

QuaranTeam 2

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GOALS

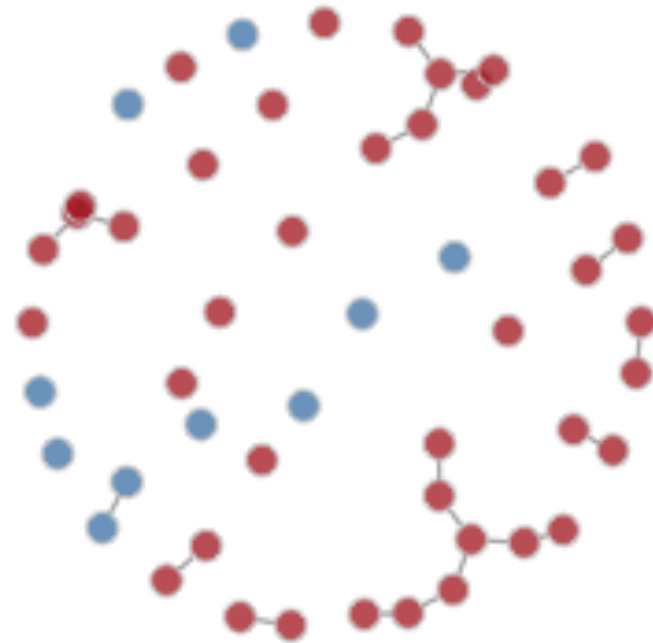
- Predict if particular counties or regions will be able to meet the capacity of care.
- Design strategies that could be used to ensure that adequate care is provided across the state of Maryland.

TOOLS

EpiModel provides tools for simulating and analyzing mathematical models of infectious disease dynamics.

Kepler is a geospatial data analysis tool that we've used to help us locate high-risk and highly infected counties in Maryland.

R and **Rstudio**, **Python** and **Jupyter Notebook**.



COVID-19 DISEASE RATES

Estimated Model Parameters

- Reproduction Number (R_0): 1.5 ~ 3.5
- Overall Fatality Ratio: 1.38% (adjusting for demography and under-ascertainment)
- Recovery Time: 24.7 days
- Hospitalization Rate: 4%
- Activity Rate: # of transmissive acts per person per day
 - $\log_{10}(\text{pop_density})$ per county
- Time steps: 90 days

SCENARIOS

No intervention

- “Business as usual”

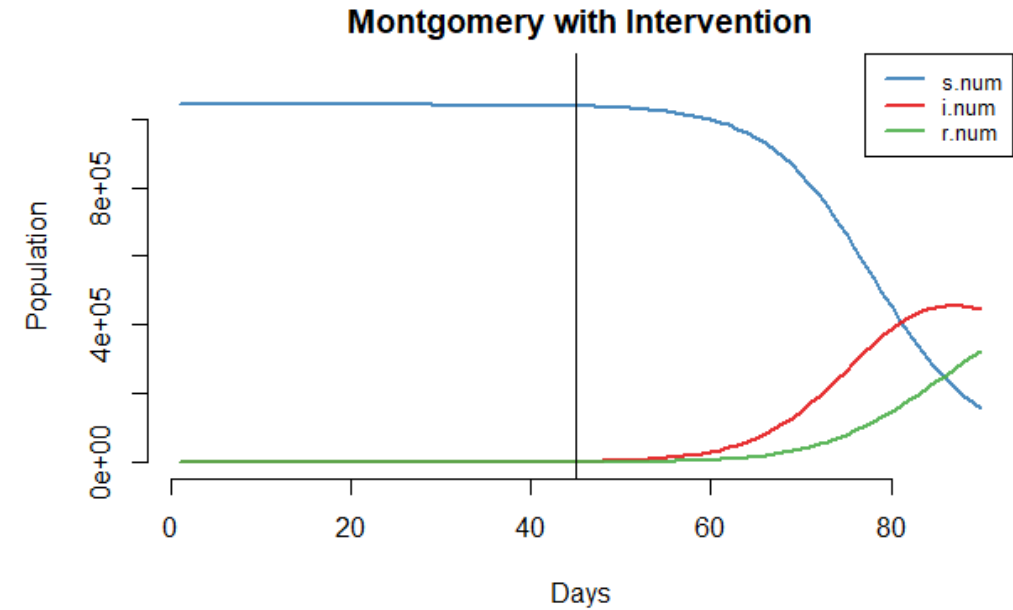
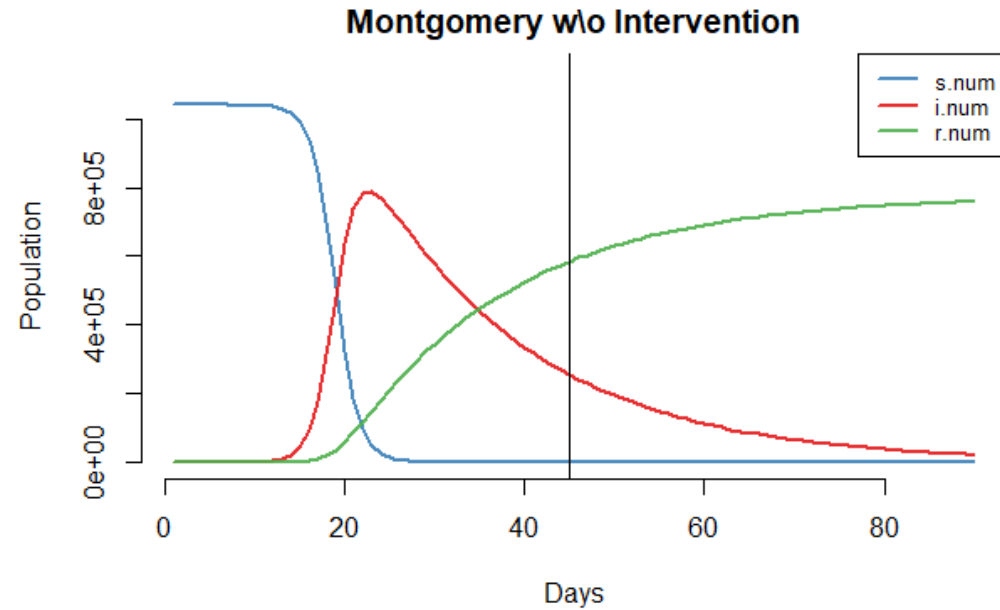
Intervention

- Simulating statewide stay-at-home order plus enhanced hygiene practices
- Basically our current “social distancing” strategy



Towson, Maryland – The Baltimore Sun

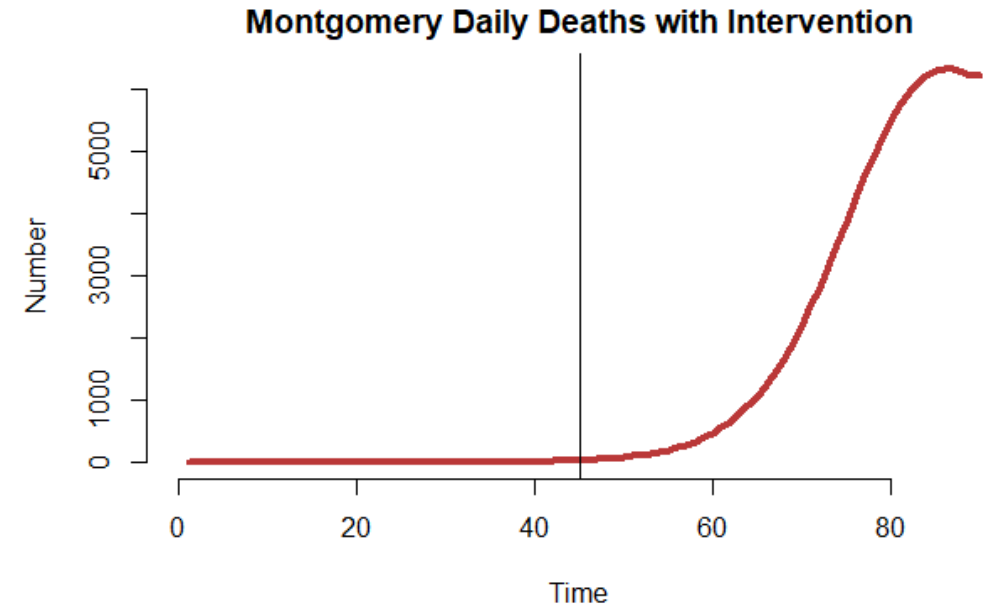
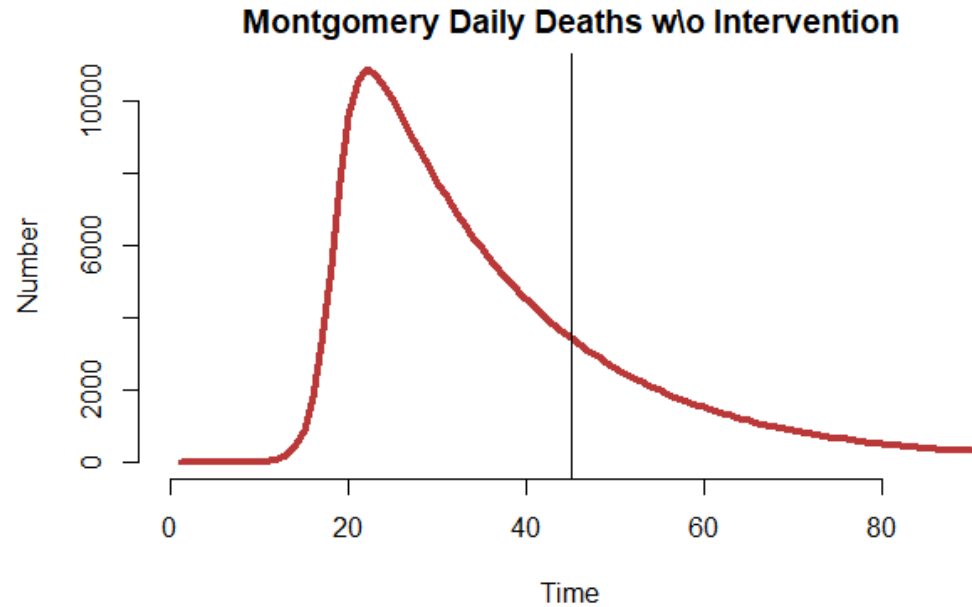
FLATTENING THE CURVE



These plots show the number of susceptible (s.num), infected (i.num), and recovered (r.num) people in Montgomery county over two 90-day simulations, each starting with one infected person on day one. The vertical line denotes day 45, which approximates the number of days since Maryland confirmed its first COVID-19 case on March 4, 2020.

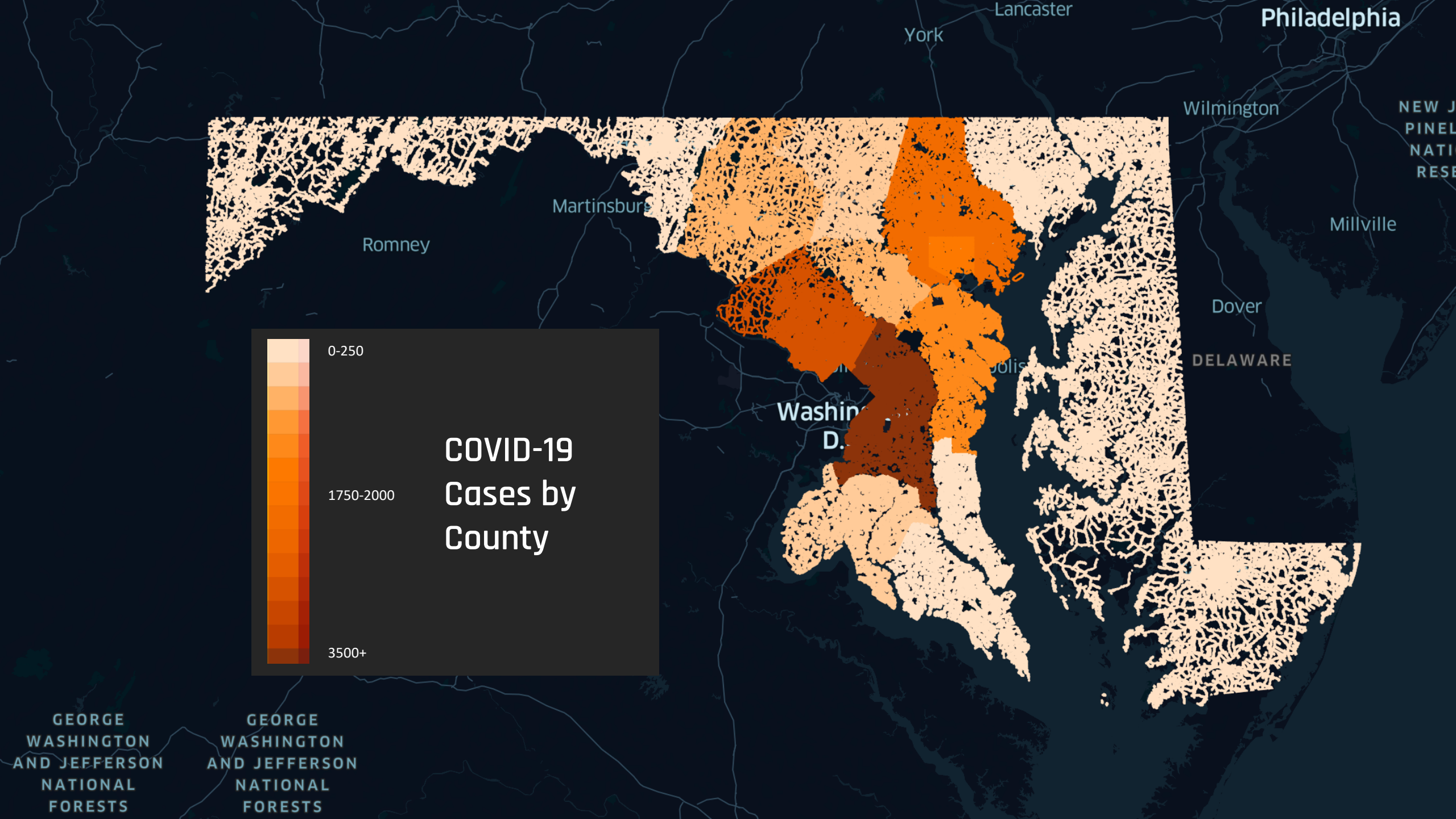
Intervention dramatically decreases the peak of the infection curve and the total number of infected, reducing the overall burden on the healthcare system.

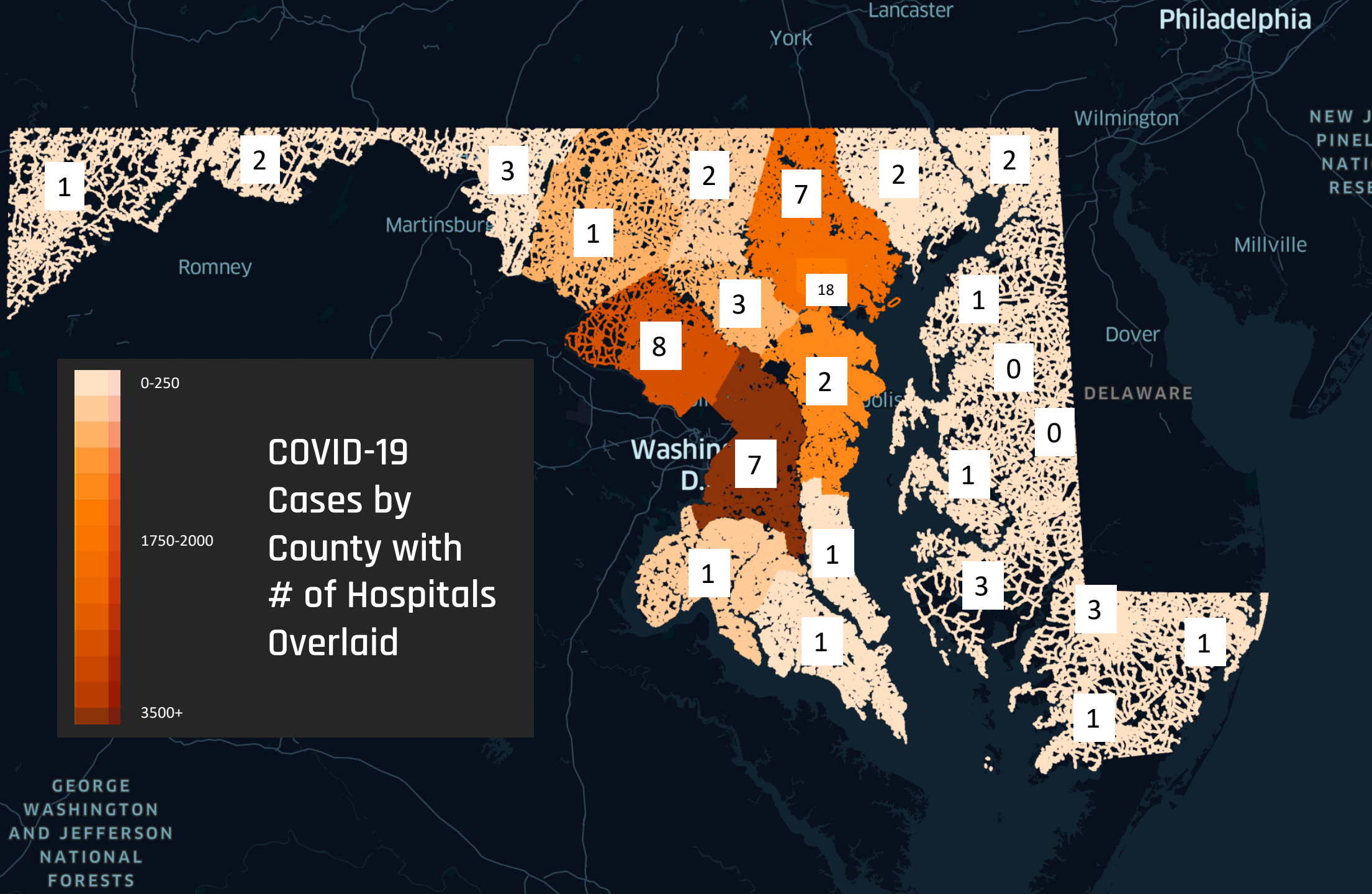
EFFECT ON MORTALITY



These plots show the number of daily deaths in Montgomery county over two 90-day simulations, each starting with one infected person on day one. The vertical line denotes day 45, which approximates the number of days since Maryland confirmed its first COVID-19 case on March 4, 2020.

Intervention decreases the total number of fatalities and gives mortuary service providers time to prepare for the increasing workload.





MODEL ACCURACY

This table compares the number of confirmed cases in Maryland on April 18, 2020 – approximately 45 days since the first confirmed case in the state on March 4, 2020 – with the number of predicted cases 45 days since the start of the model simulation with intervention.

Most of the variation can probably be explained by the change in commuting patterns during the statewide stay-at-home order.

- For example, the model over-predicted the number of cases in Baltimore City, but absent the daily commuter population, the probability of transmission greatly declines.
- Whereas many Prince George's county residents provide essential services to the capital and cannot work from home, increasing their risk of transmission.

Improvements to the model would need to consider the unique network and temporal interactions of the population, which is a current topic of academic research.

County	Actual Cases	Predicted Cases	Difference
Allegany	33	90	-57
Anne Arundel	1005	863	142
Baltimore City	1378	2347	-969
Baltimore County	1664	1203	461
Calvert	109	156	-47
Caroline	33	44	-11
Carroll	308	249	59
Cecil	131	143	-12
Charles	347	136	211
Dorchester	20	10	10
Frederick	557	239	318
Garrett	4	15	-11
Harford	195	344	-149
Howard	508	1173	-665
Kent	16	16	0
Montgomery	2404	2352	52
Prince George's	3160	2027	1133
Queen Anne's	24	40	-16
St. Mary's	101	69	32
Somerset	10	14	-4
Talbot	16	32	-16
Washington	116	204	-88
Wicomico	138	148	-10
Worcester	31	29	2

Predictions for the 45th day since the first confirmed infection versus confirmed cases in Maryland approximately 45 days since the first confirmed case on March 4, 2020.

EFFECTS OF INTERVENTION

This table shows the number of days it takes to fill the ICU and inpatient hospital beds in each county without intervention and with intervention.

It also shows the maximum number of infected persons per scenario.

Maryland's statewide stay-at-home order reduced the transmissivity rate by approximately 72%.

County	No Intervention			With Intervention		
	Days Until ICU Beds Filled	Days Until All Beds Filled	Maximum Infected	Days Until ICU Beds Filled	Days Until All Beds Filled	Maximum Infected
Allegany	13	20	49147	60	Below Capacity	7022
Anne Arundel	13	16	420110	51	67	216708
Baltimore City	14	17	466468	57	70	270204
Baltimore County	13	16	617853	53	67	336626
Calvert	11	17	63657	49	74	16778
Caroline	NA	NA	21607	NA	NA	1805
Carroll	11	16	119208	48	68	38207
Cecil	12	16	71413	51	73	15587
Charles	13	17	109598	58	74	16270
Dorchester	NA	23	19007	NA	Below Capacity	103
Frederick	NA	17	176287	NA	73	42828
Garrett	15	22	17980	80	Below Capacity	241
Harford	12	16	180250	49	67	65708
Howard	11	14	234666	44	57	131151
Kent	NA	24	12052	NA	Below Capacity	276
Montgomery	13	16	787623	50	63	457205
Prince George's	12	15	684806	46	59	393775
Queen Anne's	NA	NA	32297	NA	NA	1635
St. Mary's	13	18	75210	62	84	4789
Somerset	NA	24	15626	NA	Below Capacity	203
Talbot	NA	21	24017	NA	Below Capacity	1027
Washington	13	17	105828	55	76	28797
Wicomico	13	18	71221	58	82	16427
Worcester	NA	19	33039	NA	Below Capacity	876

RECOMMENDATIONS

Short-term

- There are increasing case numbers in high population counties, so counties with lower case numbers and more healthcare resources could ideally send skilled nurses/physicians to assist in the high-risk counties.
 - These healthcare providers should be compensated for the extra work and travel.
 - National Guard forces could be deployed systematically to support COVID-19 negative patients in counties with low risk and less need for skilled nursing/physician care.

Long-term

- Focus on continued distancing practices and slow reintegration of gatherings.
- Plan for the inevitable surge of cases.
 - Designate overflow hospitals/floors that are prepared for isolating COVID-19 positive patients.
 - Having a plan in place to move the negative patients to “safe” hospitals, and move positive patients to the overflow hospitals will allow for a rapid response to a sudden surge in positive cases.
 - For example: Harford and Carroll counties have 2 hospitals. Baltimore and Baltimore City counties will have significantly more cases and more hospitals, and so patients that are COVID-19 negative could be moved to the “quieter” hospitals in Harford and Carroll in the event of a sudden surge in hospitalizations.

REFERENCE

Slide 3

- Jenness SM, Goodreau SM and Morris M. EpiModel: An R Package for Mathematical Modeling of Infectious Disease over Networks. Journal of Statistical Software. 2018; 84(8): 1-47.
- Kepler (<https://kepler.gl/>)

Slide 4

- [https://www.thelancet.com/journals/laninf/article/PIIS1473-3099\(20\)30243-7/fulltext](https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30243-7/fulltext)

Slide 5

- <https://www.baltimoresun.com/maryland/baltimore-county/towson/cng-tt-coronavirus-streets-towson-pg-20200415-baob2hrv4fgknc6uac6niddwmbe-photogallery.html>

Slide 9

- <https://coronavirus.maryland.gov/>