Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

January 27th , 2021

(data current to January 25th-26th)

Biocomplexity Institute Technical report: TR 2021-011

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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:

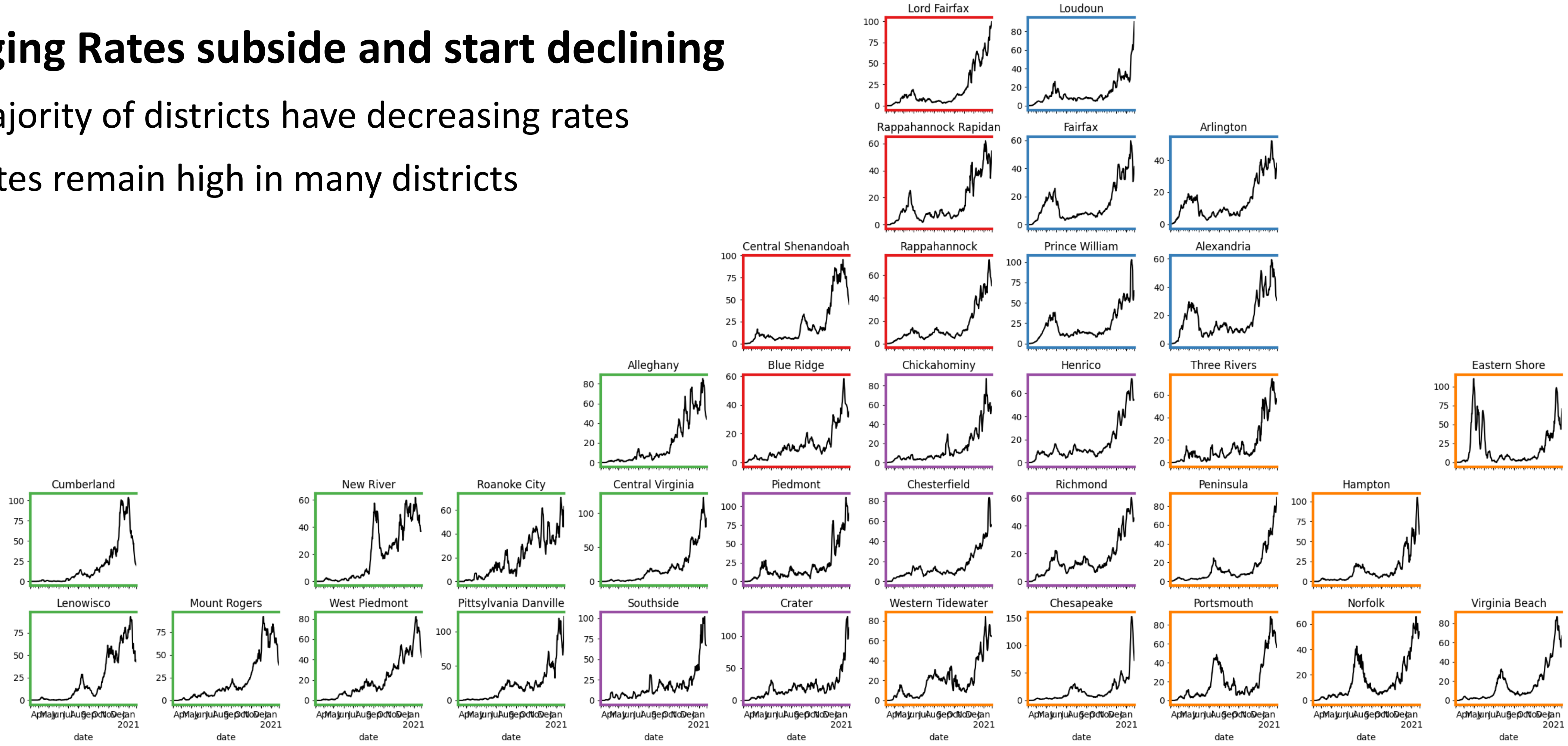
- **Case rate growth in Virginia has slowed but remains high**
- VA mean weekly incidence down sharply 54/100K from 72/100K, as national levels continued to decline (to 45/100K from 54/100K)
- Projections are mixed across commonwealth with some short-term growth at state level mainly driven by central section of the state
- Recent updates:
  - Adjusted projection window to account for shifting trends
  - Scenarios based on past control levels (best and fatigued) and emerging new variants with enhanced transmissibility
  - Further updates to vaccination schedules, accounts for partial protection from first dose and merges observed doses with goals for future vaccine administration
- 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



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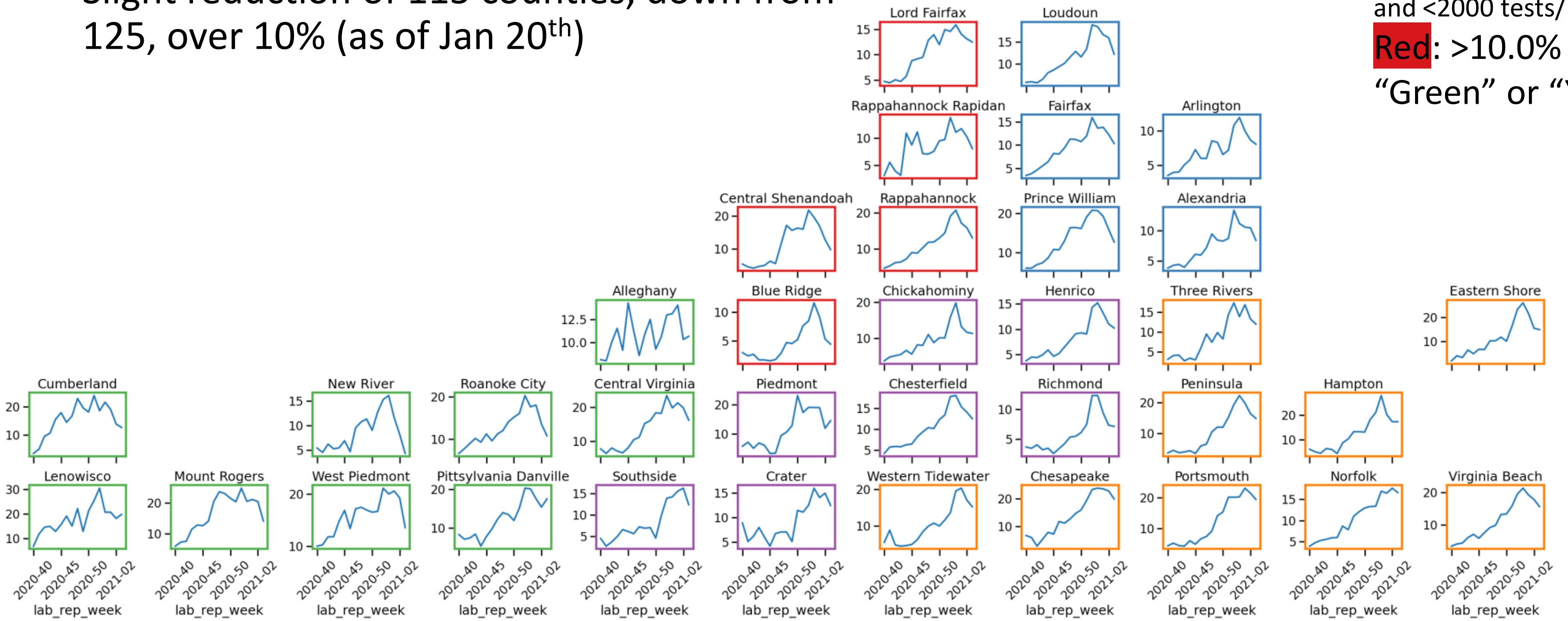
Test Positivity by VDH District

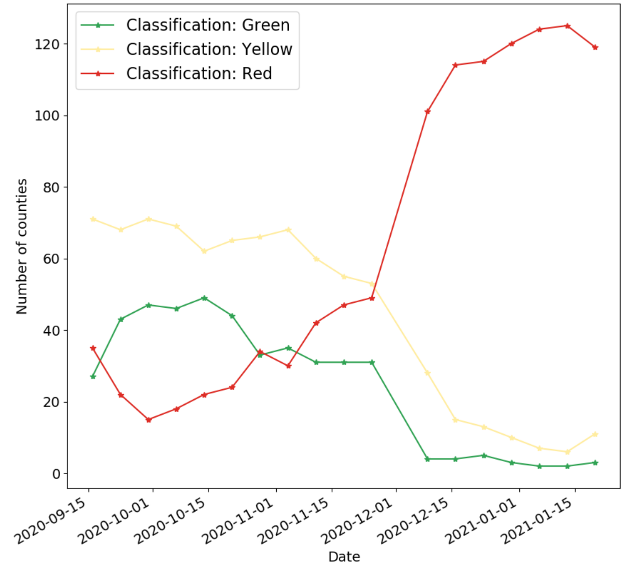
Weekly changes in test positivity by district

- Increasing levels in many districts throughout the commonwealth with many districts above 10% for several weeks
- Slight reduction of 115 counties, down from 125, over 10% (as of Jan 20th)



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"



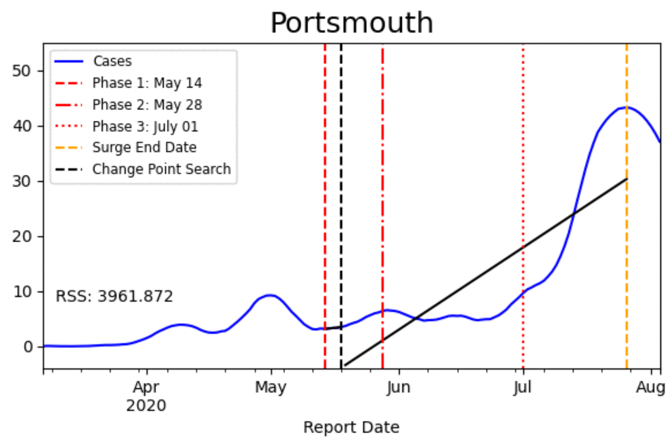
https://data.cms.gov/stories/s/q5r5-gjyu

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

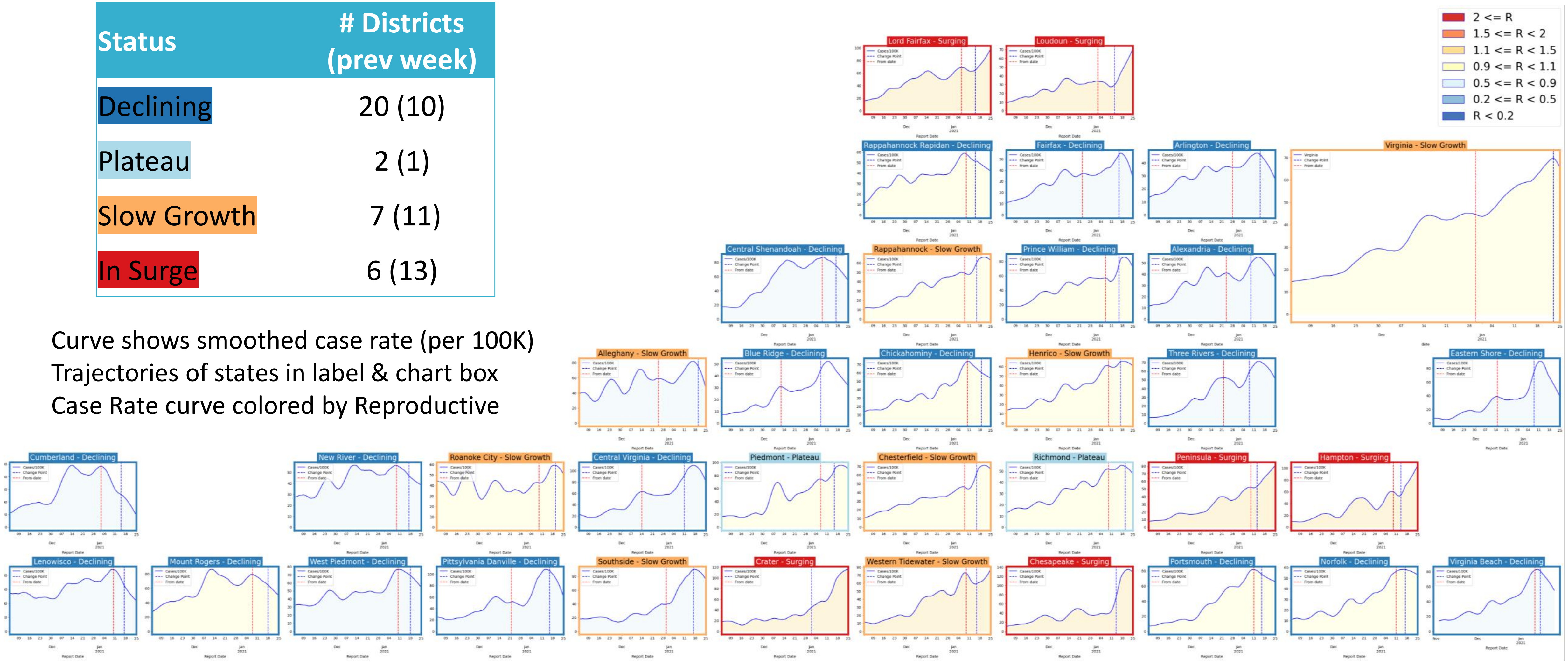


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	20 (10)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	2 (1)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	7 (11)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	6 (13)

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	20 (10)
Plateau	2 (1)
Slow Growth	7 (11)
In Surge	6 (13)

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

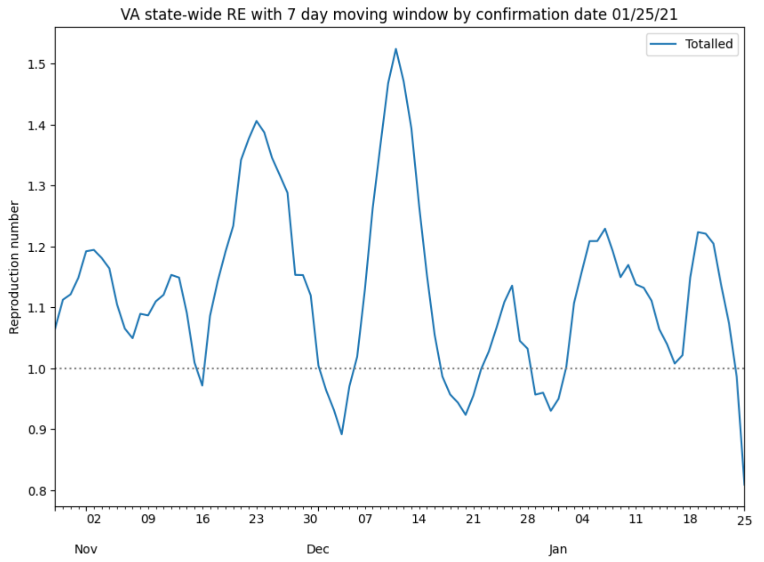
Jan 25th Estimates

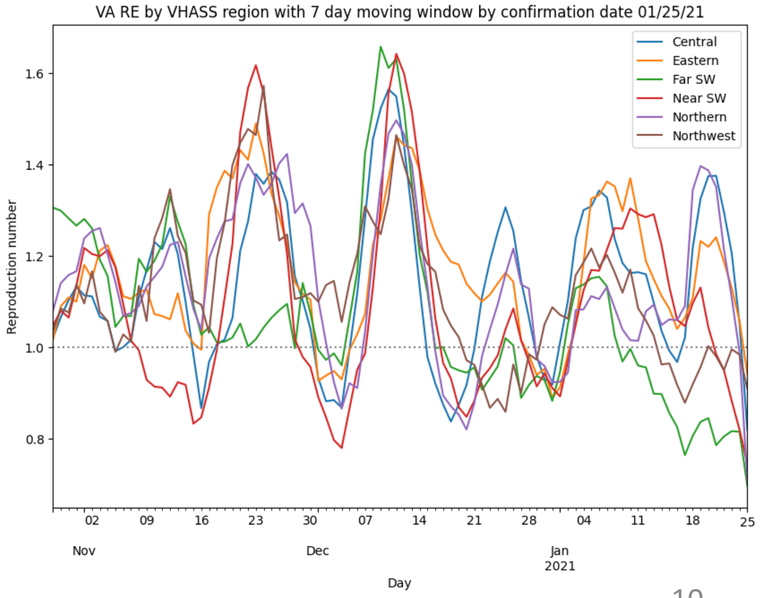
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.809	-0.340
Central	0.820	-0.398
Eastern	0.942	-0.167
Far SW	0.698	-0.109
Near SW	0.746	-0.351
Northern	0.708	-0.636
Northwest	0.910	-0.010

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

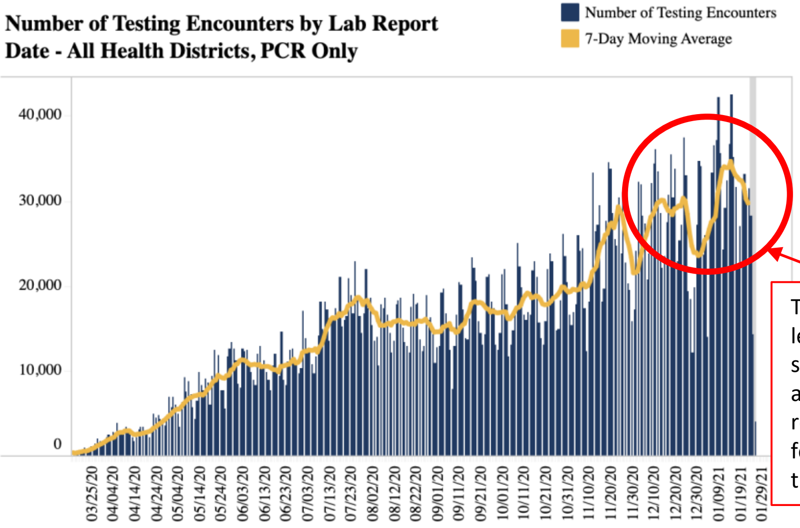
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133





Changes in Case Detection

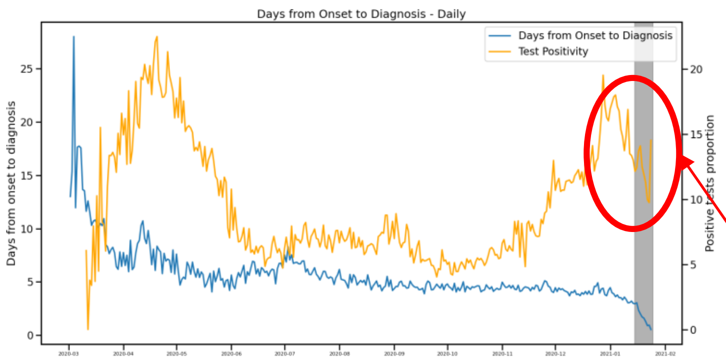
Timeframe (weeks)	Mean days	% difference from overall mean
May (17-21)	5.7	-21%
June (22-25)	5.8	-19%
July (26-30)	6.2	-14%
Aug (31-34)	4.9	-32%
Sept (35-38)	4.6	-37%
Oct (39-43)	4.5	-38%
Nov (44-47)	4.5	-38%
Dec (48-49)	4.1	-43%
Jan (00-01)	4.1	-47%
Overall (13-01)	7.2	--



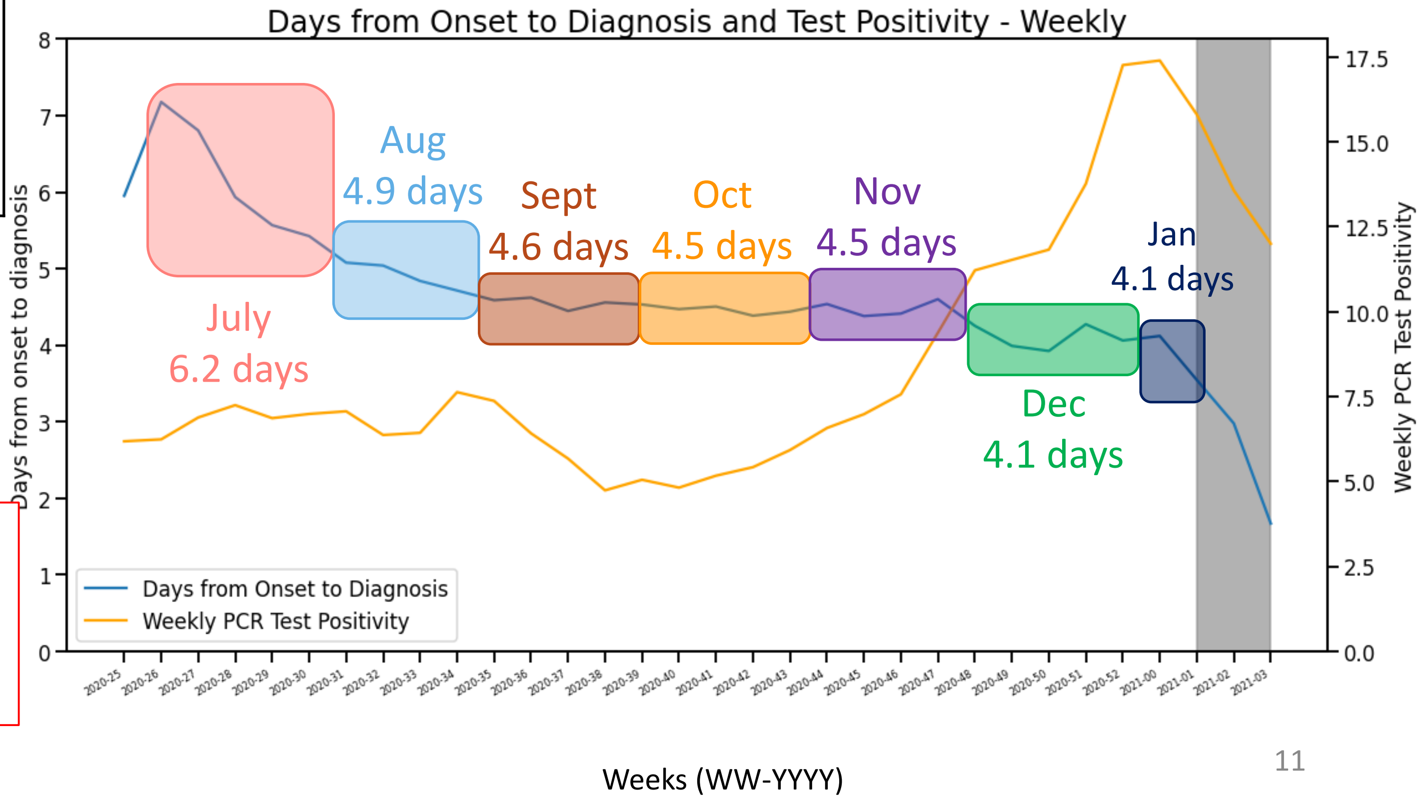
Testing levels show slight dip after strong rebound following the holidays

Accessed 9:00am January 27, 2021
https://www.vdh.virginia.gov/coronavirus/

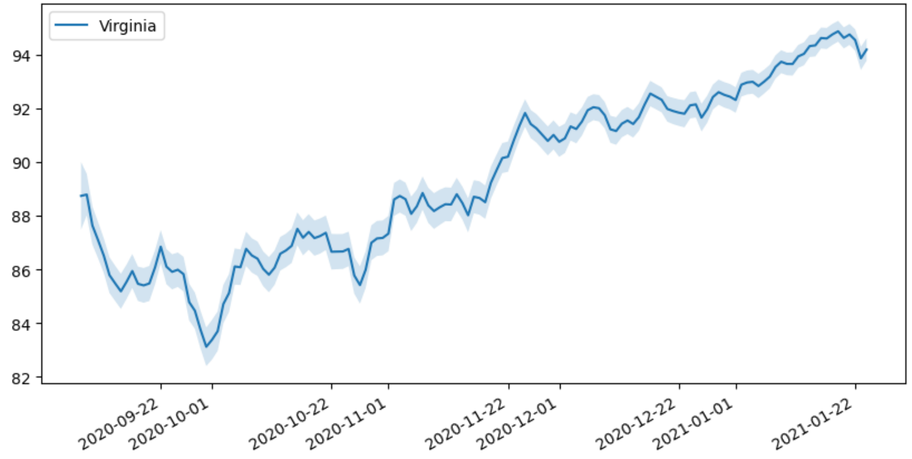
Test positivity vs. Onset to Diagnosis

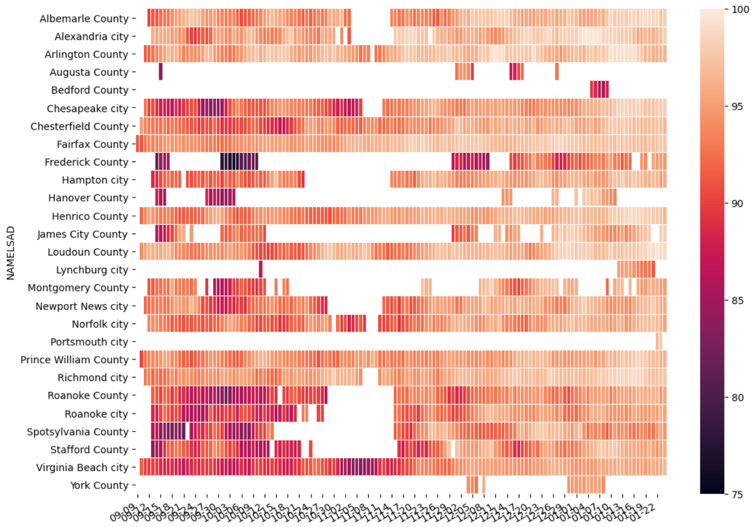


Positivity remains high but is down overall



Mask usage in Virginia



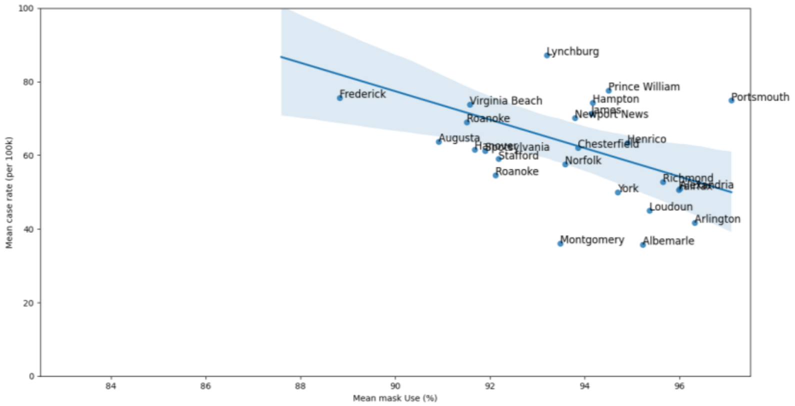


Some county level fluctuations since beginning of Sept., though data quality may be affected by sample sizes

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

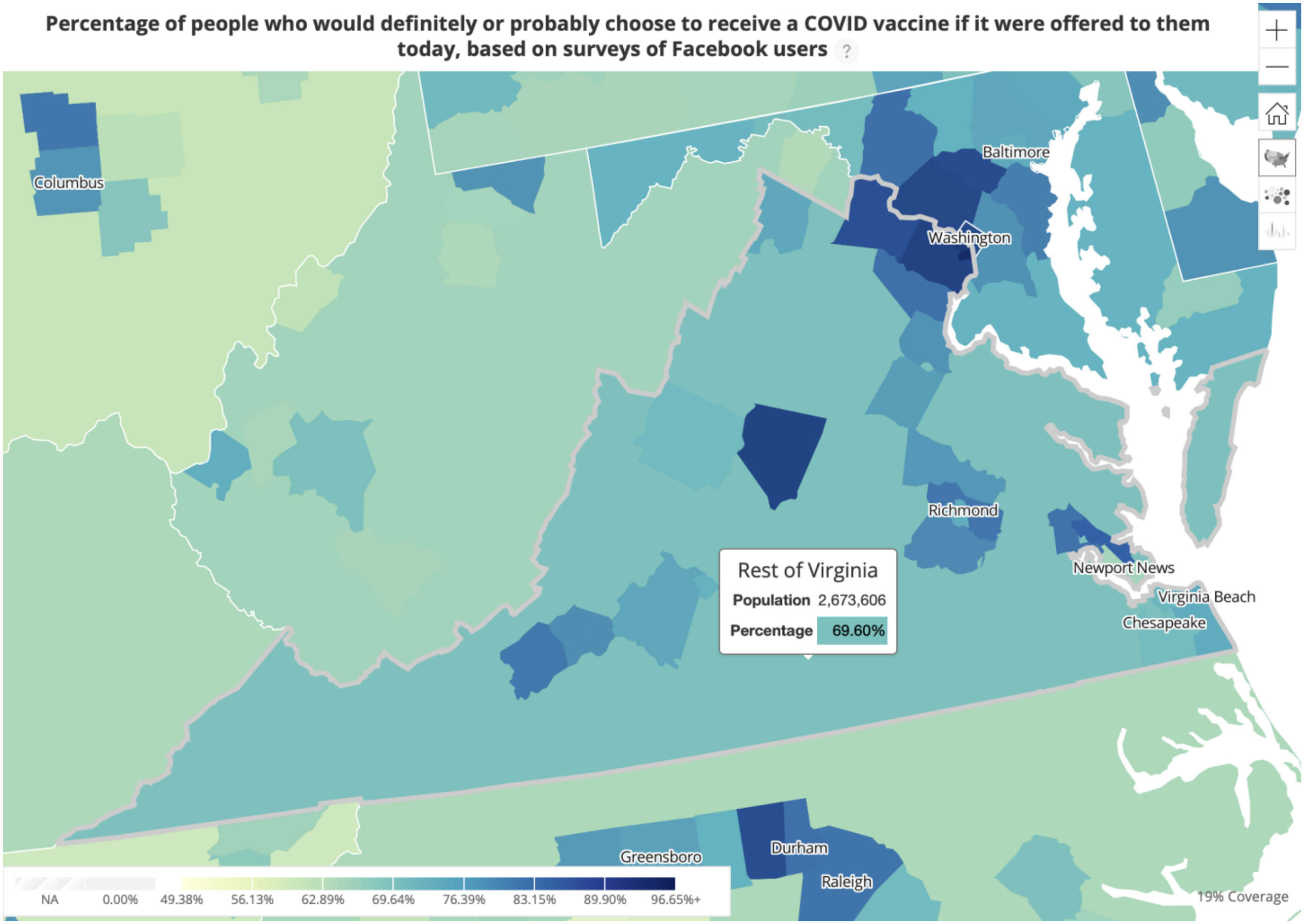


Correlations seen among VA counties between mask use and case rate are now stronger due to surging growth
Slope: - 3.8; for every % we see a ~4/100K case rate difference

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)



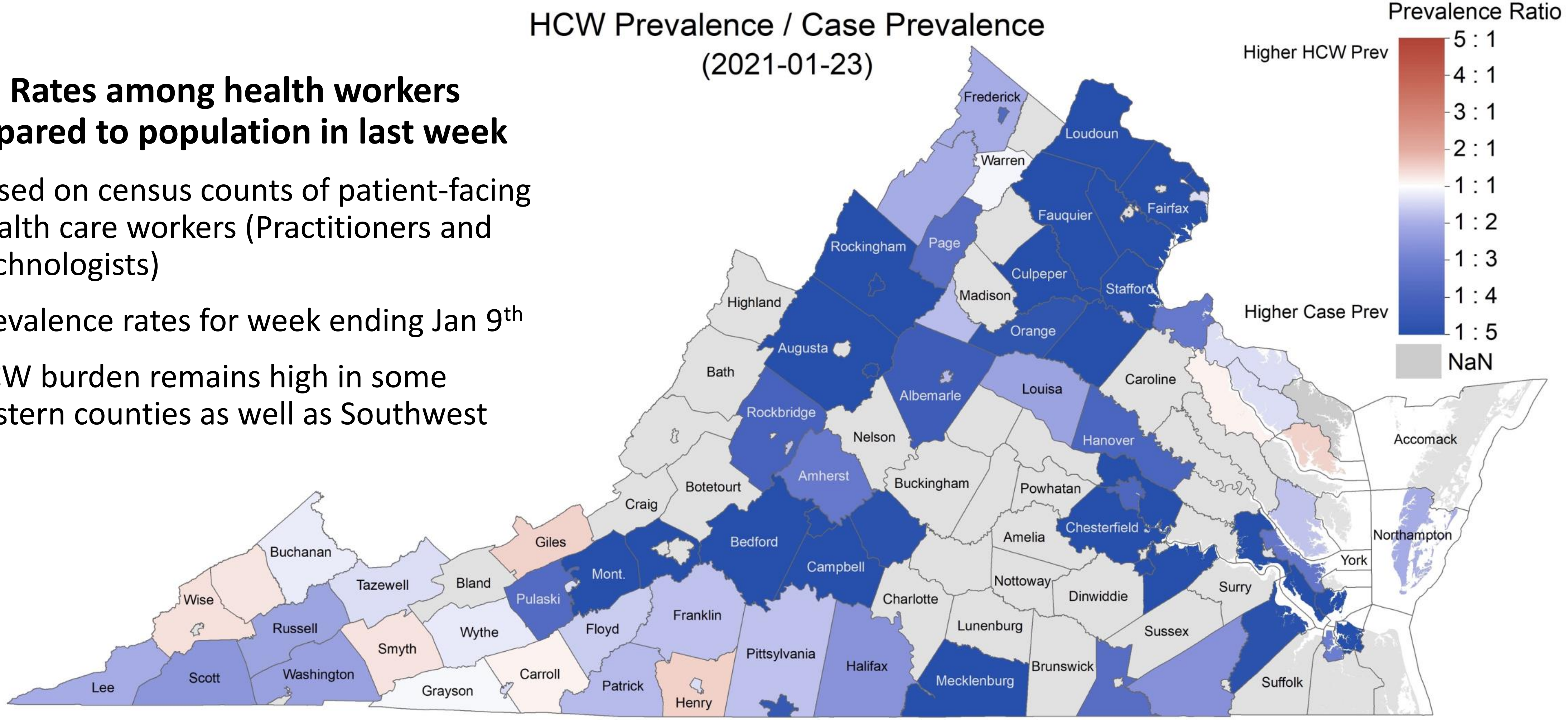
[COVIDcast Data Explorer](https://covidcast.cmu.edu)

Source: https://covidcast.cmu.edu

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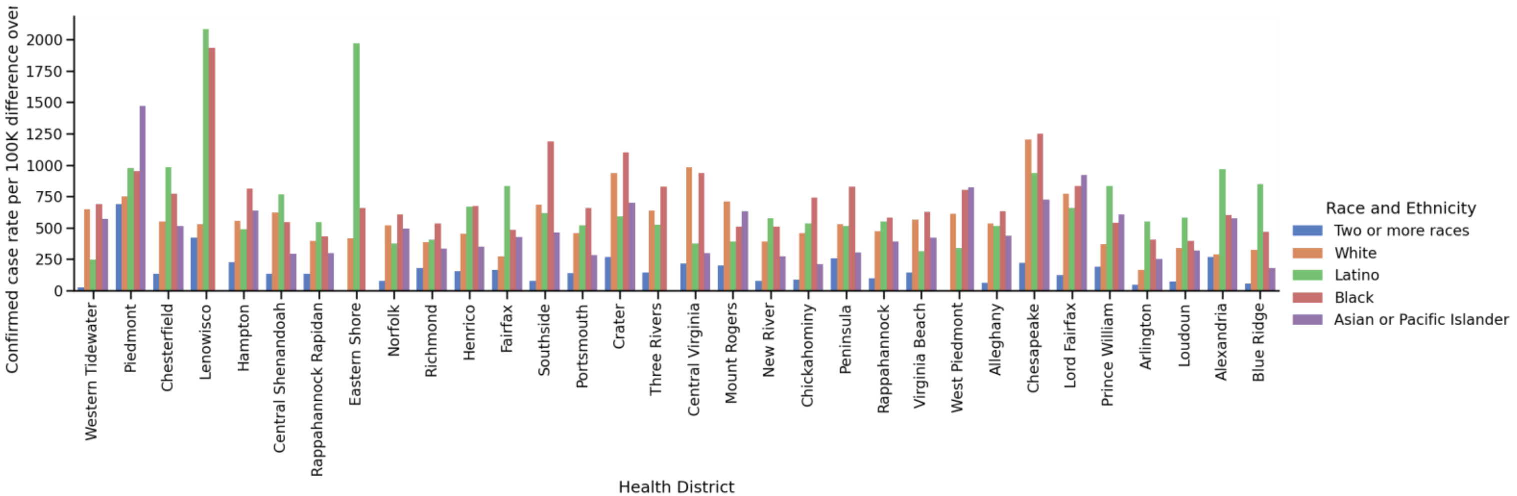
Race and Ethnicity – Recent Rate Changes (per 100K)

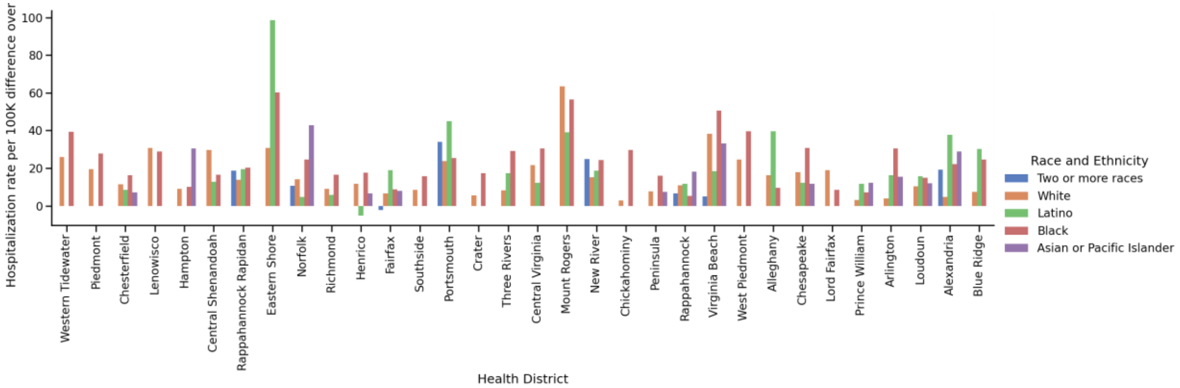
Recent Changes in Race and Ethnicity Rates (per 100k)

- 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

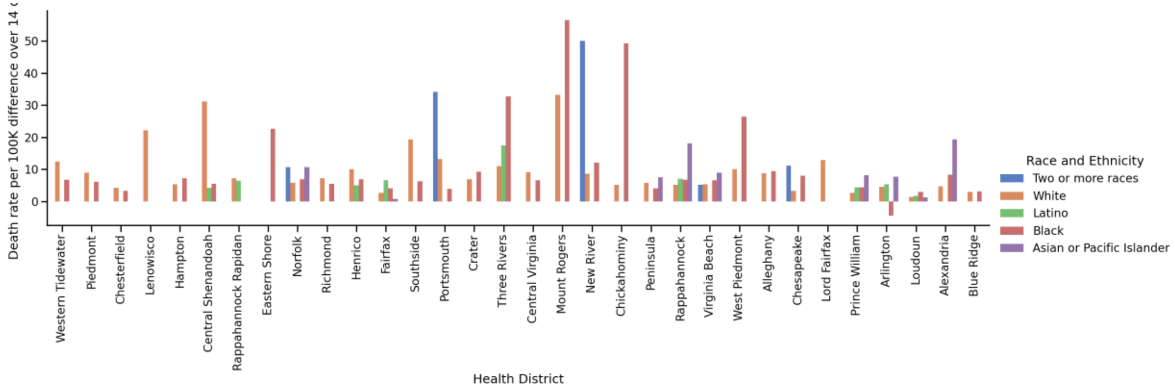
Case Rate



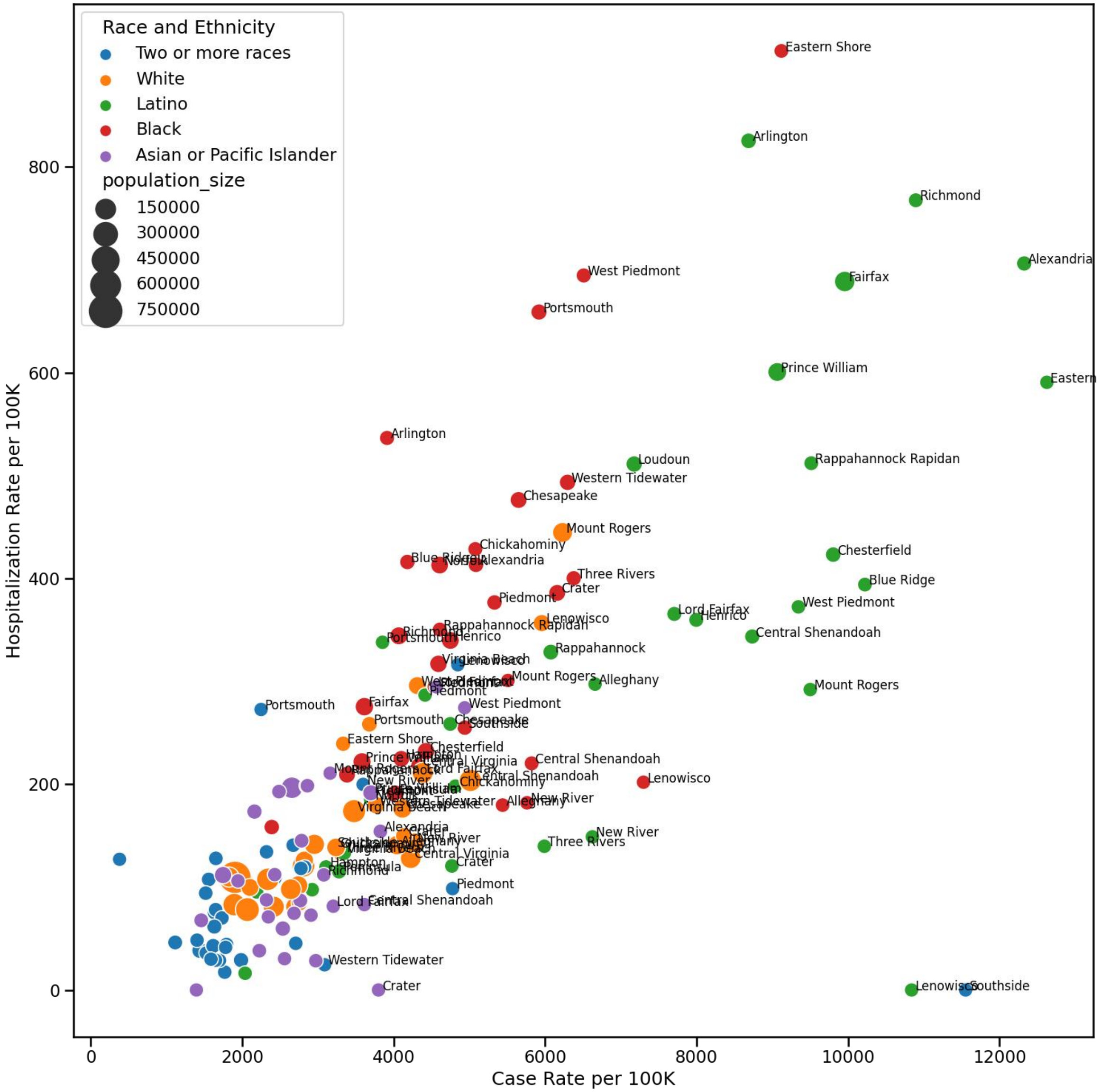
Hospitalization Rate



Death Rate



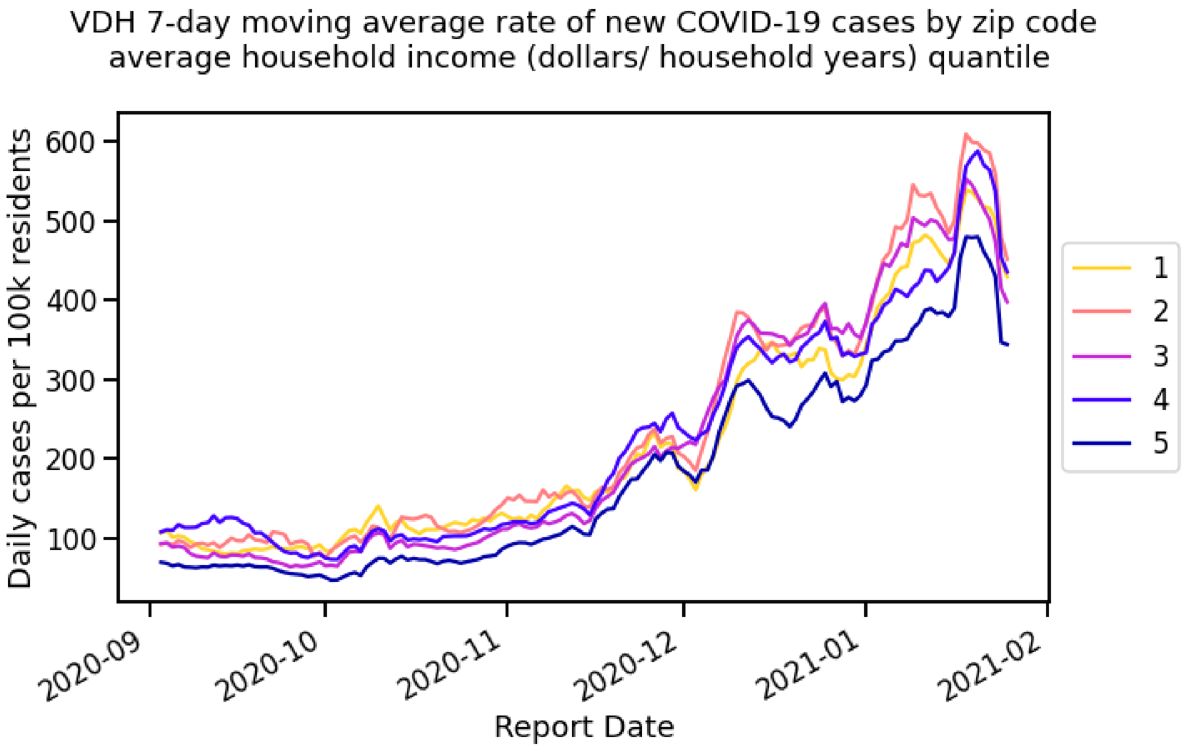
Race and Ethnicity cases per 100K



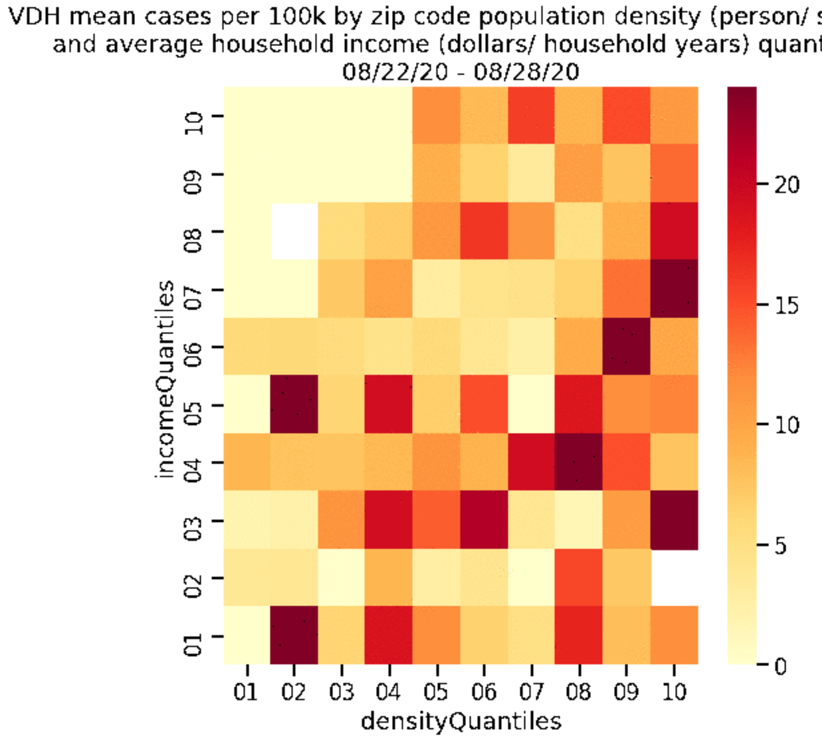
Rates per 100K of each Racial-Ethnic population by Health District

- 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



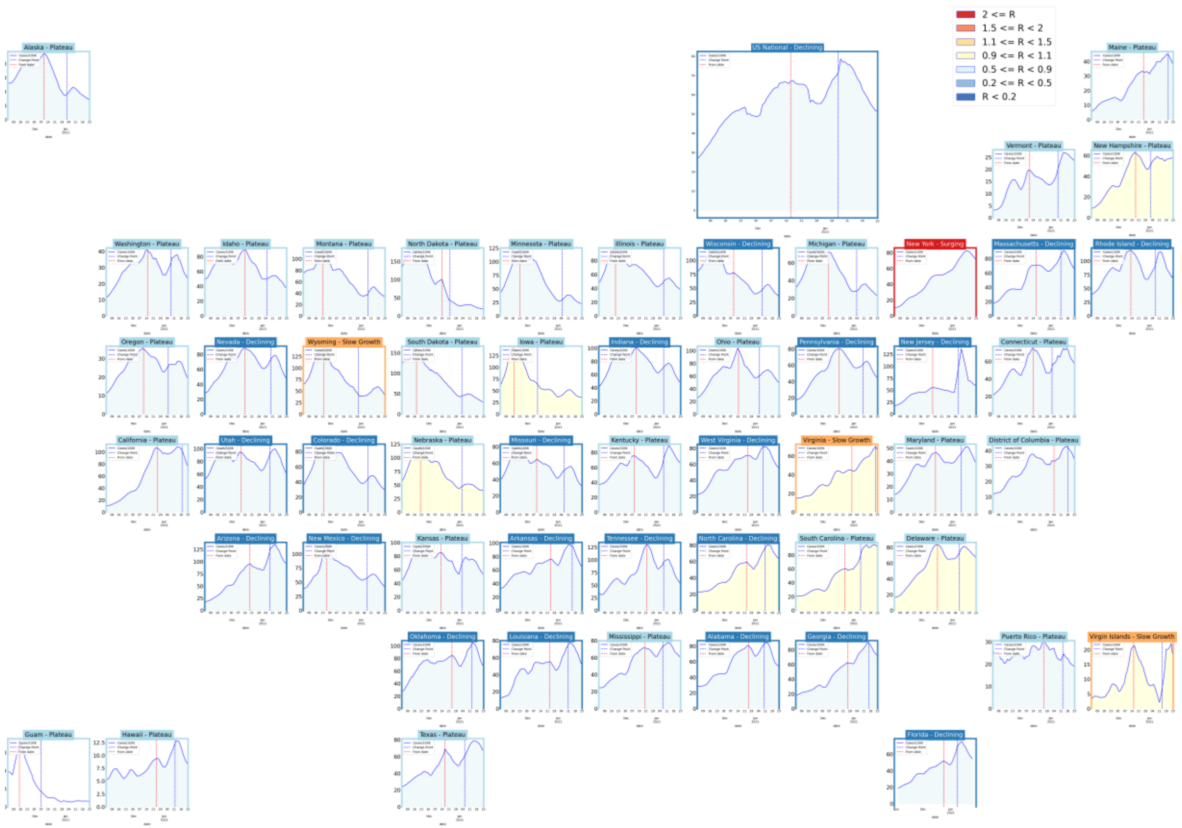
All zip codes show back into growth, wealthiest zip code now lags the rest significantly



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

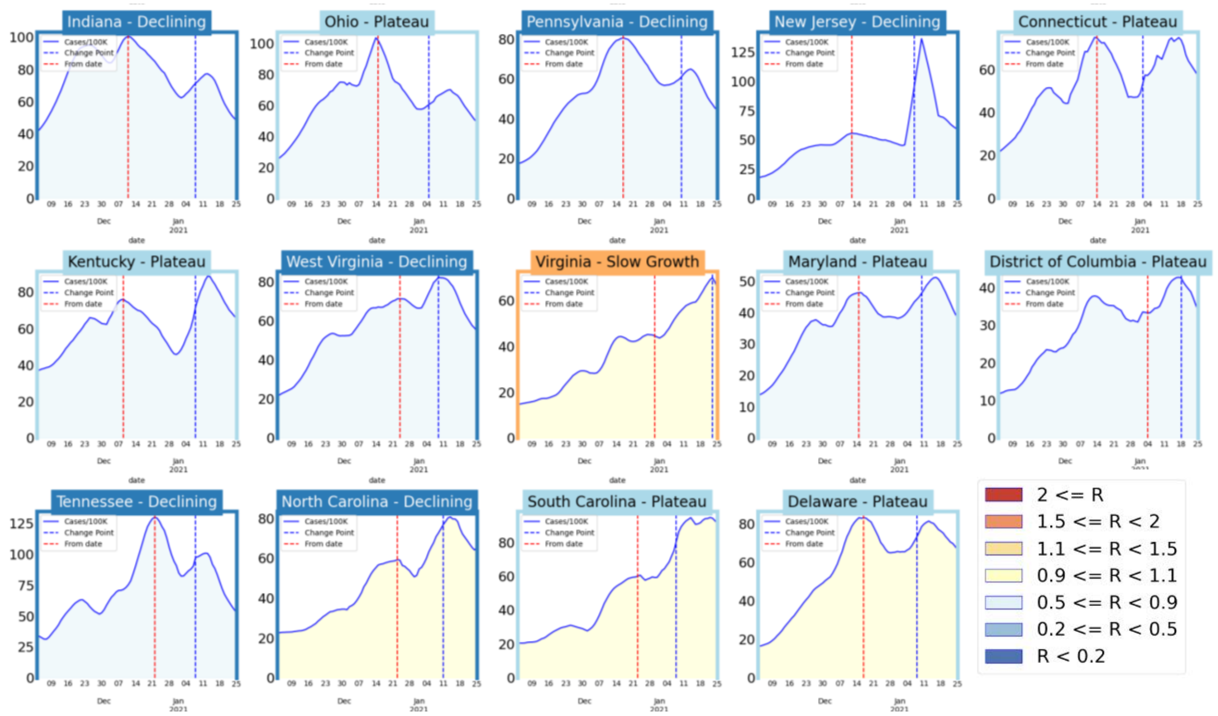
Other State Comparisons

Trajectories of States



- After a short rebound most states are plateauing (29) or declining (21)

Virginia and her neighbors



- VA growth has slowed, but is one of 3 states with slow growth
- VA and her neighbors remain relatively active compared to the rest of the US

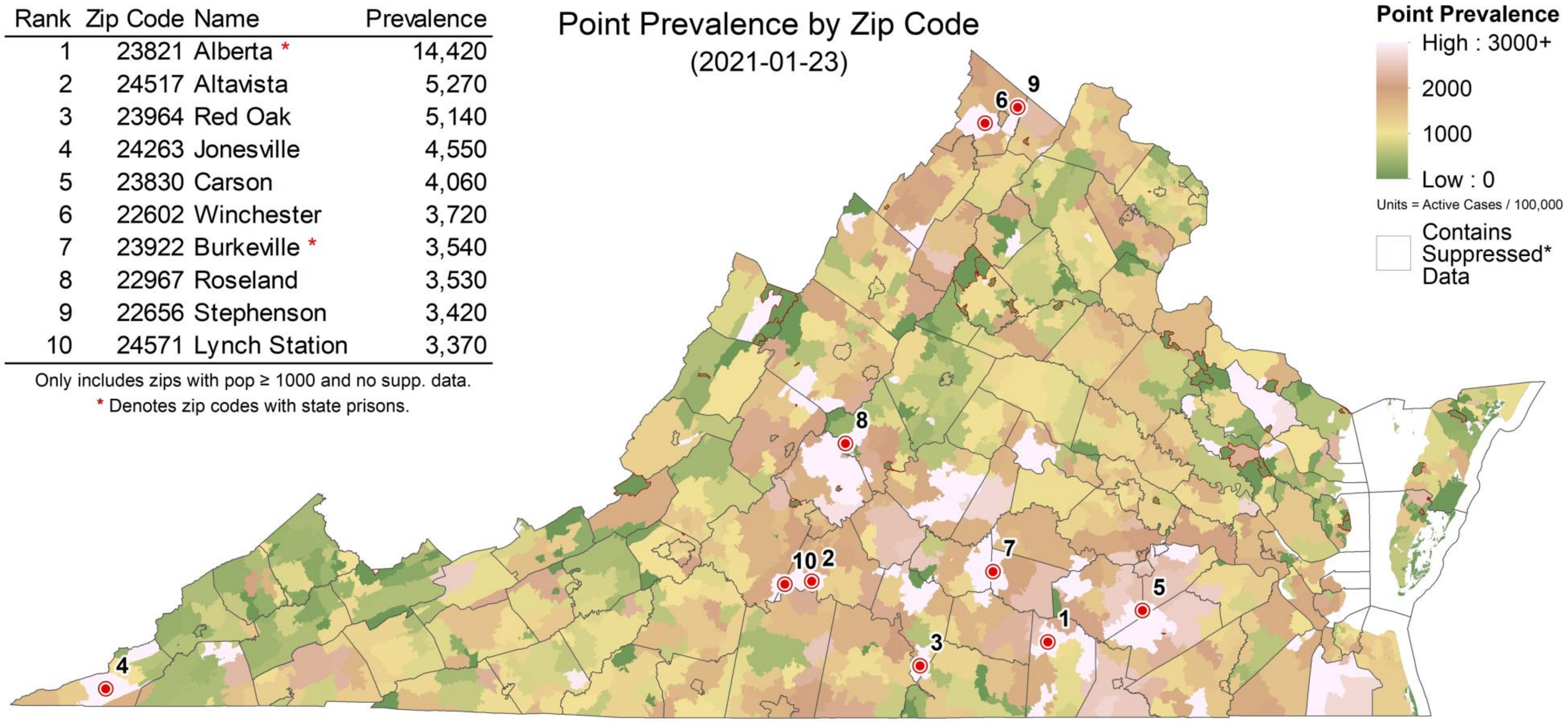
Zip code level weekly Case Rate (per 100K)

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	23821	Alberta *	14,420
2	24517	Altavista	5,270
3	23964	Red Oak	5,140
4	24263	Jonesville	4,550
5	23830	Carson	4,060
6	22602	Winchester	3,720
7	23922	Burkeville *	3,540
8	22967	Roseland	3,530
9	22656	Stephenson	3,420
10	24571	Lynch Station	3,370

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



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Risk of Exposure by Group Size

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

- 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 20 in Staunton, 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	23821	Alberta *	12
2	24517	Altavista	12
3	23964	Red Oak	14
4	24263	Jonesville	15
5	23830	Carson	17
6	22602	Winchester	17
7	23922	Burkeville *	17
8	22967	Roseland	18
9	22656	Stephenson	19
10	24571	Lynch Station	19

Only includes zips with pop ≥ 1000 and no supp. data.
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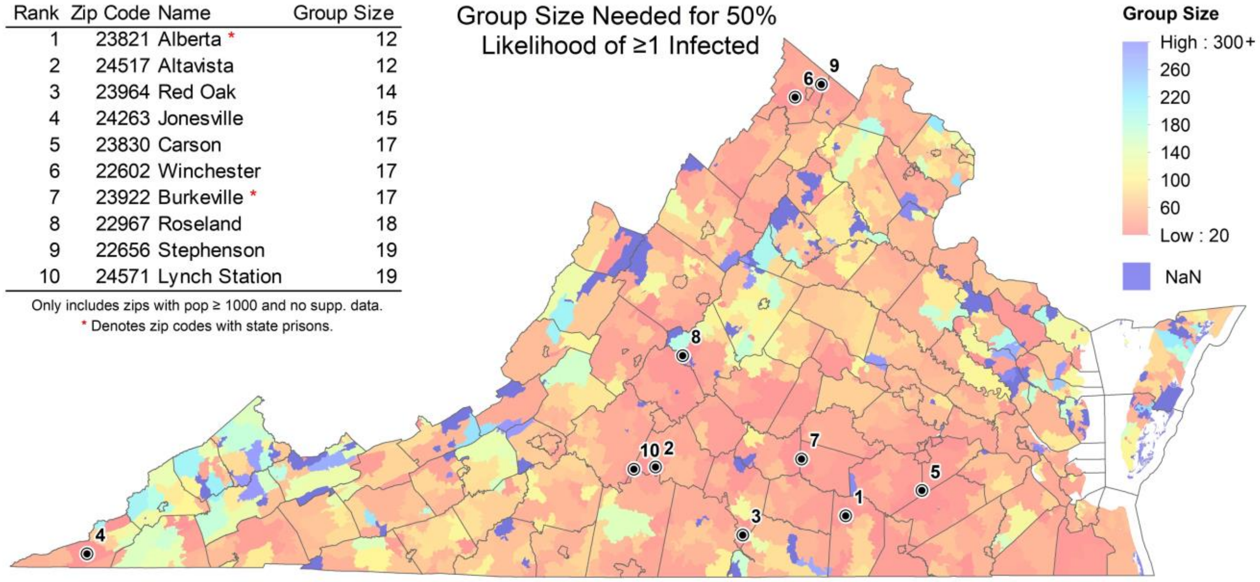
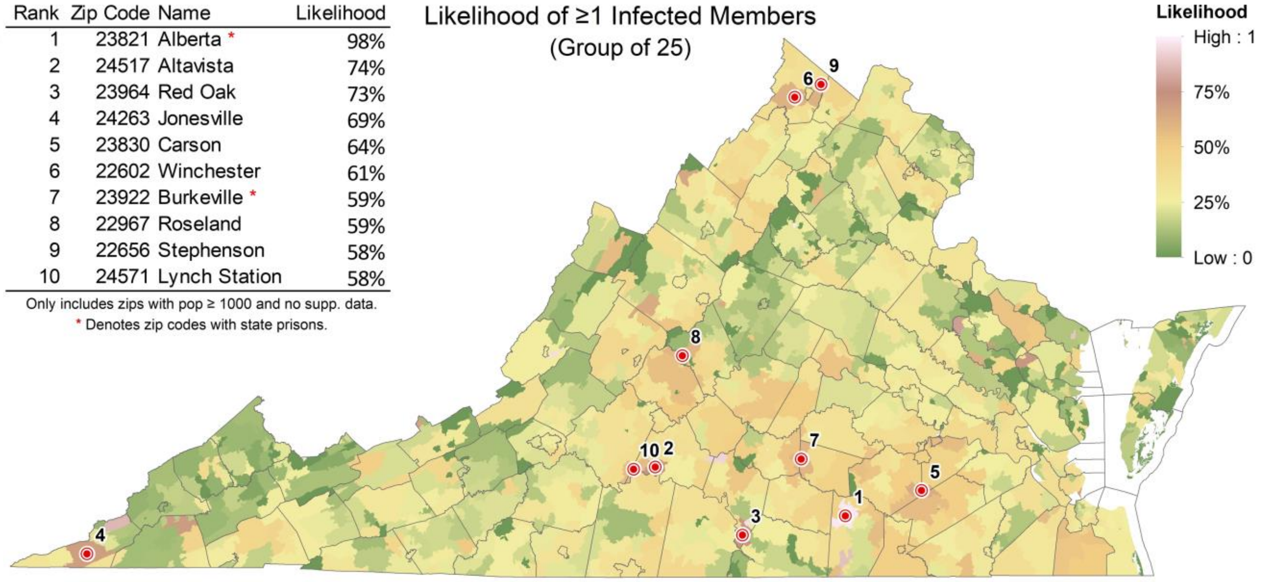


Based on zip code point prevelence for week ending 2021-01-23

Rank	Zip Code	Name	Likelihood
1	23821	Alberta *	98%
2	24517	Altavista	74%
3	23964	Red Oak	73%
4	24263	Jonesville	69%
5	23830	Carson	64%
6	22602	Winchester	61%
7	23922	Burkeville *	59%
8	22967	Roseland	59%
9	22656	Stephenson	58%
10	24571	Lynch Station	58%

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 2021-01-23

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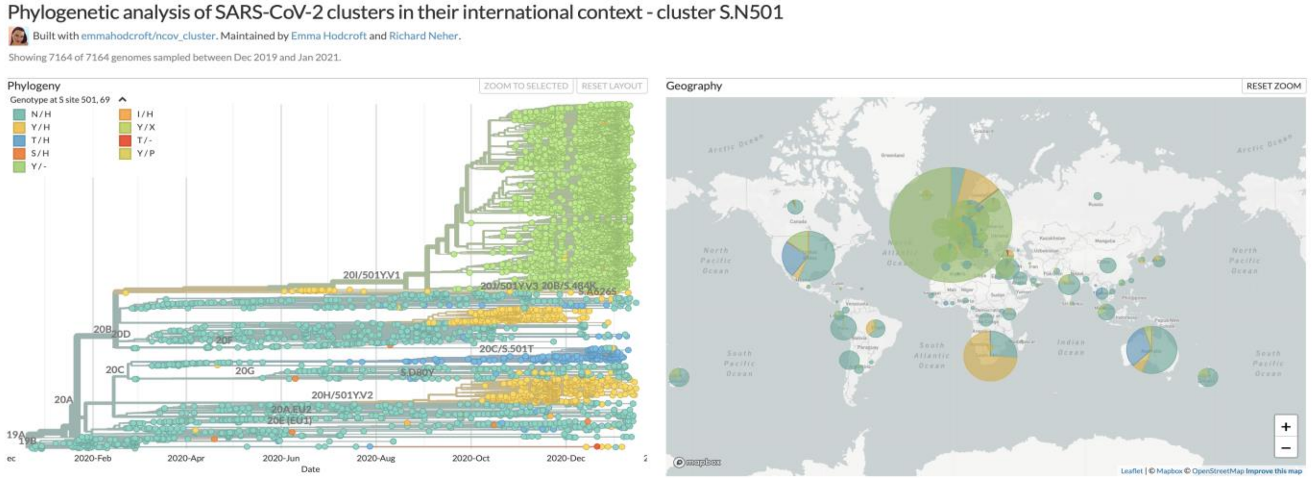
New variants of SARS-CoV2

Emerging new variants with increased transmissibility limited evidence of higher severity

- Evolution expected when virus under selective pressure

Lineage B.1.1.7

- B.1.1.7 has been detected in Virginia as well as in at least 293 cases across 25 states as of Jan 25th
- Given observed growth rate in UK and Denmark, estimate it will predominate in the US by mid-March
- Recent study suggests this variant may have higher mortality



nextstrain.org

Lineage B.1.351

- Emerging strain in South Africa is also of concern for vaccine escape
- Experiments have demonstrated reduced potency of convalescent sera and monoclonal antibodies
- Moderna vaccine demonstrated to have robust response to this variant and thus likely to remain highly effective

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

- First case reported in Minnesota on Monday Jan 25th
- 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

Model Update – Adaptive Fitting

Adaptive Fitting Approach

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

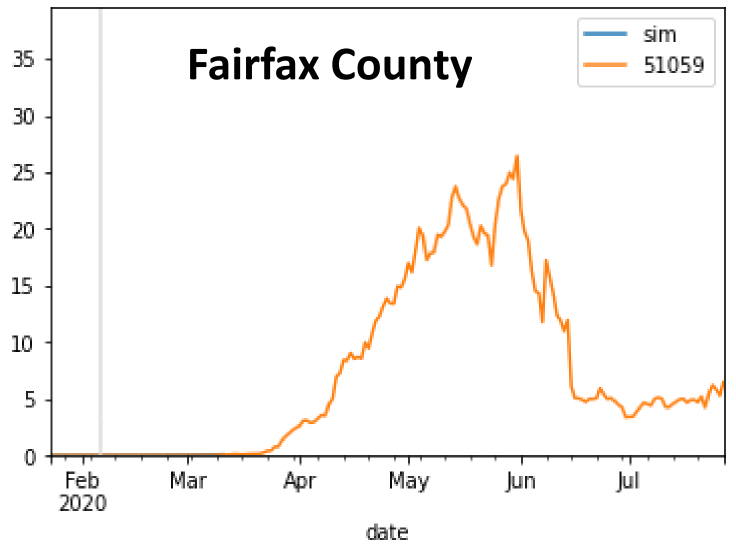
- Allows history to be precisely captured, and used to guide bounds on projections

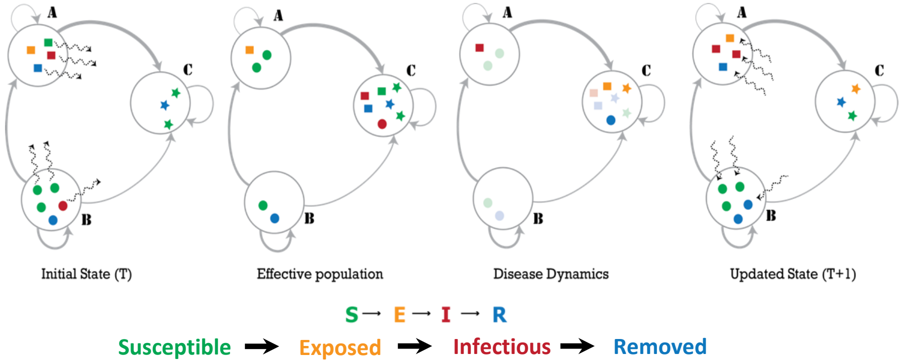
Model: An alternative use of the same meta-population model, PatchSim

  - 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

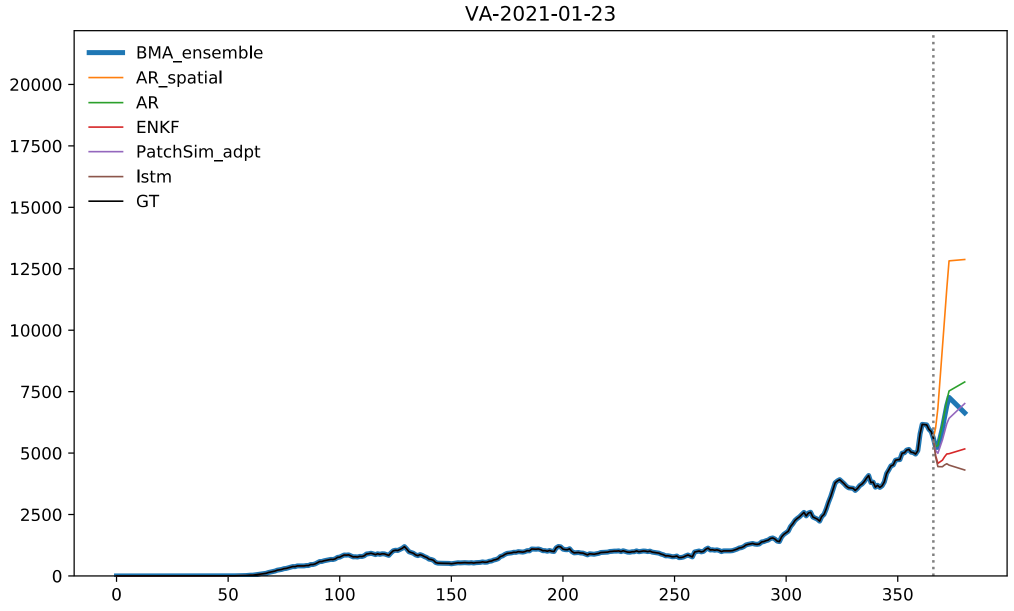


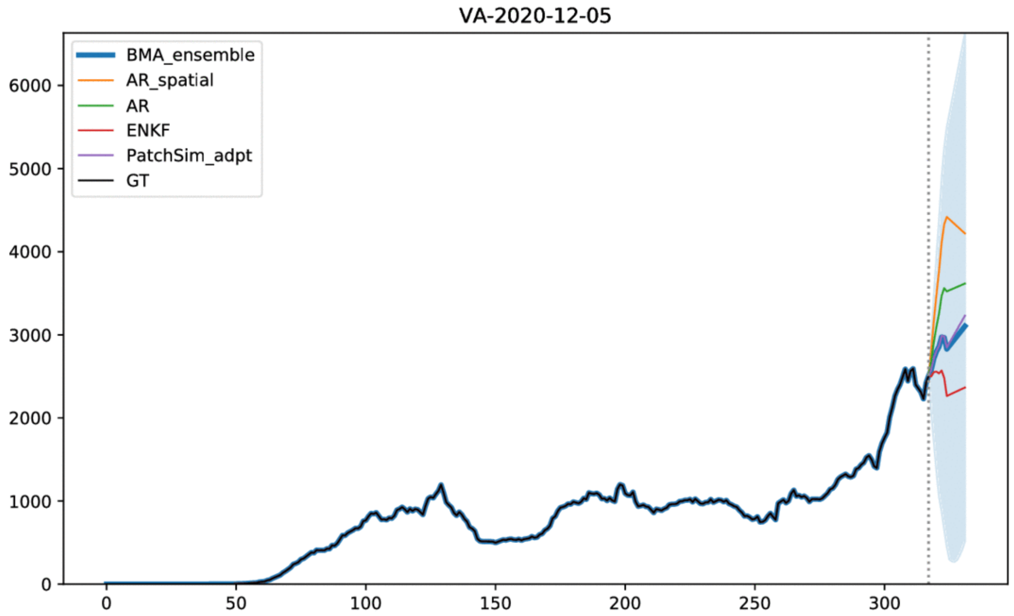


Using Ensemble Model to Guide Projections

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 15th)
- CDC Nationwide Commercial Laboratory Seroprevalence Survey estimated 4.6% [3.0% – 6.6%] seroprevalence as of Nov 12th – 26th 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%

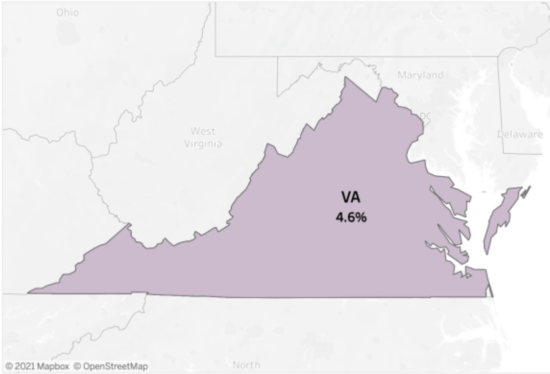
Number of Estimated Infections

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

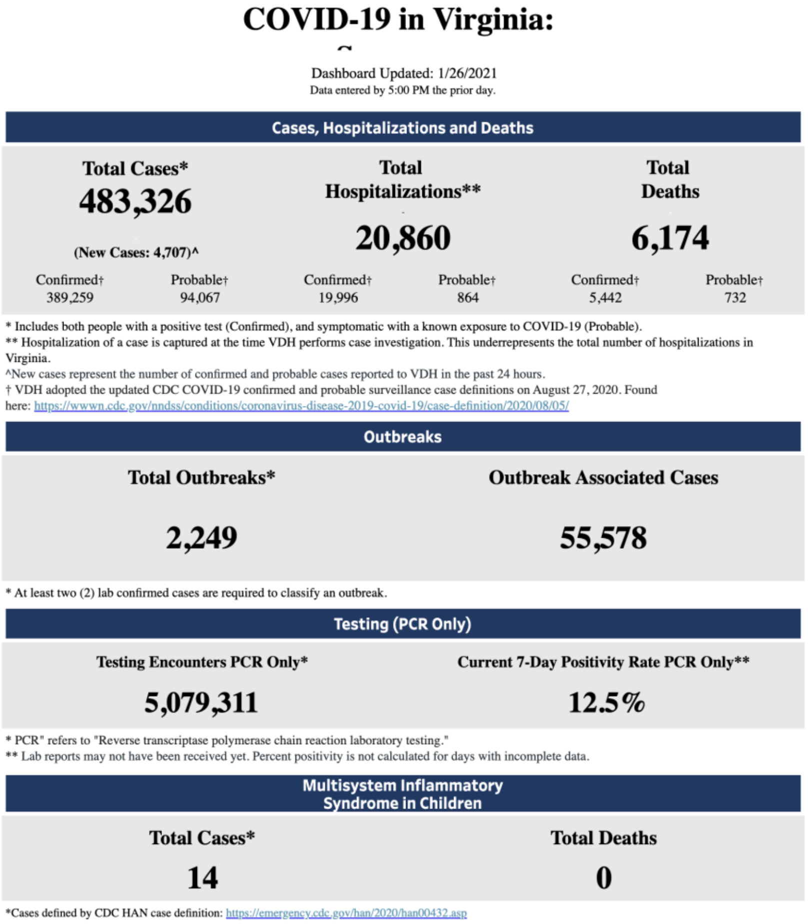
Region	Number of participants	Number antibody positive	Crude prevalence per 100 participants	Weighted prevalence* per 100 population	Weighted prevalence* (95% CI)
Central	400	8	2.0	3.0	(0.5, 5.5)
East	707	9	1.3	1.5	(-0.2, 3.2)
Northern	819	36	4.4	4.2	(2.5, 5.9)
Northwest	756	11	1.5	0.9	(0.2, 1.6)
Southwest	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: 1/26/2021
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*		Total Hospitalizations**		Total Deaths	
483,326 (New Cases: 4,707)^		20,860		6,174	
Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
389,259	94,067	19,996	864	5,442	732

* 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
2,249	55,578

* 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**
5,079,311	12.5%

* 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
14	0

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

Accessed 9:00am January 27, 2021

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

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%

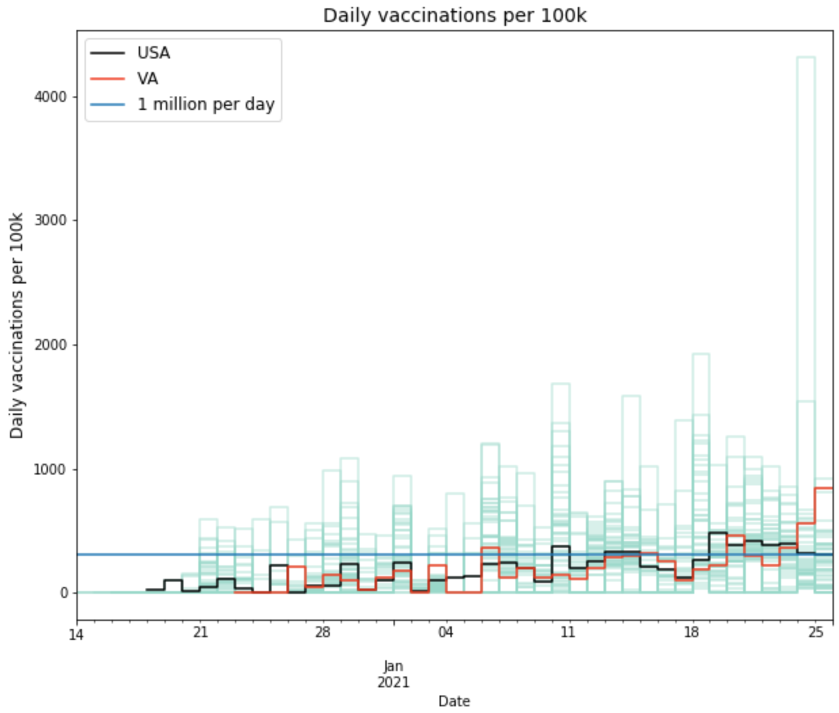
Scenarios – Novel Variants

- 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:
  - **NewVariants**: 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% with 25M per month this is reached in Aug 2021.

US Vaccination Rates



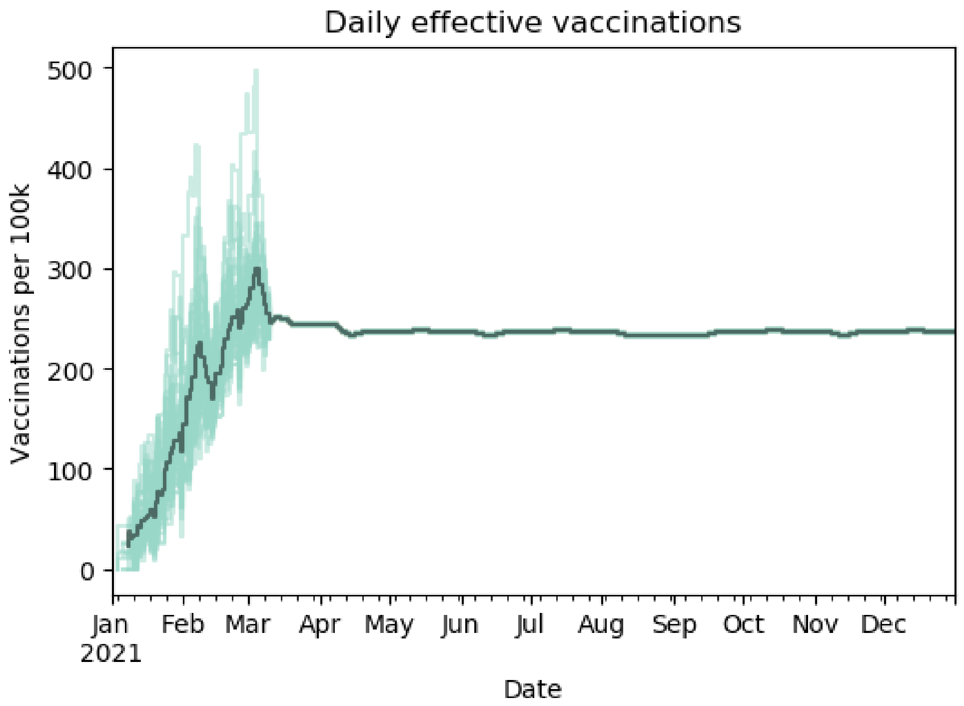
Line represents 1M doses a day goal

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

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 24)
  - Future courses based on current goals and consensus
    - **Rate**: 25M started per month in US, ~250 /100K a day
    - **Location**: Per capita distribution across all counties
  - Rates in VA for Jan 17-24 are ~420 doses administered /100K a day (some are 2^{nd} doses)

Modeled Vaccine Induced Immunity



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

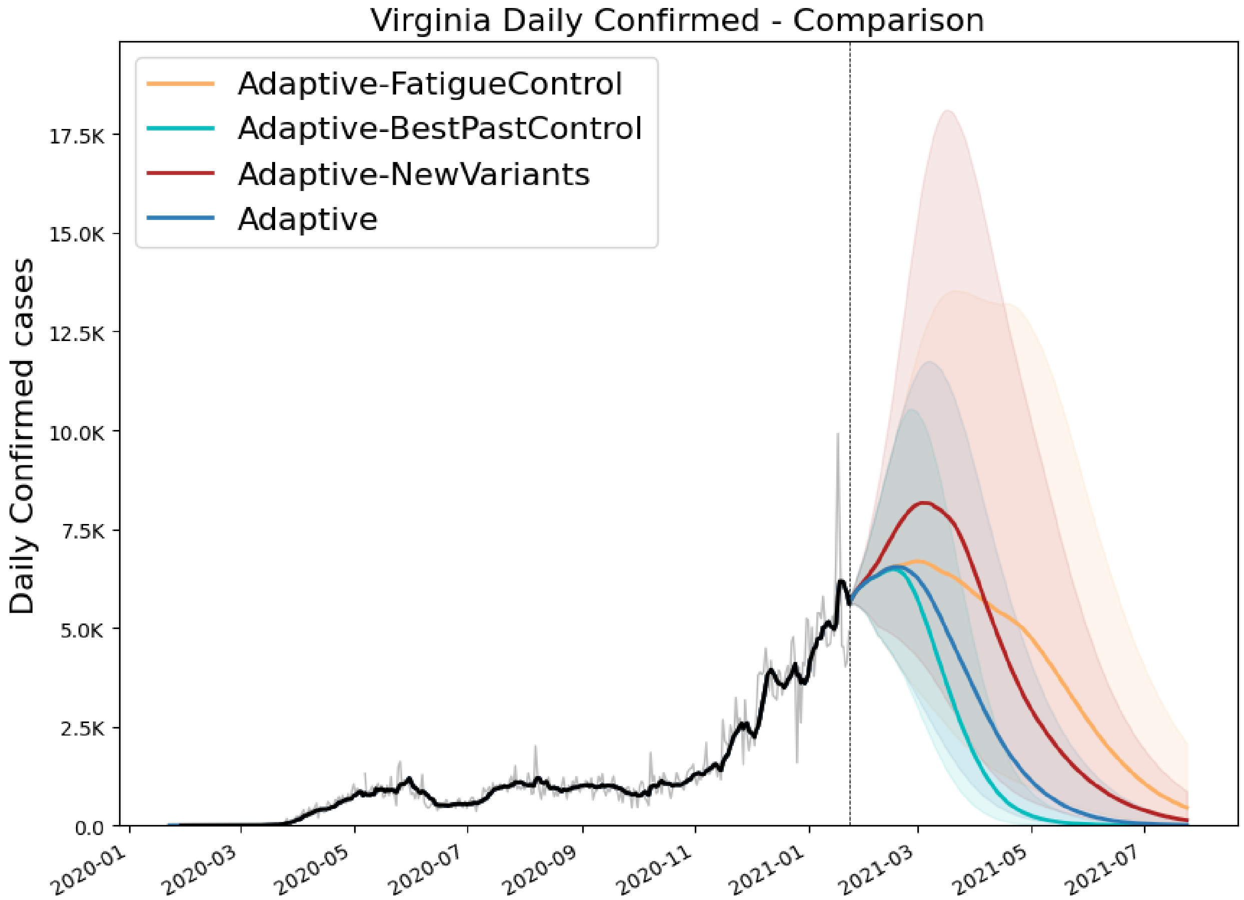
Three scenarios combine these seasonal effects and use the updated vaccine schedule

- **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-BestPastControl**: Best of the past control seasonal effects
  - If we revert to best control experienced in last 6 months
- **Adaptive-NewVariants**: Boosting of transmissibility from the emergence and eventual ubiquity of more transmissible variants
  - If new variants begin to predominate and boost transmission, this assumes current seasonal affects remain the same (eg like Adaptive)
- Counterfactuals with no vaccine ("NoVax") are provided for comparison purposes

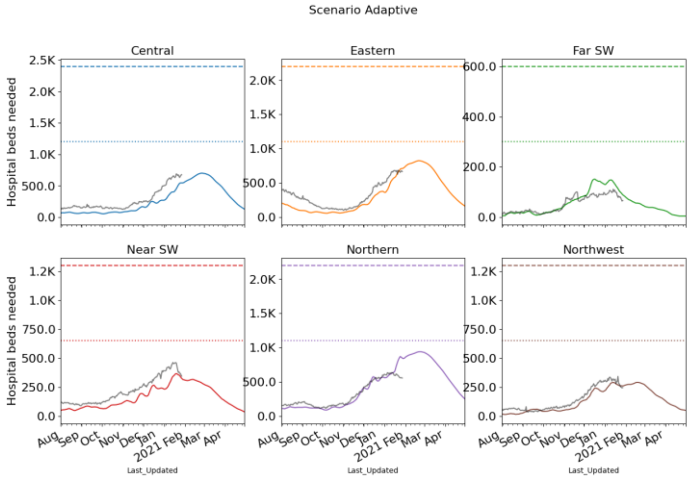
Model Results

Outcome Projections

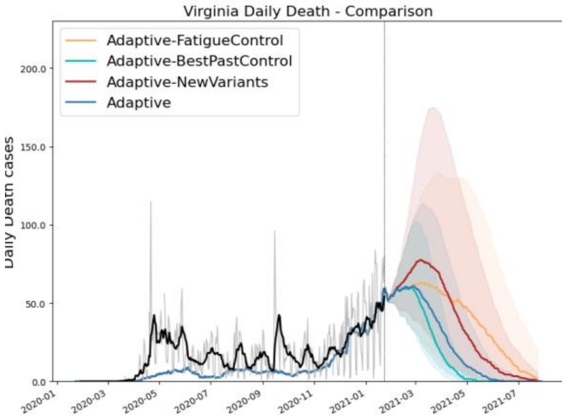
Confirmed cases



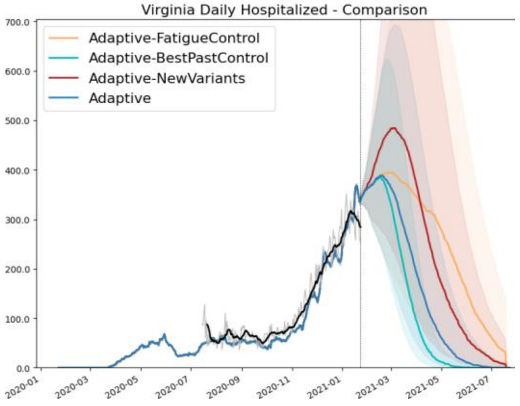
Estimated Hospital Occupancy



Daily Deaths



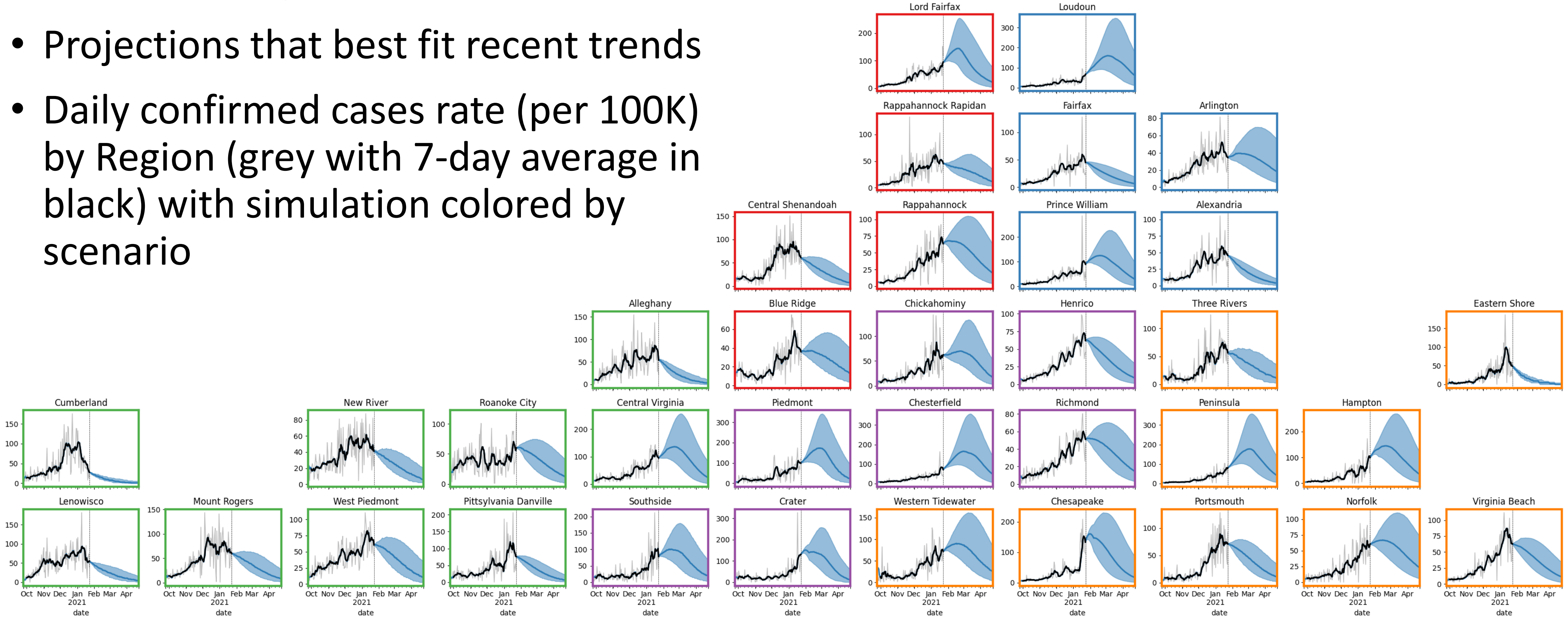
Daily Hospitalized



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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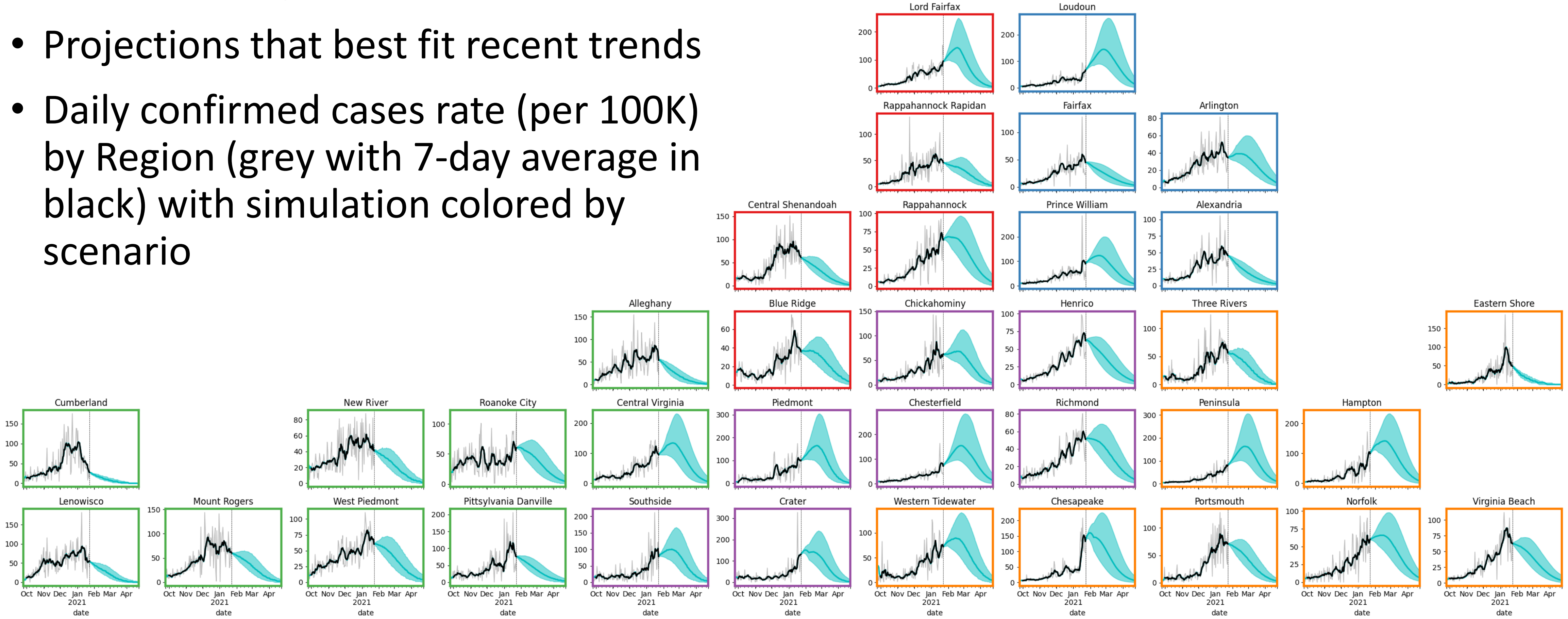
District Level Projections: Adaptive-BestPastControl

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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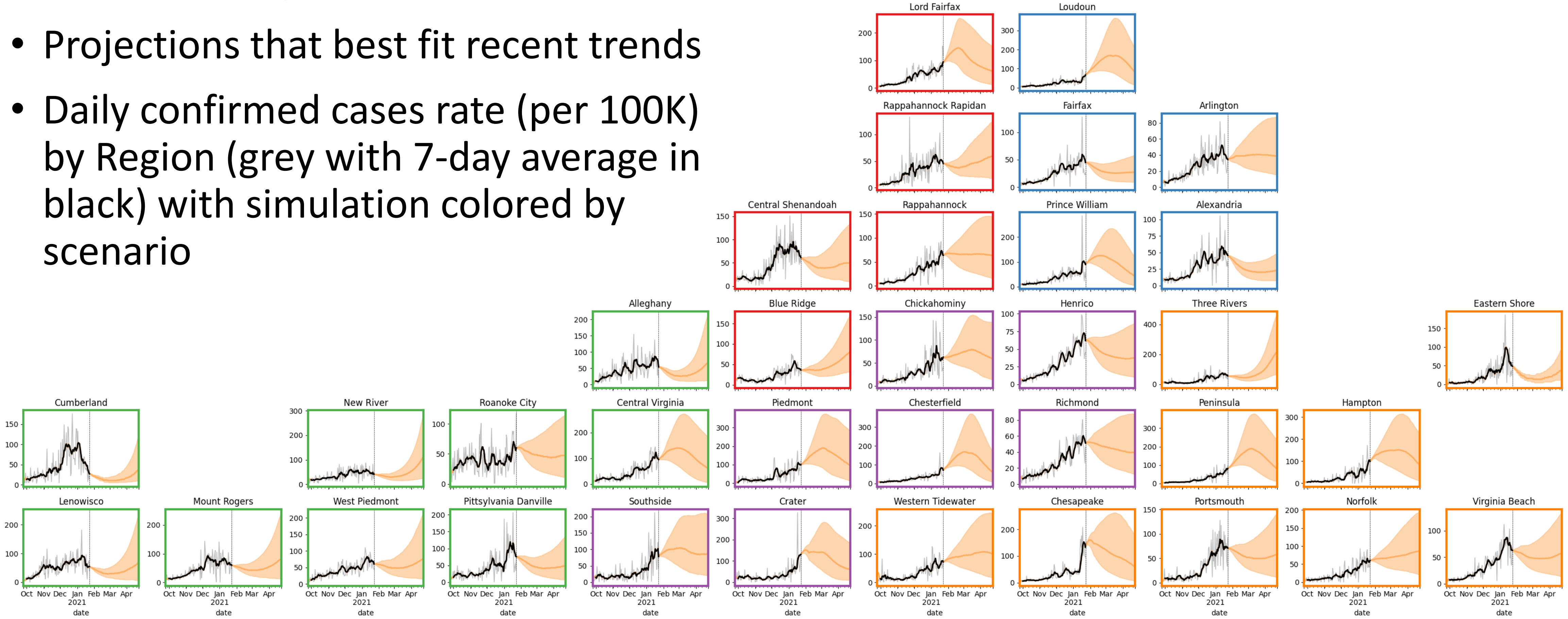
District Level Projections: Adaptive-FatigueControl

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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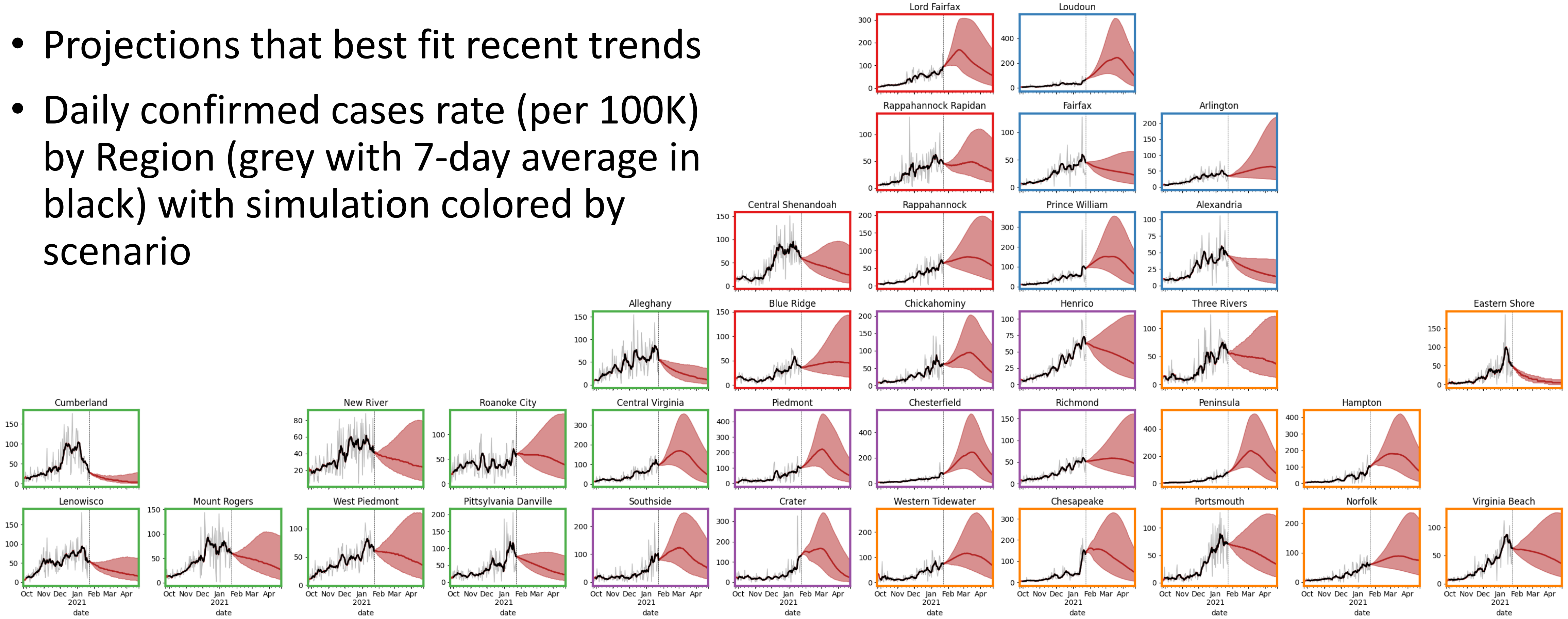
District Level Projections: Adaptive-NewVariants

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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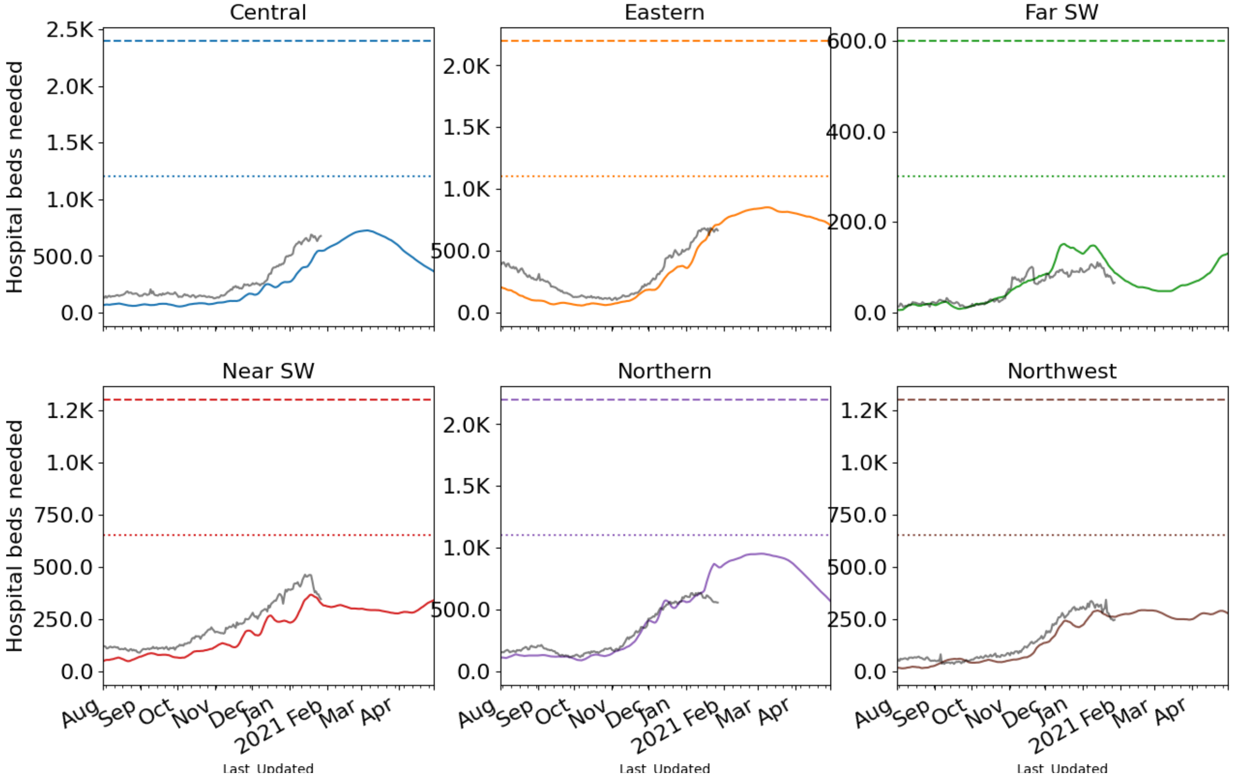
Hospital Demand and Bed Capacity by Region

Capacities* by Region – Adaptive-FatigueControl

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



Week Ending	Adaptive	Adaptive-Best Past Control	Adaptive-Fatigued Control	Adaptive-New Variants
1/24/21	41,663	41,660	41,659	41,660
1/31/21	41,820	41,822	41,837	41,972
2/7/21	43,748	43,670	43,766	44,999
2/14/21	45,117	44,903	45,134	48,730
2/21/21	45,721	45,170	45,974	52,764
2/28/21	44,900	42,669	46,529	55,822
3/7/21	42,419	37,356	46,612	57,075
3/14/21	38,396	30,630	45,550	56,326
3/21/21	33,581	23,793	44,381	54,367
3/28/21	28,716	17,572	42,901	50,487
4/4/21	23,803	12,297	41,007	44,623
4/11/21	19,175	8,211	39,219	38,225

Weekly confirmed cases

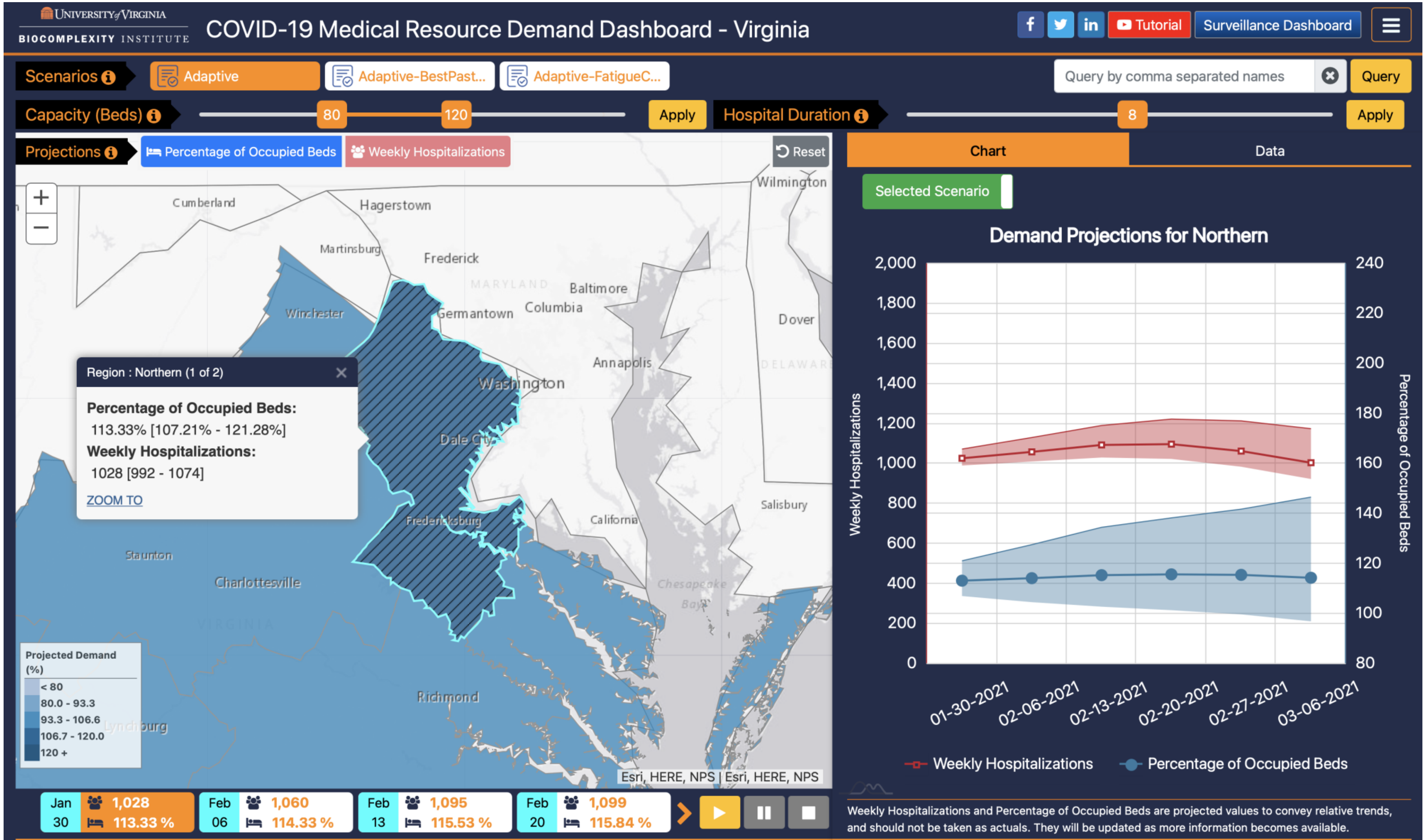
If Adaptive-FatigueControl scenario persists:

- Some regions approach initial bed capacity this winter
- Surge bed capacity is unlikely to be reached in coming 4 months

* Assumes average length of stay of 8 days

Medical Resource Demand Dashboard

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



Key Takeaways

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

- **Case rate growth in Virginia has slowed but remains high**
- VA mean weekly incidence down sharply 54/100K from 72/100K, as national levels continued to decline (to 45/100K from 54/100K)
- Projections are mixed across commonwealth with some short-term growth at state level mainly driven by central section of the state
- Recent updates:
  - Adjusted projection window to account for shifting trends
  - Scenarios based on past control levels (best and fatigued) and emerging new variants with enhanced transmissibility
  - Further updates to vaccination schedules, accounts for partial protection from first dose and merges observed doses with goals for future vaccine administration
- The situation is changing rapidly. Models will be updated regularly.

References

Venkatramanan, S., et al. "Optimizing spatial allocation of seasonal influenza vaccine under temporal constraints." *PLoS computational biology* 15.9 (2019): e1007111.

Arindam Fadikar, Dave Higdon, Jiangzhuo Chen, Bryan Lewis, Srinivasan Venkatramanan, and Madhav Marathe. Calibrating a stochastic, agent-based model using quantile-based emulation. SIAM/ASA Journal on Uncertainty Quantification, 6(4):1685–1706, 2018.

Adiga, Aniruddha, Srinivasan Venkatramanan, Akhil Peddireddy, et al. "Evaluating the impact of international airline suspensions on COVID-19 direct importation risk." *medRxiv* (2020)

NSSAC. PatchSim: Code for simulating the metapopulation SEIR model. https://github.com/NSSAC/PatchSim (Accessed on 04/10/2020).

Virginia Department of Health. COVID-19 in Virginia. http://www.vdh.virginia.gov/coronavirus/ (Accessed on 04/10/2020)

Biocomplexity Institute. COVID-19 Surveillance Dashboard. https://nssac.bii.virginia.edu/covid-19/dashboard/

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

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

Questions?

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Supplemental Slides

Estimating Daily Reproductive Number

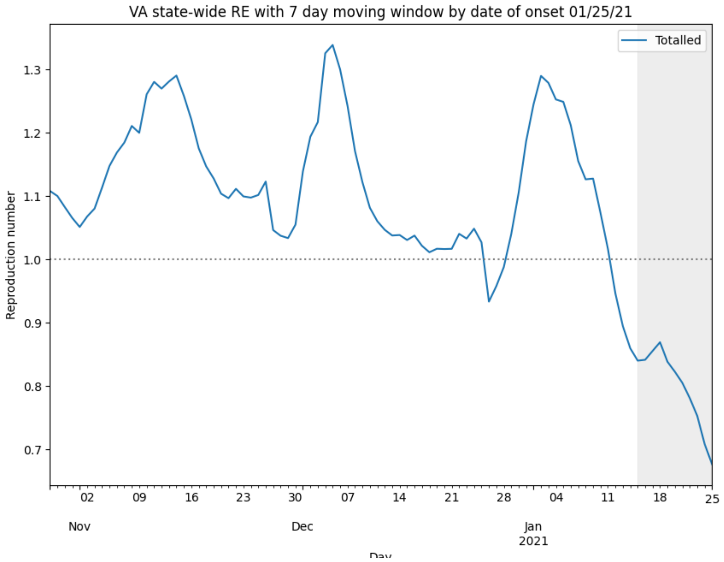
Jan 16th Estimates

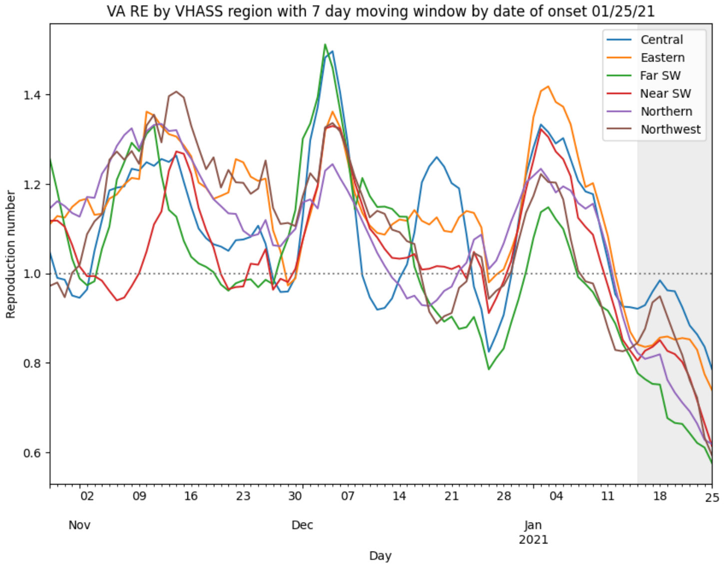
Region	Date of Onset R_e	Date Onset Diff Last Week
State-wide	0.842	-0.216
Central	0.929	-0.182
Eastern	0.835	-0.235
Far SW	0.763	-0.167
Near SW	0.827	-0.210
Northern	0.809	-0.300
Northwest	0.876	-0.053

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

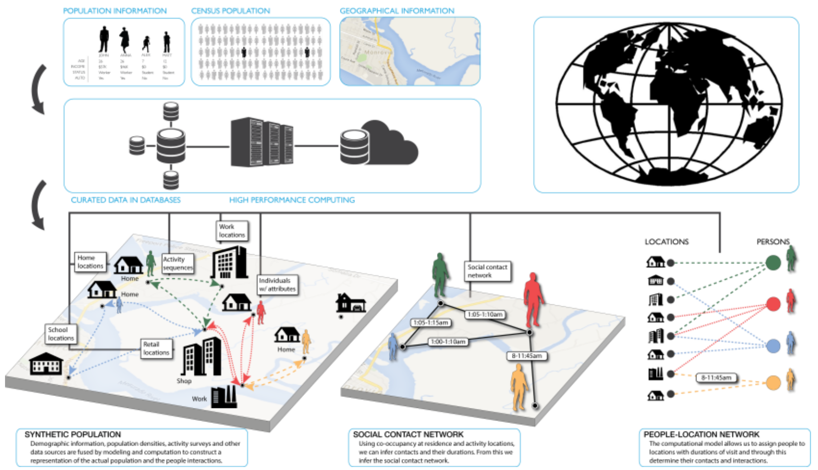




Agent-based Model (ABM)

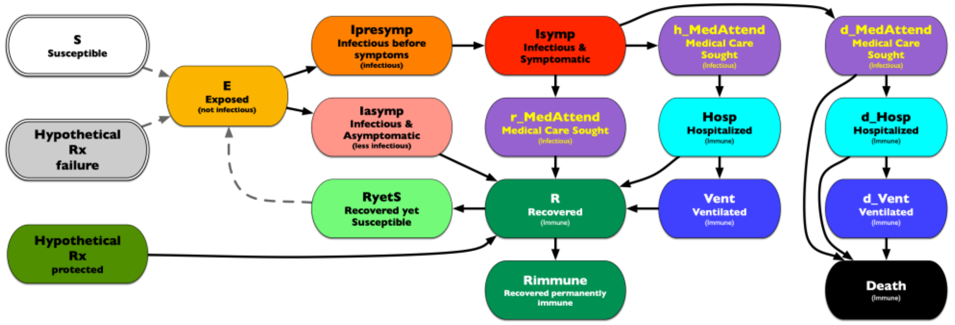
EpiHiper: Distributed network-based stochastic disease transmission simulations

- 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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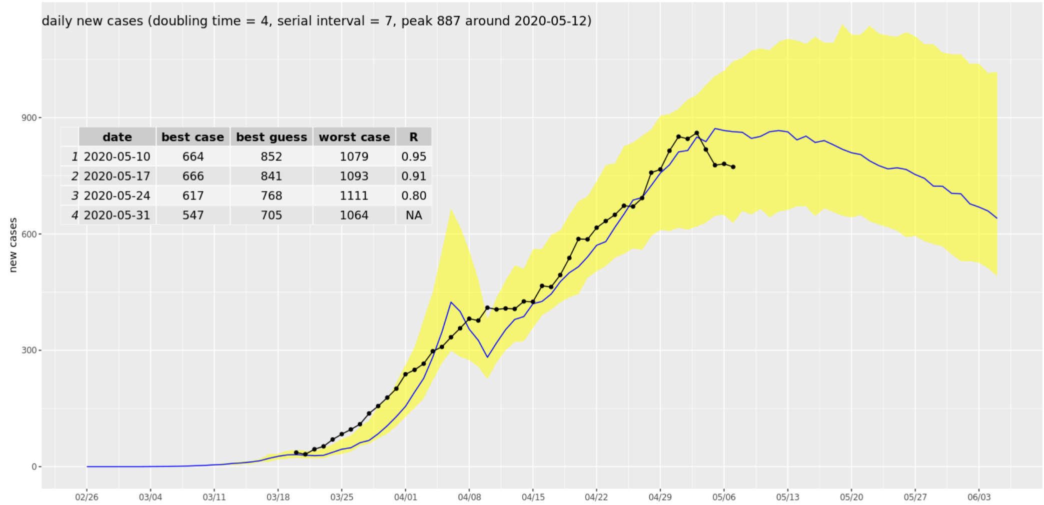
ABM Social Distancing Rebound Study Design

Study of ”Stay Home” policy adherence

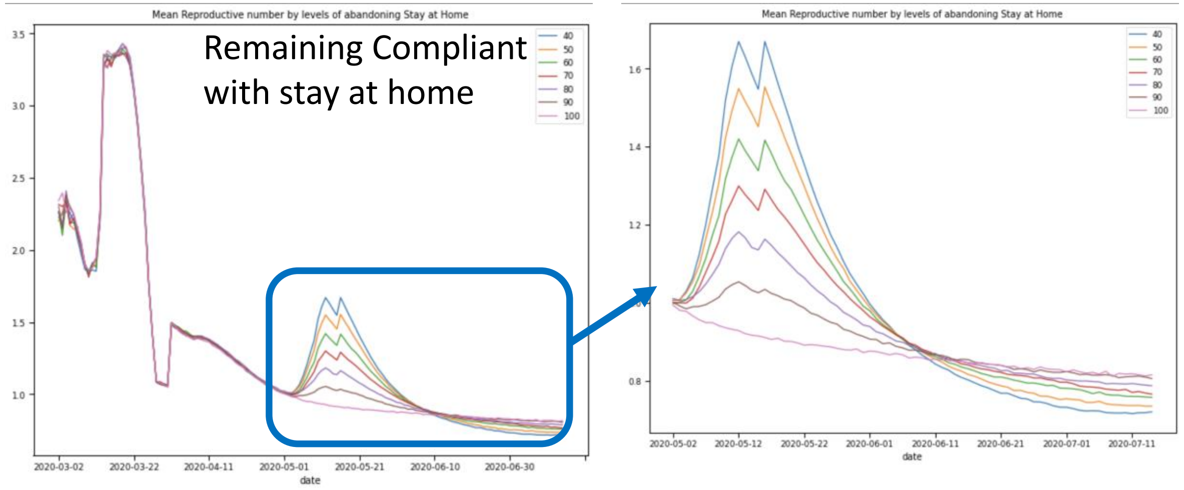
- Calibration to current state in epidemic
- Implement “release” of different proportions of people from ”staying at home”



	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