Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

# Estimation of COVID-19 Impact in Virginia

August 12th, 2020

(data current to August 11th)

Biocomplexity Institute Technical report: TR 2020-098

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# About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others


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# Overview

- **Goal**:  Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project infections through the end of summer
  - 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:

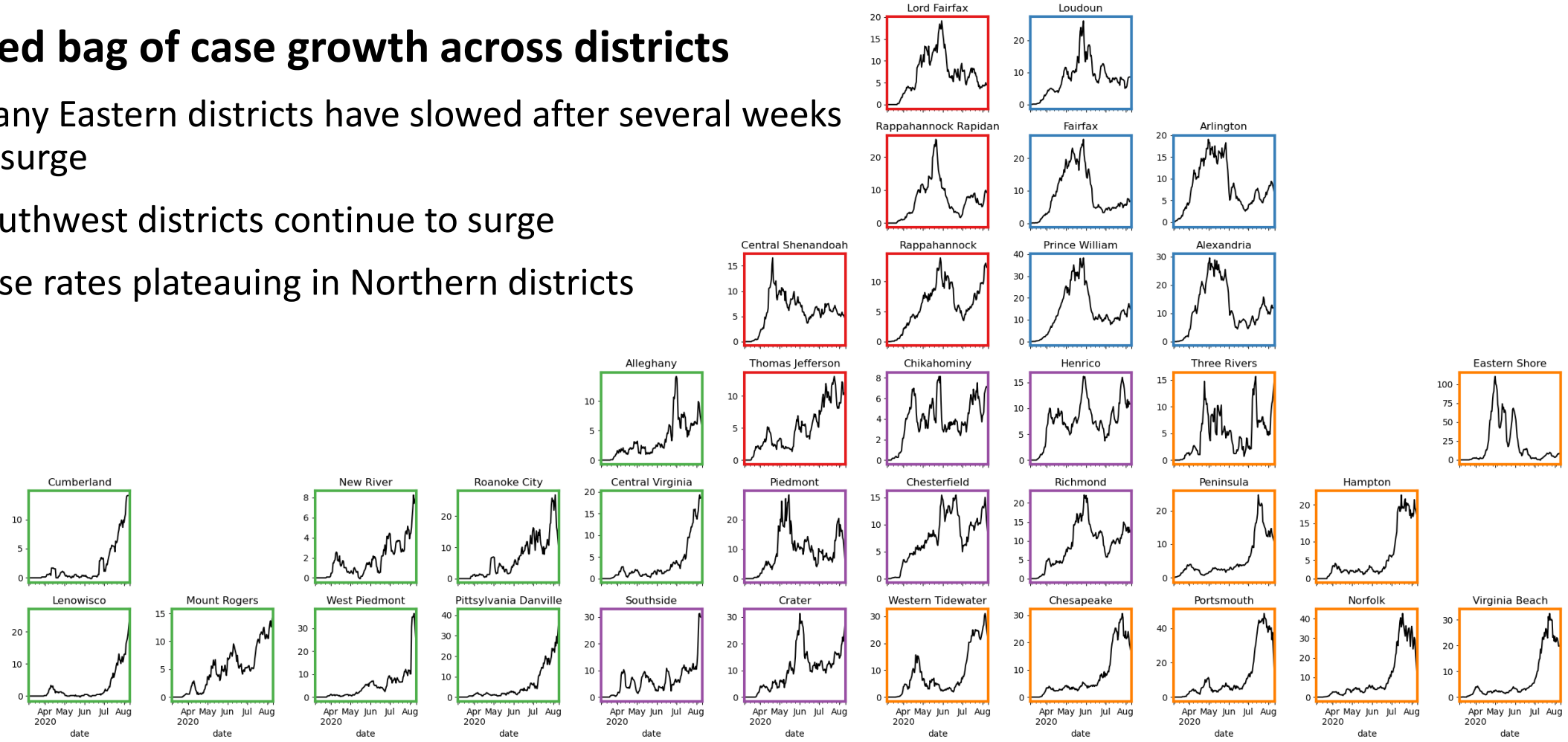
- **Most districts with recent surging growth seem to be slowing; incidence is still high.**
- Similar signs of slowed growth and declines evident across nation.
- Given the experience of other states in the nation, it is crucial to maintain control**.**
- Recent model updates:
  - Transitioned to using Adaptive Fitting projection approach
  - Added scenarios for anticipating impact of seasonal effects
  - Extend projection horizon to Nov 1
- The situation is changing rapidly. Models will be updated regularly.

# Situation Assessment

# Case Rate (per 100k) by VDH District

**Mixed bag of case growth across districts**

- Many Eastern districts have slowed after several weeks of surge
- Southwest districts continue to surge
- Case rates plateauing in Northern districts

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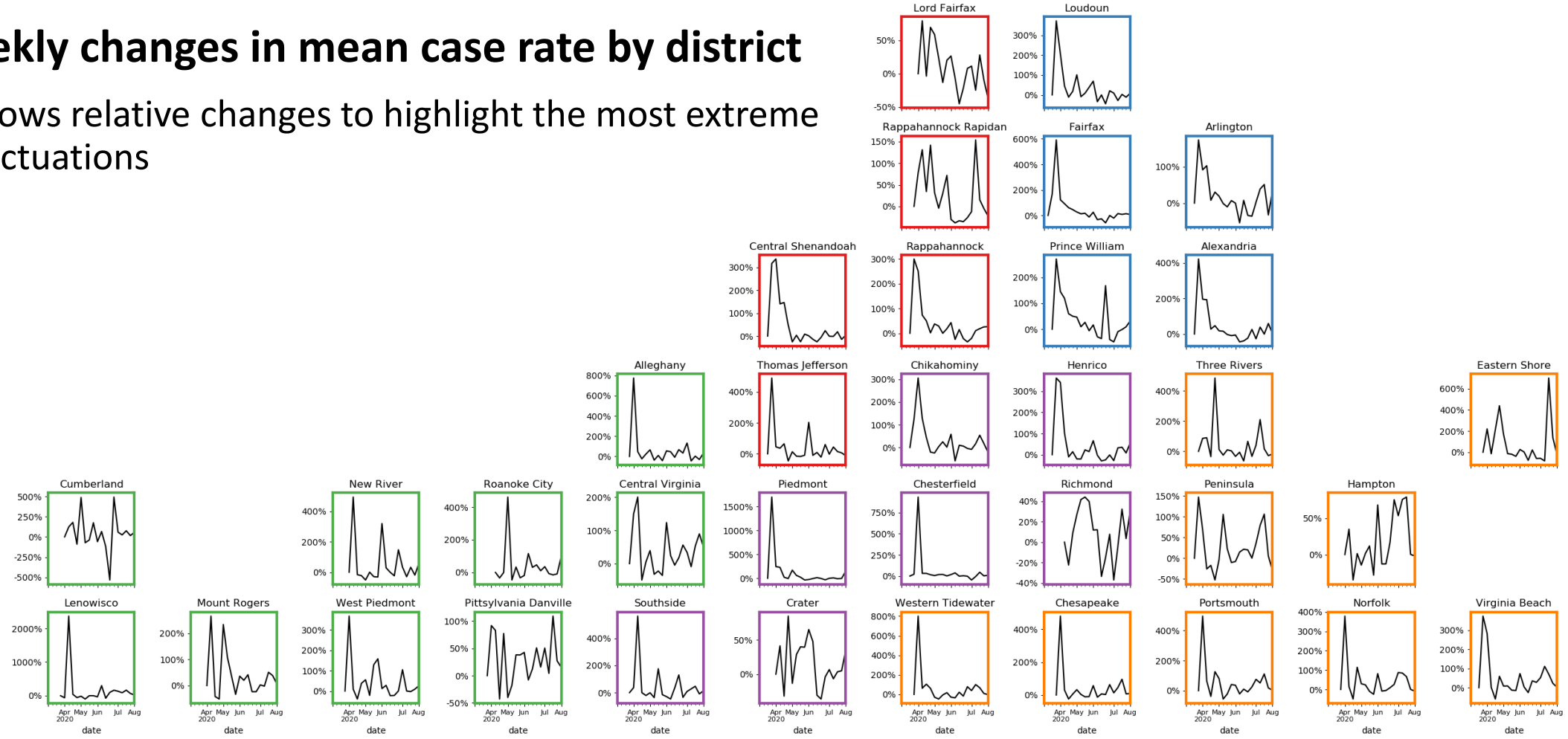
# Percent Change of Case Rate by VDH District

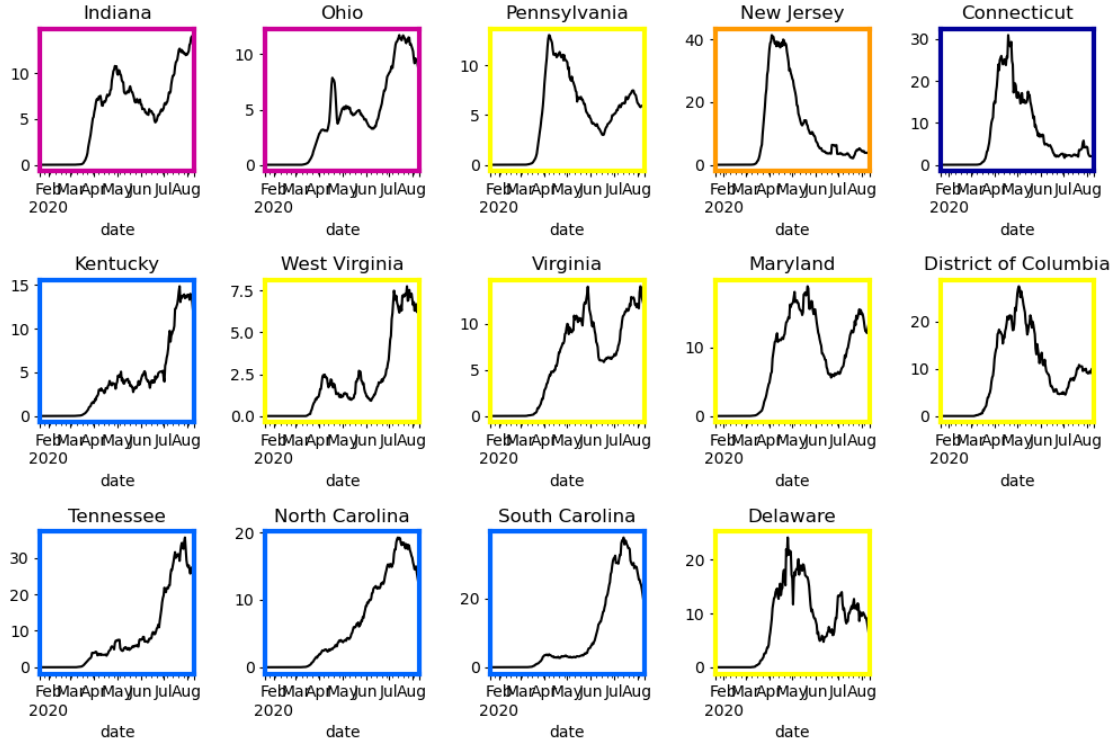
**Weekly changes in mean case rate by district**

- Shows relative changes to highlight the most extreme fluctuations

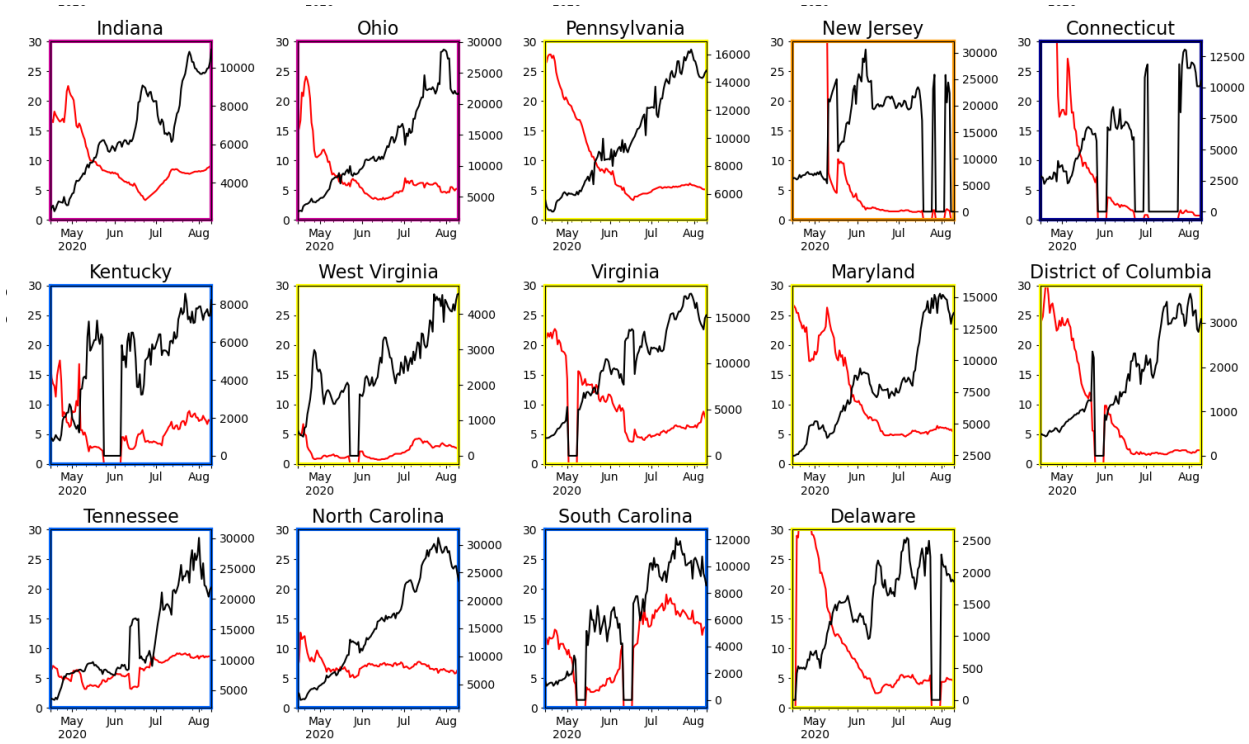


# Other State Comparisons

## Case Rate per 100K population




## Tests per Day and Test Positivity



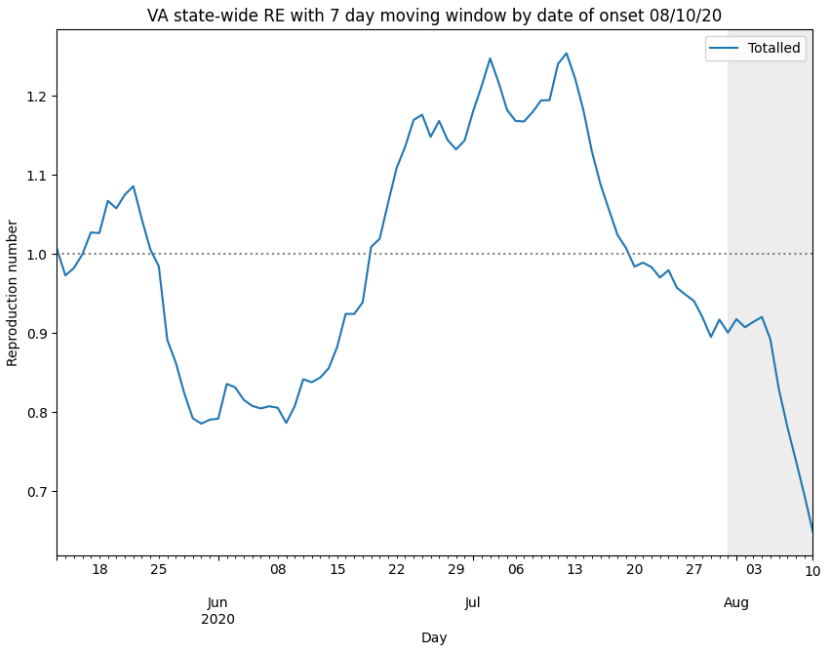

- Multiple states experiencing local ‘peak’ in case rates in the past 2 weeks
- Current data shows plateau or initial decline in case rates

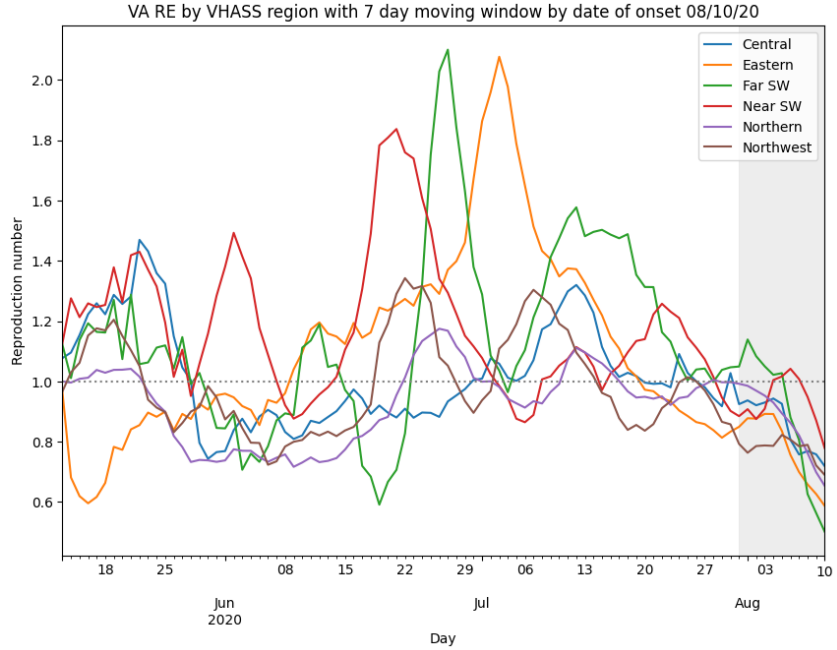
- Test positivity rates hovering around 5-10% for most neighboring states despite increased testing levels
- Mixed Trends, both increasing and decreasing

# Estimating Daily Reproductive Number

## August 1st Estimates

| Region | Current $R_e$ | Diff Last Week |
|---|---|---|
| State-wide | 0.917 | 0.008 |
| Central | 0.937 | 0.030 |
| Eastern | 0.878 | 0.017 |
| Far SW | 1.139 | 0.199 |
| Near SW | 0.908 | -0.266 |
| Northern | 0.985 | 0.102 |
| Northwest | 0.763 | -0.212 |




**Methodology**

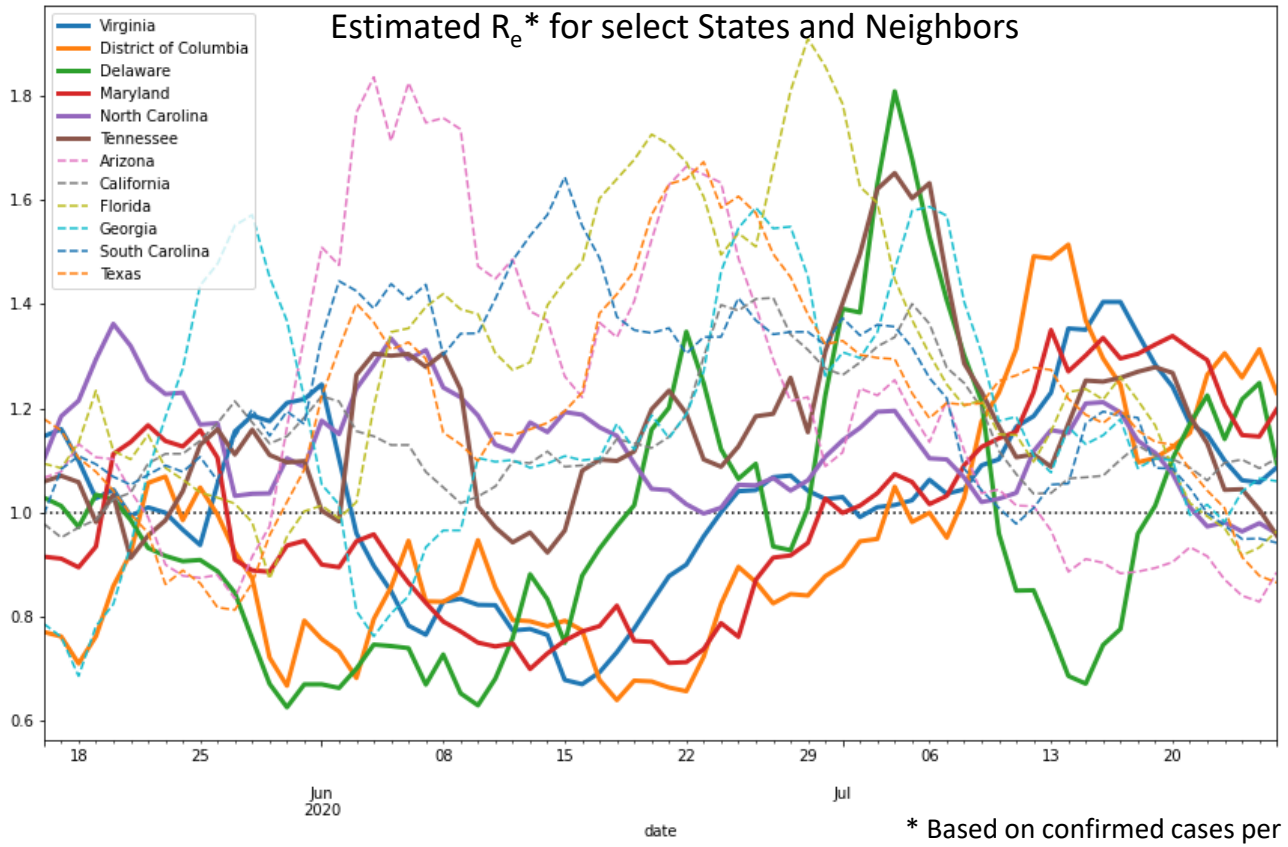
- Wallinga-Teunis method (EpiEstim[1]) for cases by date of onset
- Serial interval: 6 days (2 day std dev)
- Recent estimates may be unstable due to backfill

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

# Other State Comparisons

**Multiple states with $R_e$ in the 1-1.2 range**

- Recent national hotspots such as AZ, CA, TX, FL are decreasing
- Some neighboring states are trending down or remaining stable




VA and neighbors stable and declining

* Based on confirmed cases per day

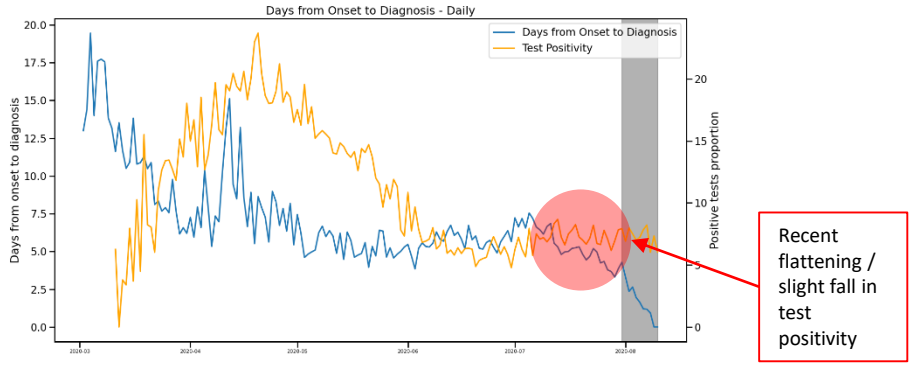
# Changes in Case Detection

Days to Diagnosis dropped but rebounding

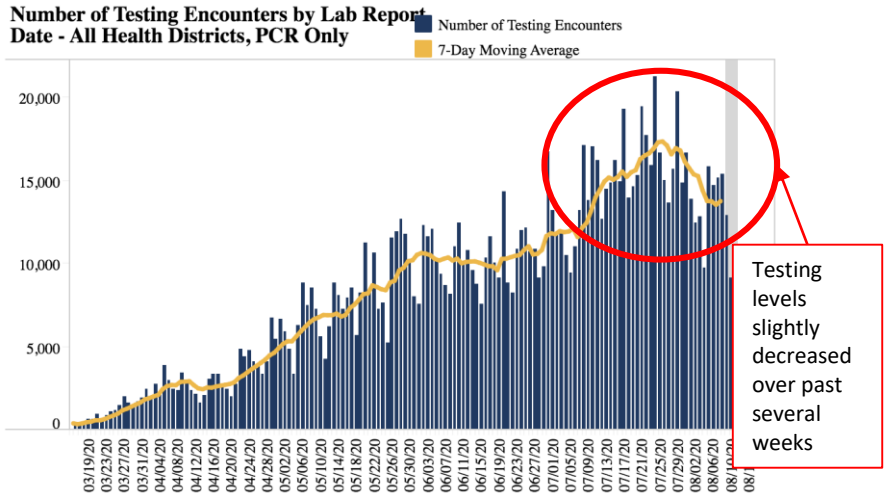
- Mid March to Late April = 8.1 days
- Late April to Late May = 5.7 days (30% lower)
- Late May to Late June = 5.5 days (32% lower)
- Early July to late July = 6.1 days (24% lower)

Rising level during weeks of test positivity rise

**Test positivity vs. Onset to Diagnosis**




Testing Encounters and test positivity have steadied and increased

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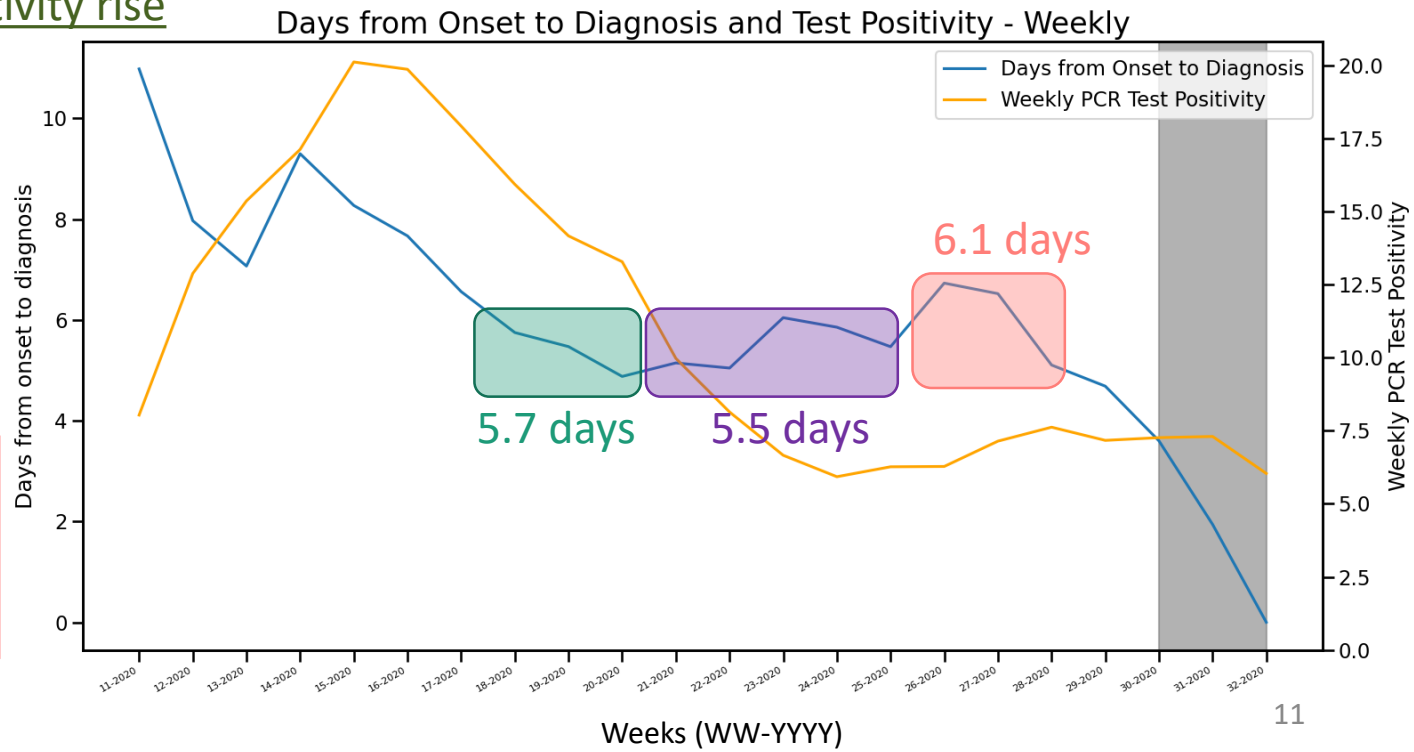
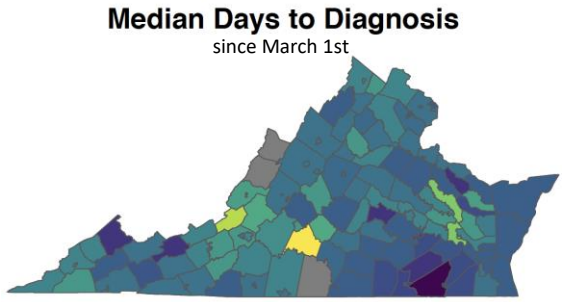


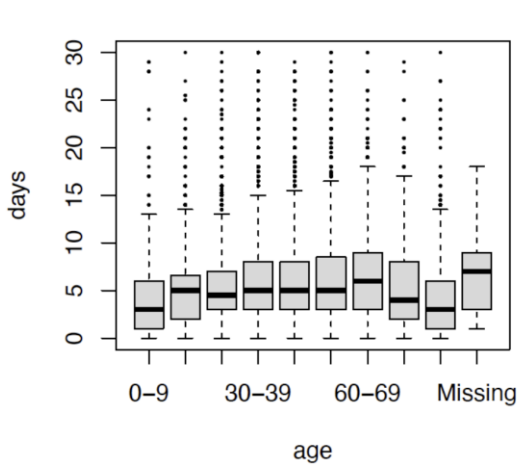
# Changes in Case Detection – By District/Age





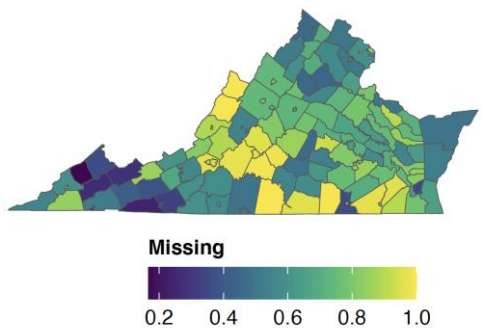


Slight variations by age group
(0-9, 70-79 and 80-89 have lower medians)
No significant variation by severity (hosp./ICU)




*up to the mid July when data is stable

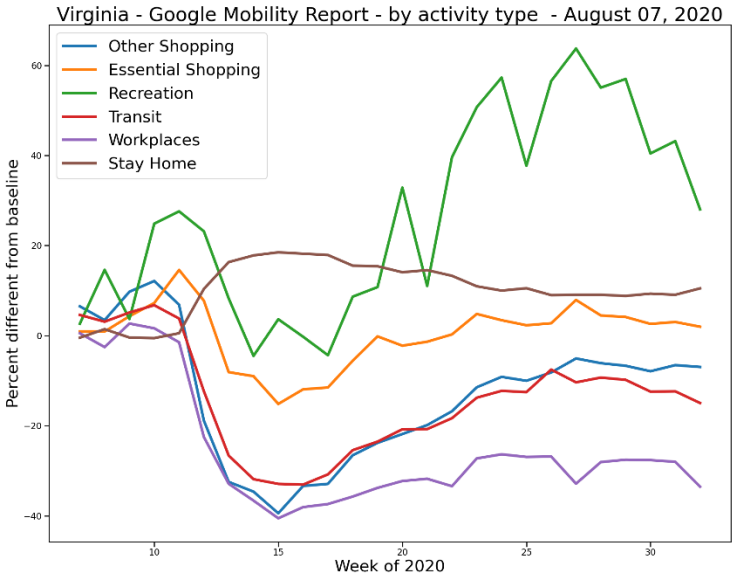
Only ~35% records have entries

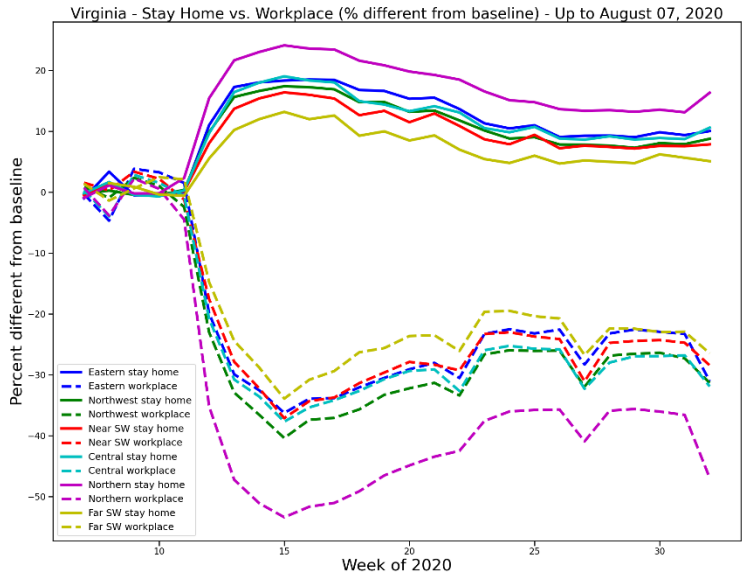


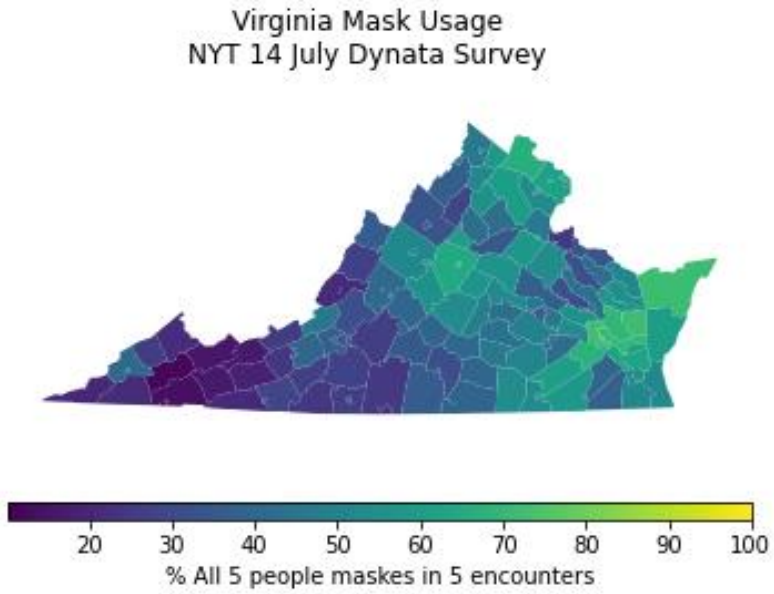
# Estimating Effects of Social Distancing

**Google Mobility data shows continued slow rebound** (as of July 26th)
https://www.google.com/covid19/mobility/

- Continued slow reduction of those staying at home. Workplace levels remain low.
    - Urban/Rural variations in levels (e.g., Northern vs Far SW)
- Essential shopping back to baseline. Other shopping/transit trending towards baseline.
- Parks and recreation significantly higher than baseline (seasonal effects).
- Masks usage not evenly distributed, higher in Northern central, lower Southwest and Richmond area



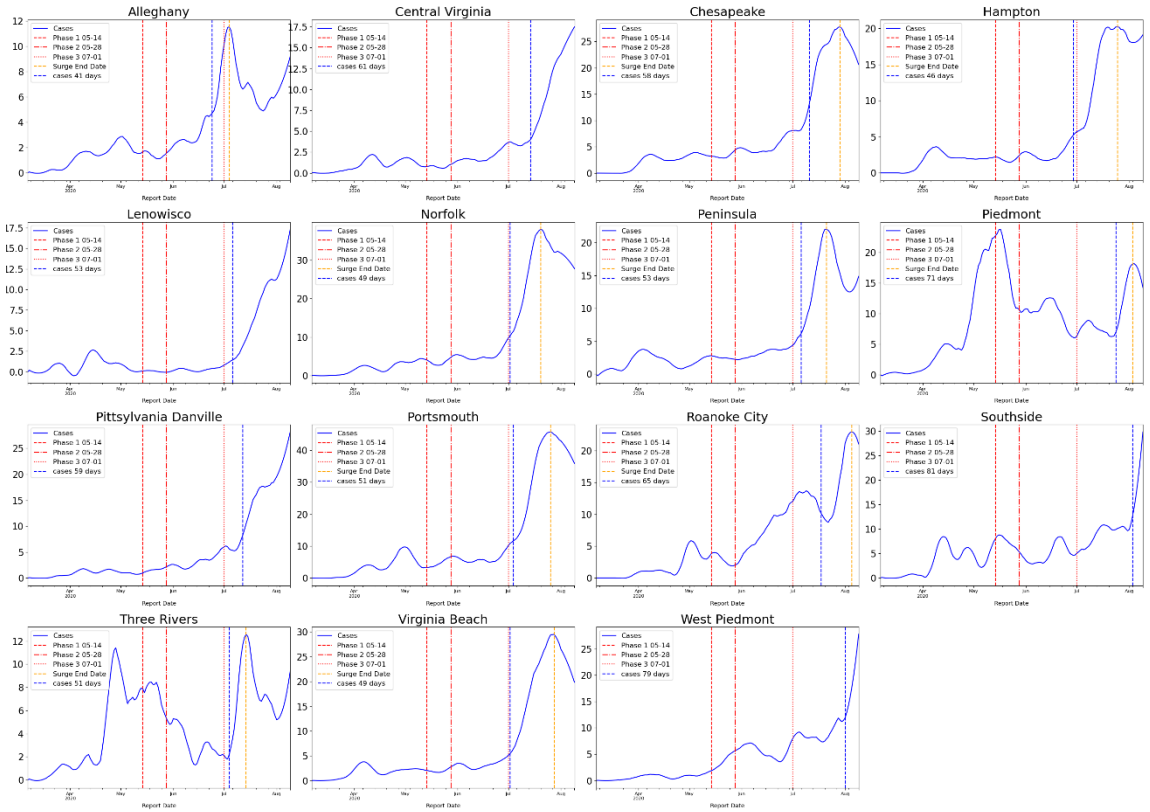



# Surges Still Significant but Slowing

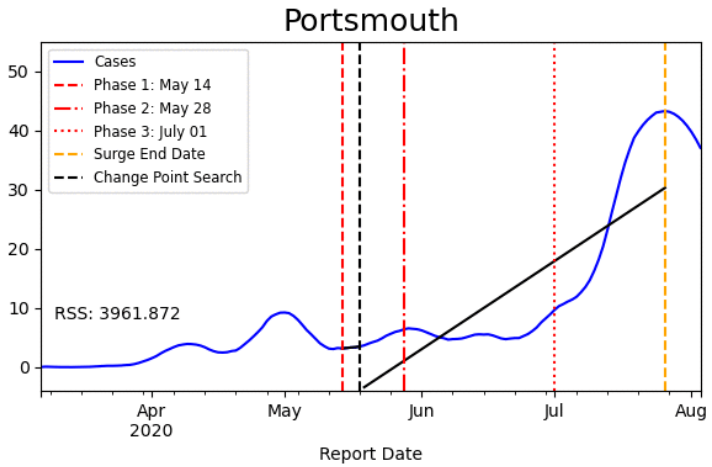
**Resurgence:** Past month marked by rapid increase in cases in much of the nation, and across Virginia

- Most surging locations have plateaued or even begun to recede
- Incidence remains high, deaths and hospitalizations have some lag time and continue to be high



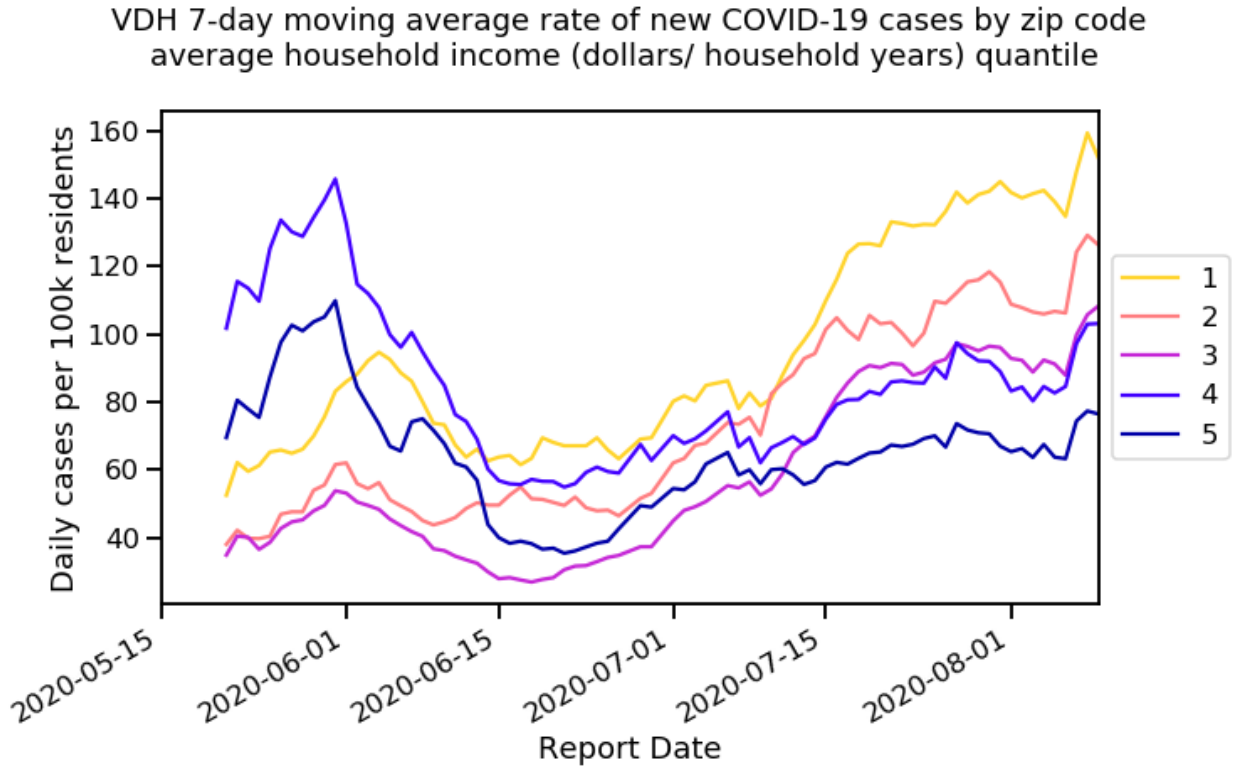

**Surge Detection:**
Continue to evaluate when and where surges are occurring

- Determine surging districts and timing with "hockey stick" fit




15 districts: Compared to 13 last week
Most are experiencing initial plateaus or declines
**In:** Southside, Lenowisco, Pittsylvania Danville, West Piedmont
**Out:** Western Tidewater, Henrico, Prince William

# Impact across Density and Income





Lower 20% income zipcodes now reporting highest case rates

Can see the evolution from denser and wealthier zipcodes to poorer and less dense zipcodes

# Model Update – Adaptive Fitting

# Adaptive Fitting Approach

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

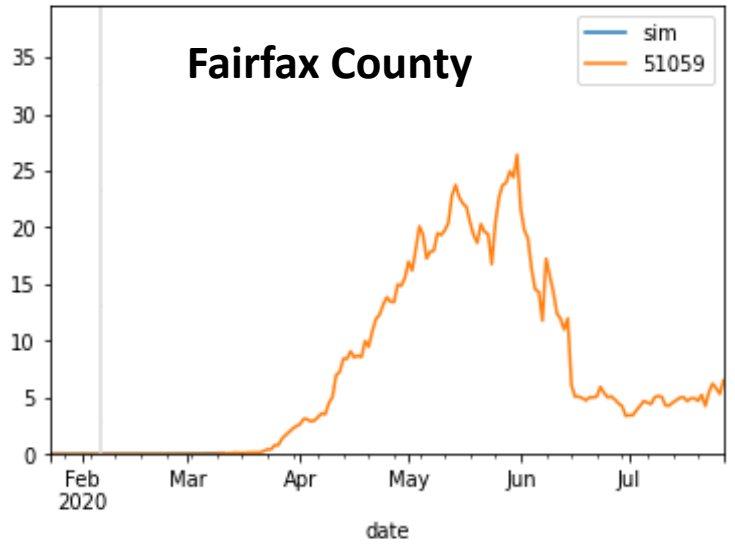
- Allows history to be precisely captured, and used to guide bounds on projections

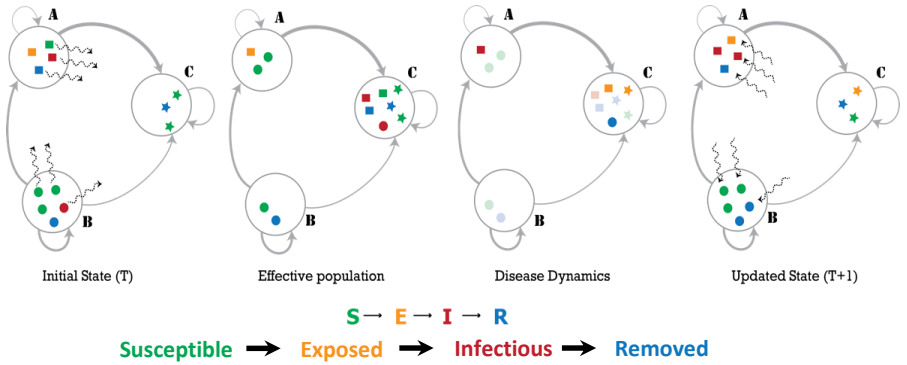
**Model:** An alternative use of the same meta-population model, PatchSim

- 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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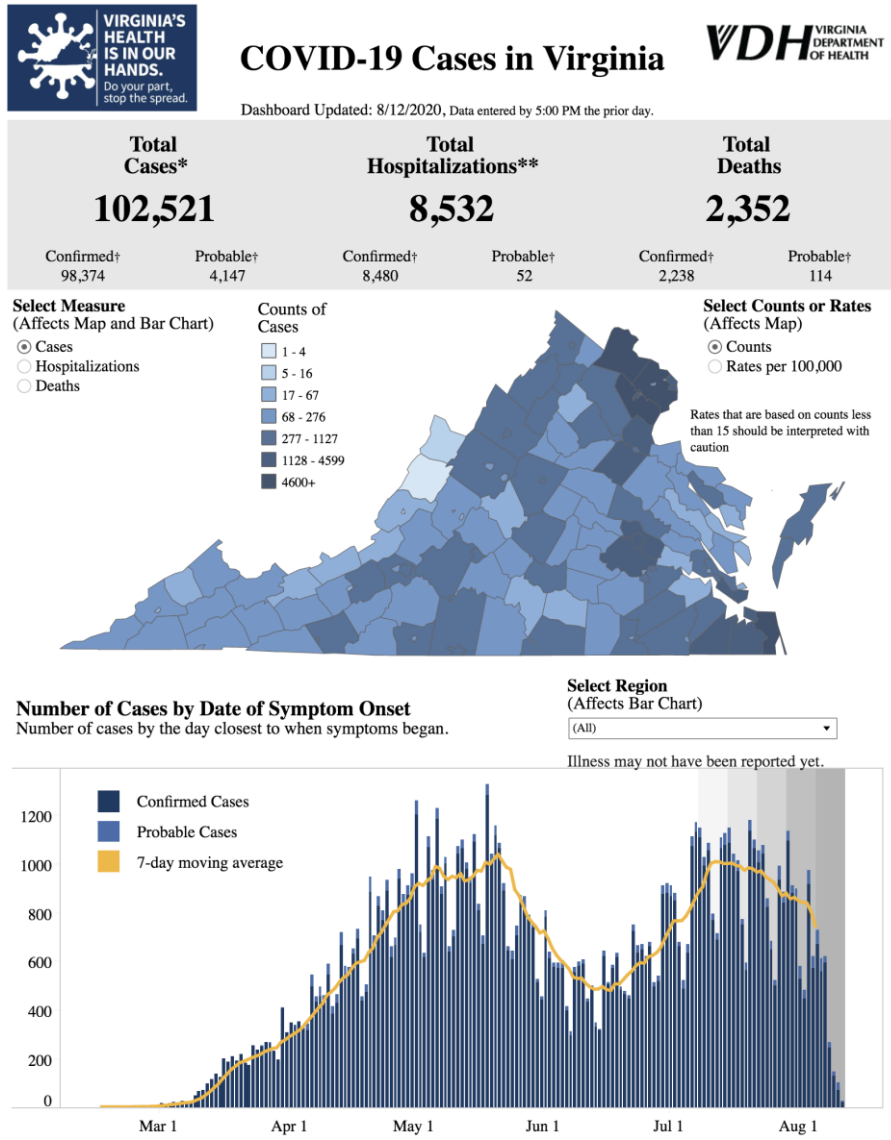
# Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (2x to 15x)
    - 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 using the most recent parameters with constraints learned from the history of the fit parameters
  - Last 14 day window used, informed by variances in the previous 4 weeks




Accessed 9am August 12, 2020
https://www.vdh.virginia.gov/coronavirus/

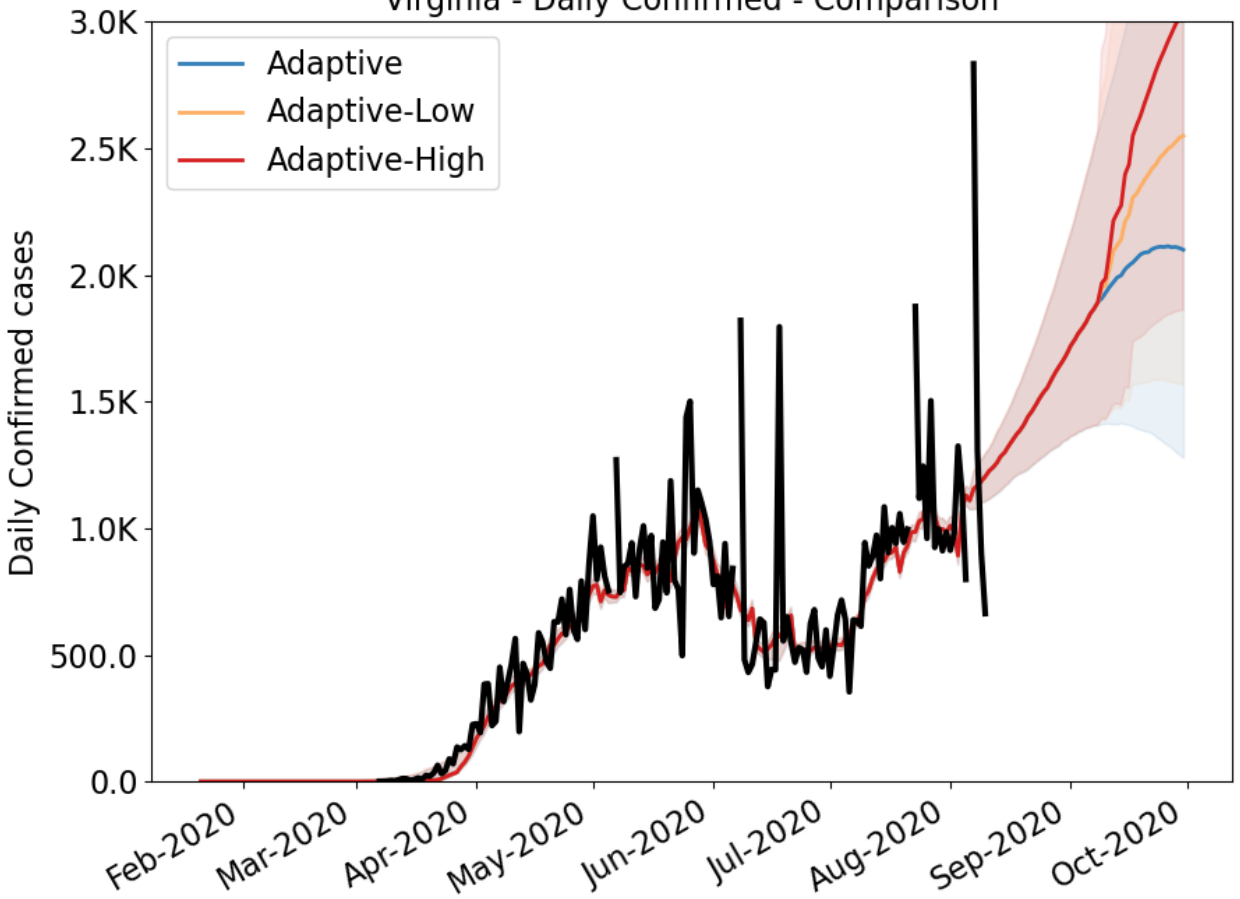
# Scenarios – Seasonal Effects

- Societal changes in the coming weeks may lead to an increase in transmission rates
  - Start of in-person school
  - Changes to workplace attendance
  - Seasonal impact of weather patterns
- Three scenarios provided to capture possible trajectories related to these changes starting following Labor day, Sept 7th, 2020
  - Adaptive: No change from base projection
  - Adaptive-Low: 10% increase in transmission starting Sept 8th, 2020
  - Adaptive-High: 20% increase in transmission starting Sept 8th, 2020

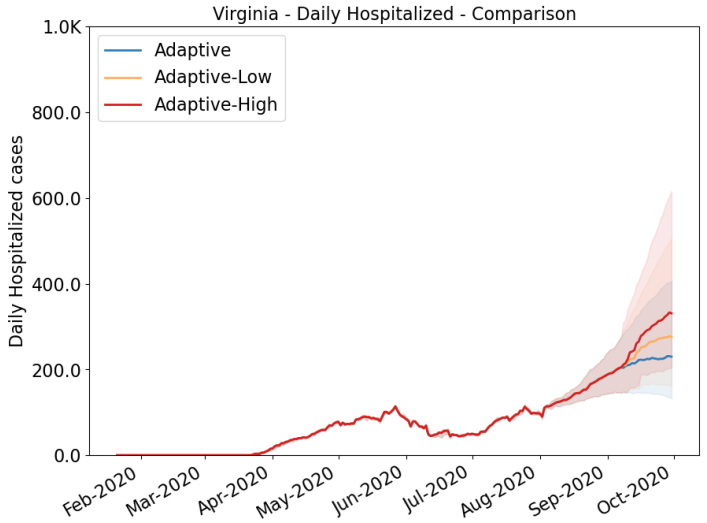
# Model Results

# Outcome Projections

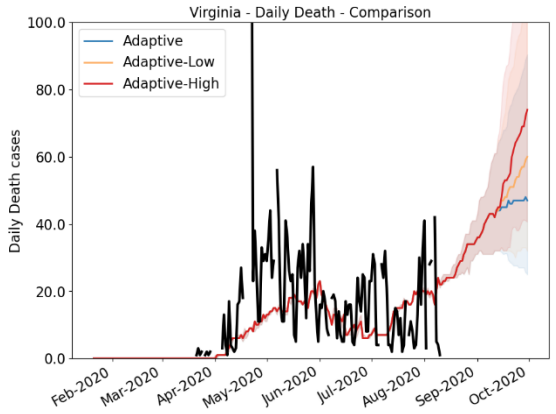
## Confirmed cases



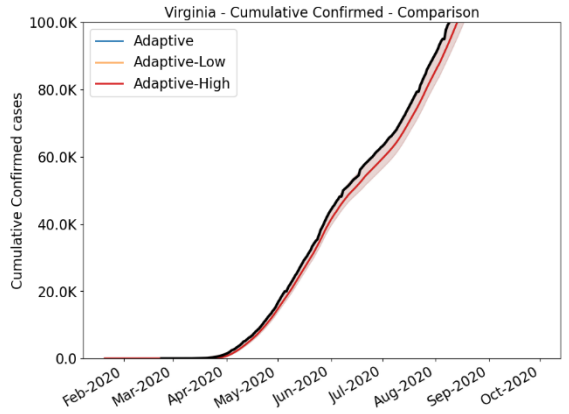

## Daily Hospitalizations




## Daily Deaths



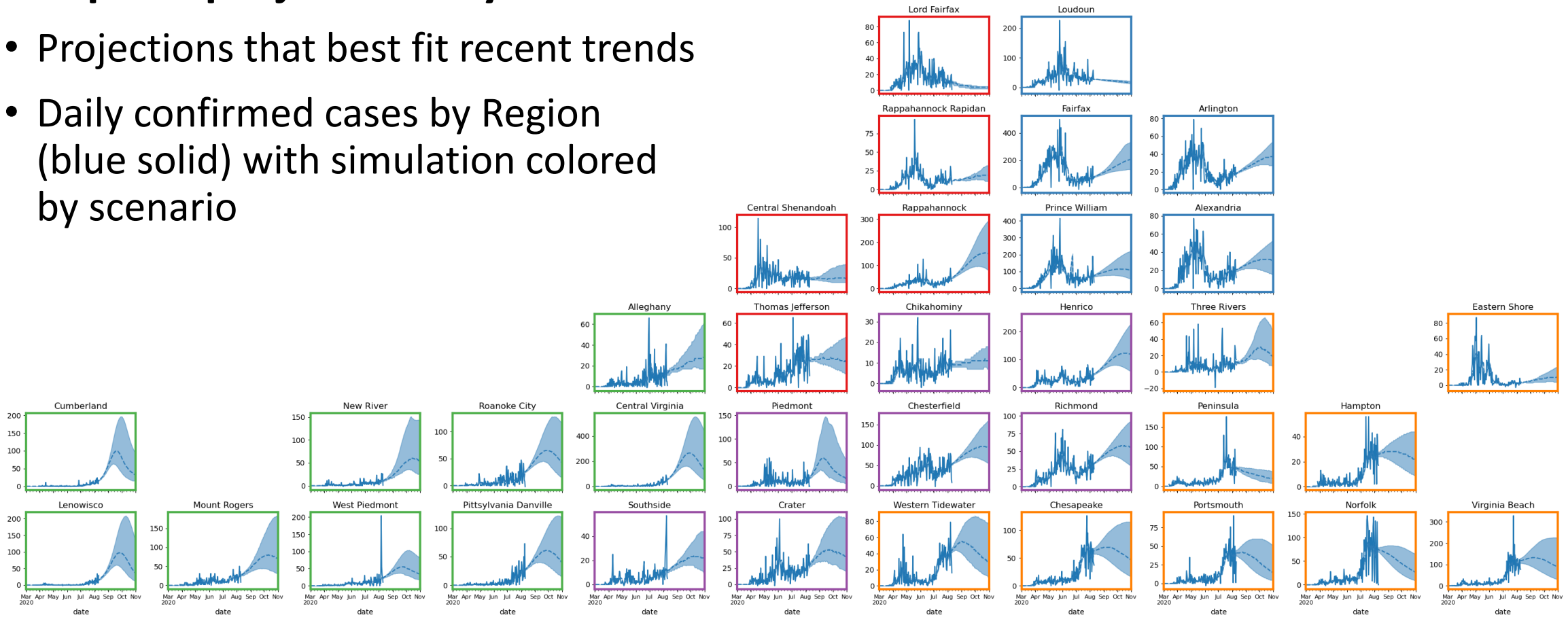

## Cumulative Confirmed cases



# District Level Projections: Adaptive

## Adaptive projections by District

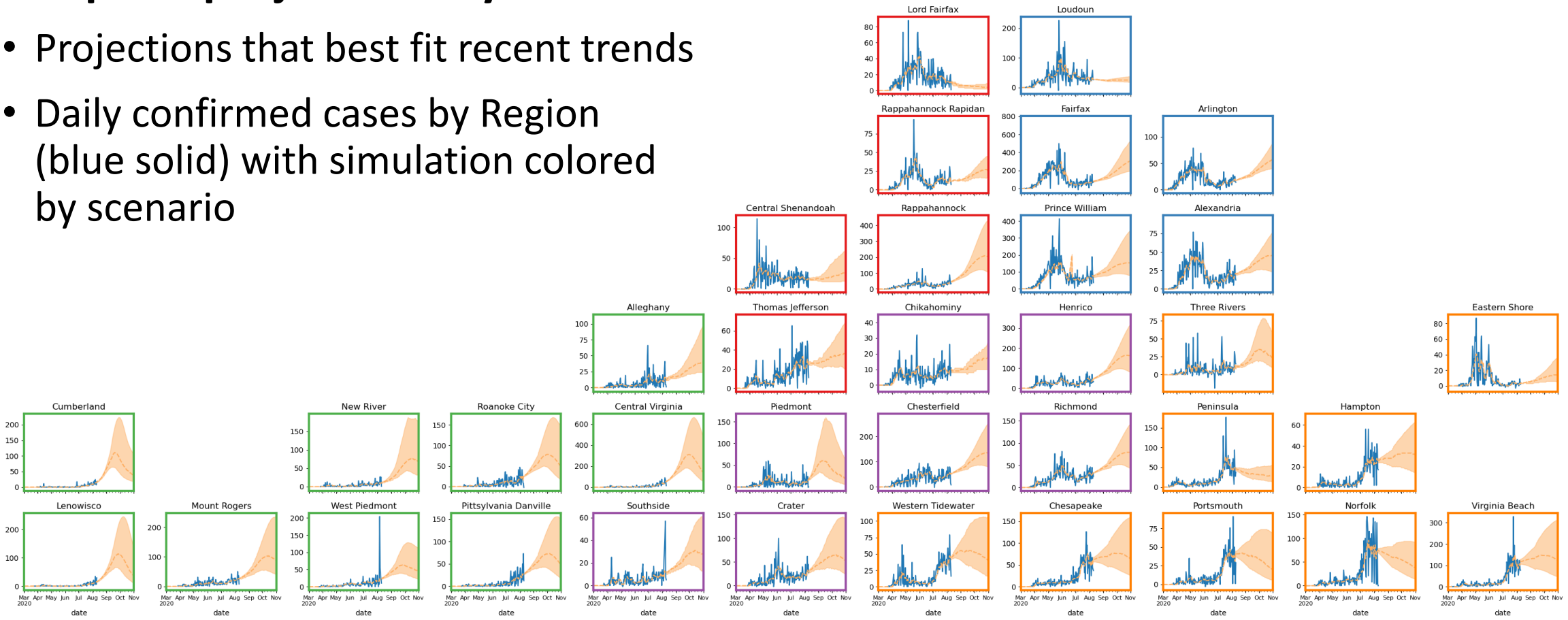
- Projections that best fit recent trends
- Daily confirmed cases by Region (blue solid) with simulation colored by scenario



# District Level Projections: Adaptive-Low

## Adaptive projections by District

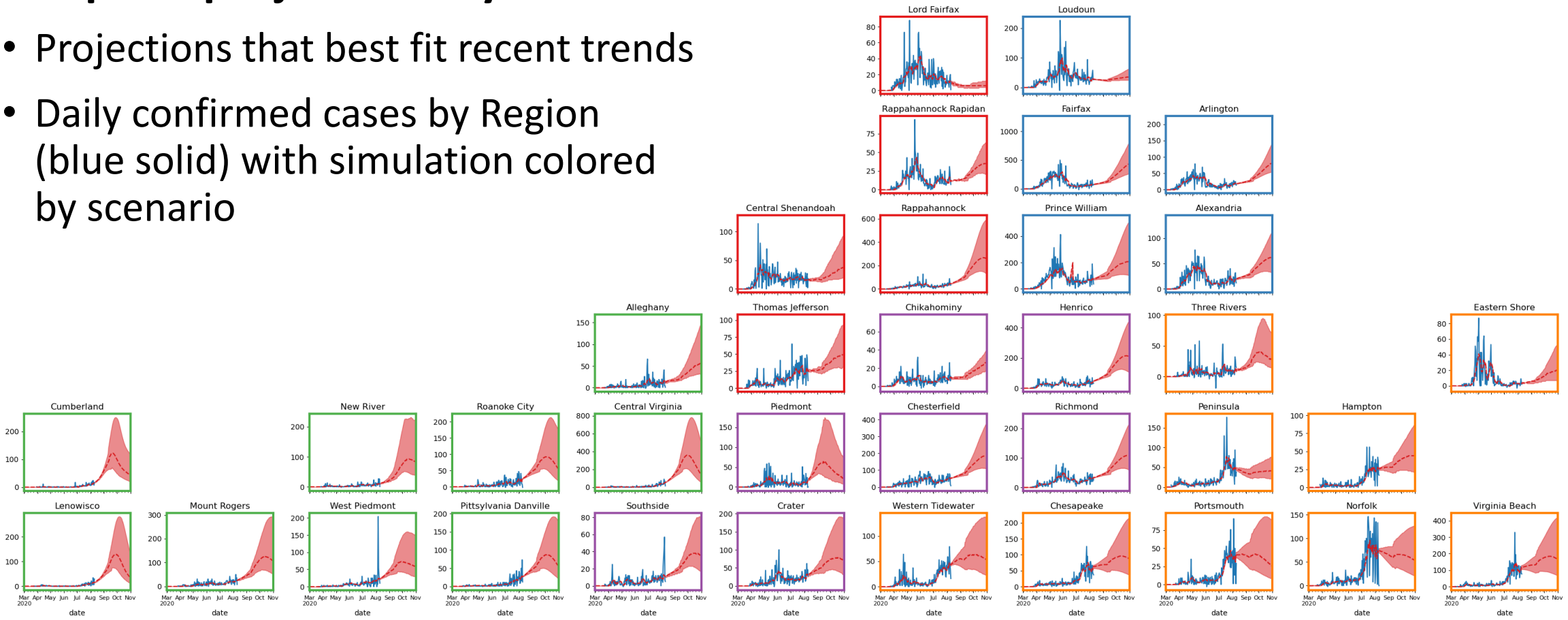
- Projections that best fit recent trends
- Daily confirmed cases by Region (blue solid) with simulation colored by scenario



# District Level Projections: Adaptive-High

## Adaptive projections by District

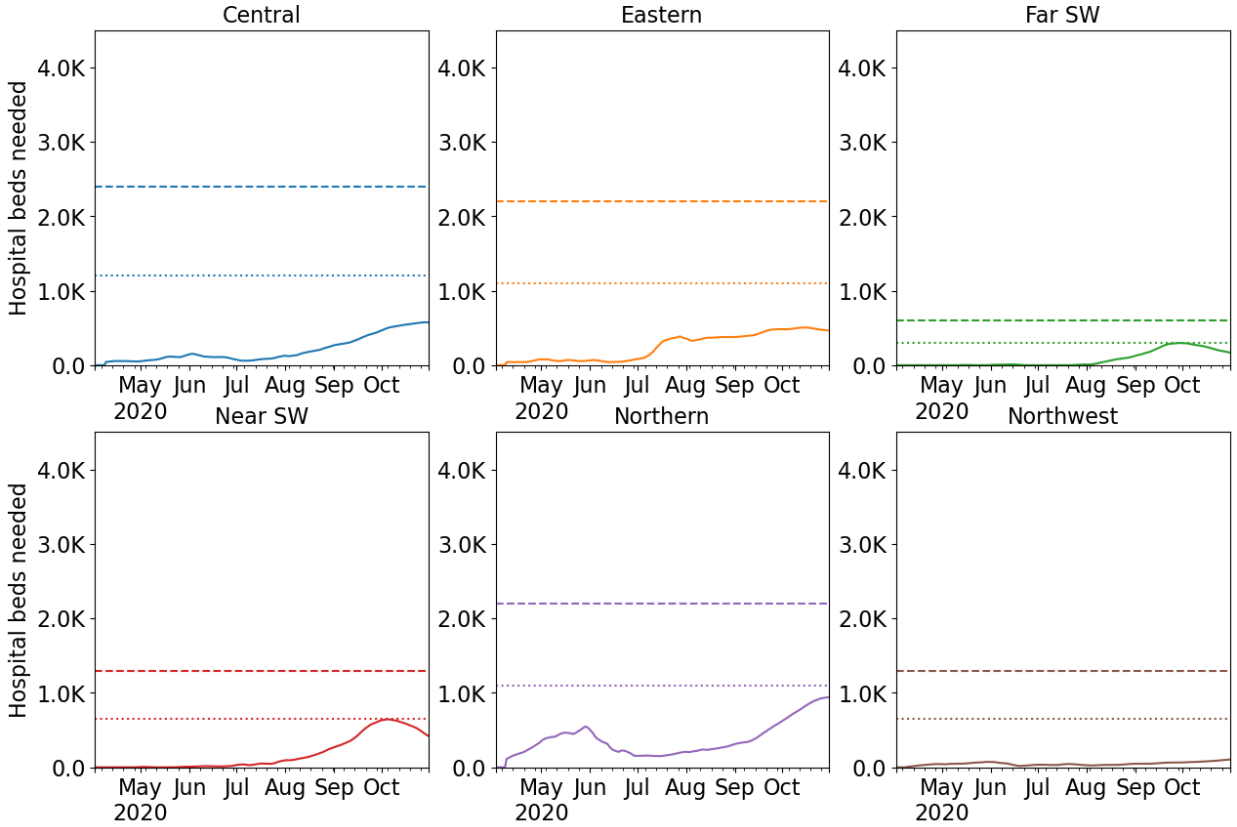
- Projections that best fit recent trends
- Daily confirmed cases by Region (blue solid) with simulation colored by scenario



# Hospital Demand and Capacity by Region

**Capacities by Region – Adaptive-High**

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




**Based on Adaptive-High scenario**

- Near and Far SW may reach capacity in late Sept
- Northern and Central have increasing trend but not expected to exceed before Nov 1st
- Other regions steady and not expected to approach capacity

* 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:

- **Most districts with recent surging growth seem to be slowing; incidence is still high.**
- Similar signs of slowed growth and declines evident across nation.
- Given the experience of other states in the nation, it is crucial to maintain control**.**
- Recent model updates:
  - Transitioned to using Adaptive Fitting projection approach
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  - Extend projection horizon to Nov 1
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# 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.

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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/

Cuebiq: COVID-19 Mobility insights. https://www.cuebiq.com/visitation-insights-covid19/

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

# Questions?

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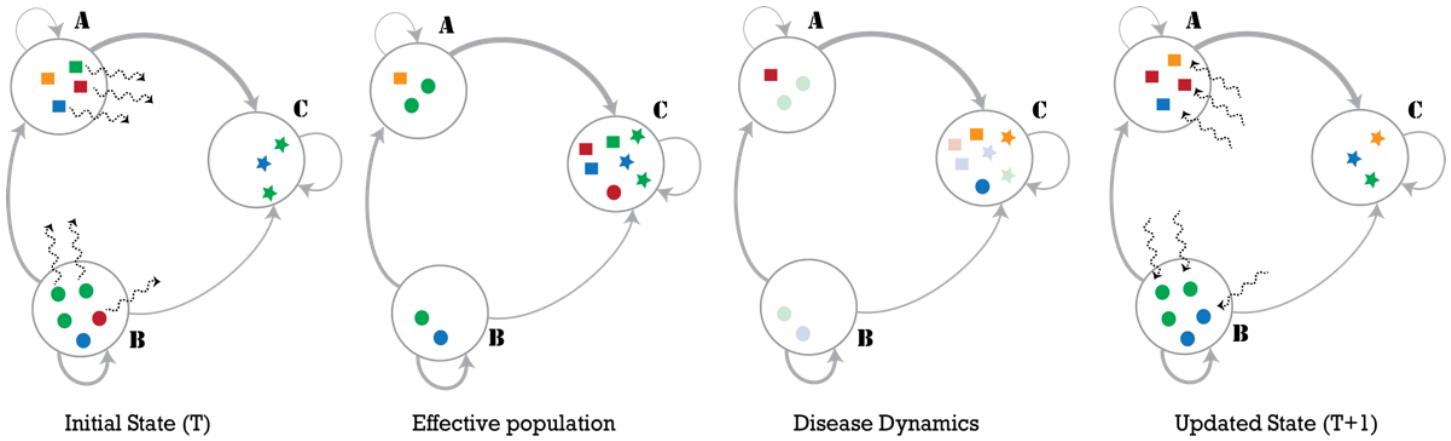
# Forecast by Projection Selection Previous Model Section

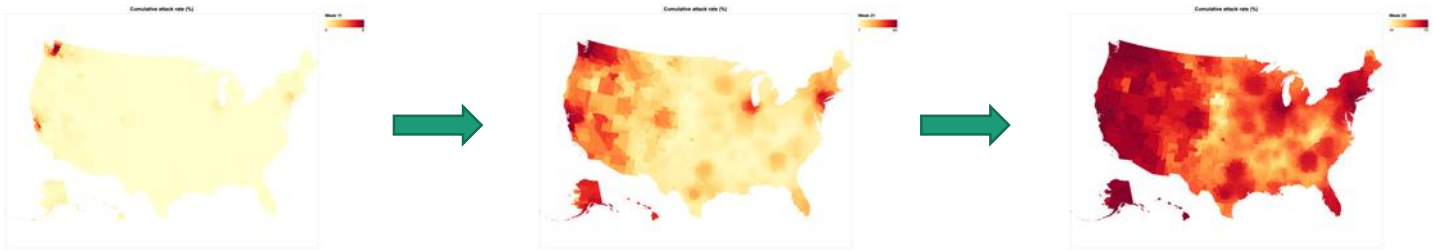
For consistency the BestFit based on the selection of the 8 scenarios are presented and provided in the data product, however, they will be phased out in the coming weeks

# Previous Model Configuration

# Simulation Engine – PatchSim

- Metapopulation model
  - Represents each population and its interactions as a single patch
  - 133 patches for Virginia counties and independent cities
- Extended SEIR disease representation
  - Includes asymptomatic infections and treatments
- Mitigations affect both disease dynamics and population interactions
- Runs fast on high-performance computers
  - Ideal for calibration and optimization



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

# Model Configuration

- **Transmission:** Parameters are calibrated to the observed case counts
  - **Reproductive number:** 2.1 - 2.3
  - **Infectious period** (time of infectiousness before full isolation): 3.3 to 5 days
- **Initial infections:** Start infections from confirmed cases by county
  - Timing and location based on onset of illness from VDH data
  - Assume 15% detection rate, so one confirmed case becomes ~7 initial infections
- **Mitigations:** Intensity of social distancing rebound and control sustaining mitigations into the future are unknowable, thus explored through 5 scenarios

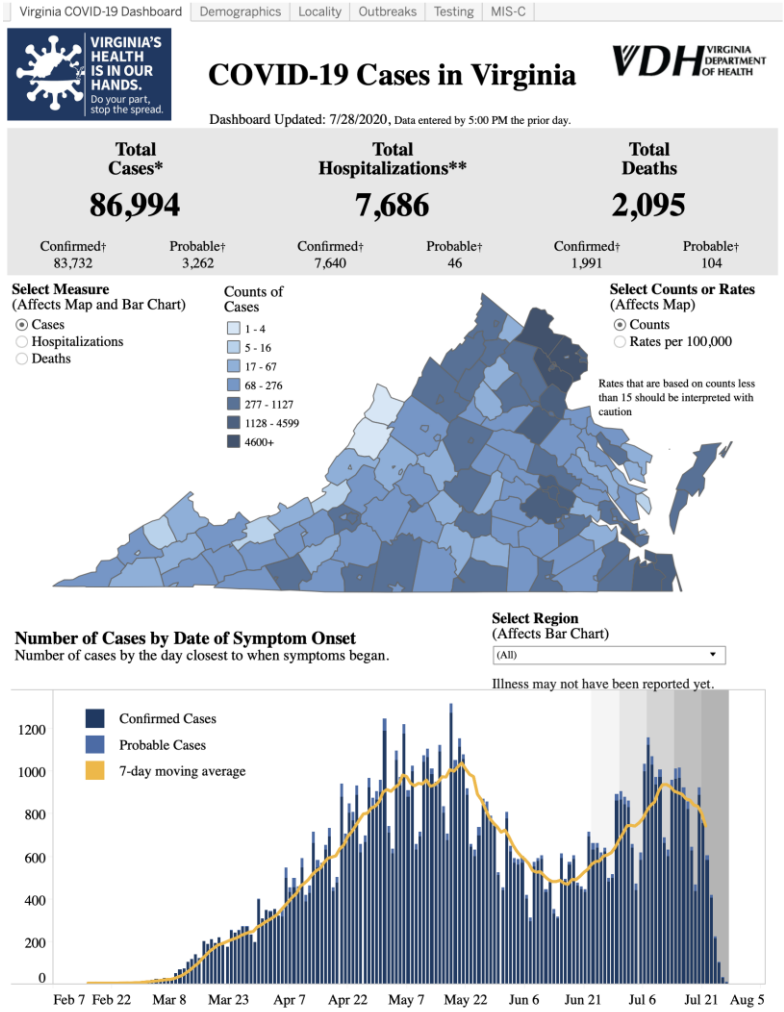
# Full Model Parameters

| | Parameter | Values | Description |
|---|---|---|---|
| Transmission | Transmissibility ($R_0$)[1] | 2.2 [2.1 – 2.3] | Reproductive number |
| | Incubation period[1] | 5 days | Time from infection to infectious |
| | Infectious period[1] | 3.3 - 5 days | Duration of infectiousness |
| | Infection detection rate[3] | 15% | 1 confirmed case becomes ~7 initial infections |
| | Percent asymptomatic[1] | 50% | Infected individuals that don't exhibit symptoms |
| Resources | Onset to hospitalization[1] | 5 days | Time from symptoms to hospitalization |
| | Hospitalization to ventilation[1] | 3 days | Time from hospitalization to ventilation |
| | Duration hospitalized | 8 days | Time spent in the hospital [4] |
| | Duration ventilated[2] | 14 days | Time spent on a ventilator |
| | Percent hospitalized[1] | 5.5% (~20% of confirmed) | Symptomatic individuals becoming hospitalized |
| | Percent in ICU[1] | 20% | Hospitalized patients that require ICU |
| | Percent ventilated[1] | 70% | ICU patients requiring ventilation |
| | Percent Fatality | 1.35% | Symptomatic individuals who die |

1 CDC COVID-19 Modeling Team. "Best Guess" scenario. Planning Parameters for COVID-19 Outbreak Scenarios. Version: 2020-03-31.
2 Up-to-date. COVID-19 Critical Care Issues. https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-critical-care-issues?source=related_link (Accessed 13APRIL2020)
3 Li et al., *Science* 16 Mar 2020:eabb3221 https://science.sciencemag.org/content/early/2020/03/24/science.abb3221 (Accessed 13APRIL2020)
4 Personal communications, UVA Health and Sentara (~500 VA based COVID patients)

# Calibration Approach

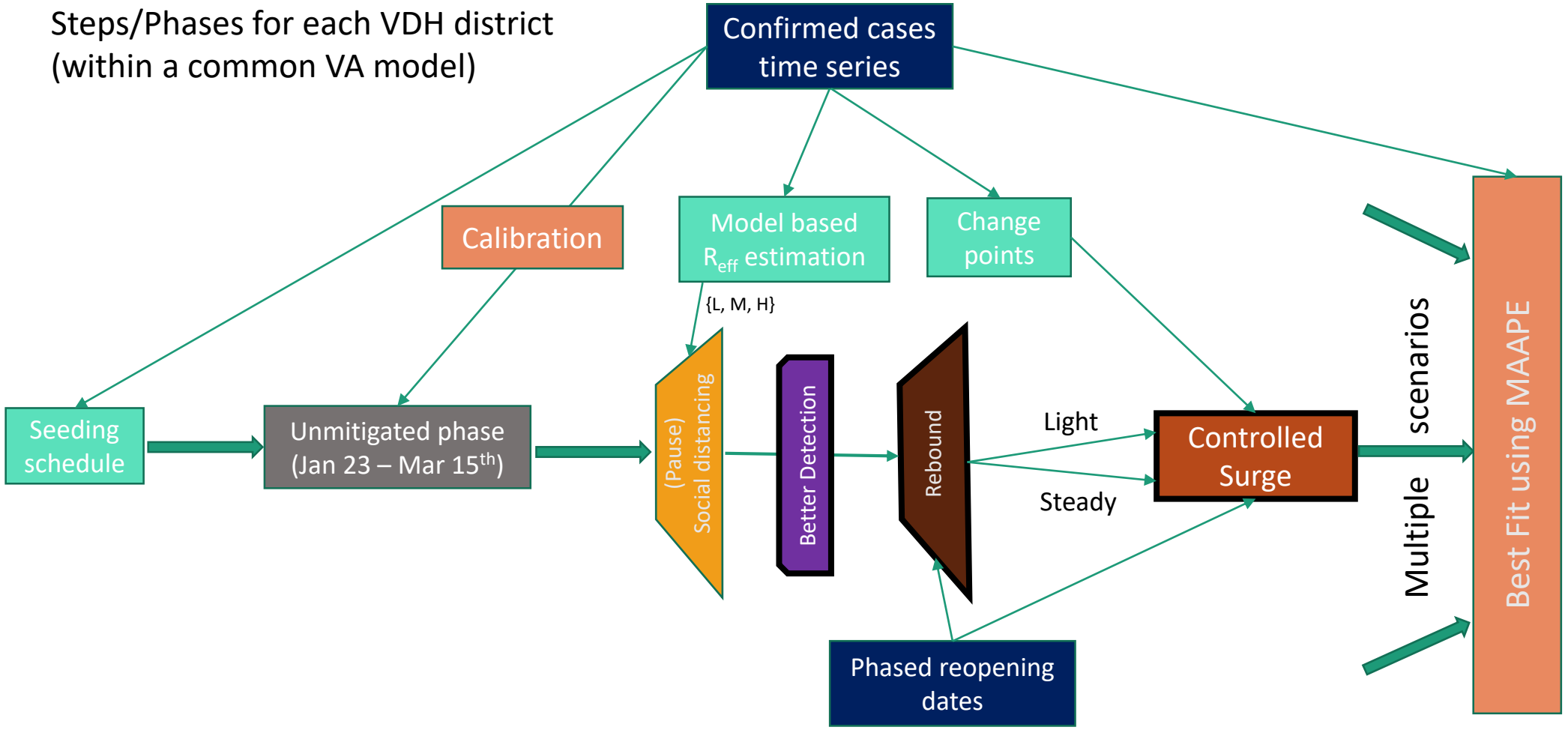
- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Model:** PatchSim initialized with disease parameter ranges from literature
- **Calibration:** fit model to observed data
  - Search transmissibility and duration of infectiousness
  - Markov Chain Monte Carlo (MCMC) particle filtering finds best fits while capturing uncertainty in parameter estimates
- **Spatial Adjustments:** VDH districts grouped to 3 tiers of growth during the Pause, with similarly scaled reductions then applied to the groups of districts
- **Project:** future cases and outcomes using the trained particles




Accessed 10pm July 28, 2020
https://www.vdh.virginia.gov/coronavirus/

# Forecasting by Projection Selection – VA COVID-19 Implementation

Steps/Phases for each VDH district
(within a common VA model)

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# Eight Scenarios for Projection

| Abbr | Rebound Intensity | Better Detection | Surge | Name |
|---|---|---|---|---|
| **LR** | Light | No | No | LightRebound |
| **LR-S** | Light | No | Yes | LightRebound-Surge |
| **LR-BD** | Light | Yes | No | LightRebound-BetterDetection |
| **LR-BD-S** | Light | Yes | Yes | LightRebound-BetterDetection-Surge |
| **S** | Steady | No | No | Steady |
| **S-S** | Steady | No | Yes | Steady-Surge |
| **S-BD** | Steady | Yes | No | Steady-BetterDetection |
| **S-BD-S** | Steady | Yes | Yes | Steady-BetterDetection-Surge |

Allow “Best Fit” method to select from “Surge” scenarios

# Historical Scenarios: Control

**Pause from Social Distancing:** Began on March 15th

- Lifted on May 15th (61 days), with two-week delay (75 days) for select counties*
- **Intensity**: Social distancing pauses and significantly reduces case growth, this level varies by VDH Health District and is fit through an analysis of growth rate during the Pause

**Intensity of Rebound:** Some districts rebounded following initial relaxation of Pause

- **Steady:** Intensity of effective mixing remains steady from Pause as infection control practices moderate increased interactions
- **Light:** Effective mixing returns to 1/6th of pre-pandemic levels
- **Full Rebound**: Interactions return completely (100%) to pre-pandemic levels, as a reference

**Tracing and Isolation**: Increased Testing Capacity coupled with infection control measures can limit the period of infectiousness without isolation

- **Better Detection**: Observed relative reductions in days from onset to diagnosis applied to infectious period from (30% → 45% → 30%) and remain stable into future for projections

* Select counties as mentioned by recent releases from Governor Northam's office
https://www.governor.virginia.gov/newsroom/all-releases/2020/may/headline-856741-en.html
https://www.governor.virginia.gov/newsroom/all-releases/2020/may/headline-856796-en.html

# Ongoing Scenarios: Surge

**Resurgence:** Much of the nation experiencing a resurgence

- Many districts in the Commonwealth also showing a resurgence
- National: 28-day delay (avg) from relaxation to surge

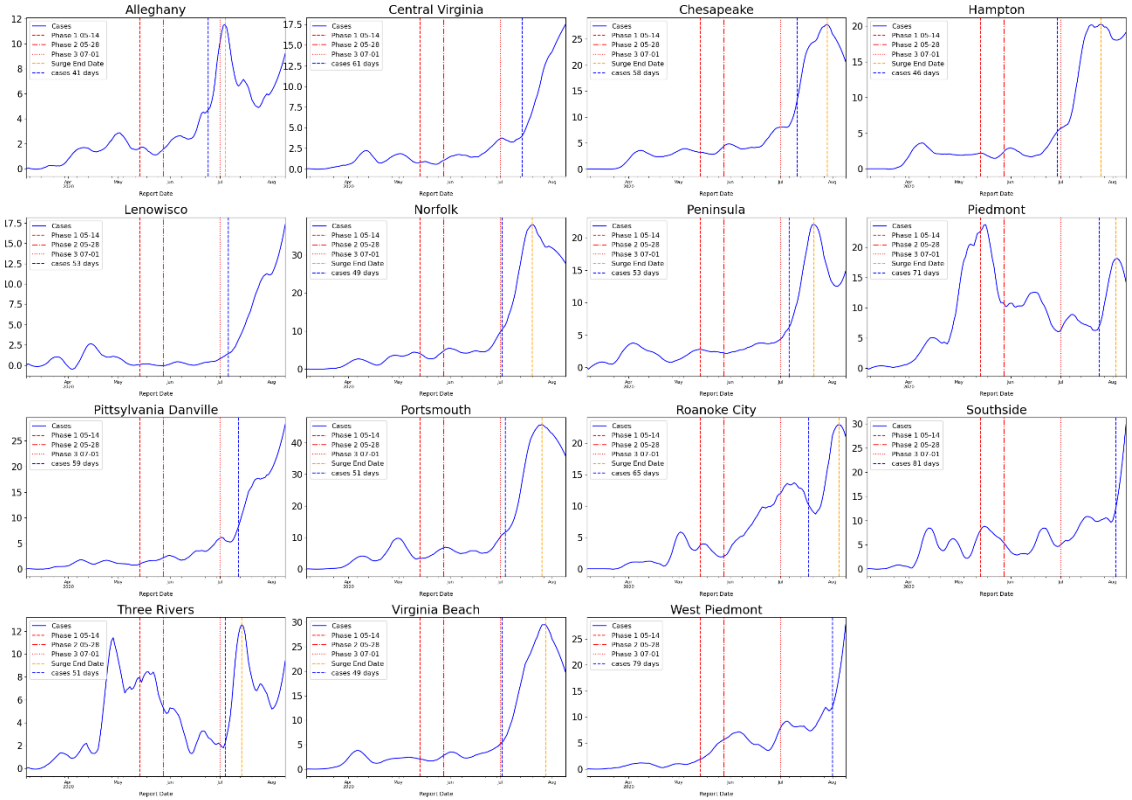
**Intensity of Surge:** Difficult to predict with limited data

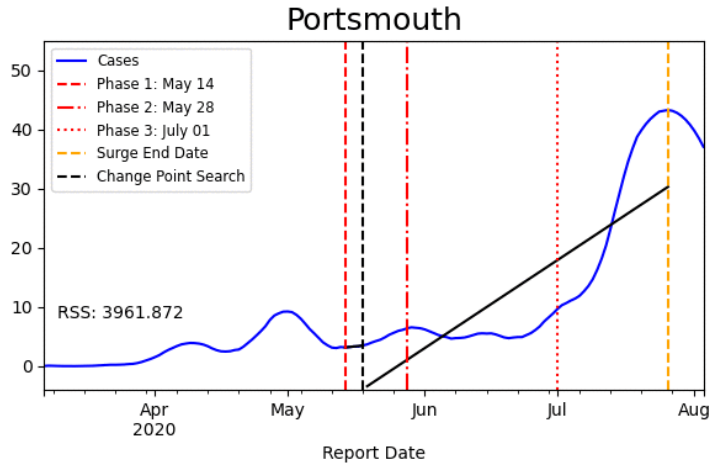
- **Strong Rebound:** Effective mixing returns 1/2 back to pre-pandemic levels

**Timing of Surge:** Past and Present

- Determine surging districts and timing - “hockey stick” fit
- Default to July 29th, (28 days from July 1st) for districts not identified
- Surge duration limited by observed or estimated peak
- Return to pre-surge levels (scenario-specific)

13 districts: Compared to 11 last week
**In:** Piedmont, Three Rivers, Prince William, Alleghany, Henrico
**Out:** Arlington, Pittsylvania-Danville, Rappahannock Rapidan

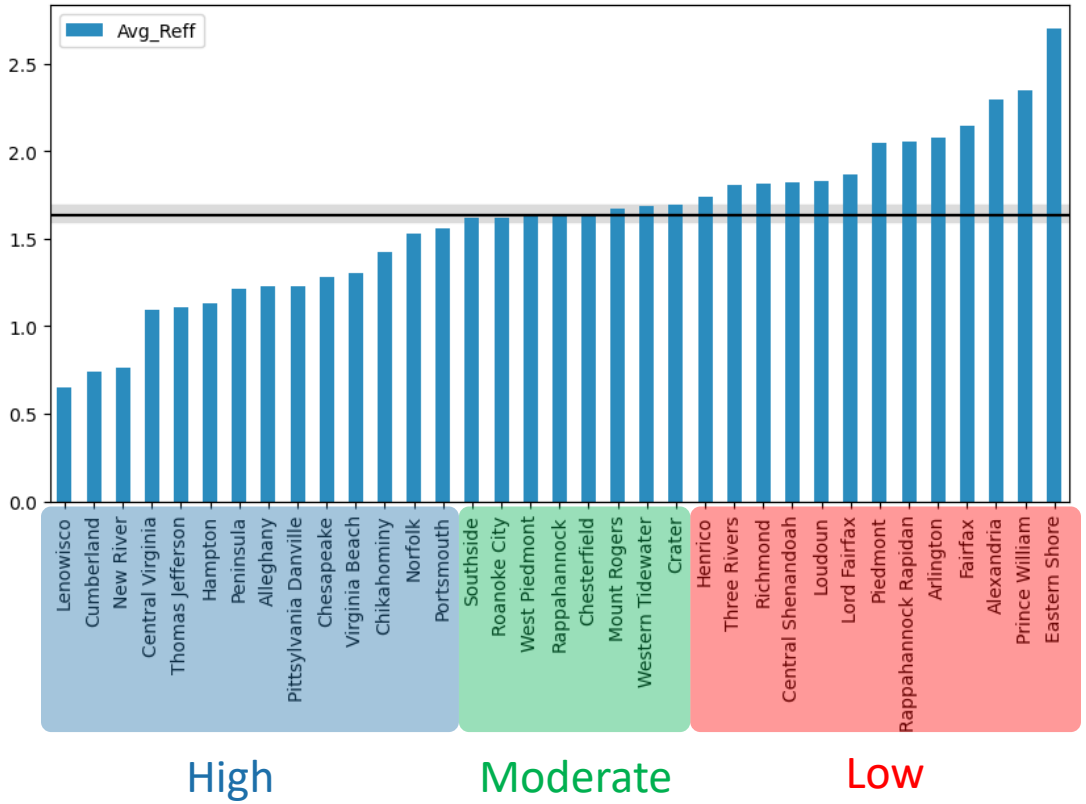


# Spatial Adjustments at District Level

**District Specific adjustments based on Growth during Pause**

- Group districts by their mean growth from mid-April to mid-May (using model based $R_{eff}$ )
- Assign reductions during Pause, and beyond, to members of these groups
- Low reduction = 40%
- Moderate reduction = 45% (previous level)
- High reduction = 55%



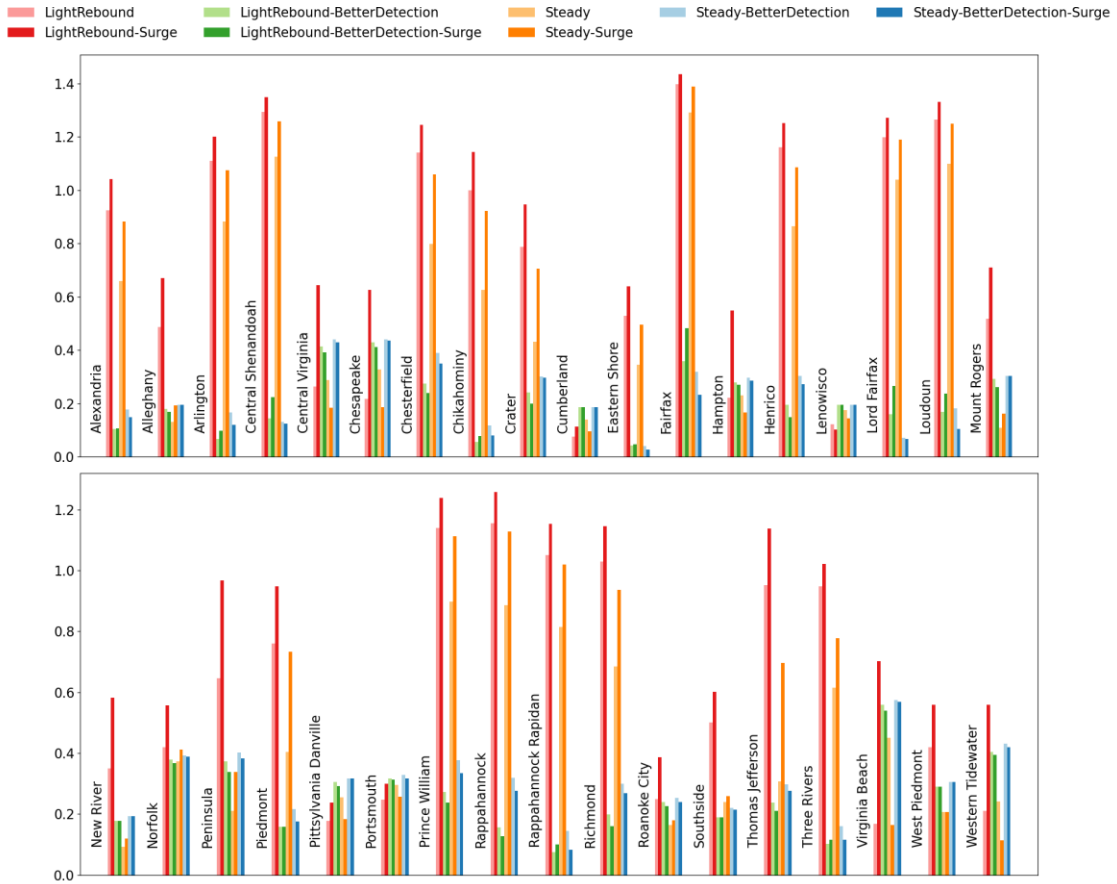
# Previous Model Results

For consistency the BestFit based on the selection of the 8 scenarios are presented and provided in the data product, however, they will be phased out in the coming weeks

{'LightRebound': 2, 'LightRebound-BetterDetection': 7, 'LightRebound-BetterDetection-Surge': 8, 'LightRebound-Surge': 1, 'Steady': 6, 'Steady-BetterDetection': 1, 'Steady-BetterDetection-Surge': 4, 'Steady-Surge': 6}

# Selection of Best Fitting Projection

**Recent incidence by district (last week) is measured against all eight projections, one with least error is selected as the "Best Fit" projection**

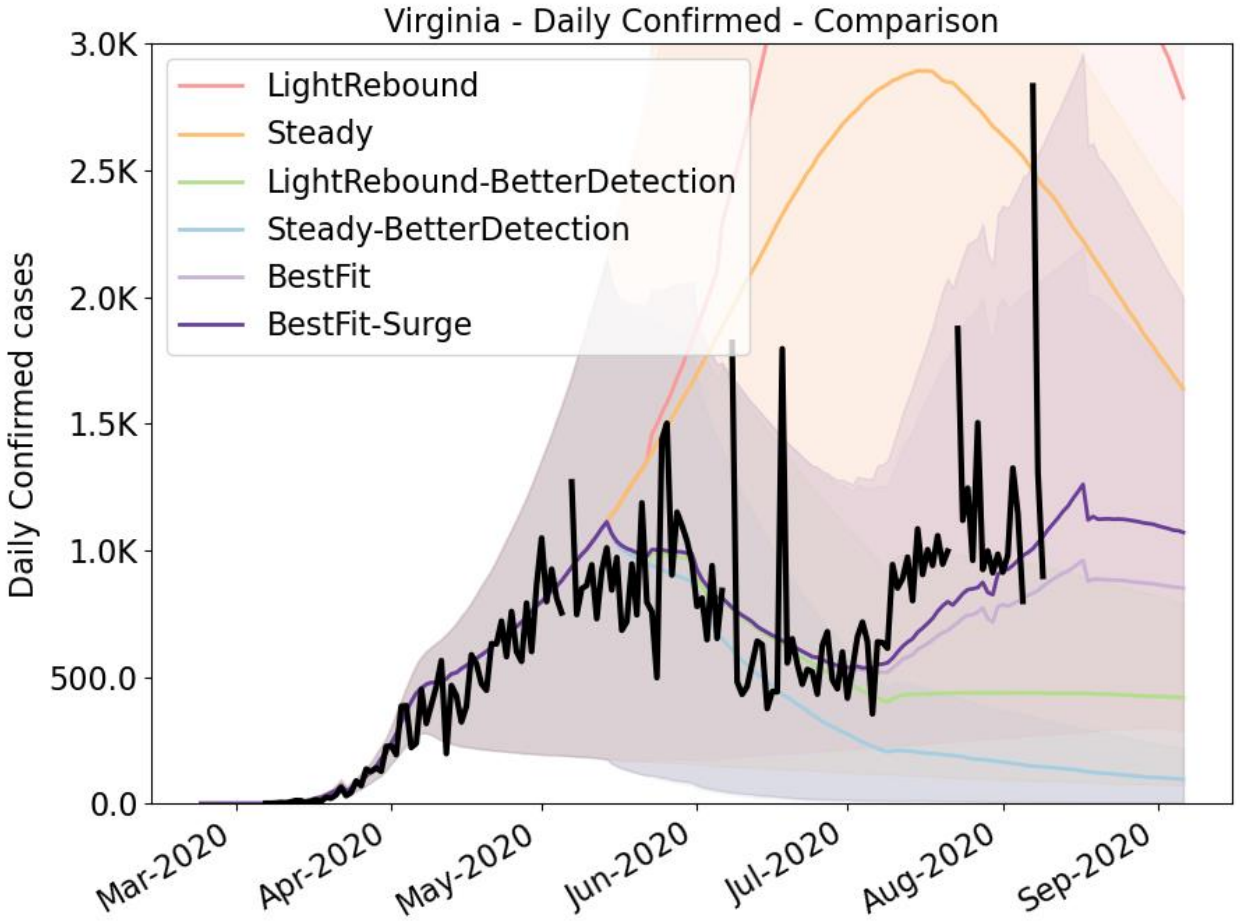



| Abbr | Name | # of Districts (last wk) |
|---|---|---|
| LR | LightRebound | 2 (4) |
| LR-S | LightRebound-Surge | 1 (2) |
| LR-BD | LightRebound-BetterDetection | 7 (7) |
| LR-BD-S | LightRebound-BetterDetection-Surge | 8 (8) |
| S | Steady | 6 (5) |
| S-S | Steady-Surge | 6 (5) |
| S-BD | Steady-BetterDetection | 1 (1) |
| S-BD-S | Steady-BetterDetection-Surge | 4 (3) |

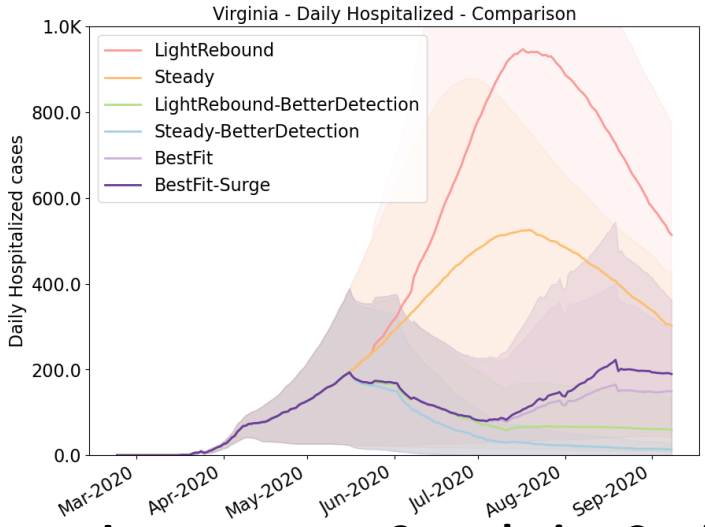
- 19 districts have Surge projections as BestFit compared to 18 last week
- Relatively stable, slight movement towards higher incidence

# Outcome Projections

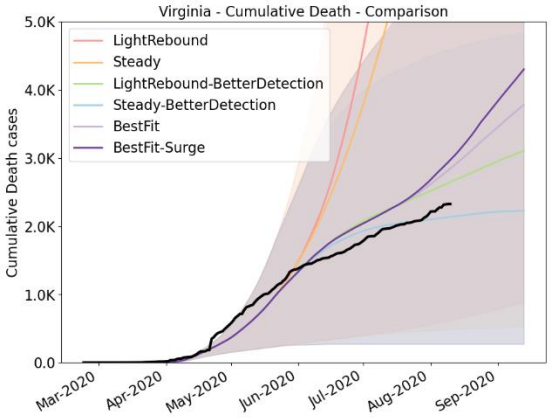
## Confirmed cases



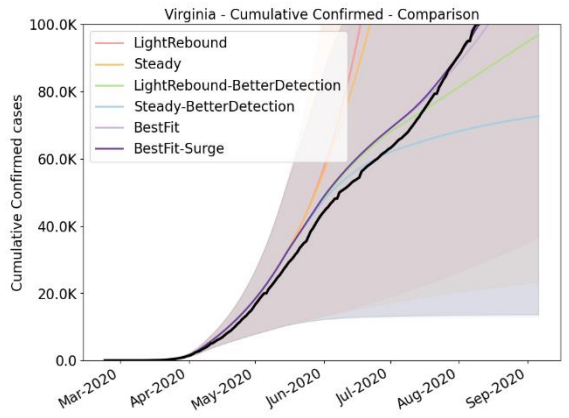

## Hospital occupancy




## Deaths



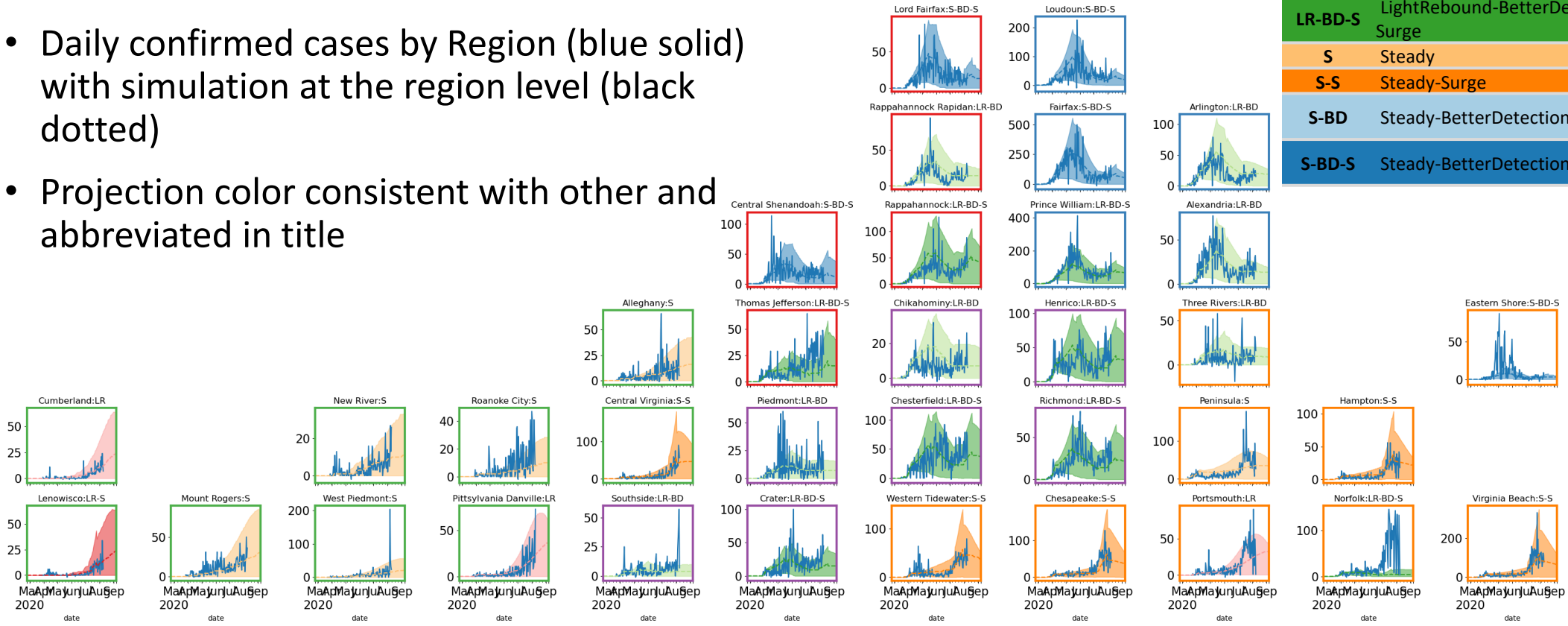

## Cumulative Confirmed cases



# District Level Projections – Daily

## Best fitting projections by District

- Projections that best fit recent trends
- Daily confirmed cases by Region (blue solid) with simulation at the region level (black dotted)
- Projection color consistent with other and abbreviated in title



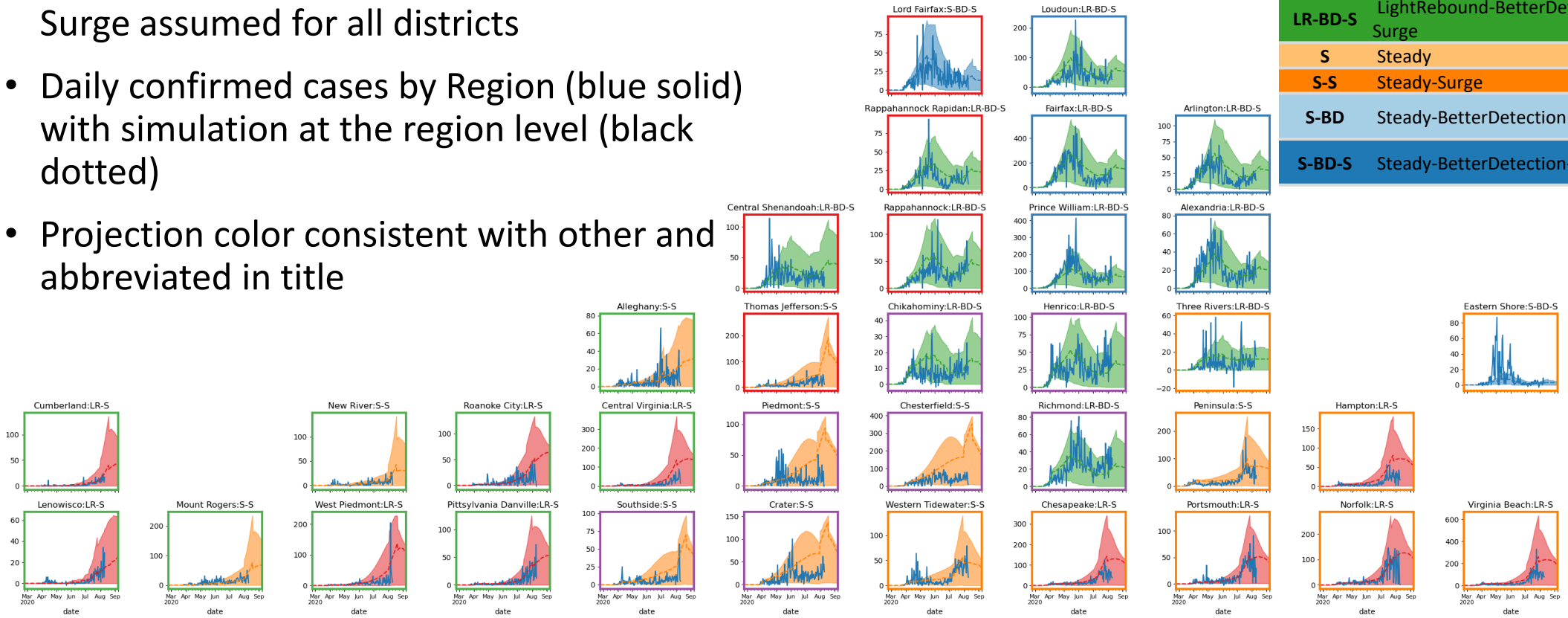

| Abbr | Name | # of Districts (last wk) |
|---|---|---|
| LR | LightRebound | 2 (4) |
| LR-S | LightRebound-Surge | 1 (2) |
| LR-BD | LightRebound-BetterDetection | 7 (7) |
| LR-BD-S | LightRebound-BetterDetection-Surge | 8 (8) |
| S | Steady | 6 (5) |
| S-S | Steady-Surge | 6 (5) |
| S-BD | Steady-BetterDetection | 1 (1) |
| S-BD-S | Steady-BetterDetection-Surge | 4 (3) |

# District Level Projections – Daily with Surge

## Best fitting projections by District

- Projections that best fit recent trends with Surge assumed for all districts
- Daily confirmed cases by Region (blue solid) with simulation at the region level (black dotted)
- Projection color consistent with other and abbreviated in title

| Abbr | Name | # of Districts (last wk) |
|---|---|---|
| LR | LightRebound | 2 (4) |
| LR-S | LightRebound-Surge | 1 (2) |
| LR-BD | LightRebound-BetterDetection | 7 (7) |
| LR-BD-S | LightRebound-BetterDetection-Surge | 8 (8) |
| S | Steady | 6 (5) |
| S-S | Steady-Surge | 6 (5) |
| S-BD | Steady-BetterDetection | 1 (1) |
| S-BD-S | Steady-BetterDetection-Surge | 4 (3) |

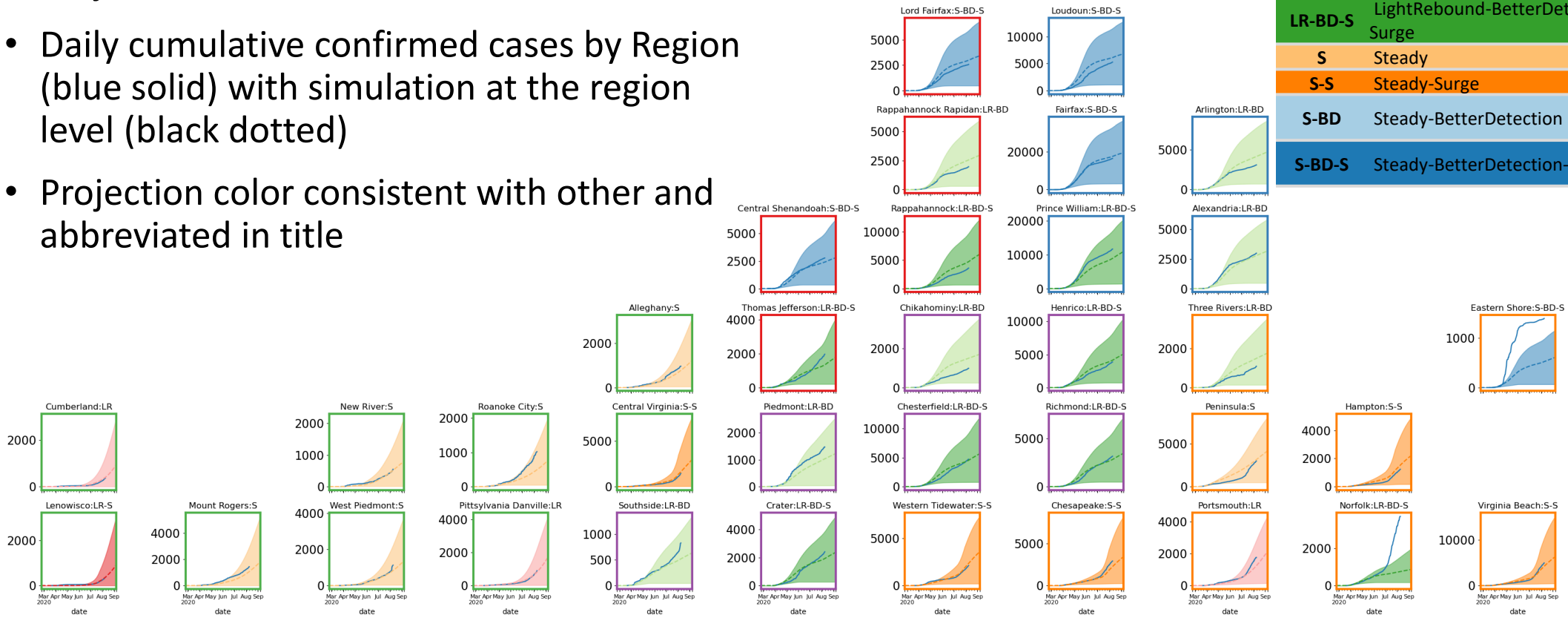


# District Level Projections - Cumulative

## Best fitting projections by District

- Projections that best fit recent trends
- Daily cumulative confirmed cases by Region (blue solid) with simulation at the region level (black dotted)
- Projection color consistent with other and abbreviated in title

| Abbr | Name | # of Districts (last wk) |
|---|---|---|
| LR | LightRebound | 2 (4) |
| LR-S | LightRebound-Surge | 1 (2) |
| LR-BD | LightRebound-BetterDetection | 7 (7) |
| LR-BD-S | LightRebound-BetterDetection-Surge | 8 (8) |
| S | Steady | 6 (5) |
| S-S | Steady-Surge | 6 (5) |
| S-BD | Steady-BetterDetection | 1 (1) |
| S-BD-S | Steady-BetterDetection-Surge | 4 (3) |



# District Level Projections – Cumulative with Surge

## Best fitting projections by District

- Projections that best fit recent trends with Surge assumed for all districts
- Daily confirmed cases by Region (blue solid) with simulation at the region level (black dotted)
- Projection color consistent with other and abbreviated in title

| Abbr | Name | # of Districts (last wk) |
|---|---|---|
| LR | LightRebound | 2 (4) |
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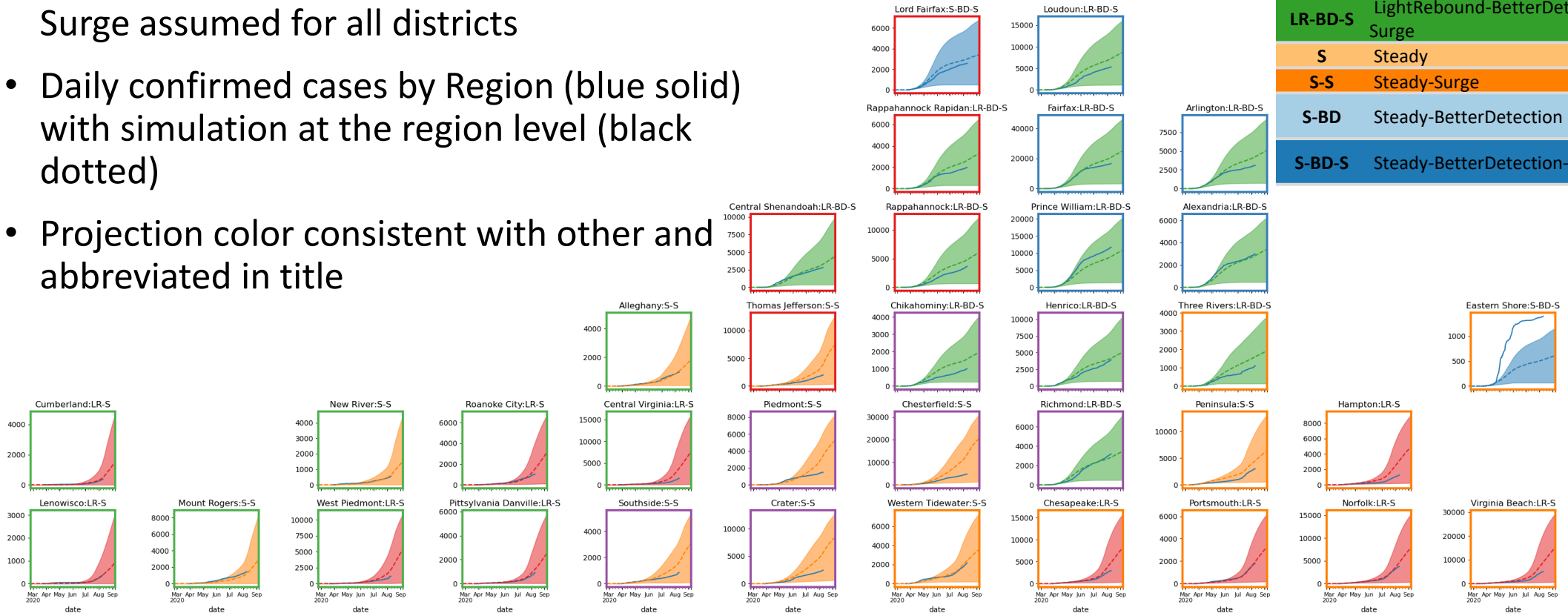
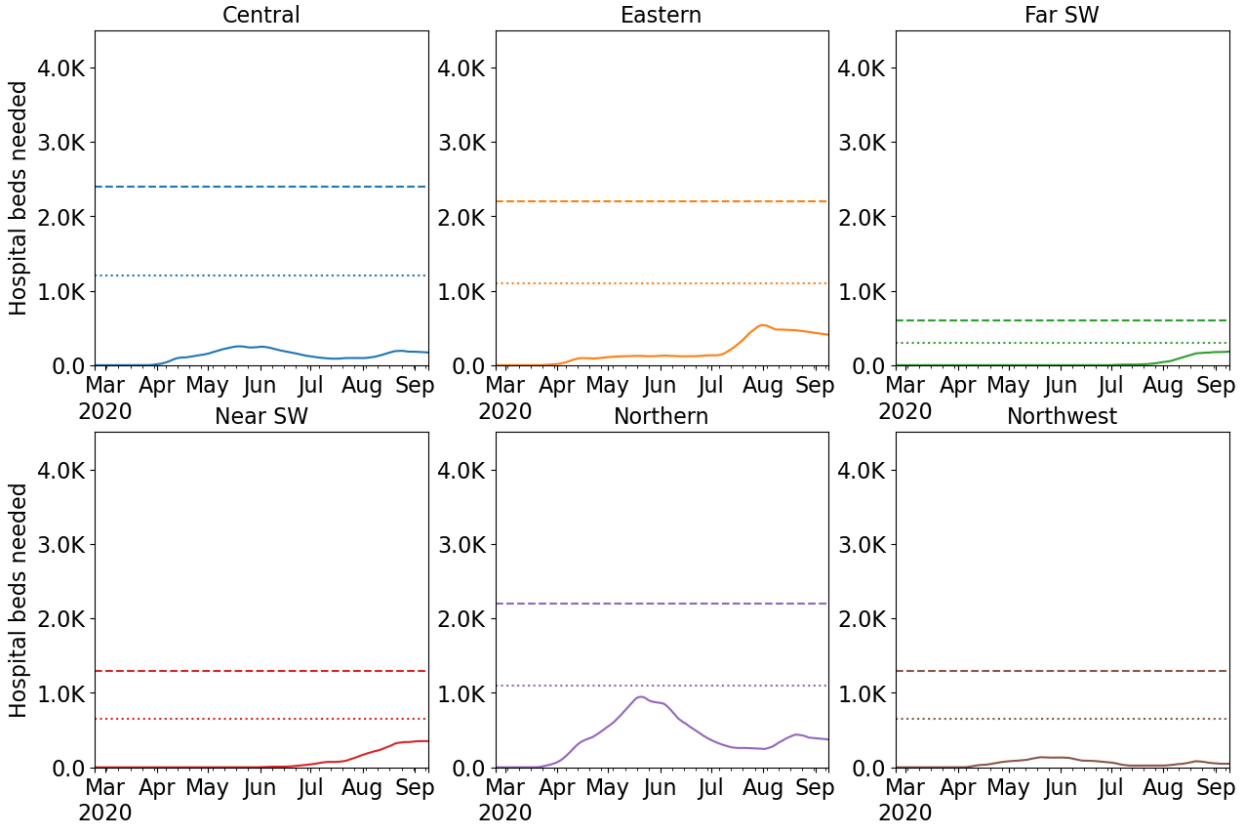
| S | Steady | 6 (5) |
| S-S | Steady-Surge | 6 (5) |
| S-BD | Steady-BetterDetection | 1 (1) |
| S-BD-S | Steady-BetterDetection-Surge | 4 (3) |



# Hospital Demand and Capacity by Region

**Capacities by Region – BestFit-Surge**

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




- Based on current best fits with controlled surge
  - Recent changes in case rates have reduced the likelihood of exceeding 80% capacity by end of August
  - However, multiple regions could potentially exceed capacity depending on fall scenarios
  - Will be re-evaluated when model horizons are updated
- Activity in neighboring states and reopening of schools/universities may make this more likely

* Assumes average length of stay of 8 days

# Supplemental Slides

# Recent Parameter Validation

**New York State announced sero-prevalence survey results on May 2nd**

- 15,000 antibody tests conducted randomly through the state at grocery stores
- **Total Attack Rate**: 12.3%

**Estimation of undetected infections**

- Total infections in NY = 2.46M, total of 300K confirmed cases
- Confirmed case detection = 12% of infections (close to 15% used in model)

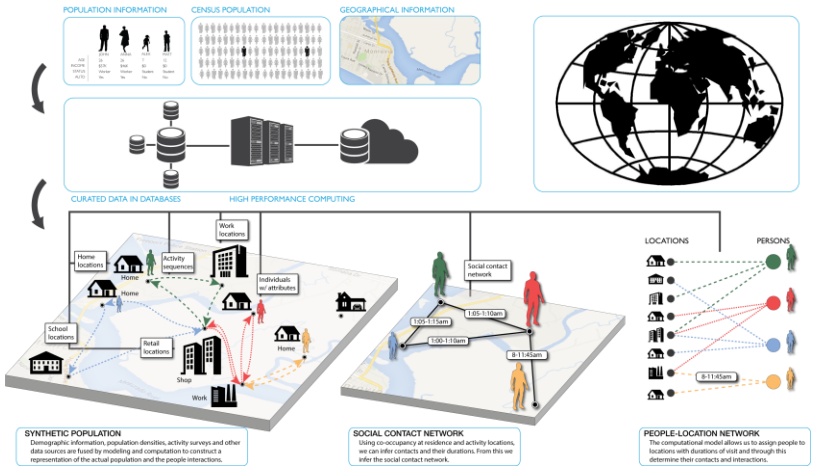
**Estimation of hospitalizations from infections**

- Total infections in NY = 2.46M, total of 66K hospitalizations
- Hospitalizations = 2.7% of infections (close to 2.25% used in model)

# Agent-based Model (ABM )

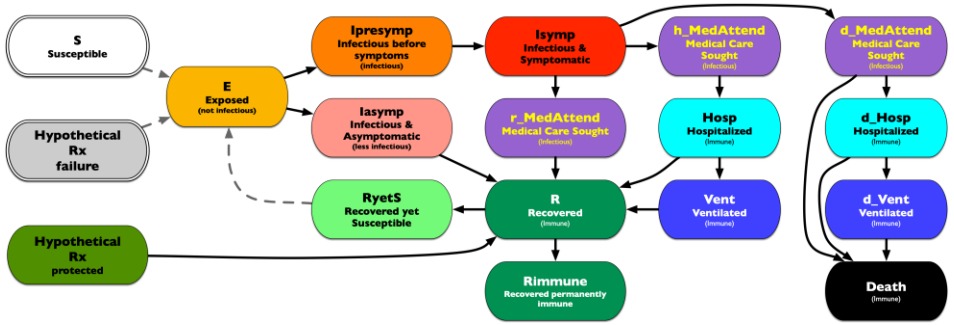
**EpiHiper: Distributed network-based stochastic disease transmission simulations**

- 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



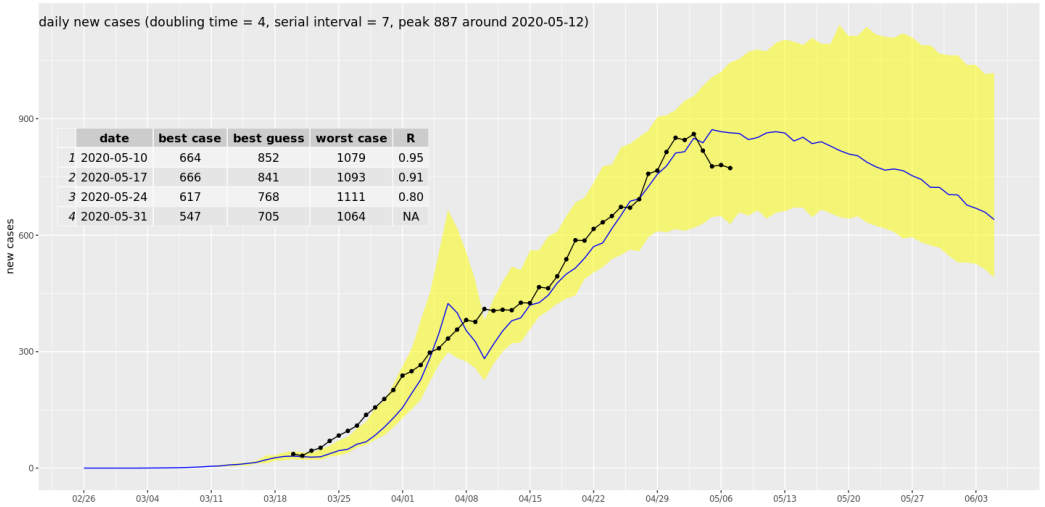

**Detailed Disease Course of COVID-19**

- 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**

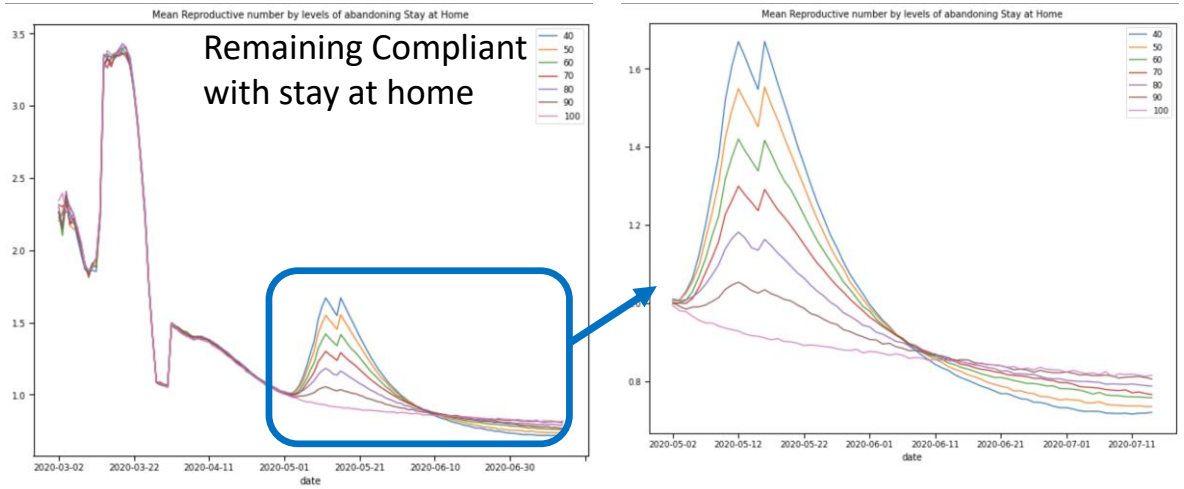
- Calibration to current state in epidemic
- Implement “release” of different proportions of people from ”staying at home”




| | 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

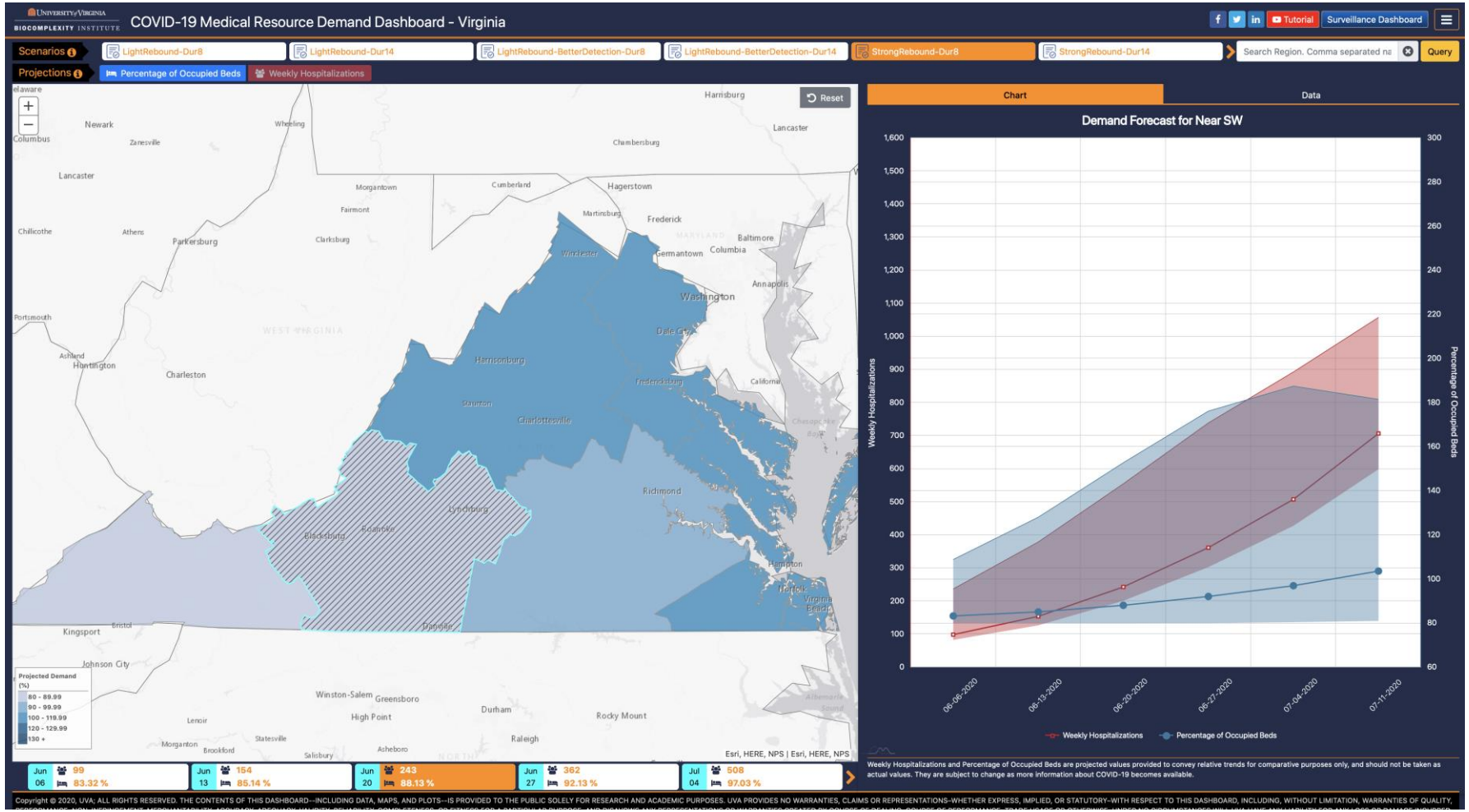



**Impacts on Reproductive number with release**

- 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 1/6$^{th}$ return to pre-pandemic levels

# Medical Resource Demand Dashboard

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

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