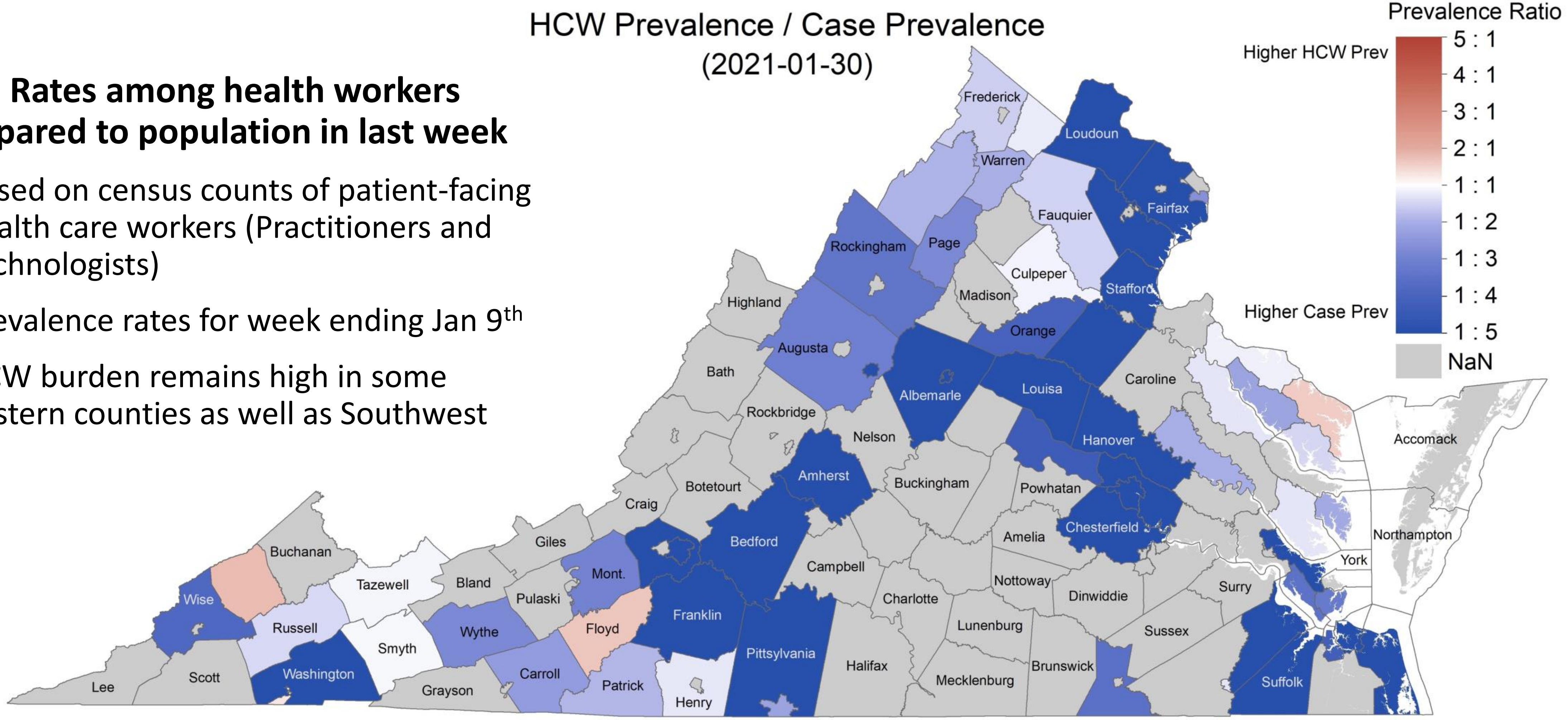
Health Care Worker Prevalence (per 100K)

Case Rates among health workers compared to population in last week

- Based on census counts of patient-facing health care workers (Practitioners and Technologists)
- Prevalence rates for week ending Jan 9th
- HCW burden remains high in some Eastern counties as well as Southwest



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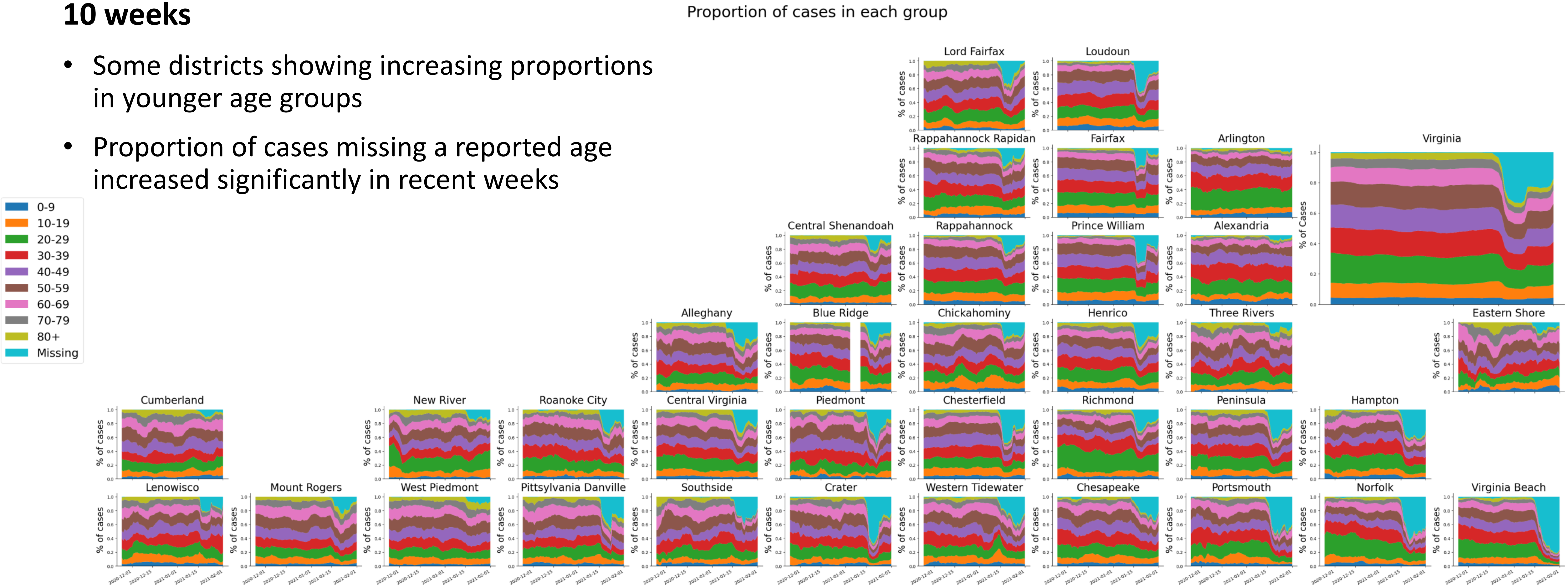
Age-Specific Case Rates

Proportion of cases by age-group for last 10 weeks

- Some districts showing increasing proportions in younger age groups
- Proportion of cases missing a reported age increased significantly in recent weeks



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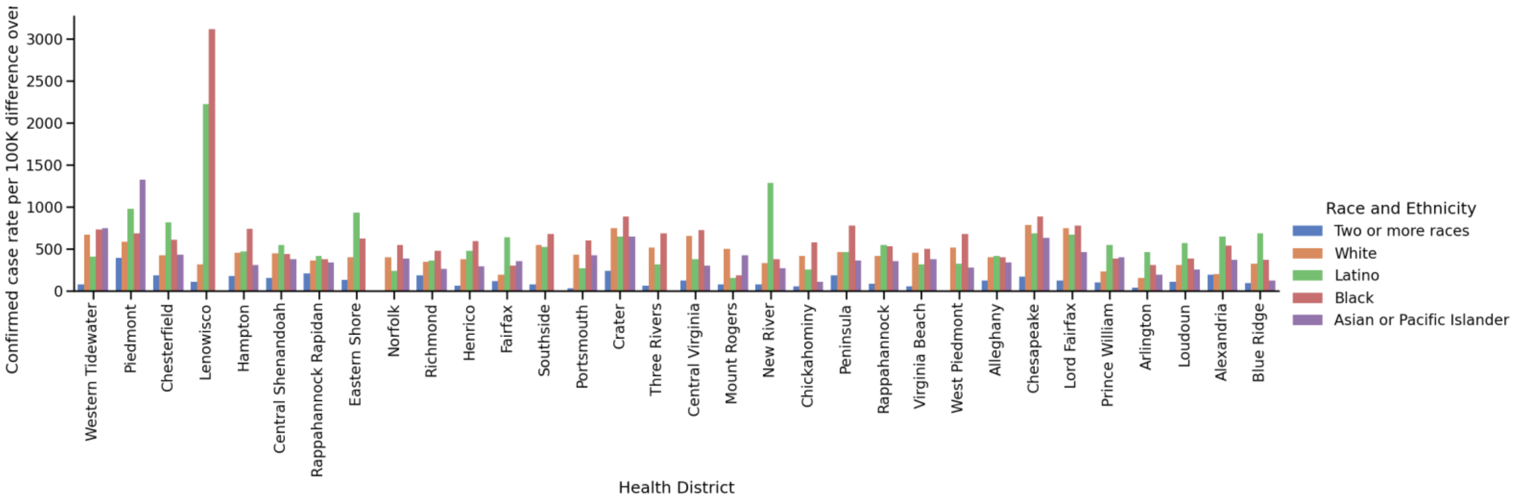
Race and Ethnicity – Recent Rate Changes (per 100K)

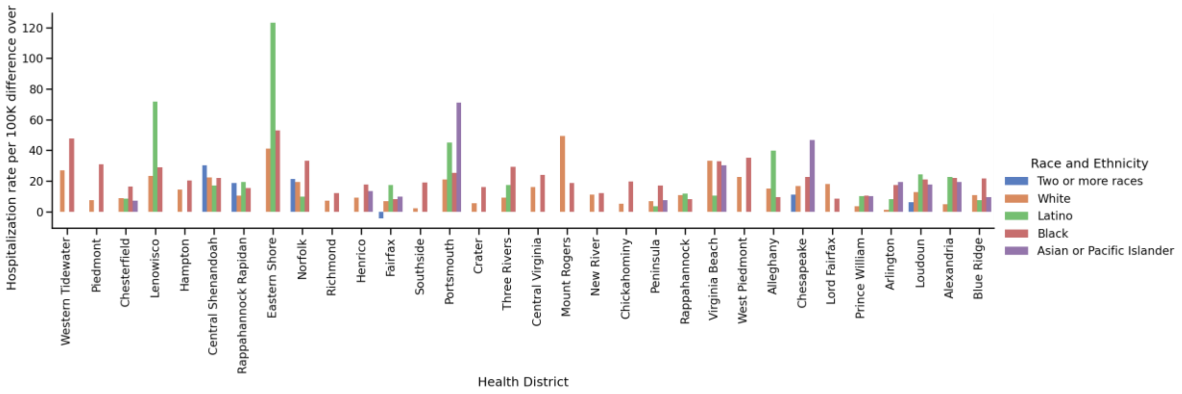
Recent Changes in Race and Ethnicity Rates (per 100k)

- Two week change in population level rates
- Black, Latinx and 2 or more races populations have much higher changes in rates; disparity is more pronounced in some districts than others
- Based on 2019 census race-ethnicity data by county

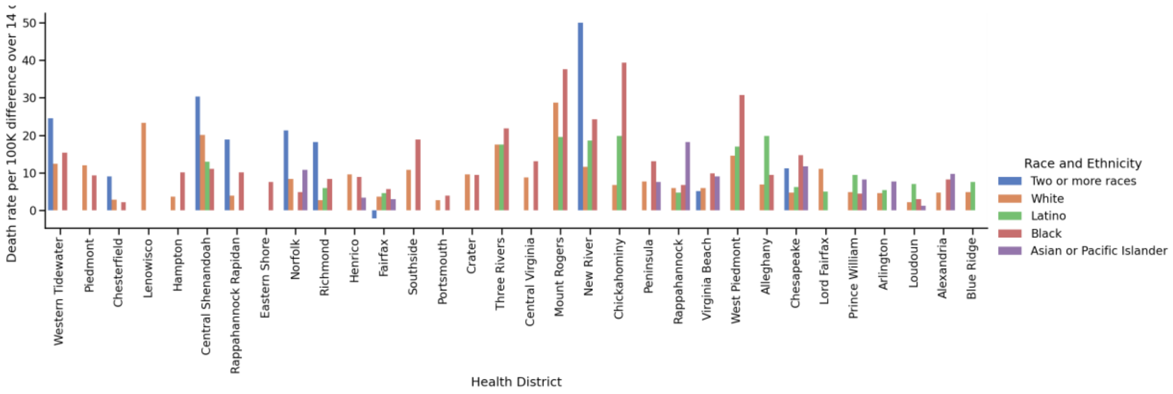
Case Rate



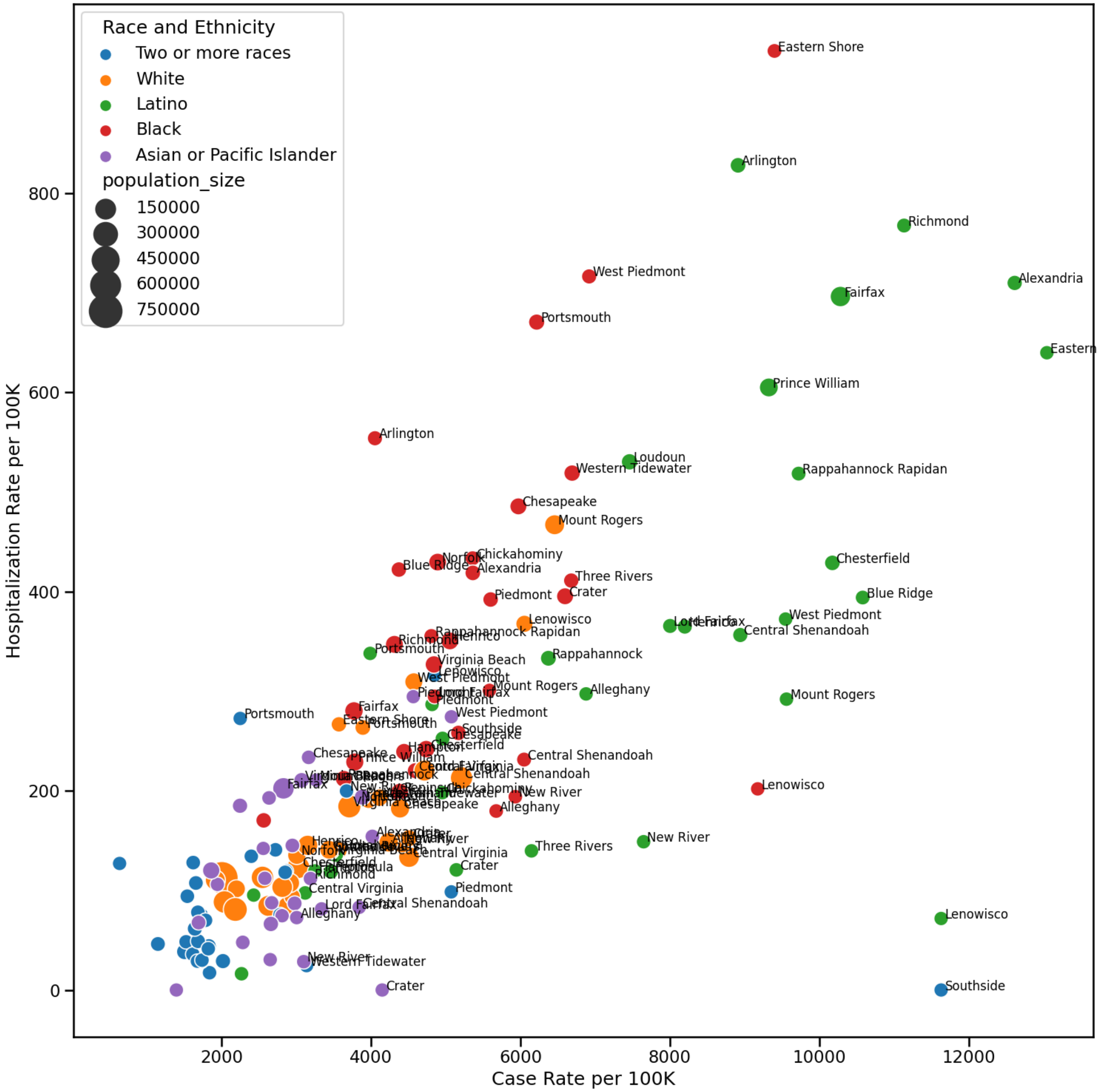
Hospitalization Rate



Death Rate



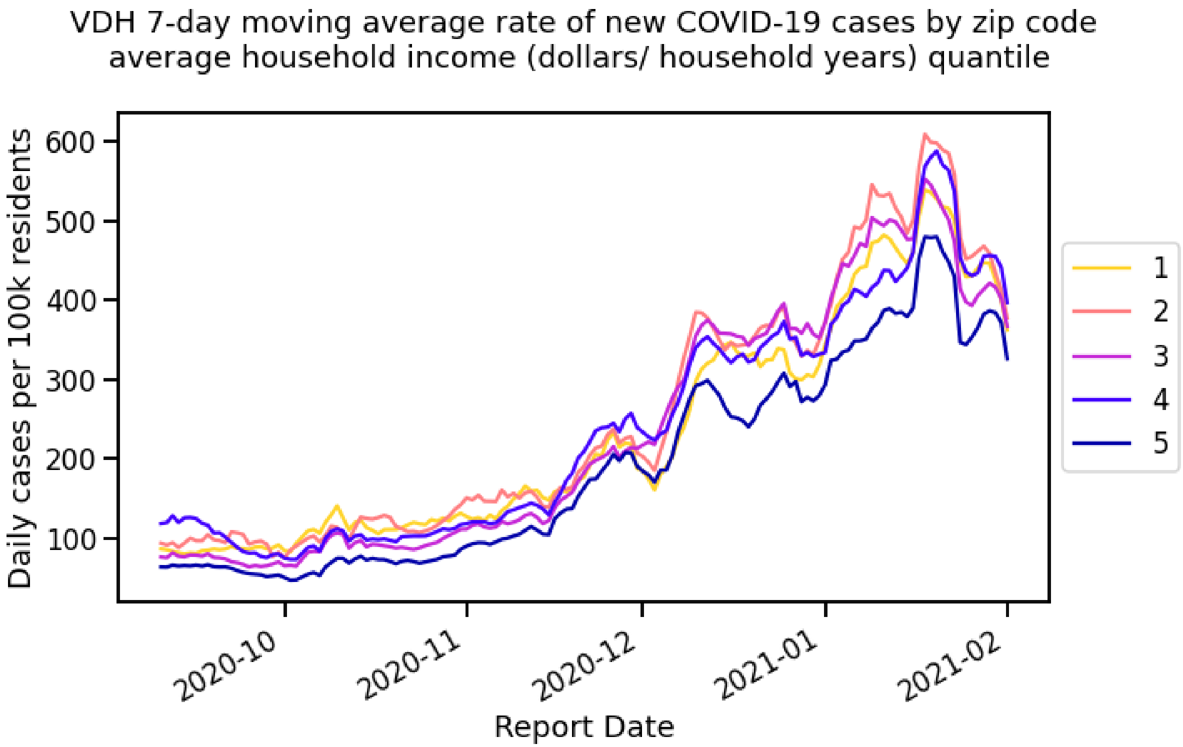
Race and Ethnicity cases per 100K



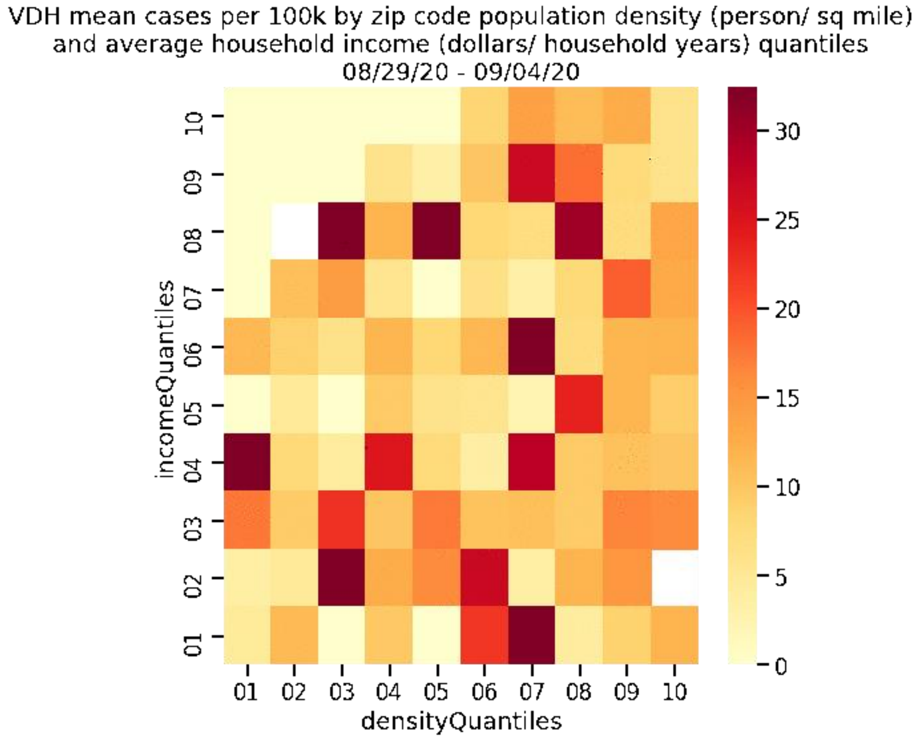
Rates per 100K of each Racial-Ethnic population by Health District

- Each Health District's Racial-Ethnic population is plotted by their Hospitalization and Case Rate
- Points are sized based on their overall population size
- Overlapping labels removed for clarity

Impact across Density and Income



All zip codes show back into growth, wealthiest zip code now lags the rest significantly



Full evolution of pandemic, shows shifts from denser and wealthier zip codes to poorer and less dense zip codes

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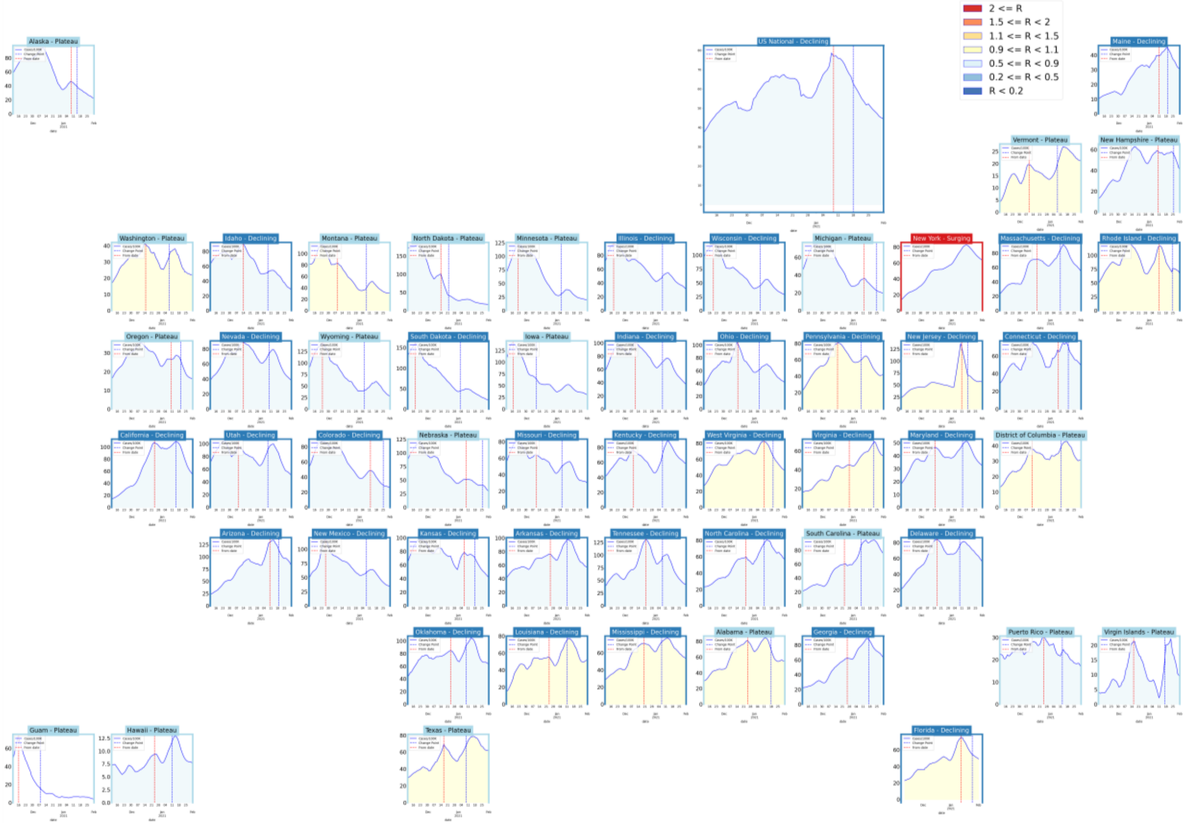
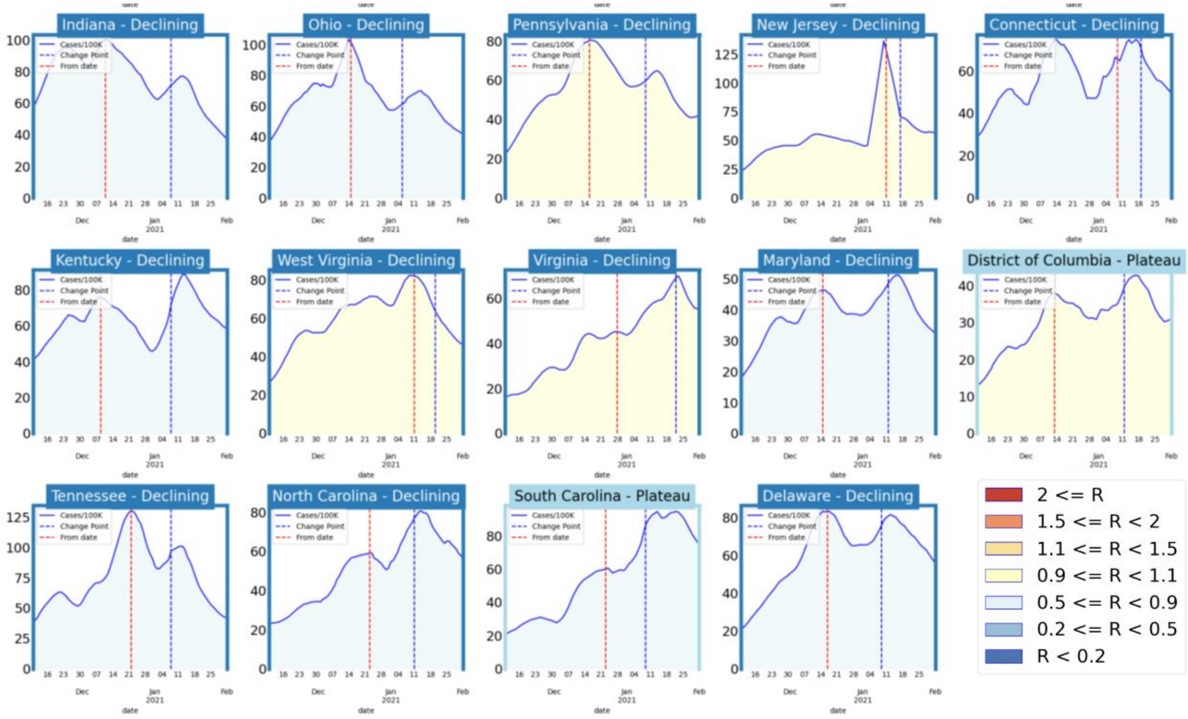
Other State Comparisons

Trajectories of States



- Declining trajectories predominate (33) with most non-declining states having recent downward trends

Virginia and her neighbors



- VA and her neighbors join the rest of the nation with declining or plateaued trajectories.
- Rates remain high in most states however

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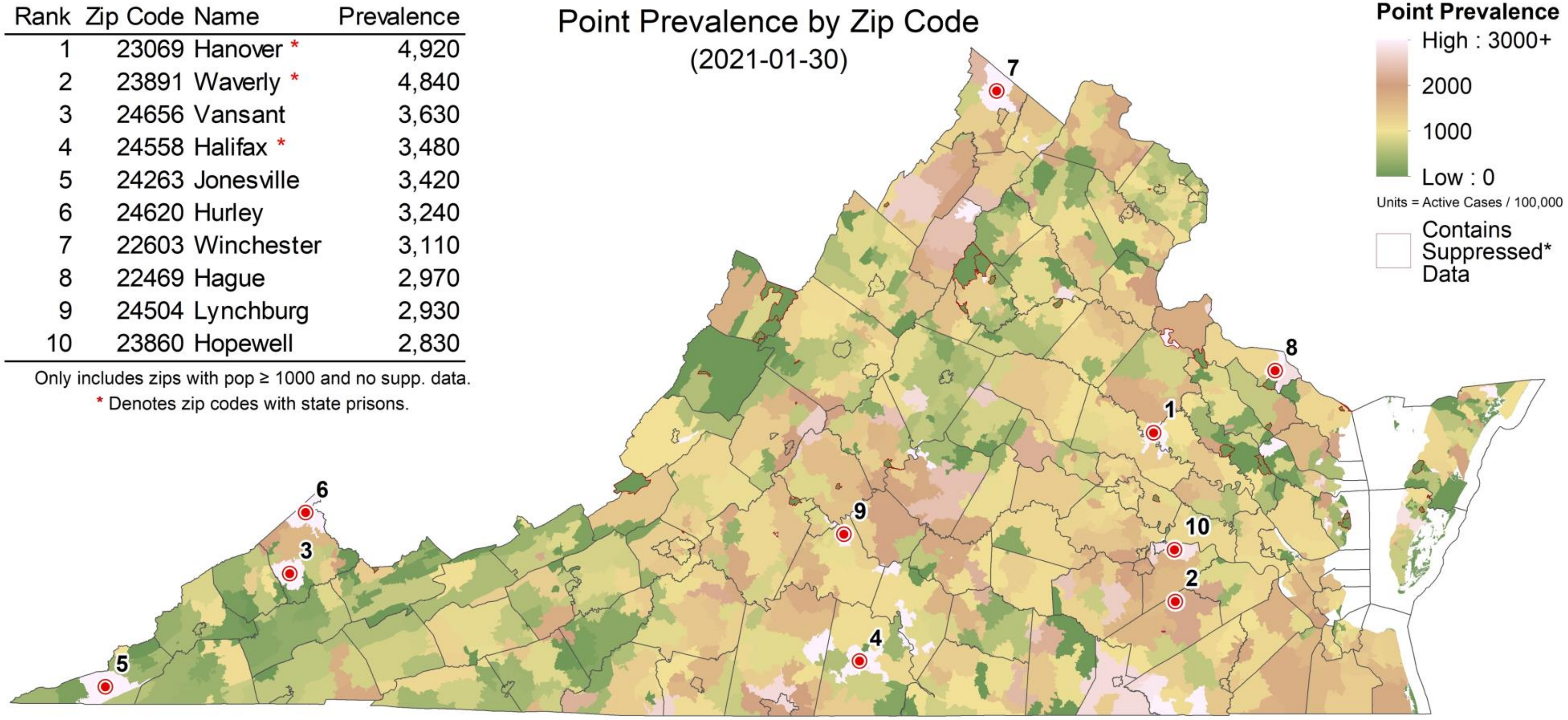
Zip code level weekly Case Rate (per 100K)

Case Rates in the last week by zip code

- Fewer prisons are in the top ten, most prisons seem to have intense rates for 2 to 3 weeks
- Concentrations of high rates in central and northwest regions
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prevalence
1	23069	Hanover *	4,920
2	23891	Waverly *	4,840
3	24656	Vansant	3,630
4	24558	Halifax *	3,480
5	24263	Jonesville	3,420
6	24620	Hurley	3,240
7	22603	Winchester	3,110
8	22469	Hague	2,970
9	24504	Lynchburg	2,930
10	23860	Hopewell	2,830

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



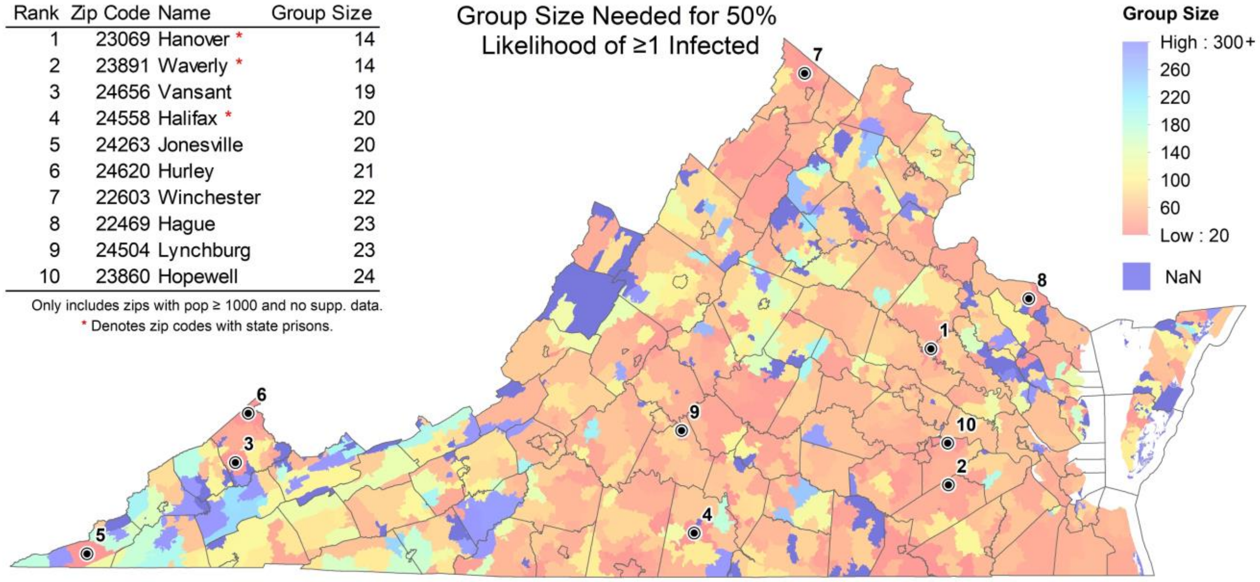
Risk of Exposure by Group Size

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

- Assumes 3 undetected infections per confirmed case (ascertainment rate from recent seroprevalence survey)
- On left, minimum size of a group with a 50% chance an individual is infected by zip code (eg in a group of 14 in Hanover, there is a 50% chance someone will be infected)
- Some zip codes have high likelihood of exposure even in groups of 25

Rank	Zip Code	Name	Group Size
1	23069	Hanover *	14
2	23891	Waverly *	14
3	24656	Vansant	19
4	24558	Halifax *	20
5	24263	Jonesville	20
6	24620	Hurley	21
7	22603	Winchester	22
8	22469	Hague	23
9	24504	Lynchburg	23
10	23860	Hopewell	24

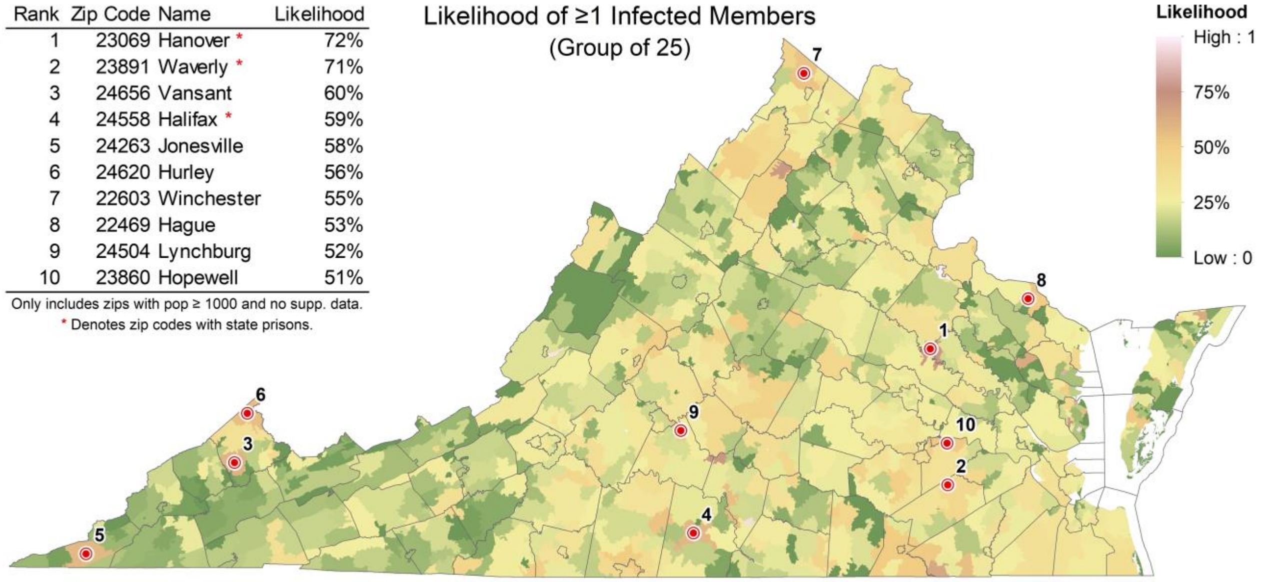
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on zip code point prevelence for week ending 2021-01-30

Rank	Zip Code	Name	Likelihood
1	23069	Hanover *	72%
2	23891	Waverly *	71%
3	24656	Vansant	60%
4	24558	Halifax *	59%
5	24263	Jonesville	58%
6	24620	Hurley	56%
7	22603	Winchester	55%
8	22469	Hague	53%
9	24504	Lynchburg	52%
10	23860	Hopewell	51%

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



Based on zip code point prevelence for week ending 2021-01-30

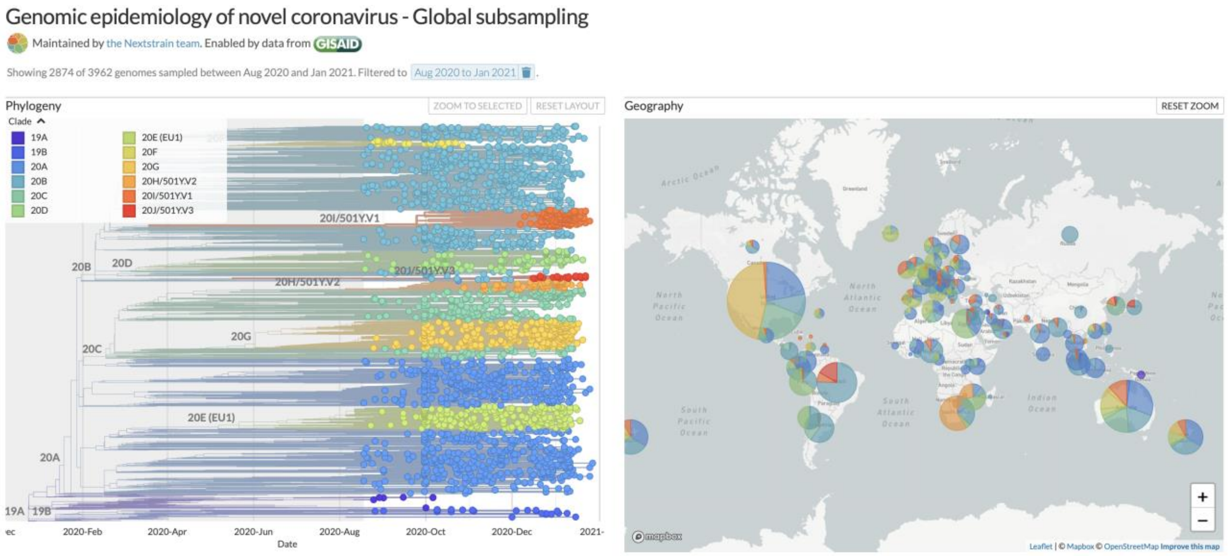
New variants of SARS-CoV2

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

- Current evidence has found new variants that:
    - Increase transmissibility
    - Increase severity (more hospitalizations and/or deaths)
    - Limit immunity from prior infection and vaccination

Lineage B.1.1.7

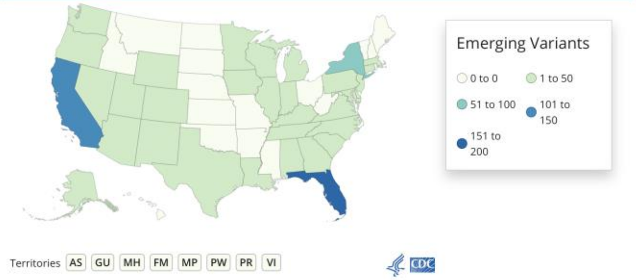
- B.1.1.7 has been detected in Virginia as well as in at least 541 cases across 33 states as of Feb 2nd (avg delay of 10-20 days from isolation to reporting), will continue to grow rapidly
- Given observed growth rate in UK and Denmark, estimate it will predominate (eg reach 50%) in the US by mid-March
- Recent study suggests this variant may have higher mortality and a bioinformatic study by PHE shows E484K mutation as is found in B.1.351 has arisen multiple times in UK based B.1.1.7



nextstrain.org

Variant	Reported Cases in US	Number of States Reporting
B.1.1.7	541	33
B.1.351	3	2
P.1	2	1

Emerging Variant Cases in the United States*†



CDC Variant Tracking

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New variants of SARS-CoV2

Lineage B.1.351

- Emerging strain predominantly South Africa shows signs of vaccine escape, currently 3 reported cases in 2 states as of Jan 31st
- Experiments have demonstrated reduced potency of convalescent sera, and monoclonal antibodies
- Moderna and Pfizer vaccine demonstrated to have robust response to this variant, and thus likely to remain highly effective
- Novovax and Johnson & Johnson vaccine demonstrated reduced efficacy in arm conducted in South Africa when this strain was circulating

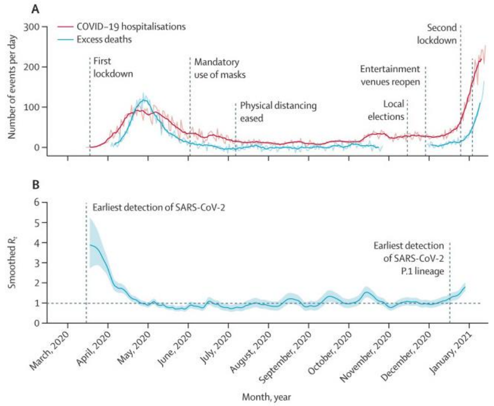
Lineage P.1 (similar mutations as in B.1.1.7 and B.1.351)

- First case reported in Minnesota on Monday Jan 25th followed by another
- Emerging strain in the Amazon also shows potential of escaping existing immunity
- Resurgence of hospitalizations in Manaus, Brazil continues this despite estimated ¾ of the population infected

Lineage B.1.429 (similar mutations as in B.1.1.7 and B.1.351)

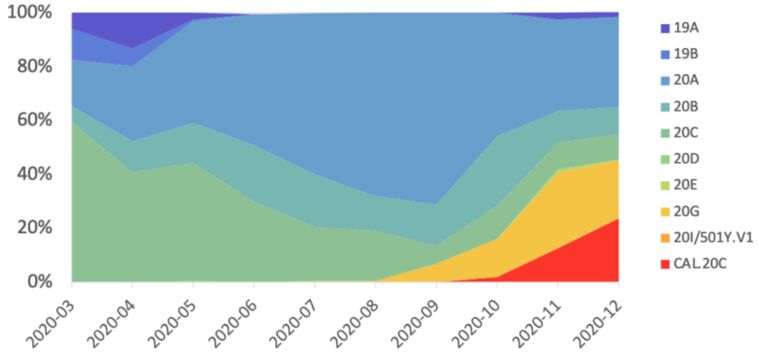
- Initially found in Southern California, conincided with surge in Nov and Dec
- Currently seen in 36% of cases in Cedars-Sinai in LA

Manaus Brazil Cases and Hospitalizations



COVID-19 hospitalisations, excess deaths, and R_t in Manaus, Brazil, 2020–21
https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)00183-5/fulltext

Prevalence of B.1.429 increasing in CA



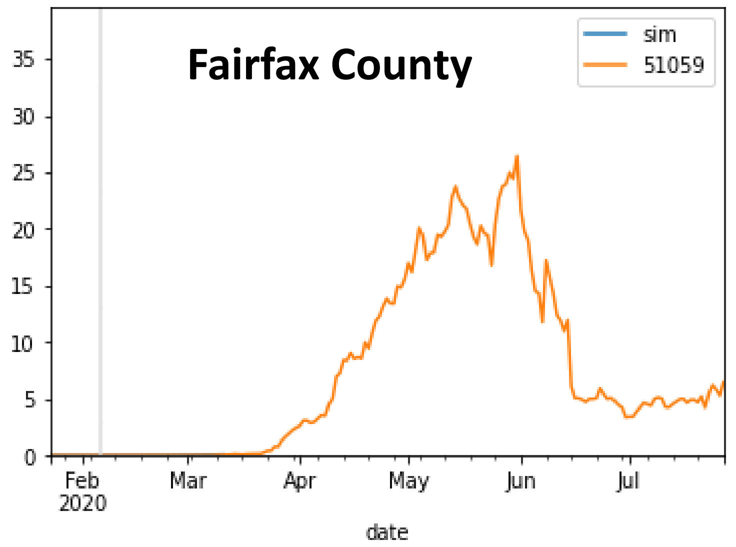
B.1.429 increased prevalence coincided with strong surge of cases in Southern California

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

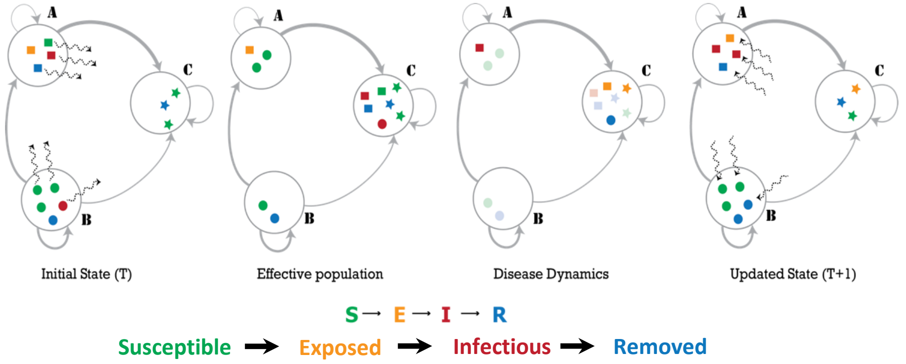


Model: An alternative use of the same meta-population model, PatchSim

- 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

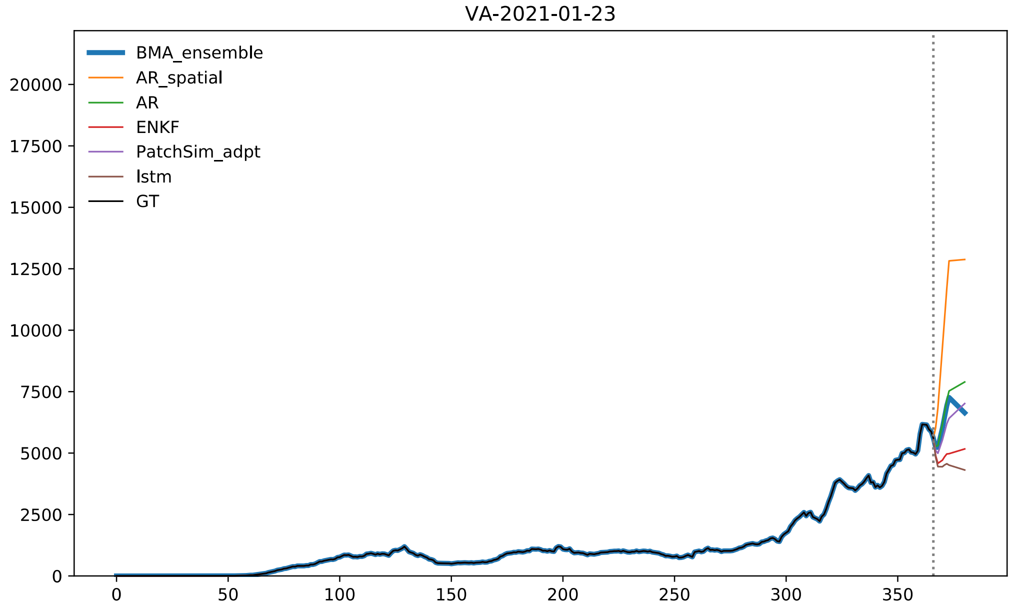
- Widespread pandemic eliminates sensitivity to initial conditions
- Uses steady 1 case per 10M population per day external seeding

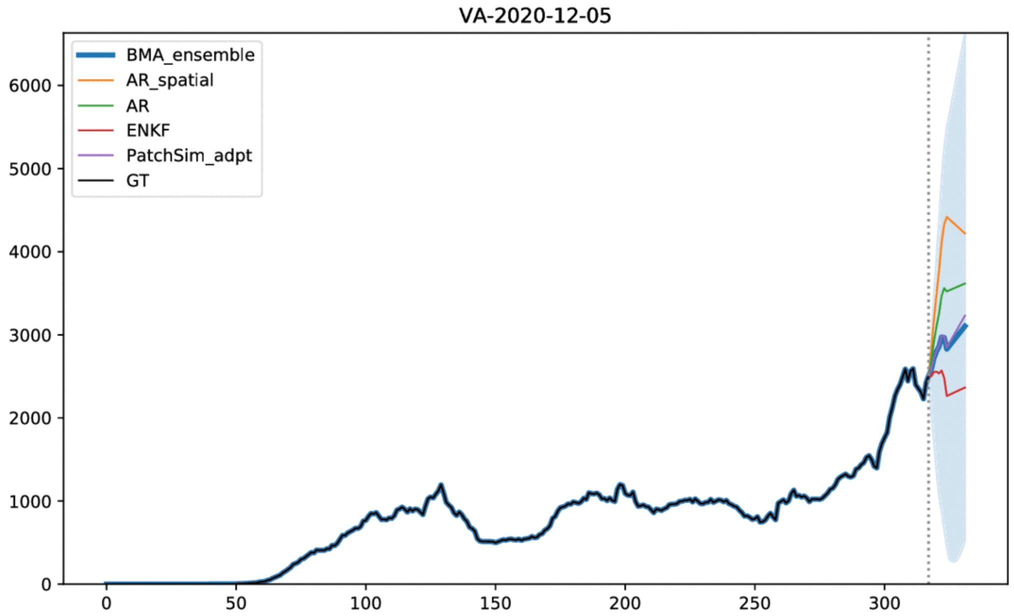


Using Ensemble Model to Guide Projections

An ensemble methodology that combines the Adaptive Fitting and machine learning and statistical models has been developed and refined

- **Models**: Adaptive Fitting, ARIMA, LSTM, AR, spatially driven AR, Kalman Filters (ENKF)
- This approach facilitates the use of other data streams (weather, mobility, etc.)
- Ensemble provides scaffolding for the Adaptive Fitting's short-term projections





Seroprevalence updates to model design

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

- Virginia Serology Study estimated 2.4% of Virginians estimated infected (as of Aug 15^{th})
- CDC Nationwide Commercial Laboratory Seroprevalence Survey estimated 4.6% [3.0% – 6.6%] seroprevalence as of Nov 12^{th} – 26^{th} up from 4.1% a month earlier

These findings are equivalent to an ascertainment ratio of ~3x, with bounds of (1x to 7x)

- Thus for 3x there are 3 total infections in the population for every confirmed case
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were being used)

VA Seroprevalence Data

November 2020 (Second Half)

Seroprevalence Estimate

4.6%

95% Confidence Interval: 3.0%-6.6%

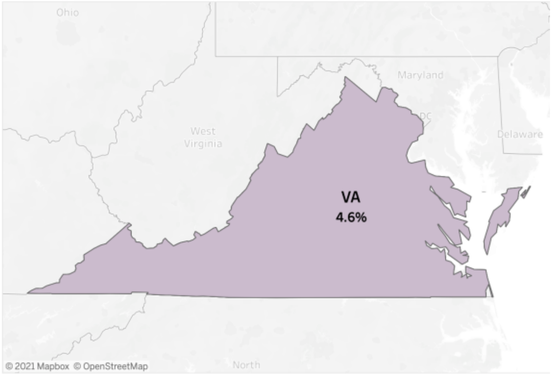
Number of Estimated Infections

387,000

95% Confidence Interval: 251,000-552,000

Total Number of Cases Reported by End of 11/30/2020

237,813



Catchment Area: **Statewide** Number of Samples Tested: **1,344**

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

Virginia Coronavirus Serology Project

Interim findings by region and statewide - July 22, 2020

Region	Number of participants	Number antibody positive	Crude prevalence per 100 participants	Weighted prevalence*	
				per 100 population	(95% CI)
Central	400	8	2.0	3.0	(0.5, 5.5)
East	707	9	1.3	1.5	(-0.2, 3.2)
Northern	819	36	4.4	4.2	(2.5, 5.9)
Northwest	756	11	1.5	0.9	(0.2, 1.6)
Southwest	431	3	0.7	1.0	(-0.2, 2.1)
Virginia	3,113	67	2.2	2.4	(1.6, 3.1)

* Weighted prevalence is reweighted by region, age, sex, race, ethnicity, and insurance status to match census population.

https://www.vdh.virginia.gov/content/uploads/sites/8/2020/08/VDH-Serology-Projects-Update-8-13-2020.pdf

Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data and ensemble's forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak
- **Project:** future cases and outcomes generated using the collection of fit models run into the future
  - **Mean trend from last 7 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories

COVID-19 in Virginia:

Dashboard Updated: 2/2/2021
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*		Total Hospitalizations**		Total Deaths	
510,380		21,516		6,517	
(New Cases: 2,740)^					
Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
408,421	101,959	20,571	945	5,684	833

* Includes both people with a positive test (Confirmed), and symptomatic with a known exposure to COVID-19 (Probable).
** Hospitalization of a case is captured at the time VDH performs case investigation. This underrepresents the total number of hospitalizations in Virginia.
^New cases represent the number of confirmed and probable cases reported to VDH in the past 24 hours.
† VDH adopted the updated CDC COVID-19 confirmed and probable surveillance case definitions on August 27, 2020. Found here: https://wwwn.cdc.gov/nndss/conditions/coronavirus-disease-2019-covid-19/case-definition/2020/08/05/

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
2,337	57,610

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

Outbreak Associated Cases: 57,610

Testing (PCR Only)

Testing Encounters PCR Only*	Current 7-Day Positivity Rate PCR Only**
5,281,726	11.5%

* 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
16	0

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

Accessed 8:00am February 3, 2021

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

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Scenarios – Seasonal Effects

- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings related to holidays, fatigue with infection control practices
- Plausible levels of transmission can be bounded by past experience
  - Assess transmission levels at the county level since May 2020
  - Use the highest and lowest levels experienced (excluding outliers) as plausible bounds for levels of control achievable
  - Transition from current levels of projection to the new levels over 2 months
- New planning Scenarios:
  - **Best of the Past**: Lowest level of transmission (10^{th} percentile)
  - **Fatigued Control**: Highest level of transmission (95^{th} percentile) increased by additional 5%

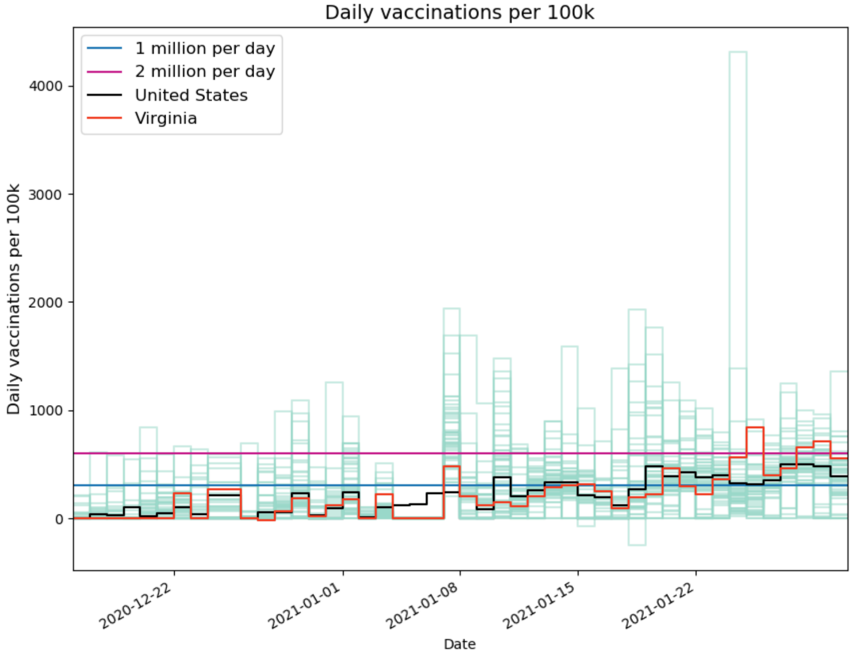
Scenarios – Novel Variants

- Several novel variants of SARS-CoV2 are being tracked
  - Some are more transmissible, some may escape immunity from previous natural infection and/or vaccination, others may be more severe
- New Variant B.1.1.7 is best understood and is in Virginia
  - Several different studies have estimated the increase in transmission to be 30-55%, we use 50% increase from the current baseline projection
  - Gradually replace the current transmissibility with the augmented transmissibility over the course of 2 months as estimated by a recent MMWR report from CDC
- Additional planning Scenarios:
  - **VariantB117**: Current projected transmissibility increases gradually over 4 months to level 50% more transmissible

Scenarios – Vaccines

- Vaccination has started, and efforts are underway to increase its pace
  - Exact achievable rollouts and level of coverage are unknown
- Vaccine efficacy varies over course of vaccine
  - FDA EUAs show 50% efficacy achieved 2 weeks after 1st dose, and 95% 2 weeks after 2nd
  - Assuming 3.5 week (average of Pfizer and Moderna) gap between doses
- Vaccine hesitancy poses a future problem
  - Currently demand far outpaces supply so we assume all courses will be administered until we reach the hesitancy threshold, for 50% this is several months in the future.

VA Vaccination Rates



Lines represents 1M & 2M doses a day goal

Current rollouts and scenarios inspired by MIDAS Network COVID-19 Scenario Hub: https://github.com/midas-network/covid19-scenario-modeling-hub

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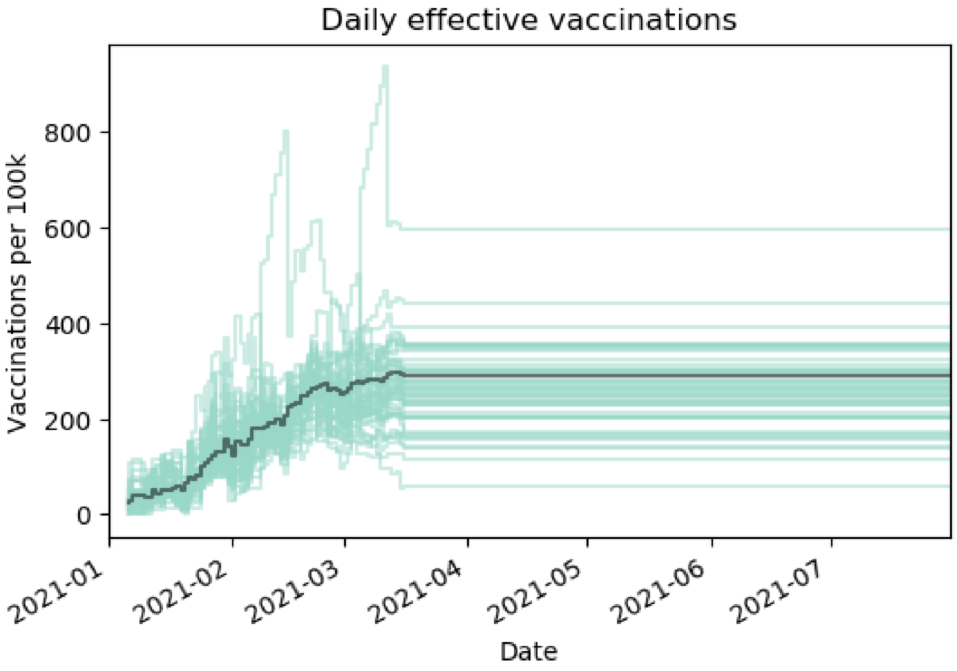
Scenarios – Vaccines

- Administration schedule uses actual administration and expected for the future
  - Use history of state-specific doses administered as captured by [Bloomberg](#) (up to Jan 19th) and [CDC](#) (Jan 20th and on)
  - Future courses based on sustaining daily average of most recent week
    - **Rate**: 486 doses per 100K per day
    - **Location**: Per capita distribution across all counties

Modeled Vaccine Induced Immunity



All US states, median in black

Current rollouts and scenarios inspired by MIDAS Network COVID-19 Scenario Hub: https://github.com/midas-network/covid19-scenario-modeling-hub

Scenarios – Seasonal Effects and Vaccines

Three scenarios combine these seasonal effects and use the updated vaccine schedule

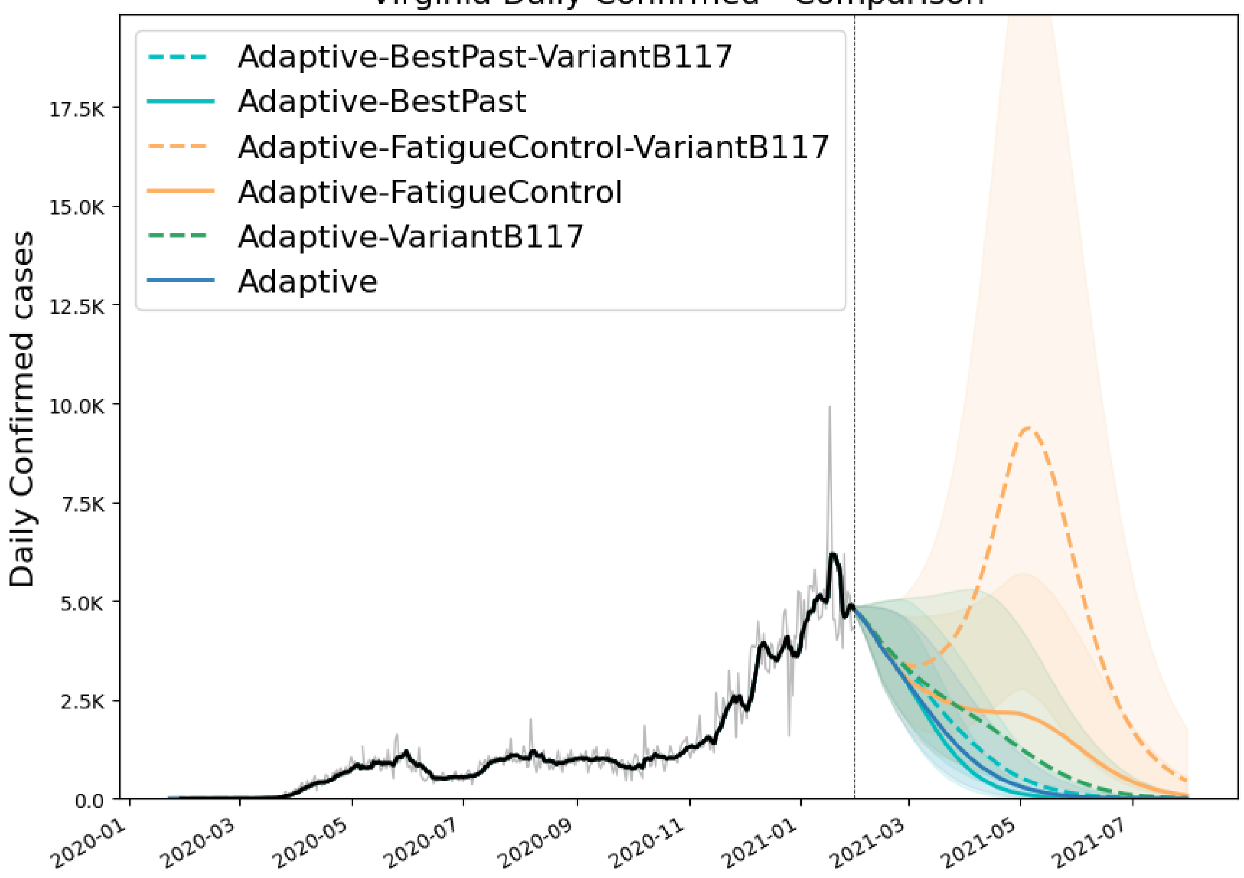
- **Adaptive**: No seasonal effects from base projection
  - If things continue as they are
- **Adaptive-FatigueControl**: Fatigued control seasonal effects
  - If we revert to slightly worst transmission experienced in last 6 months
- **Adaptive-BestPast**: Best of the past control seasonal effects
  - If we revert to best control experienced in last 6 months
- **Adaptive-VariantB117**: Boosting of transmissibility from the emergence of B.1.1.7
  - If new variants begin to predominate and boost transmission, this assumes current seasonal affects remain the same (eg like Adaptive)
- **Adaptive-FatigueControl-VariantB117:** Fatigued control and txm boost from B.1.1.7
- **Adaptive-BestPast-VariantB117:** Best of the past control vs. txm boost from B.1.1.7

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

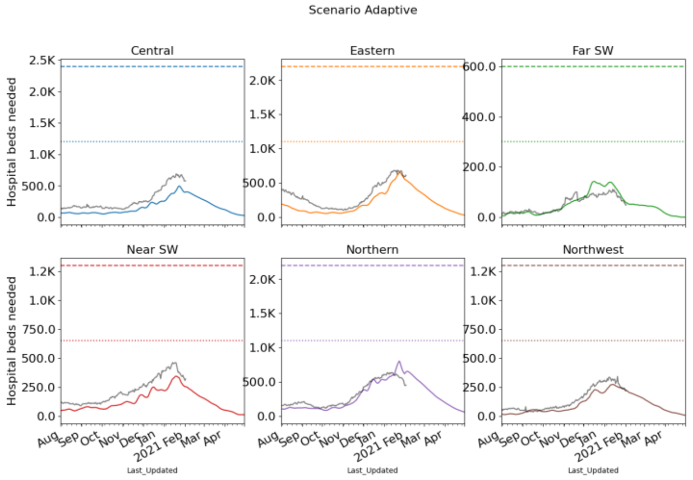
Model Results

Outcome Projections

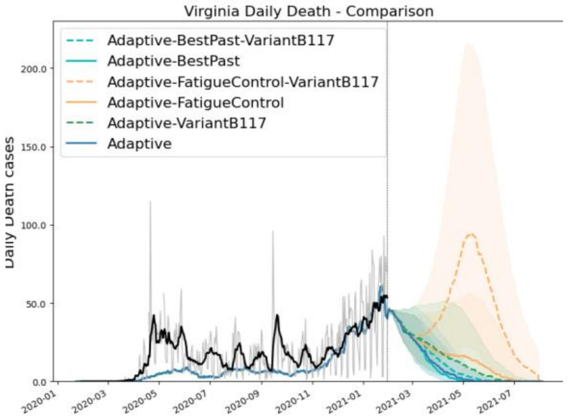
Confirmed cases



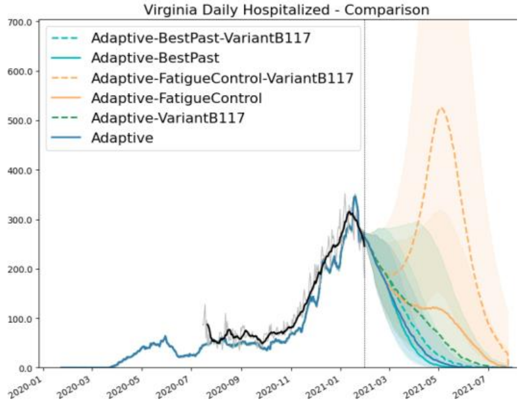
Estimated Hospital Occupancy



Daily Deaths



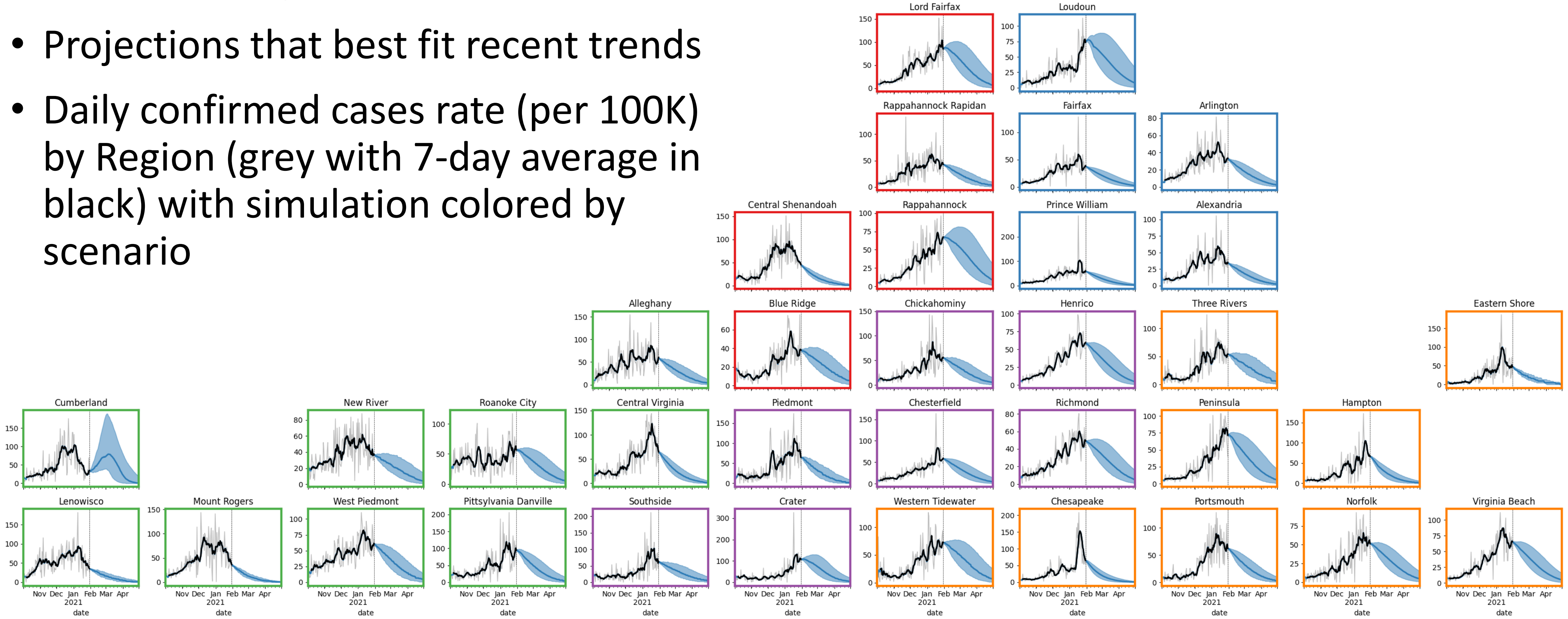
Daily Hospitalized



District Level Projections: Adaptive

Adaptive projections by District

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



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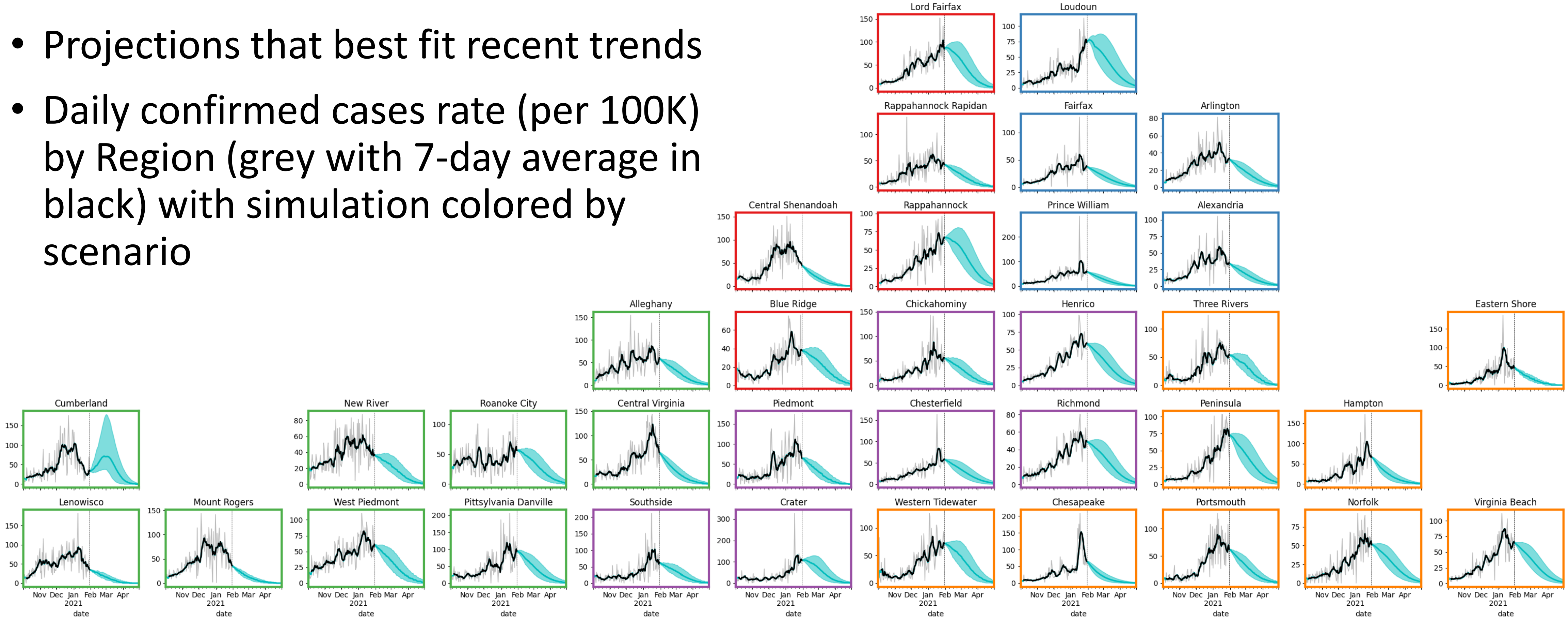
District Level Projections: Adaptive-BestPast

Adaptive projections by District

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



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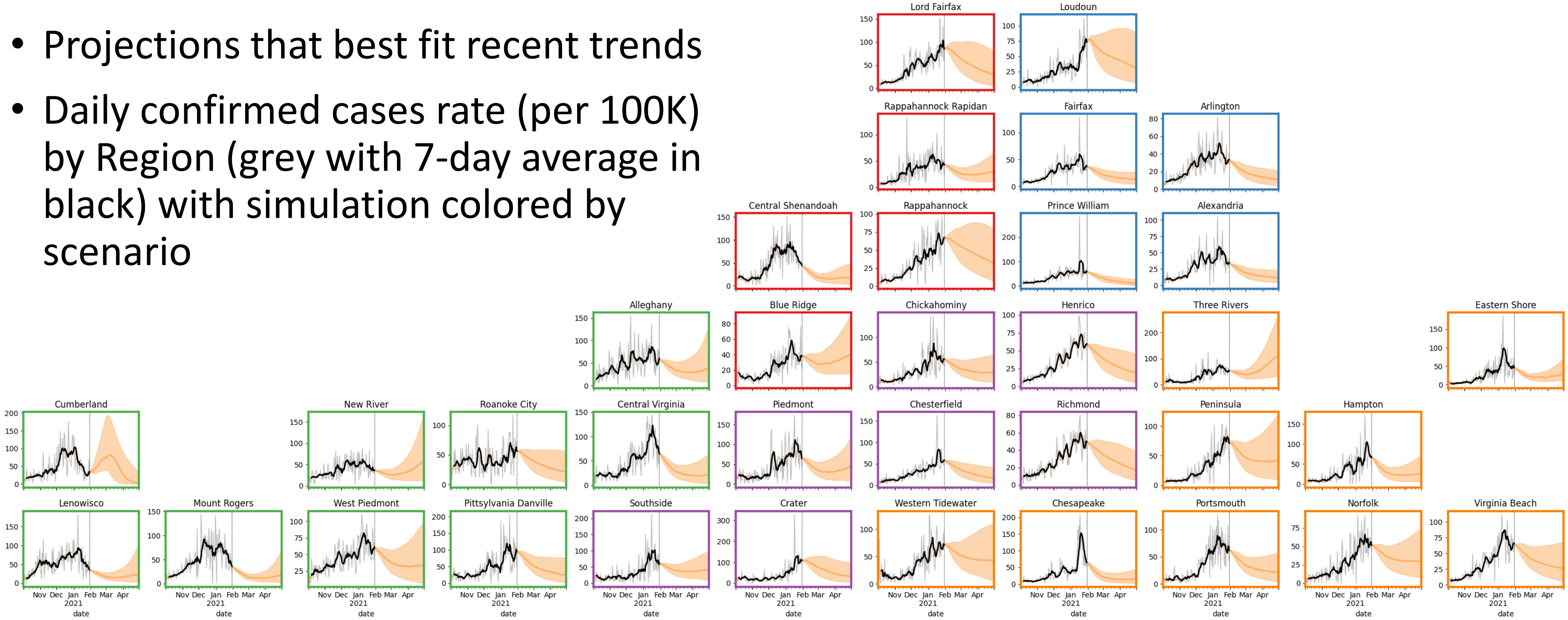
District Level Projections: Adaptive-FatigueControl

Adaptive projections by District

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



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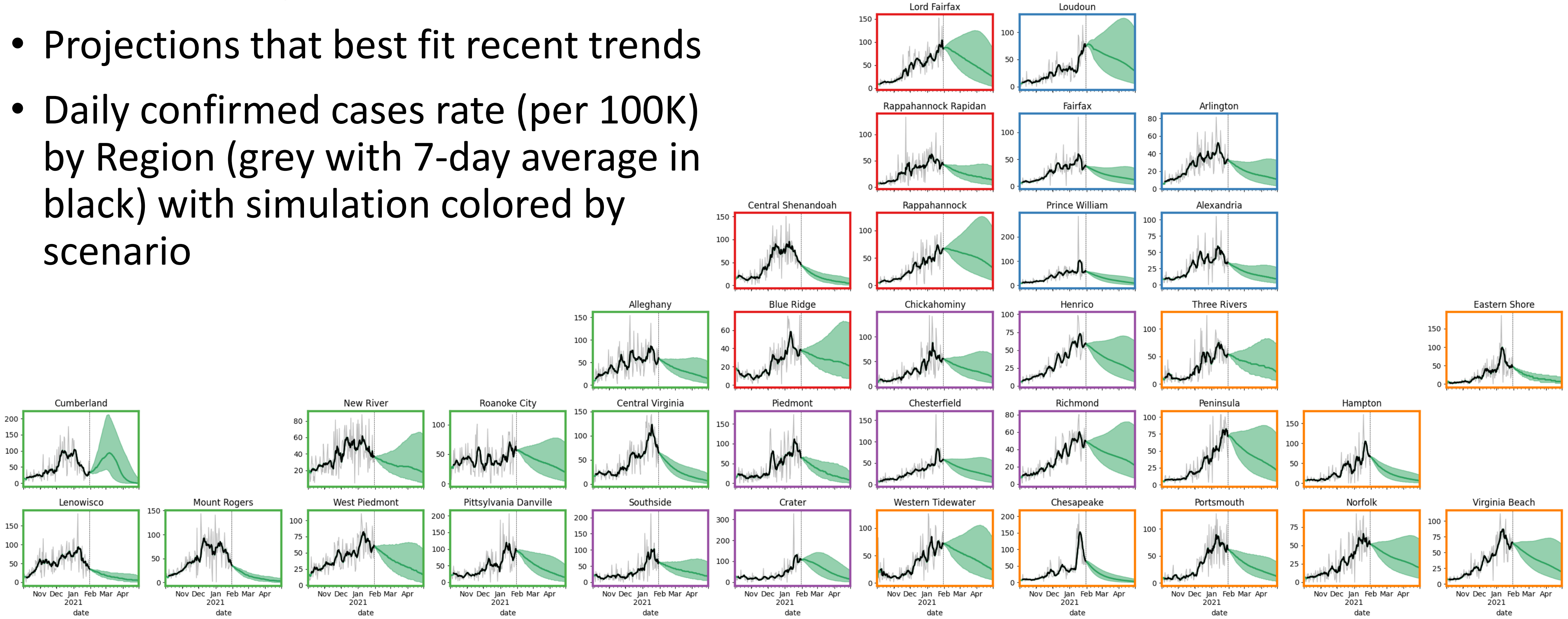
District Level Projections: Adaptive-VariantB117

Adaptive projections by District

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



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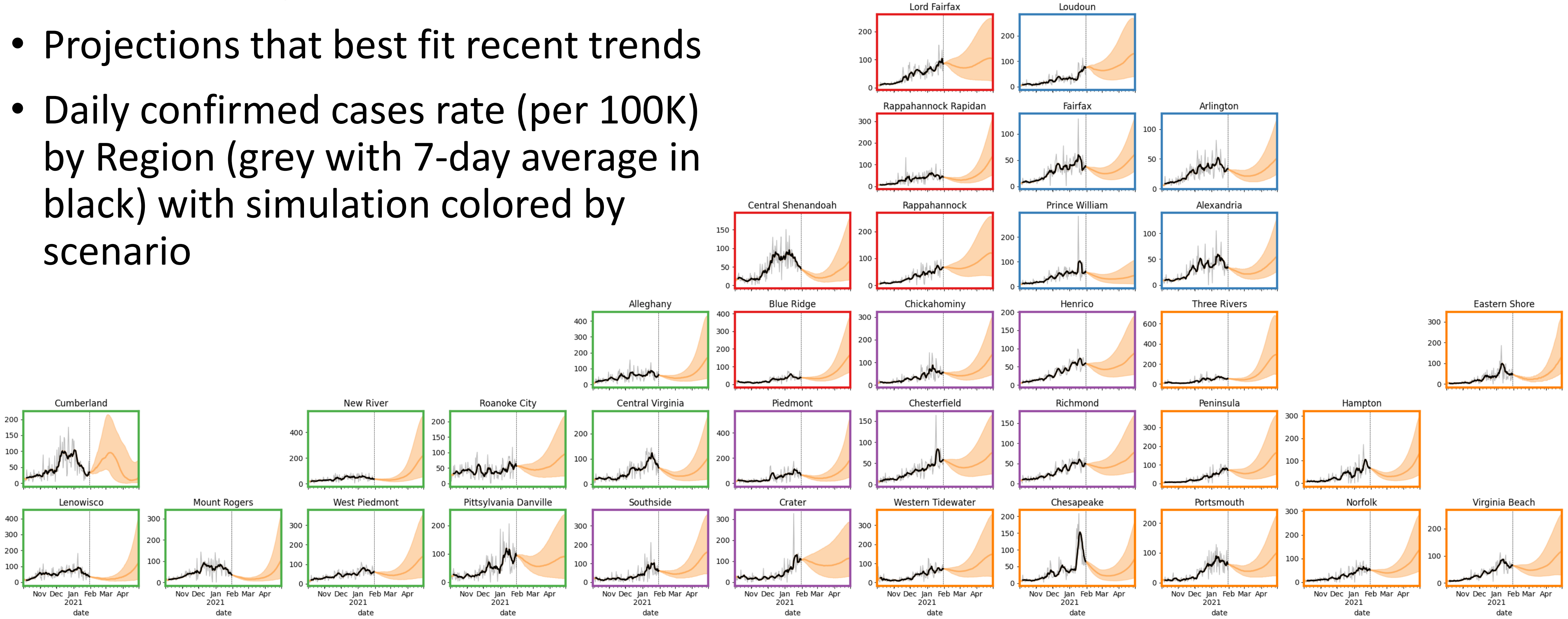
District Level Projections: Adaptive-FatigueControl-VariantB117

Adaptive projections by District

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



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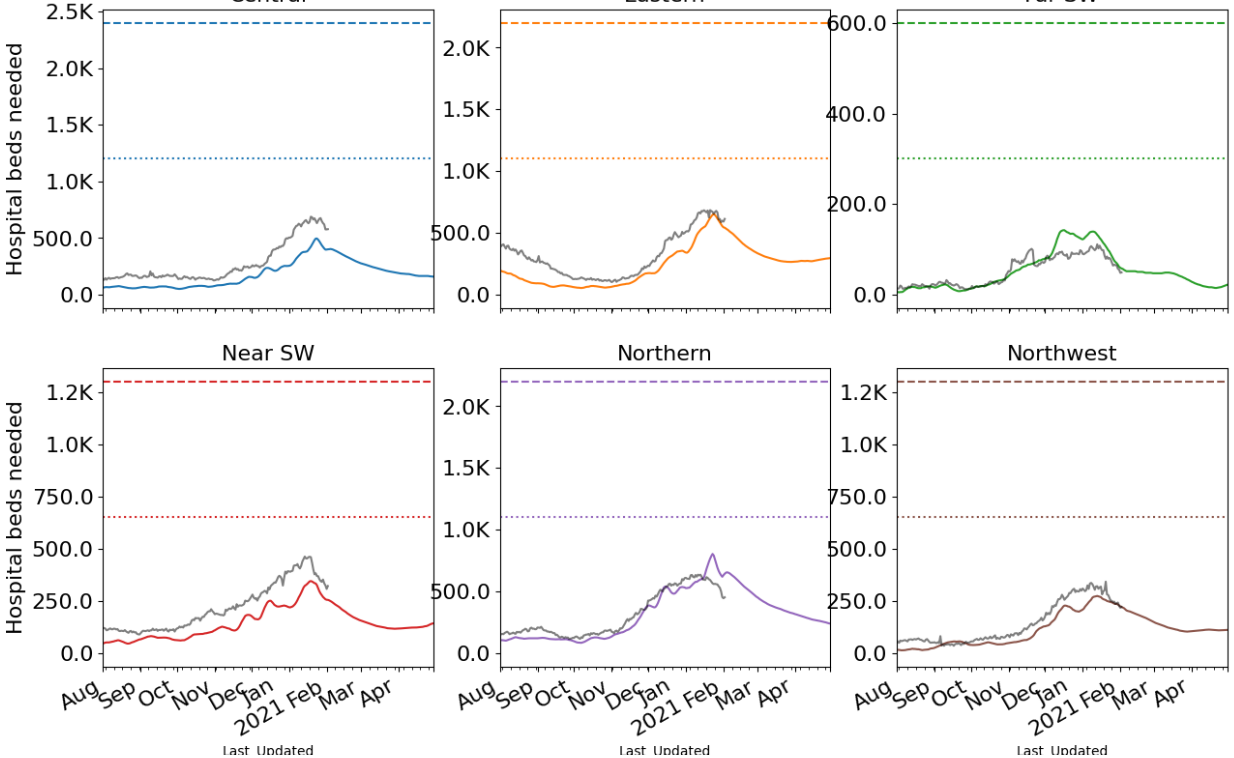
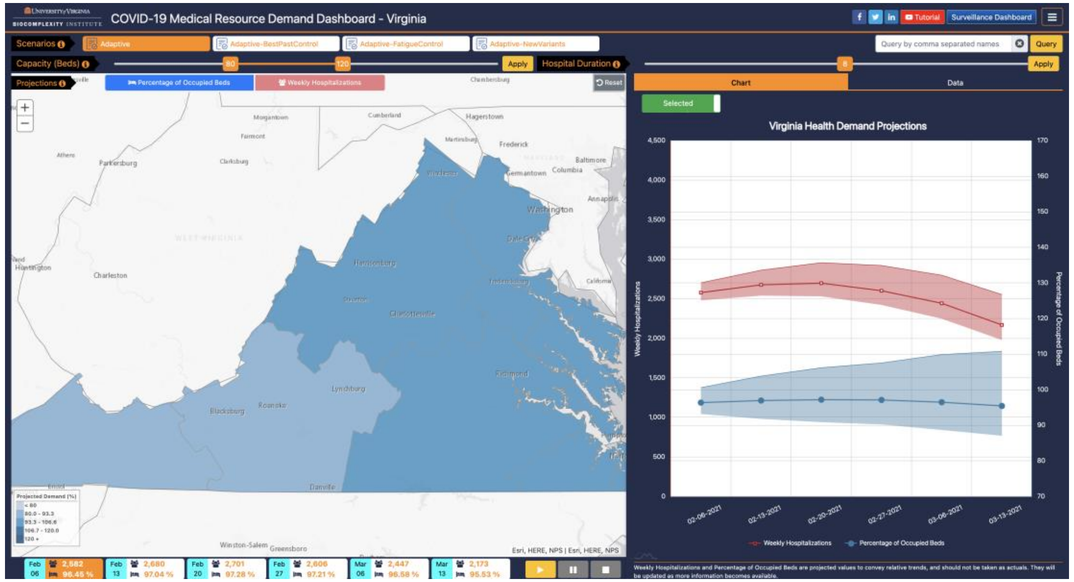
Hospital Demand and Bed Capacity by Region

Capacities* by Region – Adaptive-FatigueControl

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





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

If Adaptive-FatigueControl scenario persists:

- Surge bed capacity is unlikely to be reached in coming 4 months

* Assumes average length of stay of 8 days

Weekly Cases and Hospitalizations

Weekly confirmed cases

Week Ending	Adaptive	Adaptive-Fatigued Control	Adaptive-BestPast	Adaptive-VariantB117	Adaptive-Fatigued Control -VariantB117
1/31/21	33,286	33,286	33,286	33,284	33,286
2/7/21	31,814	31,829	31,828	31,936	31,942
2/14/21	28,527	28,584	28,578	29,157	29,158
2/21/21	25,180	25,280	25,272	26,422	26,395
2/28/21	22,074	22,354	22,128	24,098	24,265
3/7/21	18,939	20,334	18,520	22,019	23,517
3/14/21	15,934	18,980	14,825	20,167	24,047
3/21/21	13,036	17,775	11,319	18,503	25,535
3/28/21	10,348	16,788	8,296	16,949	28,068
4/4/21	8,050	16,059	5,859	15,491	31,988
4/11/21	6,110	15,603	3,964	14,049	37,671
4/18/21	4,598	15,343	2,636	12,572	45,416

Weekly Hospitalizations

Week Ending	Adaptive	Adaptive-Fatigued Control	Adaptive-BestPast	Adaptive-VariantB117	Adaptive-Fatigued Control -VariantB117
1/31/21	1,851	1,851	1,851	1,851	1,851
2/7/21	1,765	1,766	1,766	1,771	1,772
2/14/21	1,574	1,577	1,577	1,609	1,608
2/21/21	1,393	1,398	1,397	1,458	1,456
2/28/21	1,233	1,243	1,234	1,338	1,348
3/7/21	1,045	1,132	1,018	1,224	1,306
3/14/21	864	1,041	804	1,100	1,350
3/21/21	708	964	604	1,009	1,416
3/28/21	553	909	440	921	1,560
4/4/21	431	882	296	845	1,787
4/11/21	315	860	190	768	2,108
4/18/21	218	835	122	682	2,521

Key Takeaways

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

- **Case rate growth in Virginia continues to decline**
- VA mean weekly incidence down sharply 45/100K from 54/100K, as national levels continued to decline (to 37/100K from 45/100K)
- Projections are mixed across commonwealth with declines far outpacing growth
- Recent updates:
  - Scenarios expanded to add impact of transmission boosting from Variant B.1.1.7 to control-based (best of past and fatigued) scenarios
  - Further updates to vaccination schedules, with fitting now down on partially vaccinated population and future vaccinations based on current levels instead of goals
- The situation is changing rapidly. Models will be updated regularly.

References

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

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

Questions?

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Supplemental Slides

Estimating Daily Reproductive Number

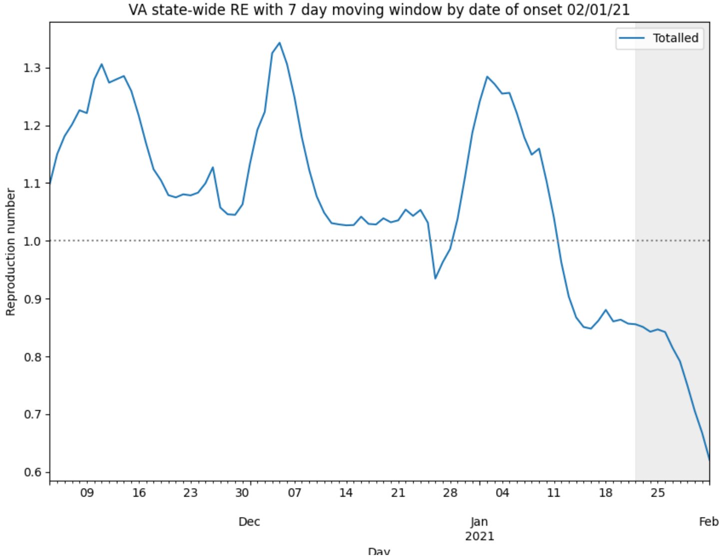
Jan 23rd Estimates

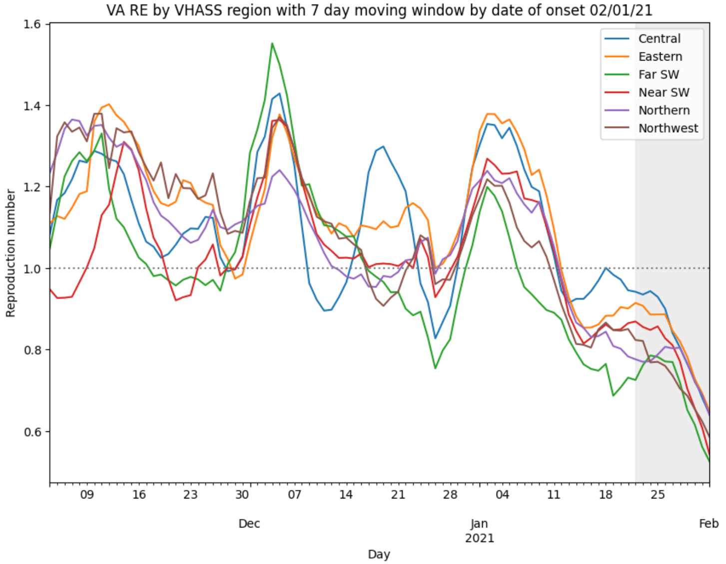
Region	Date of Onset R_e	Date Onset Diff Last Week
State-wide	0.851	0.009
Central	0.935	0.006
Eastern	0.908	0.072
Far SW	0.762	-0.002
Near SW	0.856	0.029
Northern	0.770	-0.039
Northwest	0.821	-0.055

Methodology

- Wallinga-Teunis method (EpiEstim[1]) for cases by date of onset
- Serial interval: 6 days (2 day std dev)
- Recent estimates may be unstable 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

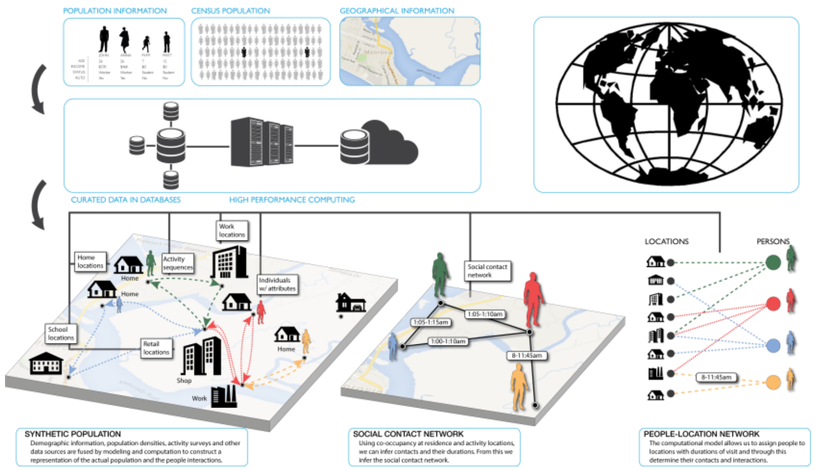




Agent-based Model (ABM)

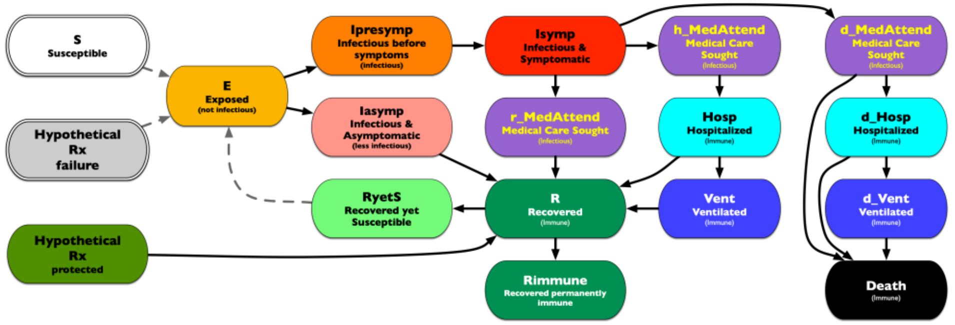
EpiHiper: Distributed network-based stochastic disease transmission simulations

- 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

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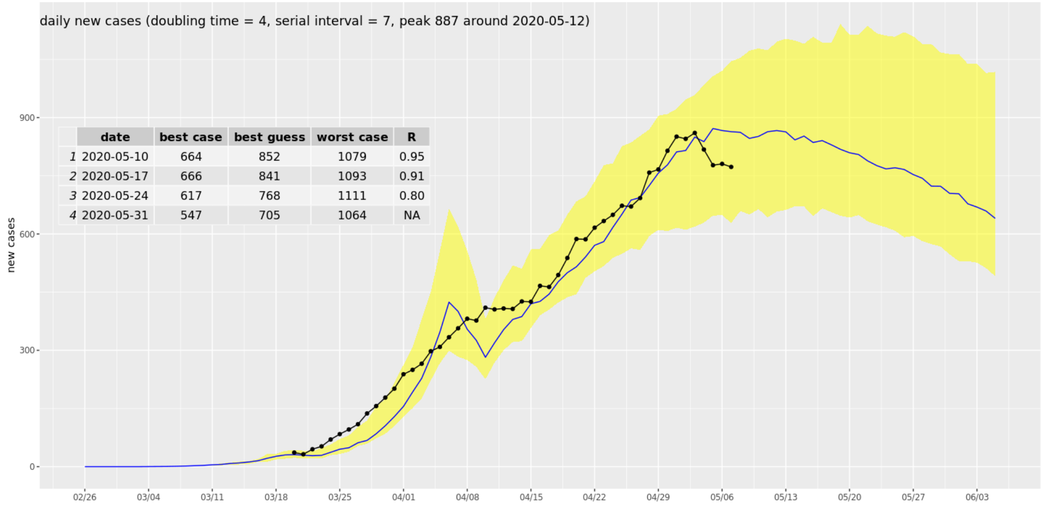
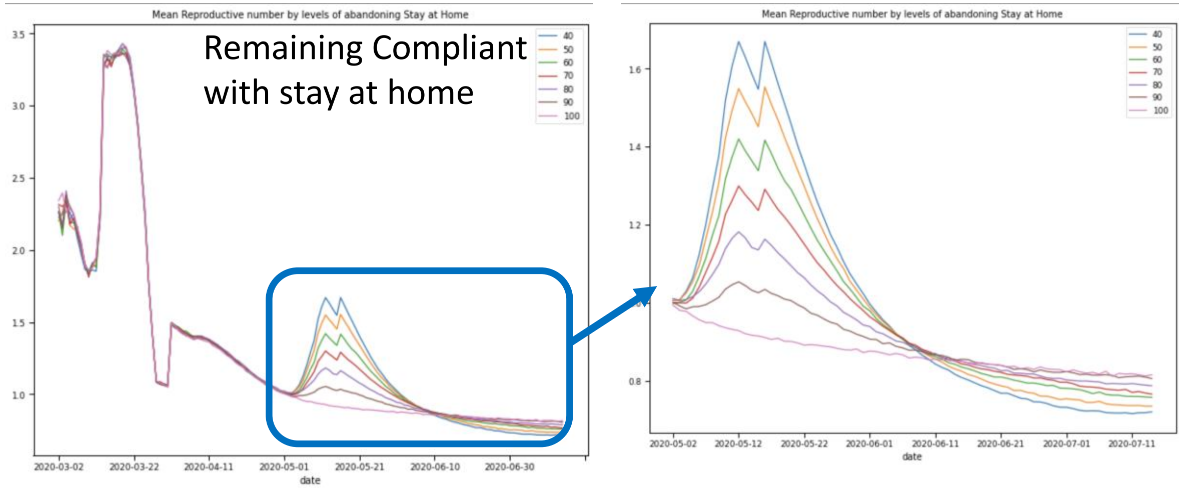
ABM Social Distancing Rebound Study Design

Study of ”Stay Home” policy adherence

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



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



Calibration to Current State

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

Impacts on Reproductive number with release

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