Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

December 9th, 2020

(data current to December 8th)

Biocomplexity Institute Technical report: TR 2020-157

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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 infections 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:

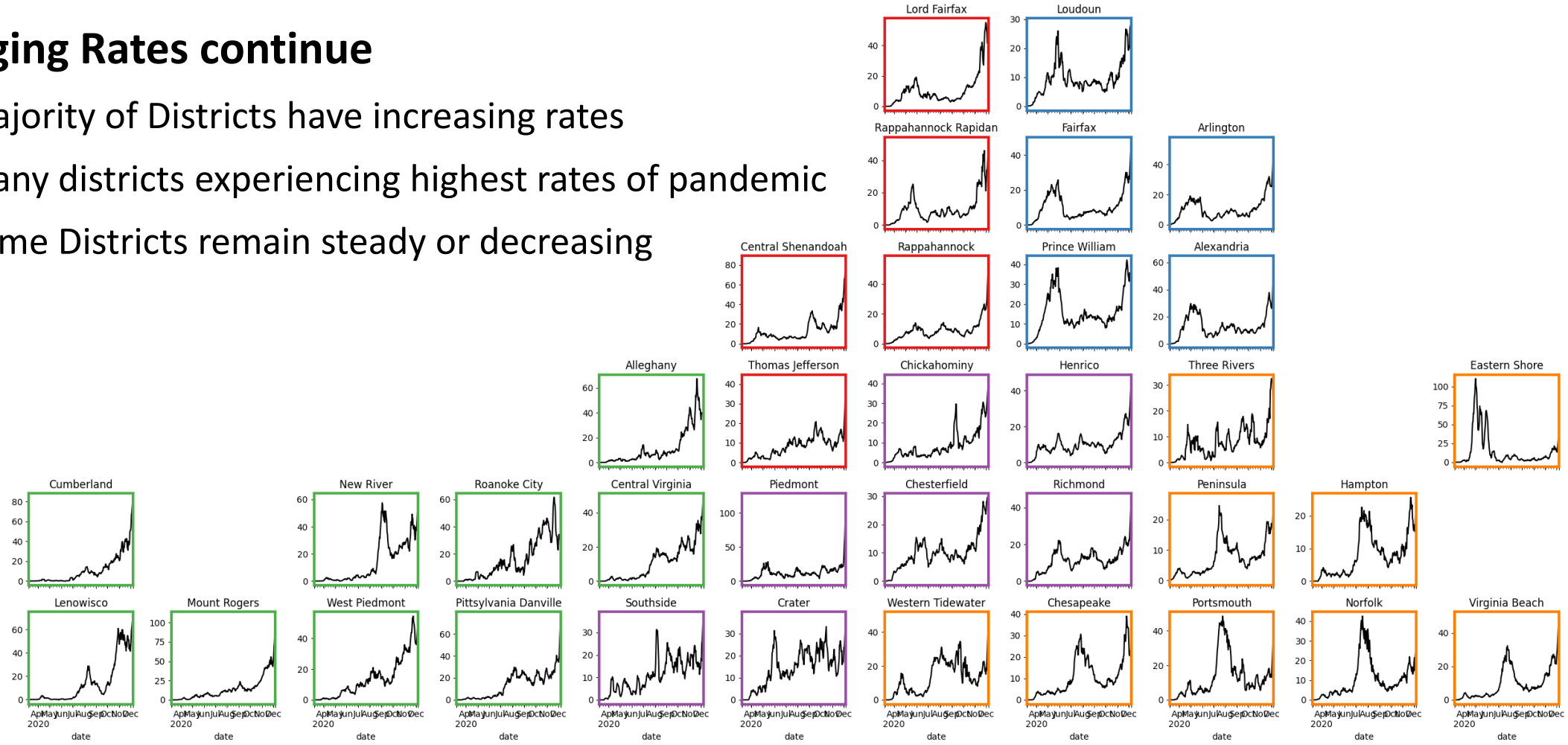
- **Case growth in Virginia seems to have rebounded following Thanksgiving holiday**
- VA mean weekly incidence (38/100K) up (from 28) as national surge also rebounds (to 68/100K from 53/100K).
- Lingering effects from reporting delays and overall testing interruptions continue to impact projections, which are mostly up.
- Recent updates:
  - Ensemble of statistical and Machine Learning models integrated with Adaptive to guide projections
  - Return projection trend window to 2 weeks to minimize holiday effects
  - Planning scenarios remain at Dec 10th and case ascertainment rates updated but are unchanged
- The situation is changing rapidly. Models will be updated regularly.

Situation Assessment

Case Rate (per 100k) by VDH District

Surging Rates continue

- Majority of Districts have increasing rates
- Many districts experiencing highest rates of pandemic
- Some Districts remain steady or decreasing



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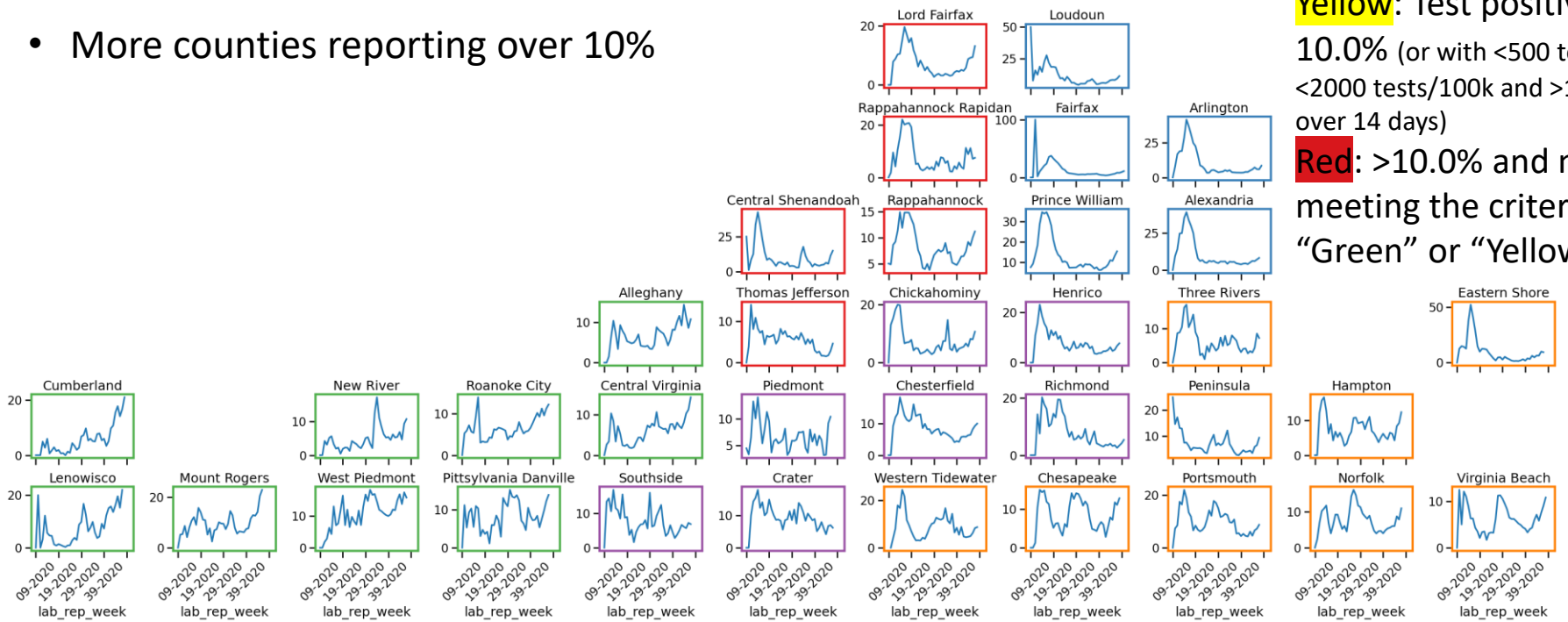
Test Positivity by VDH District

Weekly changes in test positivity by district

- Increasing levels in many districts throughout the commonwealth with many districts above 10% for several weeks
- More counties reporting over 10%

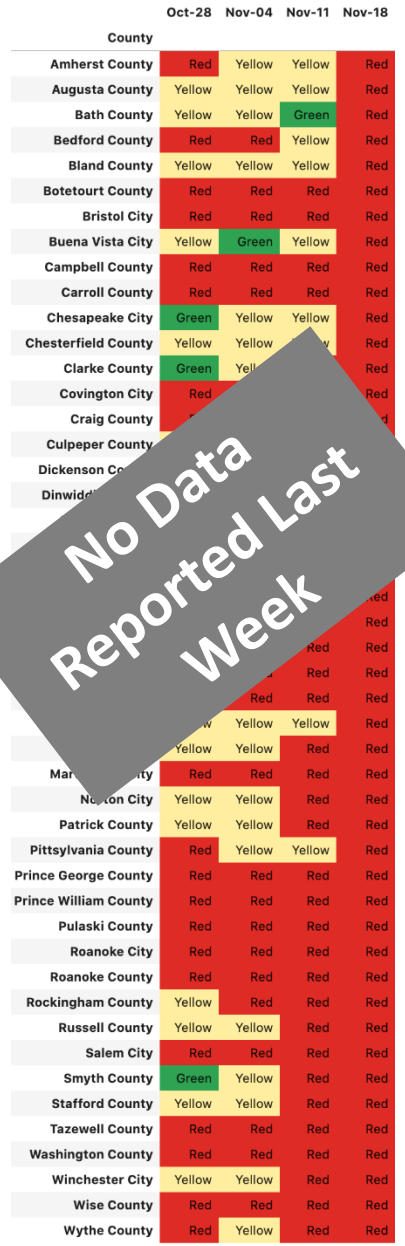


County level test positivity rates for RT-PCR tests.

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% positiv over 14 days)

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



No Data Reported Last Week

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

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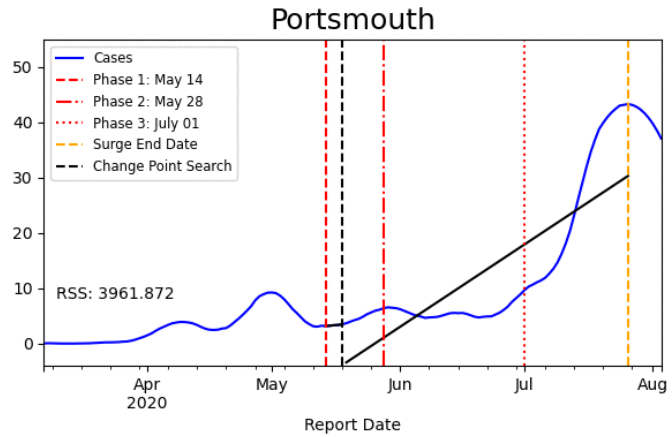
District Trajectories

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

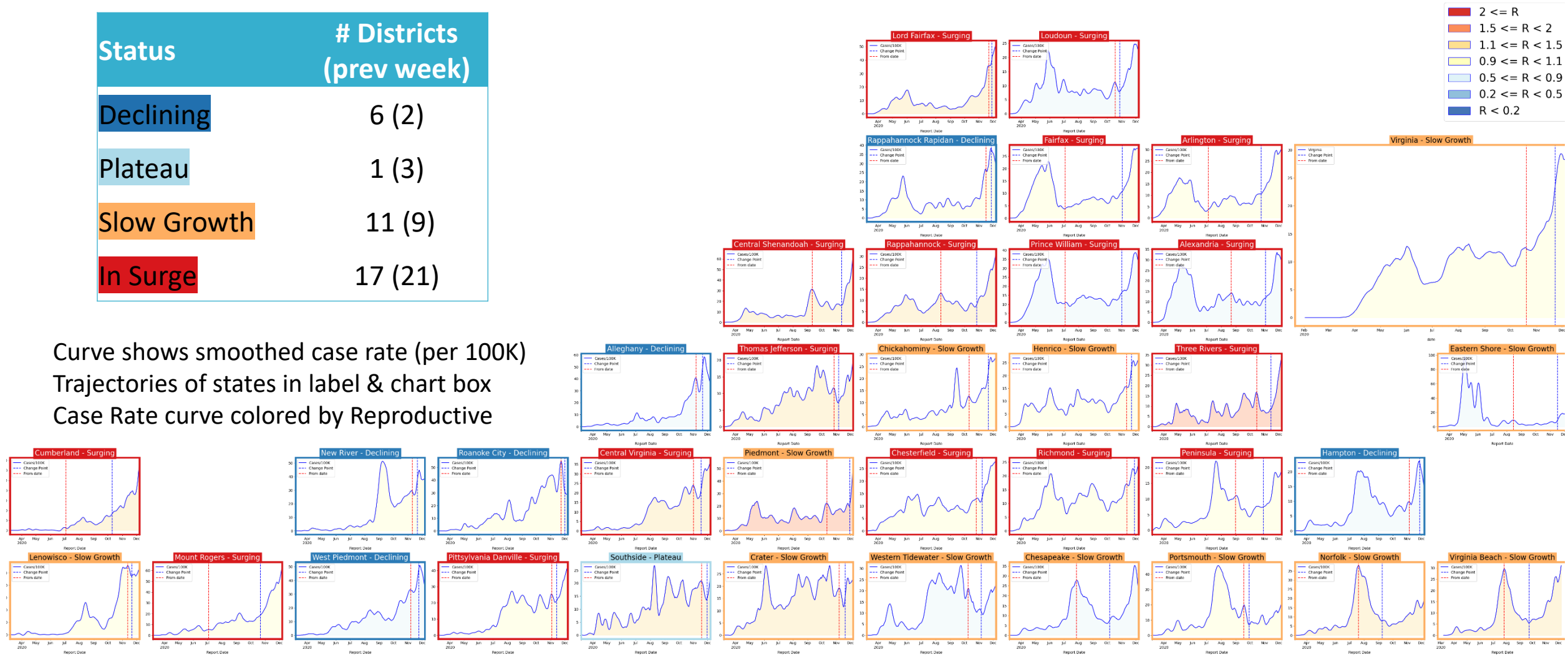


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	6 (2)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	1 (3)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	11 (9)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	17 (21)

District Trajectories

Status	# Districts (prev week)
Declining	6 (2)
Plateau	1 (3)
Slow Growth	11 (9)
In Surge	17 (21)

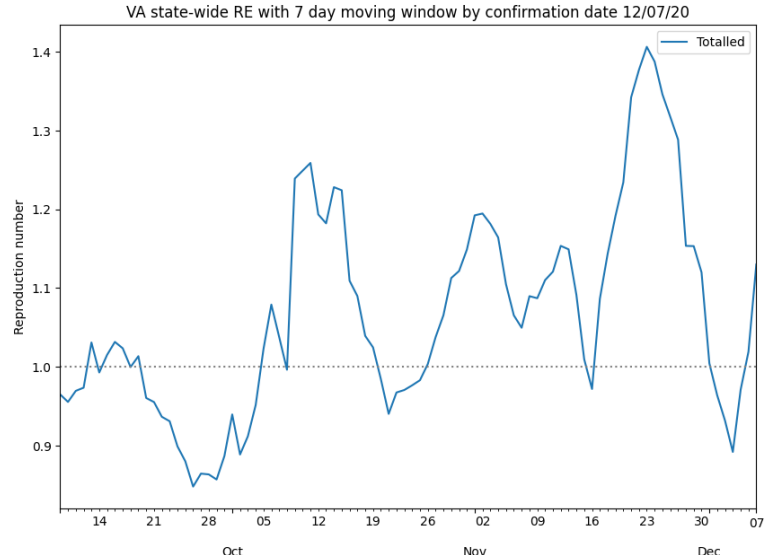
Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive

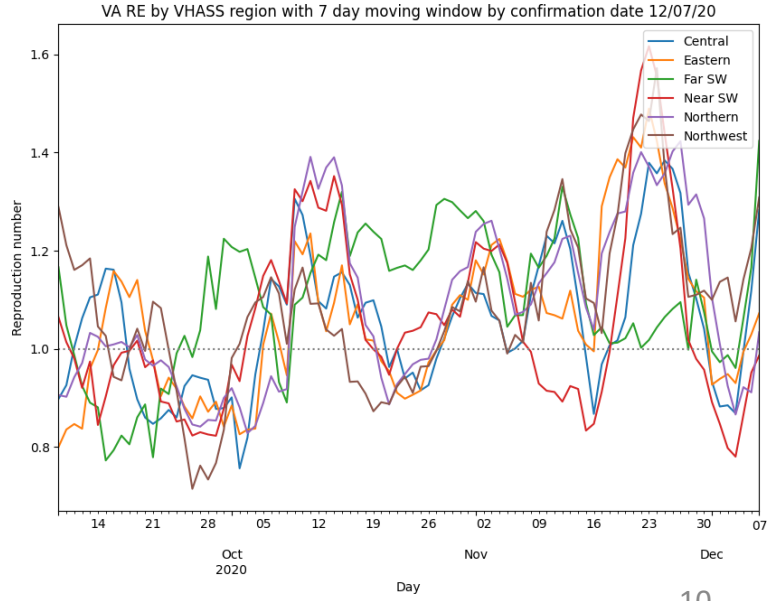


Estimating Daily Reproductive Number

Dec 7th Estimates

Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	1.130	0.010
Central	1.283	0.242
Eastern	1.073	-0.032
Far SW	1.424	0.349
Near SW	0.987	0.029
Northern	1.034	-0.232
Northwest	1.309	0.190





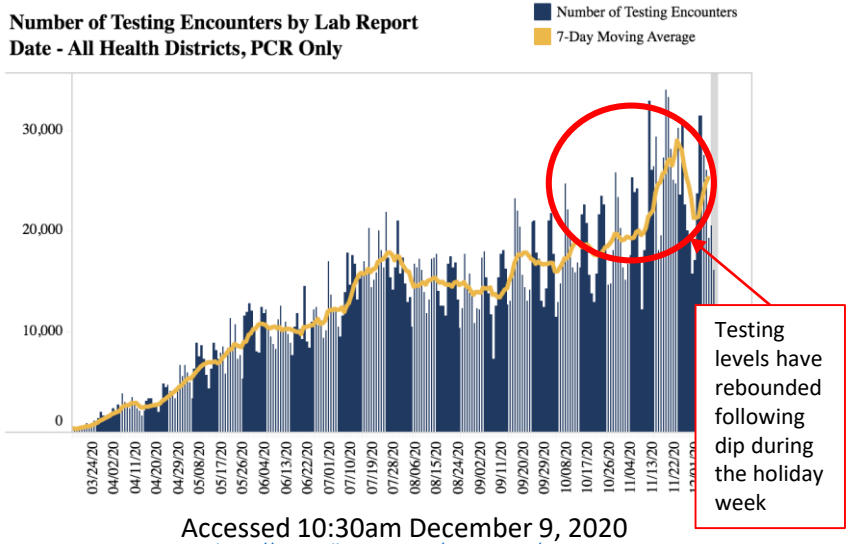
Methodology

- 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

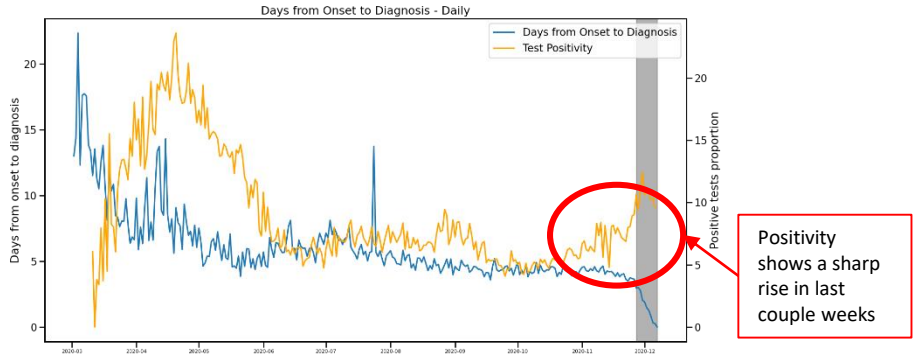
Changes in Case Detection

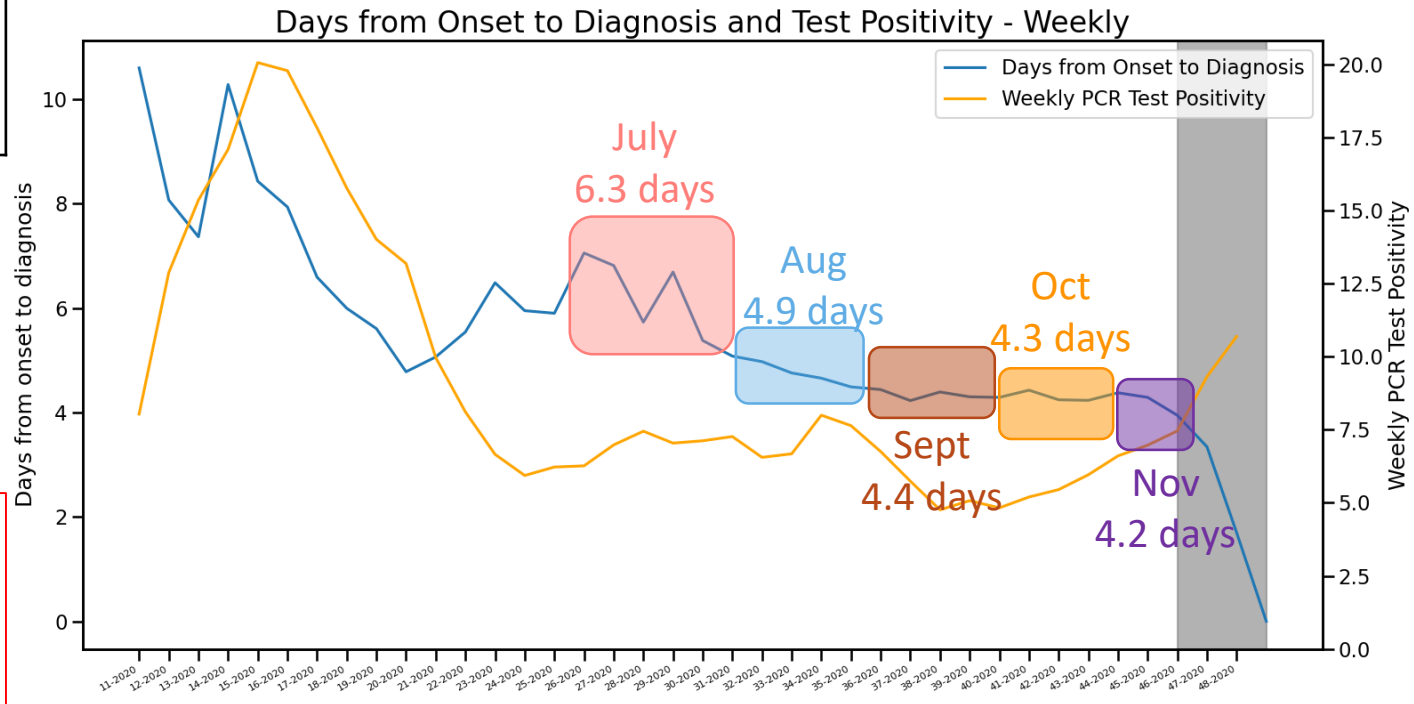
Timeframe (weeks)	Mean days	% difference from overall mean
April (13-16)	8.5	53%
May (17-21)	5.6	1%
June (22-25)	6.0	8%
July (26-30)	6.3	14%
Aug (31-34)	4.9	-12%
Sept (35-38)	4.4	-21%
Oct (39-43)	4.3	-23%
Nov (44-46)	4.2	-23%
Overall (13-46)	5.6	0%



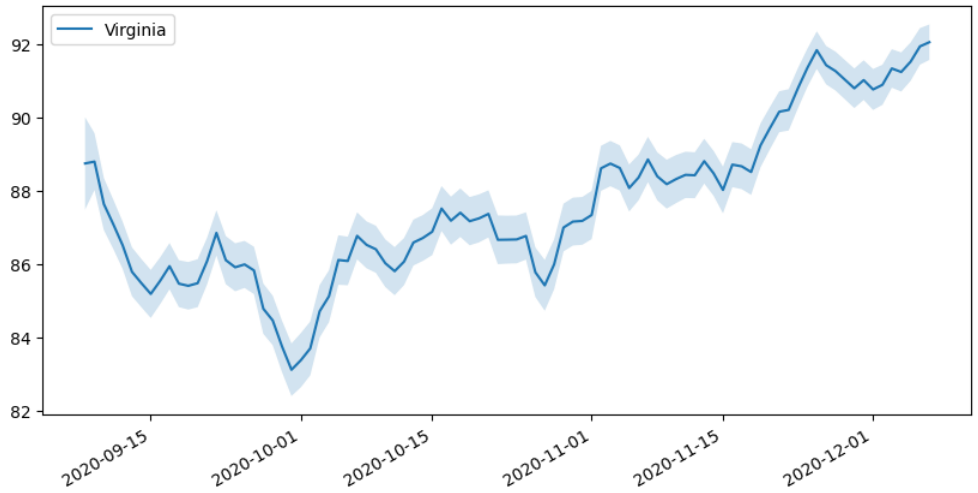
Accessed 10:30am December 9, 2020
https://www.vdh.virginia.gov/coronavirus/

Test positivity vs. Onset to Diagnosis





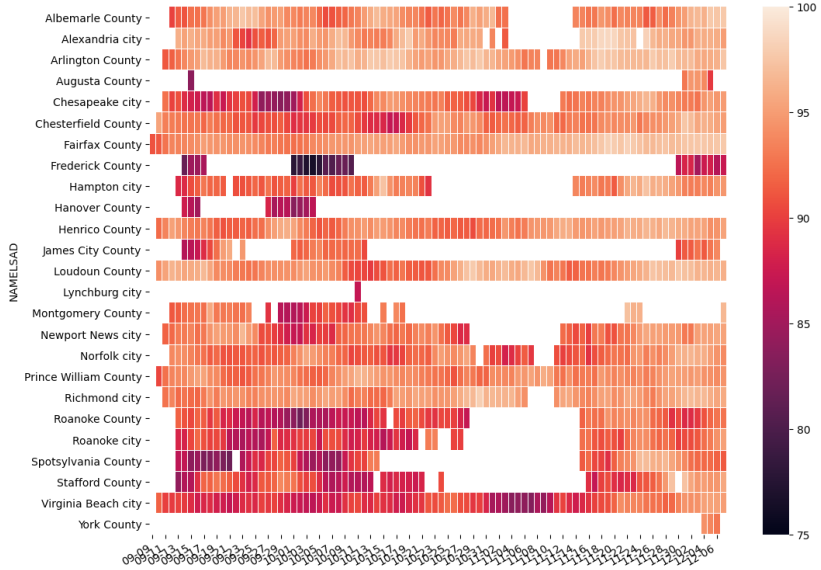
Mask usage in Virginia



State level mask usage as reported via Facebook surveys over the past month shows ranges from 83% to 89%

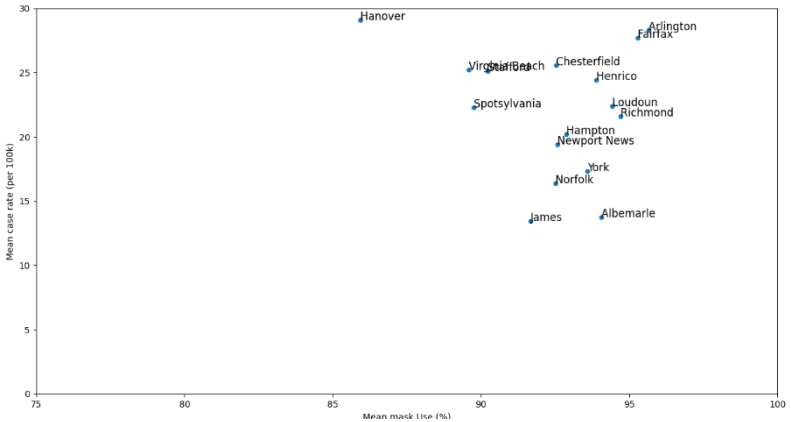
- Relatively stable over time
- Limited variance across the commonwealth
- ~3000 daily responses from VA

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



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

Correlations seen at national level with mask use and case rate start to emerge across VA counties, due to surging growth and more limited survey results due to election



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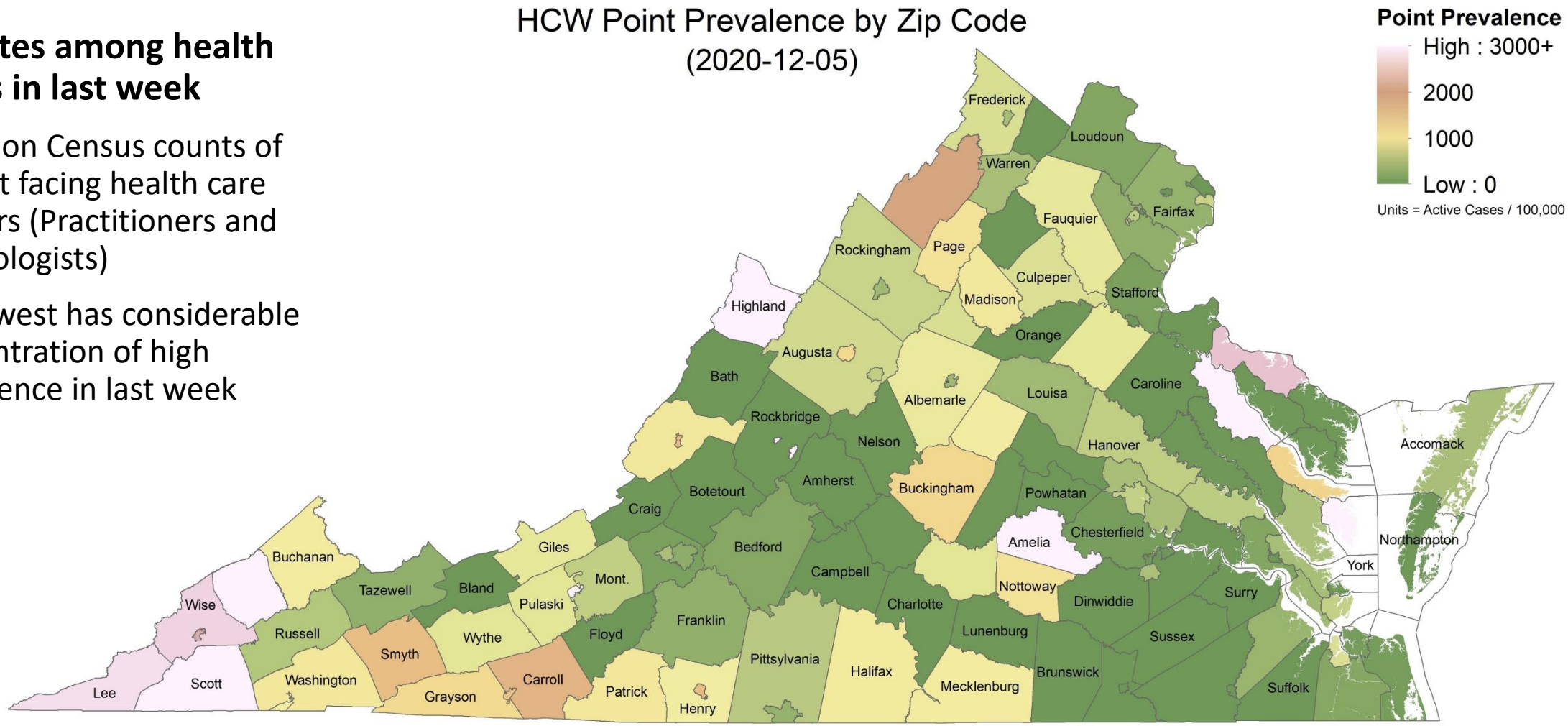
Health Care Worker Prevalence (per 100K)

Case Rates among health workers in last week

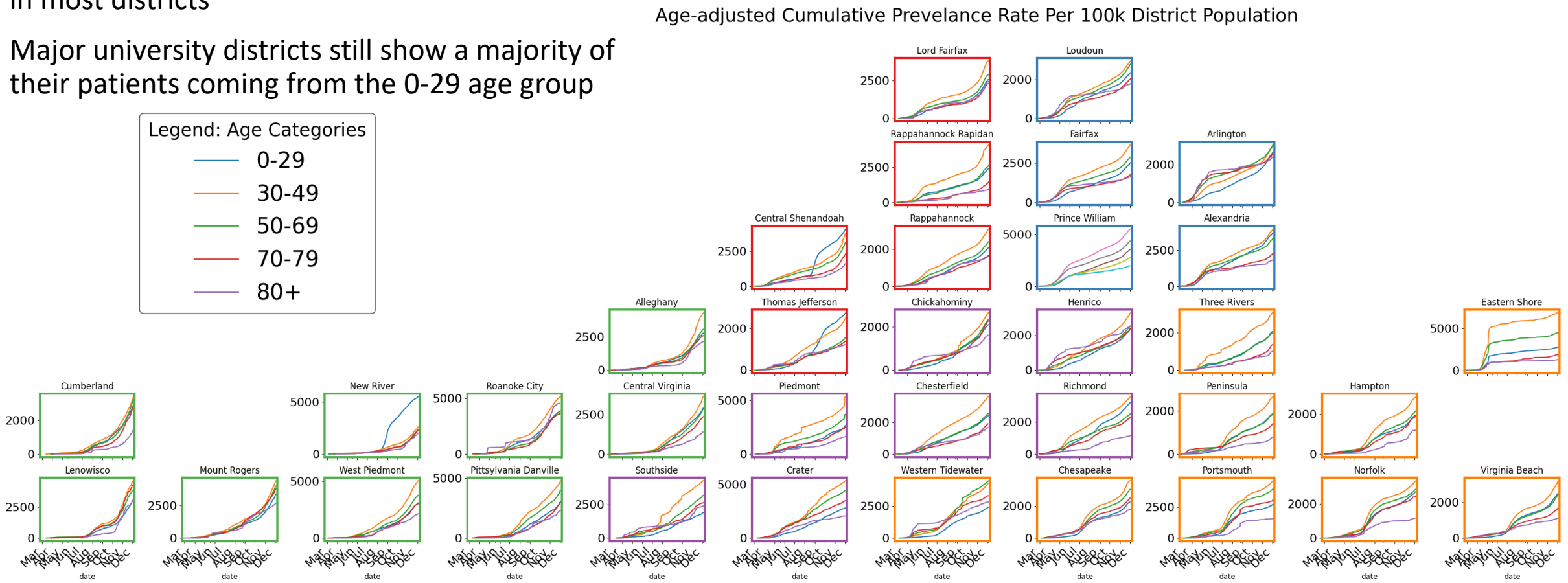
- Based on Census counts of patient facing health care workers (Practitioners and Technologists)
- Southwest has considerable concentration of high prevalence in last week



Age-Specific Attack Rates (per 100K)

Cumulative Age-Specific Attack Rates (per 100k)

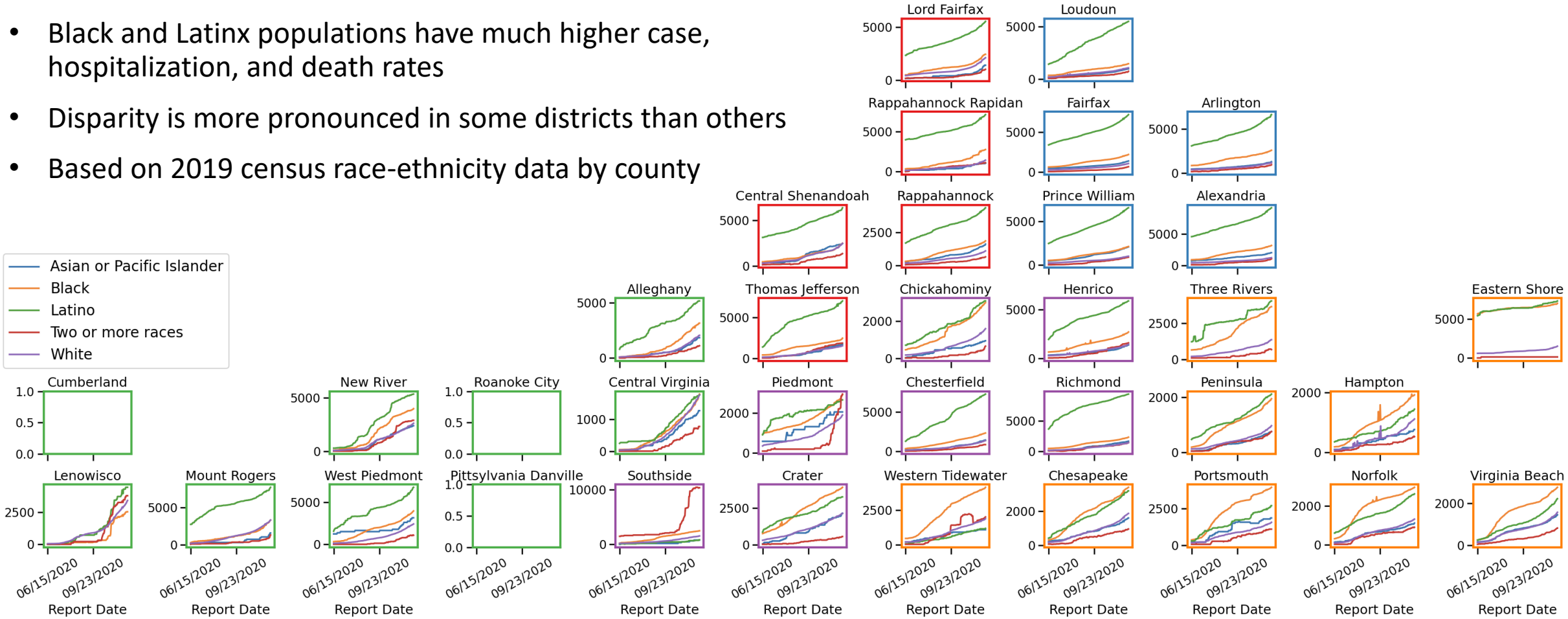
- 30-49 year olds bear the highest burden of disease in most districts
- Major university districts still show a majority of their patients coming from the 0-29 age group



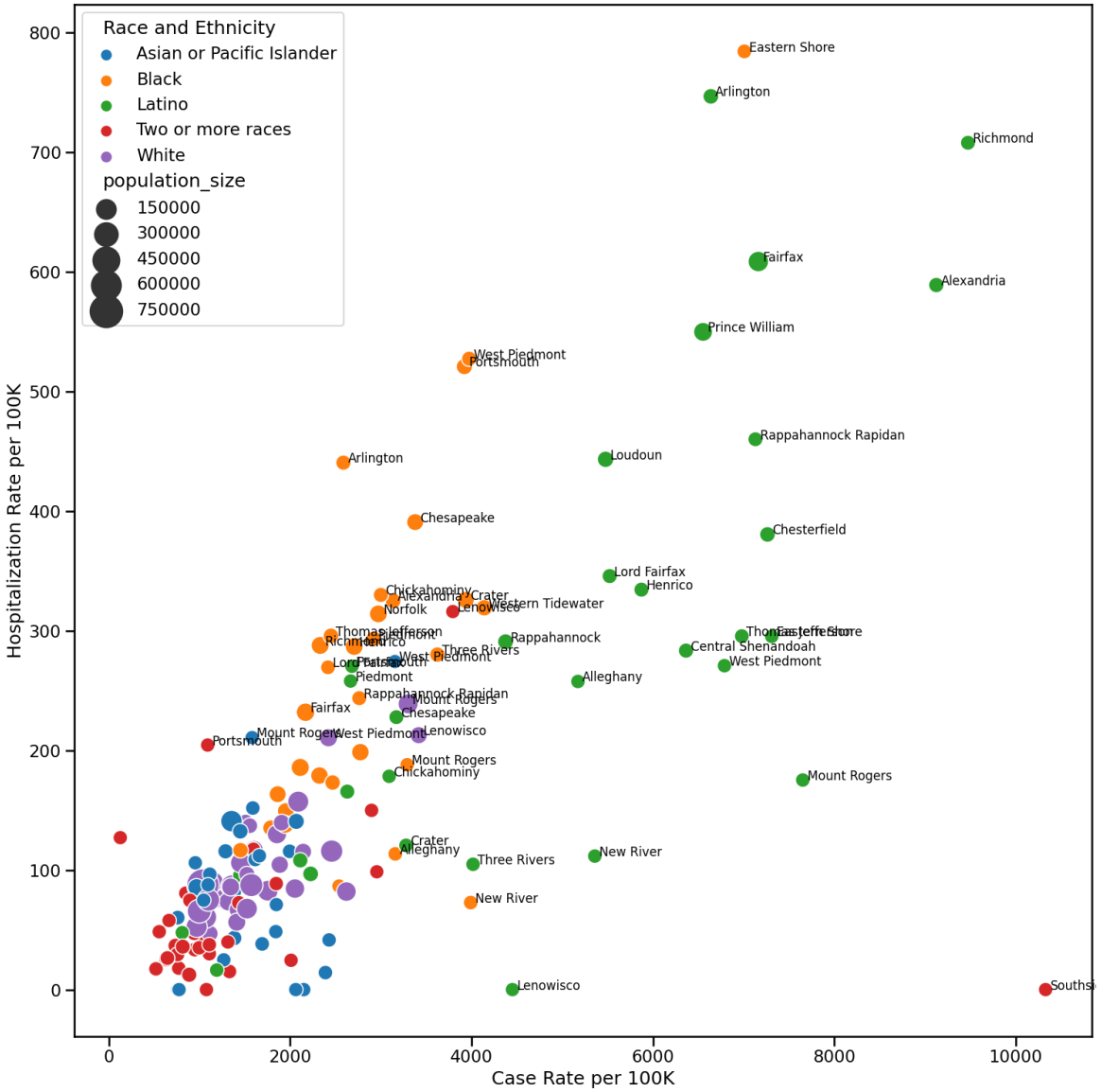
Race and Ethnicity Attack Rates (per 100K)

Cumulative Race and Ethnicity Attack Rates (per 100k)

- Black and Latinx populations have much higher case, hospitalization, and death rates
- Disparity is more pronounced in some districts than others
- Based on 2019 census race-ethnicity data by county



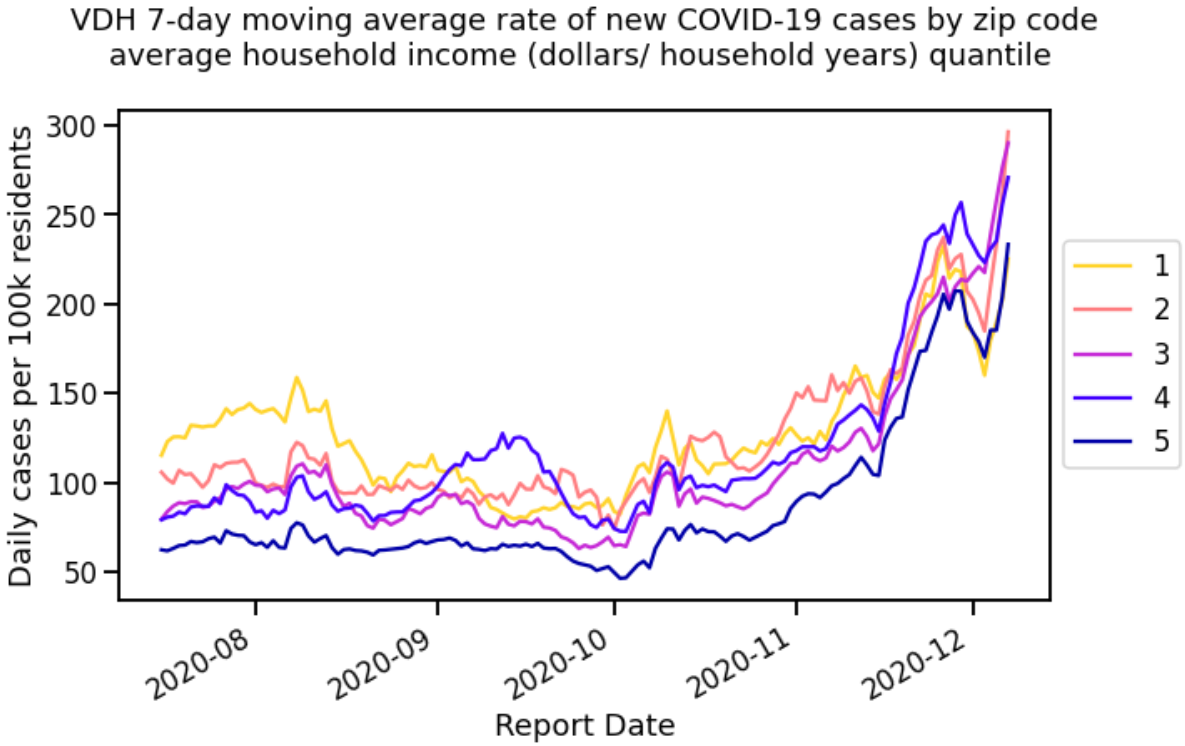
Race and Ethnicity cases per 100K



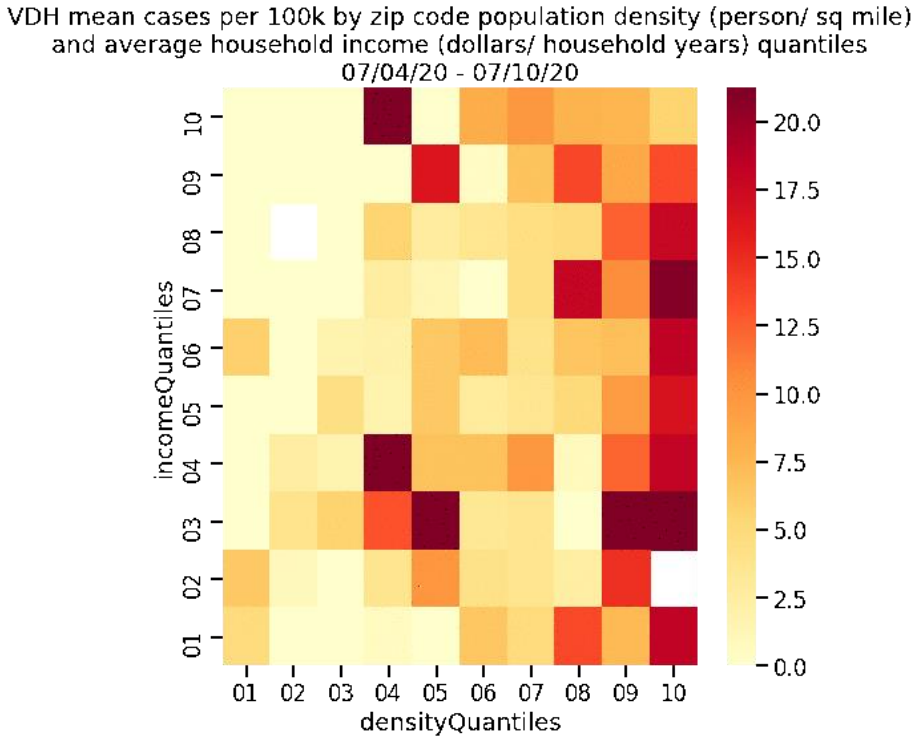
Rates per 100K of each Racial-Ethnic population by Health District

- 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



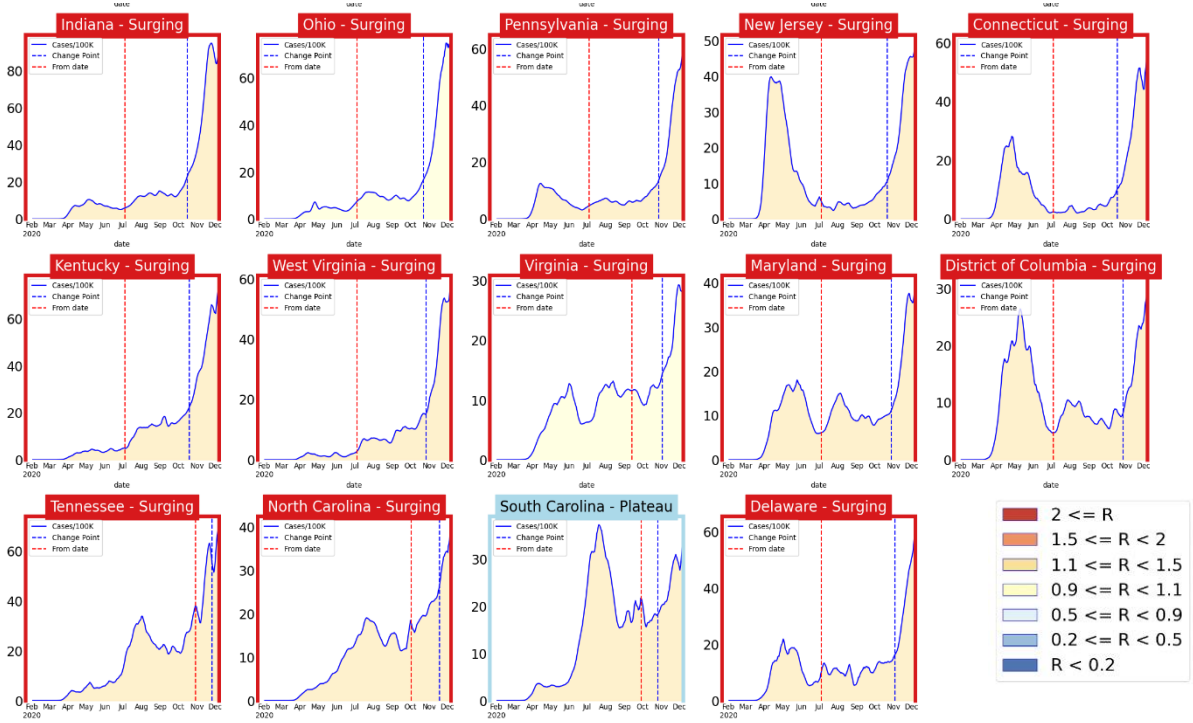
All zip codes show rapid growth and ordering is in flux with the middle quintiles (20th to 80th percentiles) bearing the highest rates



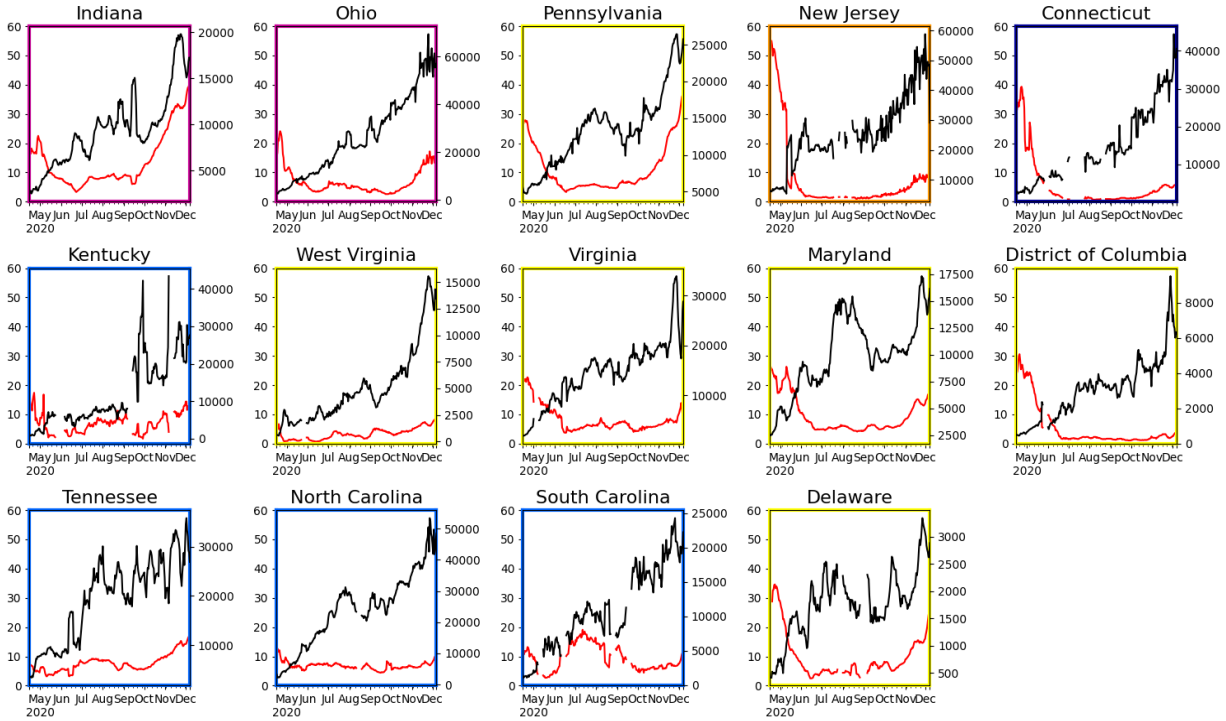
Full evolution of pandemic, shows shifts from denser and wealthier zip codes to poorer and less dense zip codes, followed by a repeat of the pattern. Recently see an uptick across the spectrum of density and income

Other State Comparisons

Trajectories of States



Tests per Day and Test Positivity



- VA and most mid-Atlantic states are in surge (34 total in US)
- Nearly all states maintain highest rates of the pandemic

- VA's test positivity rate continues to rise with many of its neighbors
- Testing volumes have increased for many with recent disruption from the holiday

Zip code level weekly Case Rate (per 100K)

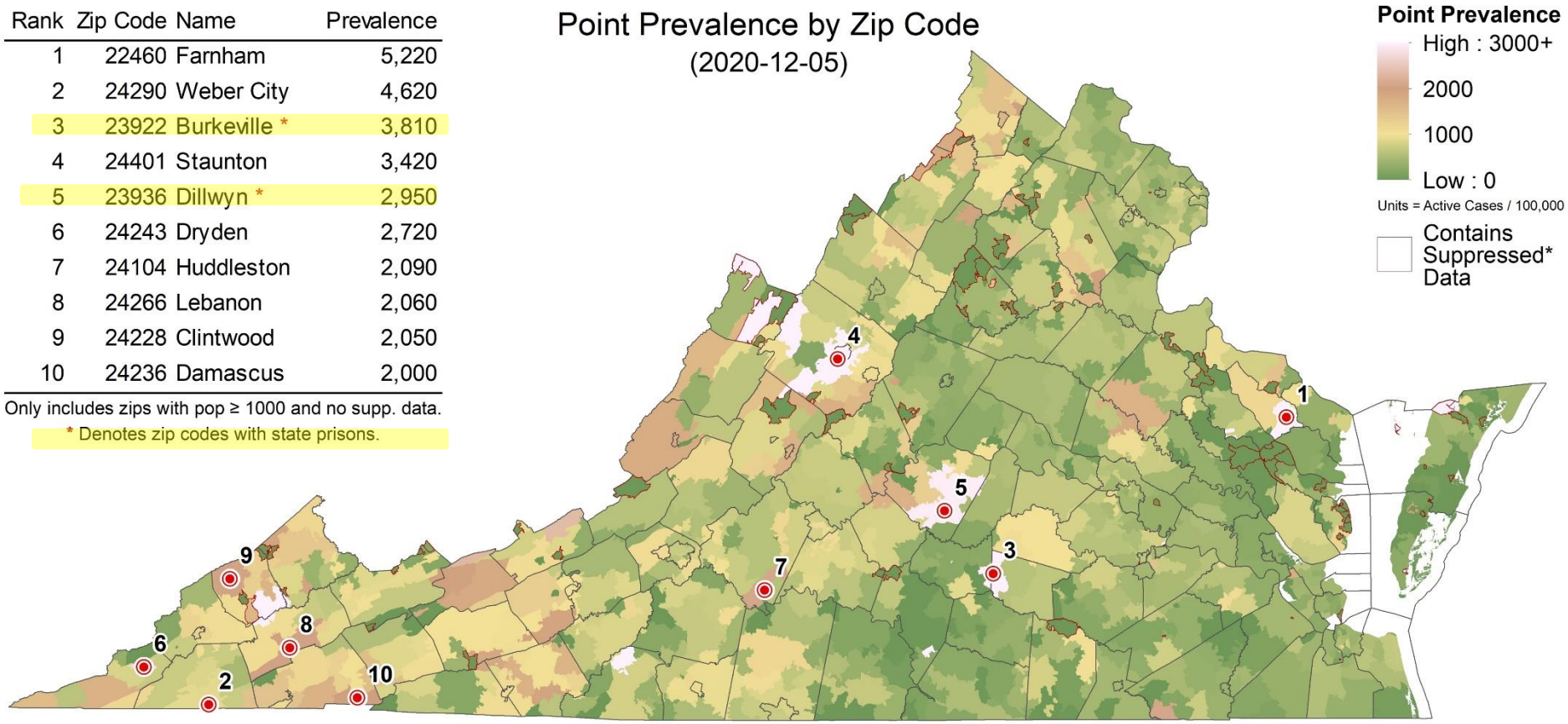
Case Rates in the last week by zip code

- Concentrations of very high prevalence in many zip codes
- Several of the top ten zip codes are home to prisons
- Southwest has considerable concentration of high prevalence zips
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prevalence
1	22460	Farnham	5,220
2	24290	Weber City	4,620
3	23922	Burkeville *	3,810
4	24401	Staunton	3,420
5	23936	Dillwyn *	2,950
6	24243	Dryden	2,720
7	24104	Huddleston	2,090
8	24266	Lebanon	2,060
9	24228	Clintwood	2,050
10	24236	Damascus	2,000

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

* Denotes zip codes with state prisons.



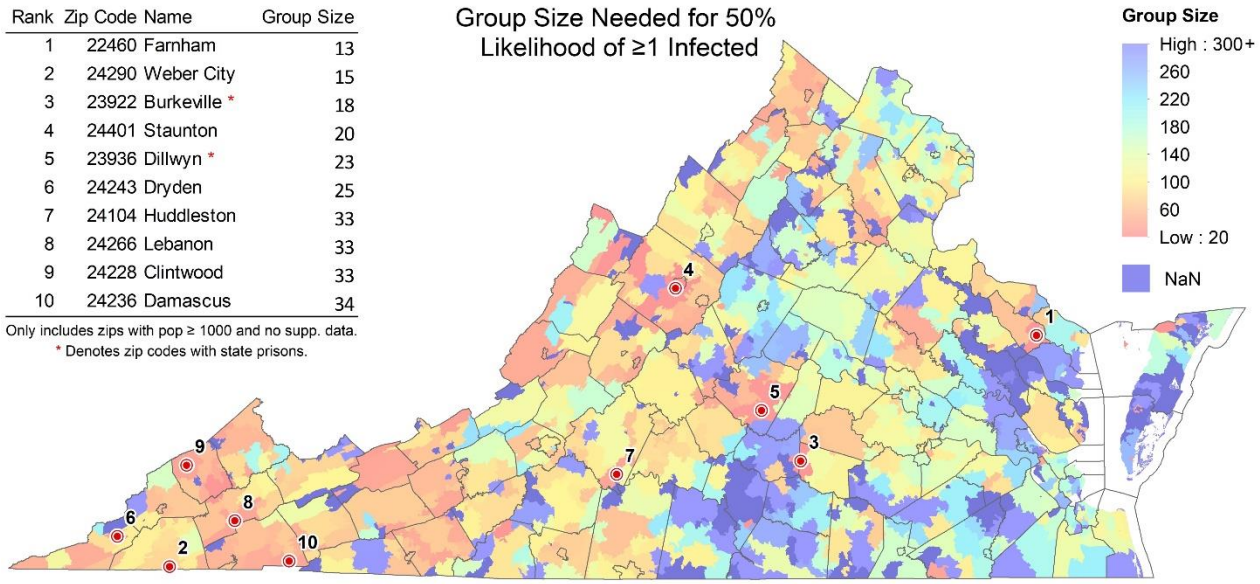
Risk of Exposure by Group Size

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 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	22460	Farnham	13
2	24290	Weber City	15
3	23922	Burkeville *	18
4	24401	Staunton	20
5	23936	Dillwyn *	23
6	24243	Dryden	25
7	24104	Huddleston	33
8	24266	Lebanon	33
9	24228	Clintwood	33
10	24236	Damascus	34

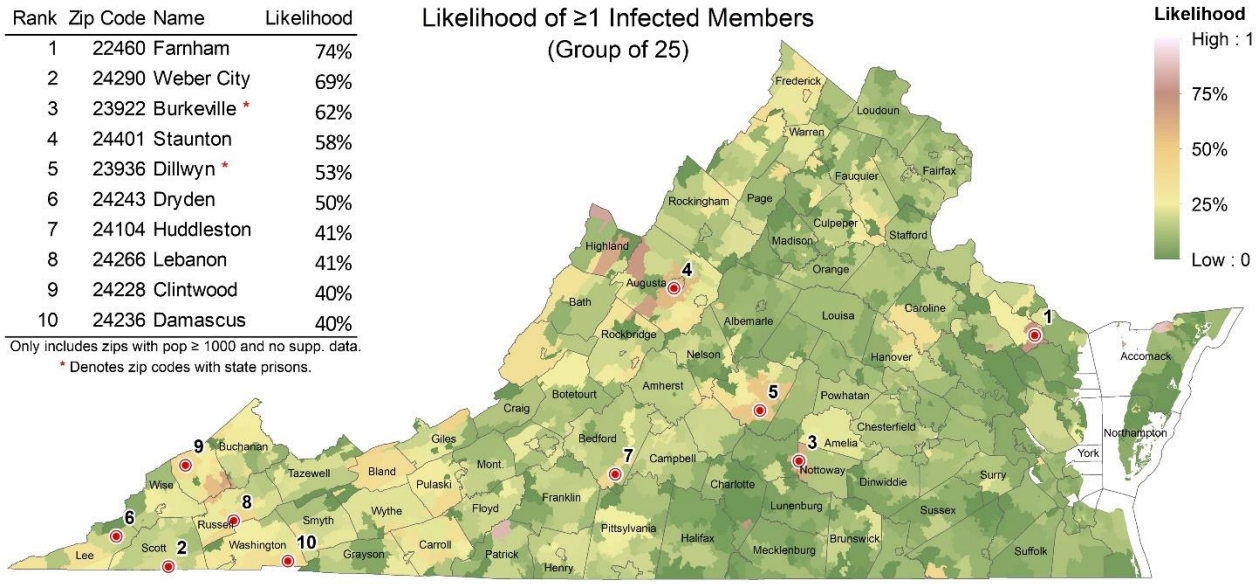
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on zip code point prevelence for week ending 2020-12-05

Rank	Zip Code	Name	Likelihood
1	22460	Farnham	74%
2	24290	Weber City	69%
3	23922	Burkeville *	62%
4	24401	Staunton	58%
5	23936	Dillwyn *	53%
6	24243	Dryden	50%
7	24104	Huddleston	41%
8	24266	Lebanon	41%
9	24228	Clintwood	40%
10	24236	Damascus	40%

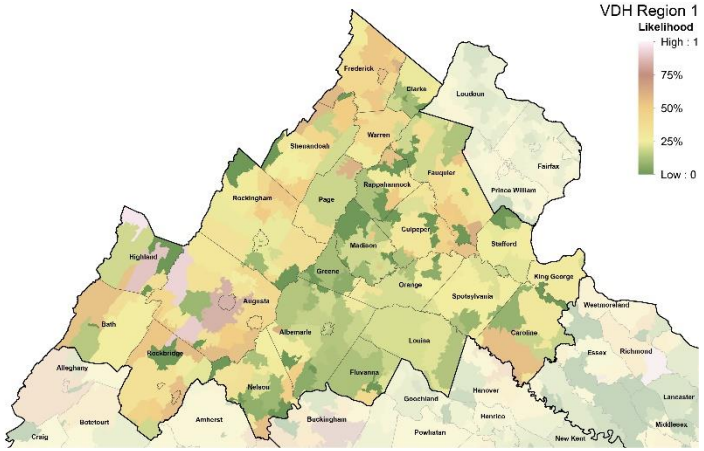
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



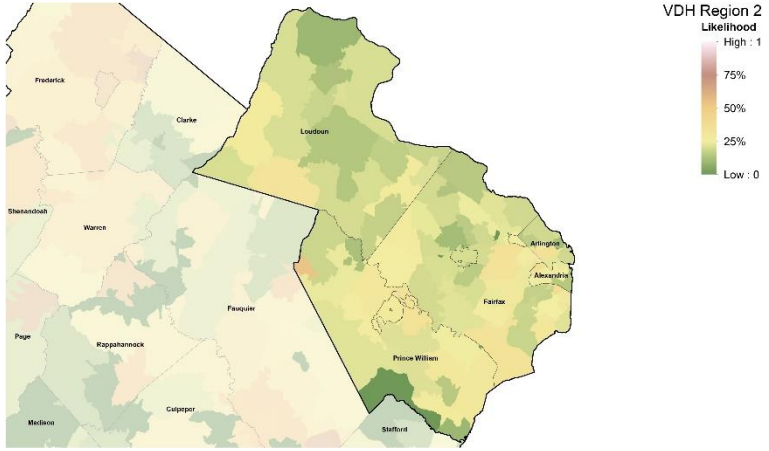
Based on zip code point prevelence for week ending 2020-12-05

Risk of Exposure in Groups of 50

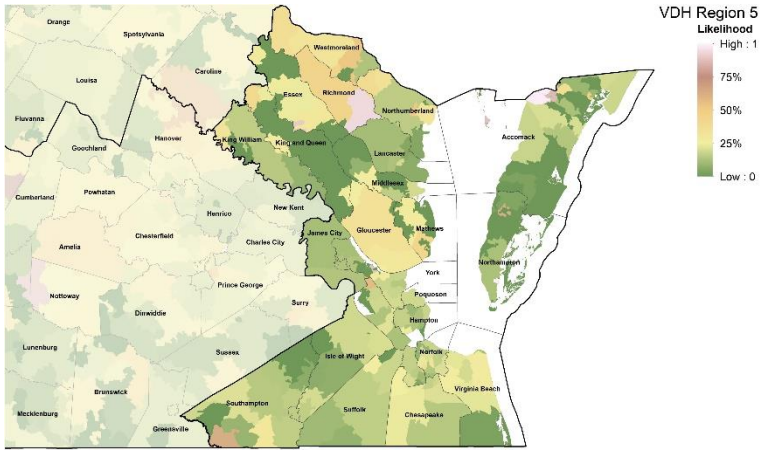
Northwest



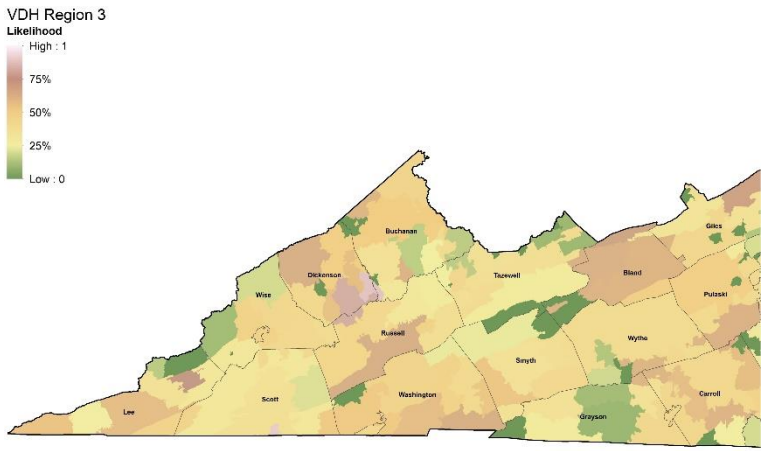
North



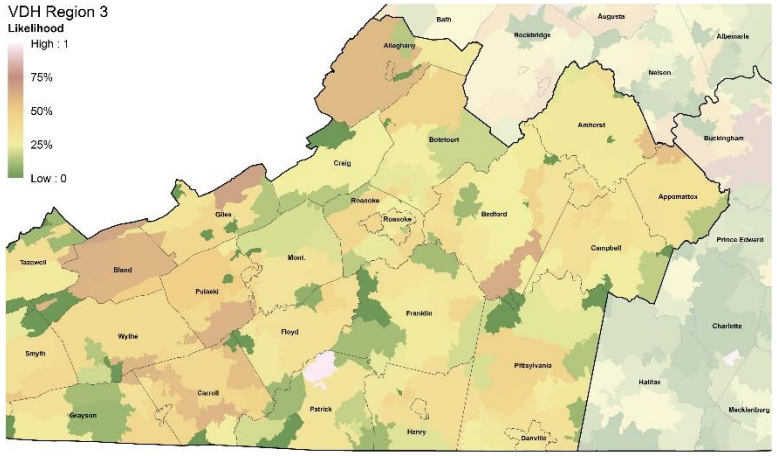
Eastern



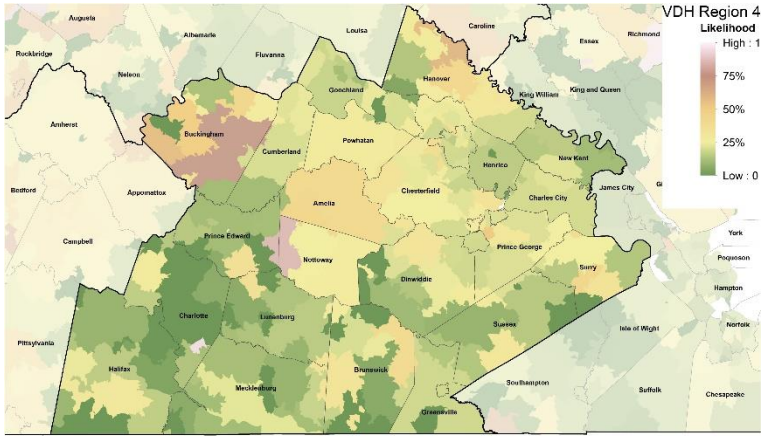
Far Southwest



Near Southwest



Central



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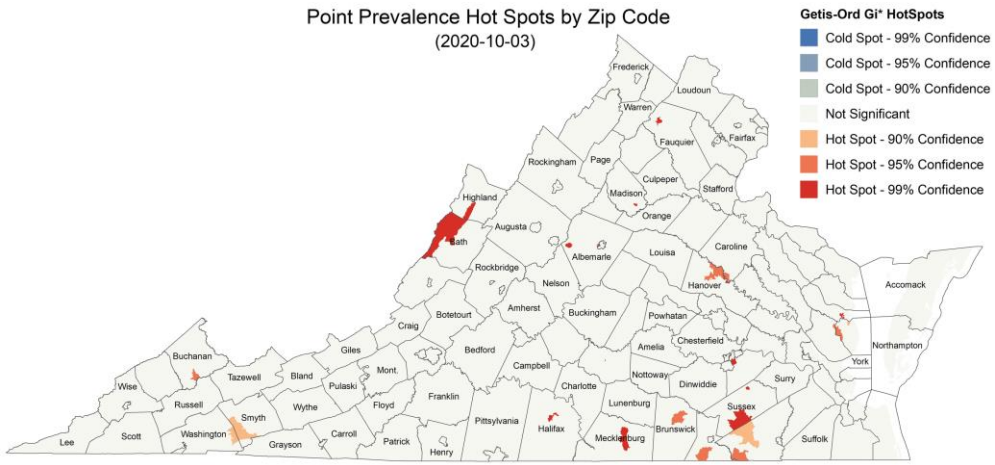
Zip Code Hot Spots

Hotspots across commonwealth

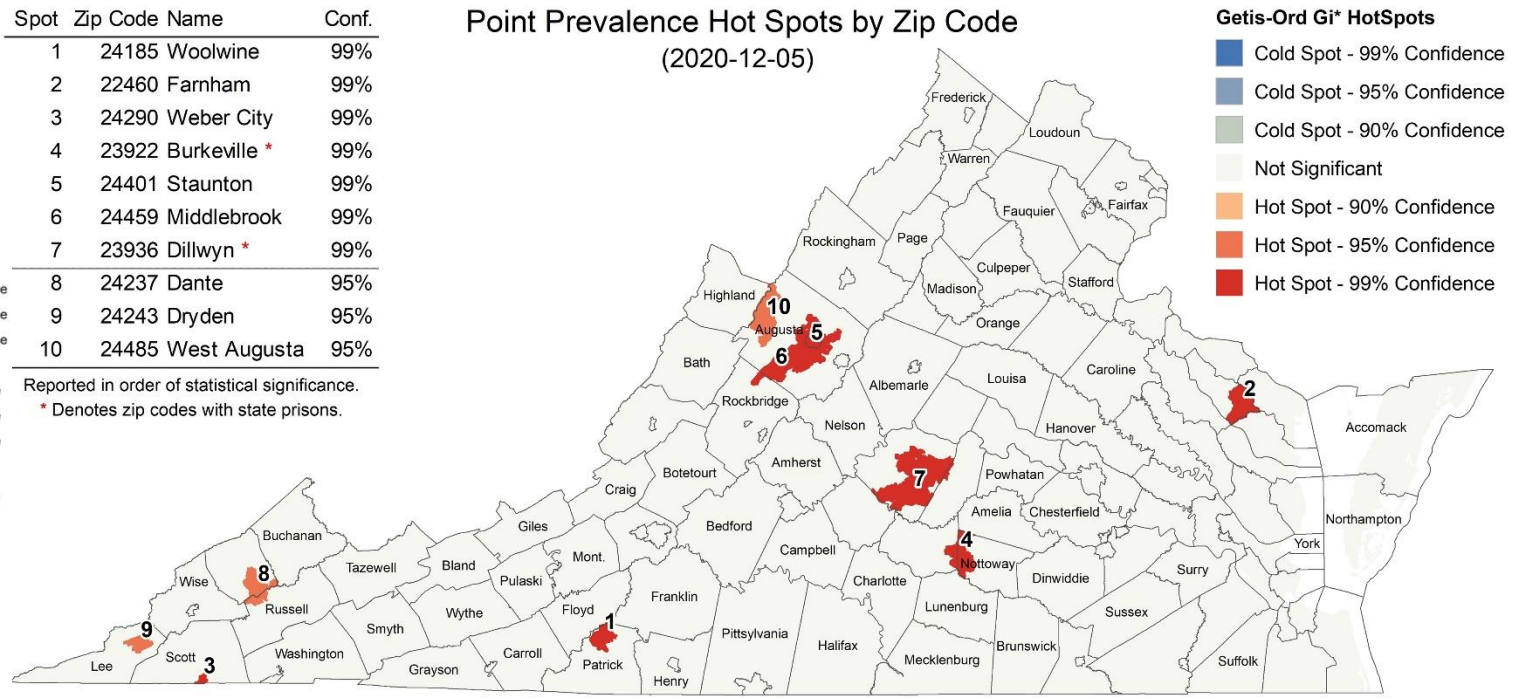
- More spread out but remain concentrated in the Southwest
- Captures some very high prevalence rates in some zips

Previous weeks



Spot	Zip Code	Name	Conf.
1	24185	Woolwine	99%
2	22460	Farnham	99%
3	24290	Weber City	99%
4	23922	Burkeville *	99%
5	24401	Staunton	99%
6	24459	Middlebrook	99%
7	23936	Dillwyn *	99%
8	24237	Dante	95%
9	24243	Dryden	95%
10	24485	West Augusta	95%

Reported in order of statistical significance.
* Denotes zip codes with state prisons.



Model Update – Adaptive Fitting

Adaptive Fitting Approach

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

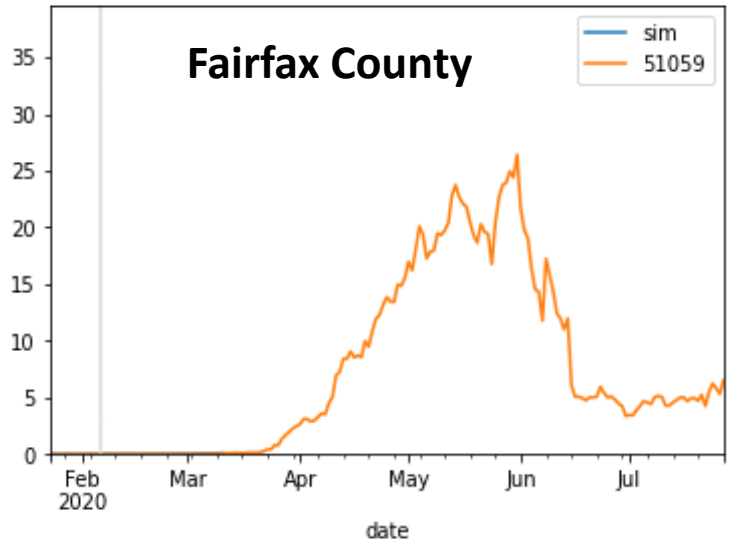
- Allows history to be precisely captured, and used to guide bounds on projections

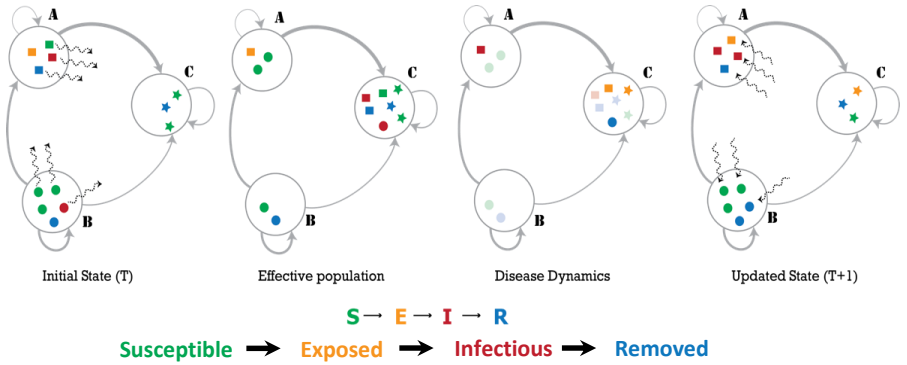
Model: An alternative use of the same meta-population model, PatchSim

- 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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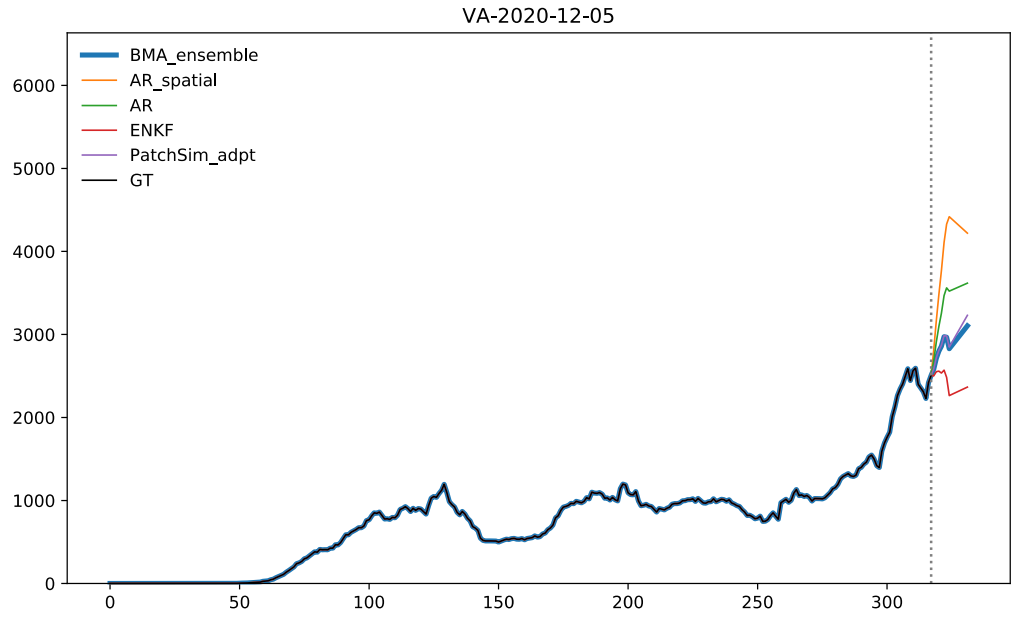
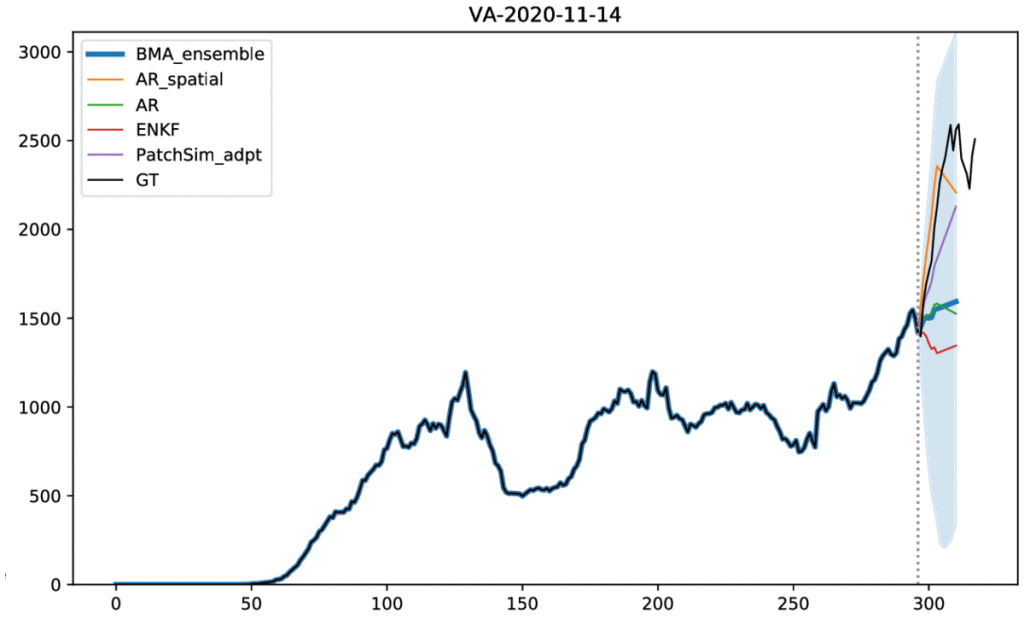
Using Ensemble Model to Guide Projections

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

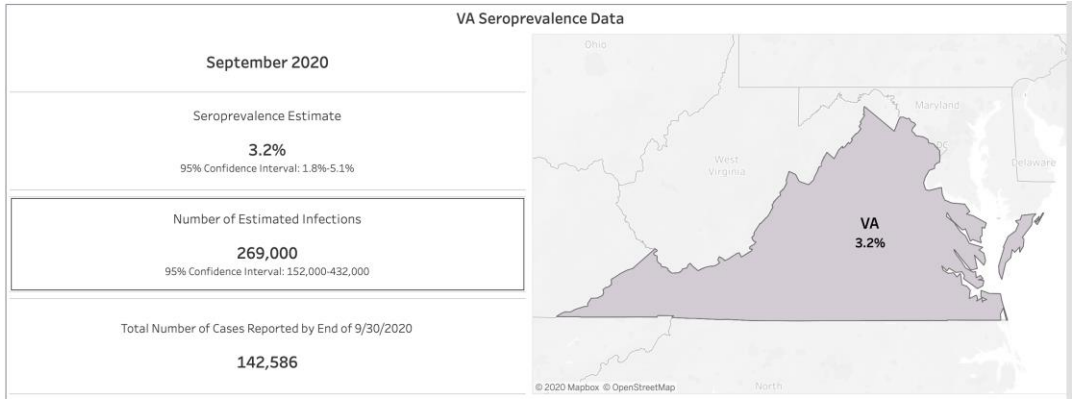




Seroprevalence updates to model design

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 3.2% [1.8% – 5.1%] seroprevalence as of Sept 10th-23rd down from 3.9% a month earlier



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

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)

Virginia Coronavirus Serology Project

Interim findings by region and statewide - July 22, 2020

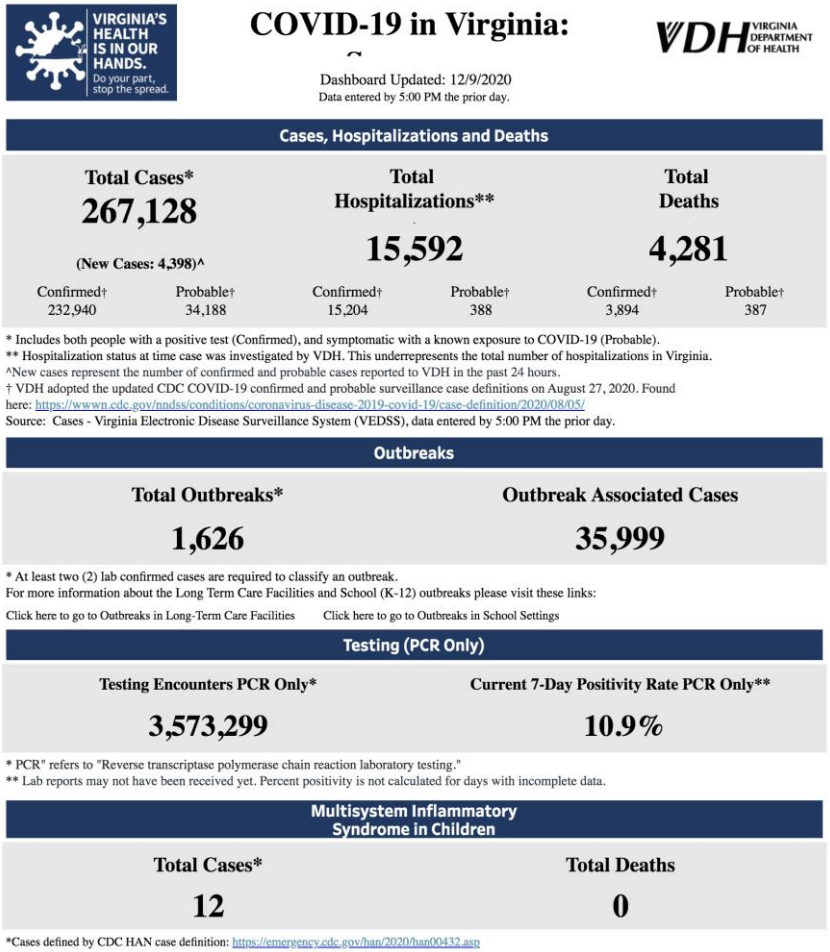
Region	Number of participants	Number antibody positive	Crude prevalence per 100 participants	Weighted prevalence*	
				per 100 population	(95% CI)
Central	400	8	2.0	3.0	(0.5, 5.5)
East	707	9	1.3	1.5	(-0.2, 3.2)
Northern	819	36	4.4	4.2	(2.5, 5.9)
Northwest	756	11	1.5	0.9	(0.2, 1.6)
Southwest	431	3	0.7	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 14 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories



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

COVID-19 in Virginia:

VDH VIRGINIA DEPARTMENT OF HEALTH

Dashboard Updated: 12/9/2020
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*		Total Hospitalizations**		Total Deaths	
267,128		15,592		4,281	
(New Cases: 4,398)^					
Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
232,940	34,188	15,204	388	3,894	387

* Includes both people with a positive test (Confirmed), and symptomatic with a known exposure to COVID-19 (Probable).
** Hospitalization status at time case was investigated by VDH. 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/
Source: Cases - Virginia Electronic Disease Surveillance System (VEDSS), data entered by 5:00 PM the prior day.

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
1,626	35,999

* At least two (2) lab confirmed cases are required to classify an outbreak.
For more information about the Long Term Care Facilities and School (K-12) outbreaks please visit these links:
Click here to go to Outbreaks in Long-Term Care Facilities Click here to go to Outbreaks in School Settings

Testing (PCR Only)

Testing Encounters PCR Only*	Current 7-Day Positivity Rate PCR Only**
3,573,299	10.9%

* 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
12	0

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

Accessed 10:30am December 9, 2020
https://www.vdh.virginia.gov/coronavirus/

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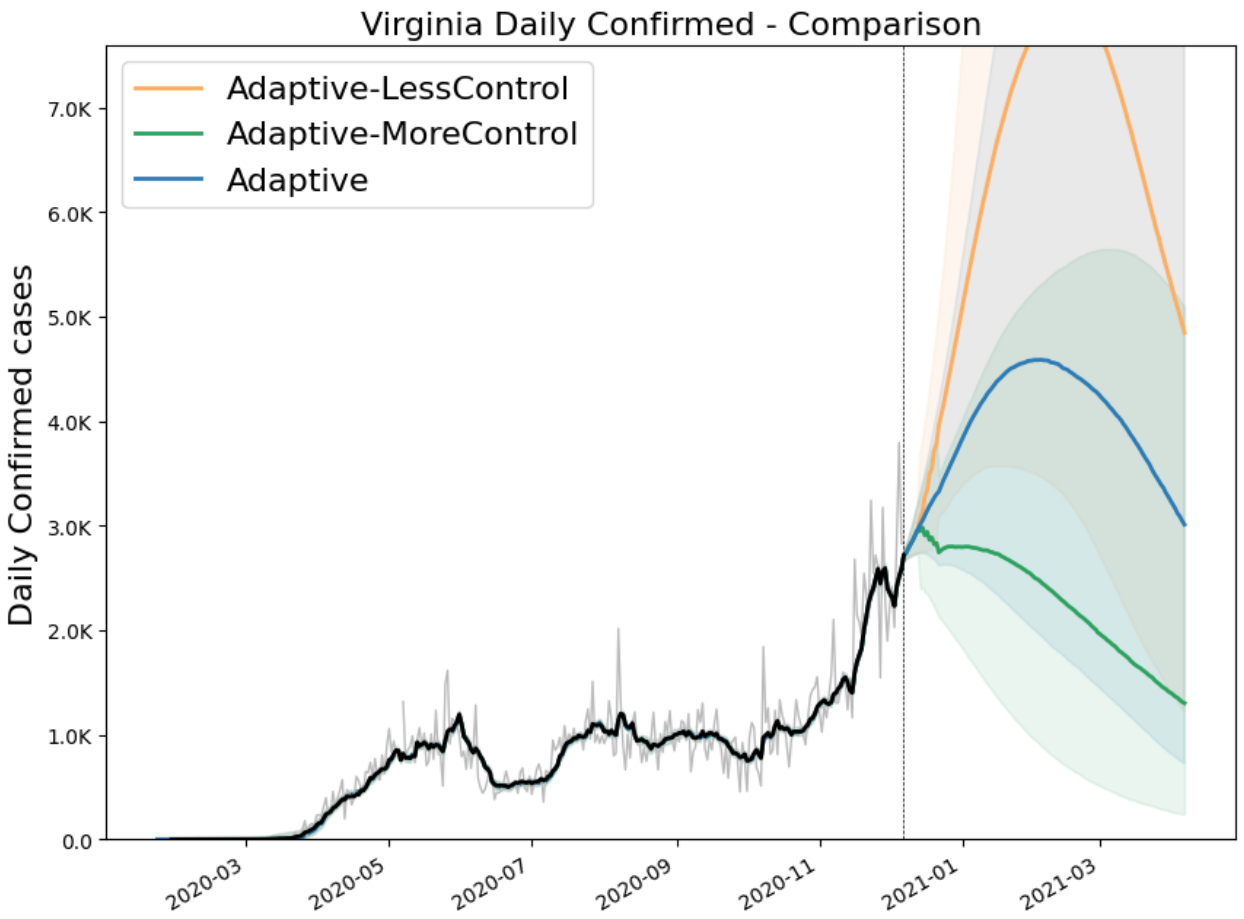
Scenarios – Seasonal Effects

- Societal changes in the past month have led to an increase in transmission rates, these could continue to drive transmission
  - Seasonal impact of weather patterns
  - More interactions at places of learning
  - Travel related to holidays and traditional large family gatherings
  - Fatigue with infection control practices
- Population's behaviors determine the level of control of transmission we can achieve
- Three scenarios capture possible trajectories starting Dec 10th, 2020
  - Adaptive: No change from base projection
  - Adaptive-MoreControl: 15% decrease in transmission starting Dec 10th, 2020
  - Adaptive-LessControl: 15% increase in transmission starting Dec 10th, 2020

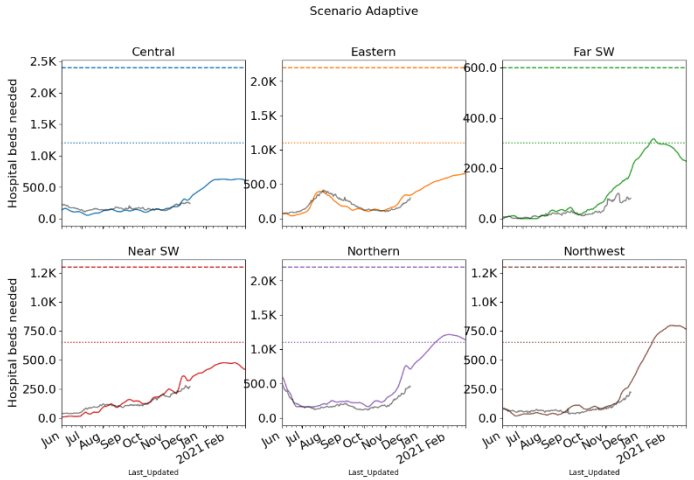
Model Results

Outcome Projections

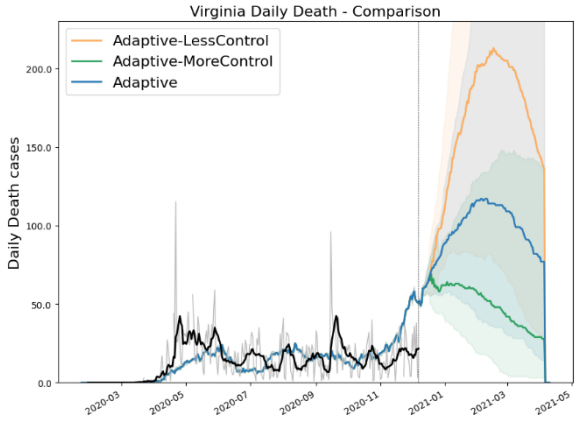
Confirmed cases



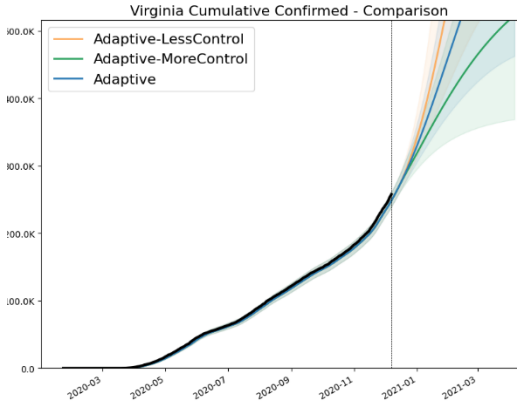
Estimated Hospital Occupancy



Daily Deaths



Cumulative Confirmed cases



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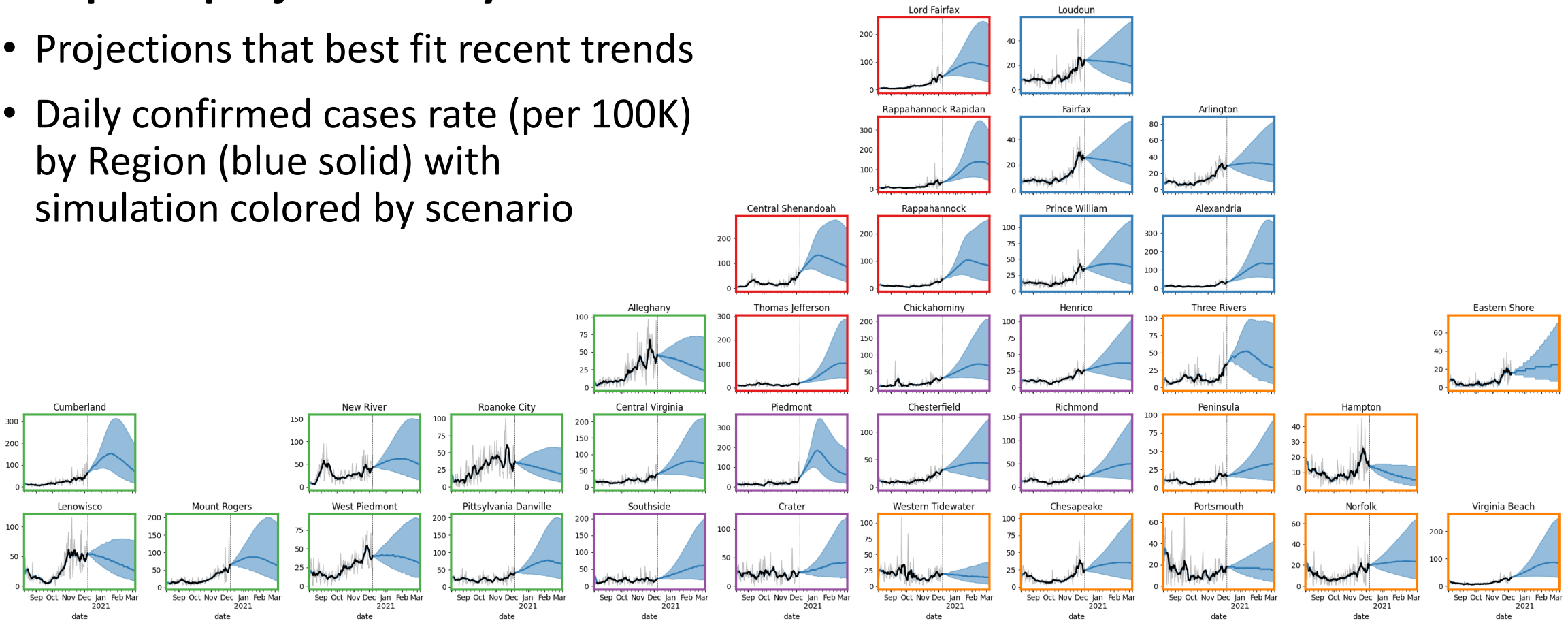
District Level Projections: Adaptive

Adaptive projections by District

- Projections that best fit recent trends
- Daily confirmed cases rate (per 100K) by Region (blue solid) with simulation colored by scenario



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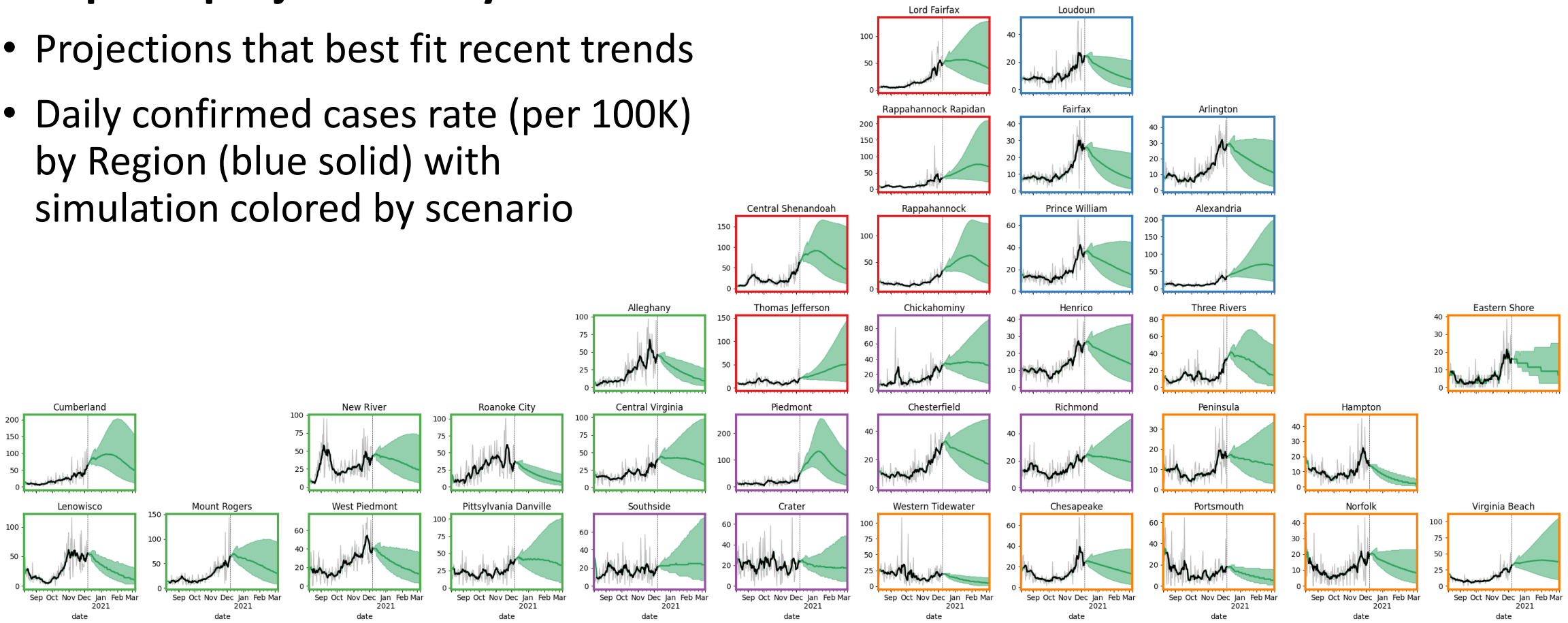
District Level Projections: Adaptive-MoreControl

Adaptive projections by District

- Projections that best fit recent trends
- Daily confirmed cases rate (per 100K) by Region (blue solid) with simulation colored by scenario



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District Level Projections: Adaptive-LessControl

Adaptive projections by District

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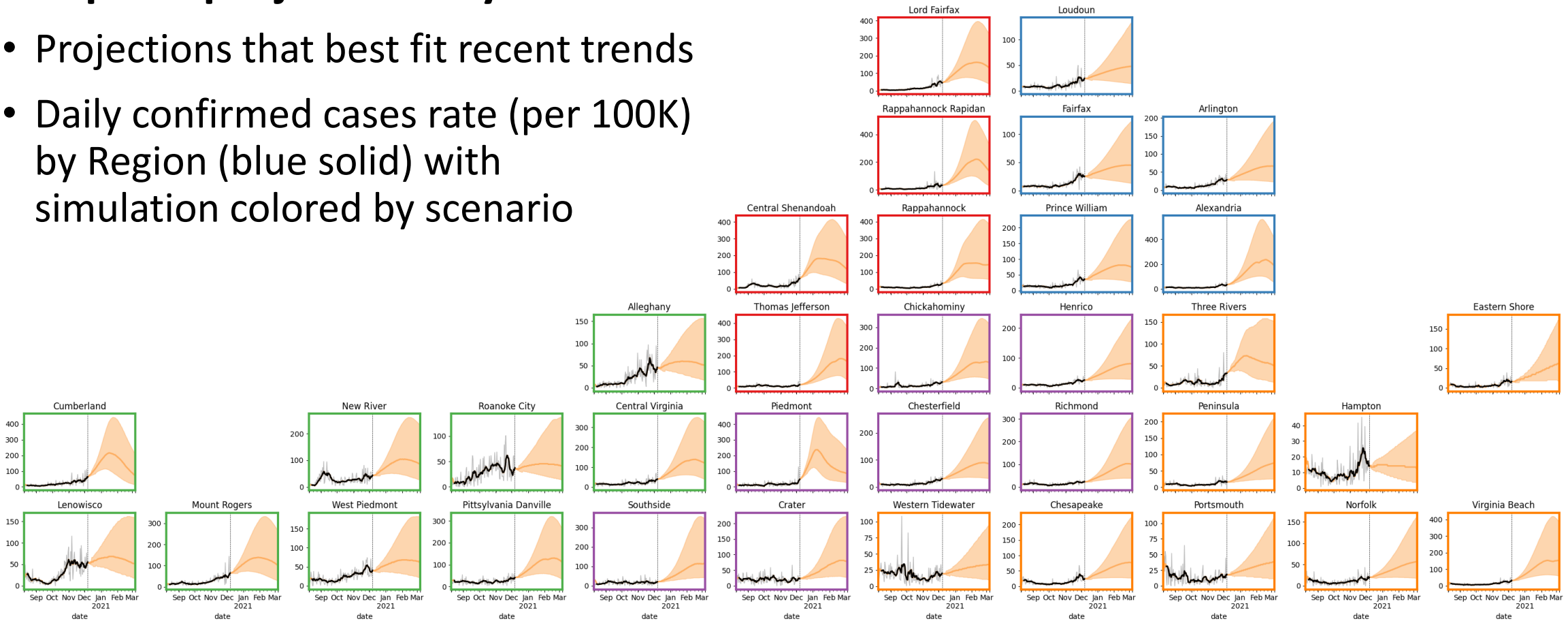
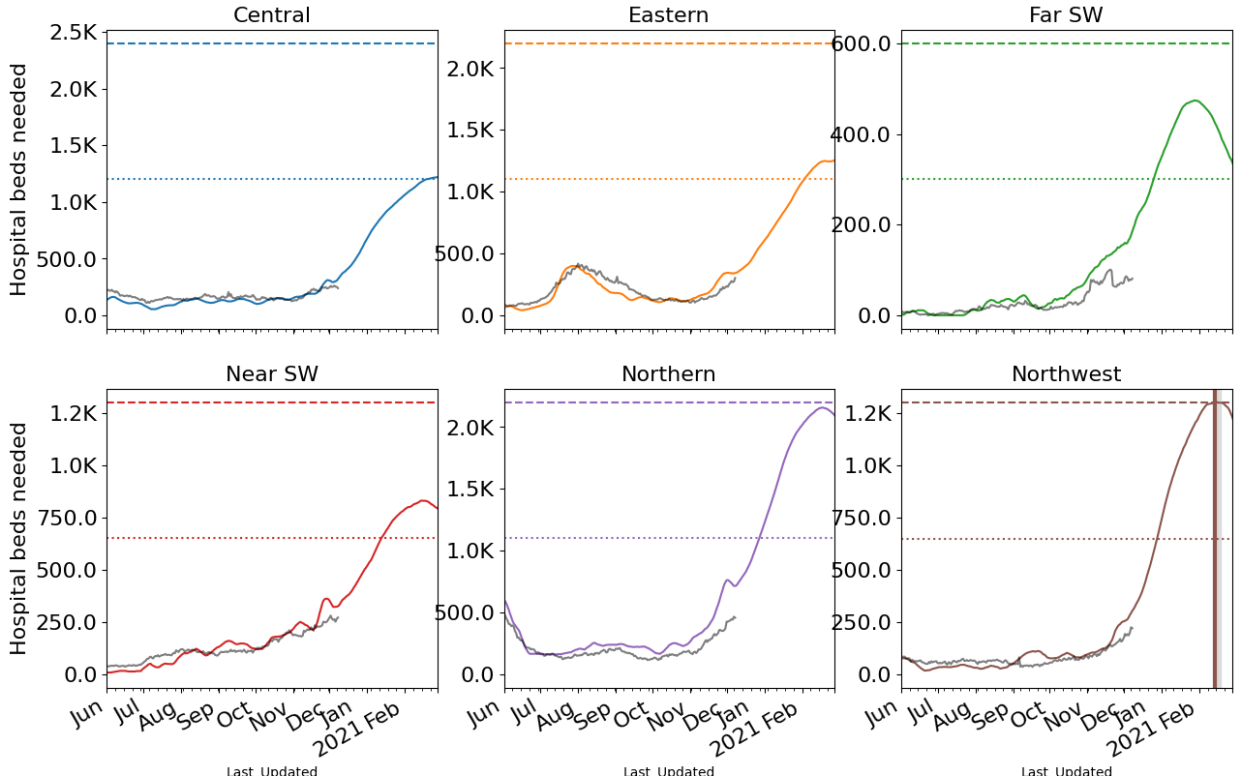


Hospital Demand and Bed Capacity by Region

Capacities* by Region – Adaptive-LessControl

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



Week Ending	Adaptive	Adaptive-LessControl
11/29/20	17,405	17,405
12/06/20	16,823	16,823
12/13/20	19,811	19,826
12/20/20	21,987	23,587
12/27/20	24,055	29,112
1/3/20	26,459	34,782
1/10/20	28,636	40,422
1/17/20	30,276	45,443
1/24/20	31,391	49,562
1/31/20	31,941	52,748
2/7/20	32,081	54,887
2/14/20	31,753	56,209

If Adaptive-LessControl scenario persists:

- All regions approach initial bed capacity this winter, starting mid-Dec through mid-Feb
- Over bed capacity possible in Northwest in mid February.

* Assumes average length of stay of 8 days

Key Takeaways

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

- **Case growth in Virginia seems to have rebounded following Thanksgiving holiday**
- VA mean weekly incidence (38/100K) up (from 28) as national surge also rebounds (to 68/100K from 53/100K).
- Lingering effects from reporting delays and overall testing interruptions continue to impact projections, which are mostly up.
- Recent updates:
  - Ensemble of statistical and Machine Learning models integrated with Adaptive to guide projections
  - Return projection trend window to 2 weeks to minimize holiday effects
  - Planning scenarios remain at Dec 10th and case ascertainment rates updated but are unchanged
- The situation is changing rapidly. Models will be updated regularly.

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

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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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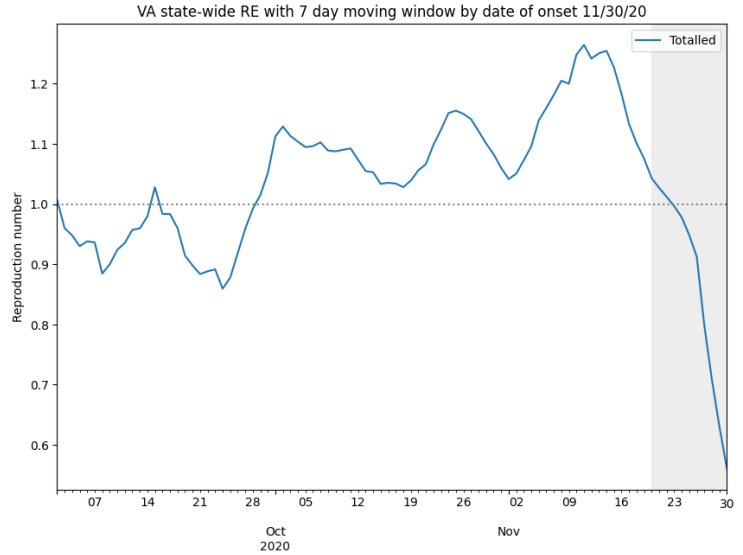
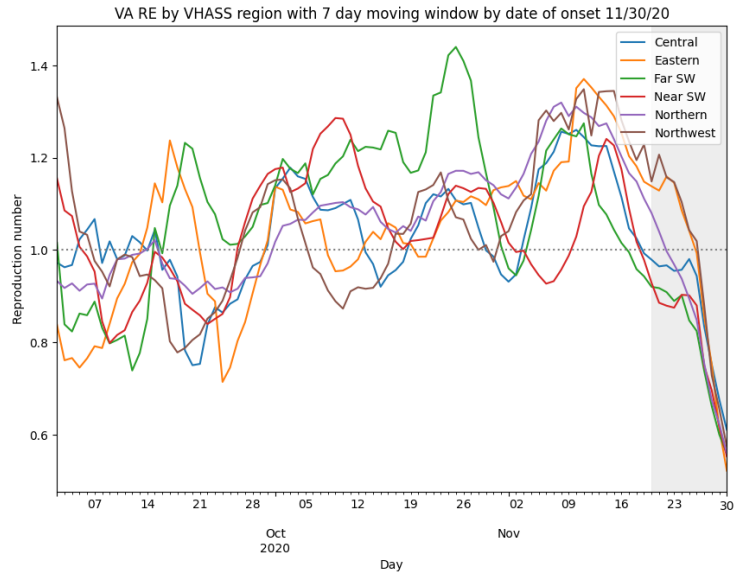
Supplemental Slides

Estimating Daily Reproductive Number

Nov 30th Estimates

Region	Date of Onset R_e	Date Onset Diff Last Week
State-wide	1.030	-0.222
Central	0.963	-0.264
Eastern	1.121	-0.188
Far SW	0.908	-0.166
Near SW	0.922	-0.311
Northern	1.069	-0.207
Northwest	1.135	-0.205





Methodology

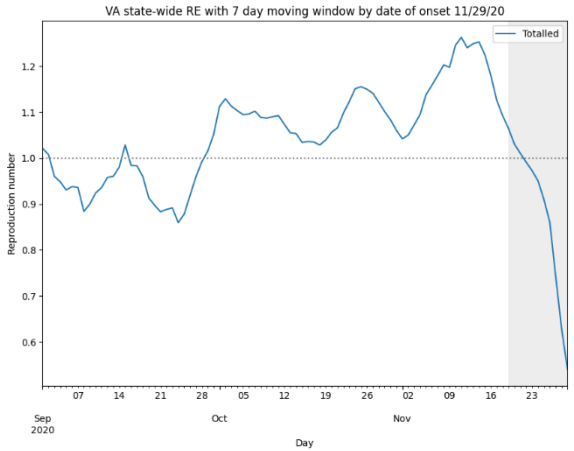
- Wallinga-Teunis method (EpiEstim[1]) for cases by date of onset
- Serial interval: 6 days (2 day std dev)
- Recent estimates may be unstable due to backfill

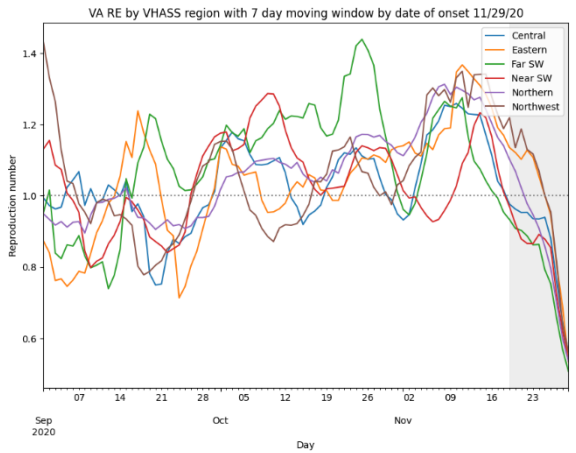
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Estimating Daily Reproductive Number

Region	Date of Onset R_e	Confirmed Date R_e	Range of R_e	Onset Diff Last Week	Confirmed Diff Last Week	Range of Diff from Last Week
State-wide	1.030	1.234	[1.03-1.234]	-0.222	0.143	[-0.22 to 0.14]
Central	0.963	1.064	[0.963-1.064]	-0.264	-0.035	[-0.26 to -0.03]
Eastern	1.121	1.369	[1.121-1.369]	-0.188	0.332	[-0.19 to 0.33]
Far SW	0.908	1.022	[0.908-1.022]	-0.166	-0.204	[-0.17 to -0.2]
Near SW	0.922	1.225	[0.922-1.225]	-0.311	0.307	[-0.31 to 0.31]
Northern	1.069	1.280	[1.069-1.28]	-0.207	0.125	[-0.21 to 0.12]
Northwest	1.135	1.399	[1.135-1.399]	-0.205	0.192	[-0.21 to 0.19]

Nov 20th Estimates





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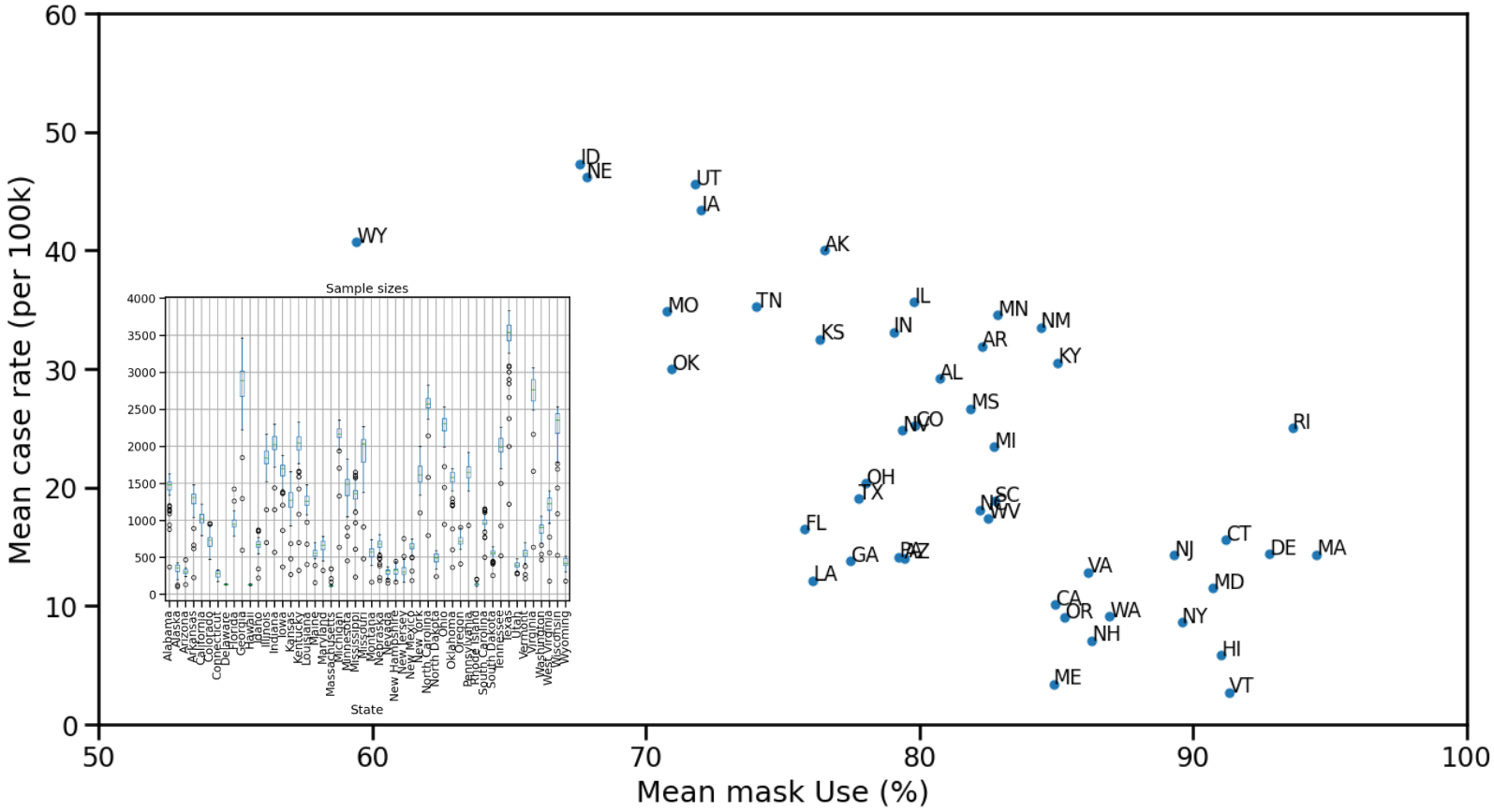
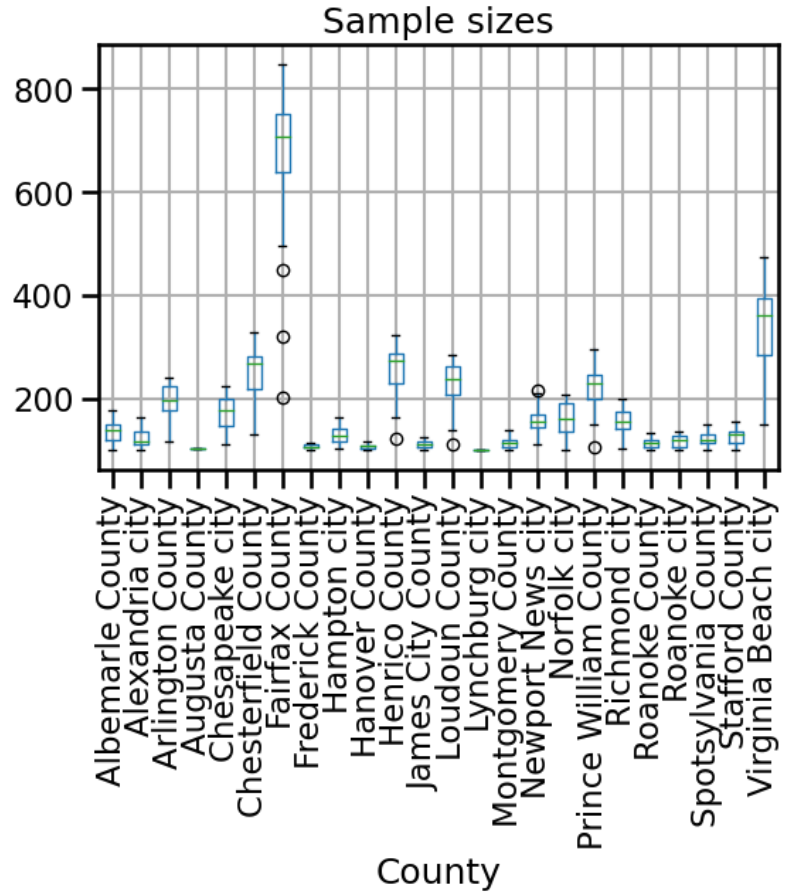
Mask usage sample sizes





Test positivity across VA counties

- CMS weekly summary (used for guiding nursing homes testing protocol)
- Data: COVID-19 Electronic Lab Reporting (CELR); HHS Unified Testing Dataset;
- County level testing counts and 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

County	Oct-21	Oct-28	Nov-04	Nov-11
Alleghany County	Yellow	Red	Red	Red
Botetourt County	Yellow	Red	Red	Red
Bristol City	Red	Red	Red	Red
Buckingham County	Green	Yellow	Red	Red
Campbell County	Red	Red	Red	Red
Carroll County	Yellow	Red	Red	Red
Charles City County	Yellow	Yellow	Green	Red
Clarke County	Green	Green	Yellow	Red
Covington City	Green	Red	Red	Red
Craig County	Red	Red	Red	Red
Culpeper County	Yellow	Yellow	Yellow	Red
Cumberland County	Green	Yellow	Yellow	Red
Dickenson County	Yellow	Yellow	Yellow	Red
Fairfax County	Yellow	Yellow	Yellow	Red
Franklin County	Red	Red	Red	Red
Frederick County	Yellow	Yellow	Yellow	Red
Galax City	Red	Red	Red	Red
Giles County	Yellow	Yellow	Red	Red
Grayson County	Yellow	Red	Red	Red
Halifax County	Green	Yellow	Yellow	Red
Henry County	Red	Red	Red	Red
Lee County	Red	Red	Red	Red
Manassas City	Red	Yellow	Yellow	Red
Martinsville City	Red	Red	Red	Red
Norton City	Green	Yellow	Yellow	Red
Patrick County	Yellow	Yellow	Yellow	Red
Prince George County	Red	Red	Red	Red
Prince William County	Yellow	Red	Red	Red
Pulaski County	Yellow	Red	Red	Red
Roanoke City	Yellow	Red	Red	Red
Roanoke County	Red	Red	Red	Red
Rockingham County	Yellow	Yellow	Red	Red
Russell County	Yellow	Yellow	Yellow	Red
Salem City	Yellow	Red	Red	Red
Scott County	Red	Red	Red	Red
Smyth County	Green	Green	Yellow	Red
Stafford County	Yellow	Yellow	Yellow	Red
Tazewell County	Red	Red	Red	Red
Washington County	Red	Red	Red	Red
Winchester City	Green	Yellow	Yellow	Red
Wise County	Red	Red	Red	Red
Wythe County	Red	Red	Yellow	Red

Red on Nov 11 (latest)

County	Oct-21	Oct-28	Nov-04	Nov-11
Amherst County	Red	Red	Yellow	Yellow
Bedford County	Red	Red	Red	Yellow
Bristol City	Red	Red	Red	Red
Campbell County	Red	Red	Red	Red
Charlotte County	Red	Red	Red	Yellow
Craig County	Red	Red	Red	Red
Franklin City	Red	Red	Red	Yellow
Franklin County	Red	Red	Red	Red
Galax City	Red	Red	Red	Red
Greensville County	Red	Green	Green	Green
Henry County	Red	Red	Red	Red
Lee County	Red	Red	Red	Red
Manassas City	Red	Yellow	Yellow	Red
Martinsville City	Red	Red	Red	Red
Prince Edward County	Red	Red	Yellow	Yellow
Prince George County	Red	Red	Red	Red
Radford City	Red	Red	Red	Yellow
Roanoke County	Red	Red	Red	Red
Scott County	Red	Red	Red	Red
Southampton County	Red	Red	Yellow	Green
Tazewell County	Red	Red	Red	Red
Washington County	Red	Red	Red	Red
Wise County	Red	Red	Red	Red
Wythe County	Red	Red	Yellow	Red

Red on Oct 21 (4-week back)

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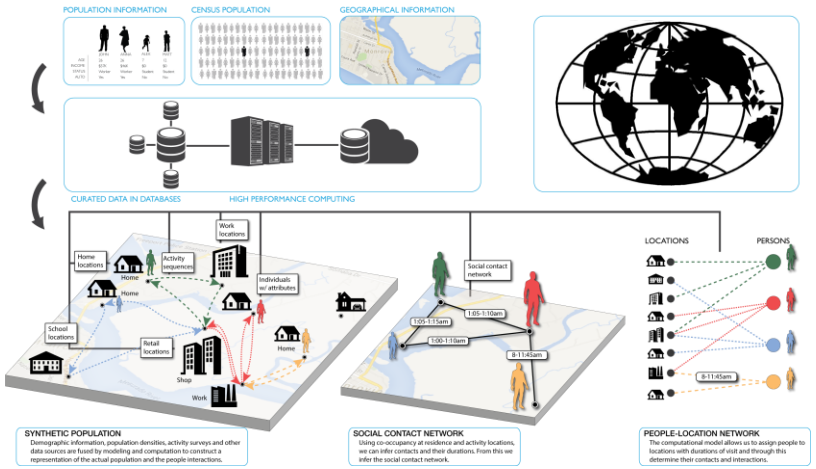
Agent-based Model (ABM)

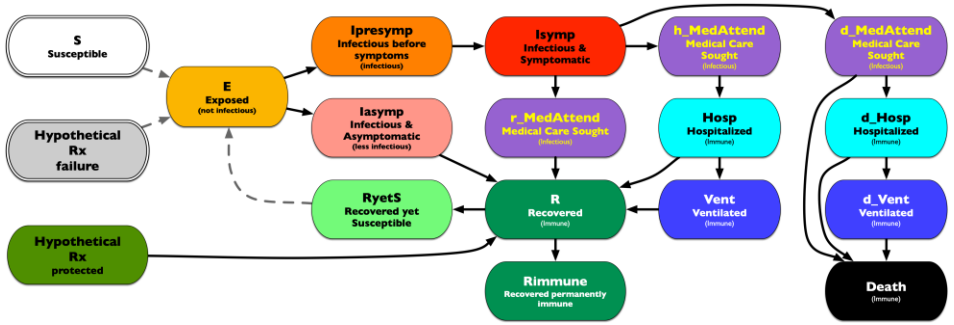
EpiHiper: Distributed network-based stochastic disease transmission simulations

- 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



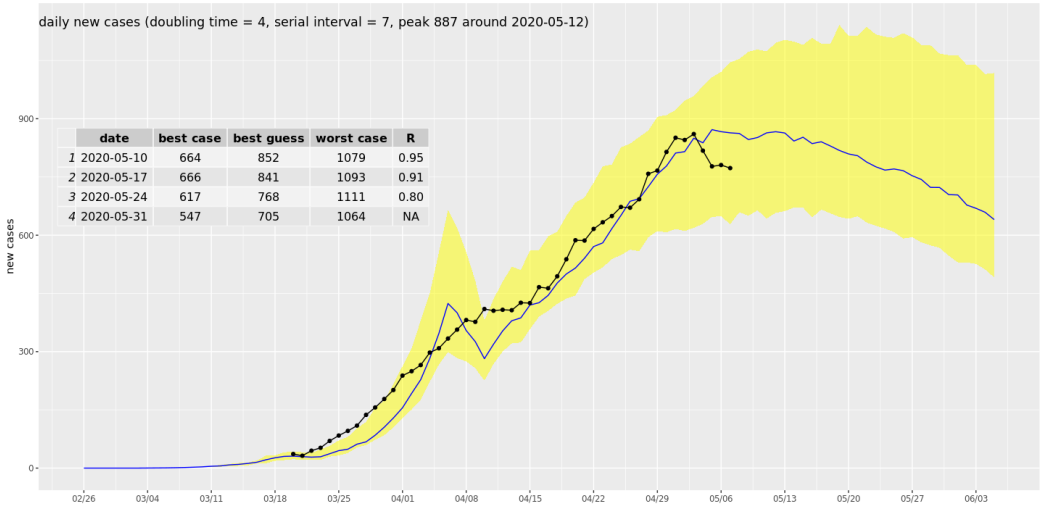
Detailed Disease Course of COVID-19

- Literature based probabilities of outcomes with appropriate delays
- Varying levels of infectiousness
- Hypothetical treatments for future developments

ABM Social Distancing Rebound Study Design

Study of ”Stay Home” policy adherence

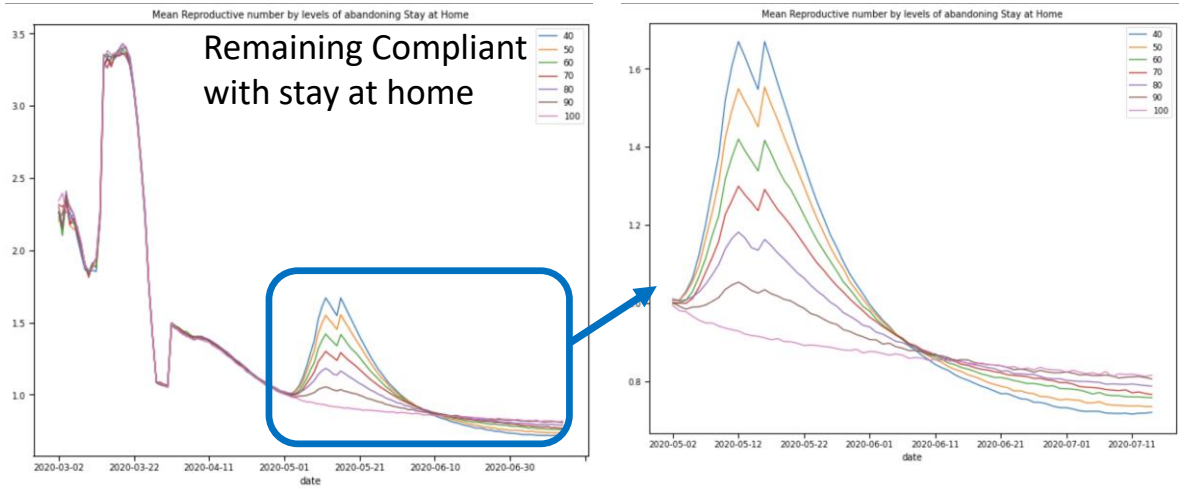
- Calibration to current state in epidemic
- Implement “release” of different proportions of people from ”staying at home”



	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

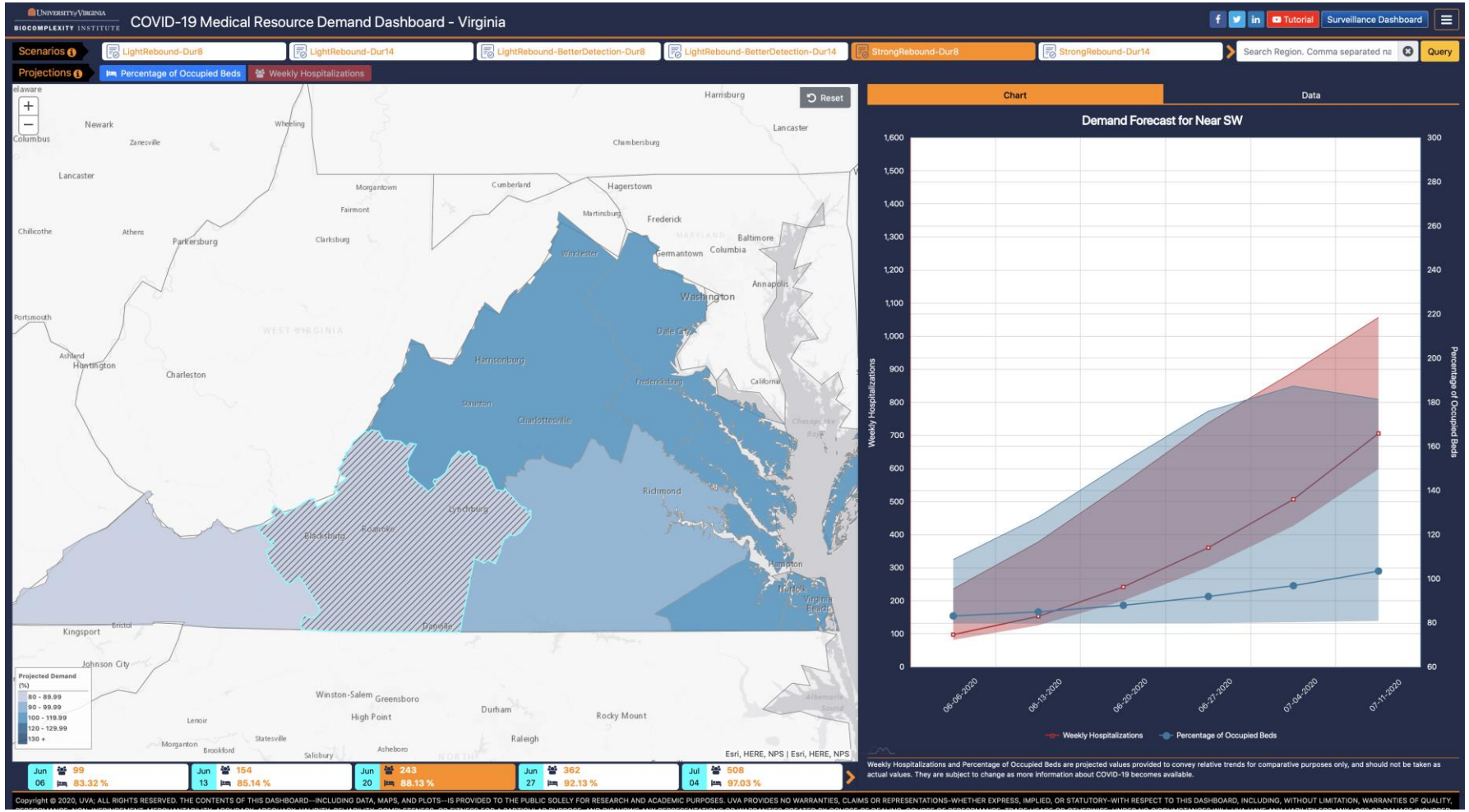


Impacts on Reproductive number with release

- 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

Medical Resource Demand Dashboard

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



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