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UNIVERSITY OF
VIRGINIA

Epidemic modeling of COVID-19 Impact in Virginia



BIOCOMPLEXITY INSTITUTE

Acknowledgments

- Biocomplexity Institute & Initiative
 - Using big data and simulations to understand massively interactive systems
 - Over 20 years of crafting and analyzing infectious disease models
 - Pandemic response and support for Influenza, Ebola, Zika; **COVID-19 support for VA and DoD.**
- Network Systems Science & Advanced Computing Division



- Sponsors

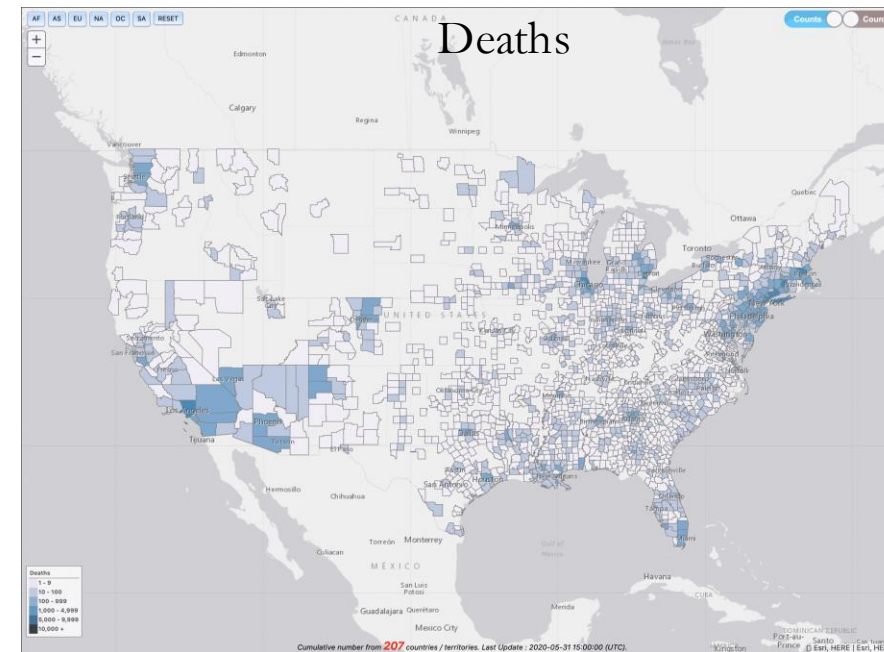
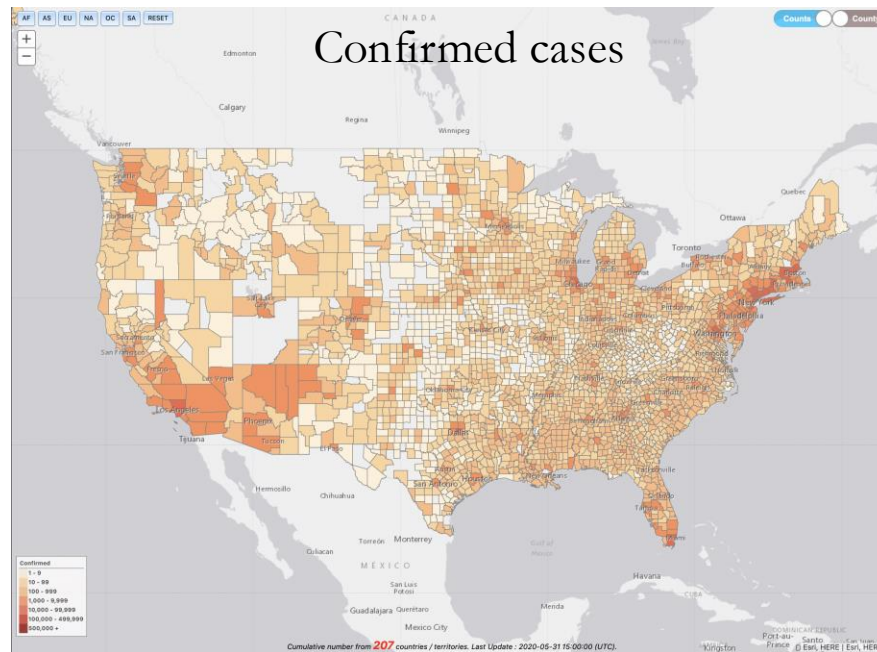


<https://covid19.biocomplexity.virginia.edu>

COVID-19 in the United States

- US deaths reach 100k on May 26th
- 1.8M confirmed cases with 1.3M active*
- 21% Case Fatality Rate[^] among the resolved cases.

USA			
⬆ 8,054 1,321,501	⬆ 16,183 1,826,506	⬆ 539 105,858	⬆ 7,590 399,147
Active	Confirmed	Deaths	Recovered



Source: COVID-19 Surveillance Dashboard <https://nssac.bii.virginia.edu/covid-19/dashboard/>

*as of Jun 1st

[^]Deaths/(Deaths+Recovered).

Overestimate due to incomplete recovery data

Radiating from Urban to Rural

*"Rural America is a geographic area that continues to face significant **health care workforce shortages** at a time when the **population is elderly**, with a higher percentage of **chronic health issues**"*

*"It's really **challenging to do track-and-trace** when you have to drive 45 minutes to an hour to get to the next town."*

*...are all going to be at the **same Walmart**. They're all going to be at the **same grocery store**. They're all going to be at the same post office.*

*The pandemic that first struck in major metropolises is now increasingly finding its front line in the country's rural areas; counties with acres of farmland, **cramped meatpacking plants**, **out-of-the-way prisons** and few hospital beds.*

*"There are a lot of important heterogeneities within states and counties that determine the trajectory of epidemics, so **state-wide or even county-wide easing of restrictions** will lead to problematic outbreaks in under-resourced rural areas."*

COVID-19 Now Reaching Into Rural America | Health News | US News

U.S. News & World Report · 19 days ago



COVID-19 now spreading fastest in small, rural counties | TheHill

The Hill · 16 days ago



Covid-19's deadly new surge is in rural America as states re-open

The Washington Post · Yesterday



As country heals, pandemic sweeps through rural counties

NBCNews.com · 2 hours ago

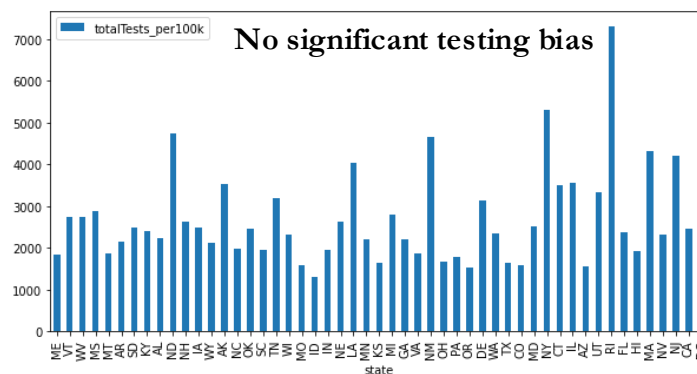
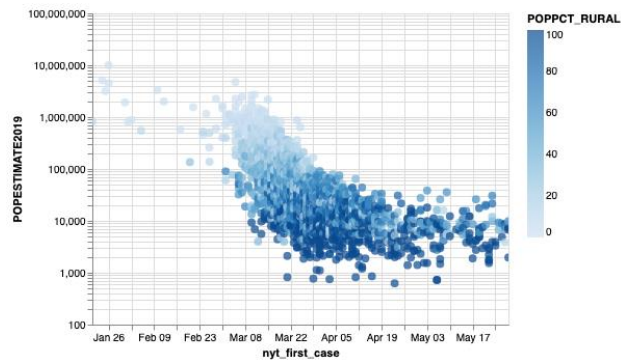


Rural counties and localized outbreaks

Emergence:

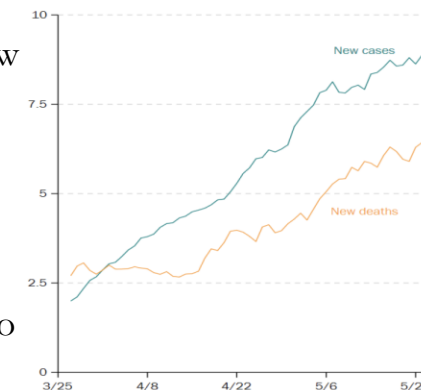
Urban counties (prior to Mar 15th)

Rural counties (after Mar 15th)



Increased percentage of new cases from rural counties

- 2% in late March
- 8% in late May
- Several rural counties experiencing spikes due to localized outbreaks



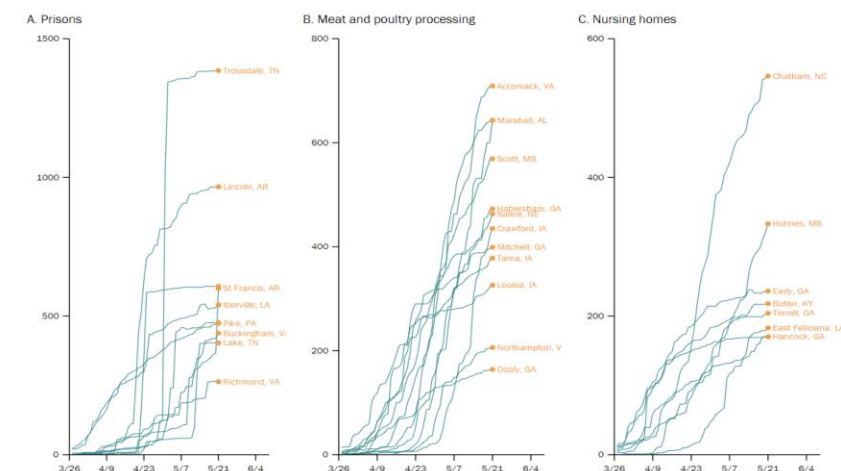
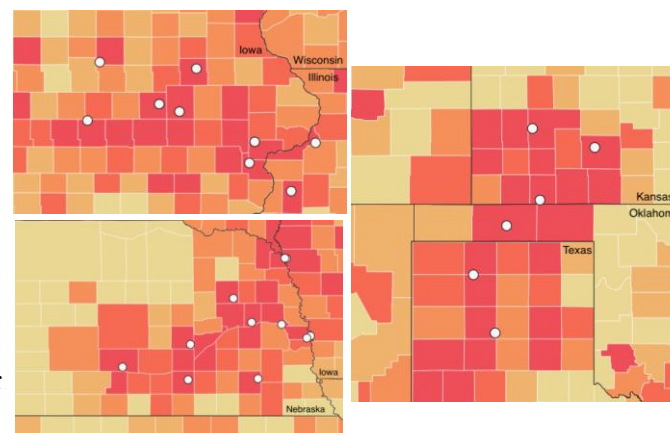
Rural Counties with Covid-19 Cases from Meatpacking Have Infection Rates 5 Times Higher

A one-of-a-kind data set shows the statistical relationship between meatpacking and the spread of Covid-19 in rural America. Information compiled by the Food & Environment Reporting Network shows how meatpacking counties have some of the highest infection rates in the United States.

By Leah Douglas and Tim Marema — On May 28, 2020 — Last updated May 29, 2020

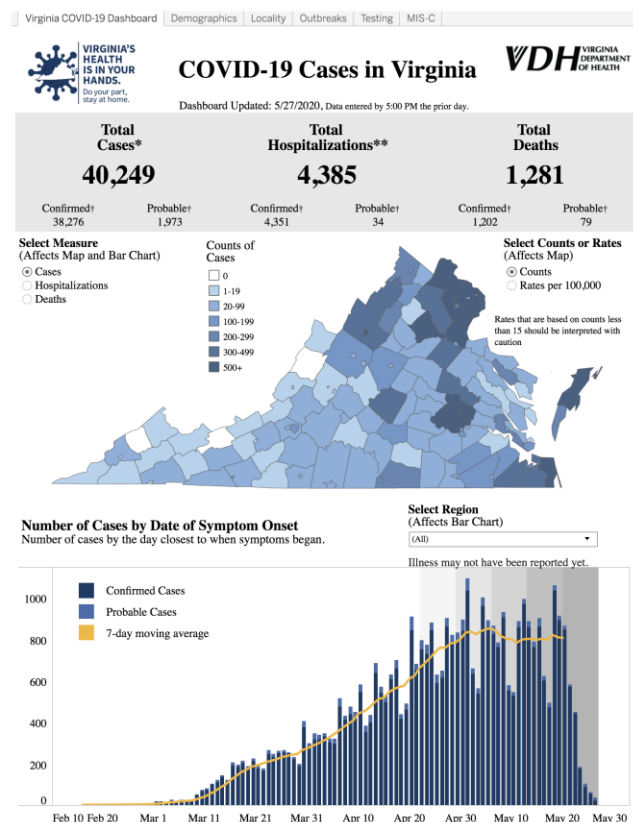
CORONAVIRUS AGRICULTURE

Source: Daily Yonder



Source: Cohen P.N. (2020), European Journal of Environment and Public Health

VDH Dashboard - UVA Model



Accessed 9:30am May 27, 2020

<https://www.vdh.virginia.gov/coronavirus/>

Weekly Executive Summary



May 29, 2020

KEY TAKEAWAYS

- Public health restrictions paused the epidemic in Virginia and bought time
- Data suggests social distancing is already relaxing
- Statewide, the reproduction rate dropped below 1.0 on May 15. It averaged 2.2 prior to March 15
- Days from onset to diagnosis have dropped ~30% in recent weeks, from 6.8 April to 4.7 in early May
 - This suggests increased testing is improving detection

<https://www.vdh.virginia.gov/coronavirus/covid-19-data-insights/>

682,882

Cases Avoided so far

0.971

Reproduction Rate
 Based on onset date
 14 days ending May 16

Interactive County level forecasts



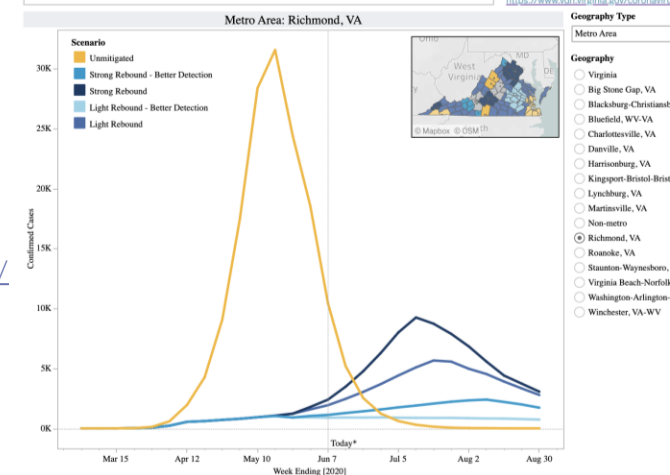
UVA COVID-19 Model Explorer



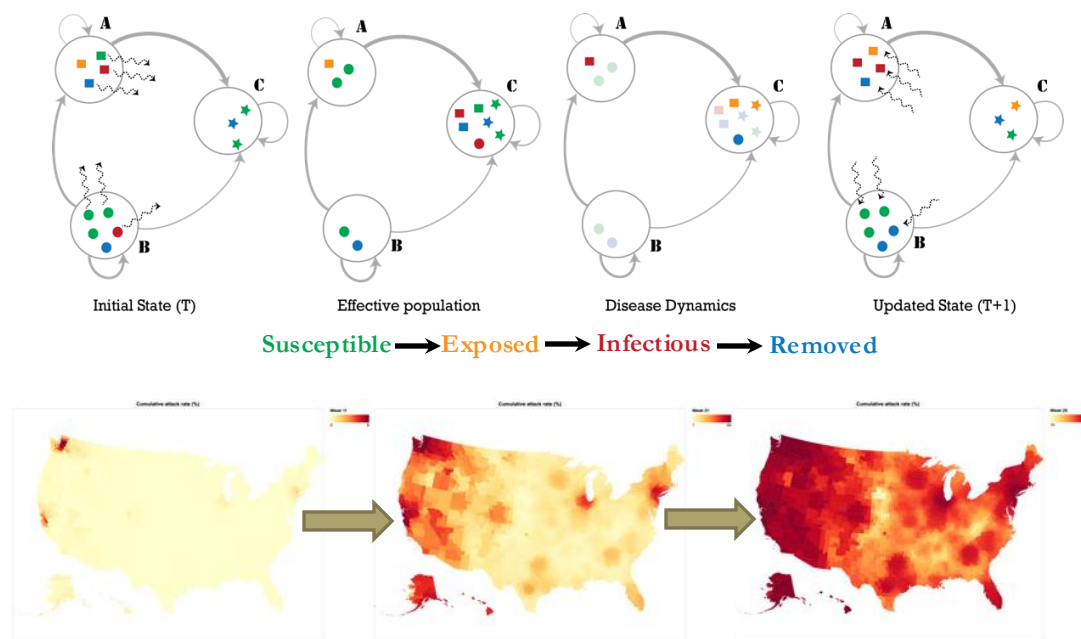
The model estimates that the community mitigation strategies employed in Virginia have prevented **129,687** confirmed cases in **Richmond, VA** so far. If **Richmond, VA** experiences better case detection and a light rebound in COVID-19 cases after public health restrictions are lifted, the model estimates new confirmed cases already peaked at **1,029** per week during the week ending **May 17, 2020**. However, if the rebound is strong and detection does not improve, the model forecasts new confirmed cases will peak at **9,251** per week during the week ending **July 12, 2020**. The Virginia Department of Health is working to increase testing and is hiring over 1,300 contact tracers, investigators and other personnel to improve detection.

Estimated Impact of Community Mitigation		
Scenario	Confirm of Cases † by To.	Confirm of Cases † by To. Avoided
Light Rebound - Better Detection	6,753	-129,687
Strong Rebound - Better Detection	6,871	-129,569
Light Rebound	7,761	-128,679
Strong Rebound	7,967	-128,473
Unmitigated	136,439	0

† Model estimates only. For case counts visit: <https://www.vdh.virginia.gov/coronavirus/>



Modeling Framework



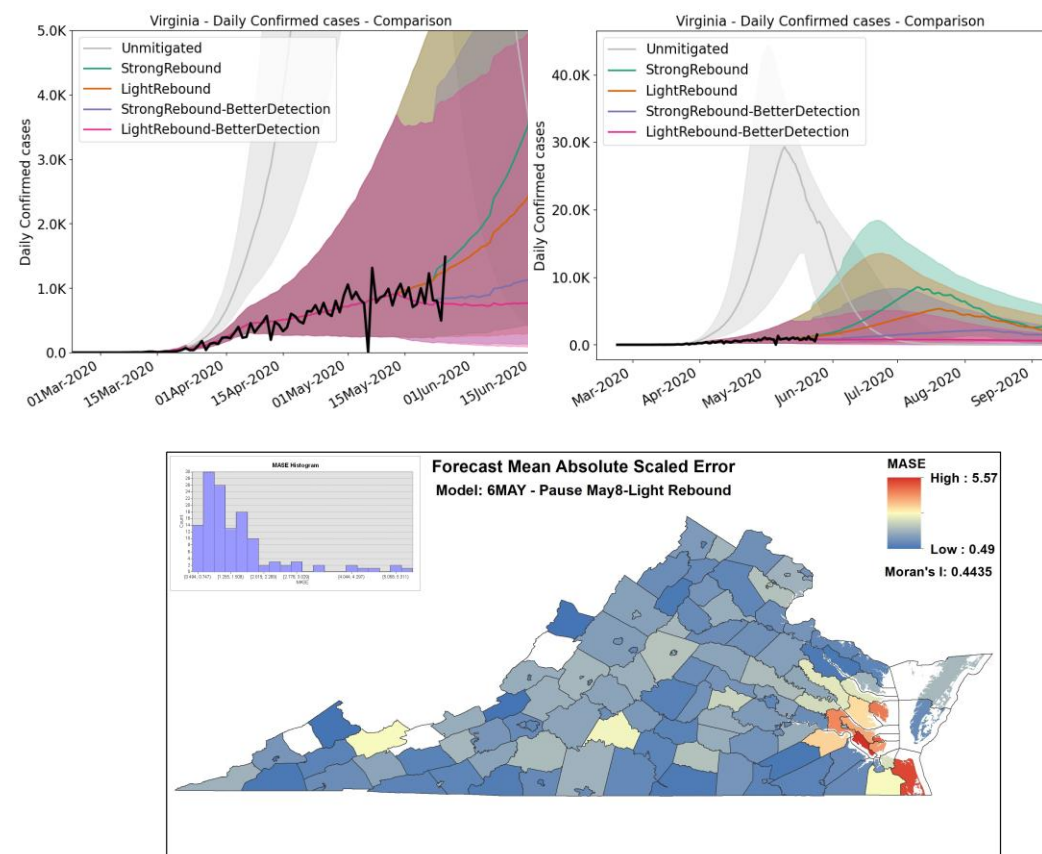
Metapopulation model (PatchSim)

- Represents each population and its interactions as a single patch
- 133 patches for Virginia counties and independent cities

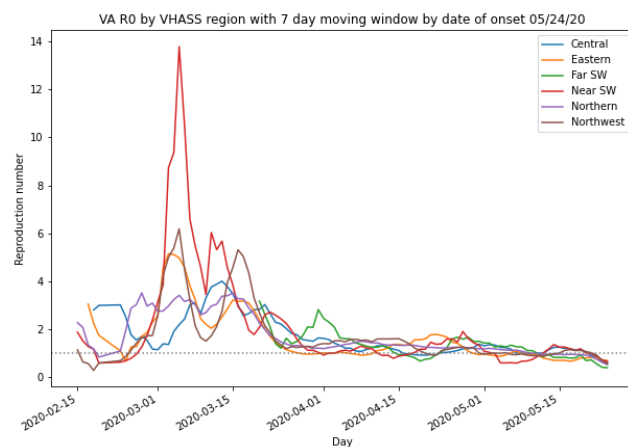
Extended SEIR representation (include asymptomatic infections)

Mitigations can affect both disease dynamics and population interactions

Scenario based projections



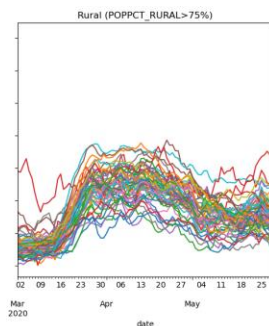
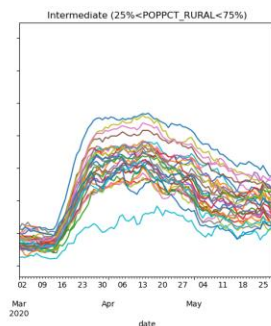
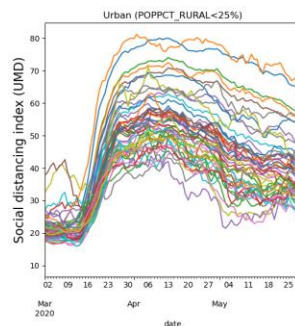
Additional Analytics



Effective Reproduction Number

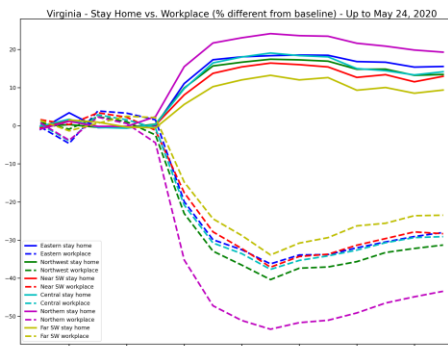
Significant variability in Social Distancing Index between Urban and Rural VA counties:

<https://data.covid.umd.edu> (as of May 29th)

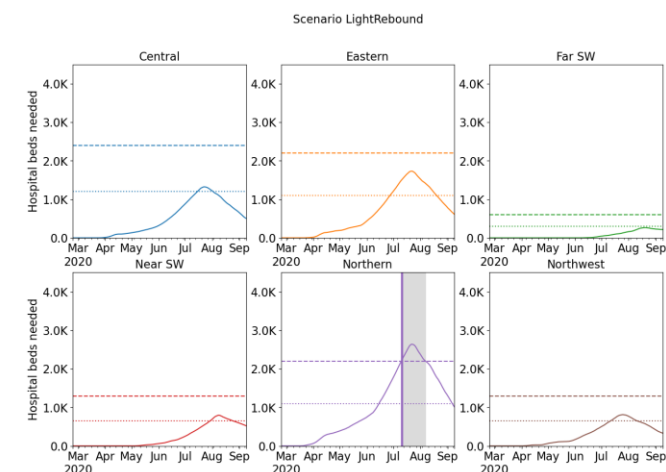


Mobility data shows VA greatly reduced activities, though outdoor activities rebounding:

<https://www.google.com/covid19/mobility/> (as of May 24th)

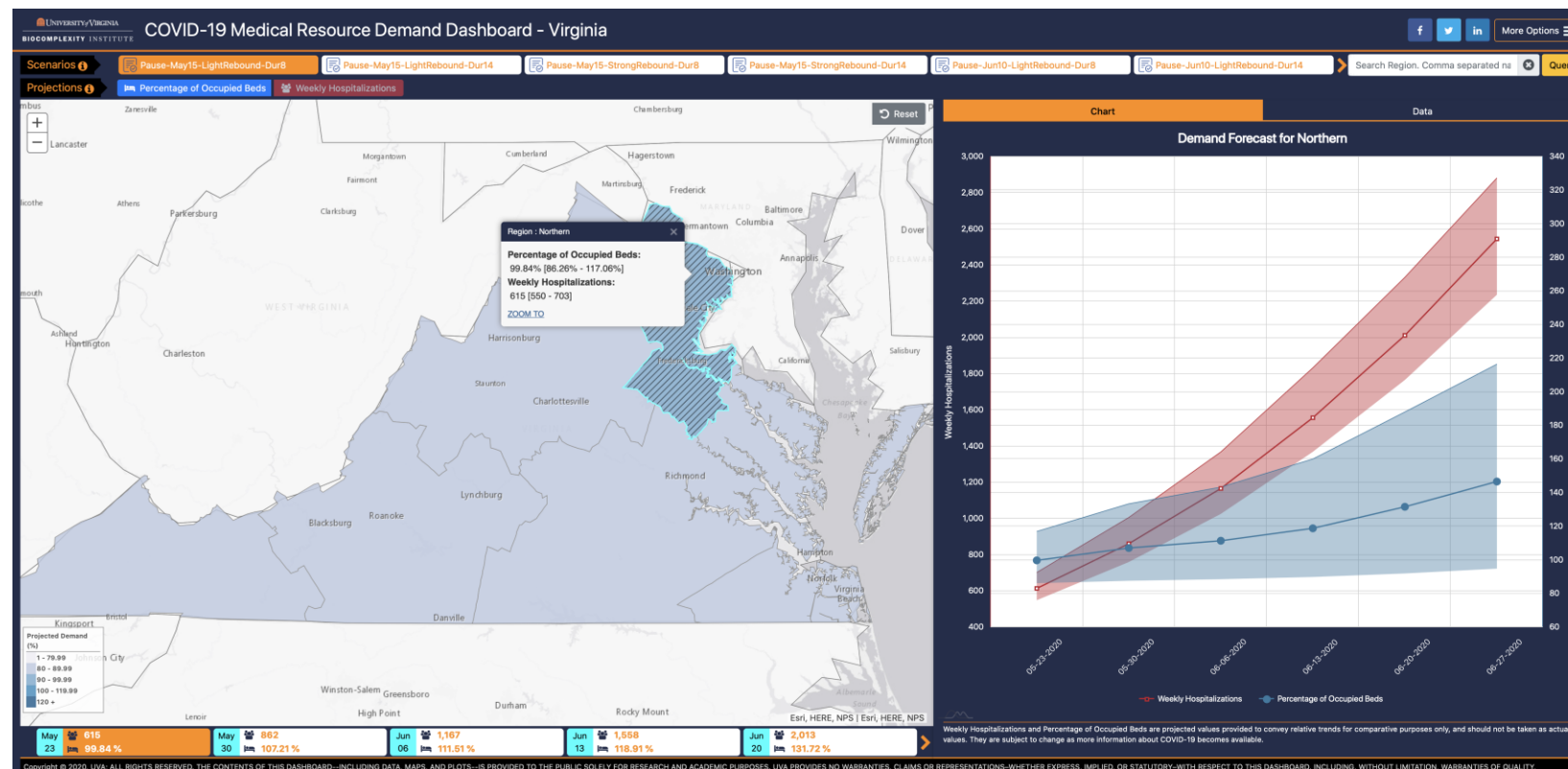


Hospital Surge



Scenario		Date Ranges
1	Strong	Late June to Mid August
2	Light	Mid July to Early Aug
3	Strong – Better Detection	None
4	Light – Better Detection	None
5	Unmitigated	Mid April to Late June

Resource Demand



Agent-based models

Social heterogeneity

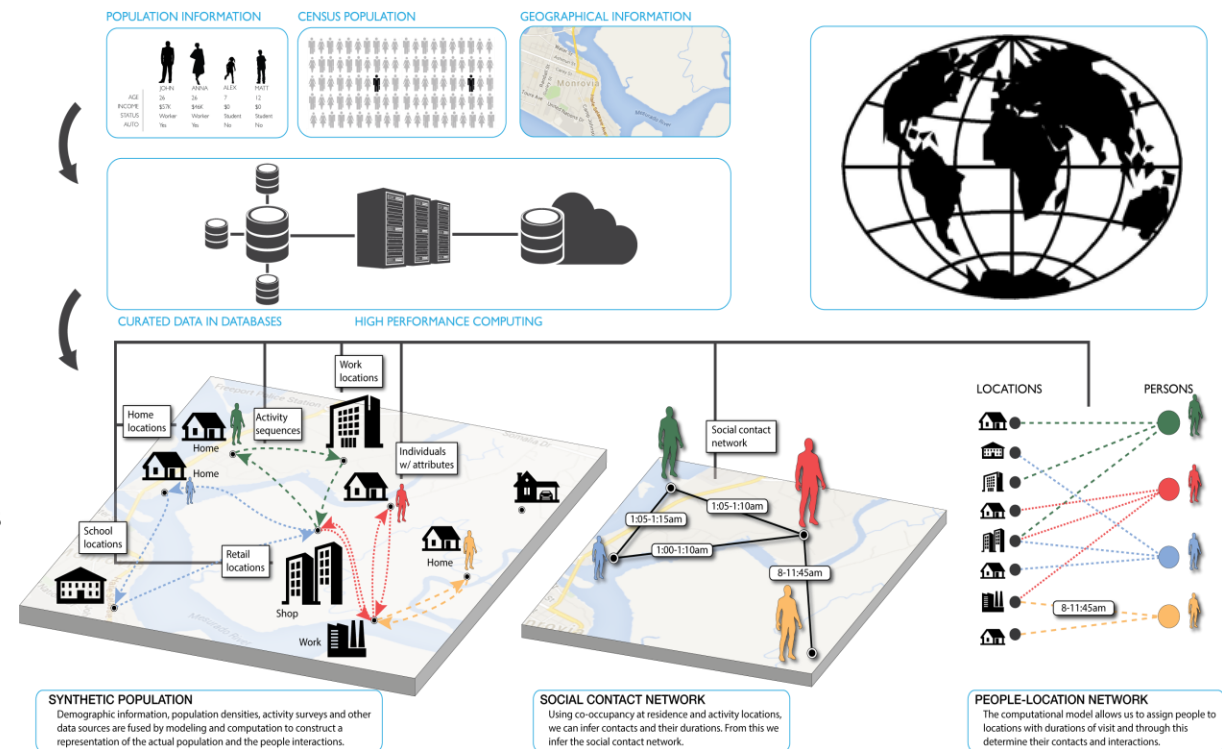
- Individual level agent-based model
- Realistic activity schedules and locations
- Explicitly captures urban/rural differences
- Social contact network based interventions

Disease model

- Age/Risk stratified probabilities/delays for outcomes (from literature)
- Varying levels of infectiousness
- Hypothetical treatments for future developments

Case studies

- Impact of improved testing
- Better quantification of stay-at-home effect
- Assisting contact tracing efforts



Implications for Modeling and Response

- Severity parameters stratified by age and underlying health conditions
- Incomplete disease and behavioral data (testing bias, mobility data);
- Calibrating across spatial resolutions is hard
- Inability to explain localized outbreaks (nursing homes, prisons, meat plants)
- Reopening is tied to inter-county (i.e., rural-urban) commutes
- Economic impact (unemployment rates) likely higher in rural areas
- Coordinating policies across the state and county levels
- Logistics planning by incorporating access disparities

Questions?

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