WISCONSIN DEPARTMENT of HEALTH SERVICES

Johns Hopkins Modeling WI COVID-19 - GOAL

Dr. Shaun Truelove simulated six scenarios representing the impact of interventions on Wisconsin's COVID-19 outbreak, based on methodology developed by Johns Hopkins University Infectious Disease Dynamics group. The goal is to extract information useful for making decisions about policy and resource allocation.

BACKGROUND

The Johns Hopkins University Infectious Disease Dynamics (JHU-IDD) methods have been adopted by FEMA for decision-making. These methods are based on models that have proven successful for understanding the impact of nonpharmaceutical interventions during the 1918 influenza pandemic. The JHU-IDD methods apply models and parameters that are perhaps the most widely used for understanding the COVID-19 pandemic.

Nonetheless, there is no quantitative method for forecasting the COVID-19 outbreak over a six-month period; the JHU-IDD report states that its collection of scenarios is "not a forecast." Our objective in reviewing the JHU-IDD report is to

- **Identify features in these scenarios that may be useful in decision-making.**
- **Identify support for these features from independent work so that they can be used in decision-making.**

SUMMARY

We identified five important results in the JHU-IDD report. We feel that these results have been, or will soon be, supported by independent research or calculation.

1. The simulations predict that Wisconsin's interventions (school closing, Safer-At-Home order) are having an impact.

   The JHU-IDD scenarios suggest that, without interventions, Wisconsin would experience at least threefold excess deaths and a sixfold higher number of patients needing beds than Wisconsin hospitals can provide. To study this independently, we compared the initial period of the outbreak to the current period (early April) of the outbreak. Our analysis demonstrates a substantial reduction in the case growth rate (i.e., an increase in the doubling time) beginning in mid-late March following the implementation of public health interventions in Wisconsin. While we cannot definitively establish a cause-effect relationship, many studies reported a slowing of the growth rate in communities or countries after interventions.

2. The timing of a substantial late peak will be determined by the lifting of the Safer-At-Home order and comprehensive testing.

   The JHU-IDD presents scenarios during which the Safer-At-Home order persists for one, two, and three months, but no follow-up testing and isolation. Each of these scenarios

exhibits a similarly shaped and substantial peak that **would dramatically overflow hospital resources**. As stated above, we find the existence of this late substantial peak very credible based on independent peer-reviewed research that describes influenza outbreaks. The UW-Madison agent-based model will serve as an independent estimation of the magnitude of this late peak.

3. The intervention scenarios suggest that we should think of our outbreak in terms of two plans: a plan for acute challenges to hospital capacity and a plan to suppress or mitigate a second wave.

   The demand on hospital resources over time can be substantially different between scenarios. The simulations suggest that we should express our conclusions in terms of short- and long-term plans. All scenarios suggest that demand will exceed hospital resources in the short term, and highlight the need for a long-term plan to suppress a substantial later peak.

4. The outbreak will strain Wisconsin hospital capacity during April.

   JHU-IDD statewide and county-level projections suggest that patients will exceed bed capacity in mid-April or early May. We find short-term resource capacity to be a significant concern based on independent short-term modeling of confirmed cases (cases that have been or will ultimately be confirmed as COVID-19). We note that the JHU-IDD scenarios suggest a more significant number of cases than does the Washington Institute for Health Metrics and Evaluation (IHME) model. We strongly prefer the JHU-IDD scenarios based on our independent calculations.

5. Comprehensive testing is an important tool for suppressing or delaying the substantial second component

   With comprehensive testing and isolation, the magnitude of the number of cases in Wisconsin will be below the threshold of hospital capacity. We find this credible based on South Korea's success in testing and isolation. We also find this result credible as long as, given time to prepare before lifting of the Stay-At-Home order, Wisconsin can develop comprehensive testing and isolation operations.

RESULTS

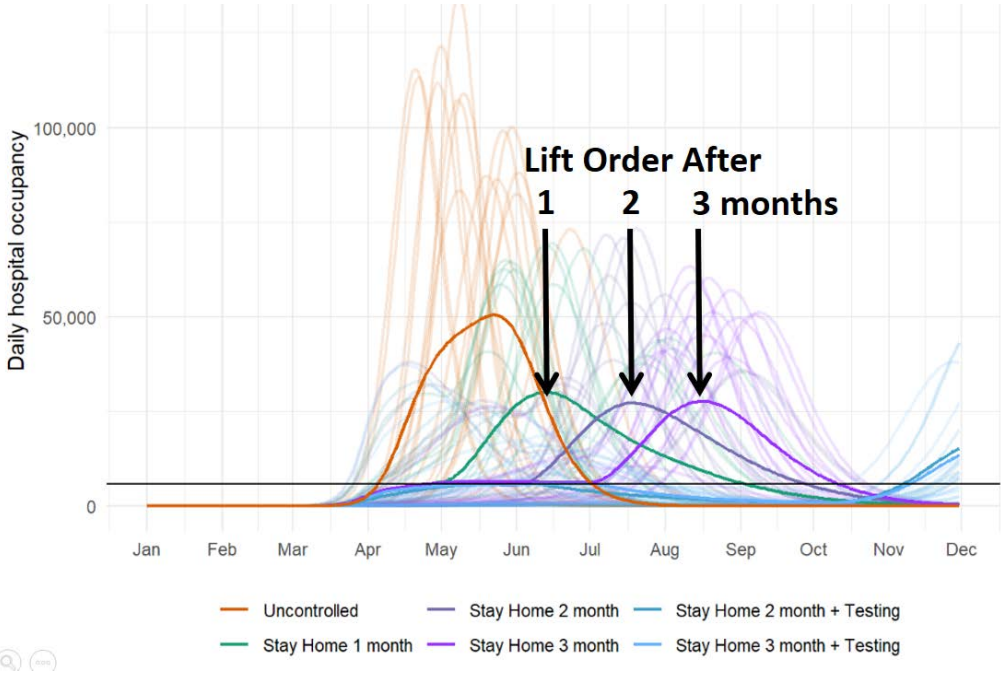
We provide additional detail to support each of the five results.

1. The simulations suggest that Wisconsin's interventions (school closing, Safer-At-Home order) are having an impact.

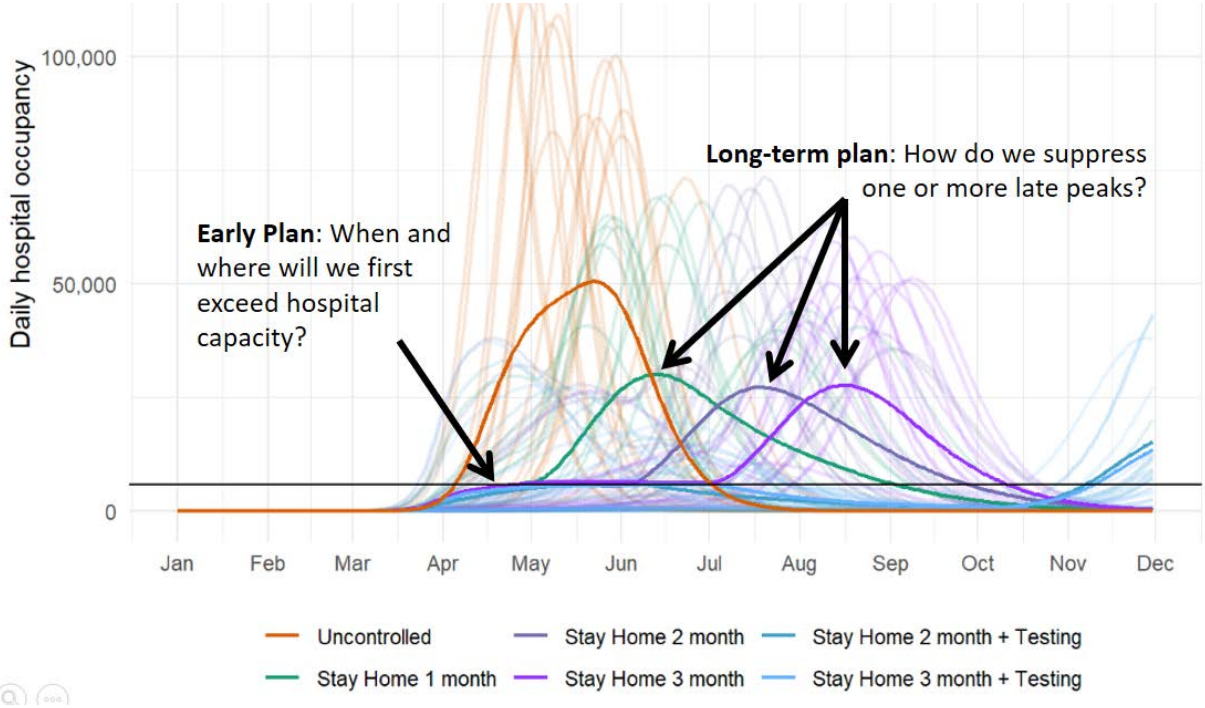
   Under the uncontrolled scenario, the JHU-IDD simulation suggests 7,500 deaths by May 1 and a maximum hospital bed occupancy of 94,000. In contrast, five scenarios that include the Safer-At-Home order suggest 2,400 or fewer deaths. We are confident with this conclusion because we have independently compared the growth rate of the epidemic before school closings and after the Safer-At-Home order. We find that the growth rate of the epidemic has slowed.

2. The timing of a substantial second peak will be determined by the lifting of the Safer-At-Home order and comprehensive testing.

   We identified, on their figure, the peaks that occur following lifting of the Stay-At-Home order after one, two, or three months, but without comprehensive testing. We find the existence of these peaks, as well as the timings, to be credible based our understanding of the current literature. We await comparison with the UW-Madison model.



3. The intervention scenarios suggest that we should think of our outbreak in terms of two plans: a plan for acute challenges to hospital capacity and a plan to suppress or mitigate a second wave.



The figure above shows the complex structure of hospital occupancy time series. Each of the six dark lines represents the hospital occupancy over time for a scenario, described in the legend. Each scenario has a peak, and each will have a second wave, even though the diagram only shows the second peaks starting to emerge for three of the scenarios. “Stay Home” refers to the Safer-At-Home order while “Testing” refers to intensive testing and isolation, similar to that implemented in South Korea. Under testing and isolation, all symptomatic cases are tested and all cases testing positive are isolated. Contact tracing is also implemented, and the close contacts of all individuals testing positive are also tested and isolated if testing positive.

While the uncontrolled outbreak (orange line) has one substantial, relatively early, peak, the three ”Stay Home” curves have an initial plateau and a substantial later peak, and the two ”Stay Home + Testing” curves have one early, relatively modest peak through October. The simulations suggest that we should express our conclusions in terms of short- and long-term plans. All scenarios suggest that demands will exceed hospital resources in the short term and the scenarios collectively highlight the need for a long-term plan to suppress a substantial late peak.

4. The outbreak will strain Wisconsin hospital capacity during April.

   The JHU-IDD intervention scenarios suggest that hospital capacity will be exceeded during April (Table 1). The JHU-IDD report provides county-level predictions of the dates on which ICU capacity will be exceeded (Table 2).

Peak Hospital Occupancy in Period		
Stay Home 1 month	**13,100**	100- 73,600
Stay Home 2 month	**11,900**	100- 71,700
Stay Home 2 month + Testing	**10,100**	100- 66,100
Stay Home 3 month	**13,800**	200- 77,400
Stay Home 3 month + Testing	**11,400**	100- 74,900
Uncontrolled	**94,200**	3,700-255,300

Table 1. Maximum demand for hospital occupancy

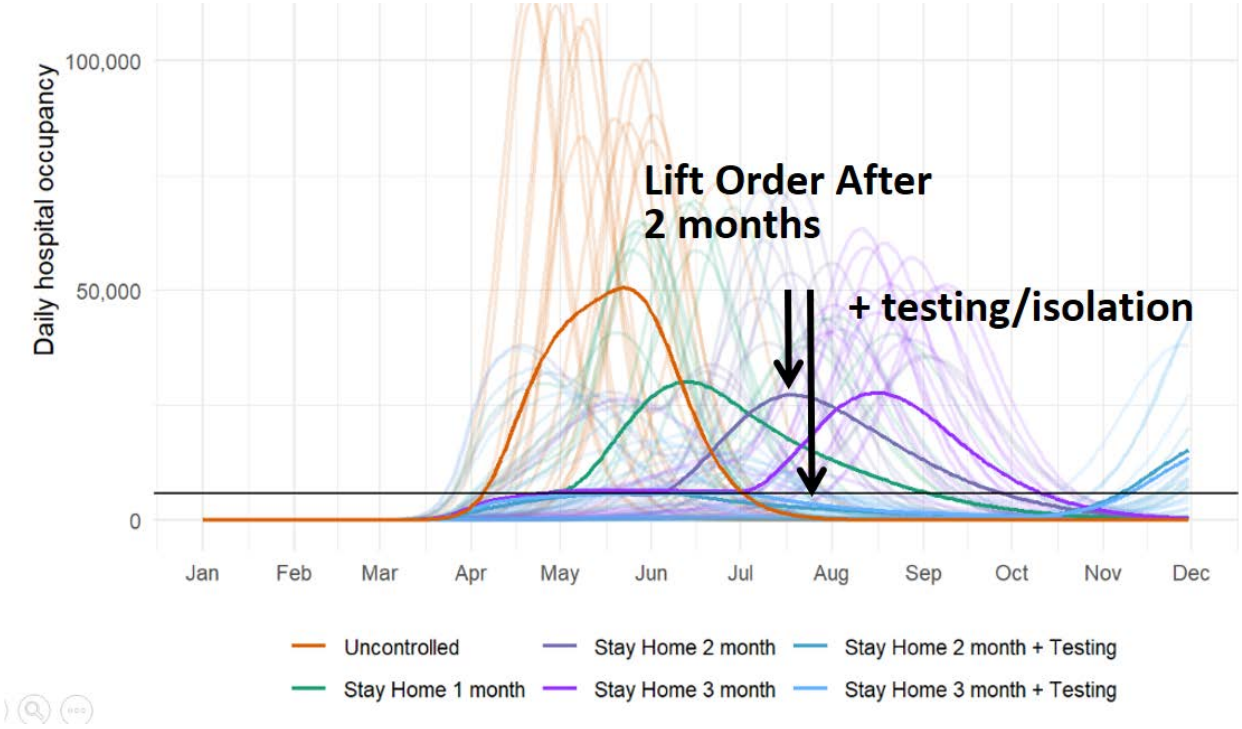
Table 2. JHU-IDD forecasts, by county, of the date on which resource capacity will be exceeded under Scenario 2.

County	Date ICU capacity exceeded.
Kenosha	April 29
Racine	May 6
Waukesha	May 6
Dane	May 11
Milwaukee	May 21

While we cannot independently confirm long-term projections, preliminary calculations based on short-term projections suggest that we should proceed with the JHU-IDD projections.

5. Comprehensive testing is an important tool for suppressing or delaying the substantial second component

   We are most impressed by the predictions associated with comprehensive testing. In the figure below we identify the second wave peak that is expected after a two-month Safer-At-Home order is lifted, as well as the same stay-at-home scenario complemented with aggressive testing and isolation. The two scenarios predict extraordinarily different consequences with respect to hospital capacity overages, cumulative cases, and death by Dec 1.



QUESTIONS OR CONCERNS

1. Are the short-term hospital capacity calculations provided by JHU-IDD overly pessimistic; IHME predictions do not suggest this level of concern and we are no are longer seeing substantial growth in the number of new cases each day?

   Based on the last few days, the count of new daily cases has levelled, but not for enough days to declare a trend. We have technical concerns about using either IHME or current counts for forecasting hospital capacity. We feel the possibility exists that both underestimate case counts in Wisconsin. Regarding IHME, it relies heavily on the idea that Wisconsin's outbreak will follow the trend experienced by other regions. If Wisconsinites were more responsive than other regions to a "Safer at Home" type of directive, the curve will be more flat, which will result in more days of high admissions, and a stronger rebound when the directive is lifted. Given that the result of under-estimating cases is more Wisconsinites losing their lives, it seems prudent to be cautious.

Regarding daily case counts, we cannot rule out the possibility that current case counts reflect the confirmation process rather than growth of the epidemic. Until we can resolve these technical concerns we prefer to rely on JHU-IDD projections.

2. What value of R0 (the basic reproduction number; the number of cases directly generated by one case in a population where all individuals are susceptible to infection) is being used for simulations?

   Our simulations were based on R0 drawn from a uniform distribution between 2 and 3. Interventions reduce R0 to prescribed distributions of extents. We discussed the choice of SEIR (a statistical model based on a Susceptible, Exposed, Infected and Recovered population) parameters, based on both R0 and the serial interval, with Shaun Truelove. Briefly, our choice of R0 and serial interval must be matched with each other and with the population. Shaun expressed concern about applying the new R0 to Wisconsin, but we agreed that we will study the effect of varying R0 on our five conclusions once we are running the simulations ourselves.

SUMMARY OF HOSPITAL RESOURCE CAPACITY RESULTS FOR TWO PLANS

Table 3. Projected counts of hospital occupancy and ICU capacity at peak, as well as cumulative deaths and infections.
We provide counts for two periods: Plan 1 = Acute, through May 1 and Plan 2= Peak, which varies by scenario.
Scenarios are 1) Uncontrolled, 2) Safer-At-Home, 1 month, 3) Safer-At-Home, 2 months, 4) Safer-At-Home, 2months + Test/isolate, 5) Safer-At-Home 3, months, and 6) Safer-At-Home, 3months + Test/isolate

	Period[1]		Hospital Occupancy[1]		ICU Capacity[2]		Ventilator Need[3]		Cumulative Deaths[1]		Cumulative Infections[1]	
Scenario	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2
1	1-May	5/1-7/1	94,200	182,000	22,600	86,900	15,820	60,830	7,500	43,200	1,977,400	3,271,300
2	1-May	5/1-7/1	13,100	90,400	4,800	36,700	3,360	25,690	2,200	21,900	422,900	2,684,200
3	1-May	7/1-9/1	11,900	87,400	4,500	41,000	3,150	28,700	2,100	25,900	373,800	2,311,800
4	1-May	9/1-12/30	10,100	34,200	3,600	7,800	2,520	5,460	1,600	10,000	311,300	954,500
5	1-May	7/1-9/1	13,800	73,300	5,200	34,700	3,640	24,290	2,400	20,000	423,200	2,472,800
6	1-May	9/1-12/30	11,400	30,800	4,400	9,200	3,080	6,440	2,100	8,900	360,400	849,100

[1] From JHU-IDD report Table 1, which provides total number of cases within the specified time interval, but does not include ICU or Ventilators.

[2] From JHU-IDD report Tables 2-7, which provide ICU "daily peak capacity" through the end of the specified period up to Oct 1.

[3] Ventilator estimates are estimated based on the percent of ICU cases that were under ventilations in the US (Seattle 70%)