Estimation of COVID-19 Impact in Virginia

July 6th, 2022
(data current to July 3rd – 5th)
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

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Model Development, Outbreak Analytics, and Delivery Team

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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 remain high and are slightly up, hospitalizations are climbing more quickly than cases**
- VA weekly case rate slightly up to 221/100K from 215/100K
  - US also slightly down to 218/100K from 233/100K
  - VA hospital occupancy (rolling 7 day mean of 599) continues to rise for past 10 days
- Omicron sub-variants BA.4 and BA.5 continue to grow, crossing 50% combined with BA.5 outpacing BA.4

The situation continues to change. Models continue to be updated regularly.
Situation Assessment
Case Rates (per 100k) and Test Positivity

County level RT-PCR test positivity

Green: <5.0% (or <20 tests in past 14 days)
Orange: 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

<table>
<thead>
<tr>
<th>Trajectory</th>
<th>Description</th>
<th>Weekly Case Rate (per 100K) bounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declining</td>
<td>Sustained decreases following a recent peak</td>
<td>below -0.9</td>
</tr>
<tr>
<td>Plateau</td>
<td>Steady level with minimal trend up or down</td>
<td>above -0.9 and below 0.5</td>
</tr>
<tr>
<td>Slow Growth</td>
<td>Sustained growth not rapid enough to be considered a Surge</td>
<td>above 0.5 and below 2.5</td>
</tr>
<tr>
<td>In Surge</td>
<td>Currently experiencing sustained rapid and significant growth</td>
<td>2.5 or greater</td>
</tr>
</tbody>
</table>
District Trajectories – last 10 weeks

<table>
<thead>
<tr>
<th>Status</th>
<th># Districts (prev week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declining</td>
<td>8 (23)</td>
</tr>
<tr>
<td>Plateau</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Slow Growth</td>
<td>24 (7)</td>
</tr>
<tr>
<td>In Surge</td>
<td>2 (0)</td>
</tr>
</tbody>
</table>

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

8-Jul-22
CDC’s new COVID-19 Community Levels

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

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Stay up to date with COVID-19 vaccines</td>
<td>▪ 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</td>
<td>▪ Wear a mask indoors in public</td>
</tr>
<tr>
<td>▪ Get tested if you have symptoms</td>
<td>▪ Stay up to date with COVID-19 vaccines</td>
<td>▪ Stay up to date with COVID-19 vaccines</td>
</tr>
<tr>
<td></td>
<td>▪ Get tested if you have symptoms</td>
<td>▪ Get tested if you have symptoms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Additional precautions may be needed for people at high risk for severe illness</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>New COVID-19 Cases</th>
<th>Indicators</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per 100,000 people in the past 7 days</td>
<td>New COVID-19 admissions per 100,000 population (7-day total)</td>
<td>&lt;1.0.0</td>
<td>10.0-19.9</td>
<td>≥20.0</td>
</tr>
<tr>
<td></td>
<td>Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)</td>
<td>&lt;10.0%</td>
<td>10.0-14.9%</td>
<td>≥15.0%</td>
</tr>
<tr>
<td>Fewer than 200</td>
<td>New COVID-19 admissions per 100,000 population (7-day total)</td>
<td>NA</td>
<td>&lt;10.0</td>
<td>≥10.0</td>
</tr>
<tr>
<td></td>
<td>Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)</td>
<td>NA</td>
<td>&lt;10.0%</td>
<td>≥10.0%</td>
</tr>
</tbody>
</table>

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.

CDC Data Tracker Portal

8-Jul-22
CDC’s new COVID-19 Community Levels

Red outline indicates county had 200 or more cases per 100k in last week

Pale color indicates either beds or occupancy set the level for this county

Dark color indicates both beds and occupancy set the level for this county

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 from: CDC Data Tracker Portal
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

July 5th Estimates

<table>
<thead>
<tr>
<th>Region</th>
<th>Date Confirmed</th>
<th>(R_e)</th>
<th>Date Confirmed Diff Last Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>State-wide</td>
<td>0.952</td>
<td></td>
<td>-0.044</td>
</tr>
<tr>
<td>Central</td>
<td>0.971</td>
<td></td>
<td>-0.037</td>
</tr>
<tr>
<td>Eastern</td>
<td>0.945</td>
<td></td>
<td>-0.121</td>
</tr>
<tr>
<td>Far SW</td>
<td>0.953</td>
<td></td>
<td>-0.002</td>
</tr>
<tr>
<td>Near SW</td>
<td>1.020</td>
<td></td>
<td>0.182</td>
</tr>
<tr>
<td>Northern</td>
<td>0.931</td>
<td></td>
<td>-0.069</td>
</tr>
<tr>
<td>Northwest</td>
<td>0.933</td>
<td></td>
<td>-0.016</td>
</tr>
</tbody>
</table>

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: updated to 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

Wastewater Monitoring

Wastewater provides a coarse early warning of COVID-19 levels in communities

- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago
- Current virus levels are at or exceeding max of previous historical levels, has slowed, though more sites are entering upper quintiles

USA

Percent Change over 15 days for the past weeks (US) - Proportions

Data Source: CDC Data Tracker

Virginia - Historic percentile of current detected levels over the past weeks

category

1. 1% to 10% 2. 11% to 99% 3. 100% or more
COVID-like Illness Activity

COVID-like Illness (CLI) gives a measure of COVID transmission in the community

- Emergency Dept (ED) based CLI is more correlated with case reporting
- Urgent Care (UC) is a leading indicator but prone to some false positives
- Current trends in UC CLI have plateaued for last four weeks state-wide, mixed by region
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

Omicron Updates

- BA.2.12.1 growth has started to decline, shrinking to 40% after 5 weeks in the the 65%-75% prevalence range (Region 3)
- BA.4 growing, nowcasted at 18% (up from 17% last week)
- BA.5 also growing rapidly, nowcasted at 41% (up from 25% last week)
- BA.4 and BA.5 have same mutation as BA.1 that produces S-gene target failure, so can be tracked in more real time with SGTF from some PCR tests

SGTF in San Diego

Walgreens
based on sequencing and thus lags by 2 weeks now National
31% BA.4/5

Currently estimated to be over 80% in San Diego
SARS-CoV2 Omicron and Sub-Variants

As detected in whole Genomes in public repositories

VoC Polynomial Fit Projections

Note: Data lags force projections to start in past. Everything from dotted line forward is a projection.
1. The National Center for Health Statistics (NCHS) reported an 18.4% increase in US maternal mortality.

2. UK analysis suggests wastewater analysis can be a cost effective early indicator of increasing case count.

3. New study from Denmark indicates people who tested positive had a 3.5 times increased risk of being diagnosed with Alzheimer’s disease, 2.6 times with Parkinson’s disease, 2.7 times with ischaemic stroke and a 4.8 times increased with intracerebral haemorrhage.

4. UKHSA technical update highlights growth advantage of BA.5 due to immune escape. Increase in hospitalizations being monitored.

5. Constellation of symptoms 6 months after infection in young adults is suggestive of a higher risk of developing metabolic disorders and possible cardiovascular complications.

As part of a government-funded epidemiological surveillance pilot program, a wastewater-based epidemiology approach was used to monitor the occurrence of SARS-CoV-2 in Sixteen schools (10 primary, 5 secondary and 1 post-16 and further education for a total of 17 sites) in England. A lead/lag analysis was performed between the weekly positivity rates in schools and community cases to identify the maximum correlation between school and community timeseries using the Pearson’s correlation coefficient. This analysis shows a maximum correlation between the two times series when school data are shifted two weeks into the future (Pearson’s correlation coefficient 0.33, p<0.01) suggesting that the signal in school wastewater precedes the increase in the number of cases in the community.

A new study which analysed the health records of more than half of the Danish population, found that those who had tested positive for COVID-19 were at an increased risk of Alzheimer’s disease, Parkinson’s disease, and ischaemic stroke. Out of the 919,731 individuals that tested for COVID-19 within the study, researchers found that the 43,375 people who tested positive had a 3.5 times increased risk of being diagnosed with Alzheimer’s disease, 2.6 times with Parkinson’s disease, 2.7 times with ischaemic stroke and a 4.8 times increased with intracerebral haemorrhage.

“Laboratory data from Genotype2Phenotype (G2P) Consortium (unpublished) and others suggest that there is a minimal change in fusogenicity of the spike of BA.4 and BA.5 (compared to other Omicron variants), and that the entry route is similar to that of BA.1 and BA.2. Other data from G2P (cited when available) shows some changes in the interaction with the human host cell by BA.4 and BA.5 virus compared with earlier Omicron variants that could be associated with increased fitness. Neutralisation data has been described previously. Taken together the laboratory data suggest small changes in antigenicity and potentially small increases in fitness may both contribute to the observed growth advantage.”

A Swiss study 501 participants (5.6% females) with a median age of 21 years (range 19-29). Cases of previous COVID-19 (>6 months since diagnosis, n=177) were compared with never infected controls (n=248). Even mild infections in young adults can lead to sequelae that persist several months post infection with significantly more fatigue, hyposomnia, poorer psychological scores and a short-term, negative impact on male fertility. Other symptoms include higher body mass index, dyslipidemia and lower physical endurance 6 months post COVID-19.

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https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6482270

https://www.medrxiv.org/content/10.1101/2022.02.11.222736v1


https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0270168

https://www.jamanetwork.com/journals/jamanetworkopen/fullarticle/2793640
United States Case Rates

- Rebounding activity, mainly in the Northeast

<table>
<thead>
<tr>
<th>Status</th>
<th># States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declining</td>
<td>33 (38)</td>
</tr>
<tr>
<td>Plateau</td>
<td>12 (12)</td>
</tr>
<tr>
<td>Slow Growth</td>
<td>4 (5)</td>
</tr>
<tr>
<td>In Surge</td>
<td>5 (6)</td>
</tr>
</tbody>
</table>
Virginia and Her Neighbors
United States Hospitalizations

- Hospital admissions are lagging case rates
- Declines seem to be leveling off in Northeast, surges in southern in Central US follow cases

<table>
<thead>
<tr>
<th>Status</th>
<th># States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declining</td>
<td>5 (10)</td>
</tr>
<tr>
<td>Plateau</td>
<td>11 (13)</td>
</tr>
<tr>
<td>Slow Growth</td>
<td>27 (19)</td>
</tr>
<tr>
<td>In Surge</td>
<td>10 (11)</td>
</tr>
</tbody>
</table>
County-level comparison to last Summer

Recent Incidence Compared to Weekly Summer Mean by County
Mean: 21.91; Median: 2.17; IQR: 1.02-4.41

Recent Incidence Compared to Weekly Summer Mean by County
Mean: 4.01; Median: 3.13; IQR: 2.16-4.46
Using Ensemble Model to Guide Projections

Ensemble methodology that combines the Adaptive with machine learning and statistical models such as:

- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

Weekly forecasts done at county level.

Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

Ensemble forecast provides additional ‘surveillance’ for making scenario-based projections.

Also submitted to CDC Forecast Hub.
Last projection comparison – 1 week ago

With Last Week’s Case Data
Virginia Daily Confirmed - Comparison 2022-06-11

With This Week’s Case Data
Virginia Daily Confirmed - Comparison 2022-06-11
Key Takeaways

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

• **Case rates remain high but are slowly declining, hospitalizations have started to decline**

• VA 7-day mean daily case rate down to 29/100K from 34/100K
  - US has flattened, only slightly up to 30/100K from 29/100K
  - VA hospital occupancy (rolling 7 day mean of 544) has declined slightly after a couple weeks in a plateau

• Omicron sub-variants BA.4 and BA.5 continue to grow with BA.5 starting to outpace BA.4

• Model projections from last week remain on target

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 Outreach locations**: Collaboration with VDH state and local, Stanford, and SafeGraph to leverage anonymized cell data to help identify sites most frequently visited by different demographic groups
Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios

• Round 13 results getting finalized
  • Scenarios: New Variant in Summer and waning compared (yes/no new variant vs. 4 month or 10 month waning)
  • Prelim results shared internally
  • Only national consortium tracking Omicron wave well

• Rounds 4-12 now available

*Round 4 Results were published May 5th, 2021 in MMWR*
Busiest Places: Mobility Data Can Assist

**SafeGraph provides fine-grained mobility measures**

- **SafeGraph**: anonymized geolocation data aggregated from numerous cell phone apps
- One of the most fine-grained and high-coverage mobility data sources available: 6.4 million POIs in the US; 158,869 POIs in VA
- Has been utilized by hundreds of researchers, governments, and the CDC to aid COVID-19 efforts (Chang, Pierson, Koh, et al., *Nature 2020*; Chang et al, KDD 2021)
- Daily and hourly number of visits to points-of-interest (POIs), i.e., non-residential locations such as restaurants, bars, gas stations, malls, grocery stores, churches, etc.
- Weekly reports per POI of *where visitors are coming from* (at the census block group level)
- Still has **limitations** to be aware of (e.g., less representation among children and seniors)
Find the Busiest Locations

POIs are individual addresses, need some aggregation to busy areas

Busiest locations vary by day of week (and time of day)
Find locations visited by Target Population

Census Block Groups in Danville

1. Use census data to characterize the populations of the different census block groups
2. Identify most frequently visited POIs for each CBG
3. Cluster most visited POIs
4. Provide potential sites grouped by the demographic groups they likely serve

Goal: Provide frequently visited locations based on populations and vaccination levels one desires to reach

Example: List of locations in the Southside frequented by Black Virginians
Overview of the current roster of targeted populations

These are the current roster of targeted population groups that we are providing as part of the weekly delivery to VDH. (This roster is subject to change.)

- Whole population (eg, no target population filters are applied)
- Race Black
- Ethnicity Latinx
- Ages 20-40
- Ages 20-30
- Ages 30-40
- Unvaccinated populations
- Latinx or Black NEW
### Data Elements in the CSV

<table>
<thead>
<tr>
<th>County</th>
<th>VDH District</th>
<th>Population Group</th>
<th>S2 Key (L14)</th>
<th>Rank</th>
<th>LocationWeight</th>
<th>AreaMostVisitedDay</th>
<th>HighlyVisitedAddress</th>
<th>AreaMostVisitedPeriod</th>
<th>Lat</th>
<th>Lon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accomack Cc Eastern Shor</td>
<td>Latinx or Black</td>
<td>89ba2b55</td>
<td>1</td>
<td>4966.030095</td>
<td>Friday</td>
<td>25297 Lankford Hwy Rt 13 N, Onley, VA</td>
<td>Friday 17:00-21:00</td>
<td>37.6978738</td>
<td>-75.7167963</td>
<td></td>
</tr>
<tr>
<td>Accomack Cc Eastern Shor</td>
<td>Latinx or Black</td>
<td>89ba2caf</td>
<td>2</td>
<td>3728.476005</td>
<td>Friday</td>
<td>26036 Lankford Hwy, Onley, VA</td>
<td>Friday 15:00-19:00</td>
<td>37.6816811</td>
<td>-75.722612</td>
<td></td>
</tr>
<tr>
<td>Accomack Cc Eastern Shor</td>
<td>Latinx or Black</td>
<td>89ba2b57</td>
<td>3</td>
<td>3508.193676</td>
<td>Saturday</td>
<td>25274 Lankford Hwy, Onley, VA</td>
<td>Saturday 13:00-17:00</td>
<td>37.69859</td>
<td>-75.722612</td>
<td></td>
</tr>
<tr>
<td>Accomack Cc Eastern Shor</td>
<td>Latinx or Black</td>
<td>89bbd4ad</td>
<td>4</td>
<td>2582.802769</td>
<td>Wednesday</td>
<td>25102 Lankford Hwy, Onley, VA</td>
<td>Sunday 11:00-15:00</td>
<td>37.7023677</td>
<td>-75.7109811</td>
<td></td>
</tr>
<tr>
<td>Accomack Cc Eastern Shor</td>
<td>Latinx or Black</td>
<td>89ba2b53</td>
<td>5</td>
<td>1844.868961</td>
<td>Sunday</td>
<td>25102 Lankford Hwy, Onley, VA</td>
<td>Friday 16:00-20:00</td>
<td>37.7030842</td>
<td>-75.7167963</td>
<td></td>
</tr>
<tr>
<td>Albemarle C Blue Ridge</td>
<td>Latinx or Black</td>
<td>89b38647</td>
<td>1</td>
<td>14088.0684</td>
<td>Thursday</td>
<td>1215 Lee St, University of Virginia</td>
<td>Thursday 07:00-11:00</td>
<td>38.0327733</td>
<td>-78.5007680</td>
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<tr>
<td>Albemarle C Blue Ridge</td>
<td>Latinx or Black</td>
<td>89b477ff</td>
<td>2</td>
<td>6999.363545</td>
<td>Saturday</td>
<td>1980 Rio Hill Ctr, Charlottesville</td>
<td>Saturday 12:00-16:00</td>
<td>38.0873911</td>
<td>-78.4723533</td>
<td></td>
</tr>
<tr>
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<td>Latinx or Black</td>
<td>89b38645</td>
<td>3</td>
<td>5824.383454</td>
<td>Wednesday</td>
<td>Cabell Hall S25 McCormick Rd</td>
<td>Wednesday 11:00-15:00</td>
<td>38.0333334</td>
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<tr>
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<td>4</td>
<td>5078.488029</td>
<td>Friday</td>
<td>540 Pantops Ctr, Pantops, VA</td>
<td>Thursday 11:00-15:00</td>
<td>38.0334982</td>
<td>-78.4553011</td>
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<tr>
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<td>Latinx or Black</td>
<td>89b387fd</td>
<td>5</td>
<td>4655.844131</td>
<td>Saturday</td>
<td>100 Twenty ninth Place Ct, Cha</td>
<td>Saturday 11:00-15:00</td>
<td>38.077516</td>
<td>-78.4780369</td>
<td></td>
</tr>
</tbody>
</table>

- **Rank & LocationWeight**: The LocationWeight is estimated # of visits to POIs in the L14 from the target group. Rank indicates the order from most- to 25th most-visited.
- **AreaMostVisitedDay**: This is the day of the week when most visitors go to this S2 location. This is not target group-specific.
- **AreaMostVisitedPeriod**: This is the 4-hour period in the week when the L14 sees its highest traffic. This is not target group-specific.
- **HighlyVisitedAddress**: This is the address of the POI in the L14 that sees the most visits. It is provided to make it easier to find the L14 on the map.
- **Lat and Lon**: This is the latitude and longitude for the center of the L14.
Mobility Data Updated Weekly

Box: https://virginia.box.com/s/03kq8el0kzd9w43wz2g3myozov76uizo
- Excel sheets and simple HTML maps packaged for use

VDH has a dashboard available upon request to allow interactive viewing
- Dashboard is restricted to VDH offices and those who VPN into the CoV Network
References


NSSAC. PatchSim: Code for simulating the metapopulation SEIR model. [https://github.com/NSSAC/PatchSim](https://github.com/NSSAC/PatchSim)


Google. COVID-19 community mobility reports. [https://www.google.com/covid19/mobility/](https://www.google.com/covid19/mobility/)

Questions?

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Biocomplexity COVID-19 Response Team

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