Estimation of COVID-19 Impact in Virginia

August 18th, 2021
(data current to August 15th – 18th)

Biocomplexity Institute Technical report: TR 2021-092
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 in Virginia continue to rise quickly amidst a background of surges across the nation**

• VA mean weekly incidence up to 24/100K from 14/100K, US up to 38/100K (from 25/100K)

• Vaccination rates continue to pick speed and acceptance among the unvaccinated persists

• Projections continue to show significant uptick in activity, with larger growth possibly fueled by Delta’s increasing prevalence, even in areas with high vaccination coverage

• Recent updates:
  • Updated Surge Control scenario to commence sooner as mask use has increased recently
  • Adjusted hospitalization and death modeling to adapt to the observed impacts of Delta

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 30% of counties with TPR > 10%

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>
<th># Districts (prev week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declining</td>
<td>Sustained decreases following a recent peak</td>
<td>below -0.9</td>
<td>0 (1)</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>
<td>0 (1)</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>
<td>2 (23)</td>
</tr>
<tr>
<td>In Surge</td>
<td>Currently experiencing sustained rapid and significant growth</td>
<td>2.5 or greater</td>
<td>33 (10)</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>0 (0)</td>
</tr>
<tr>
<td>Plateau</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Slow Growth</td>
<td>2 (2)</td>
</tr>
<tr>
<td>In Surge</td>
<td>33 (33)</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.
Estimating Daily Reproductive Number

August 16th Estimates

Methodology

- Wallinga-Teunis method (EpiEstim) 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

Vaccination Administration Slows

Regional Vaccine courses initiated per day:
- Total counts of first dose of vaccines across regions
- Continued rise across all regions
- Reflected in 1st dose of Pfizer and Moderna uptick
Vaccinations Shift to Younger Populations
Vaccination Acceptance by Region

Corrections to surveys:
• Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
• Correction approach:
  • Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  • Cross-validate coarse corrections against HPS survey at the state level and corrected in same manner

<table>
<thead>
<tr>
<th>Region</th>
<th>COVIDcast accepting corrected</th>
<th>VDH proportion eligible vaccinated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>76%</td>
<td>66%</td>
</tr>
<tr>
<td>Eastern</td>
<td>73%</td>
<td>62%</td>
</tr>
<tr>
<td>Far SW</td>
<td>59%</td>
<td>52%</td>
</tr>
<tr>
<td>Near SW</td>
<td>68%</td>
<td>58%</td>
</tr>
<tr>
<td>Northern</td>
<td>94%</td>
<td>77%</td>
</tr>
<tr>
<td>Northwest</td>
<td>71%</td>
<td>65%</td>
</tr>
<tr>
<td>Virginia</td>
<td>78%</td>
<td>67%</td>
</tr>
</tbody>
</table>

Grey Bar: Survey measured and corrected acceptance
Green Bar: Proportion of eligible population administered a vaccine
Dots: Proportion administered at least one dose for each county
Vaccine Acceptance Components over Time

Vaccine Acceptance has risen as vaccination rates have climbed

- Corrected Acceptance reflects the daily measured overall acceptance and has risen in the past couple days
- Unvaccinated Acceptance shows still ~10% of those who are unvaccinated are definitely or probably willing to be vaccinated
- Unvax acceptance has declined a bit and leveled off in last couple of weeks, final 10% may be waiting for FDA approval

Data Source: https://covidcast.cmu.edu
Vaccine Acceptance by Region - COVIDcast

Levels of Acceptance and potential acceptance in flux:

- Most regions (except Central and Far SW) see vaccine uptake in the “Definitely Yes”.
- Among the unvaccinated, about 20-30% remain in the Definitely/Probably “Yes” categories.
- About 50% of the Unvaccinated seem to be in the “Definitely Not” category.

Data Source: [https://covidcast.cmu.edu](https://covidcast.cmu.edu)
Reasons for Hesitancy vary across tiers of likeliness to accept the vaccine

- Probably Yes and Probably No most concerned about side effects & are waiting to see
- Definitely No are concerned about side effects but also don’t think they need the vaccine and don’t trust the government, though don’t need is declining
- Most other reasons are below 30% within these tiers of likeliness
Reasons for Hesitancy vary across Regions

- Side Effects and waiting to see safety are primary
- Most movement in last couple weeks seen in trust of govt and efficacy
Mask Usage Increases

Self-reported mask usage has declined for months, but rebounded
• State-wide up to 50% from 43% a couple weeks ago
• Similar to US overall, with mixed movement across VA counties

Data Source: https://covidcast.cmu.edu
Mask Wearing by Vaccine Willingness

Among the different tiers of vaccine acceptance, mask wearing increasing
- Only those who would “definitely not” take the vaccine if offered have a low level of mask usage
- “Probably Not” beginning to stagnate in mask usage
- All other Vaccine willingness levels have similar mask wearing levels

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

<table>
<thead>
<tr>
<th>New WHO Name</th>
<th>Transmissibility</th>
<th>Immune Evasiveness</th>
<th>Vaccine Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancestral</td>
<td>—</td>
<td>—</td>
<td>✓</td>
</tr>
<tr>
<td>D614G</td>
<td>+</td>
<td>—</td>
<td>✓</td>
</tr>
<tr>
<td>B.1.1.7</td>
<td>+++</td>
<td>—</td>
<td>✓</td>
</tr>
<tr>
<td>B.1.351</td>
<td>+</td>
<td>+++</td>
<td>✓</td>
</tr>
<tr>
<td>P.1</td>
<td>Gamma</td>
<td>++</td>
<td>✓</td>
</tr>
<tr>
<td>B.1.429</td>
<td>Epsilon</td>
<td>++</td>
<td>✓</td>
</tr>
<tr>
<td>B.1.526</td>
<td>Iota</td>
<td>+</td>
<td>✓</td>
</tr>
<tr>
<td>B.1.617.2</td>
<td>Delta</td>
<td>++++*</td>
<td>++*</td>
</tr>
</tbody>
</table>

*Relative transmissibility to B.1.1.7 yet to be fully defined

†Effectiveness from real world evidence vs. severe illness, not all vaccines are effective vs all variants, and importance of 2-doses, especially for B.1.617.2 for which 1-dose of mRNA or AZ is only ~30% effective ‡May carry more immune escape than P.1, to be determined

WHO and Eric Topol

CDC Variant Tracking
SARS-CoV2 Variants of Concern

Alpha α - Lineage B.1.1.7

**Prevalence:** Nationally low, decline from a high of 60% (VA reached about 80%)

**Transmissibility:** Estimated increase of 50% compared to previous variants. B.1.1.7’s mutations boost its overall levels of viremia; study from Public Health England shows contacts of B.1.1.7 cases are more likely (50%) to test positive

**Severity:** Increased risk of hospitalization (60%) and mortality (60%). Danish study shows B.1.1.7 to have a 64% higher risk of hospitalization, while Public Health Scotland studies showed a range of 40% to 60%; Study in Nature estimates 60% higher mortality

Beta β - Lineage B.1.351

**Prevalence:** Levels have remained low, as this variant’s transmissibility can’t compete with B.1.1.7, however, as more of the population becomes immune it may gain an advantage

**Immune Escape:** Many studies show that convalescent sera from previously infected individuals does not neutralize B.1.351 virus well which is predictive of protection, however, vaccine induced immunity shows signs of effectiveness

Gamma γ - Lineage P.1

**Prevalence:** Nationally low, declining from a high of 12%

Study estimates 17-32% of all infections in Manaus in 2021 were reinfections, which helps explain data from Brazil demonstrating P.1’s continued dominance in Rio despite presence of B.1.1.7
SARS-CoV2 Variants of Concern

**Delta δ - Lineage B.1.617.2** and related subvariants

- Delta plus δ+ lineage which contains the K417N mutation is emerging as a sub-variant that is even more transmissible; declared a VoC in India
- Delta variant now dominates most of Europe and US
- CDC recommends resumption of mask wearing indoors due to reports of breakthrough infections of the vaccinated possibly being transmissible
- **Recent study from Mayo clinic** shows Delta reducing the efficacy of mRNA vaccines (Pfizer more so than Moderna) along with other reports. **Israeli study** showed 64% efficacy against infection, however, a 3rd dose may counteract this reduction
- **Public Health Scotland study in Lancet** suggests Delta is 2x more likely to cause hospitalization than Alpha
- Subvariant AY.3 of Delta is increasingly prevalent (15.4%), may be more transmissible than Delta itself
Recent preprint from Rockefeller University showed that neutralizing activity against SARS-CoV-2 is polyclonal and heterogeneous among individuals with respect to epitope targets, indicating potential enhancements to future vaccines. Additionally showed significant potency and breadth of neutralization to various mutant profiles following mRNA vaccination of previously SARS-CoV-2 infected individuals. Researchers at University of Nottingham show that multiple exposures to SARS-CoV-2 spike protein in the context of a delayed second dose expand the neutralizing breadth of the antibody response to neutralization-resistant SARS-CoV-2 variants. Meta-analysis estimated that 80% of the infected patients with SARS-CoV-2 developed one or more long-term symptoms. Potential biases of using only data pulls from GISAID for surveillance. B.1.621 sequences being rejected for surveillance due to potential biases.
A recent study from New Delhi characterizes the effectiveness of the AstraZeneca vaccine against the Delta variant. Researchers found that efficacy was only 18% effective at preventing symptomatic infections among HCW after 21 days.

Ontario study of 6280 households maps the frequency and distribution of age among 1717 secondary attacks. Showed that younger children (0-3 years) may transmit covid more frequently to their household than other age segments.

Recent CMU study found that even a moderate amount of well-timed restrictions can have a substantial impact on lowering COVID-19 transmission. Also observed a clear geographical impact on SARS-CoV-2 trajectories.
Variant of Concern Trajectories

United States

Virginia

Prevalence

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UNIVERSITY OF VIRGINIA
Other State Comparisons

Trajectories of States

- Most of the country is in Surge, some with very high case rates
- Early surges show some signs of slowing, but continue rapid growth

Virginia and her neighbors

- VA and many neighbors show slight upward trends
- Many neighbors are in surge and/or have returned to rates above 10/100K
Hospitalizations across the US

Hospitalization rates remain low in VA, but rapid change is possible as seen in other states

- Hotspot states see rapid rise in hospitalizations especially among the younger age groups
- Nationally pediatric hospitalizations are at an all time high since the pandemic began

Virginia

![Virginia Hospitalizations](https://covid.cdc.gov/covid-data-tracker/#new-hospital-admissions)

Florida

![Florida Hospitalizations](https://covid.cdc.gov/covid-data-tracker/#new-hospital-admissions)

Louisiana

![Louisiana Hospitalizations](https://covid.cdc.gov/covid-data-tracker/#new-hospital-admissions)
Recent Cases Correlate with Vax Coverage

**Mean cases per 100K vs. vaccine coverage**
- States with lower vax coverage have had the worst case spikes
- Virginia 14th out of 51 states in fully vaccinated coverage

**Virginia Counties**
- Counties with higher vax coverage are maintaining lower case rates (e.g., Albemarle, Fairfax city)
- Many counties with low vax coverage starting to rise as delta surge reaches more remote areas of state
Recent Incidence Compared to Worst Week

Percentage of counties with Higher case rates

<table>
<thead>
<tr>
<th>Region</th>
<th>Above Summer’20 Mean</th>
<th>Above 50% of Worst Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virginia</td>
<td>90.9%</td>
<td>5.3%</td>
</tr>
<tr>
<td>United States</td>
<td>90.7%</td>
<td>24.7%</td>
</tr>
</tbody>
</table>
Zip code level weekly Case Rate (per 100K)

Case Rates in the last week by zip code

- Clusters of high prevalence in Southwest and Eastern
- Some counts are low and suppressed to protect anonymity, those are shown in white.
Risk of Exposure by Group Size

Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people (group size 25)

- **Group Size**: Assumes 2 undetected infections per confirmed case (ascertainment rate from recent seroprevalence survey), and shows minimum size of a group with a 50% chance an individual is infected by zip code (eg in a group of 50 in Lyndhurst, there is a 50% chance someone will be infected)

![Graph showing group size needed for 50% likelihood of ≥1 infected](image1)

**From Last Week**

Group Size Needed for 50% Likelihood of ≥1 Infected

<table>
<thead>
<tr>
<th>Rank</th>
<th>Zip Code Name</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22962 Lyndhurst</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>24174 Thaxton</td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>22969 Hanover</td>
<td>57</td>
</tr>
<tr>
<td>4</td>
<td>22967 Roseland</td>
<td>65</td>
</tr>
<tr>
<td>5</td>
<td>24312 Austville</td>
<td>65</td>
</tr>
<tr>
<td>6</td>
<td>24216 Appalachia</td>
<td>71</td>
</tr>
<tr>
<td>7</td>
<td>24200 Weber City</td>
<td>72</td>
</tr>
<tr>
<td>8</td>
<td>22482 Kilmarnock</td>
<td>75</td>
</tr>
<tr>
<td>9</td>
<td>24314 Bastian</td>
<td>75</td>
</tr>
<tr>
<td>10</td>
<td>22576 Weems</td>
<td>76</td>
</tr>
</tbody>
</table>

*Only includes zip codes with size ≥150 and no data code.

* Denotes zip codes with state prisons.

![Graph showing group size needed for 50% likelihood of ≥1 infected](image2)

Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2021-06-14.
Current Hot-Spots

Case rates that are significantly different from neighboring areas or model projections

- **Spatial**: Getis-Ord Gi* based hot spots compare clusters of zip codes with weekly case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations

- **Temporal**: The weekly case rate (per 100K) projected last week compared to observed by county, which highlights temporal fluctuations that differ from the model’s projections
Model Update – Adaptive Fitting
Adaptive Fitting Approach

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

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

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

- Allows for future “what-if” Scenarios to be layered on top of calibrated model
- Eliminates connectivity between patches, to allow calibration to capture the increasingly unsynchronized epidemic

**External Seeding:** Steady low-level importation

- Widespread pandemic eliminates sensitivity to initial conditions
- Uses steady 1 case per 10M population per day external seeding
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.
Seroprevalence updates to model design

Several seroprevalence studies provide better picture of how many actual infections have occurred

- CDC Nationwide Commercial Laboratory Seroprevalence Survey estimated 14.5% [12% – 18%] seroprevalence as of March 4th – 17th up from 10.5% a month earlier

These findings are equivalent to an ascertainment ratio of ~2x in the future, with bounds of (1.3x to 3x)

- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- This measure now fully tracks the estimated ascertainment over time
- Uncertainty design has been shifted to these bounds (previously higher ascensions as was consistent earlier in the pandemic were being used)

https://covid.cdc.gov/covid-data-tracker/#national-lab
Calibration Approach

• **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting

• **Calibration:** fit model to observed data and ensemble’s forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak

• **Project:** future cases and outcomes generated using the collection of fit models run into the future
  - Mean trend from last 7 days of observed cases and first week of ensemble’s forecast used
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories

Accessed 8:15pm August 17, 2021
https://www.vdh.virginia.gov/coronavirus/
Scenarios – Transmission Conditions

• Variety of factors continue to drive transmission rates
  • Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices

• Plausible levels of transmission can be bounded by past experience
  • Assess transmission levels at the county level from May 1, 2020 – Sept 1, 2020 or current, whichever is highest

• Projection Scenario:
  • **Adaptive-Delta**: Control remains as is currently experienced into the future with assumption that Delta continues to become more dominant
  • **Adaptive-Surge Control**: Starting now behaviors and mitigation efforts ramp up over a 2-week period culminating in a 25% reduction in transmission
  • **Adaptive-SpringControl**: Immediate return to the mean levels of transmission experienced in May 2021
Scenarios – Vaccination Conditions

Vaccine Characteristics

• **Pfizer/Moderna**: 50% after first dose, 95% after second dose (3.5 week gap)
• **J & J**: 67% efficacy after first (and only) dose
• Delay to efficacy from doses is 14 days, immunity lasts at least 7m (NEJM study)

Vaccine Administration Scenarios

• **Status quo (no label)**: COVIDcast corrected acceptance estimates (statewide mean is ~78%) reached by end of October.
• **Optimistic (VaxOpt)**: Expand VA mean acceptance to ~85% (with all counties reaching a minimum of 65%, max of 95%) by end of October
• Acceptance at county level = regional acceptance +/- relative current vax
• Front-loaded rollout (two-thirds of the remaining in half the time)

Source: https://ckelly17.github.io/vaccine_dashboard.html

Weekly VA doses administered by manufacturer

Monthly first doses

<table>
<thead>
<tr>
<th>Status</th>
<th>Date</th>
<th>Virus/Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status quo</td>
<td>2020-12-31</td>
<td>100.6K, 100.6K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-01-31</td>
<td>640.6K, 640.6K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-03-31</td>
<td>556.4K, 556.4K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-02-28</td>
<td>1.3K, 1.3K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-04-30</td>
<td>1.2K, 1.2K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-05-30</td>
<td>572.6K, 572.6K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-06-30</td>
<td>241.0K, 241.0K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-07-02</td>
<td>195.4K, 195.4K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-08-31</td>
<td>399.6K, 406.3K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-09-30</td>
<td>418.6K, 570.6K</td>
</tr>
<tr>
<td>Status quo</td>
<td>2021-10-31</td>
<td>206.3K, 277.7K</td>
</tr>
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<td>VaxOpt</td>
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</table>
Scenarios – Delta δ Variant Condition

Variant Delta δ has exhibited ability to outcompete other variants and now is dominant in the US and most states

Transmissibility: Delta’s relative transmissibility compared to Alpha is better understood (60% more transmissible) and its weighted growth fits a 60% growth advantage well

Immune Escape: Delta has been observed to evade immunity, both natural and vaccine-induced, however, uncertainty remains high thus this is NOT factored into the model

Severity: Delta, similar to Alpha, appears to cause more severe illness with estimates ranging from 50% to 200%, at the moment assume 60%

Delta Variant Scenario:
• Continues to grow on 60% more transmissible trajectory, reached 50% prevalence on June 29th and is also 60% more severe than Alpha

19-Aug-21
# Projection Scenarios – Combined Conditions

<table>
<thead>
<tr>
<th>Name</th>
<th>Txm Controls</th>
<th>Variant Boosting</th>
<th>Vax</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive-Delta</td>
<td>C</td>
<td>60%</td>
<td>SQ</td>
<td>Likely trajectory based on conditions remaining similar to now, but with increasing prevalence of Delta variant</td>
</tr>
<tr>
<td>Adaptive-Delta-VaxOpt</td>
<td>C</td>
<td>60%</td>
<td>VO</td>
<td>Vaccination through October reaches an optimistically high level of expanded coverage (85%), with increasing prevalence of Delta variant</td>
</tr>
<tr>
<td>Adaptive-SurgeControl</td>
<td>25%</td>
<td>60%</td>
<td>SQ</td>
<td>Transmission rates in the next month reduced through increased control from non-pharmaceutical interventions, with status quo vax and Delta</td>
</tr>
<tr>
<td>Adaptive-SpringControl</td>
<td>Spring</td>
<td>60%</td>
<td>SQ</td>
<td>Transmission rates return the rates experienced in May 2021 with status quo vaccination and increasing prevalence of Delta</td>
</tr>
</tbody>
</table>

**Transmission Controls:**
- **C** = Current levels persist into the future
- **25%** = Transmission rates are reduced by 25% with a gradual introduction, concluding in 4 weeks
- **Spring** = Transmission rates return to May 2021 levels

**Variant Boosting:**
- **None** = Variety of variants, no future txm boosting, but with severity impacts from current levels
- **60%** = Prevalence of Delta ramps up according to logistic growth and is 60% more transmissible

**Vaccinations:**
- **SQ** = Status quo acceptance leads to low rates of vaccination through the summer
- **VO** = Vaccination acceptance optimistically expands with increased rates through the summer
Model Results
Outcome Projections

Confirmed cases
Virginia Daily Confirmed - Comparison

- Adaptive-Delta
- Adaptive-Delta-VaxOpt
- Adaptive-SpringControl
- Adaptive-SurgeControl

Estimated Hospital Occupancy

Daily Deaths
Virginia Daily Death - Comparison

Death ground truth from VDH “Event Date” data, most recent dates are not complete

Daily Hospitalized
Virginia Daily Hospitalized - Comparison
District Level Projections: Adaptive-Delta

Projections by Region

Projections by District

Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario.
District Level Projections: Adaptive-Delta-VaxOpt

Projections by Region

- Near SW
- Northwest
- Northern
- Far SW
- Central
- Eastern

Projections by District

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

Projections by Region

Projections by District

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

Projections by Region

Near SW  Northwest  Northern
Far SW  Central  Eastern

Projections by District

Daily confirmed cases rate (per 100K) by District (grey with 7-day average in black) with simulation colored by scenario
Virginia’s Progress on Population Immunity

Natural Immunity and Vaccines combine to produce a population level of immunity

- Duration of immunity from infection with SARS-CoV2 still not well understood
  - We assume a conservative 6 month period of protection for these calculations
  - Do not factor in variant immune escape
  - Natural immunity is well calibrated to recent seroprevalence surveys

- Vaccine induced immunity is likely to last longer, we assume indefinite protection
  - This also assumes that all administered vaccines remain protective against current and future variants

- Population immunity depends on a very high proportion of the population getting vaccinated
  - Current models track measured seroprevalence

* As of August 15, 2021 (updated to account for entire population)
**Hospital Demand and Bed Capacity by Region**

*Assumes average length of stay of 8 days*

**Capacities** by Region – Adaptive-Delta
COVID-19 capacity ranges from 80% (dots) to 120% (dash) of total beds

Adaptive-Delta scenario shows that if the Delta fueled surge continues unabated:
- Eastern, Southwest and Northwest could approach initial capacities

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

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

• **Case rates in Virginia continue to rise quickly amidst a background of surges across the nation**

• VA mean weekly incidence up to 24/100K from 14/100K, US up to 38/100K (from 25/100K)

• Vaccination rates continue to pick speed and acceptance among the unvaccinated persists

• Projections continue to show significant uptick in activity, with larger growth possibly fueled by Delta’s increasing prevalence, even in areas with high vaccination coverage

• Recent updates:
  • Updated Surge Control scenario to commence sooner as mask use has increased recently
  • Adjusted hospitalization and death modeling to adapt to the observed impacts of Delta

• 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
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 8 in planning
- Round 7 now available

**Round 4 Results were published May 5th, 2021 in MMWR**
COVID-19 Scenario Modeling Hub – Round 7

Round 7 scenarios explore the effects of a variant similar to Delta (B.1.617.2) against different backgrounds of vaccination. Includes some vax escape

Vaccinations by Nov 30
- LowVacc – 70% overall coverage
- HighVacc – 80% overall coverage

Emerging Variant Impact (5% prevalence on May 29th)
- LowVar – 40% more transmissible
- HighVar – 60% more transmissible

https://covid19scenariomodelinghub.org/viz.html
Modeling Hub – Round 7 Prelim Results

https://covid19scenariomodelinghub.org/viz.html
## COVID-19 Scenario Modeling Hub – Round 8 (ongoing)

Round 8 scenarios targeted at exploring the effect of waning immunity (natural and vaccine-induced) and varying levels of protection after waning

### Waning Rates
- Slow – exp. waning with mean=3yrs
- Fast – exp. waning with mean=1yr
- No waning (Sc A) as baseline

### Protection after Waning
- Age stratified protection from infection
- 80% or 90% protection from hosp/death

<table>
<thead>
<tr>
<th>Slow Waning</th>
<th>Fast Waning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Protection</strong></td>
<td><strong>Low Protection</strong></td>
</tr>
<tr>
<td>Scenario A</td>
<td>Scenario B</td>
</tr>
<tr>
<td>No Waning:</td>
<td>Waning:</td>
</tr>
<tr>
<td>- Vaccine-induced and natural immunity retain their initial protection throughout the simulation period</td>
<td>- Exponentially distributed immune waning with mean of 1 year (time to transition to partially immune state)</td>
</tr>
<tr>
<td>In partially immune state:</td>
<td>In partially immune state:</td>
</tr>
<tr>
<td>- Protection from infection is:</td>
<td>- Protection from infection is:</td>
</tr>
<tr>
<td>- 70% ≤ 65yrs</td>
<td>- 50% ≤ 65yrs</td>
</tr>
<tr>
<td>- 35% &gt; 65yrs</td>
<td>- 25% &gt; 65yrs</td>
</tr>
<tr>
<td>- Protection from hospitalization and death is 80%</td>
<td>- Protection from hospitalization and death is 80%</td>
</tr>
</tbody>
</table>

See detailed notes on each scenario below
- Slow waning of natural and vaccine-induced immunity (from no waning to exponential waning with mean of 3 yrs)
- Fast waning of natural and vaccine-induced immunity (exponential waning with mean of 1 year)

[https://covid19scenariomodelinghub.org/](https://covid19scenariomodelinghub.org/)
Data Recommended Mobile Vax Clinic Sites

Detailed and Timely Locations

Data Delivered and Disseminated to Locals
Provides a list of areas most visited by a given demographic group based on SafeGraph mobility data that links visits to specific sites and the home Census Block Group of the anonymized visitors.

Demographic Groups: Black, Lantinx, Young Adults (20-40), Unvaccinated, and Whole Population

Data Included: Rank, Weight, most visited Day of Week, Highly Visited Address, and Lat-Long of area

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

Example: List of location in the Southside frequented by 20-40 year olds.
Data Recommended Mobile Vax Clinic Sites

Overlap of locations between groups

Different groups visit different areas
- Least overlap between Black and Latinx
- Overlap in ages highest, but drops with large gap
- Districts have different overlap patterns
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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Supplemental Slides
Agent-based Model (ABM)

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

- Assess the impact on transmission under different conditions
- Assess the impacts of contact tracing

**Synthetic Population**
- Census derived age and household structure
- Time-Use survey driven activities at appropriate locations

**Detailed Disease Course of COVID-19**
- Literature based probabilities of outcomes with appropriate delays
- Varying levels of infectiousness
- Hypothetical treatments for future developments