Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

March 9th, 2022

(data current to March 6th – 9th)

Biocomplexity Institute Technical report: TR 2022-017

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biocomplexity.virginia.edu

About Us

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

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Overview

- **Goal**: Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

Key Takeaways

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

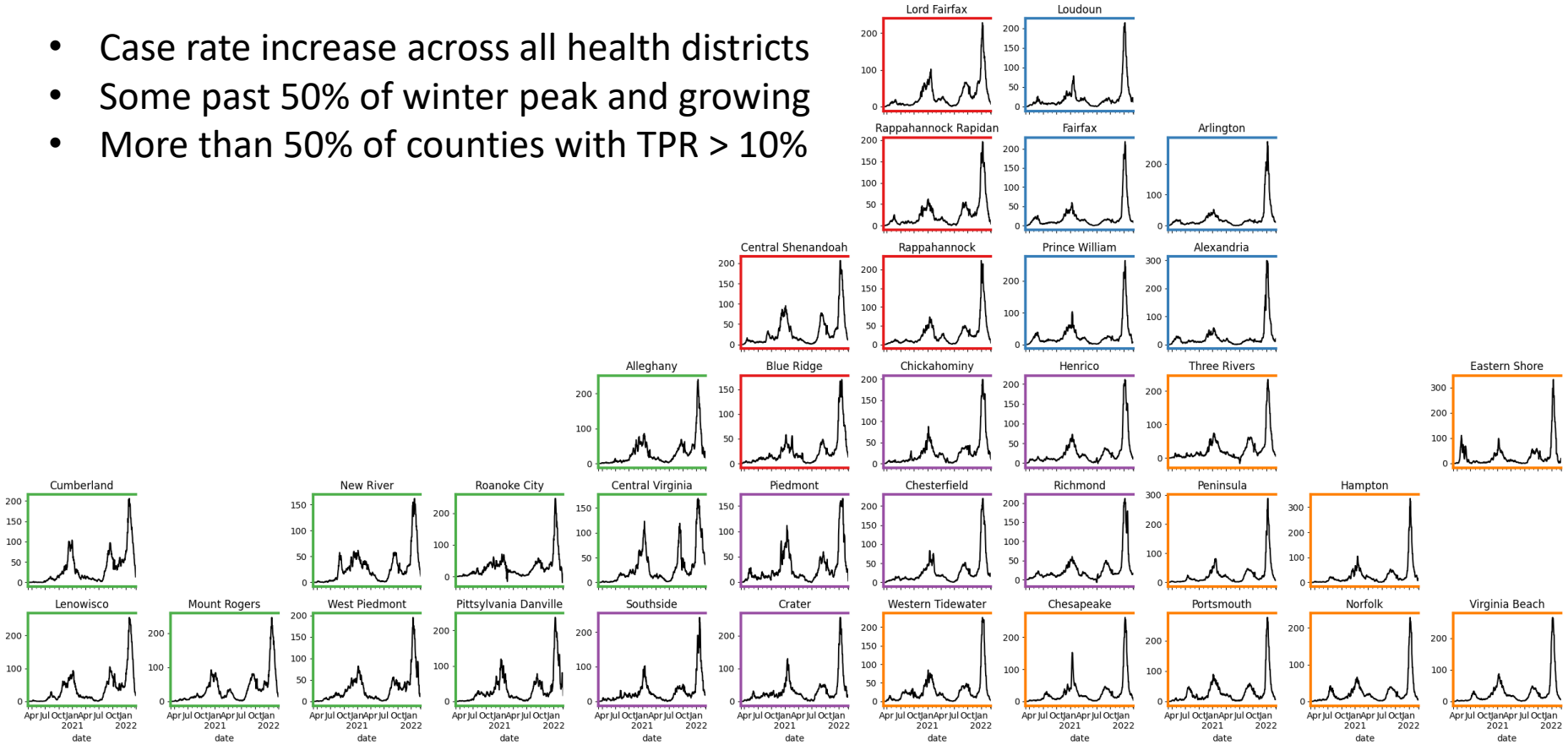
- **Case rates and hospitalizations continue to dramatic decline**
- VA 7-day mean daily case rate is sharply down to 14/100K from 19/100K
  - US is also considerably down to 13/100K (from 22/100K)
- BA.2 subvariant growth is slowed by the drastic declines, likely to take longer to reach predominance than initial trends suggested

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

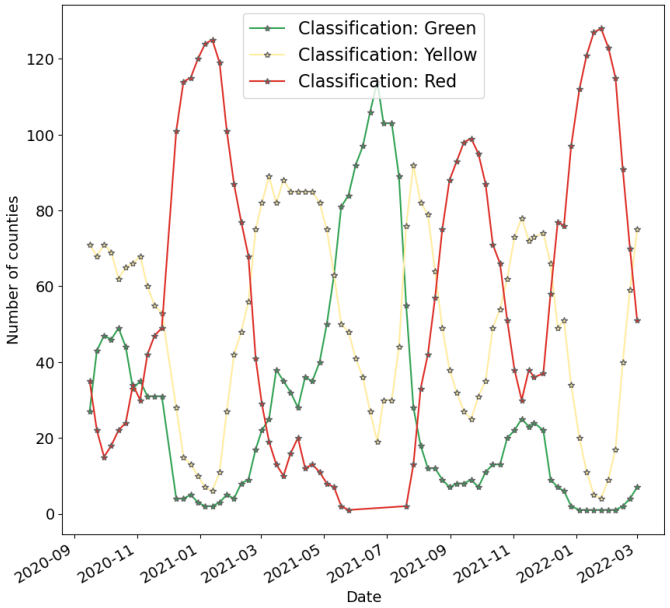
Situation Assessment

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)

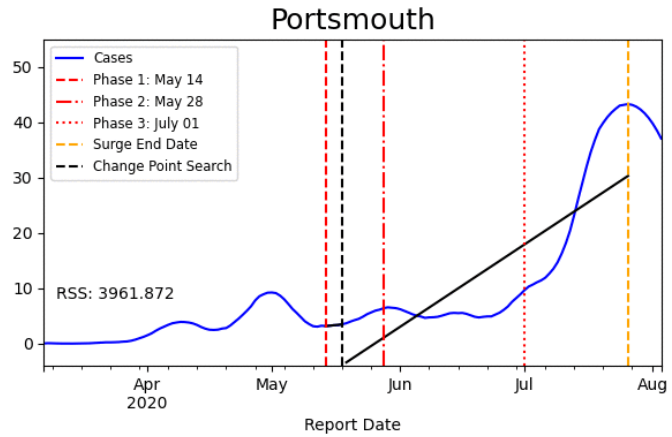
Red: >10.0% (and not "Green" or "Yellow")

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

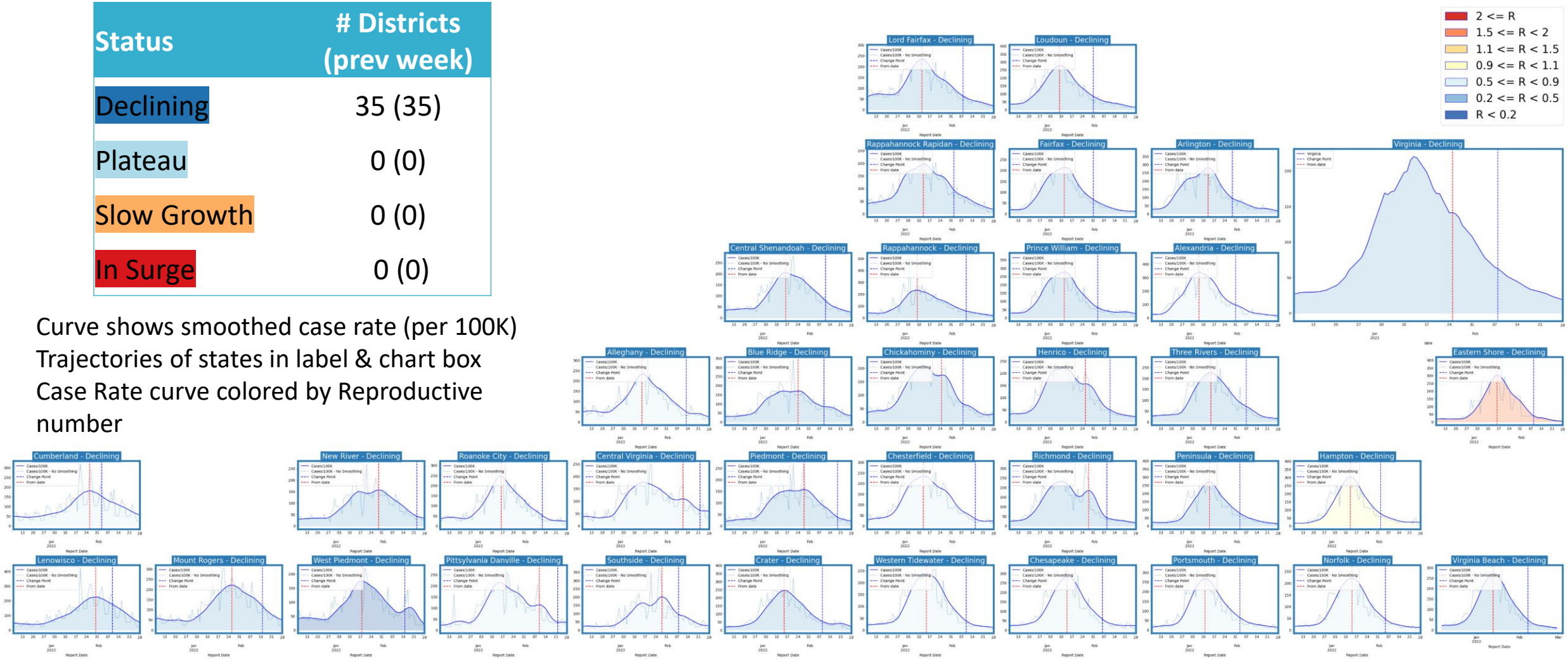


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	35 (35)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	0 (0)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	0 (0)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	0 (0)

District Trajectories – last 10 weeks

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

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



CDC's new COVID-19 Community Levels

What Prevention Steps Should You Take Based on Your COVID-19 Community Level?

Low	Medium	High
• Stay up to date with COVID-19 vaccines • Get tested if you have symptoms	• If you are at high risk for severe illness, talk to your healthcare provider about whether you need to wear a mask and take other precautions • Stay up to date with COVID-19 vaccines • Get tested if you have symptoms	• Wear a mask indoors in public • Stay up to date with COVID-19 vaccines • Get tested if you have symptoms • Additional precautions may be needed for people at high risk for severe illness

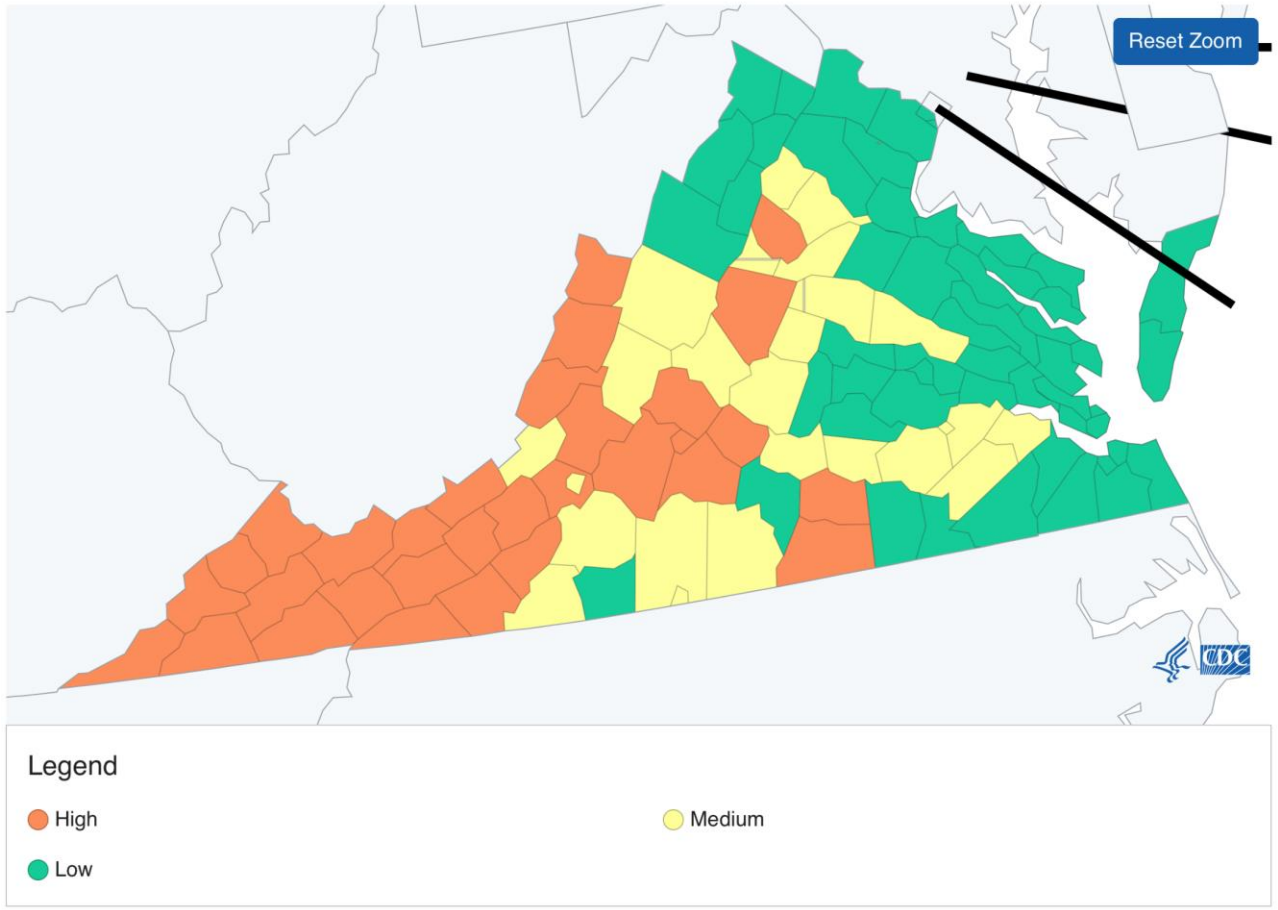
People may choose to mask at any time. People with symptoms, a positive test, or exposure to someone with COVID-19 should wear a mask.

COVID-19 Community Levels – Use the Highest Level that Applies to Your Community

New COVID-19 Cases Per 100,000 people in the past 7 days	Indicators	Low	Medium	High
Fewer than 200	New COVID-19 admissions per 100,000 population (7-day total)	<10.0	10.0-19.9	≥20.0
	Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)	<10.0%	10.0-14.9%	≥15.0%
200 or more	New COVID-19 admissions per 100,000 population (7-day total)	NA	<10.0	≥10.0
	Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)	NA	<10.0%	≥10.0%

The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

Data provided by CDC
Updated: March 3, 2022



[CDC Data Tracker Portal]

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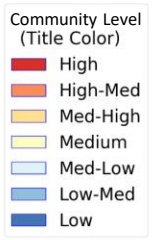
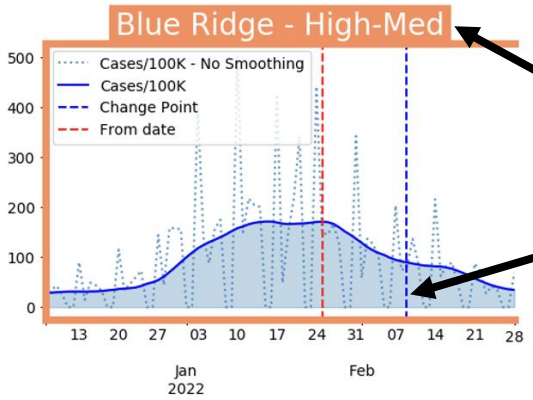
District Trajectories with Community Levels



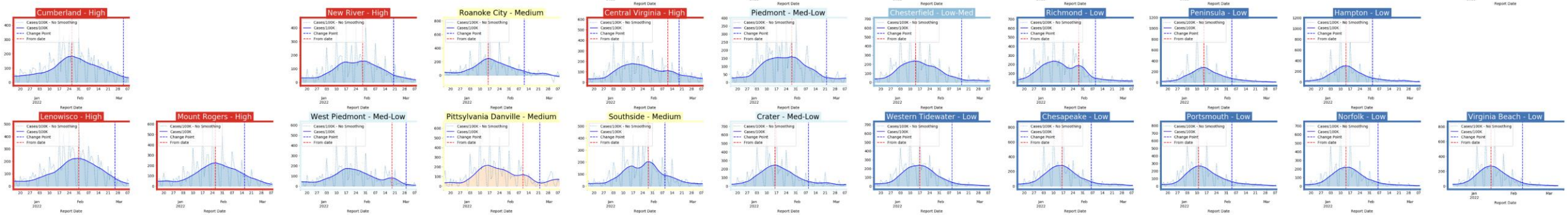
Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory



District's Aggregate Community Level

Aggregate level a simple mean of all levels for counties in district

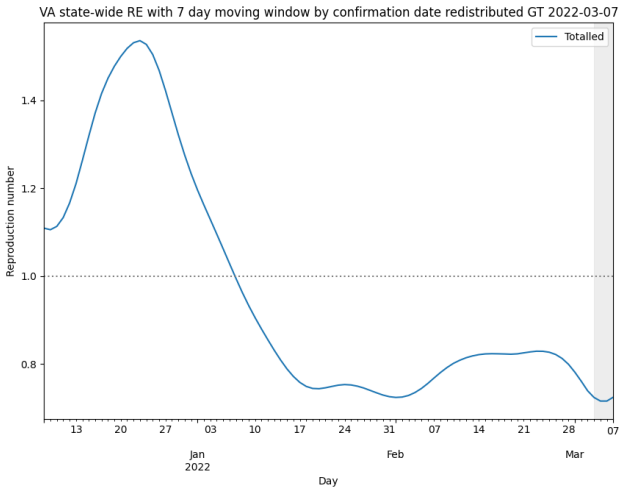
Case rate Trajectory

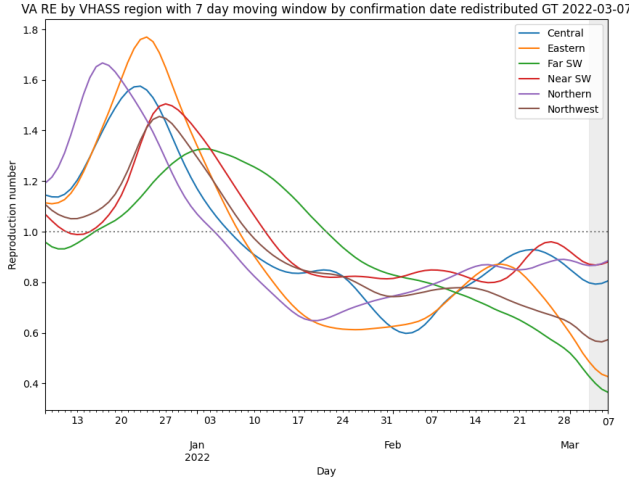


Estimating Daily Reproductive Number – Redistributed gap

March 8th Estimates

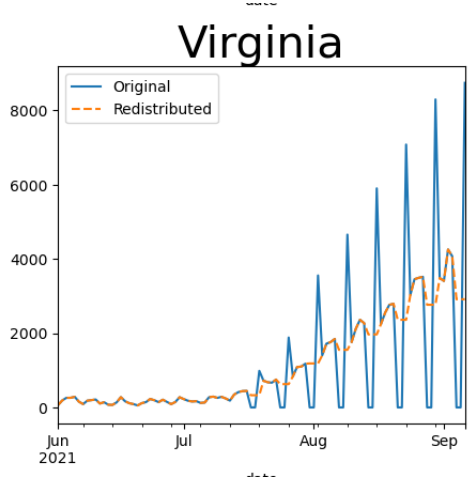
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	0.740	0.095
Central	0.881	0.045
Eastern	0.446	-0.306
Far SW	0.450	-0.047
Near SW	0.772	0.005
Northern	0.921	0.283
Northwest	0.649	0.091





Skipping Weekend Reports & holidays biases estimates

Redistributed "big" report day to fill in gaps, and then estimate R from "smoothed" time series



Methodology

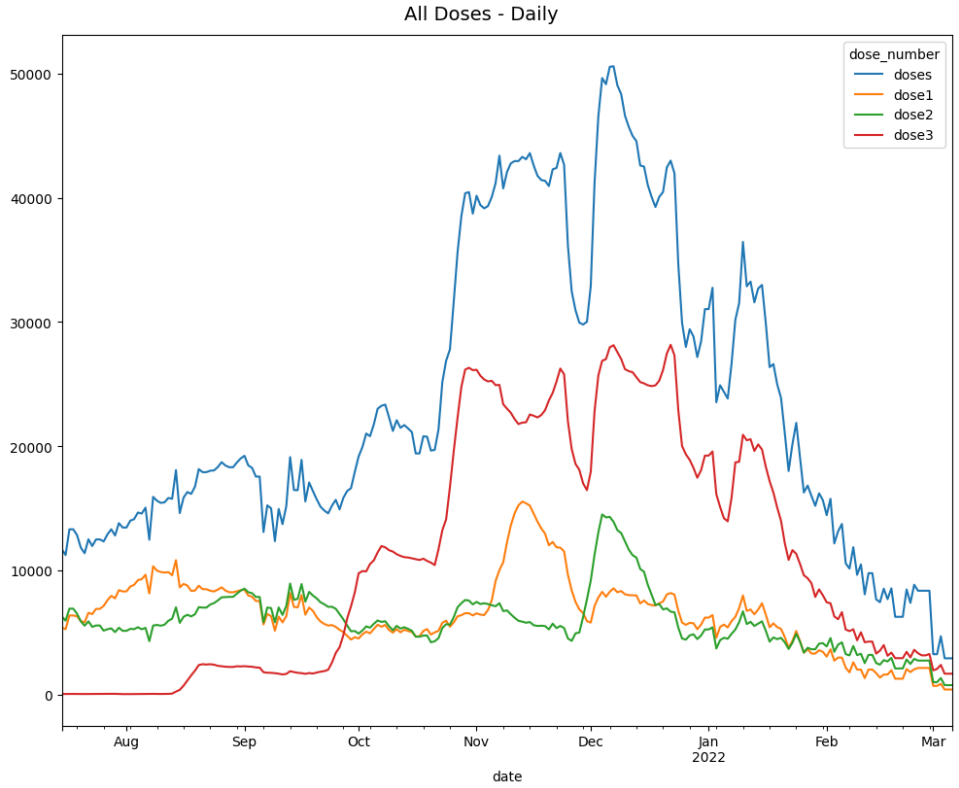
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: Discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

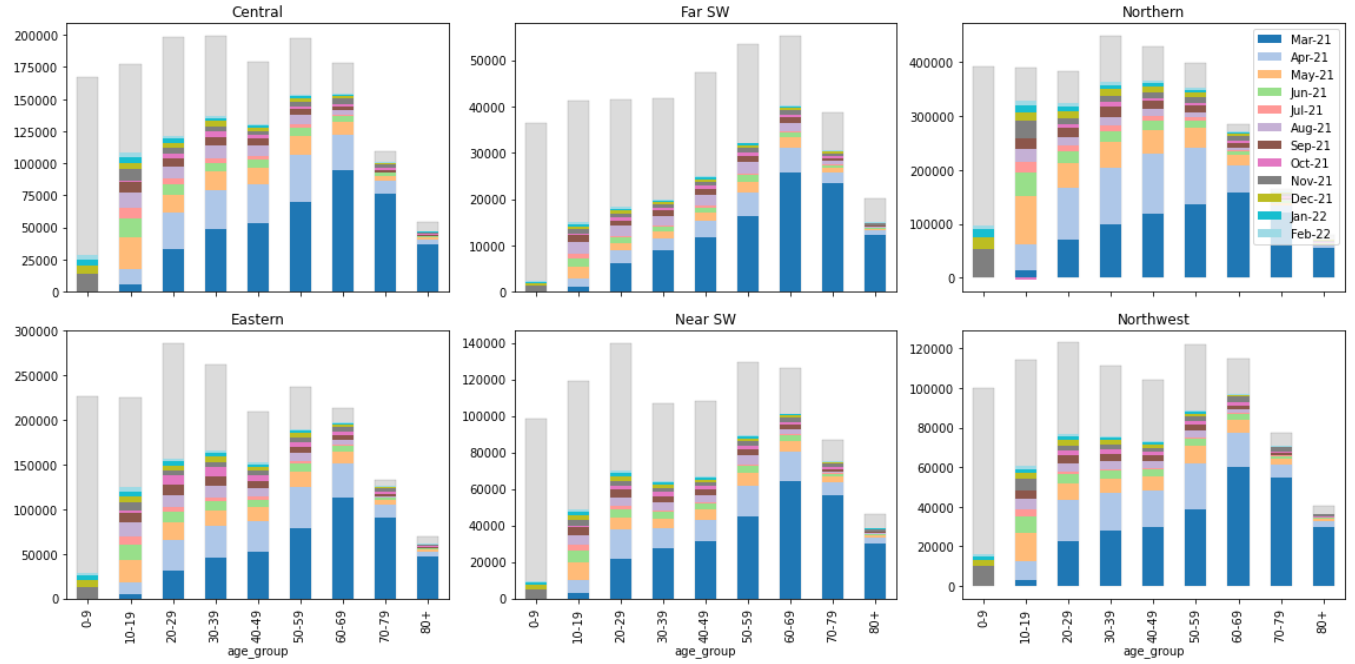
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Vaccination Administration in Virginia

Vaccine Doses administered:

- Doses administered rates approach levels first experienced when vaccines were first available
- Considerable reduction in vaccination rate experienced since mid-January
- Third dose administration outpaces 1st dose

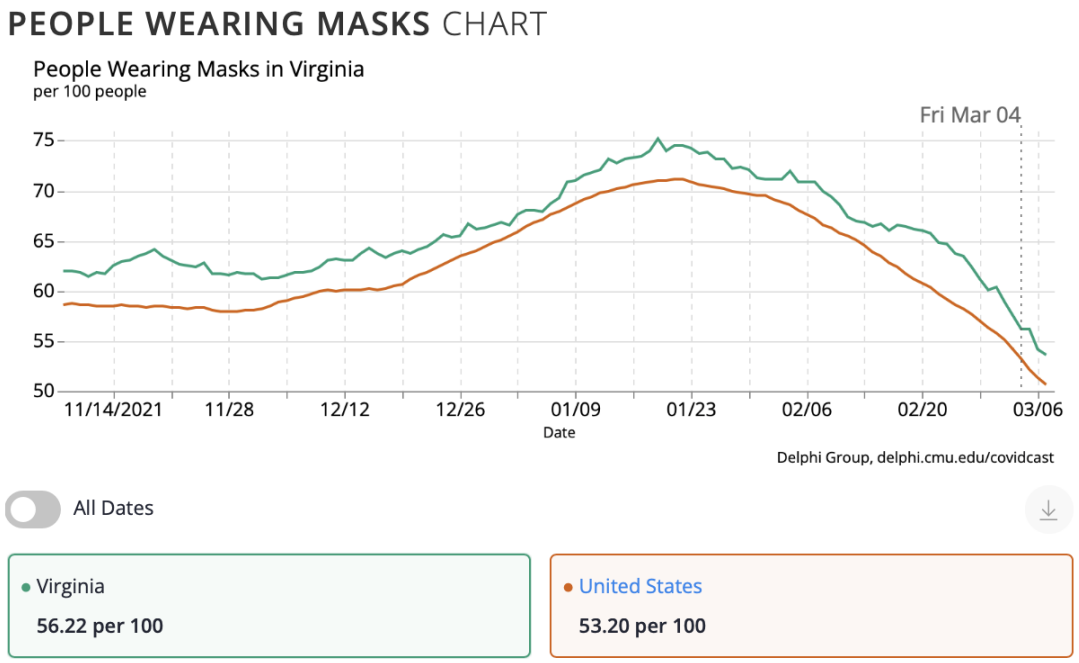


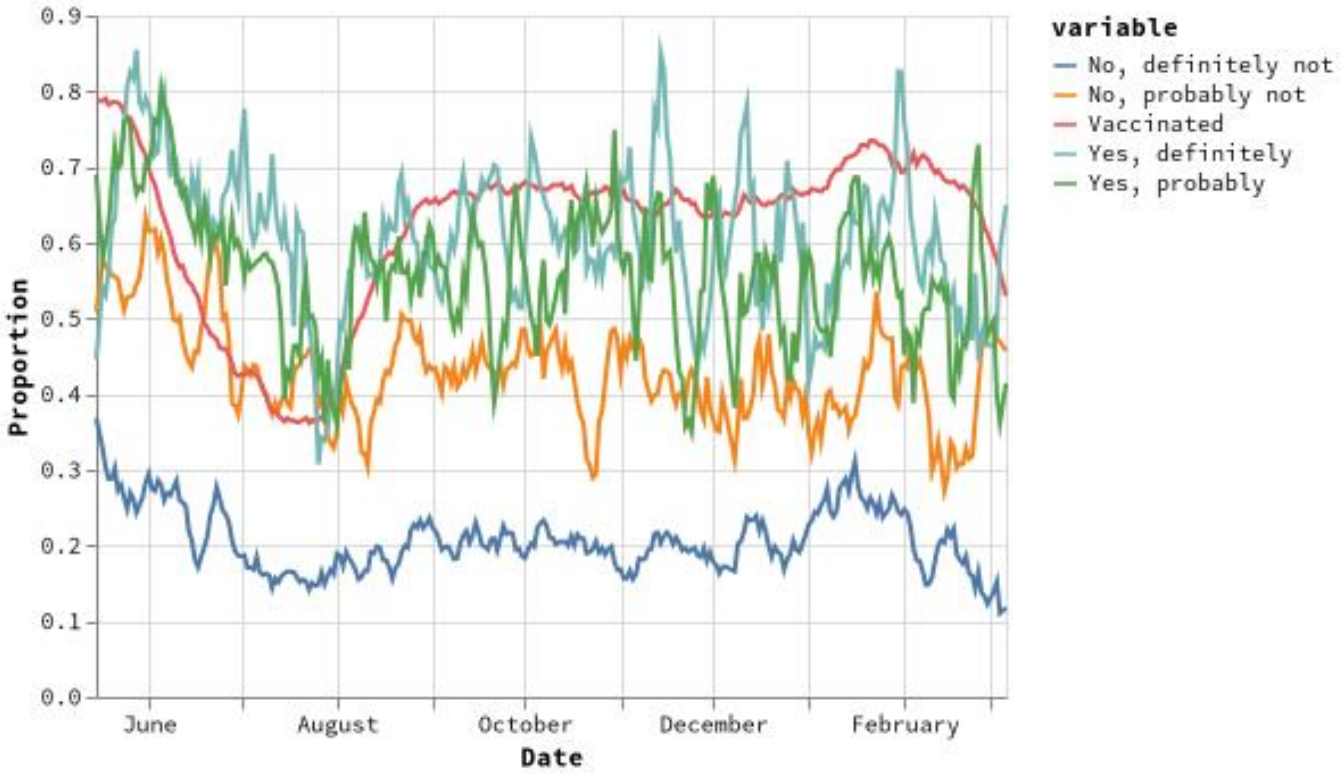


Mask Usage

Self-reported mask usage continues to fall

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



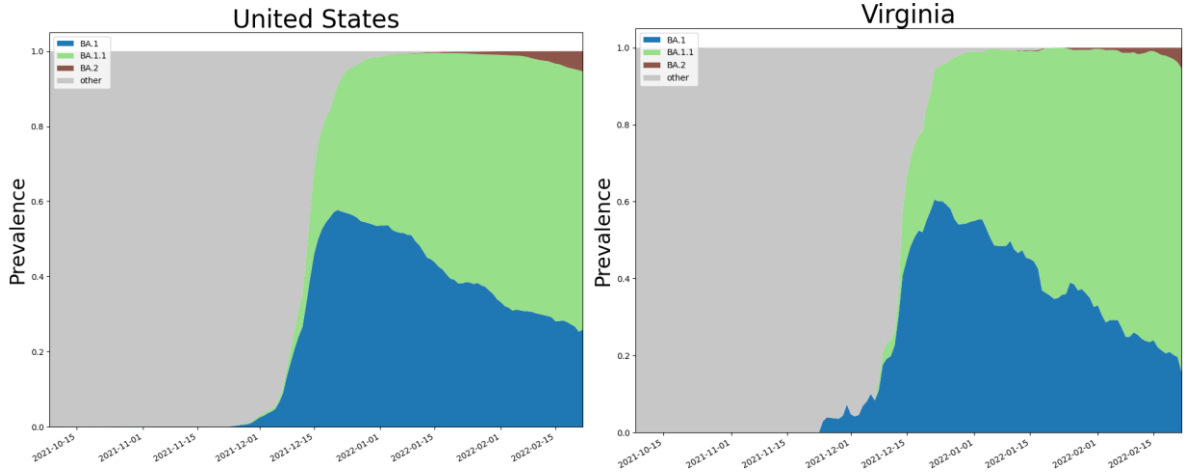


Data Source: https://covidcast.cmu.edu

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



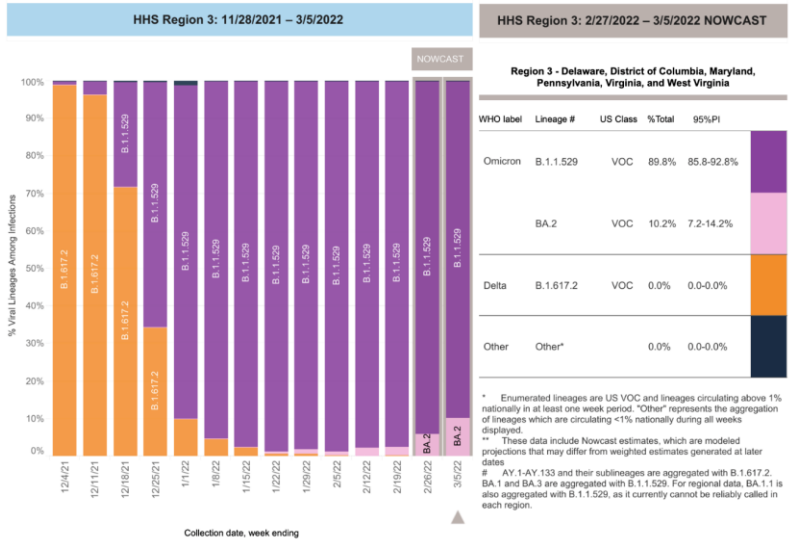
WHO label	Pango lineage*	GISAID clade	Nextstrain clade	Additional amino acid changes monitored*	Earliest documented samples	Date of designation
Alpha	B.1.1.7	GRY	20I (V1)	+S:484K +S:452R	United Kingdom, Sep-2020	18-Dec-2020
Beta	B.1.351	GH/501Y.V2	20H (V2)	+S:L18F	South Africa, May-2020	18-Dec-2020
Gamma	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](#)

Omicron Prevalence

CDC nowcast for week ending Feb 19th shows 10.2% BA2 in Region 3 (11.38% BA2 for USA)

Pace of growth faltering significantly

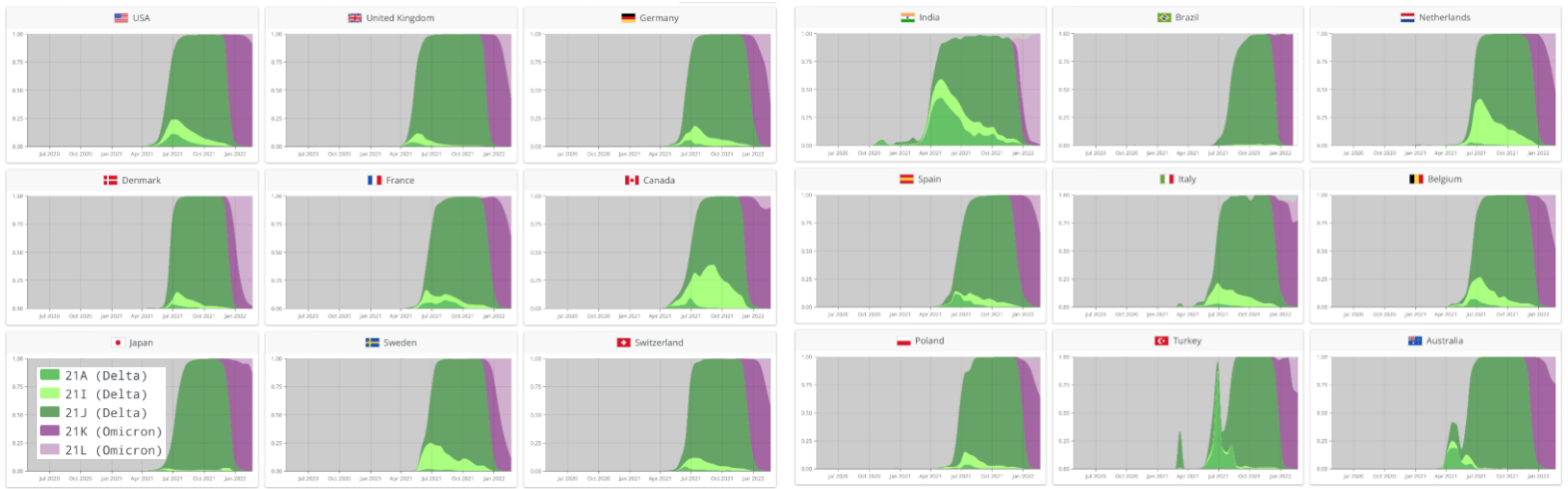


CDC [CDC Variant Tracking](#)

SARS-CoV2 BA.2 subvariant Tracking

BA.2 subvariant growing rapidly in some European countries

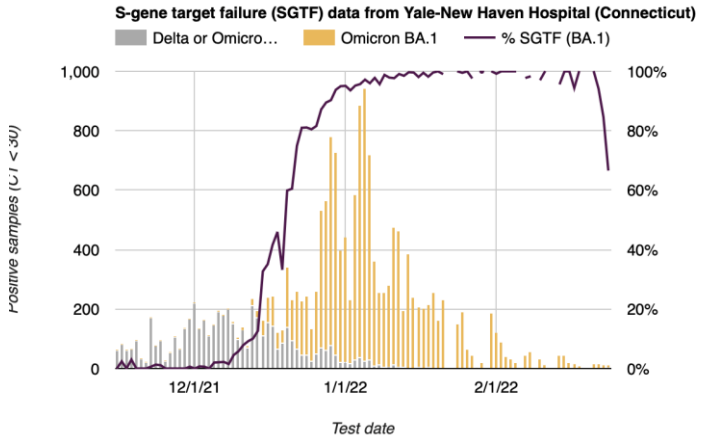
- Both Delta and the Omicron BA.2 subvariant don't have the SGTF signal with PCR tests, so the reduction caused by Omicron BA.1 SGTF can be an imperfect signal for increased BA.2
- Subvariant BA.2 in all HHS regions of USA, Region 3 (includes VA) has highest estimated prevalence
- BA.2 is now majority subvariant in most northern European countries and India and some neighbors



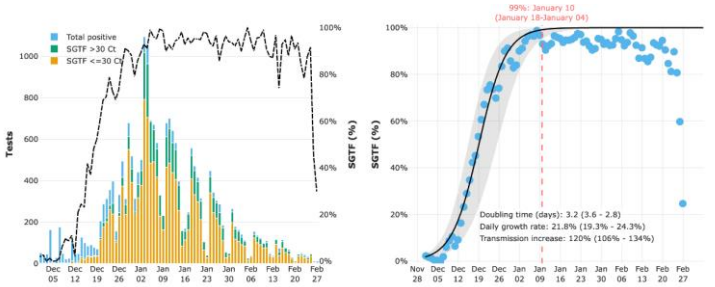
CoVariants.org

SGTF proxy in US

[Yale- New Haven]



[San Diego]



Some drops in SGTF in CT and CA

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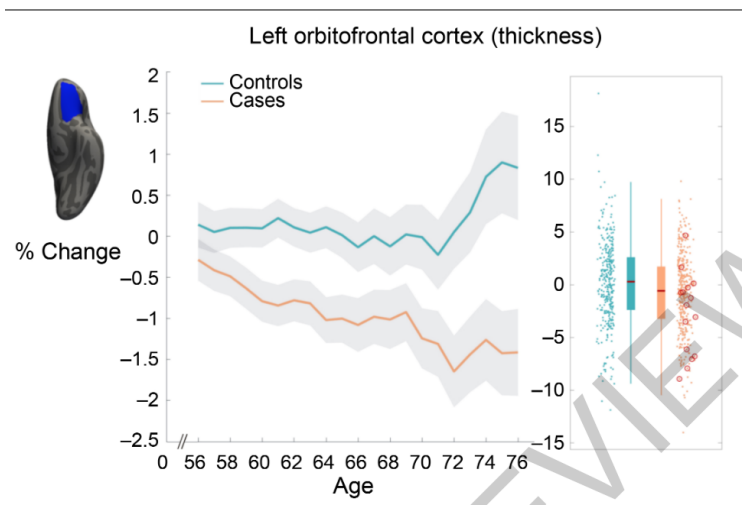
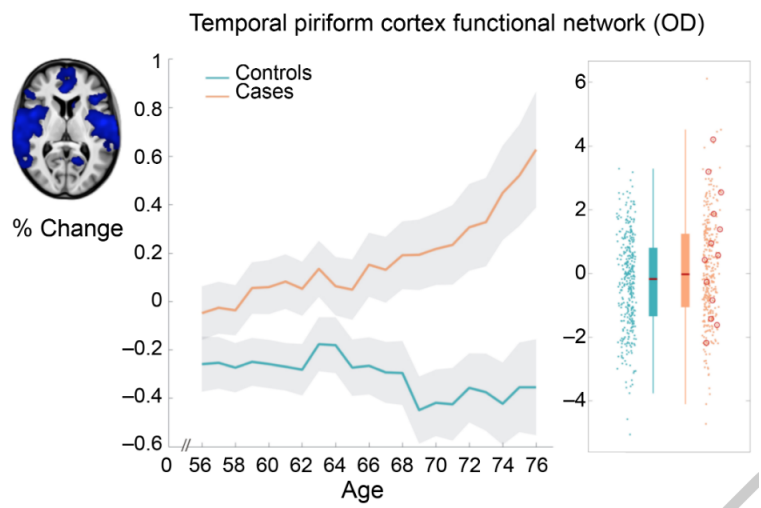
Pandemic Pubs

1

1. SARS-CoV-2 is associated with changes in brain structure.
2. Despite comparable levels of infection, New Zealand and Hong Kong show very different levels of death per million people. Thought largely due to vaccine uptake among the elderly.





UK Biobank brain imaging study of 785 participants aged 51-81 scanned twice. Study includes 401 cases infected between the two scans. Infected group had an average of 141 days between infection and second scan. Study identified significant longitudinal effects when comparing the two groups, including: **(i) greater reduction in grey matter thickness and tissue-contrast in the orbitofrontal cortex and parahippocampal gyrus, (ii) greater changes in markers of tissue damage in regions functionally-connected to the primary olfactory cortex, and (iii) greater reduction in global brain size.** The infected participants also showed on average larger cognitive decline between the two timepoints.
https://www.nature.com/articles/s41586-022-04569-5

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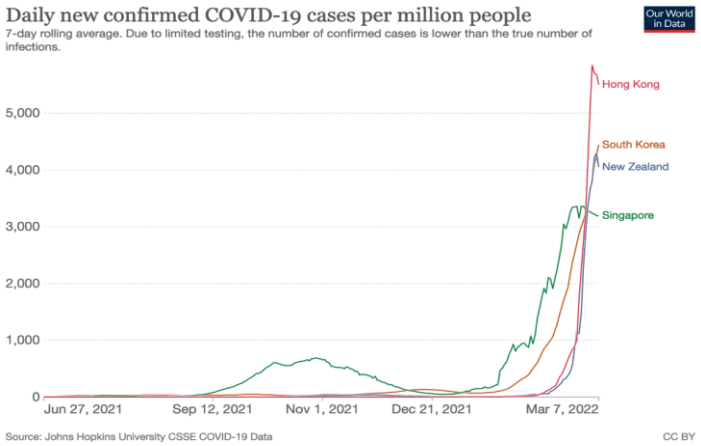
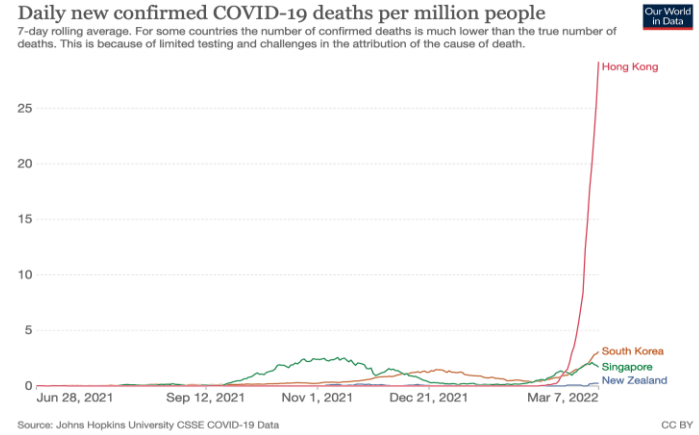
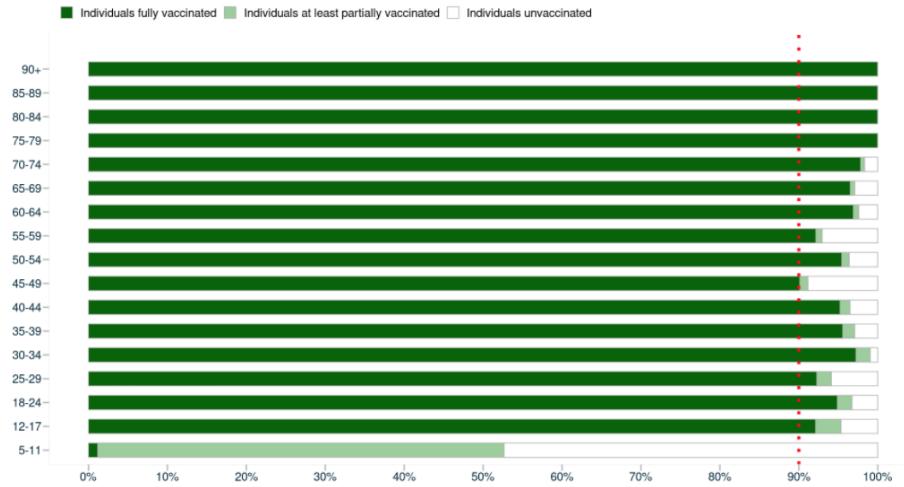
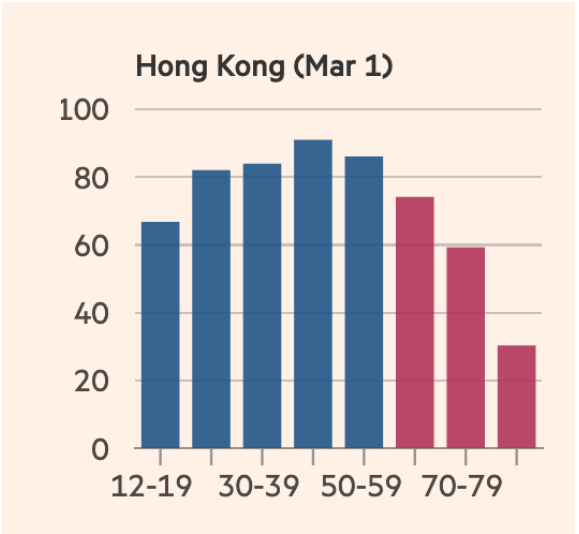




New Zealand Vaccination by age



Hong Kong Vaccination by age



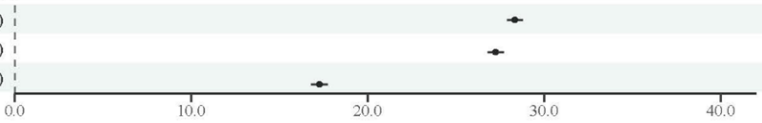
https://twitter.com/EricTopol/status/1500166810703843328

Pandemic Pubs

1. Denmark at the population-level, where the majority of test-positives (96.0%) were not hospitalized during acute infection, a considerable proportion experience post-acute symptoms and sequelae 6-12 months after infection.
2. CDC officially advises 12-39 yo males to consider a 8 week interval between 1st and 2nd dose vaccines, and broadens the recommended interval for all 12 and over.
3. During Omicron dominance the effectiveness against cases of BNT162b2 declined rapidly for children, particularly those 5-11 years. However, vaccination of children 5-11 years was protective against severe disease and is recommended.
4. Qatar study shows infection with one Omicron sub-lineage induces "strong, but not full protection" against reinfection from another.

1

Health problem	Positive (n,%)	Negative (n,%)	Risk Difference (95% CI)
Physical exhaustion	25,492 (45.5%)	5,879 (7.3%)	40.45 (39.99, 40.97)
Mental exhaustion	20,810 (37.7%)	5,877 (7.4%)	32.58 (32.11, 33.09)
Difficulties concentrating	16,720 (29.7%)	2,812 (3.4%)	28.34 (27.91, 28.78)
Memory issues	16,149 (28.7%)	3,057 (3.7%)	27.25 (26.80, 27.71)
Sleep problems	11,850 (22.9%)	4,936 (6.5%)	17.27 (16.81, 17.73)



Symptom	Positive (n,%)	Negative (n,%)	Risk Difference (95% CI)
Dysosmia	6,674 (10.9%)	604 (0.7%)	10.92 (10.68, 11.21)
Dysgeusia	5,365 (8.8%)	551 (0.6%)	8.68 (8.43, 8.93)
Fatigue/exhaustion	6,799 (11.1%)	2,868 (3.1%)	8.43 (8.14, 8.74)
Dyspnea	3,277 (5.4%)	813 (0.9%)	4.87 (4.65, 5.09)
Reduced strength legs/arms	3,381 (5.5%)	1,024 (1.1%)	4.68 (4.45, 4.89)
Sleeping legs/arms	2,841 (4.7%)	1,236 (1.3%)	3.50 (3.29, 3.72)
Muscle/joint pain	3,217 (5.3%)	1,772 (1.9%)	3.46 (3.24, 3.69)
Headache	3,740 (6.1%)	2,868 (3.1%)	3.04 (2.78, 3.28)
Dizziness	2,430 (4.0%)	1,495 (1.6%)	2.38 (2.18, 2.57)
Chest pain	1,695 (2.8%)	780 (0.8%)	2.01 (1.85, 2.16)

Denmark nationwide cross-sectional study including 152,880 individuals aged 15-years or older. Data were collected 6, 9 or 12 months after the test using web-based questionnaires. More than half (53.1%) of test-positives reported at least one of the following conditions: concentration difficulties, memory issues, sleep problems, mental or physical exhaustion, compared to 11.5% of test-negatives.
https://www.medrxiv.org/content/10.1101/2022.02.27.22271328v1.full.pdf

2

TABLE 2. COVID-19 vaccination schedule for the primary series in the general population*

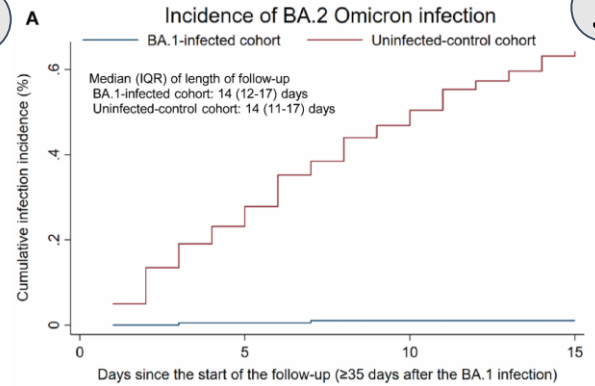
Primary series vaccine manufacturer	Age group	Number of doses in primary series	Number of booster doses	Interval between 1st and 2nd dose	Interval between primary series and booster dose
Pfizer-BioNTech	5–11 years	2	NA	3 weeks	NA
Pfizer-BioNTech	≥12 years	2	1	3-8 weeks†	≥5 months
Moderna	≥18 years	2	1	4-8 weeks†	≥5 months
Janssen	≥18 years	1	1	NA	≥2 months

*For the vaccination schedule for people who are moderately or severely immunocompromised, see Table 3

†An **8-week** interval may be optimal for some people ages 12 years and older, especially for males ages 12 to 39 years. A **shorter interval** (3 weeks for Pfizer-BioNTech; 4 weeks for Moderna) between the first and second doses remains the recommended interval for: people who are moderately to severely immunocompromised; adults ages 65 years and older; and others who need rapid protection due to increased concern about community transmission or risk of severe disease.

CDC recently updated guidance on vaccinations to acknowledge an 8-week interval between doses may be optimal for those 12 years and older,
https://www.cdc.gov/vaccines/covid-19/clinical-considerations/covid-19-vaccines-us.html#primary-series

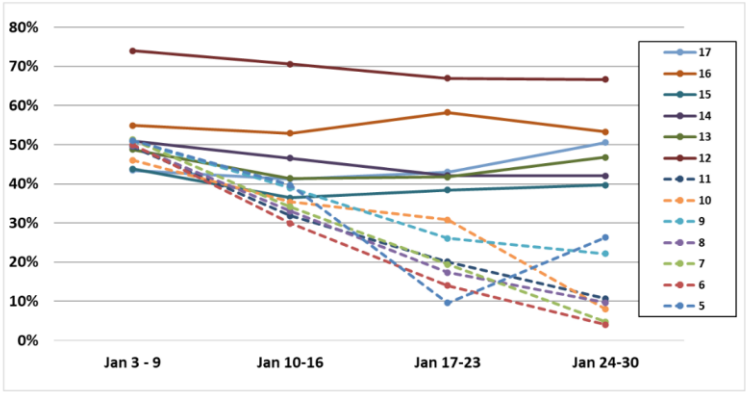
4



Qatar: Two national matched, retrospective cohort studies were conducted to estimate effectiveness of BA.1 infection against reinfection with BA.2 (N=20,197; BA.1-against-BA.2 study), and effectiveness of BA.2 infection against reinfection with BA.1 (N=100,925; BA.2-against-BA.1 study). **BA.1 is 94.9% effective against BA.2; BA.2 is 85.6% effectives against BA.1**
https://www.medrxiv.org/content/10.1101/2022.02.24.22271440v1

3

Figure 1: Vaccine Effectiveness against Infection, by Week and Year of Age



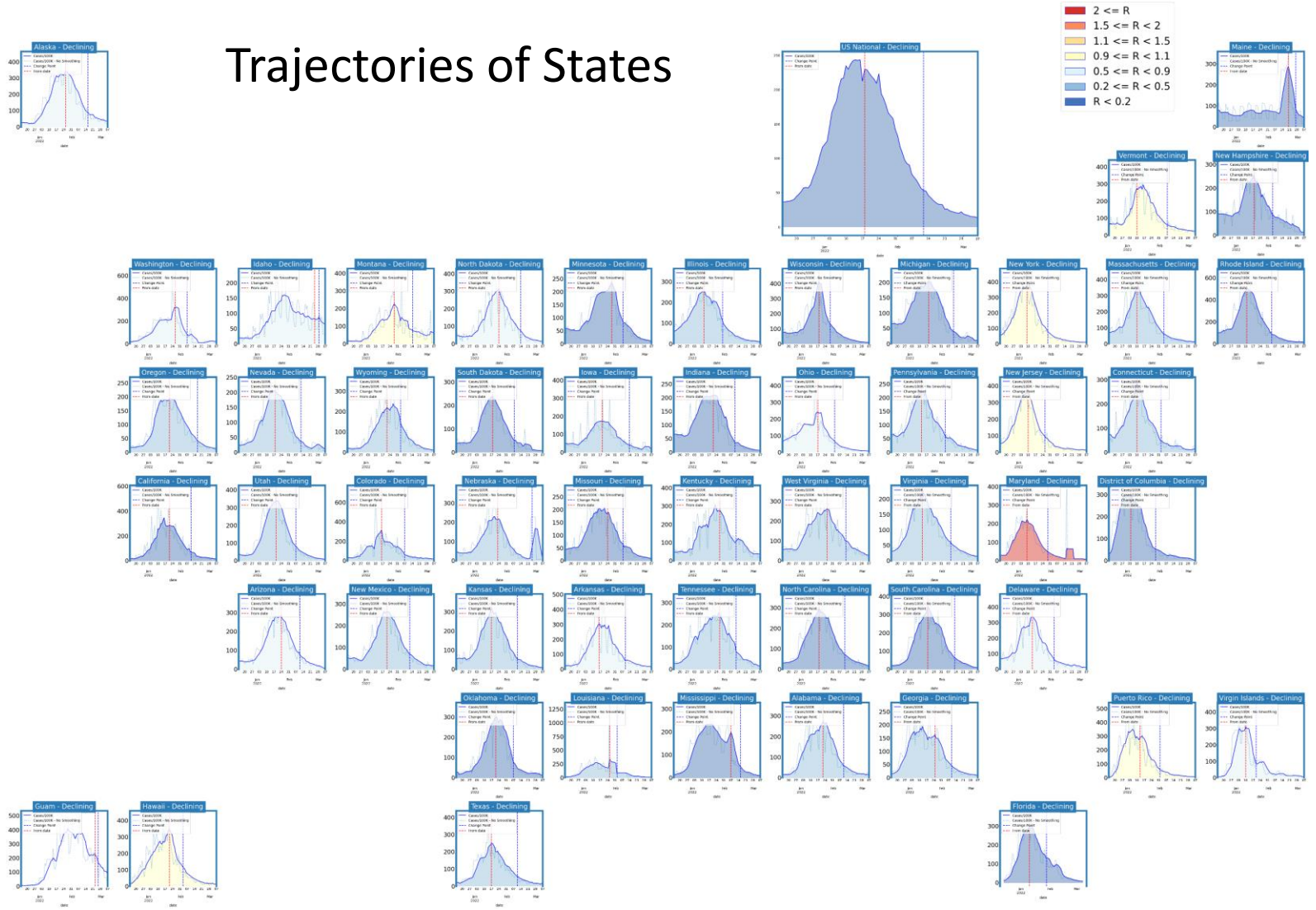
Incidence rate ratios, comparing cases during January 3 - January 30, 2022 for unvaccinated versus children newly fully-vaccinated December 13, 2021-January 2, 2022, by time Since Full Vaccination. Possible relationship between CDC recommended dosing in #2 and demonstrated waning in younger age groups
https://www.medrxiv.org/content/10.1101/2022.02.25.22271454v1

United States Overall

- Nation completely declining
- Most are sustained declines

Status	# States
Declining	54 (54)
Plateau	0 (0)
Slow Growth	0 (0)
In Surge	0 (0)

Trajectories of States



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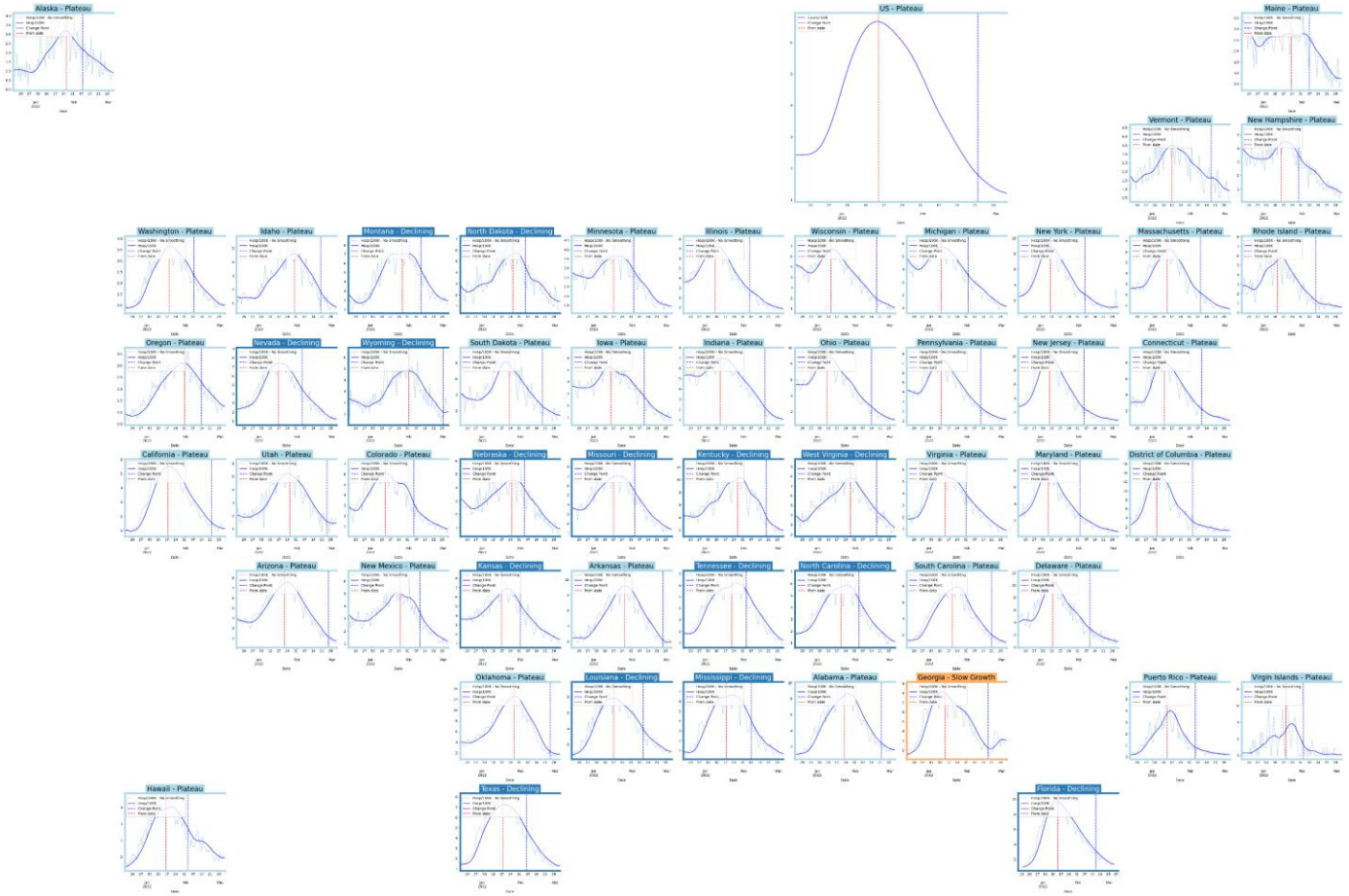
United States Hospitalizations

- Hospital admissions are lagging case rates, and are declining

Status	# States (prev week)
Declining	15 (27)
Plateau	37 (26)
Slow Growth	1 (0)
In Surge	0 (0)

Trajectories of States



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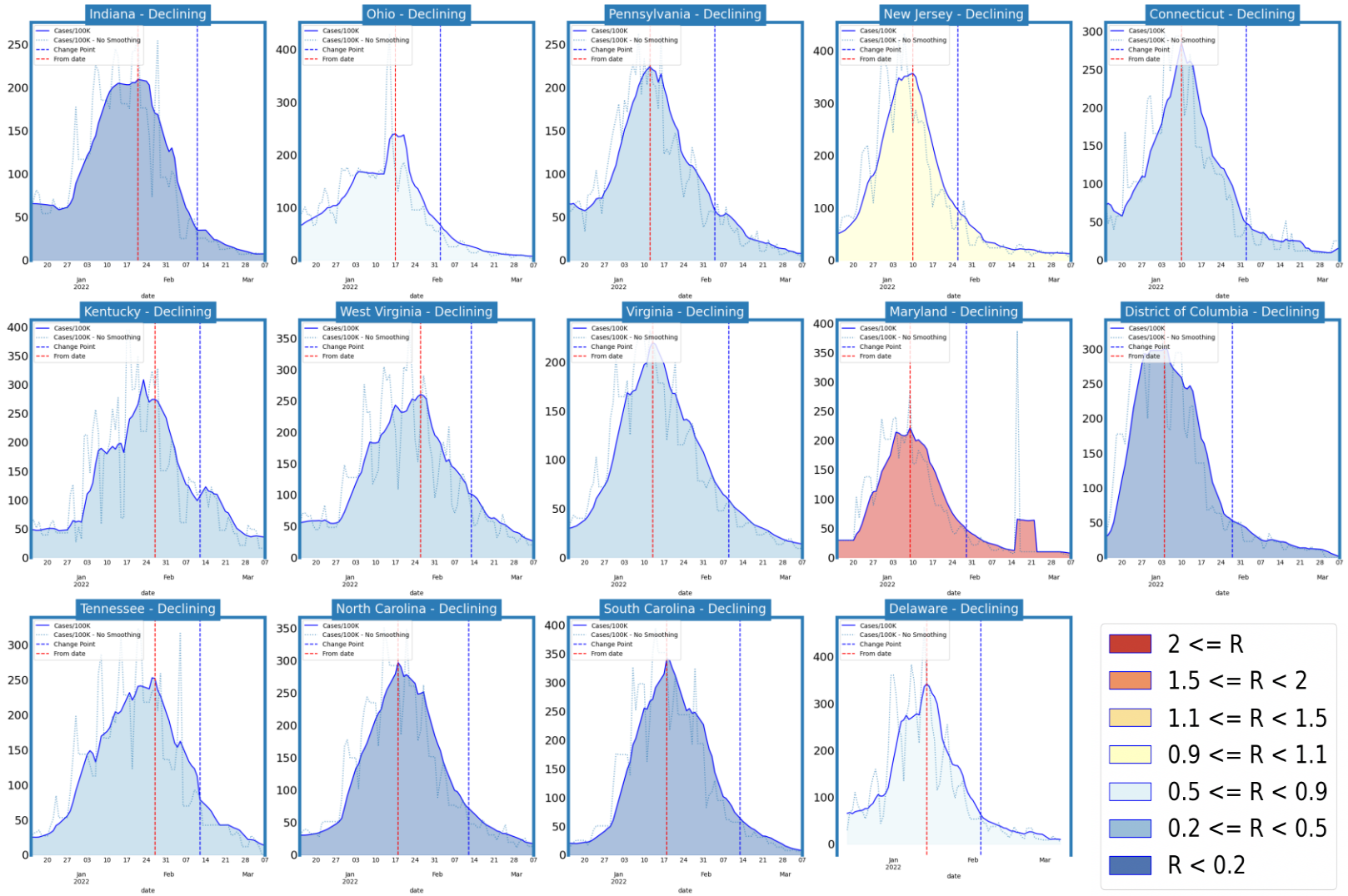
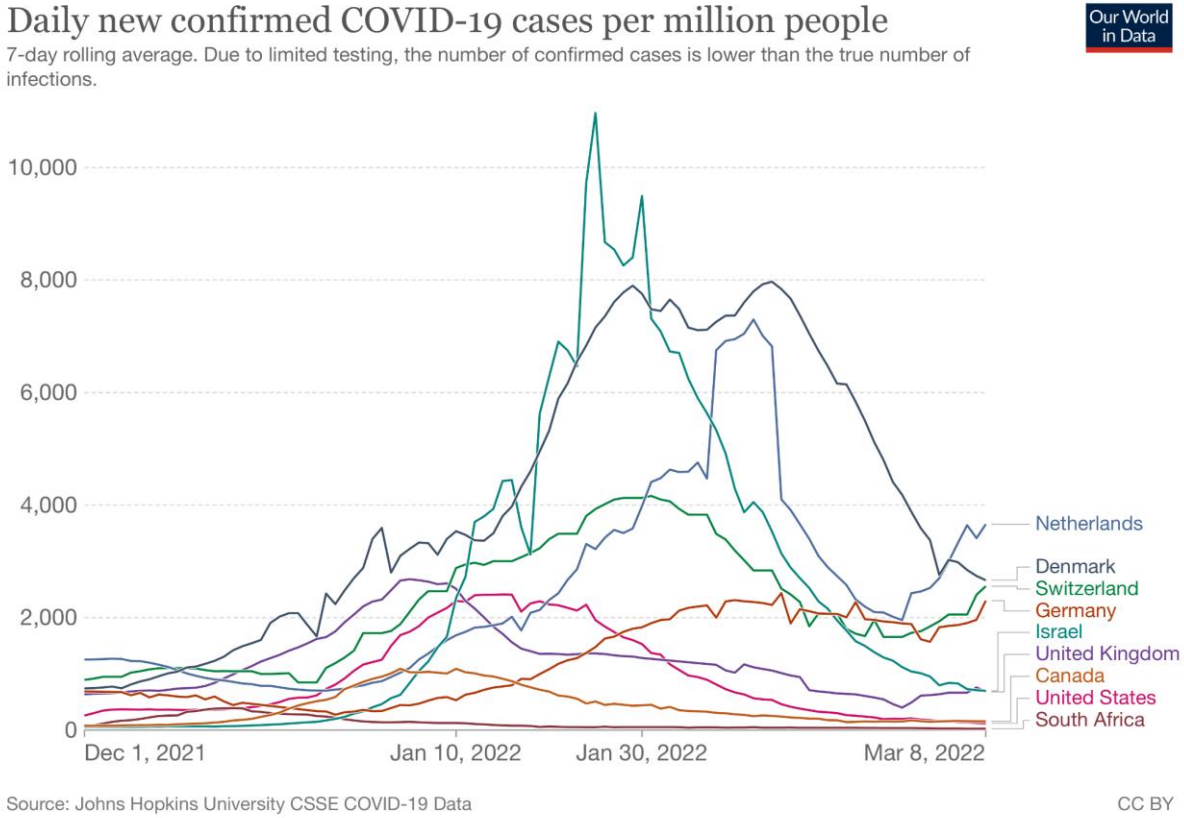
Virginia and Her Neighbors

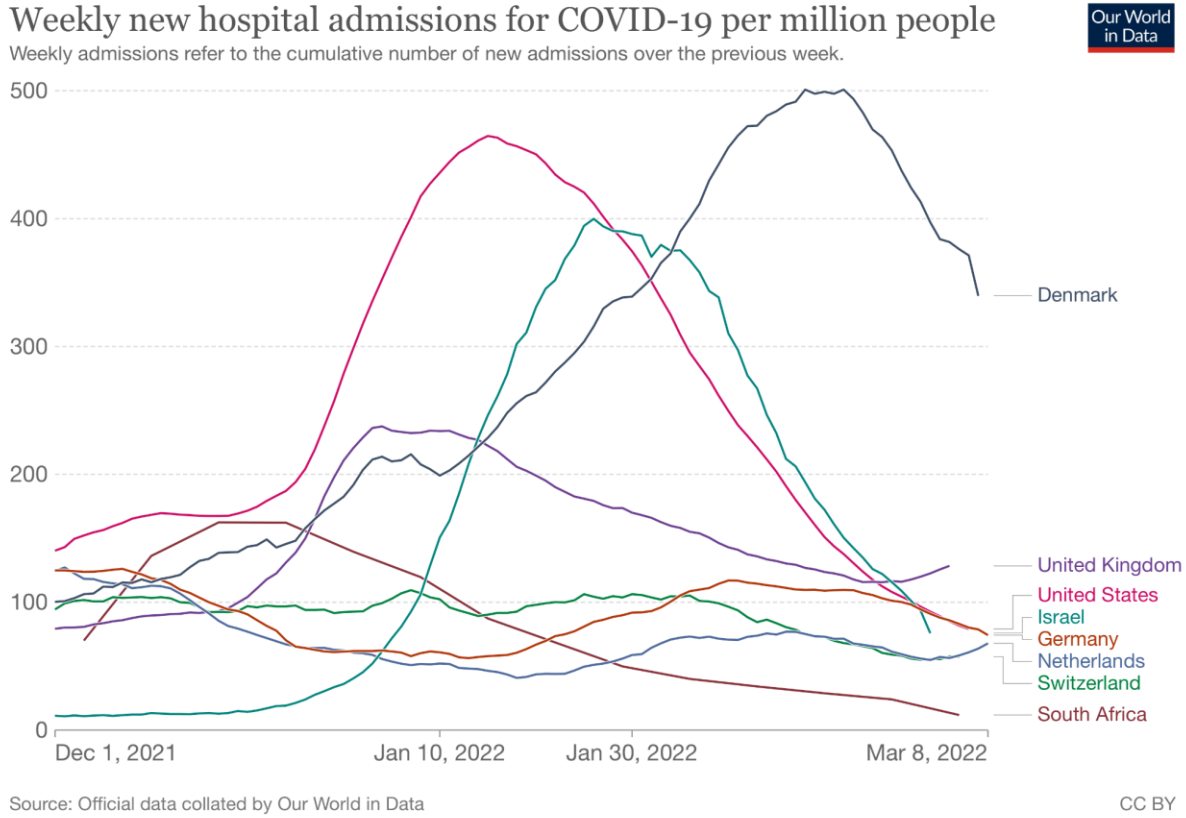
- Case rates are much lower and dipping into the moderate range
- Many now below 15/100K



Other Countries

- UK, Netherlands, and Switzerland show increases in hospitalizations
- Cases also rebounding in several European countries

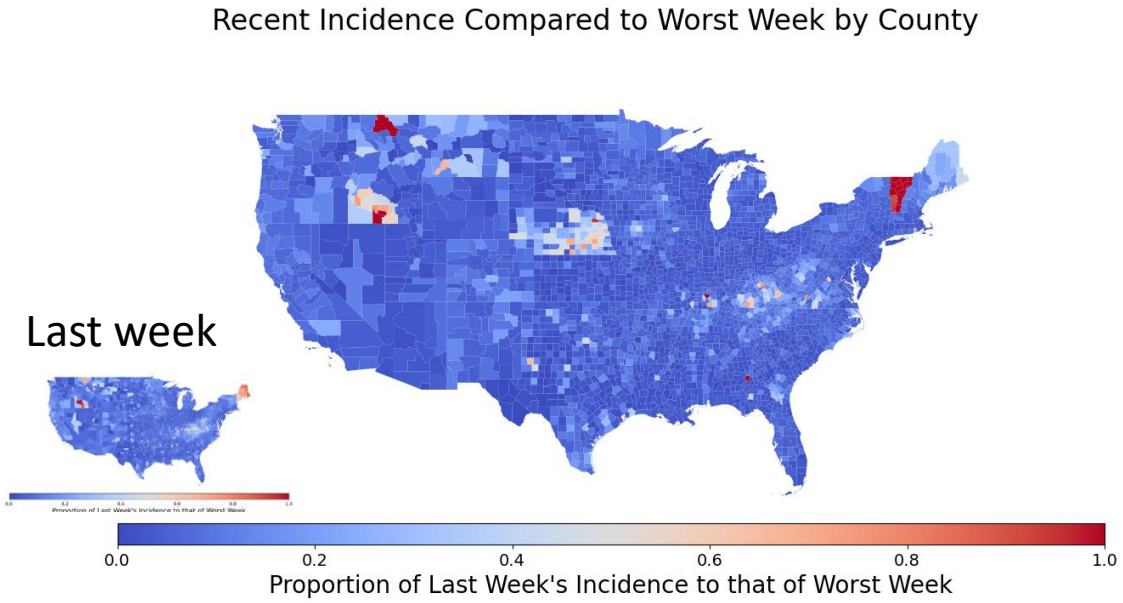


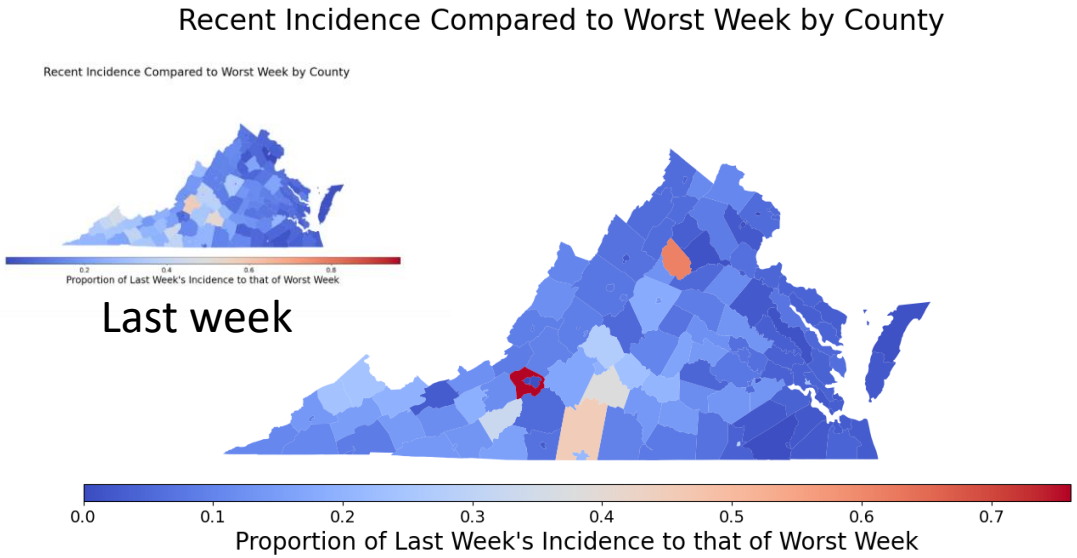


Our World in Data

County-level comparison to previous highest peak

- 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

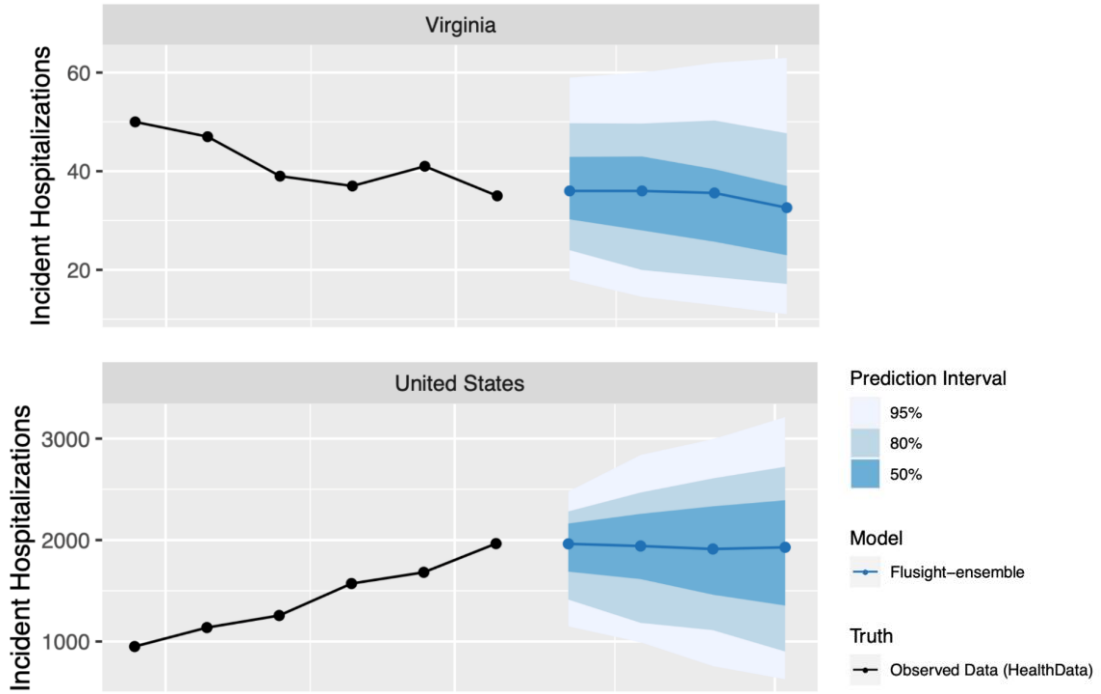




Current Influenza Hospitalization Forecast

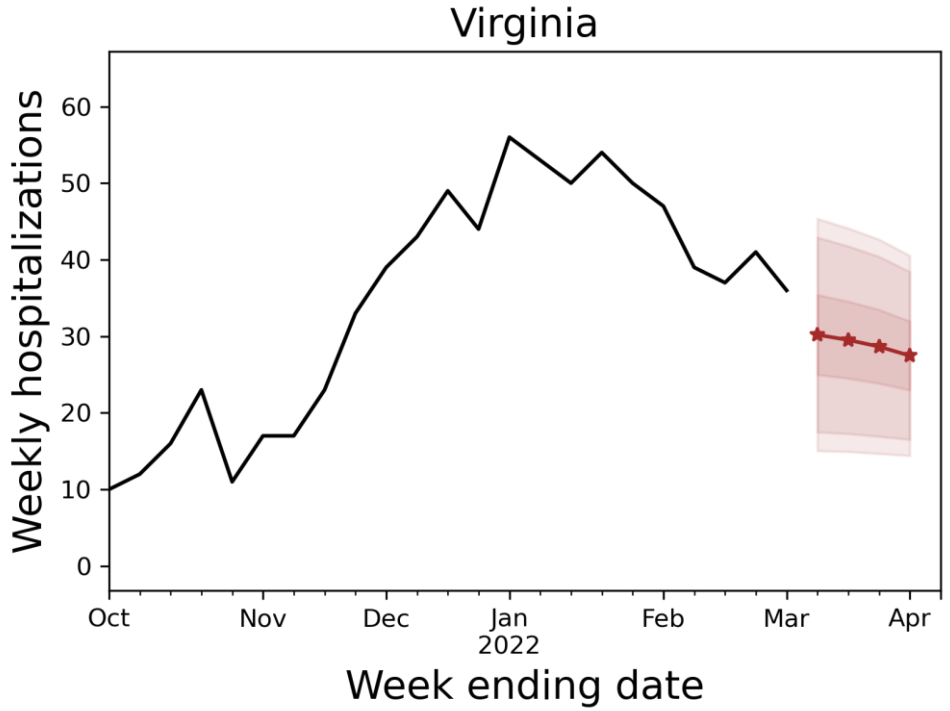
Statistical models for submitting to CDC FluSight forecasting challenge

- Similar to COVID-19 case forecasts, uses a variety of statistical and ML approaches to forecast weekly hospital admissions for the next 4 weeks for all states in the US



[CDC FluSight](#)
Ensemble Forecasts
(Mar 7)

Hospital Admissions for Influenza and Forecast for next 4 weeks (UVA ensemble)



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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