Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

January 12th, 2022

(data current to Jan 2nd – 4th)

Biocomplexity Institute Technical report: TR 2022-003

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

Key Takeaways

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

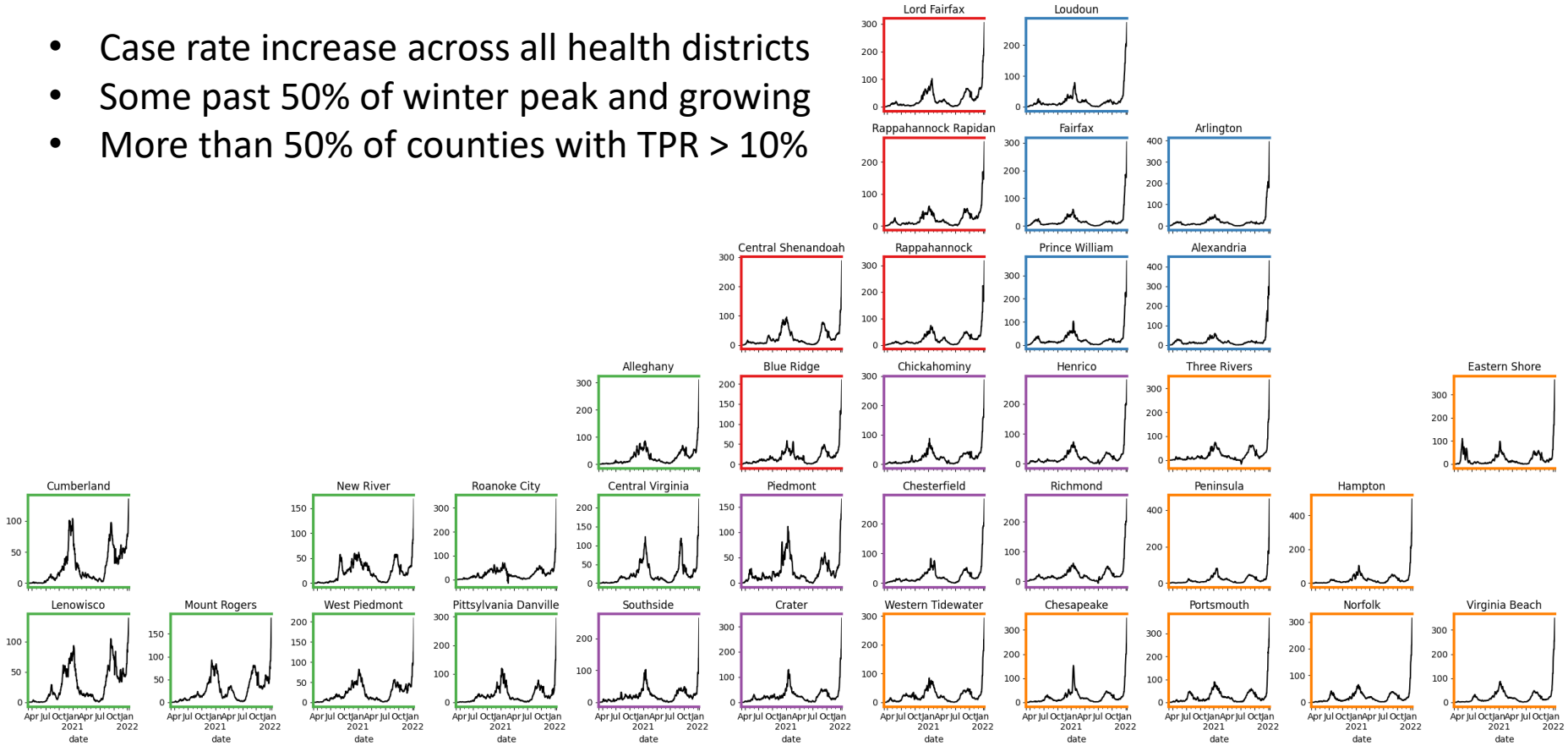
- **Case rates remain at unprecedented levels throughout the commonwealth may show some signs of slowing**
- VA 7-day mean daily case rate up to 197/100K from 155/100K; US is up to 230/100K (from 144/100K)
- Projections show a continued sharp rise in case-rates for several weeks:
  - Omicron is able to infect and transmit more between those with immunity from previous infections and vaccinations; hospitalizations will also rise despite reduced severity as case-rates out pace this reduction
  - Case ascertainment will drop as fewer infections cause severe disease, testing capacities are met, and at-home testing rises
- Recent model updates:
  - Overhauled model structure further refined to better capture different tiers of immunity and the immune evasion of the Omicron variant

The situation continues to change. Models continue to be updated regularly.

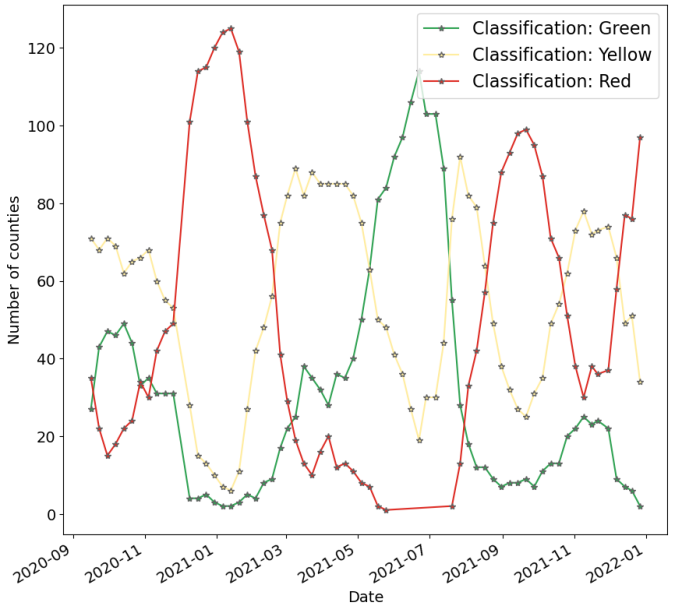
Situation Assessment

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%



Data source: https://data.cms.gov/covid-19/covid-19-nursing-home-data



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)

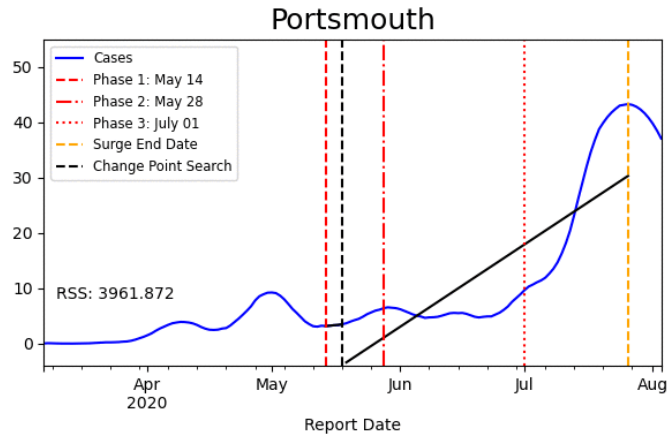
Red: >10.0% (and not "Green" or "Yellow")

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

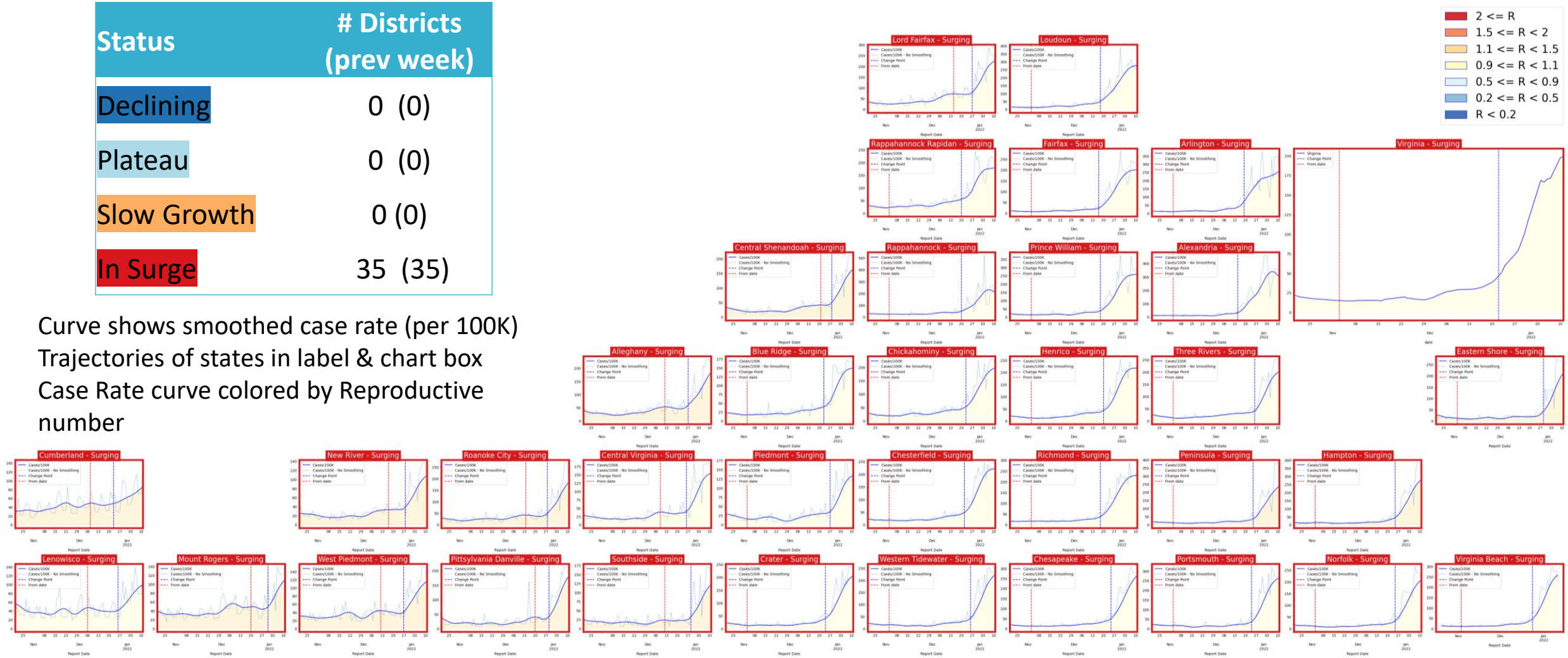


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	5 (1)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	0 (0)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	9 (13)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	21 (21)

District Trajectories – last 10 weeks

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

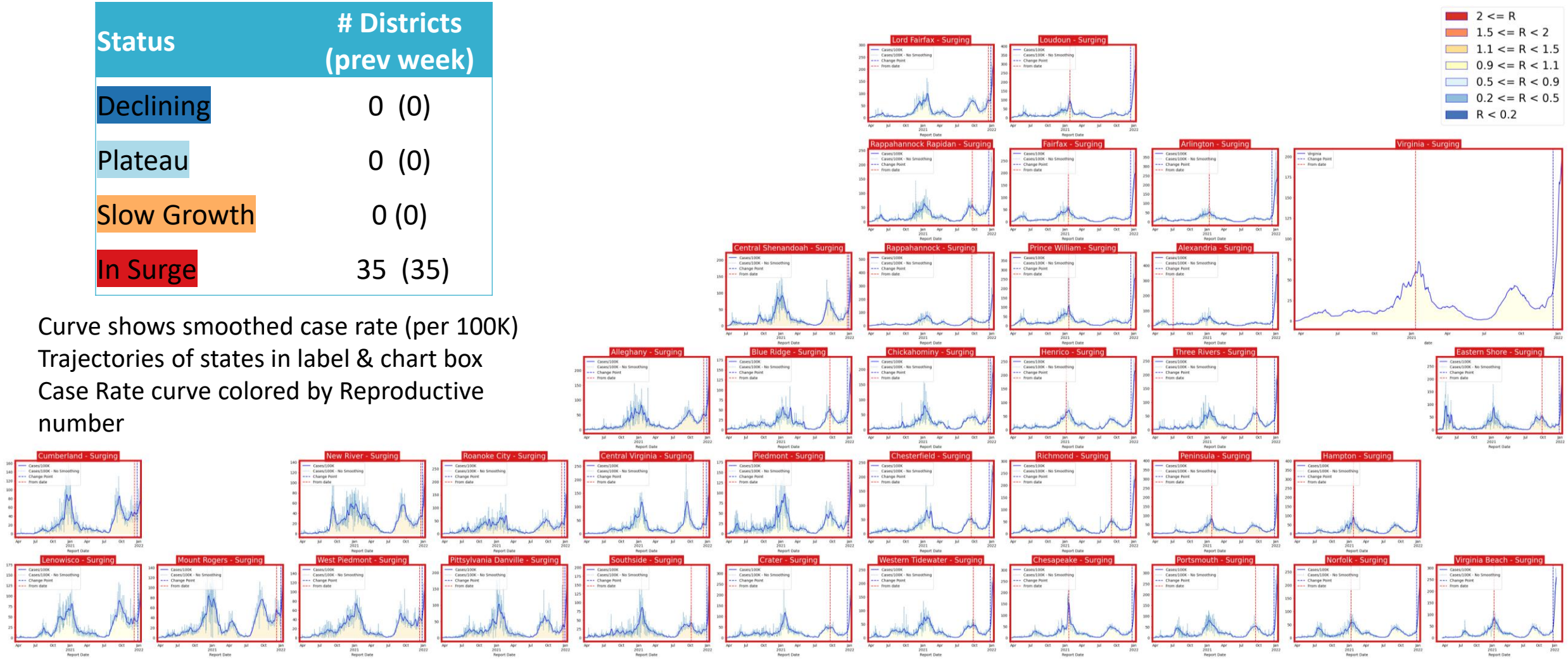
Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive number



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

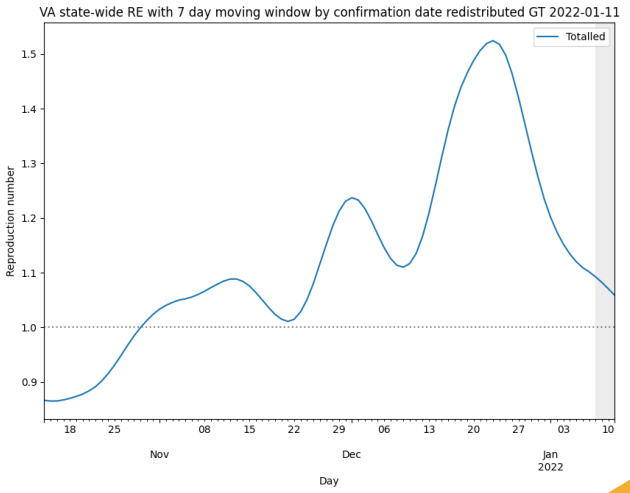


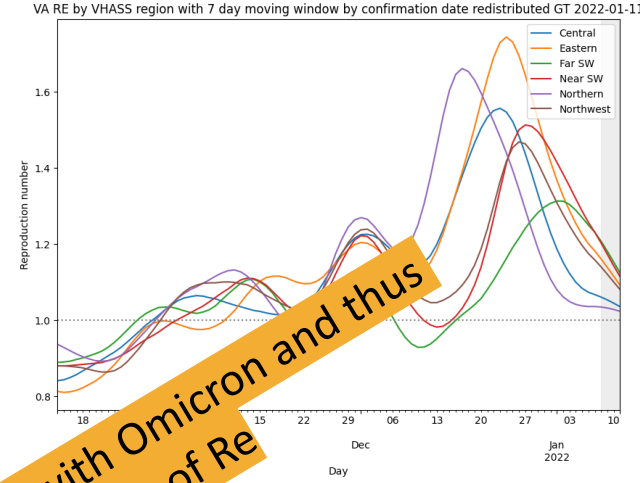
UNIVERSITY of VIRGINIA
BIOCOMPLEXITY INSTITUTE

Estimating Daily Reproductive Number – Redistributed gap

Jan 10th Estimates

Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	1.082	-0.076
Central	1.048	-0.122
Eastern	1.129	-0.084
Far SW	1.118	0.003
Near SW	1.154	-0.070
Northern	1.037	-0.100
Northwest	1.111	-0.102

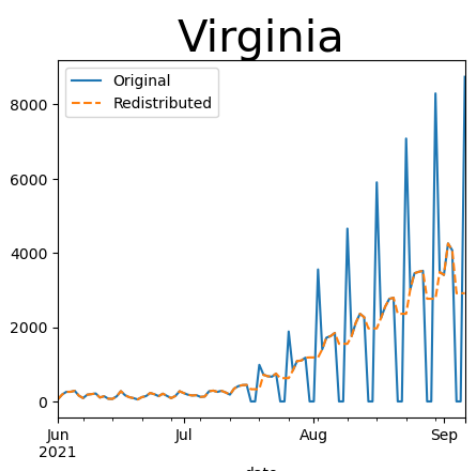




Serial interval may be smaller with Omicron and thus affecting the estimation of Re

Skipping Weekend & holidays biases estimates

Redistributed "bi… …y to fill in gaps, and then estimate R from "smoothed" …



Methodology

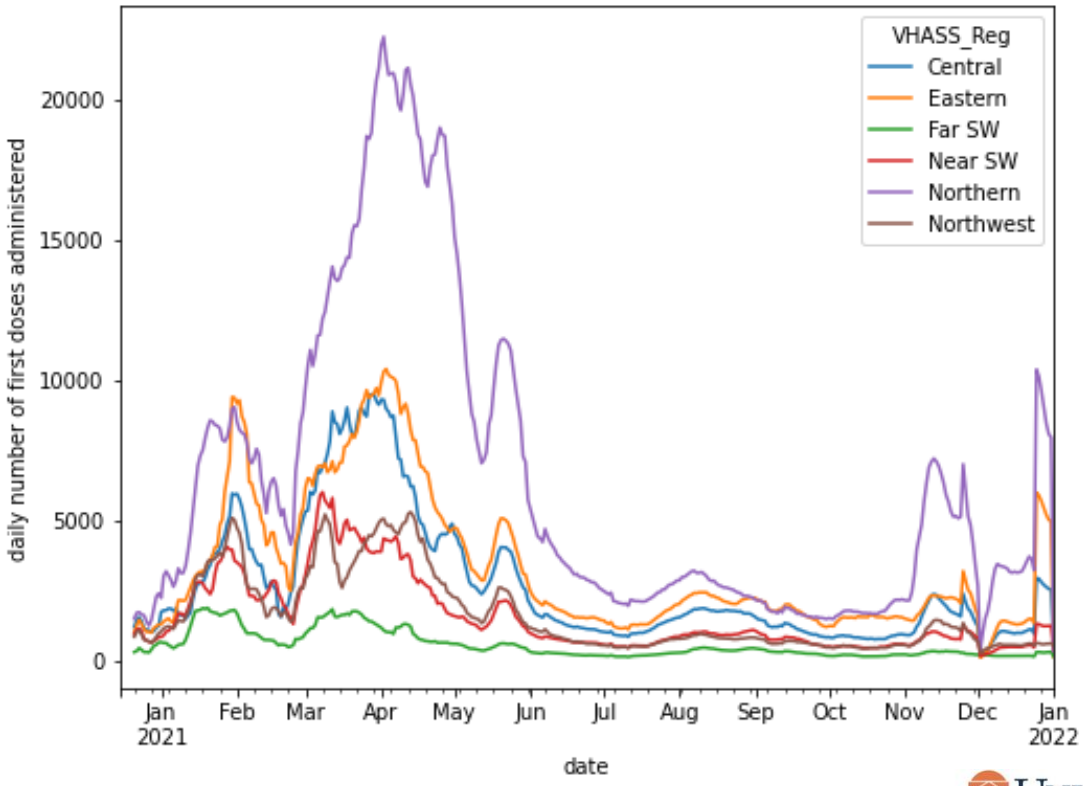
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: Discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

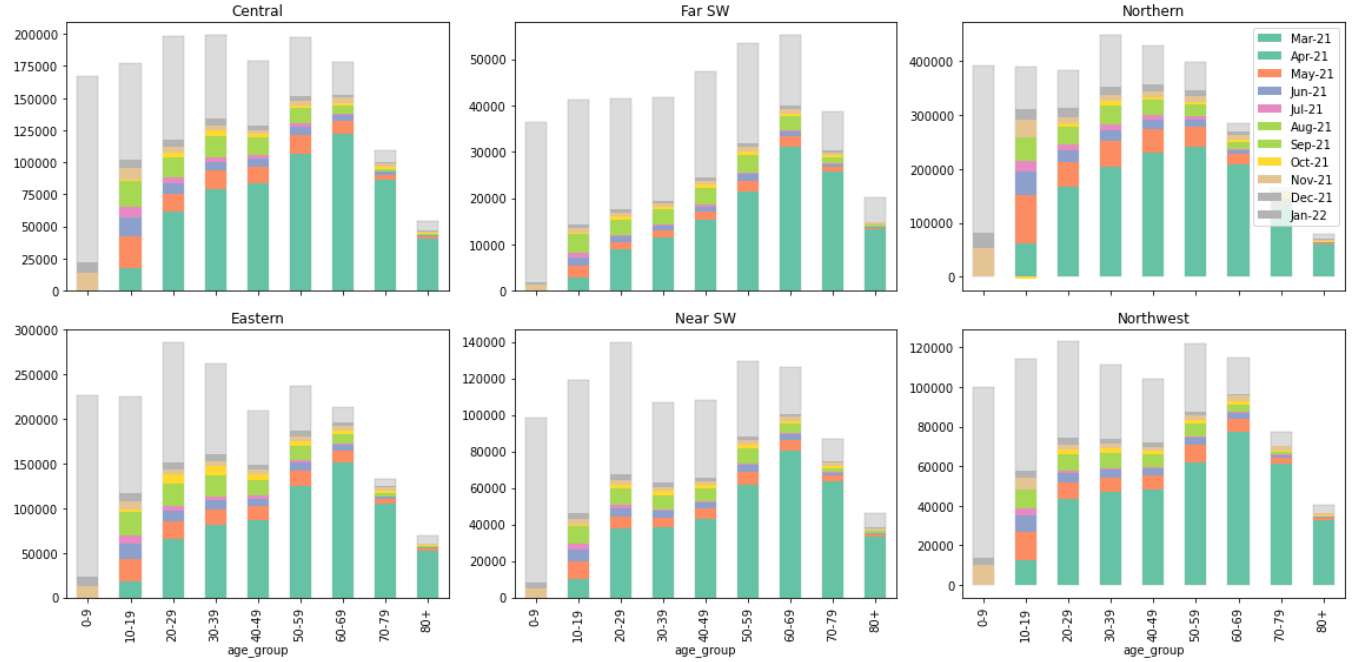
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Vaccination Administration of First Doses

Regional Vaccine courses initiated per day (% eligible):

- Uptick with 5-11 year old eligibility but interrupted by holidays etc.
- Age-specific proportions of population vaccinated show recent progress in younger ages



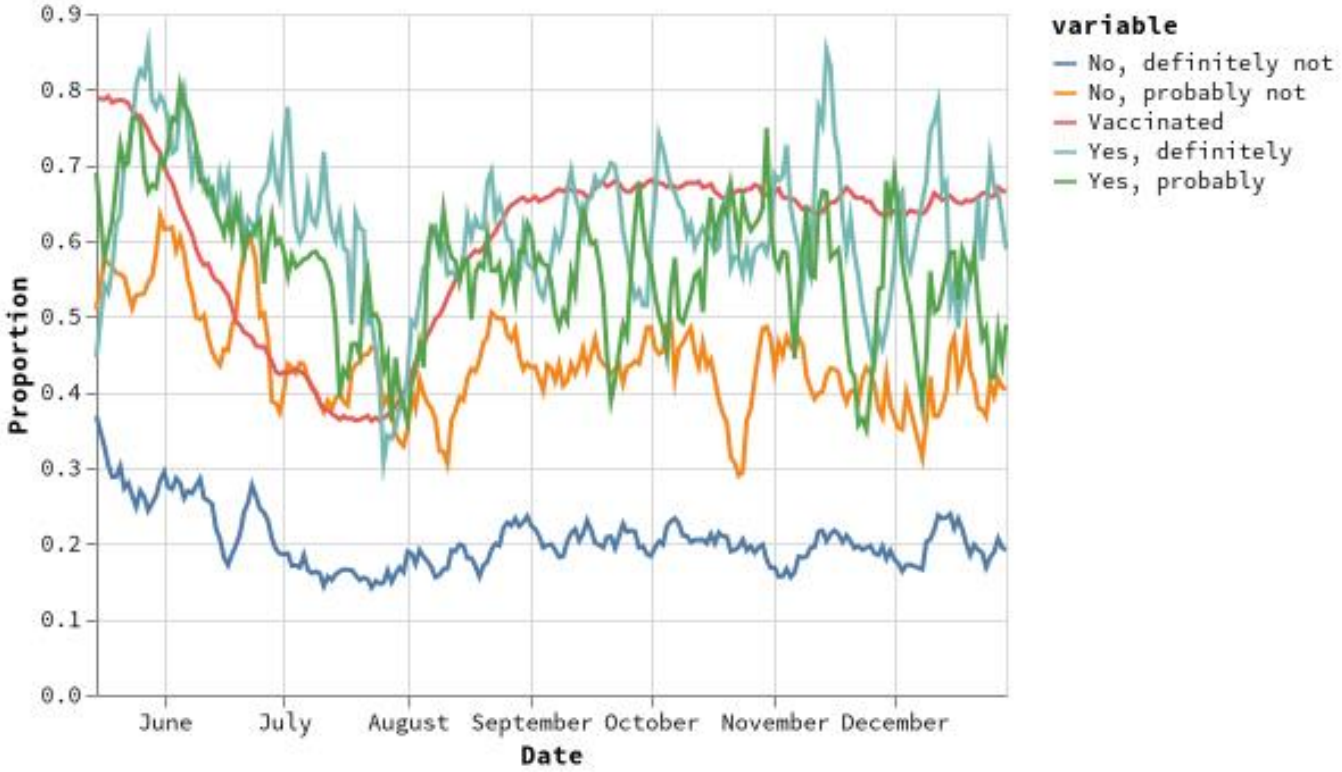


UNIVERSITY of VIRGINIA
BIOCOMPLEXITY INSTITUTE

Mask Usage Stalls

Self-reported mask usage has increased slightly to ~64% (mid 60s in previous months)

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



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

SARS-CoV2 Variants of Concern

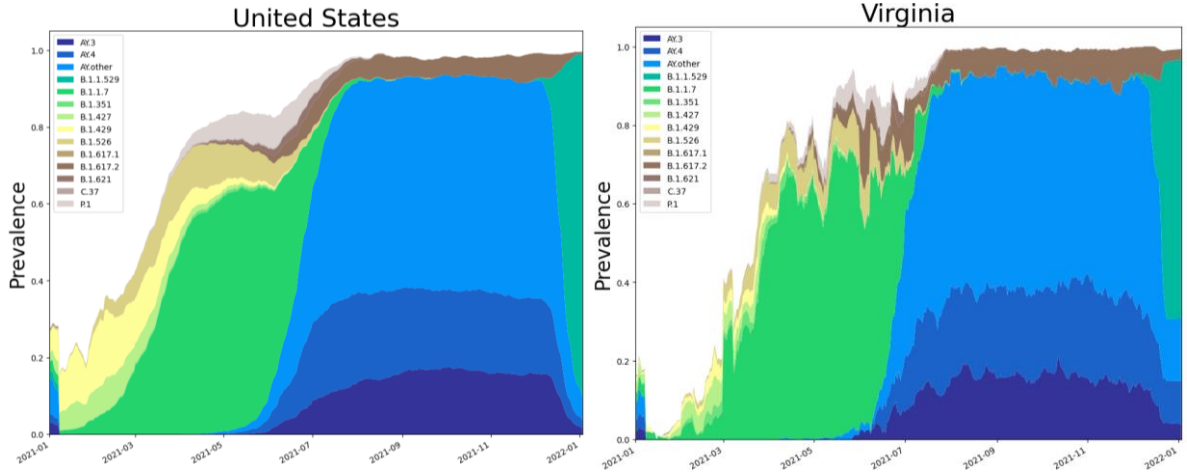
Emerging new variants will alter the future trajectories of pandemic and have implications for future control

- 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

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

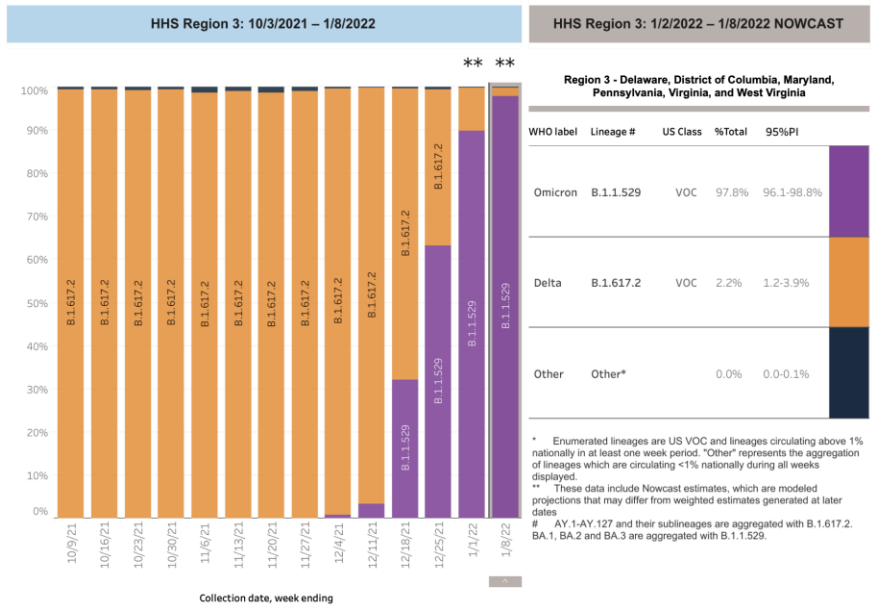
World Health Organization [WHO](#)

GISAID outbreak.info



Omicron Prevalence revised again from previous weeks

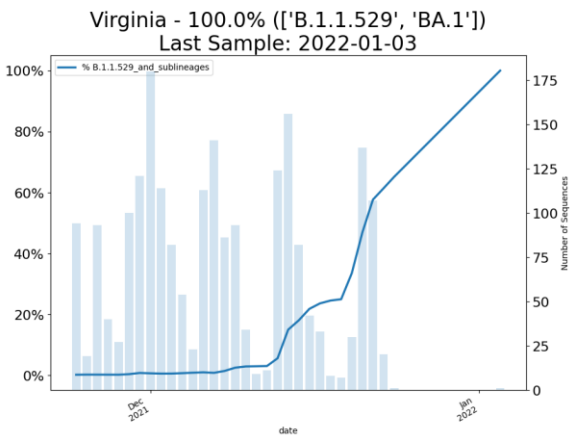
CDC nowcast calling for 97.8% in Region 3 on week ending Jan 8

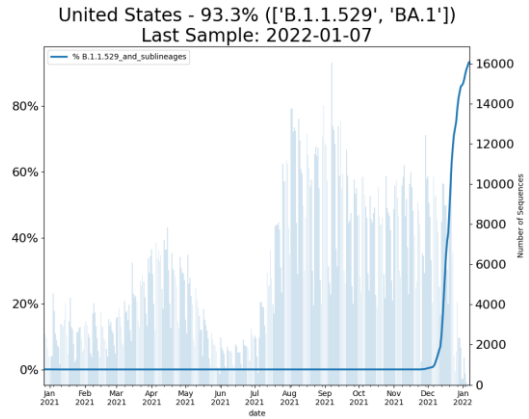


CDC [CDC Variant Tracking](#)

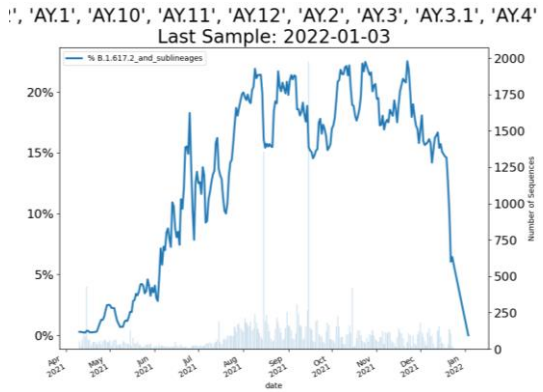
SARS-CoV2 Variants of Concern

Omicron ο - Lineage B.1.1.529



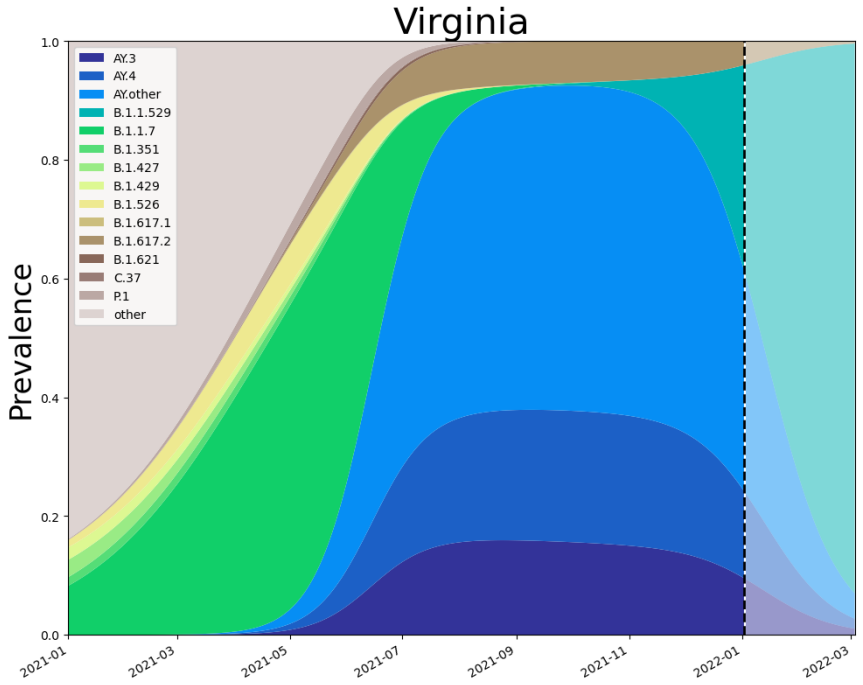


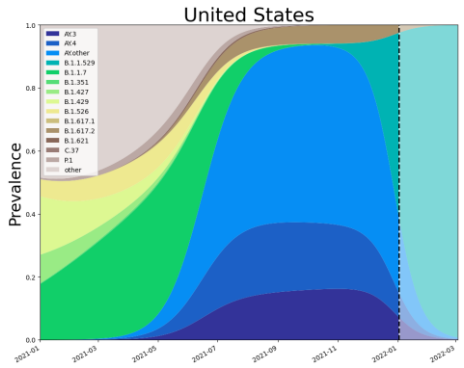
Delta δ - Lineage B.1.617.2



GISAID outbreak.info

VoC Polynomial Fit Projections

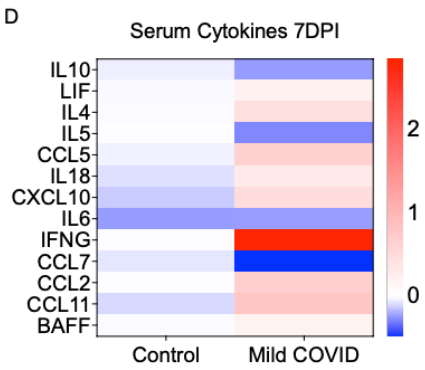


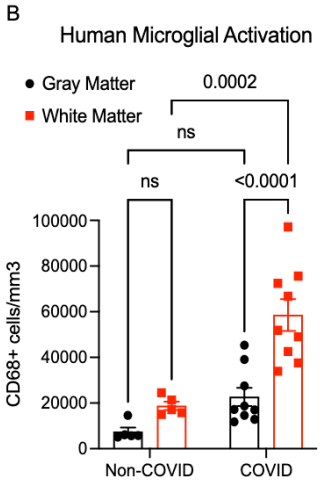


Sequelae of SARS-COV-2 01/11/22

1. Researchers at Stanford and Yale find striking similarities between neuropathophysiology after cancer therapy and after SARS-CoV-2 infection, and elucidate cellular deficits that may contribute to lasting neurological symptoms following even mild SARS-CoV-2 infection.
2.Study shows a 50-80% reduction in 7/10 most commonly reported symptoms 4-11 months following SARS-COV2 infection in vaccinated adults.
3. CDC study finds increased risk of diabetes in children post infection.

1





Humans experiencing long-COVID with cognitive symptoms (48 subjects) similarly demonstrate elevated CCL11 levels compared to those with long-COVID who lack cognitive symptoms (15 subjects). In mice, pro-inflammatory CSF cytokines/chemokines were elevated for at least 7-weeks post-infection; among the chemokines demonstrating persistent elevation is CCL11, which is associated with impairments in neurogenesis and cognitive function.
https://www.biorxiv.org/content/10.1101/2022.01.07.475453v1

3

Database/Characteristic	No. (%) Pediatric overall	COVID-19	Non–COVID-19	ARI	Non-ARI
IQVIA					
Total no. of patients	1,698,753	80,893	404,465	404,465	808,930
Age, mean (SD), yrs	12.3 (4.3)	12.3 (4.3)	12.3 (4.3)	12.3 (4.3)	12.3 (4.3)
Age group, yrs					
0–4	124,530 (7.3)	5,930 (7.3)	29,650 (7.3)	29,650 (7.3)	59,300 (7.3)
5–11	483,273 (28.4)	23,013 (28.4)	115,065 (28.4)	115,065 (28.4)	230,130 (28.4)
12–15	592,830 (34.9)	28,230 (34.9)	141,150 (34.9)	141,150 (34.9)	282,300 (34.9)
16–17	498,120 (29.3)	23,720 (29.3)	118,600 (29.3)	118,600 (29.3)	237,200 (29.3)
Female sex	850,857 (50.1)	40,517 (50.1)	202,585 (50.1)	202,585 (50.1)	405,170 (50.1)
Hospitalized at index encounter	6,473 (0.4)	566 (0.7)	614 (0.2)	1,602 (0.4)	3,691 (0.5)
New diabetes diagnosis†					
Overall	**937 (0.06)**	**68 (0.08)**	**132 (0.03)**	**227 (0.06)**	**510 (0.06)**

Persons aged <18 years with COVID-19 were more likely to receive a new diabetes diagnosis >30 days after infection than were those without COVID-19 and those with prepandemic acute respiratory infections. Non–SARS-CoV-2 respiratory infection was not associated with an increased risk for diabetes.
https://www.cdc.gov/mmwr/volumes/71/wr/mm7102e2.htm

2

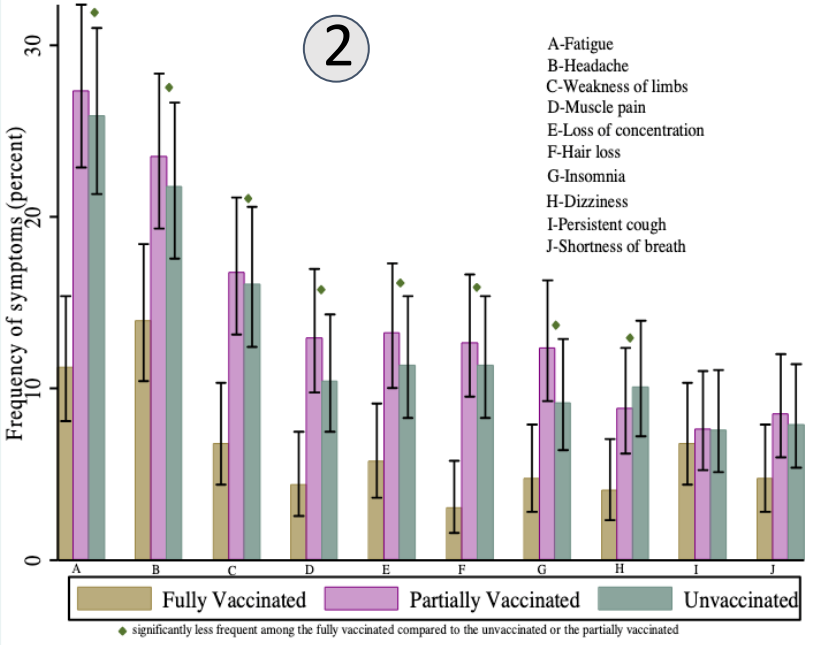


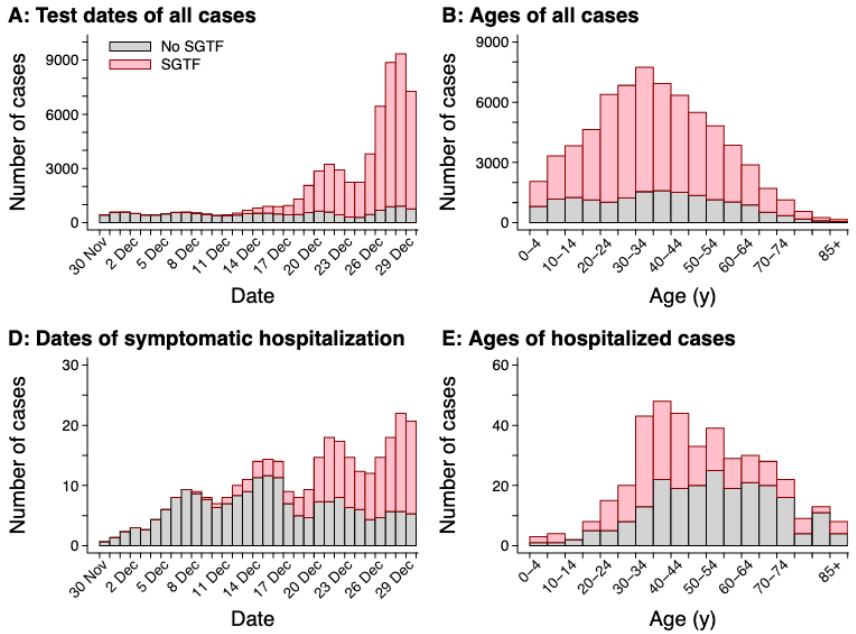
Figure 1B. Frequency of most commonly reported post-acute symptoms according to vaccination status

Researchers in Israel surveyed 951 individuals to determine presentation of long covid symptoms based on vaccination status. At the time of the survey, Israel policy specified that SARS-CoV-2-infected individuals were eligible for a single dose of vaccine. Giving rise to a high fraction of individuals who were partially vaccinated having been infected pre-vaccination.
https://www.medrxiv.org/content/10.1101/2022.01.05.22268800v1.article-info

Omicron 01/11/22

1. Large Kaiser Permanente study shows reduced severe outcomes of Omicron infections relative to Delta.
2. In both the US and UK record numbers of children are being admitted to the hospital with Covid.

2



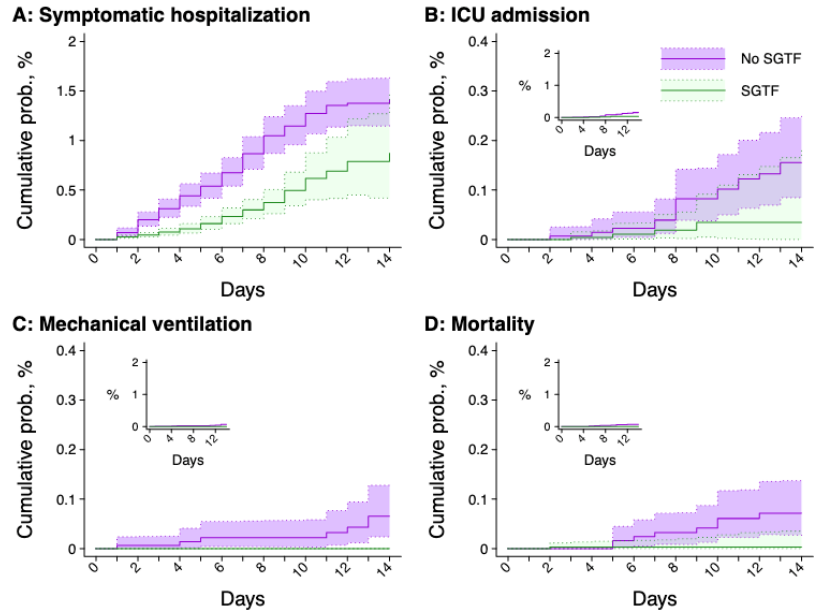
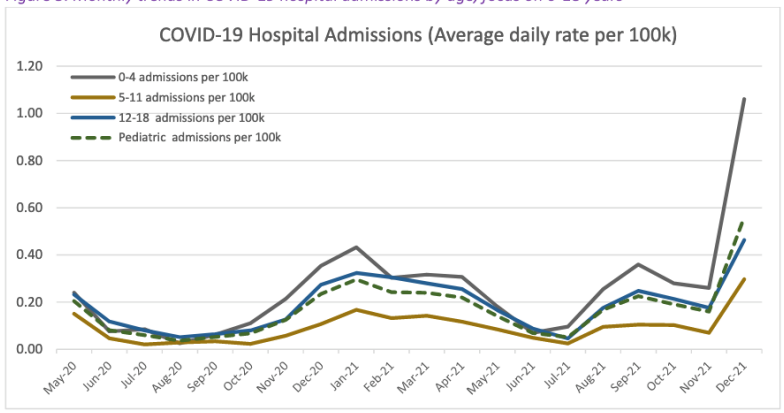


Table 2. COVID-19 new hospital admission rates by age, December 5, 2021 – January 1, 2022

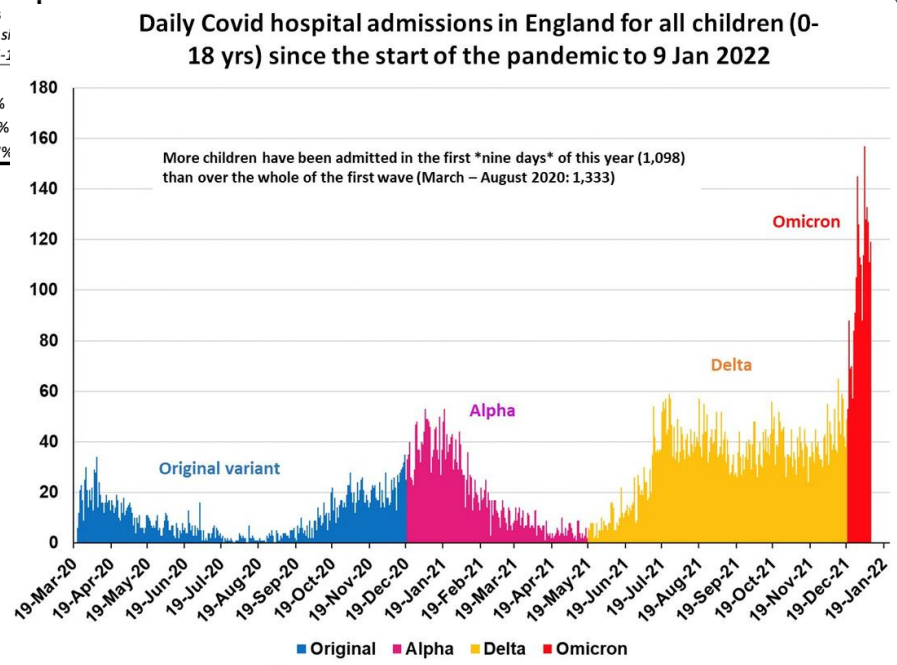
	0-4 years		5-11 years		12-18 years		19-64 years		65+ years	
	Rate	*Change since Dec. 5-11*	*Rate*	*Change since Dec. 5-11*	*Rate*	*Change since Dec. 5-11*	*Rate*	*Change since Dec. 5-11*	*Rate*	*Change si Dec. 5-1*
December 5 - 11	0.44	--	0.18	--	0.13	--	1.87	--	7.62	--
December 12 - 18	0.56	+29%	0.19	+5%	0.34	+153%	2.17	+16%	7.94	+4%
December 19 - 25 (excl. 25th)	1.43	+226%	0.42	+130%	0.60	+353%	2.78	+48%	8.70	+14%
December 26 – January 1	3.91	+791%	0.79	+335%	1.52	+1,047%	6.39	+241%	21.87	+187%

** Rates are 7-day average admissions per 100,000*

Figure 3. Monthly trends in COVID-19 hospital admissions by age, focus on 0-18 years



https://health.ny.gov/press/releases/2022/docs/pediatric_covid-19_hospitalization_report.pdf



Data from https://coronavirus.data.gov.uk/

https://twitter.com/chrischirp/status/1481057673688846336

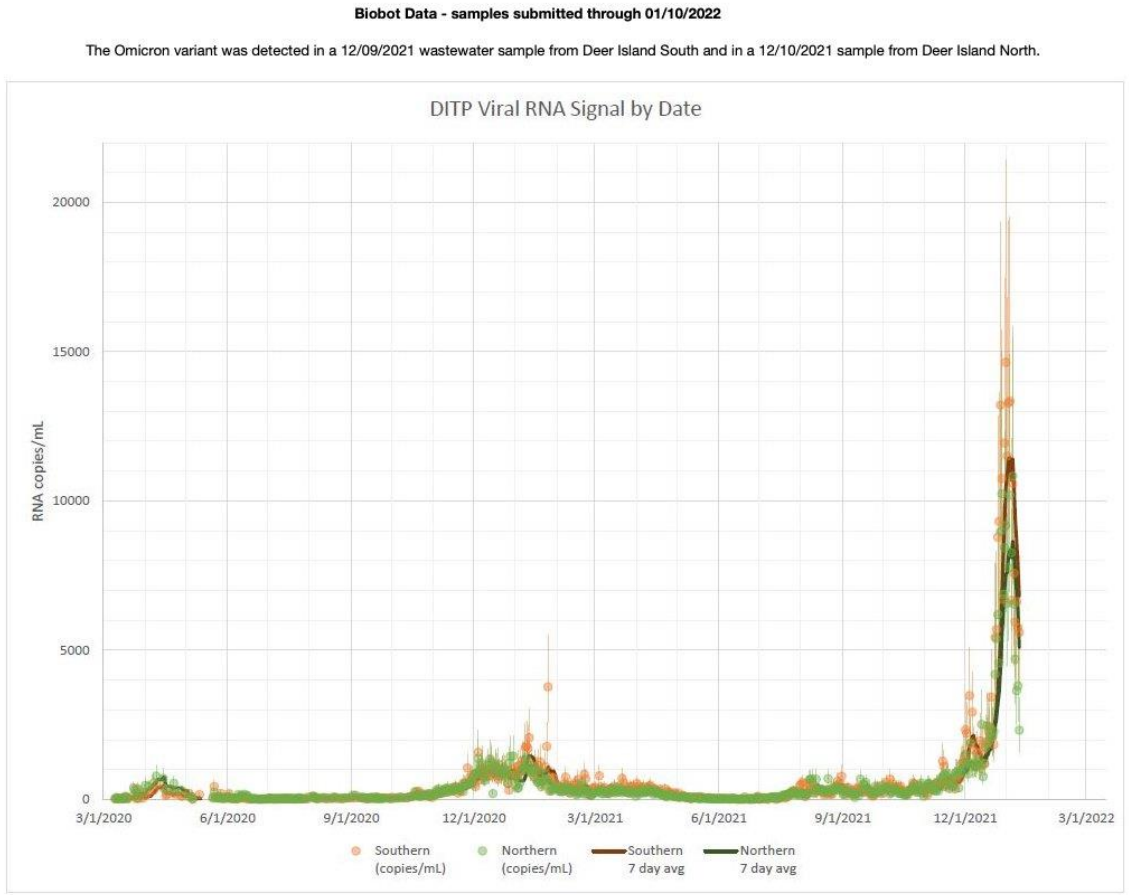
1

Berkeley school of public health investigators looked at clinical outcomes in Kaiser Permanente patients infected with Omicron (B.1.1.529) SARS-CoV-2 variant in southern California. The study among 52,297 cases with SGTF (Omicron) and 16,982 cases with non-SGTF saw a 53% reduction in risk of symptomatic hospital admission due to Omicron and greater reductions in ICU, ventilation, and death as compared to Delta. Among those first ascertained while asymptomatic we also see a 31% reduction in symptoms with Omicron; and relative to Delta 70% shorter length of hospital stay among patients admitted for Omicron infections

https://www.medrxiv.org/content/10.1101/2022.01.11.22269045v1

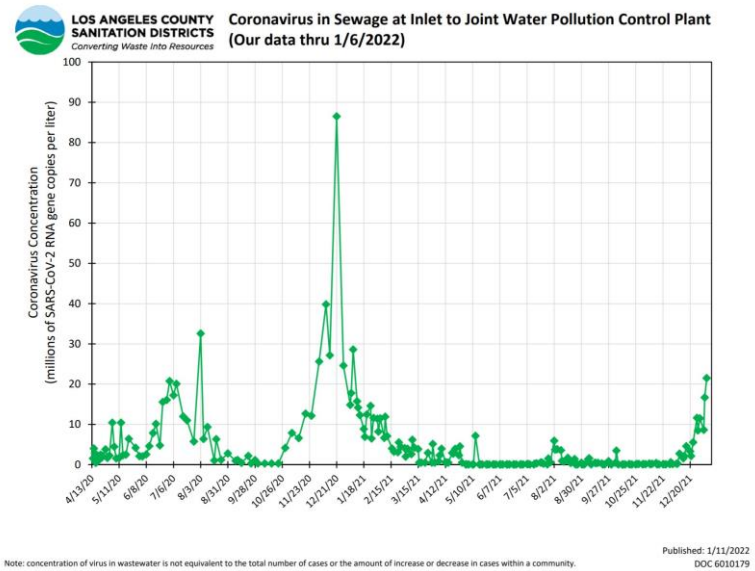
Wastewater as Leading Indicator

Boston Wastewater Surveillance

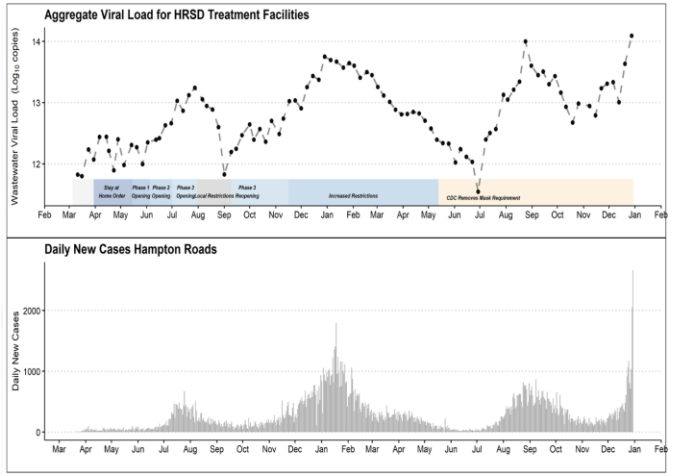


https://www.mwra.com/biobot/biobotdata.htm

Los Angeles Wastewater Surveillance



Hampton Roads Virginia Wastewater Surveillance



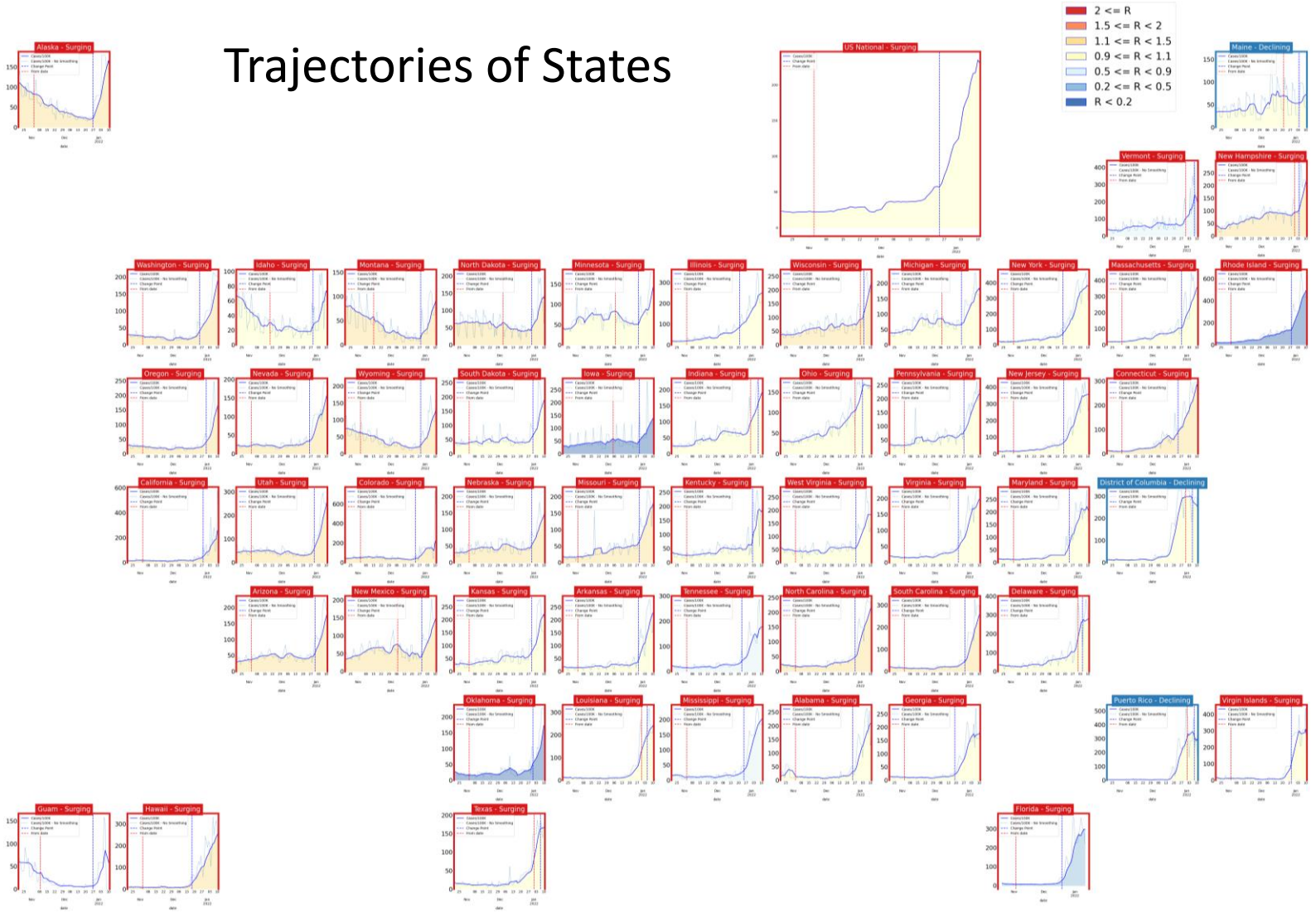
Hopeful trend from Boston, but Omicron arrived in Boston a little earlier than Los Angeles (data from LA is also delayed).

United States Overall

- Most of nation is in Surge
- Growth has spread from Northeast into Midwest and South

Status	# States
Declining	3 (3)
Plateau	0 (3)
Slow Growth	0 (6)
In Surge	51 (42)

Trajectories of States



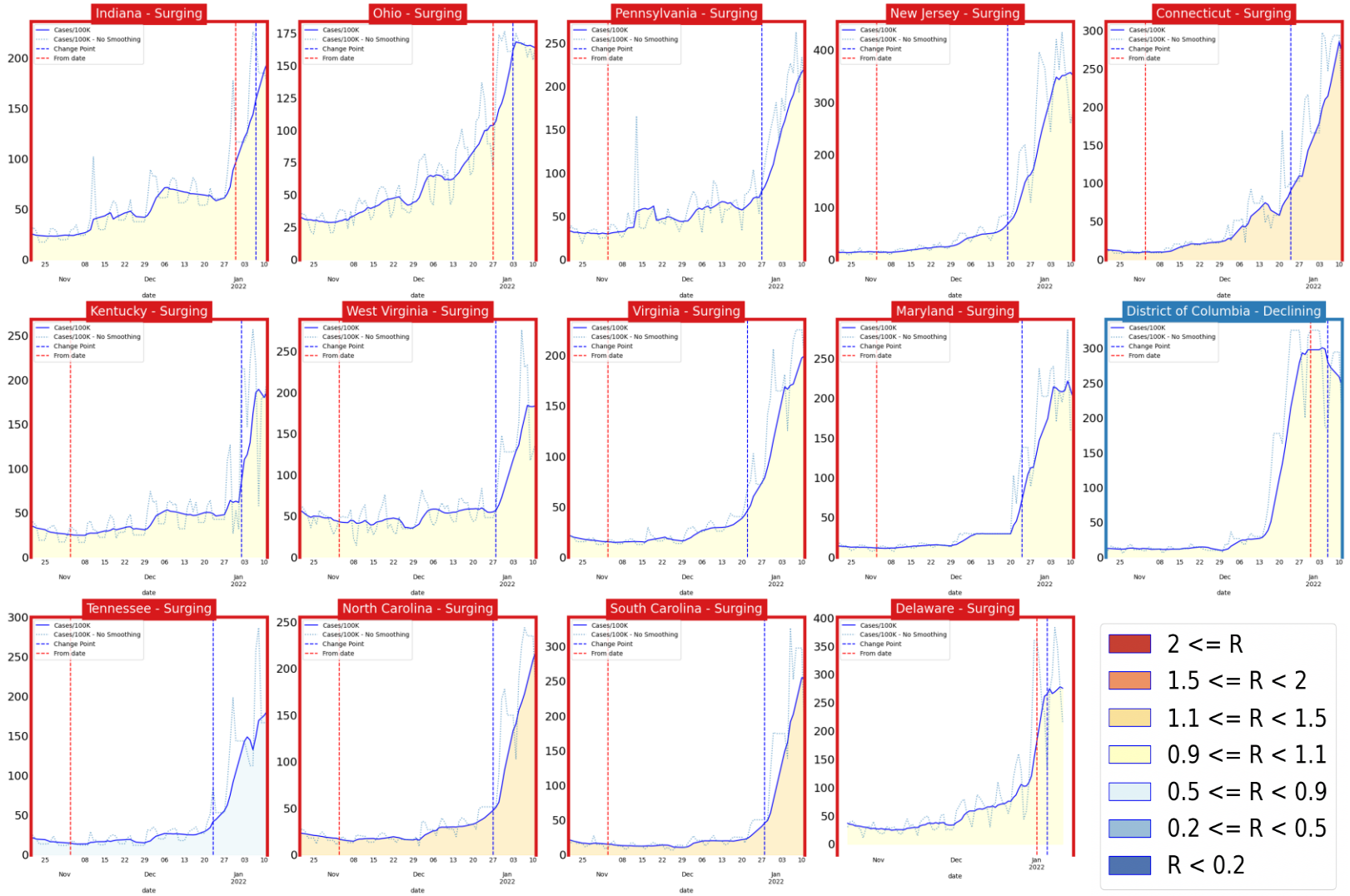
UNIVERSITY of VIRGINIA

BIOCOMPLEXITY INSTITUTE

Virginia and Her Neighbors

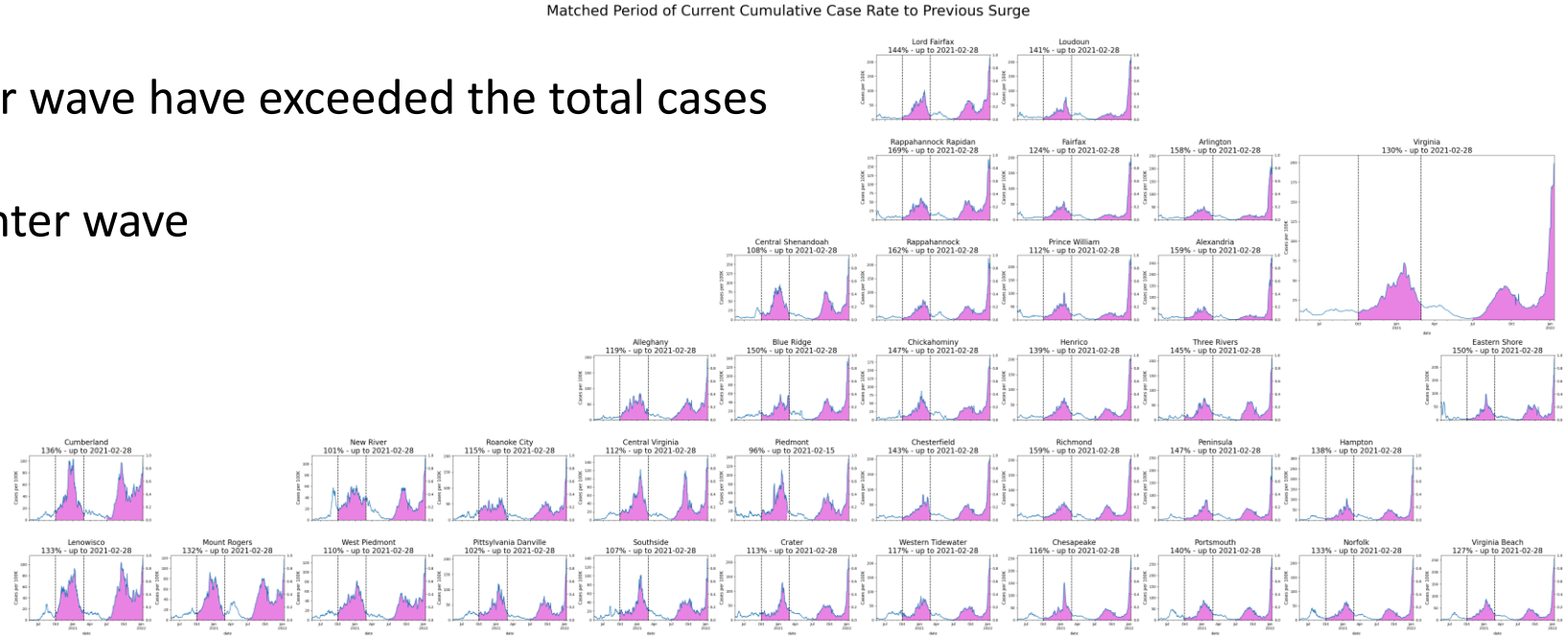
- All of Virginia and neighbors experiencing rapid growth of case rates

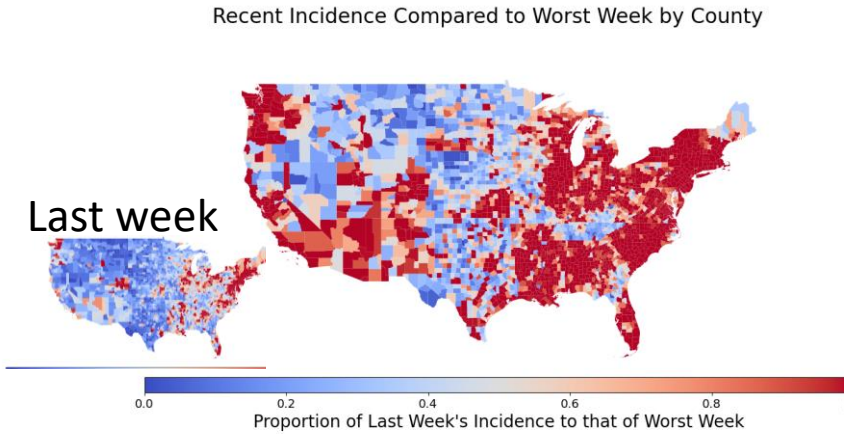
- All experiencing more than 100/100K daily incident case rates
- DC has had several days of decline but has been at VERY high levels
- Some signs of slowing across the board

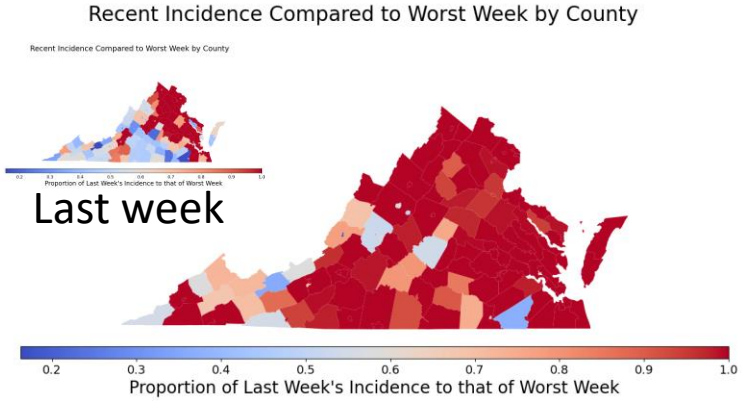


Virginia and Her Neighbors

- Current Delta and Fall-Winter wave have exceeded the total cases from last Fall-Winter wave
- Now at 130% of previous winter wave







- 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

Key Takeaways

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

- **Case rates have accelerated to unprecedented levels throughout the commonwealth**
- VA 7-day mean daily case rate up to 155/100K from 79/100K; US is up to 144/100K (from 80/100K)
- Projections show a continued sharp rise in case-rates for several weeks:
  - Omicron is able to infect and transmit more between those with immunity from previous infections and vaccinations; hospitalizations will also rise despite reduced severity as case-rates out pace this reduction
  - Case ascertainment will drop as fewer infections cause severe disease, testing capacities are met, and at-home testing rises
- Recent model updates:
  - Overhauled model structure further refined to better capture different tiers of immunity and the immune evasion of the Omicron variant

The situation continues to change. Models continue to be updated regularly.

Additional Analyses

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

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