Neuberger Berman Data Science Team

CHIEF DATA SCIENTIST: Michael Recce

All Models Are Wrong, but Some Are Useful

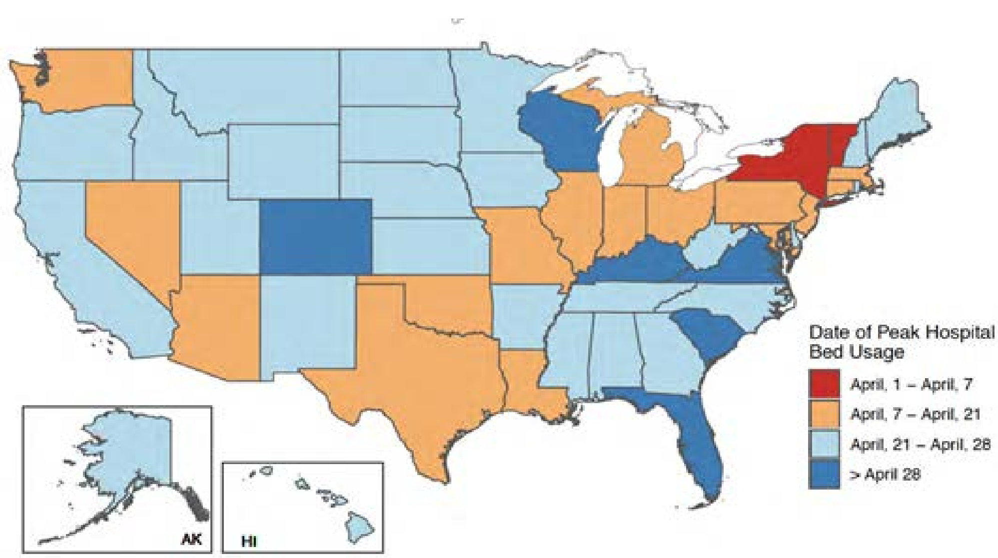
The Neuberger Berman Data Science team has evaluated a wide range of models for the time course and impact of the COVID-19 epidemic. These models incorporate different levels of detail, and are intended to assess the way the disease spreads and to predict the impact of policy decisions on the pandemic. One of the most useful models, in our view, was released as a preprint last Thursday (see below), by the Health Institute in Washington, funded by the Gates Foundation. This team of 20 PhDs has produced a detailed prediction, based on various assumptions and approximations, of the first wave of COVID-19 in the United States.

Base Case

This model predicts that peak hospital demand will occur in the second week of April, with excess demand of 8,000 to 250,000 hospital beds, and 2,500 to 58,000 ICU beds. The study predicts 40,000 to 160,000 deaths (less than the 200,000 number Dr. Fauci spoke about on Sunday March 29) in the United States over the next four months, with July 1 as a possible date for the start of a phased return to business as usual. We refer to this as the first wave, given that after this predicted outcome, the study predicts that less than 5% of the U.S. population will have been exposed to the coronavirus, *leaving the remaining 95% still at risk of exposure.* So, if this model is accurate, this return to work would need to be managed carefully to avoid triggering a second wave of infection to the at-risk population. Professor Emanuel described a detailed plan for managing the return to work March 29 in *The New York Times.* One of the most important parts of this plan is widespread testing of both symptomatic and asymptomatic people.

This work models each state in the United States individually, starting from conditions on March 25, and it makes a set of critical assumptions. In particular, it assumes that social distancing decreases the spread of the virus, with four distinct types of policy: *1) school closures, 2) non-essential business closures, 3) stay-at-home recommendations, 4) travel restrictions.* In the model, the effect of these policies to flatten the curve (slow the speed of virus spread) depends on the number of steps taken. In the model, a calendar day with 1 measure is counted as 0.67 days, days with 2 measures as 0.33 days, and days with 3 or 4 measures are modeled as days with no spread. The model assumes that the entire country has implemented sufficient controls to help stop the spread by April 2. The authors do not explicitly model the impact of a delay, but a delay would likely increase the overall impact of the virus on the United States, and delay the time at which it is brought under control. A key factor is the amount of movement that occurs between regions with a more stringent policy and regions with a less stringent policy. This is discussed in detail below.

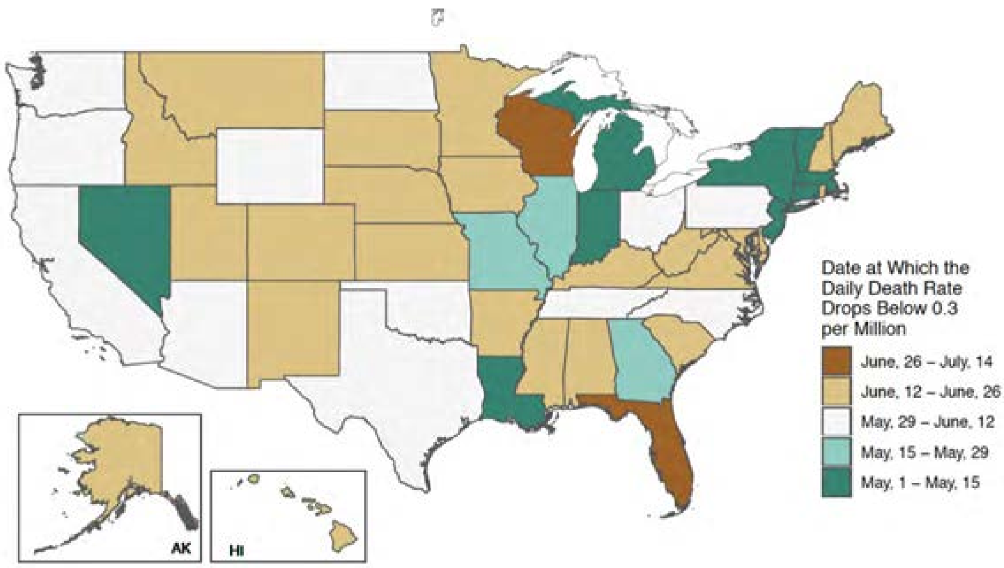
Peak Hospital Usage – Model Estimates



Source: IHME preprint, March 25, 2020

This data shows the date range of peak hospital demand for each state, as predicted by the model. Governor Cuomo referred to this as a "rolling apex" in his briefing today. In the model, the assumed implementation of stricter policies, across all states, on April 2 significantly reduces the overall severity in states that are at an earlier stage of the spread of COVID-19.

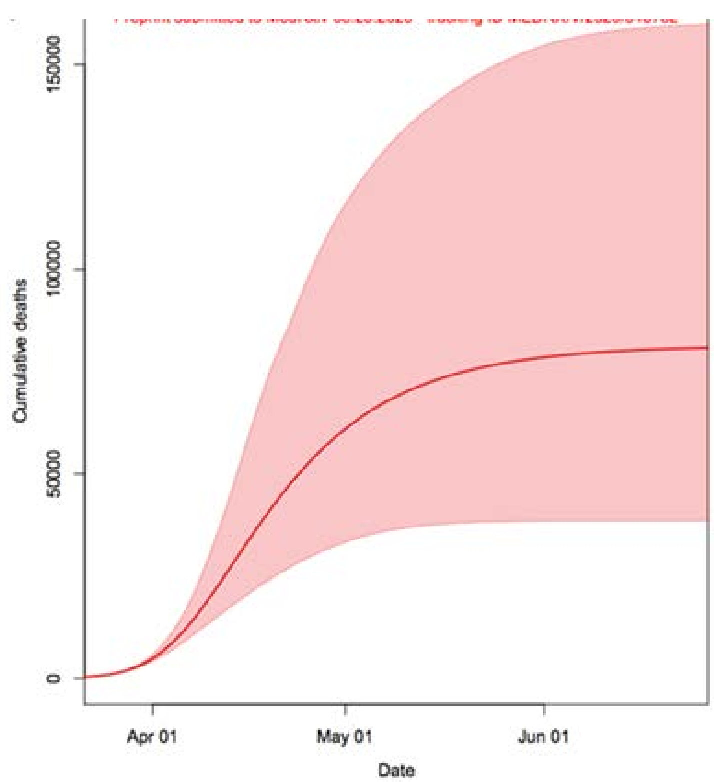
Death Rate Reduction – Model Estimates



Source: IHME preprint, March 25, 2020

The model predicts a time range for each state, as shown above, to become sufficiently clear from the virus.

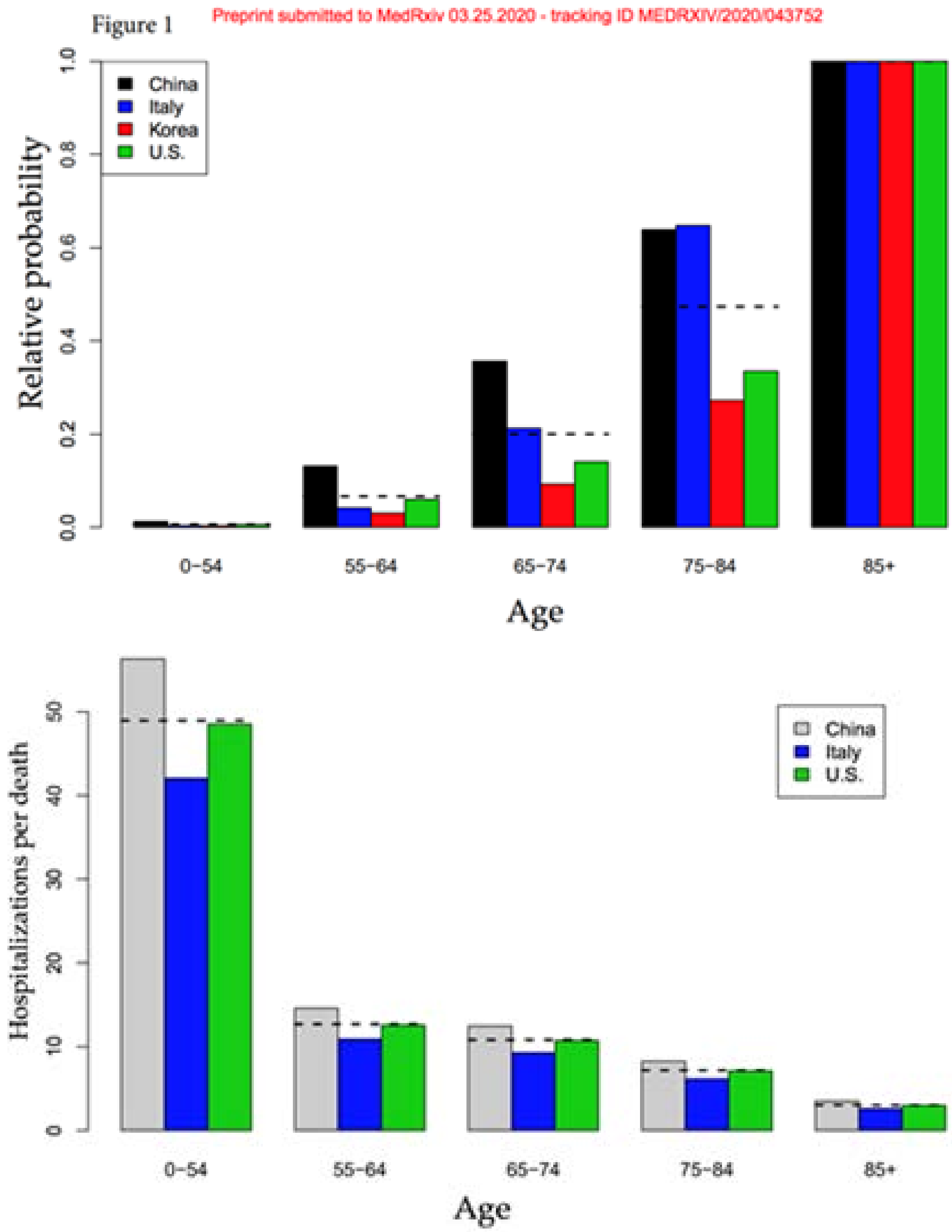
Cumulative Death – Model Estimates



Source: IHME preprint, March 25, 2020

As a result of all of the approximations and assumptions used in the model, there is a wide range in the predicted number of deaths. Assuming a mortality rate of 1%, the number of cases can be backed out of this graph as roughly 100 times the number of deaths. With more data and improved models, accuracy could improve within a week.

Impacts by Age



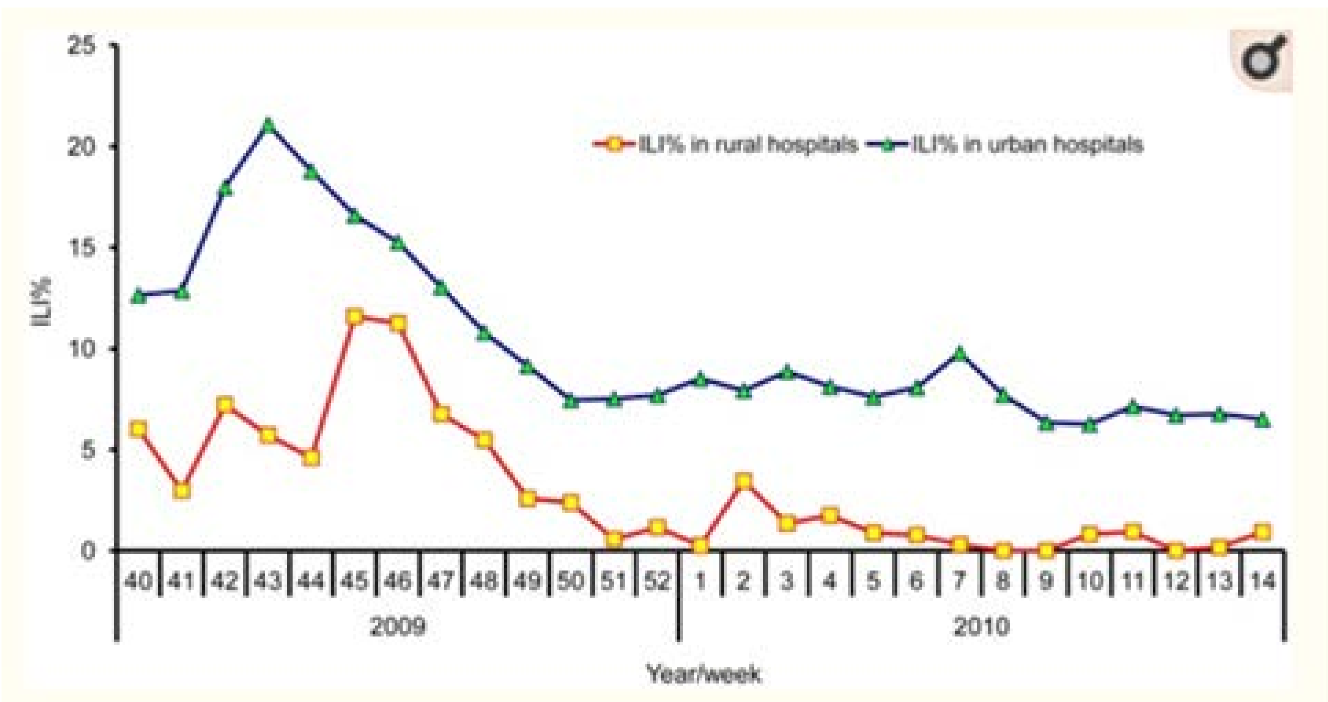
Source: [IHME preprint](), March 25, 2020. Figure 1 shows the normalized age-pattern of death based on data from Italy, South Korea, China and the U.S. Figure 2 shows the age-specific ratio of admissions to deaths based on data from Italy, China, and the U.S.

One of the well-described characteristics of this disease is that it has disproportionally effected older people, as is shown in the figure above from the study. However, it seems the largest load on the hospitals is from the younger patients. The analysis above, from the study, shows the number of patients in the hospital, in each age group, for every death.

Conditions for Lower Impact: Is There a Chance of Better News?

The model assumes that the spread of the epidemic is just based on population, and that people in each region (urban and rural) are equally likely to be exposed to an infected individual. The graph below is from a 2014 paper (Y. Zhang, et. al.) with ILI (influenza-like illness) reported at rural and urban hospitals from the 2009 HIN1 flu epidemic. The data shows that rural areas had a delayed peak of infections and less than half of the number of cases. In this case, isolation of a community reduced the chance that the community overall experienced the virus.

HIN1 Epidemic: Influenza-Like Illness

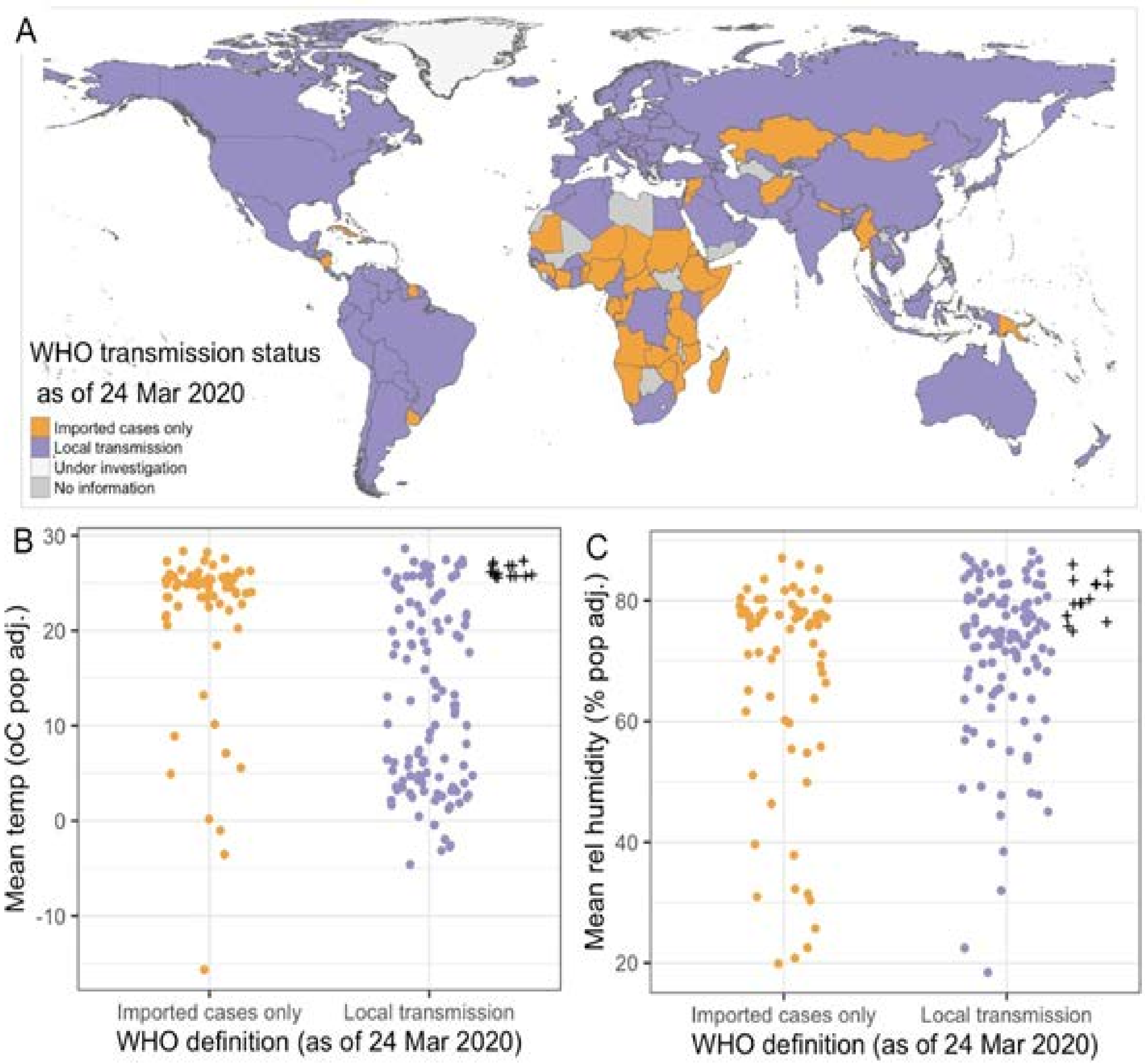


Source: Y. Zhang, et. al. 2014

This may not reflect the current rural dynamics in the United States (or other countries), as many people in suburbs and rural areas commute long distances to cities to work.

The other factor, not included in the model, is the impact of weather. Last week, we reported results from Sajadi and colleagues at the University of Maryland showing that the weather could reduce the spread by lowering R0 (the average number of people infected by a currently infected person). If R0 is sufficiently reduced (below 1), the spread of the virus can be temporarily stopped. As described last week, this prediction has been challenged by a number of other academic teams. In particular, a preprint published by the World Health Organization last week separated the cases in each country into those that were imported (through travel) and those that occurred from community spread. The key result shown below is that temperature and humidity seem to have no impact on blocking community spread. *This could suggest that changes in the weather may not help.*

WHO Transmission Status

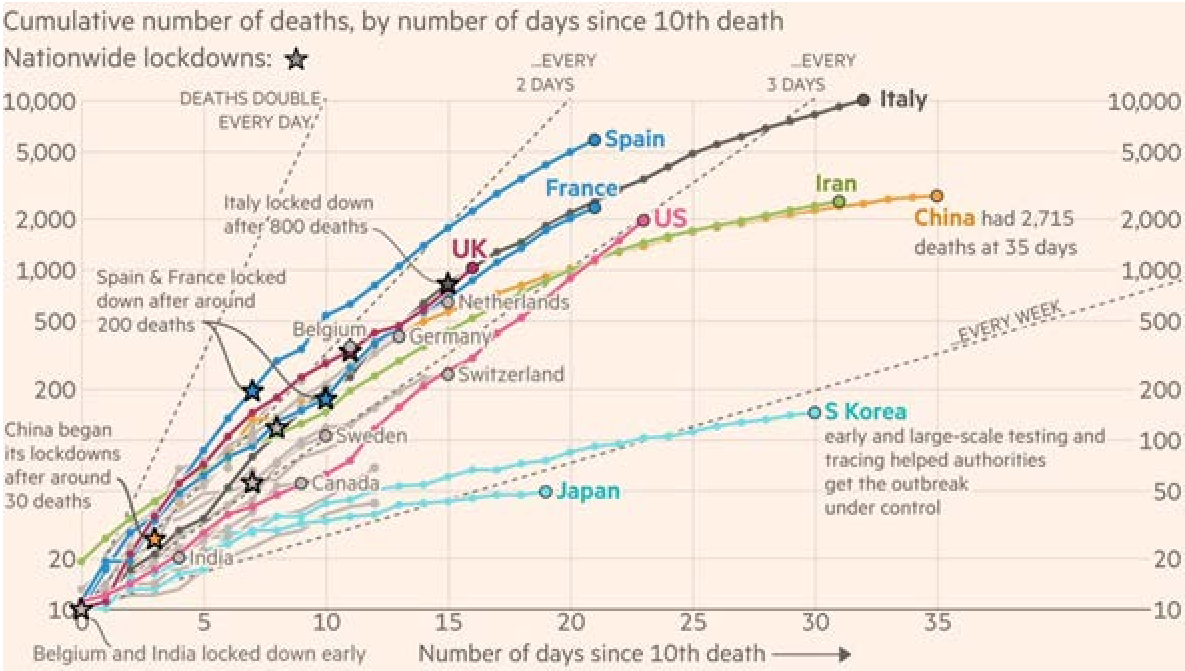


Source: World Health Organization; https://cmmid.github.io/topics/covid19/current-patterns-transmission/role-of-climate.html

Conditions for a Worse Impact: What Do We Need to Watch?

Social distancing reduces the spread of the disease. Widespread testing of both symptomatic and asymptomatic people reduces the spread of the disease. Every country and jurisdiction is implementing a different policy and at a different time in the disease spread. The plot below is annotated from the coronavirus tracker on the Financial Times web page. The economic impact experienced by each country will likely be determined by the length of their delay, duration of their eventual lock down, and by the extent to which the country is able to control the flow of the virus, while a vaccine and treatments are under development. In particular, Sweden and the Netherlands are opting for a less restrictive policy.

Deaths and Lockdowns by Country



Source: Financial Times (as of March 29).

In the United States, while some states have closed schools and non-essential businesses, and imposed travel restrictions, others have not. It may be a challenge to implement these restrictions uniformly across the country. This could result in a more negative economic and social outcome than is contained in the bases case above.

An example of cell phone data (provided by a vendor) shows (on the left) a set of cell phones on a beach in Miami during spring break. The graphic on the right shows the same cell phones after the vacationers have returned home. We believe that the severity of conditions in the epicenter, along with active lobbying, will likely lead to a tightening of movement restrictions in the United States.

On March 29, Rhode Island implemented then rescinded a policy to block New Yorkers from entering the state, and there have been discussions of quarantine. As long as different policies are in place across neighboring jurisdictions, quarantines will likely be in the news and may ultimately impact movement of goods and services.

Cell Phone Location Comparison

Source: Techtonix GEO on YouTube (as of March 26); Neuberger Berman

The infection rate of a virus is parameterized using R0, but the average infection rate does not accurately describe the process. As is often true, it is a Pareto distribution (the 80:20 rule), so some individuals may infect many others and most infected people may infect no one. There are a number of papers, which I plan to describe in the future, that argue that infection may be mostly from people with mild or no symptoms, that infection may be more from surfaces than droplets in the air, and that infection may be from the younger age groups.

Countries that manage to control the epidemic and that, through this process, minimize the economic impact to business and factories, will likely disproportionally be advantaged. Publically traded companies with a substantial footprint in these countries may potentially perform better. How well each country does matters: Winning and losing do not produce the same outcome in this battle.