NEUBERGER | BERMAN

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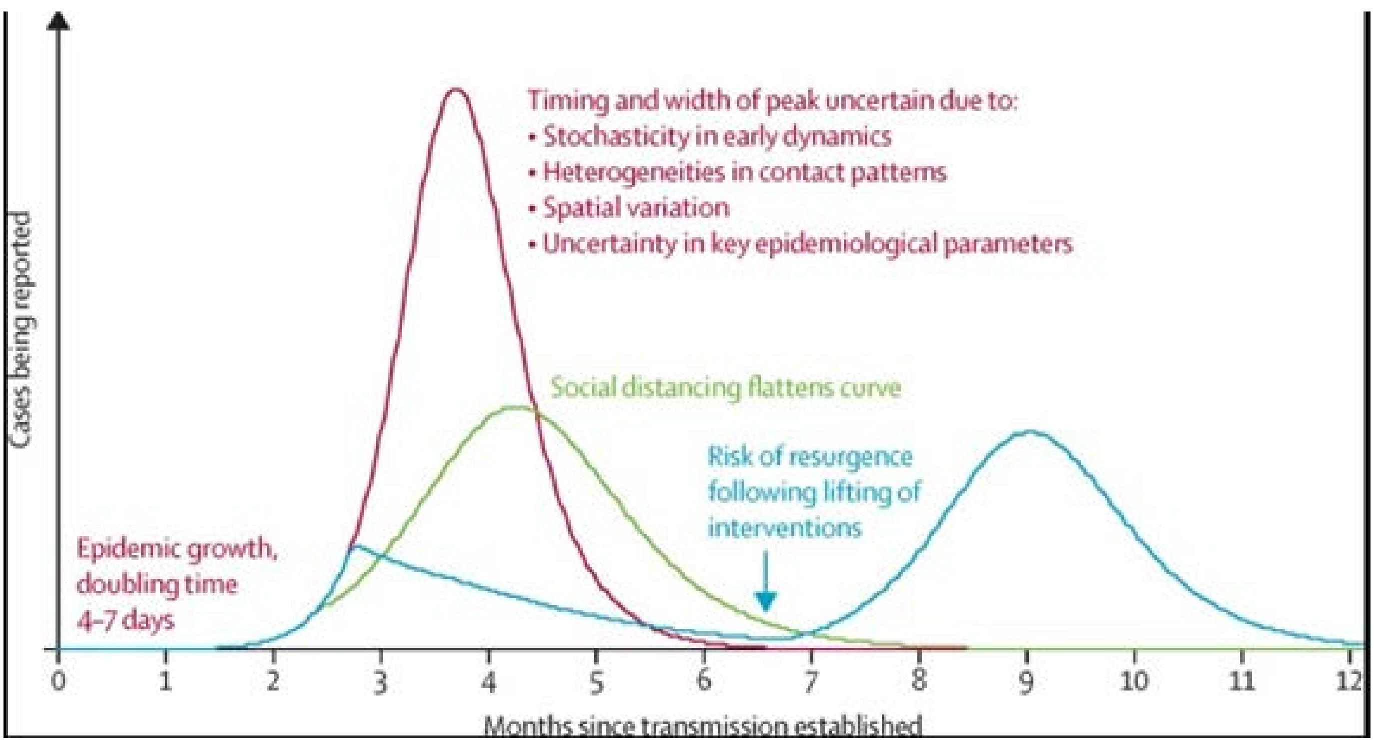
April is the Cruelest Month

When will the peak arrive, and when can we restart the economy?

This epidemic has occurred so quickly, has so dramatically damaged world economies, and there are so many views about how serious it is. Mostly, everyone wants to know if we are implementing the right policies, when the virus will peak, and when we can restart the economy. Many forecasts, including the model from the Institute for Health Metrics and Evaluation (IHME), predict a peak in April, at least for the states with the most advanced epidemics. We forecast that U.S. deaths will likely increase by 23,000 to 42,000 by the week of April 13, and could peak in New York on April 19. In this note, we provide some framing of the dynamics of epidemics, and the impact of different policies and end states.

What Is an Epidemic? Can the Models Tell Us Anything Useful?
Let's first consider a simple model of an epidemic. The graph below shows the progression of an epidemic under the three key different types of policy.

Epidemic Progression and Policy Model



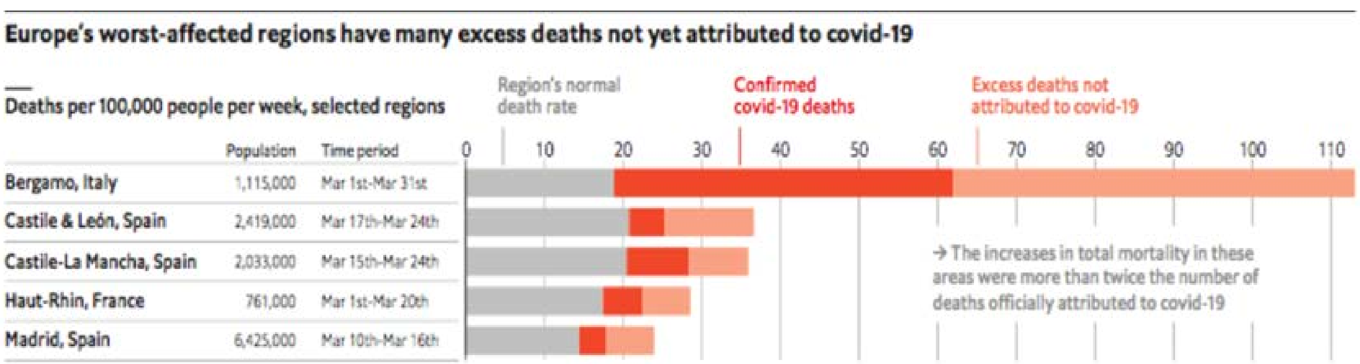
Source: R.M. Anderson et al, *The Lancet* 3/9/2020.

'Do Nothing' Policy
First, consider the policy colored red in the figure. In this approach, nothing is done to stop the epidemic. The number of cases (or hospitalizations, or deaths) grows exponentially from month zero to month three or four. The rate of doubling is determined by how infectious the disease is. The key parameter is R0, or the average number of people infected by an infected person. If R0 is 1.7 the number of cases doubles every day; if it is 1.1 the number of cases doubles every week (just like the "rule of 72").

The red curve peaks and returns to zero because the rate is not just R0, it is R0 times St (susceptibility), which is called Rt. At some point, the epidemic cannot continue to grow because there are no more people to infect. The average number of people that can be infected by an infected individual at some time in the progression (Rt) is R0 times the percentage of the population that is still susceptible. If everyone is susceptible, we just have Rt equals R0—and the exponential growth part of the curve (months zero to four in the plot). As many infected people recover and become immune, St becomes smaller and Rt becomes smaller. If Rt is less than one (as with negative rates), the curve is in exponential decline, and it returns to zero.

The advantage of the red curve is that the experience is over as fast as possible—a short, sharp shock to the healthcare system and society. The disadvantage is not knowing what fraction of the population will be killed, and the scale of resulting economic and social shock. The best estimates for this number are about 1% (in the Imperial College model a 0.9% death rate times 75% of population of 327 million), hence a 2.2 million people estimate for the United States. As the R0 of the virus decreases, due to increasing herd immunity, it only reaches 75% of the population. In this policy, the fatality rate could also be higher if hospitals have insufficient capacity. See the recent data below from Italy and Spain, where a comparison is made between the current rate of death and the historically expected rate for the month of March. The data supports that less than half of these deaths were attributed to COVID-19. Hospitals can help save people, but may have difficulties performing this function if they are at capacity.

Excess Deaths Not Tied to Coronavirus



Source: gap.ecdc.europa.eu/public. As of April 2, 2020.

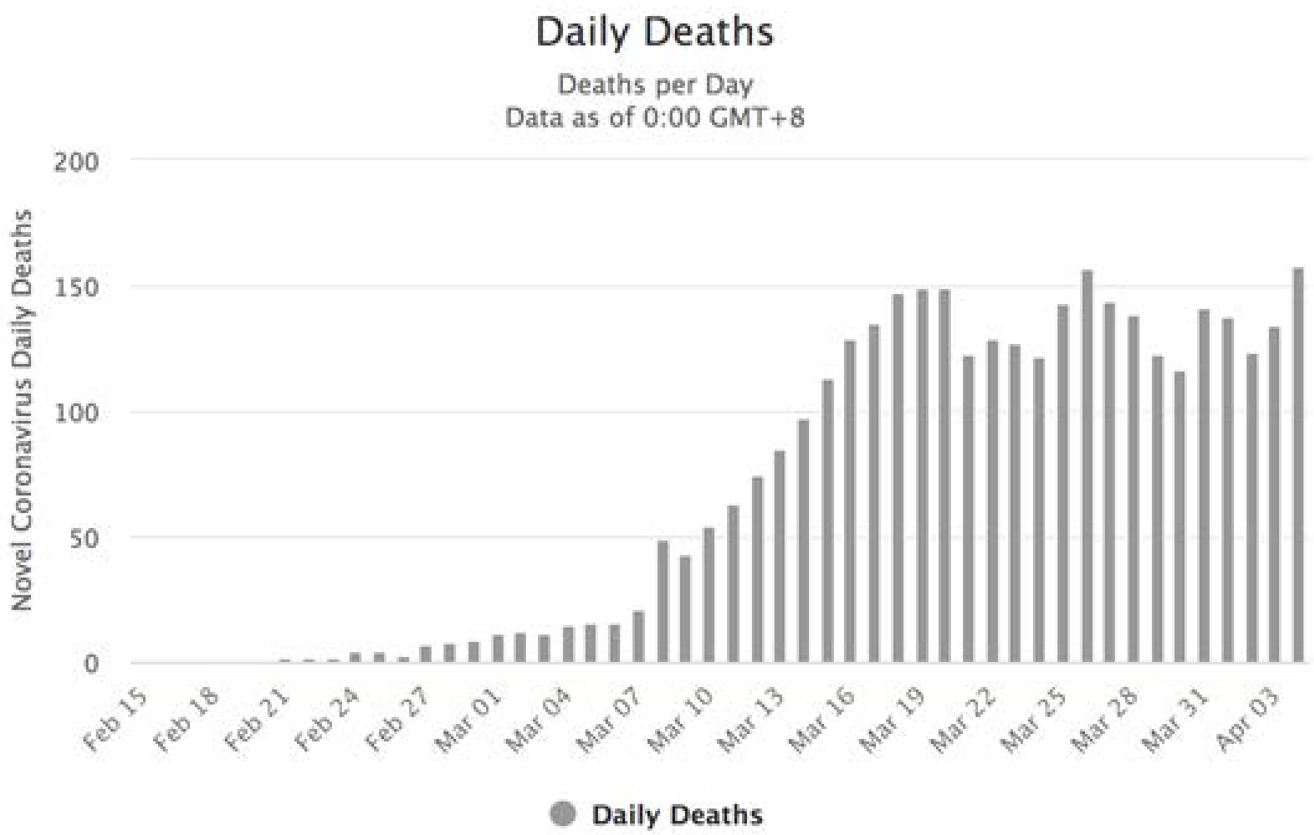
'Flatten the Curve' Policy
Next consider the green, social distancing, curve in the epidemic model figure. In this scenario, R0 is reduced through social distancing, thereby artificially decreasing the compounding rate. This is accomplished by, for example, lower density of people (e.g., six-foot spacing), wearing face masks and hand washing. As shown in the figure, this flattens the curve but the trajectory could potentially lead to the same number of deaths, as everyone is still infected, just with a delay. This decreases the peak of the shock to the health care system, and society, and provides more time to develop treatments and vaccines.

'Stop the Spread' Policy
The blue curve is a very different policy, and is actually the path that most countries and jurisdictions are trying to follow. In this scenario, the growth of the epidemic is stopped at a point between month two and month three in the epidemic model figure by non-medical interventions. This more dramatic change, including, for example, shutting schools and non-essential businesses, lowers R0 to less than one, and the exponential growth becomes an exponential decline. The rate of this decline depends on how much R0 is really reduced—the more dramatic the interventions the faster the recovery. On this path, the number of deaths in the population is significantly lower, but the population could still be susceptible. The faster interventions are put in place, and the more complete they are, the fewer deaths may occur. However, the remaining susceptibility of the population requires that other controls be put in place, like testing and quarantine, to manage the risk of a second wave of infection that is shown in month seven of the figure.

The graph on page 3 shows the daily deaths reported in Iran. Note that a peak was hit on March 19, but the number of daily deaths has held constant (at a plateau). This could occur if the policy put in place has reduced R0 sufficiently to flatten the curve, but not sufficiently to stop the spread of the virus.

Note that the blue curve after the first peak has a longer tail on the way to recovery than on the way up. The tail on the recovery side of the curve depends on the success of the interventions to stop the spread of the disease. If the implemented policy is not sufficient, this tail could last a very long time, affecting the timeline and process of restarting the economy.

Iran Mortality Figures



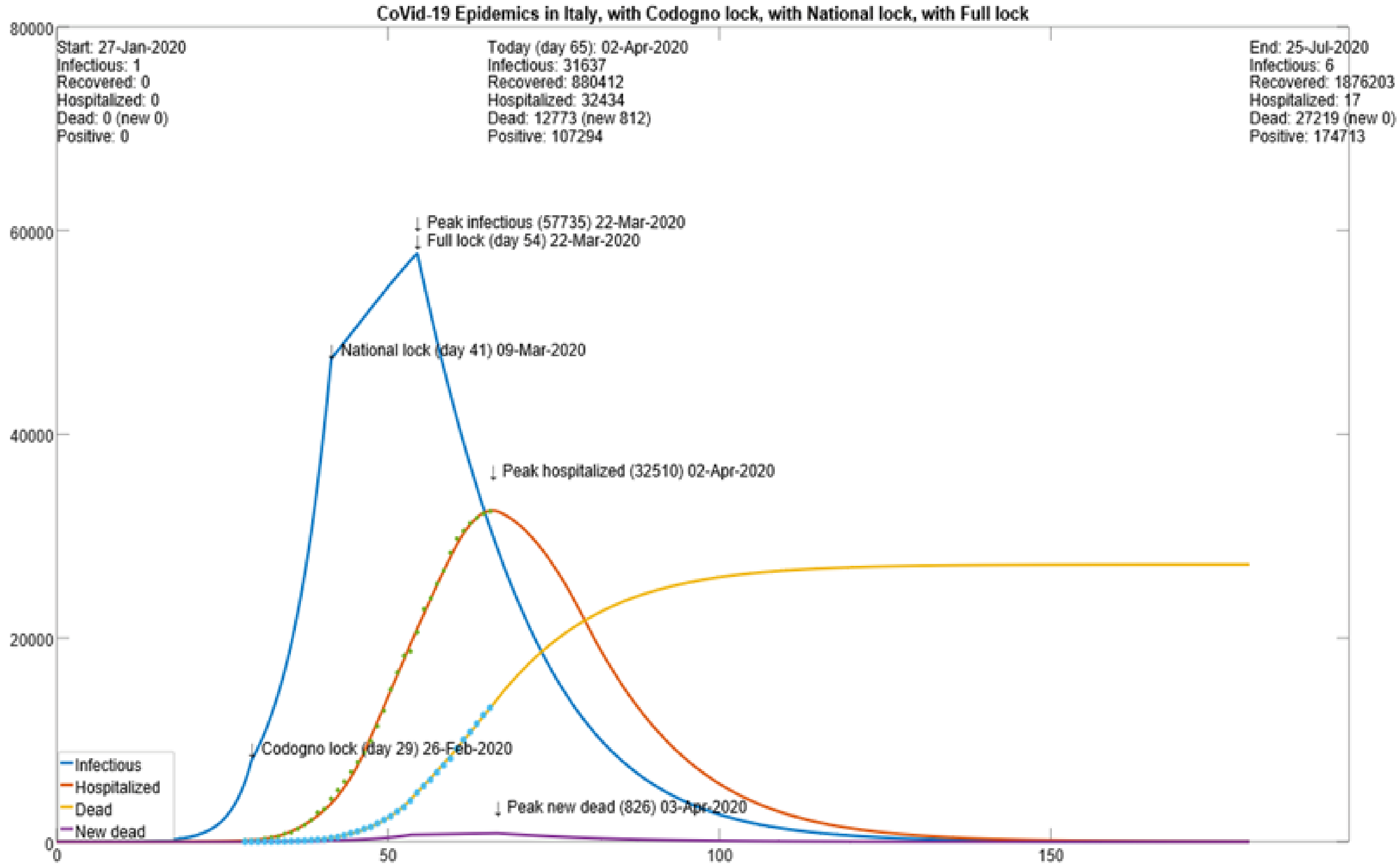
Source: worldometers.info/coronavirus/country/iran.

In the blue curve on page 1, the (first) peak occurs exactly at the moment that the interventions are put in place. This is not generally the experience in the COVID-19 epidemic due to the lack of sufficient testing. The impact of the interventions are not visible until hospitalization and deaths decrease, since these numbers are delayed behind cases by about two weeks. Also, there are delays in implementing policies, and therefore before R0 decreases.

Impact of Interventions in Italy

Due to insufficient testing, in almost all countries, these models are fit using the death data, and this could provide an indication of the actual number of cases. The data science team is evaluating models and methods to estimate the impact of policies that are being put in place in individual countries, and in individual states and counties. It seems that Brazil and Turkey intend to follow the red curve, and Sweden intends to follow the green curve, in the epidemic model above. Italy has put in place interventions in order to follow the blue curve. The figure on the next page shows an epidemic model fit to the data from Italy.

Model Scenarios in Italy



Source: Professor Grasso, Messina University, Italy. April 2, 2020.

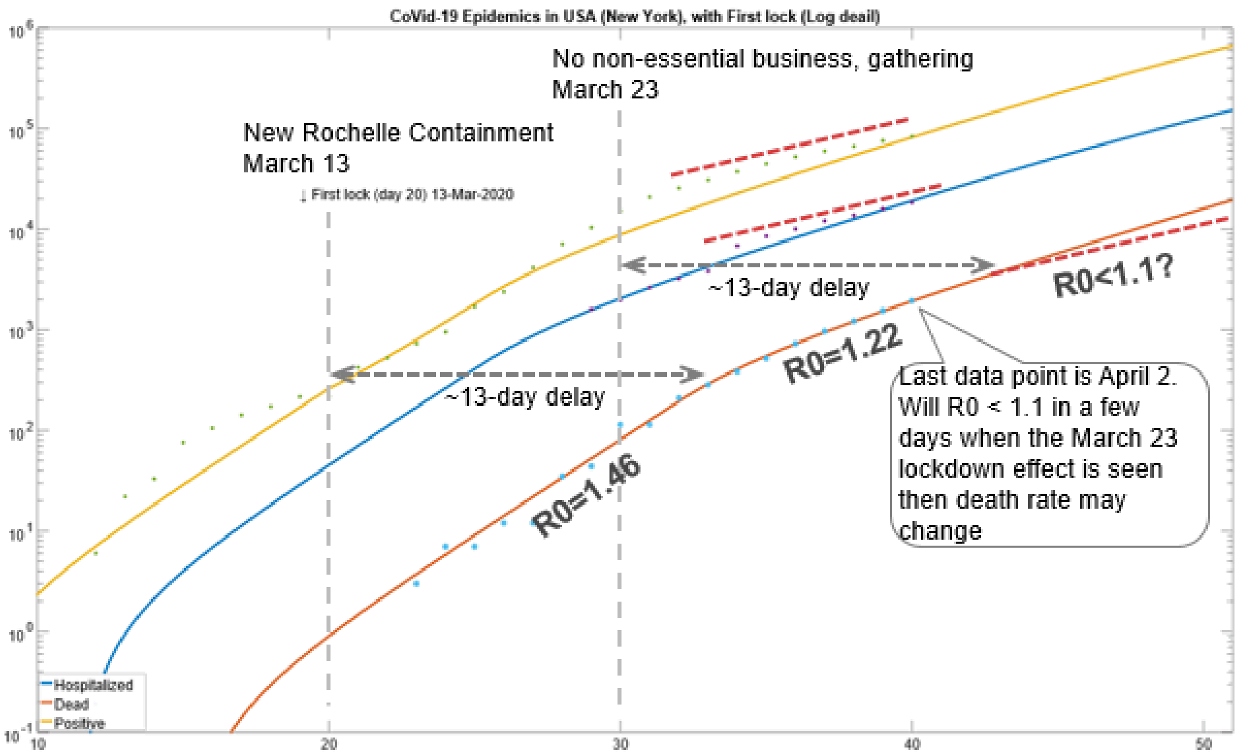
The blue line, as in the first figure, shows the number of new positive cases of COVID-19, and it is an output of the model. The data on hospitalizations and deaths are used to fit the model (light blue dots). The impact of three different interventions are visible in the number of new cases, and the last intervention (full lockdown) is what really has turned the direction of the spread of the virus. This could make it possible to predict peak hospitalizations, peak deaths, and the point when new cases are sufficiently small to stop the lockdown.

The model predicts that on July 25 there will be less than 10 active cases after Italy recovers, but that over 27,000 will have died. Note that when the peak occurred in the Chinese data there were a total of 24,000 cases on February 4, and the phase-in of opening the economy started on March 17 (about six weeks later). If the Italian lockdown had been as effective as the Chinese lockdown, which could have suggested phasing back in the end of May, but instead this will most likely not occur until mid-June.

What Could Happen in the U.S.?

The best-case scenario is that the U.S. follows the trend line in Italy, rather than the trend line in Iran. The U.S. is about 15 days behind Italy, but the outcome could depend on how effective the March 23 policy has been at stopping the spread of the virus. From our evaluation, there is an approximately 13-day delay between the change in policy and a corresponding decrease in the death rate. After a few more days, it may be possible to estimate the new R0 value that resulted from this intervention. If the intervention has been as effective as in Italy, we forecast 23,000 additional deaths in the U.S. by the week of April 13 (these are people who have COVID-19 now and may have been tested). Our base case is that the U.S. has not locked down to the same extent as Italy, so the number of new deaths may be as high as 42,000.

COVID-19 Projections for the U.S.



Source: Professor Grasso, Messina University, Italy, as of April 3, 2020.

At this point, it is not possible to determine the effectiveness of the current restrictions that are in place in the United States. The last intervention was on March 23, and this is still being gradually implemented in different ways by different states. Another open question in the U.S. models is if the peaks will occur at different times in different states, or if the peaks will occur at the same time. The IHME model has the peaks occurring at the same time, under the assumption that the whole country locked down to the same extent. The current prediction from the IHME model, shown below, has the peak deaths for the United States occurring in 11 days.

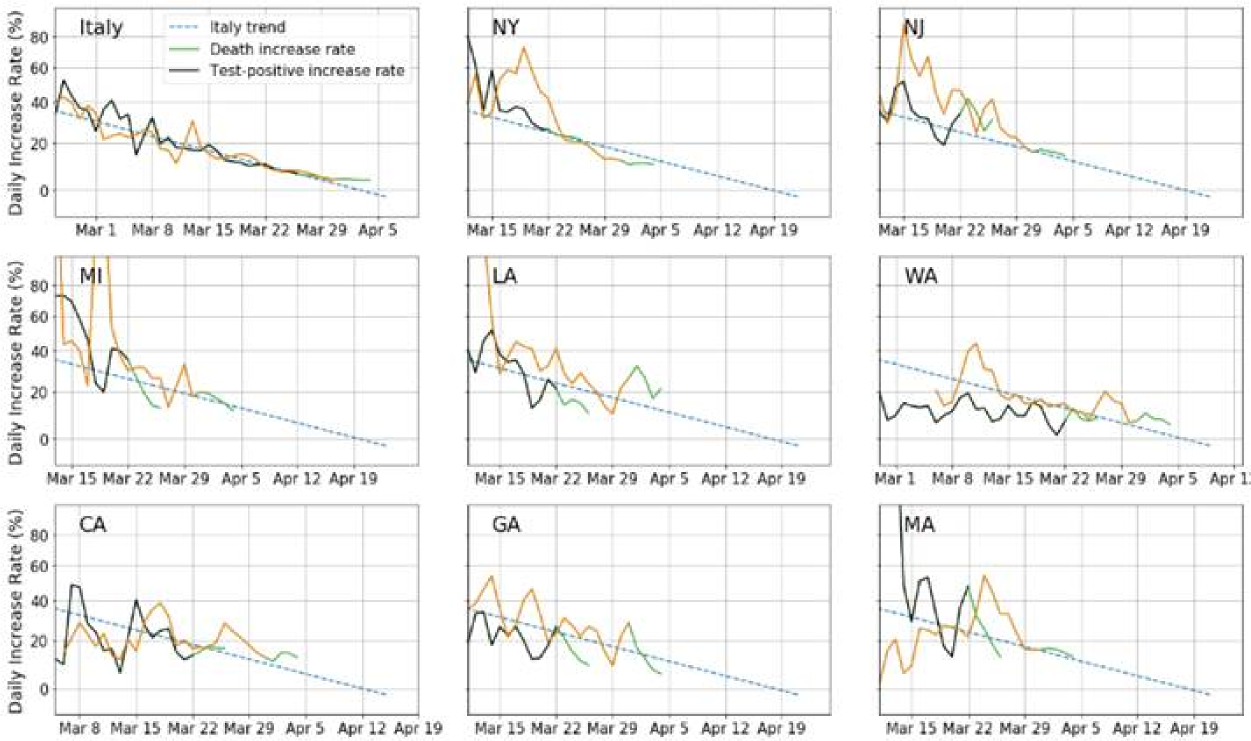
IHME Mortality Forecast

Source: IHME, as of April 5, 2020.

In the next graph, we show the progress of the epidemic in the eight states with the most COVID-19 cases, plotted to the trend line in Italy.

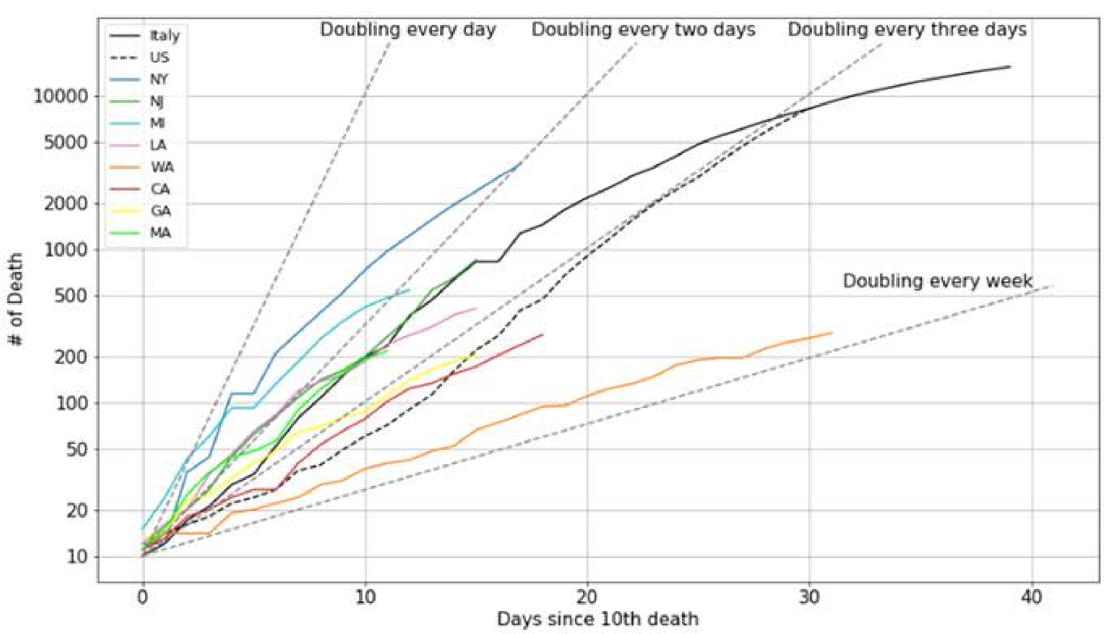
Note that New York, New Jersey, Michigan, Louisiana and Georgia seem to have followed the trend line but that California, Washington and Massachusetts has not.

Comparison: Italy and Eight U.S. States with the Most COVID-19 Cases



Source: Neuberger Berman, Data from Johns Hopkins, as of April 3, 2020.

Doubling Rate: Italy and Eight U.S. States with the Most COVID-19 Cases



Source: Neuberger Berman, data from Johns Hopkins, as of April 3, 2020

The figure above shows the doubling rate for deaths in each of these states. Note that Washington is clearly an outlier.

Summary

We believe that April could turn the corner, with peak cases and peak new deaths occurring in New York and, most likely, in New Jersey, Michigan and Louisiana.

In the next few days, it may be possible to determine if the interventions that occurred across the country on about March 23 were sufficient to stop the spread of COVID-19. With this data, and better estimates of the post March 23 value for R0, it will be possible to provide a better estimate for the date of a phased restart of the economy. The best estimate from our model is at least 15 days after Italy, or in early July.