Network Systems
Science & Advanced
Computing

Biocomplexity Institute
& Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

January 26th, 2022

(data current to Jan 22nd – 25th)

Biocomplexity Institute Technical report: TR 2022-006

UNIVERSITY *of* VIRGINIA

BIOCOMPLEXITY INSTITUTE

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

Points of Contact

Bryan Lewis
brylew@virginia.edu

Srini Venkatramanan
srini@virginia.edu

Madhav Marathe
marathe@virginia.edu

Chris Barrett
ChrisBarrett@virginia.edu

Model Development, Outbreak Analytics, and Delivery Team
Przemyslaw Porebski, Joseph Outten, Brian Klahn, Alex Telionis,
Srinivasan Venkatramanan, Bryan Lewis,
Aniruddha Adiga, Hannah Baek, Chris Barrett, Jiangzhuo Chen, Patrick Corbett,
Stephen Eubank, Galen Harrison, Ben Hurt, Dustin Machi, Achla Marathe,
Madhav Marathe, Mark Orr, Akhil Peddireddy, Erin Raymond, James Schlitt, Anil Vullikanti,
Lijing Wang, James Walke, Andrew Warren, Amanda Wilson, Dawen Xie

UNIVERSITY of VIRGINIA

BIOCOMPLEXITY INSTITUTE

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

UNIVERSITY *of* VIRGINIA

BIOCOMPLEXITY INSTITUTE

Situation Assessment

UNIVERSITY *of* VIRGINIA

**BIOCOMPLEXITY** INSTITUTE

Case Rates (per 100k) and Test Positivity

- Case rate increase across all health districts
- Some past 50% of winter peak and growing
- More than 50% of counties with TPR > 10%
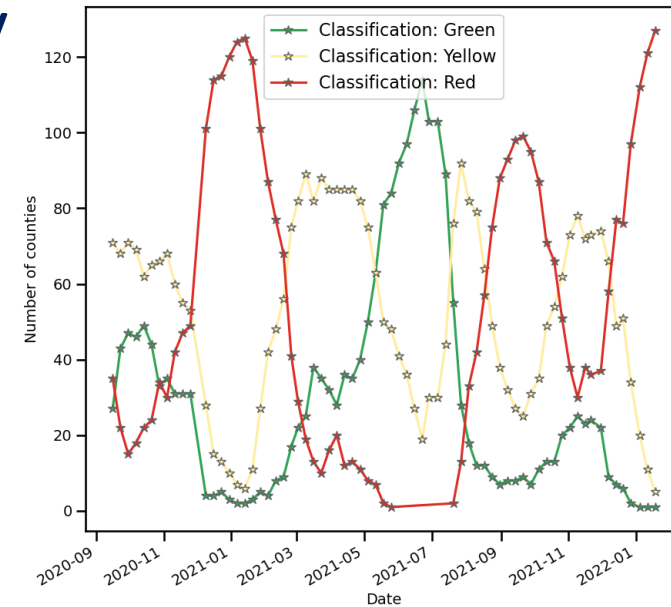

County level RT-PCR test positivity
Green: <5.0% (or <20 tests in past 14 days)
Yellow: 5.0%-10.0% (or <500 tests and <2000 tests/100k and >10% positivity over 14 days)
Red: >10.0% (and not "Green" or "Yellow")

UNIVERSITY of VIRGINIA

BIOCOMPLEXITY INSTITUTE
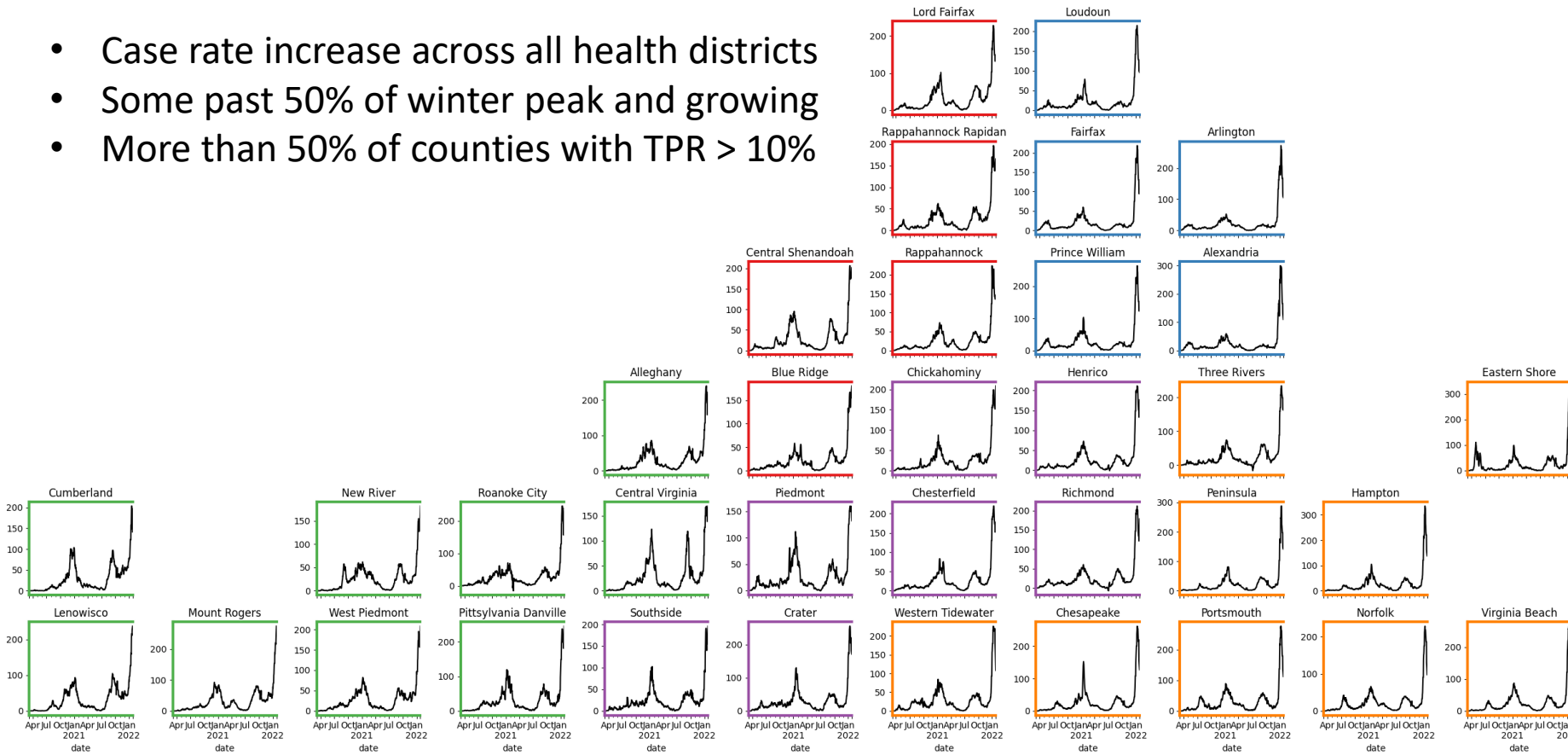
District Trajectories

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
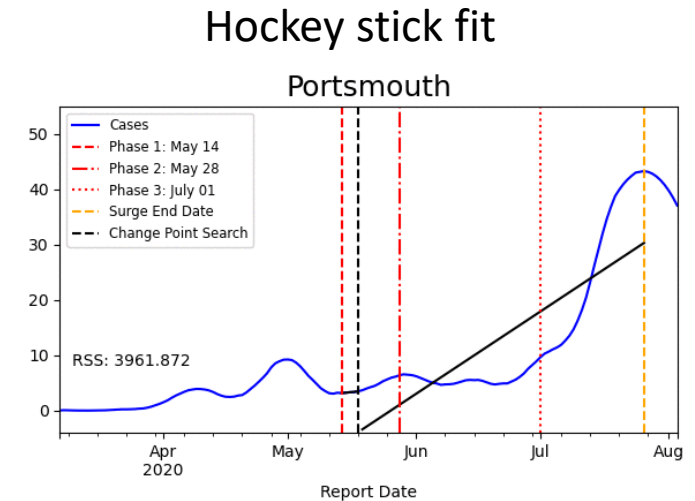
Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	22 (0)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	0 (0)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	1 (1)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	12 (34)

UNIVERSITY of VIRGINIA

BIOCOMPLEXITY INSTITUTE

District Trajectories – last 10 weeks

| Status	# Districts (prev week)
Declining	22 (0)
Plateau	0 (0)
Slow Growth	1 (1)
In Surge	12 (34)

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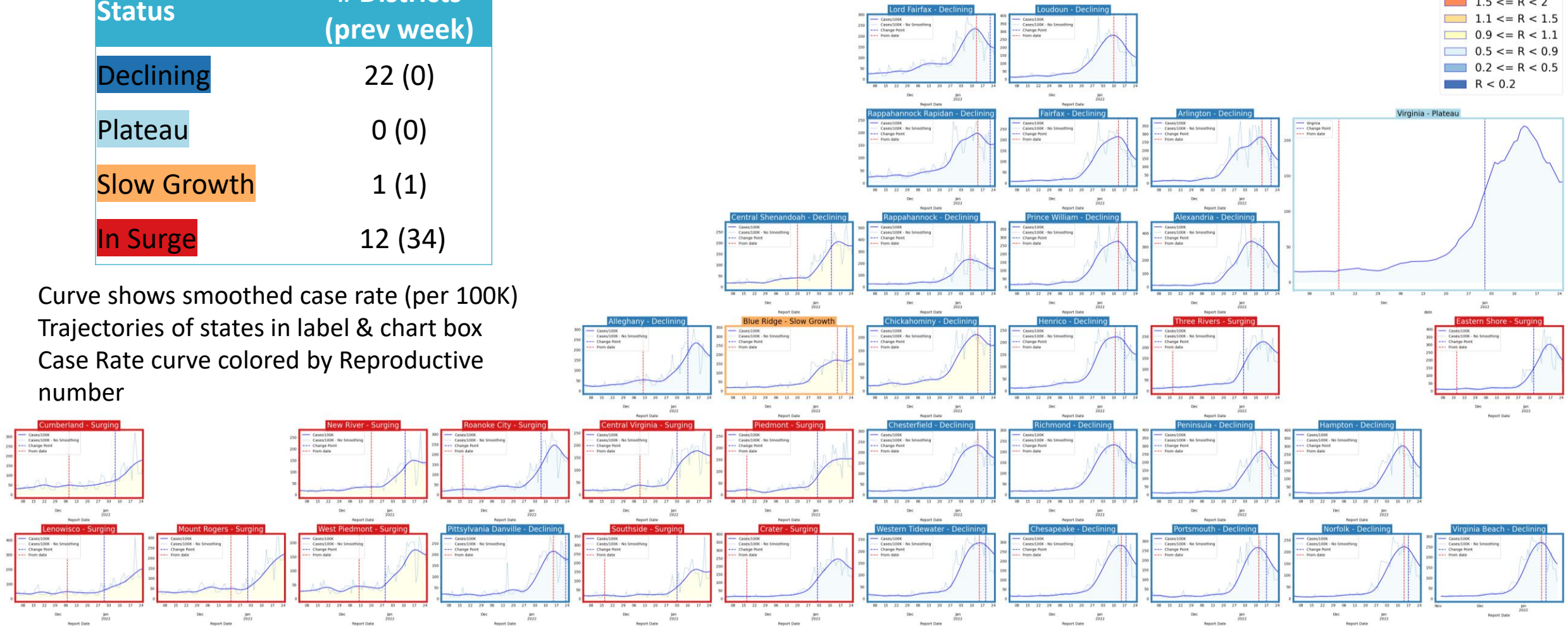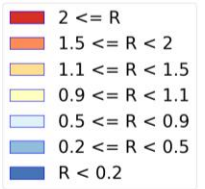
District Trajectories – full history

Status	# Districts (prev week)
Declining	0 (0)
Plateau	0 (0)
Slow Growth	0 (0)
In Surge	35 (35)

Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive number
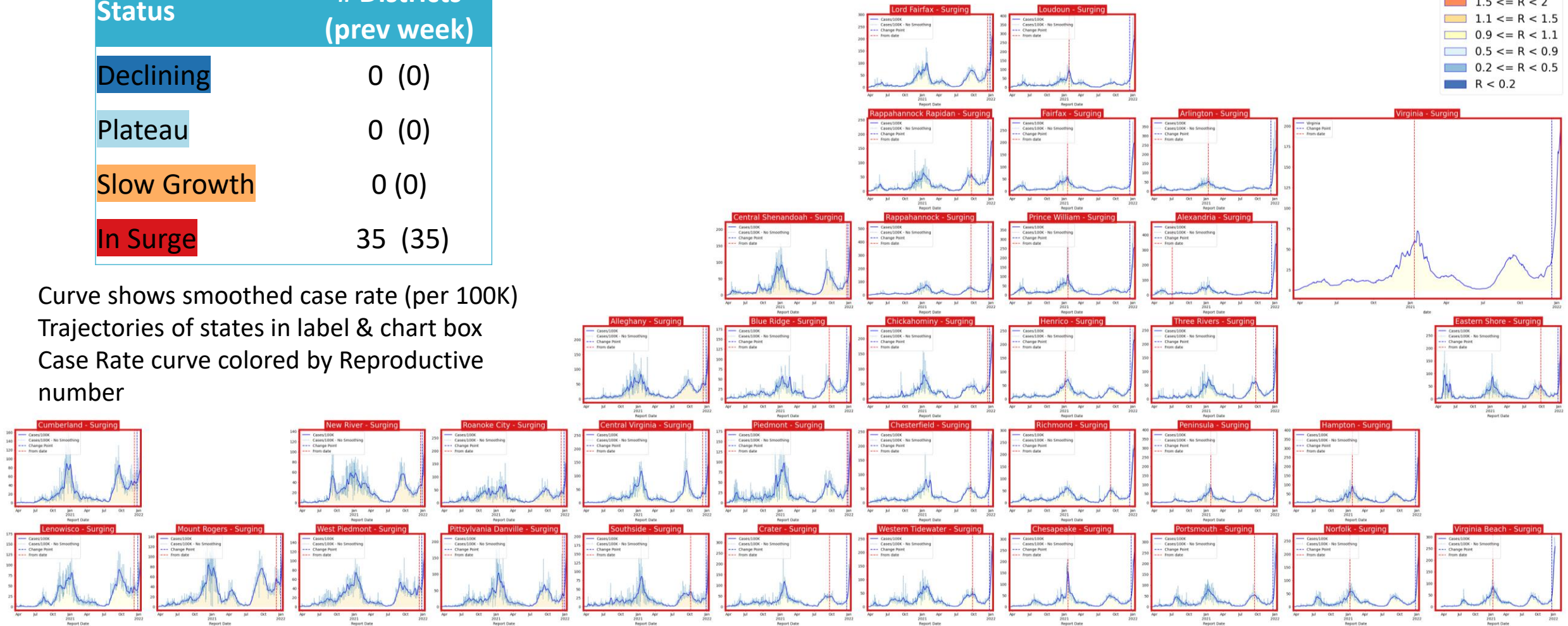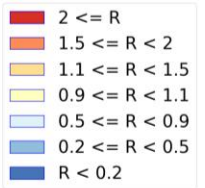
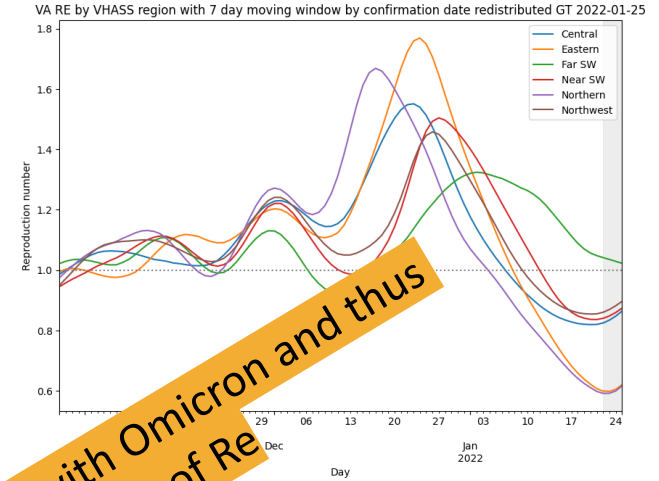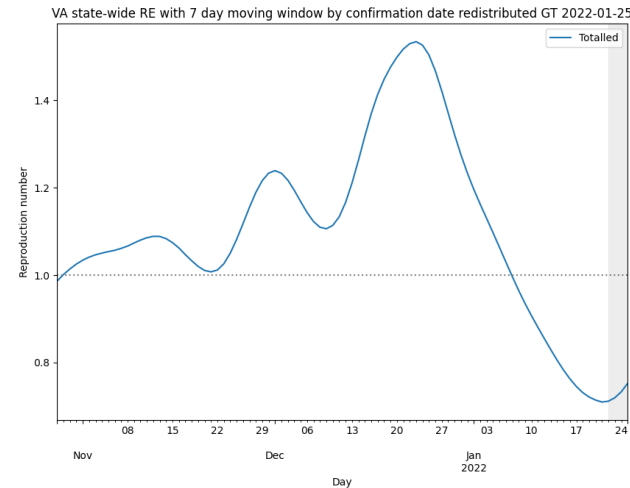# Estimating Daily Reproductive Number – Redistributed gap

Jan 24th Estimates

Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.746	-0.215
Central	0.828	-0.127
Eastern	0.685	-0.293
Far SW	1.035	-0.100
Near SW	0.879	-0.193
Northern	0.538	-0.332
Northwest	0.911	-0.073

Methodology

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

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

VA state-wide RE with 7 day moving window by confirmation date redistributed GT 2022-01-25

VA RE by VHASS region with 7 day moving window by confirmation date redistributed GT 2022-01-25

Serial interval may be smaller with Omicron and thus affecting the estimation of Re

Skipping Weekends & holidays biases estimates
Redistributed "... ... ... to fill in gaps, and then estimate R from "smoothed" ...
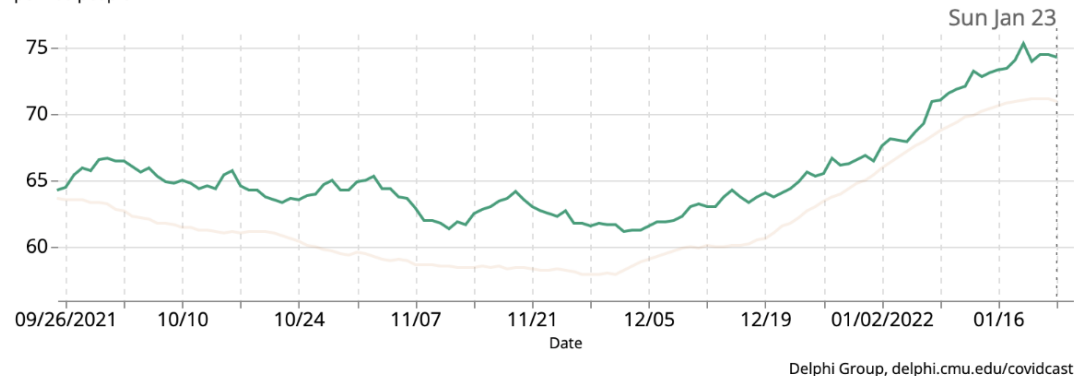
Virginia
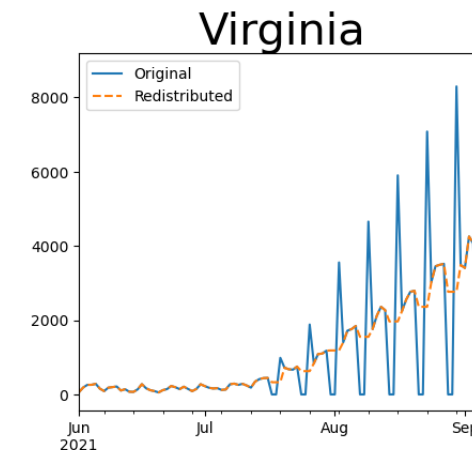
Mask Usage Continues to Rise

Self-reported mask usage seems to be leveling off at ~75% (up from mid 60s in previous months)

- US and VA experienced similar increases
- Mask wearing remains lower amongst unvaccinated especially among least willing to be vaccinated

Data Source: https://covidcast.cmu.edu
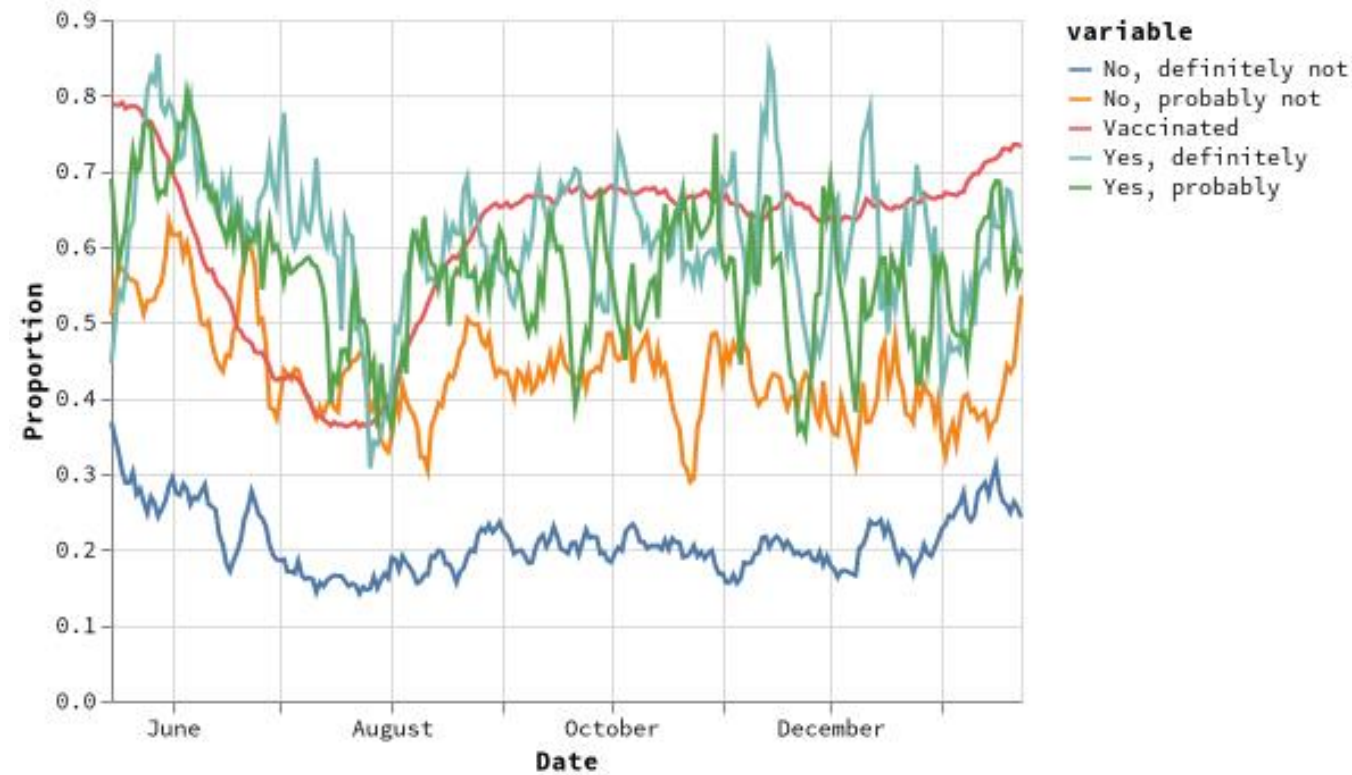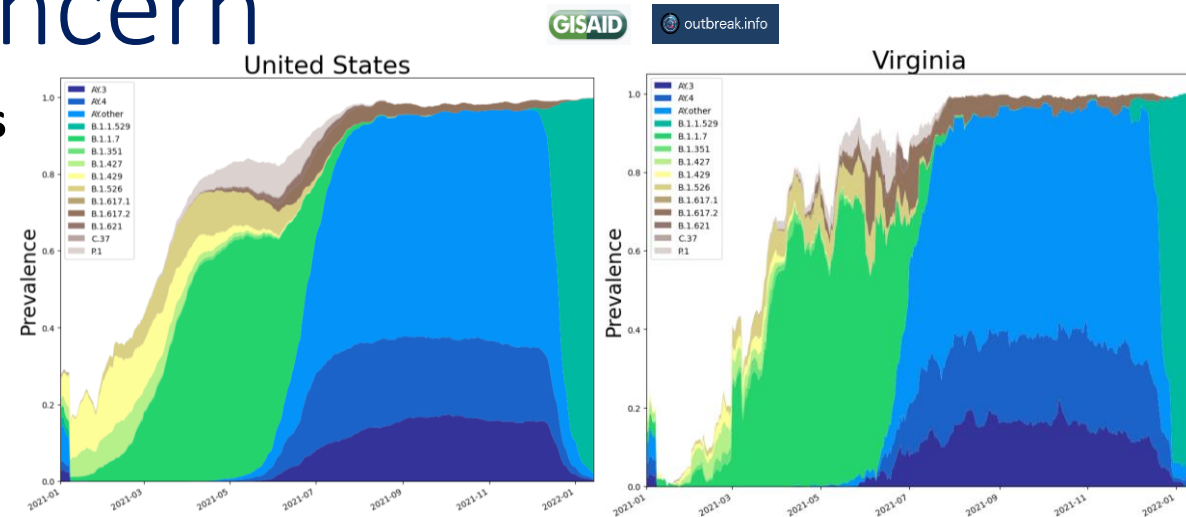
SARS-CoV2 Variants of Concern

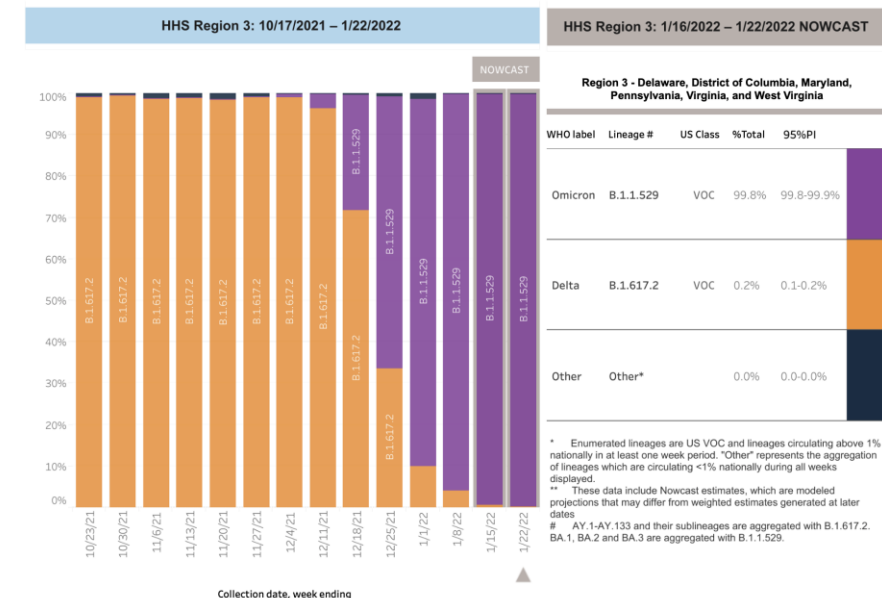**Emerging new variants will alter the future trajectories of pandemic and have implications for future control**

- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations

- Genomic surveillance remains very limited
  - Challenges ability to estimate impact in US to date and estimation of arrival and potential impact in future

United States

Virginia

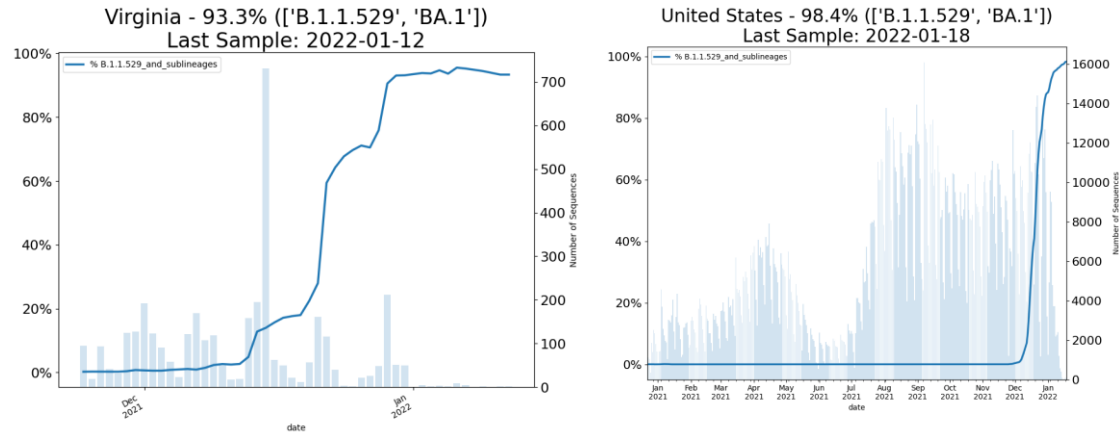| WHO label	Pango lineage*	GISAID clade	Nextstrain clade	Additional amino acid changes monitored°	Earliest documented samples	Date of designation
Alpha	B.1.1.7	GRY	20I (V1)	+S:484K +S:452R	United Kingdom, Sep-2020	18-Dec-2020
Beta	B.1.351	GH/501Y.V2	20H (V2)	+S:L18F	South Africa, May-2020	18-Dec-2020
Gamma	P.1	GR/501Y.V3	20J (V3)	+S:681H	Brazil, Nov-2020	11-Jan-2021
Delta	B.1.617.2	G/478K.V1	21A, 21I, 21J	+S:417N +S:484K	India, Oct-2020	VOI: 4-Apr-2021 VOC: 11-May-2021
Omicron*	B.1.1.529	GRA	21K, 21L	+R346K	Multiple countries, Nov-2021	VUM: 24-Nov-2021 VOC: 26-Nov-2021

World Health Organization WHO

Omicron Prevalence revised again from previous weeks

CDC nowcast calling for 97.8% in Region 3 on week ending Jan 8

HHS Region 3: 10/17/2021 – 1/22/2022

HHS Region 3: 1/16/2022 – 1/22/2022 NOWCAST

Region 3 - Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia

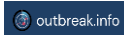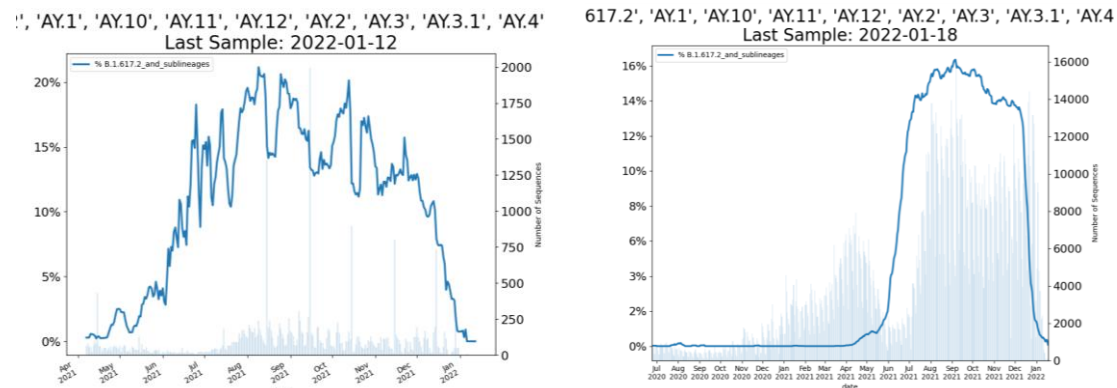| WHO label	Lineage #	US Class	%Total	95%PI
Omicron	B.1.1.529	VOC	99.8%	99.8-99.9%
Delta	B.1.617.2	VOC	0.2%	0.1-0.2%
Other	Other*		0.0%	0.0-0.0%

CDC CDC Variant Tracking

SARS-CoV2 Variants of Concern

Omicron ο - Lineage B.1.1.529

Delta δ - Lineage B.1.617.2


VoC Polynomial Fit Projections
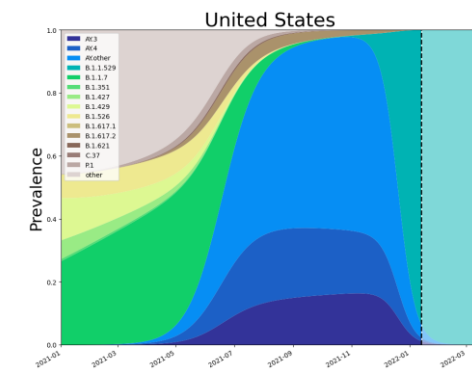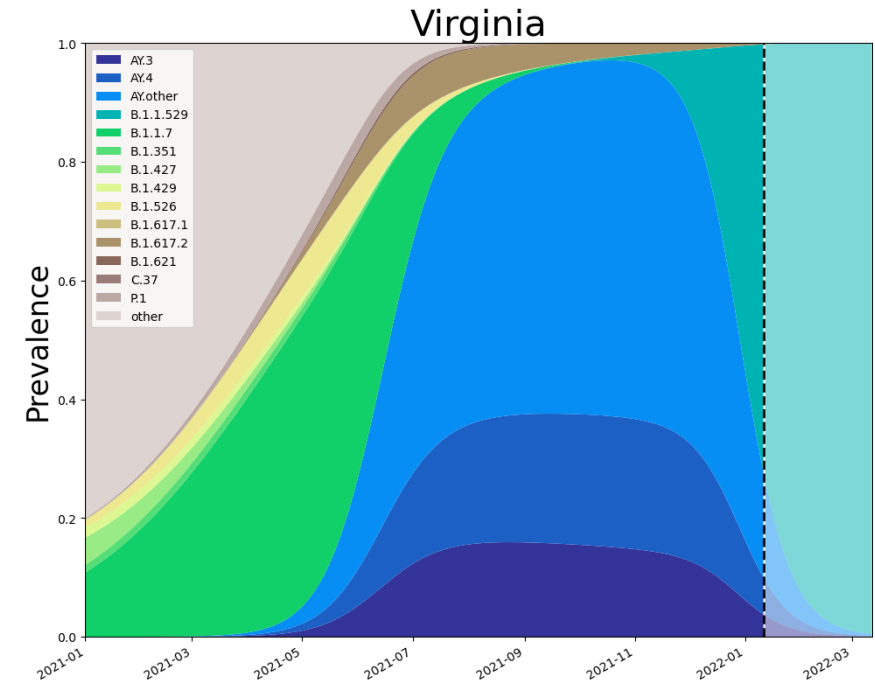
Omicron 01/25/22

1. Omicron lineage B.A.2 has been designated a VUI by UK. It does not have the necessary mutation to use the SGTF signal to identify in PCR tests.

2. Pfizer study at 4 months post booster gives moderate neutralization and follows same decay kinetics as wild-type strain

3. Many people who experience neurologic symptoms that linger after acute COVID-19 are less than 50 years old and were healthy and active prior to infection

Putative neuropathogenic effects of SARS-CoV-2

Infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can lead to neuropsychiatric effects during acute COVID-19, including confusion, stroke, and neuromuscular disorders. These may arise from neuroinflammation, coagulopathy, neuronal injury, and possibly viral infection in the central nervous system. Causes of Long Covid symptoms affecting the nervous system may result from the emergence and persistence of these mechanisms.
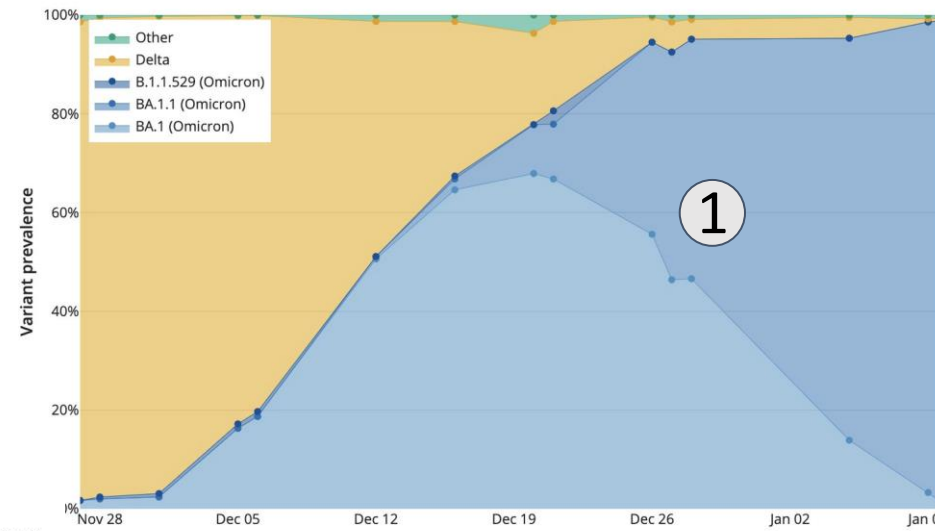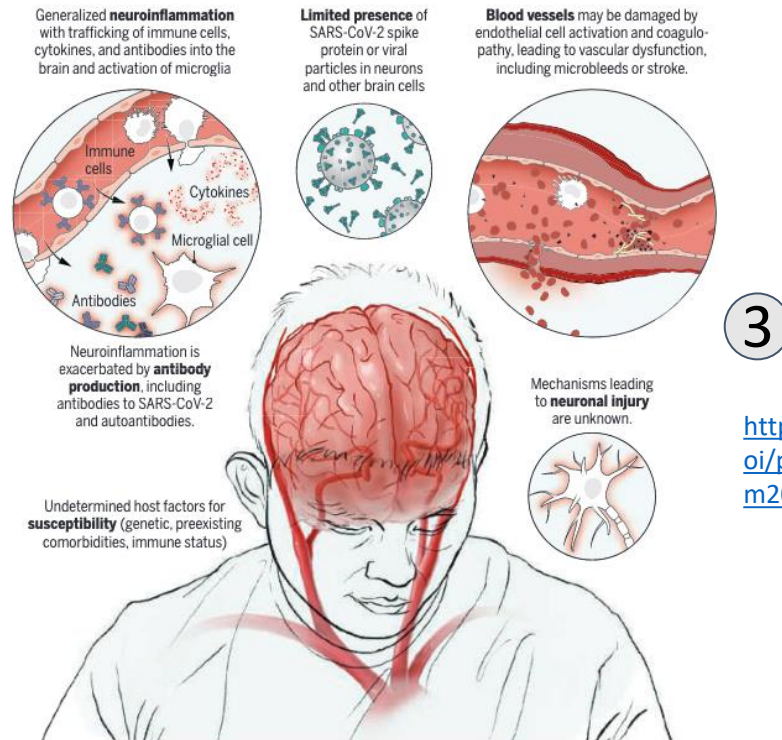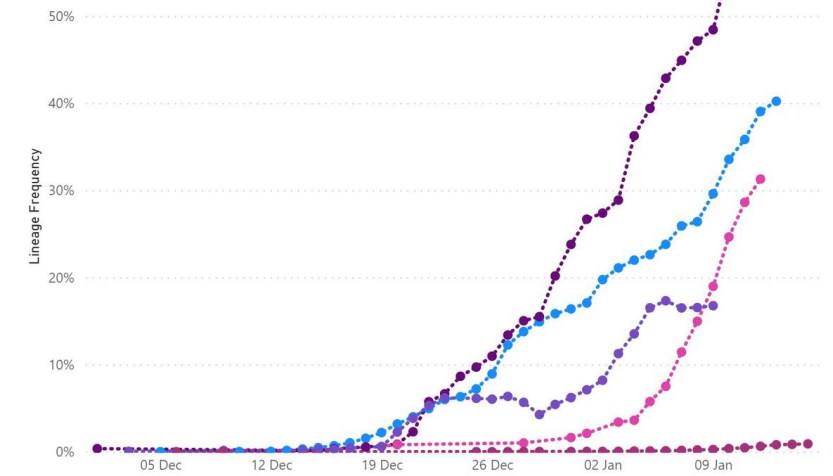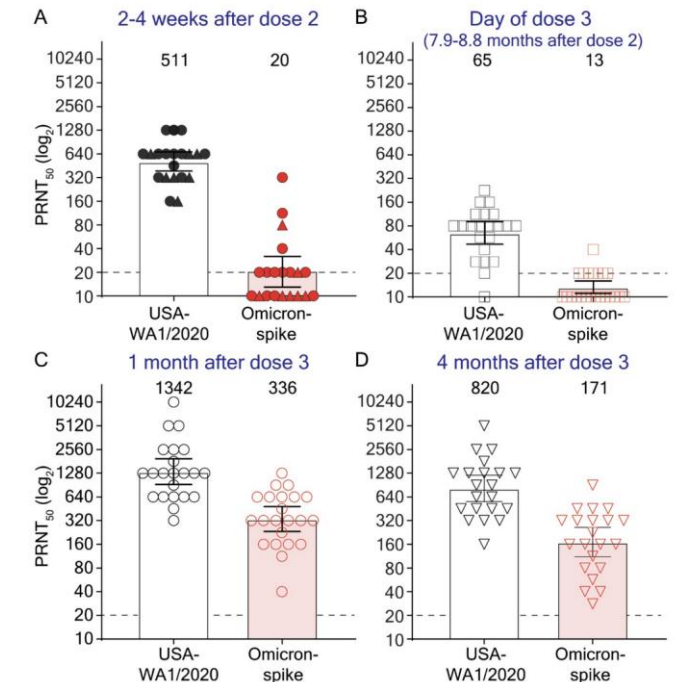
Omicron lineages, B.A.1.1 in San Diego (left) and B.A.2 in multiple countries (right) have large shifts in prevalence. Characterization of these lineages is ongoing.
https://twitter.com/erictopol/status/1485365279622189056
https://twitter.com/k_g_andersen/status/1485784424729886722


https://www.science.org/doi/pdf/10.1126/science.abm2052

These data suggest that a third-dose vaccine strategy could minimize the health impact of Omicron. This is supported by initial reports demonstrating that while vaccine effectiveness against symptomatic infection due to Omicron may wane following a third dose of BNT162b2, the effectiveness against hospitalization remains high.
https://secureservercdn.net/50.62.198.70/1mx.c5c.myftpupload.com/wp-content/uploads/2022/01/MEDRXIV-2021-268439v2-Sigal.pdf

01/25/22 Part 2

1. Updated risk calculator
2. Immunological dysfunction persists for 8 months following initial mild-to-moderate SARS-CoV-2 infection
3. Alpha, Beta, Delta, and Omicron variants exhibit more than two-fold longer survival times than those of the Wuhan strain and maintained infectivity for more than 16 h on the skin
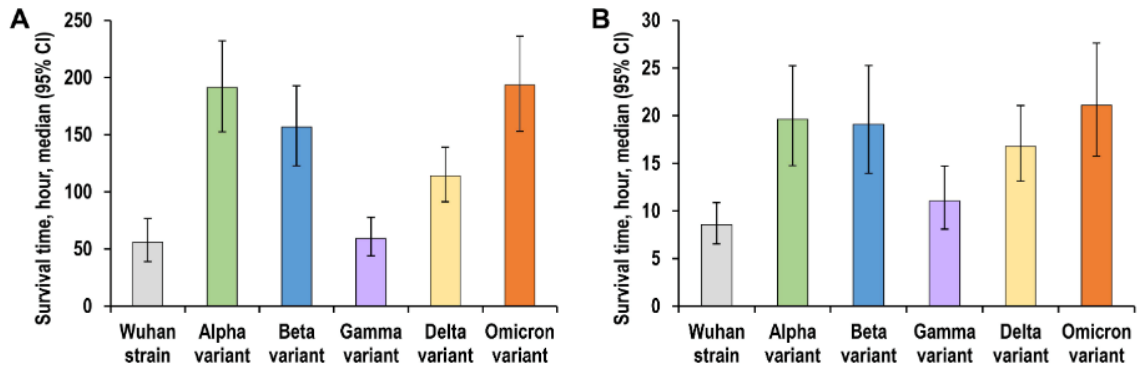4. Researchers identify four risk factors that contribute to the presentation of long covid.
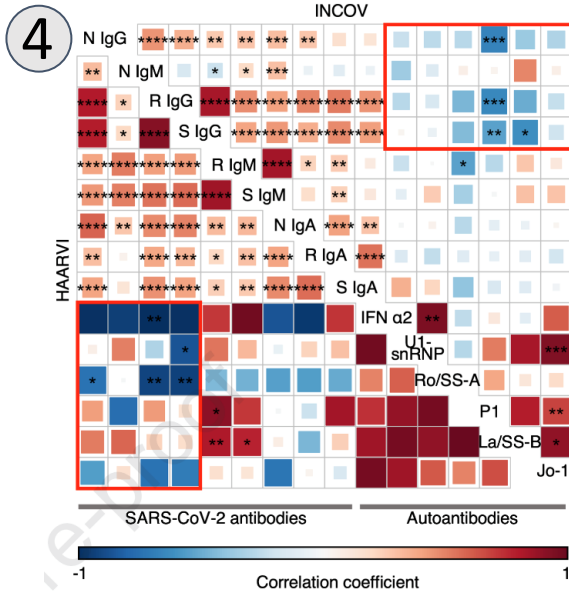
Longitudinal investigation of 309 COVID-19 patients from initial diagnosis to convalescence (2-3 months later), integrated with clinical data, and patient-reported symptoms identified four risk factors 1) level of viral RNA during infection 2) presence of specific autoantibodies 3) reactivation of Epstein-Barr virus 4) Type 2 diabetes
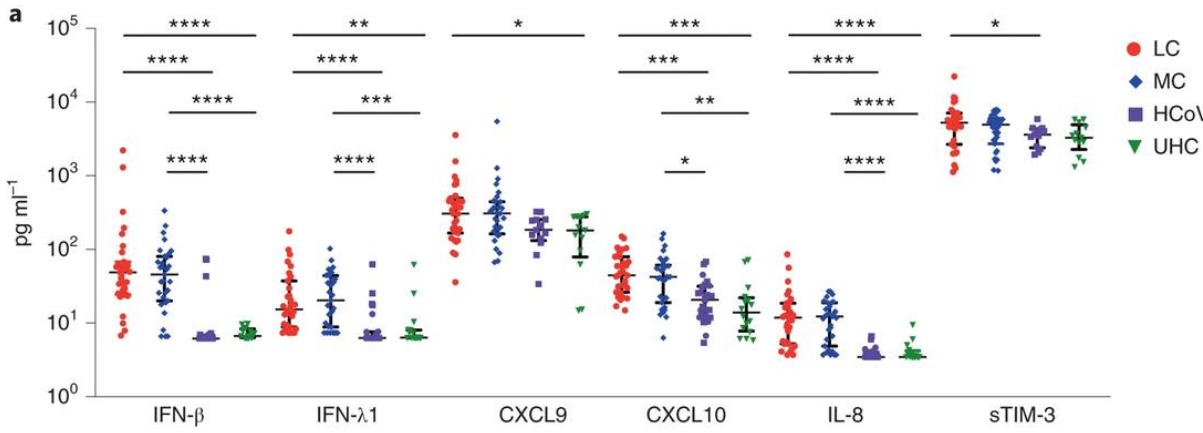https://www.cell.com/cell/fulltext/S0092-8674(22)00072-1#relatedArticles

Based on a review of many practical indicators of Airborne Transmission Risk researchers have published a calculator to estimate transmission odds in different settings.
https://pubs.acs.org/doi/10.1021/acs.est.1c06531
https://theconversation.com/heres-where-and-how-you-are-most-likely-to-


Patients with LC had highly activated innate immune cells, lacked naive T and B cells and showed elevated expression of type I IFN (IFN-β) and type III IFN (IFN-λ1) that remained persistently high at 8 months after infection. Long Covid (LC), Mild Covid (MC), Common Cold (HCoV), Healthy (UHC)
https://www.nature.com/articles/s41590-021-01113-x

Researchers in Kyoto highlight the survival time of different VoCs on skin and plastic surfaces. The high environmental stability of these VOCs could increase the risk of contact transmission and contribute to their transmission.
https://www.biorxiv.org/content/10.1101/2022.01.18.476607v1.full

United States Overall

- Nation shifting to decline
- Following weeks of surge, peaks have formed and declines started in the East and South, Plains and Western US still facing growth
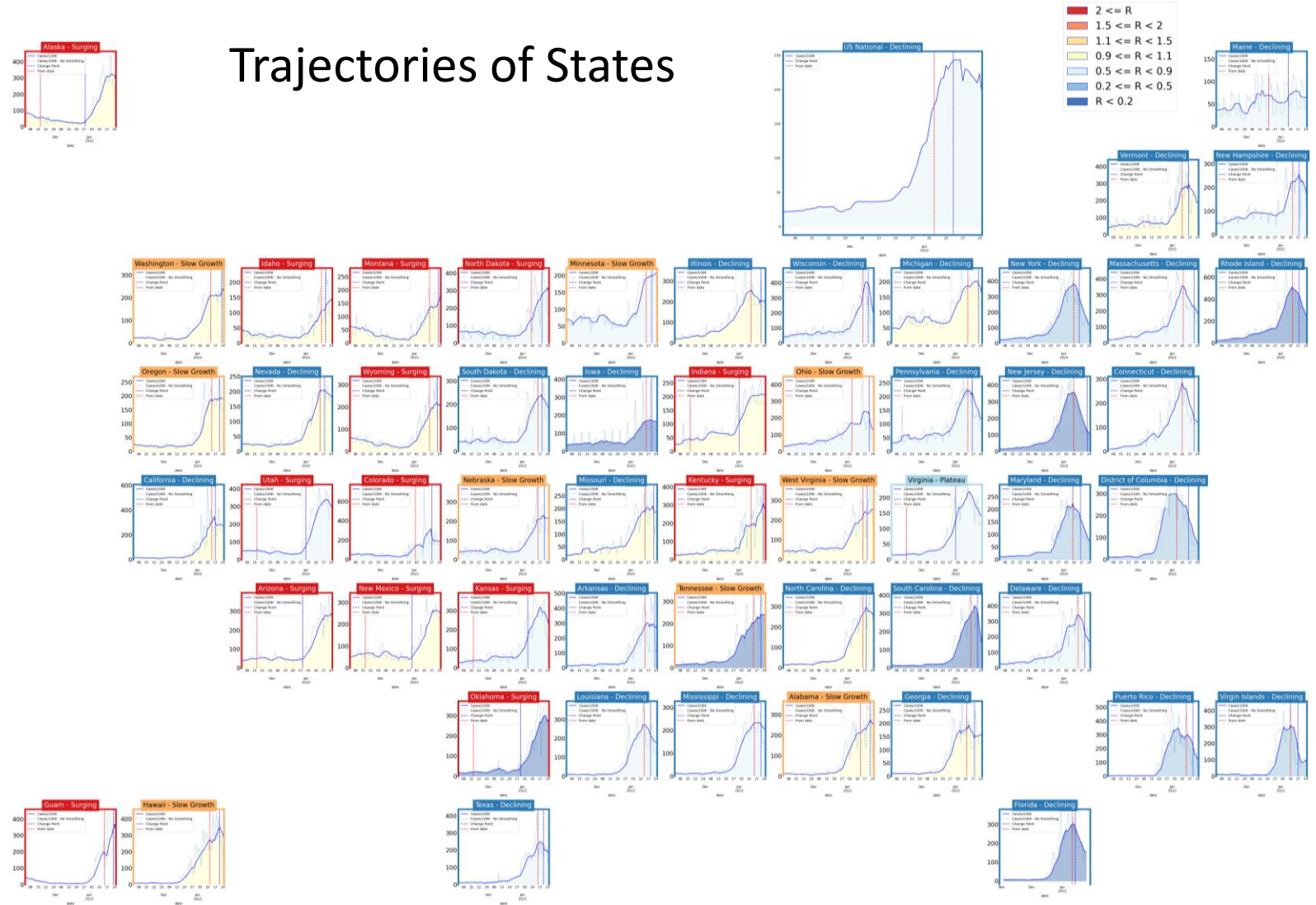
Status	# States
Declining	30 (9)
Plateau	1 (1)
Slow Growth	9 (7)
In Surge	14 (37)

Trajectories of States

UNIVERSITY of VIRGINIA

BIOCOMPLEXITY INSTITUTE

Virginia and Her Neighbors

- Case rates are high, but have shifted to rapid declines in most of the neighborhood

- All experiencing more than 100/100K daily incident case rates
- Those with some growth show initial signs of slowing and flattening out

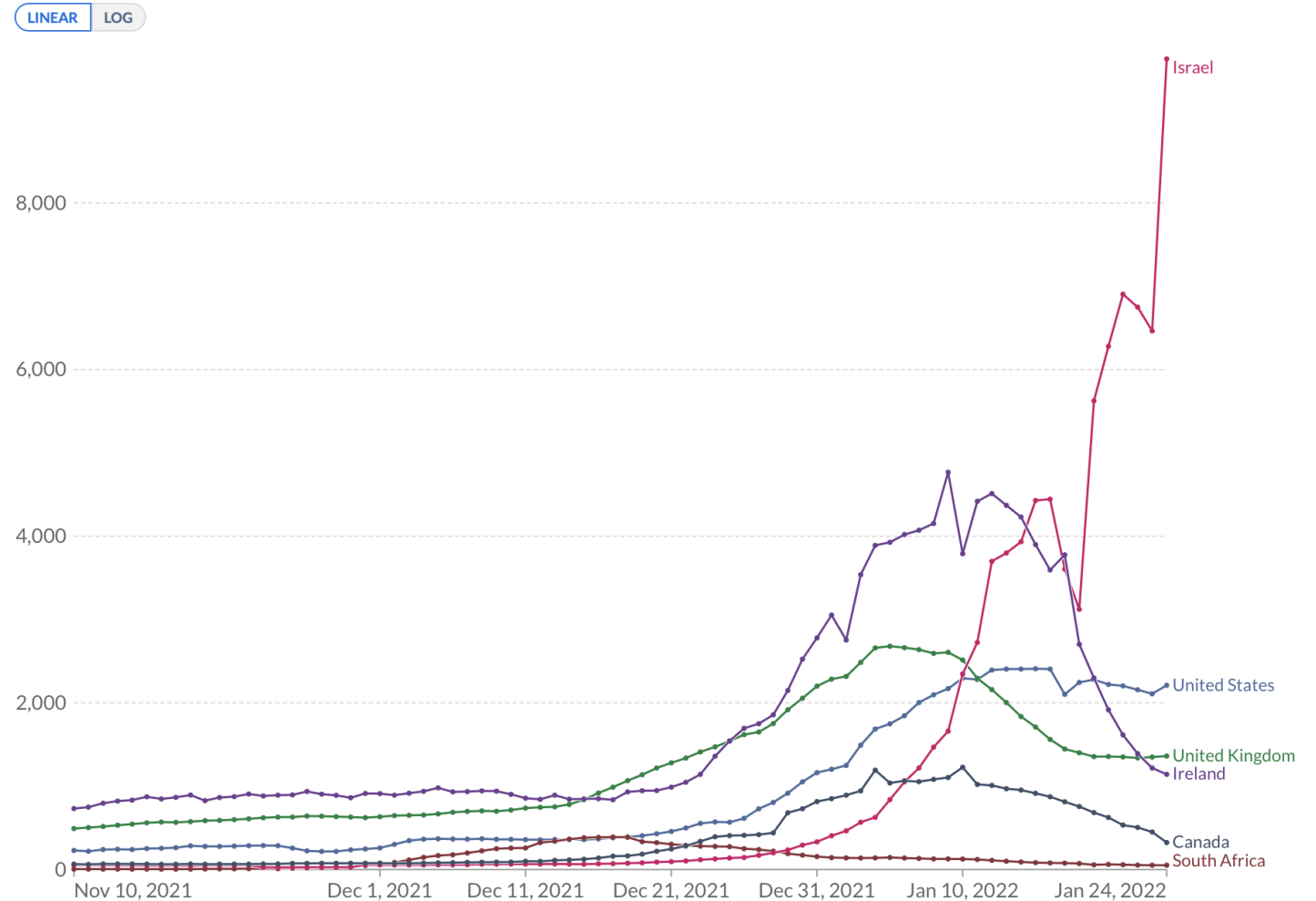UNIVERSITY of VIRGINIA

BIOCOMPLEXITY INSTITUTE
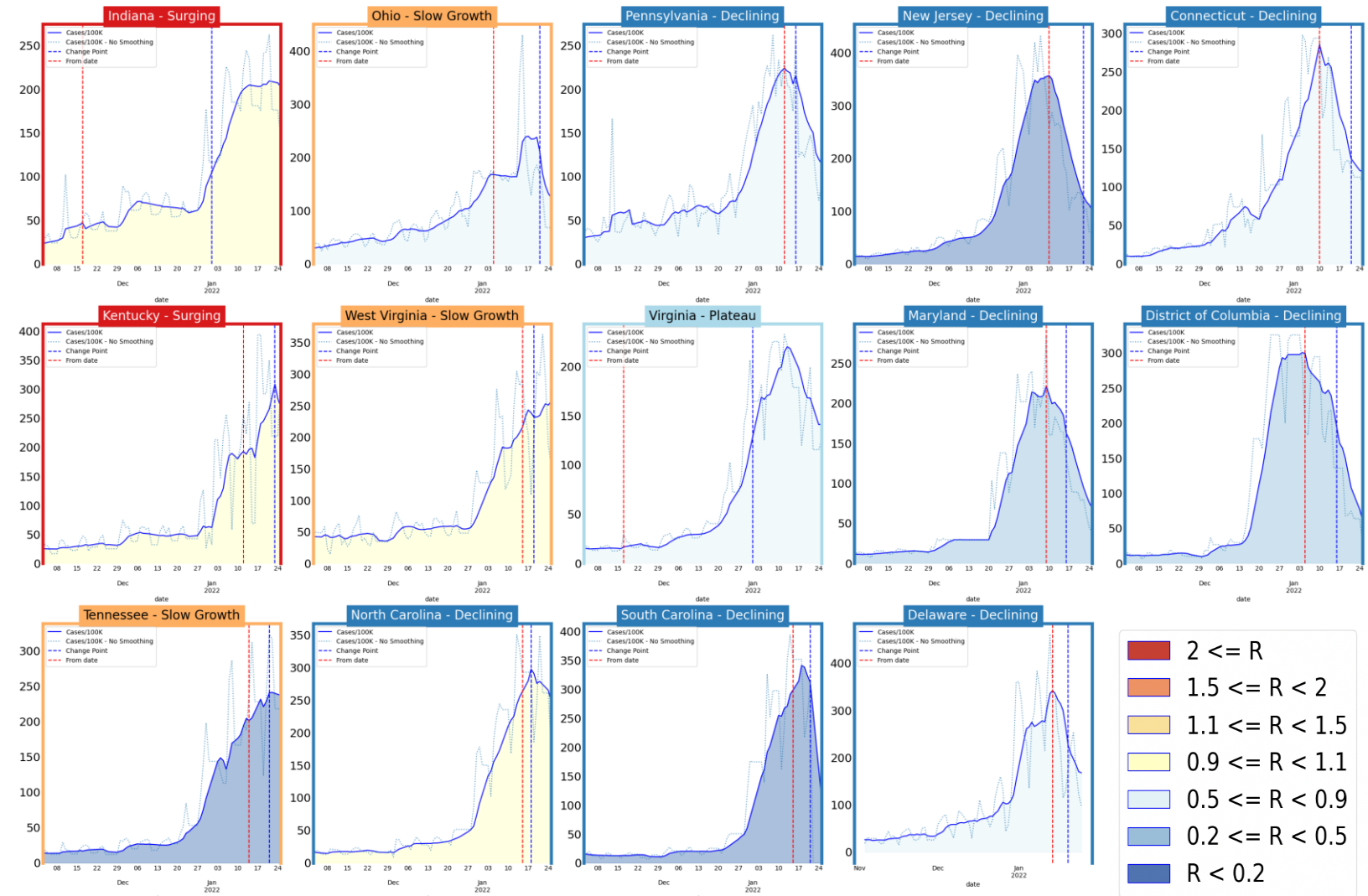
Other Countries

- Many countries that have experienced Omicron have declined but may be reaching a new plateau

- Israel, despite very high vaccination levels, still experiencing significant case rates

Daily new confirmed COVID-19 cases per million people
7-day rolling average. Due to limited testing, the number of confirmed cases is lower than the true number of infections.
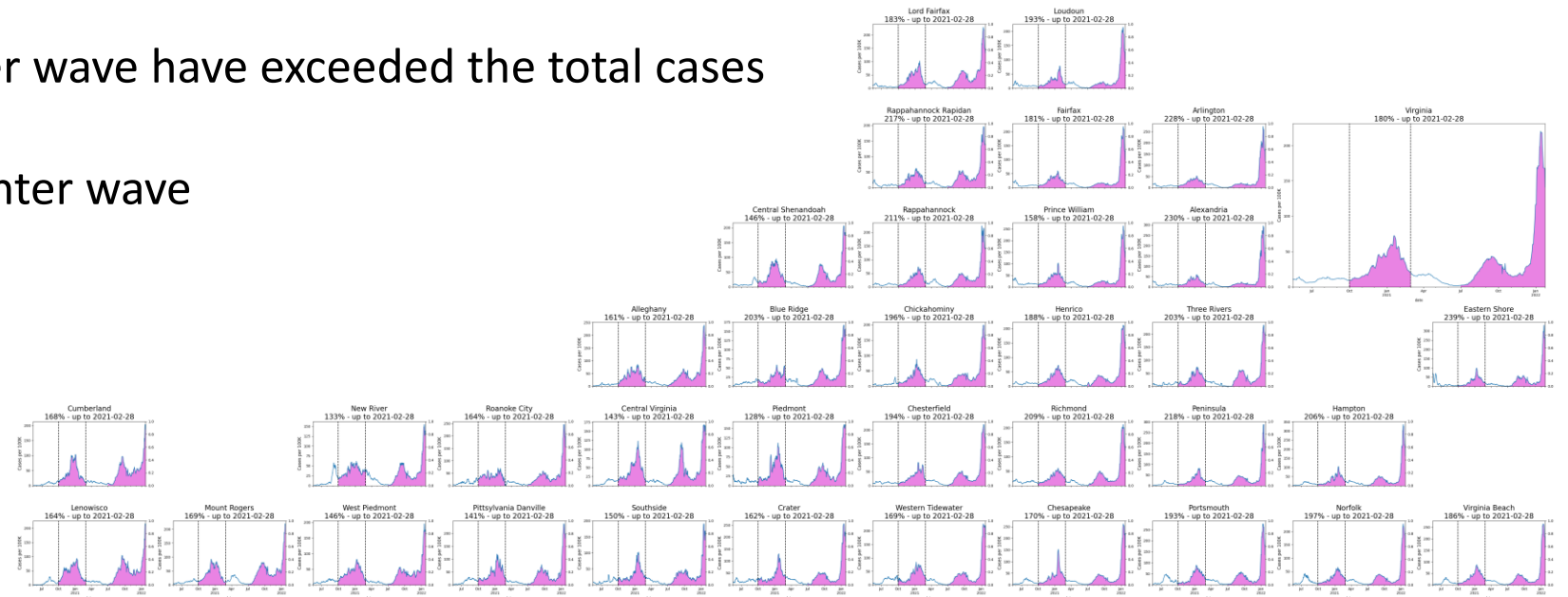
Source: Johns Hopkins University CSSE COVID-19 Data
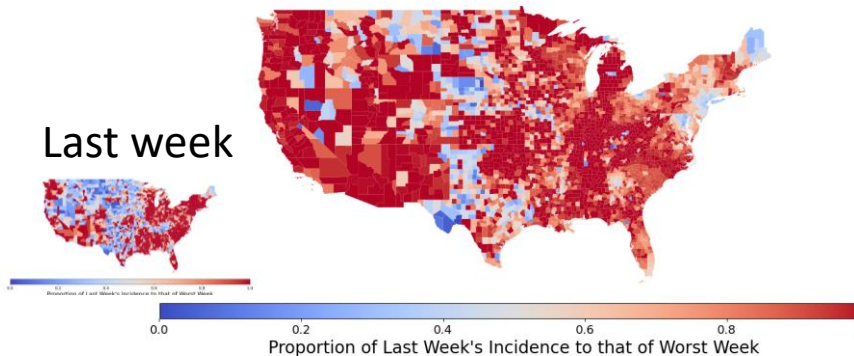
Our World in Data

Comparison to previous waves

- Current Delta and Fall-Winter wave have exceeded the total cases from last Fall-Winter wave
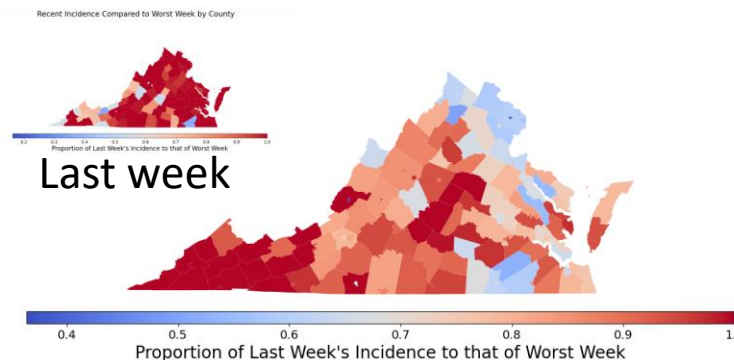- Now at 180% of previous winter wave

Matched Period of Current Cumulative Case Rate to Previous Surge

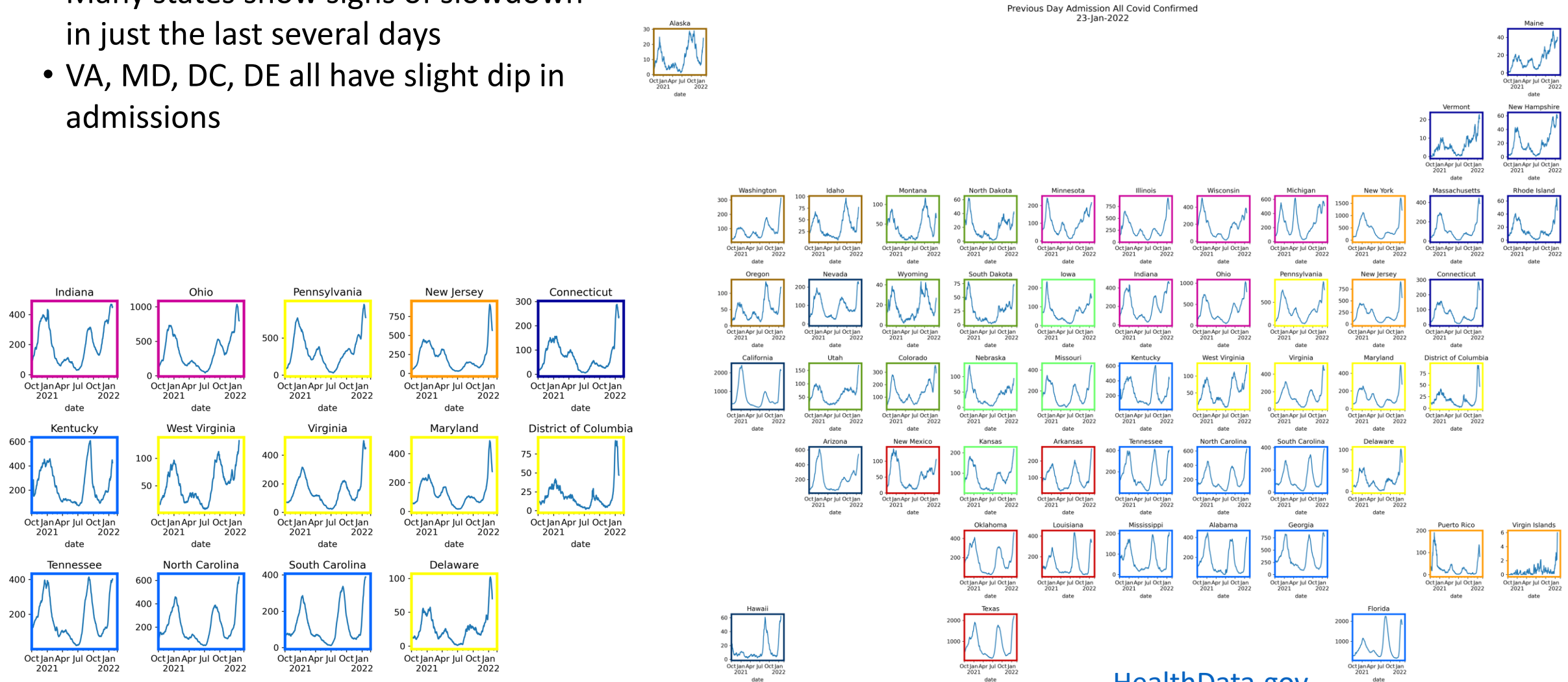

Recent Incidence Compared to Worst Week by County

Last week

Proportion of Last Week's Incidence to that of Worst Week

Recent Incidence Compared to Worst Week by County

Last week

Proportion of Last Week's Incidence to that of Worst Week

- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably

BIOCOMPLEXITY INSTITUTE

COVID-19 Hospital Admissions

- Many states show signs of slowdown in just the last several days
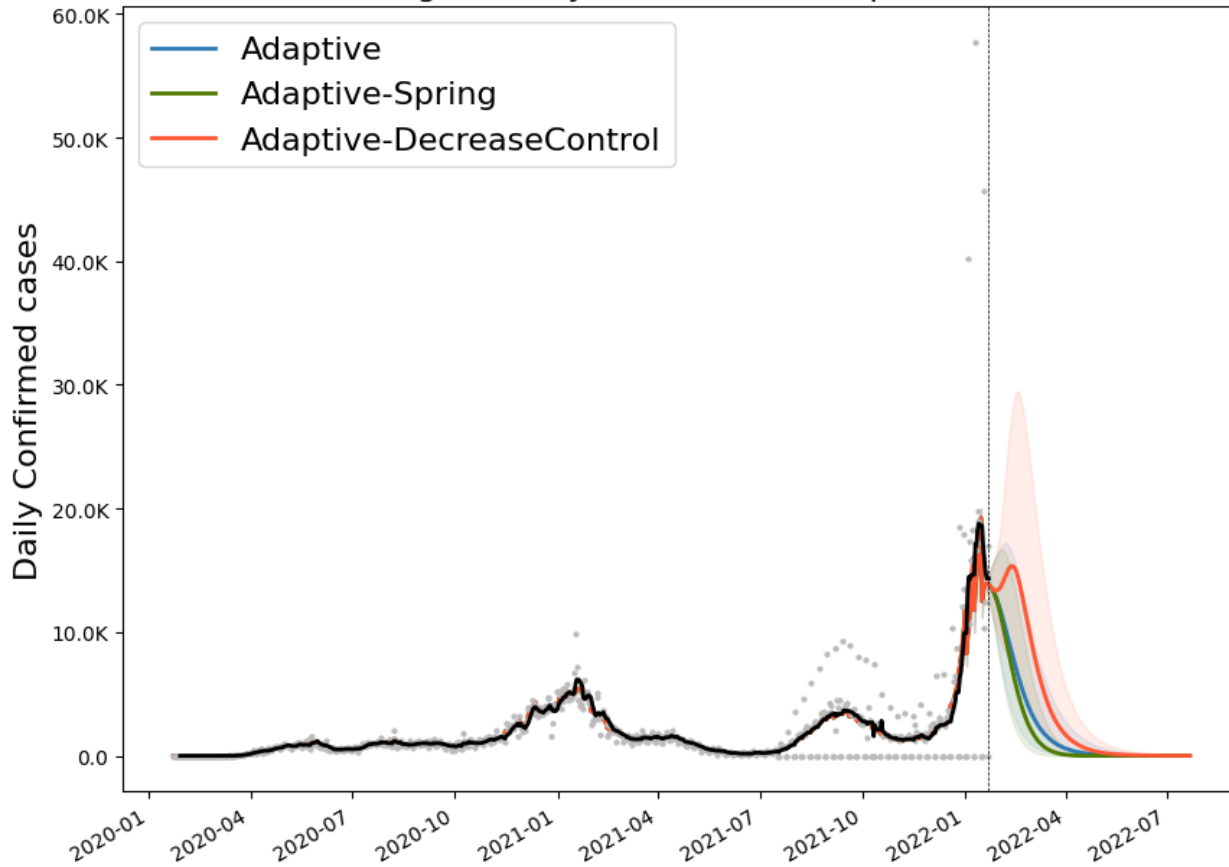- VA, MD, DC, DE all have slight dip in admissions

Previous Day Admission All Covid Confirmed
23-Jan-2022

HealthData.gov

BIOCOMPLEXITY INSTITUTE

Light Update
Model Results

UNIVERSITY *of* VIRGINIA

BIOCOMPLEXITY INSTITUTE

Outcome Projections

Confirmed cases

Closer Look

UNIVERSITY of VIRGINIA
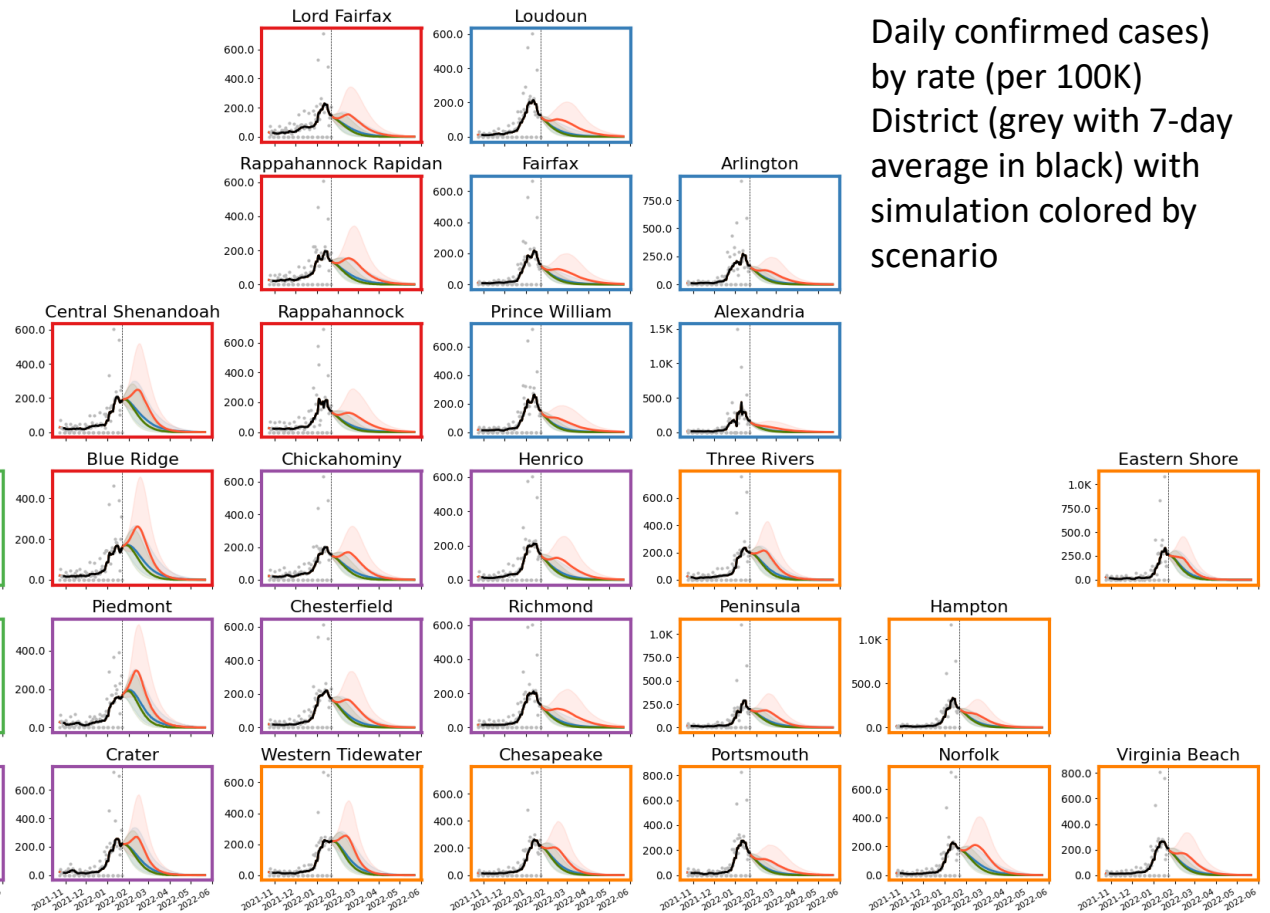
BIOCOMPLEXITY INSTITUTE
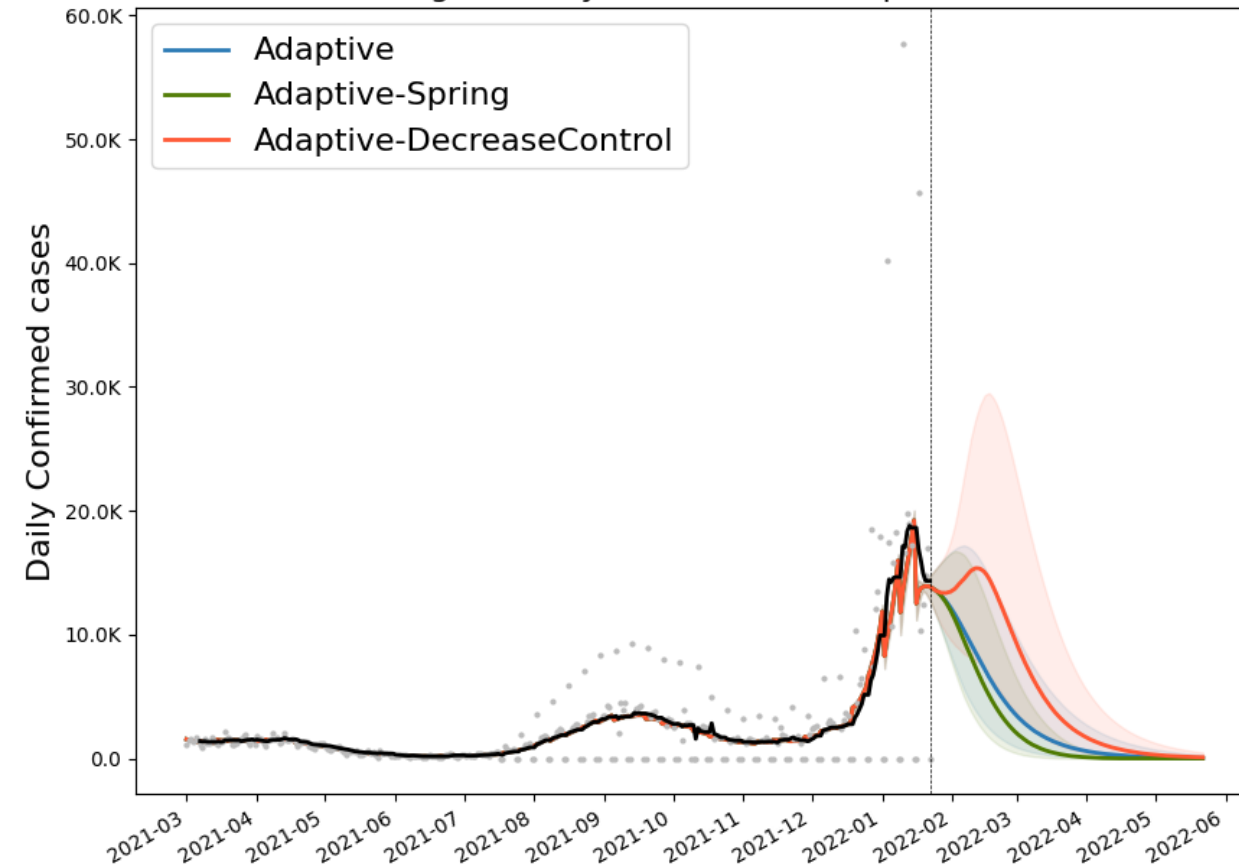
Detailed Projections: All Scenarios

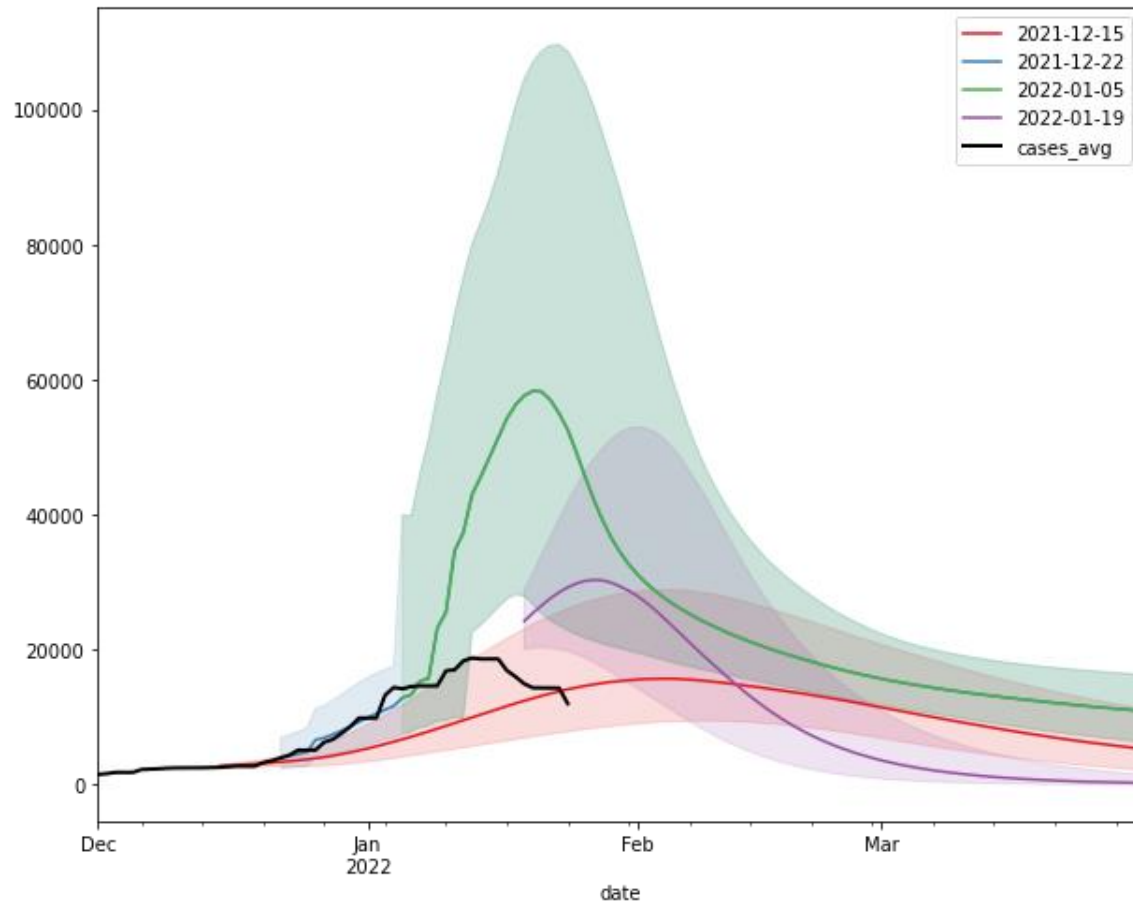## Projections by Region
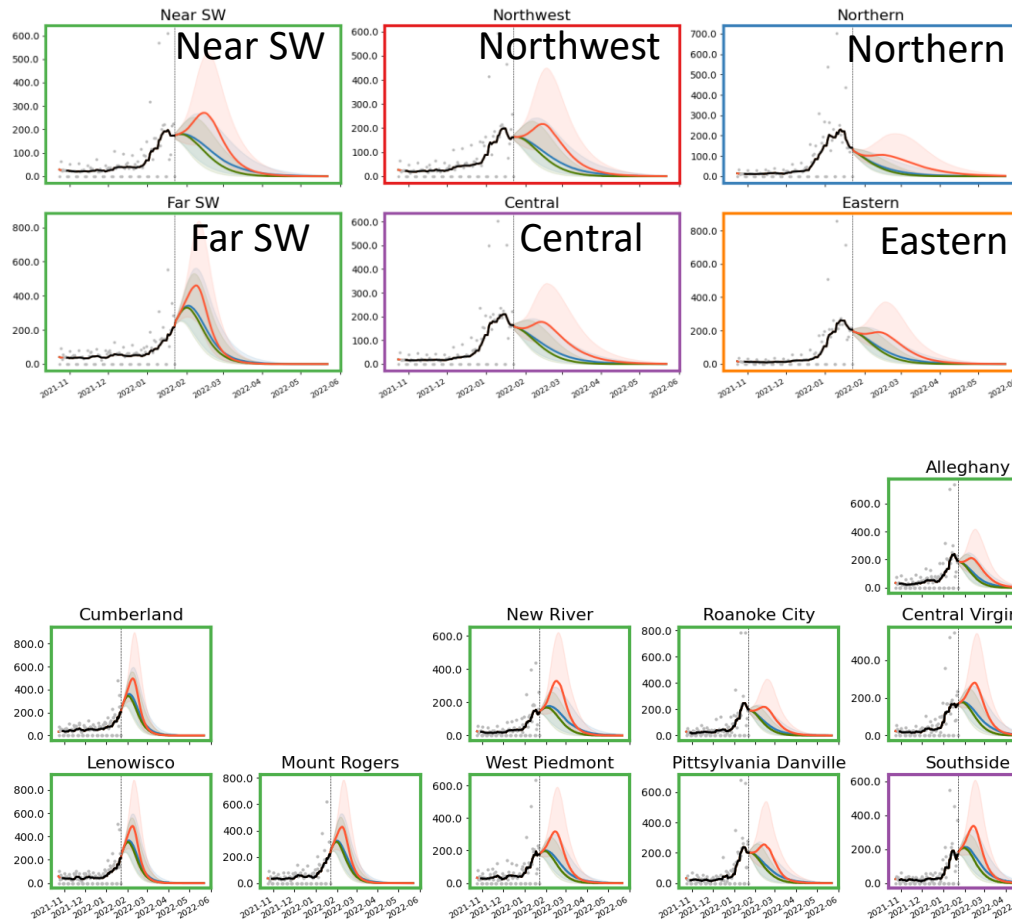
Projections by District

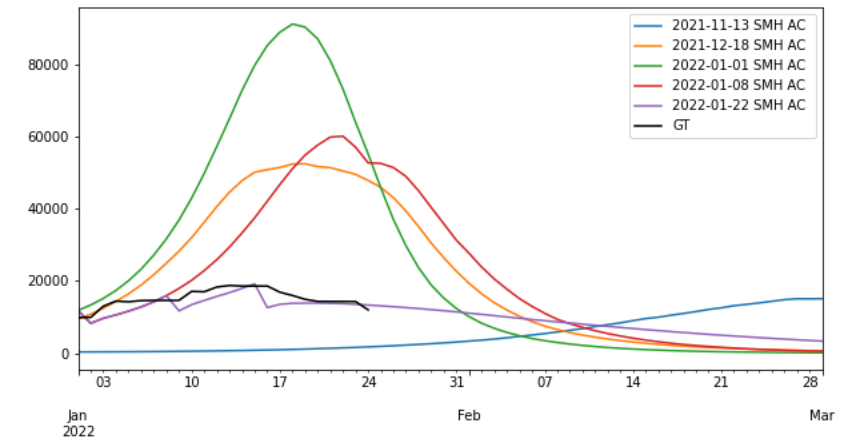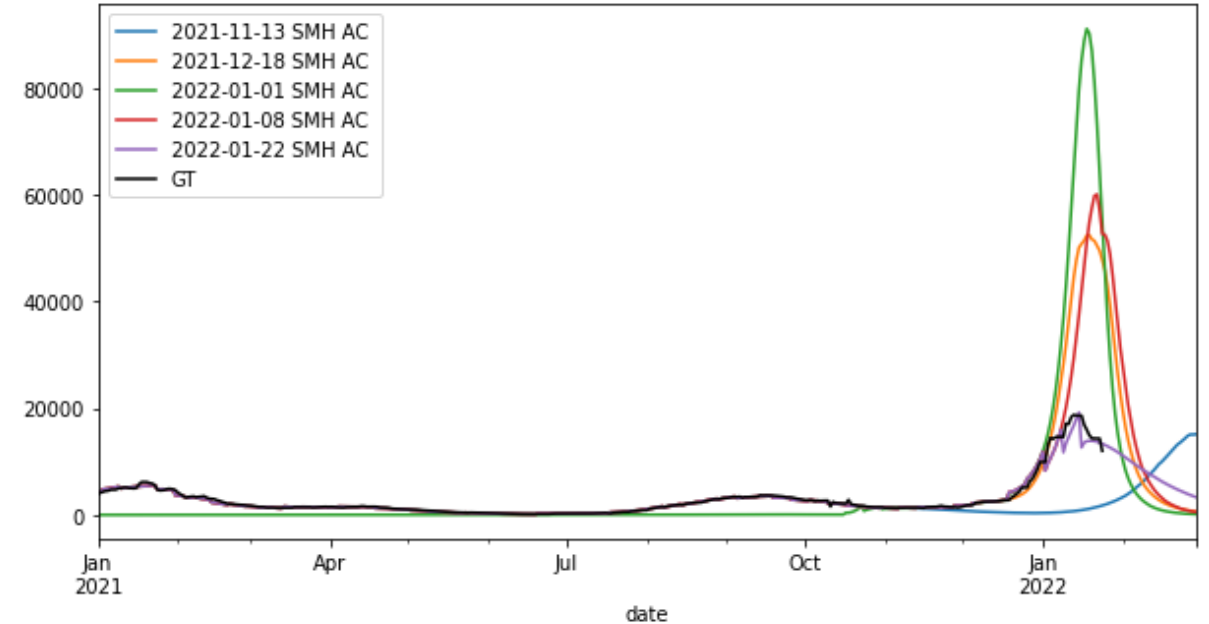Daily confirmed cases) by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

UNIVERSITY *of* VIRGINIA

BIOCOMPLEXITY INSTITUTE

Evaluation of past projections

County level projections

State Level from Scenario Modeling Hub

UNIVERSITY *of* VIRGINIA

BIOCOMPLEXITY INSTITUTE

Additional Analyses

UNIVERSITY of VIRGINIA

BIOCOMPLEXITY INSTITUTE

Overview of relevant on-going studies

Other projects coordinated with CDC and VDH:

- **Scenario Modeling Hub:** Consortium of academic teams coordinated via MIDAS / CDC to that provides regular national projections based on timely scenarios

- **Genomic Surveillance:** Analyses of genomic sequencing data, VA surveillance data, and collaboration with VA DCLS to identify sample sizes needed to detect and track outbreaks driven by introduction of new variants etc.

- **Mobility Data driven Mobile Vaccine Clinic Site Selection:** Collaboration with VDH state and local, Stanford, and SafeGraph to leverage anonymized cell data to help identify

UNIVERSITY *of* VIRGINIA

BIOCOMPLEXITY INSTITUTE

COVID-19 Scenario Modeling Hub

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios that vary vaccine rates (high – low) and impact of the Delta variant (high and low)

- Round 12 underway to update 11

- Round 11 recently released to assist in federal response to Omicron wave

- Only national consortium tracking Omicron wave well

- Rounds 4-11 now available

Round 4 Results were published May 5th, 2021 in MMWR

https://covid19scenariomodelinghub.org/viz.html

Projected Incident Cases by Epidemiological Week and by Scenario for Round 11 - US
(- Projection Epiweek; -- Current Week)

Scenario A ; Optimistic severity, High immune escape/L | Scenario B ; Optimistic severity, Low immune escape/High transmissibility increase

View: Ensemble