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Biotechnology | North America

COVID-19: A Prescription To Get The US Back To Work

We see a slow return to work with US cases peaking in ~50 days. We expect social distancing reductions in June as diagnostic/serology testing are widely available and hospital capacity is extended. Variable levels of social distancing will remain until a vaccine is widely available in Spring 2021.

US likely to experience two peaks – one for the coastal regions and one for the interior:

We have built individual state models to look at the time to peak across the US. While we expect an initial peak in ~14 days for the cities with the first outbreaks, we see a second peak from interior regions of the country pushing the ultimate US peak to mid-May ([Exhibit 1](#)). While we would expect some resumption in activity in the coastal regions prior to a full US peak, we believe resumptions will be limited until a full US peak. Governors will be hesitant to broadly relax their social distancing until the immediate threat of imported cases is diminished. We believe our view of a peak in mid-May could be underappreciated by the market.

Governors are likely to be cautious in relaxing social distancing; We believe three key criteria must be met prior to a start of resumption in activity.

Importantly, investors should expect social distancing to wax and wane over the next year to contain "hot spots" before a vaccine is widely available: (1) While new cases will peak first, we do not believe Governors are likely to allow any meaningful resumption until cumulative mortality peaks which lags new cases by ~20 days. This suggests nominal resumption could begin in June; (2) States will need to have appropriate public health infrastructure and testing capacity to allow for surveillance of new "hot spots" which we also expect in June. The CDC currently maintains a flu surveillance network which tracks annual influenza activity. We believe a national surveillance system of a similar scale will be required to track COVID-19; and (3) serology testing (blood testing to see who is immune to the virus) must also be pervasive, which we also believe will take until June. With these in place, local governments are likely to start to allow more free movement. That said, if new infections materialize, we would expect significant social distancing measures to return.

Coming back to work will happen in stages with reduced staffing in the office:

We believe the first wave to return will be those who have recovered from the virus (positive serology) and the young/healthy. We see a maximum of 50% of employees being allowed back in the office over the summer months. We do argue that schools should be re-opened for the fall as kids do not appear to be significant vectors for disease spread. Importantly, investors should expect new waves of infection to arrive, as early as this fall. Those new waves will require

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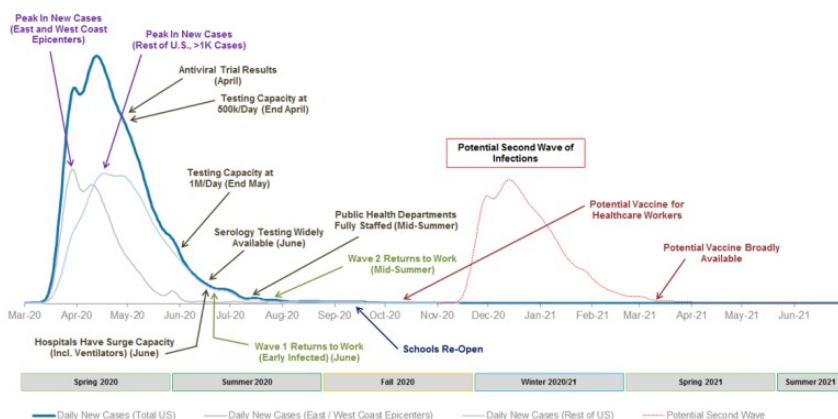
variable levels of social distancing that are turned on or off depending on the level of the outbreak. The reason we highlight the need for an effective COVID-19 surveillance network is that the scope of these outbreaks can be minimized if they are discovered early. South Korea's handling of its outbreak is a prime example of this potential. Variable levels of social distancing are likely to persist through 2021 until there is a widely available vaccine. *Overall, investors should prepare for reduced levels of activity until there is a vaccine and should expect social distancing to wax and wane as hot spots develop over the next 1-2 years.*

Drug pipeline presents the only near-term opportunity to meaningfully alter the speed of resumption: Ahead of full availability of a vaccine, promising antivirals and antibody therapies are in the pipeline with data starting in April through the late-summer. We believe at least some of these drugs can be successful and help turn severe cases into more mild forms of the disease. Such a success could reduce the potential strain on hospitals and allow public health officials to support a broader re-opening of the economy ahead of a vaccine's availability. See our recent note on the [upcoming treatments for COVID-19 here](#).

We highlight key datapoints from China that can provide a benchmark for a resumption in activities. Importantly, we believe the US will lag China for key reasons we outline inside the report: China's peak new cases occurred on February 3. 80% of hotels reopened as of February 27, ~99% of businesses resumed some form of activity as of March 17, and 73% of restaurants reopened as of March 18. ~50% of metro passengers resumed travel as of March 26. China's economy reached ~80% of prior production levels ~40 days from the peak.

Exhibit 1: Projected timeline and milestones for a return to work in the US

Actual/Estimated New Case Count (United States, Non-Cumulative)



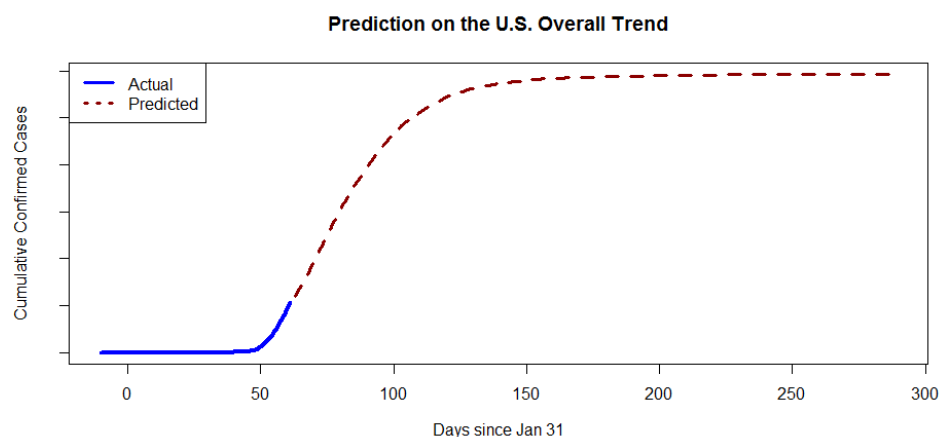
Source: Morgan Stanley Research

When Will The US Reach This Outbreak's Peak In New Daily Cases?

New U.S. regional models suggest geographic disparity in the outbreak stage. The overall country is likely to peak in ~20 days and reach a plateau of cumulative cases in ~2 months.

We built state-level models for the U.S. for all states with at least 1,000 cumulative confirmed cases as of 4/1, using the same methodology described before (see [here](#)). We identified 6 states as the leading states in terms of the outbreak stage: WA, CA, NY, NJ, MA, and MI, based on the start timing and spread scale. While the leading states are like to approach a peak within ~1-2 weeks, the rest of the country appears to lag by ~3 weeks. See [Exhibit 1](#) and [Exhibit 2](#) for the time to peak of the leading states, lagging states, and the overall country.

Exhibit 2: U.S. Overall Outbreak Dynamics Obtained by Aggregating Regional Models

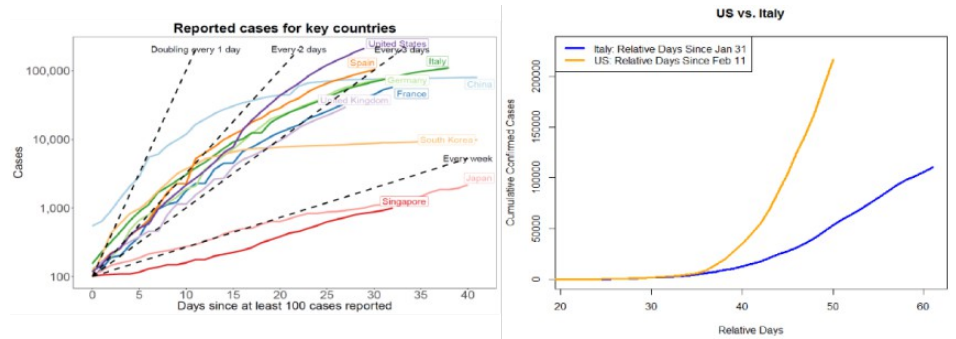


Source: Morgan Stanley Research, China CDC, <https://github.com/nytimes/covid-19-data>

Key charts impacting our view on the US outbreak

- **US cases growing the fastest** – The US has now the largest number of cases among all countries, while the growth rate of US cases is now the highest among all countries we follow (see slope of US curve in left panel of [Exhibit 3](#)) and is accelerating faster than Italy when adjusted for the start of the respective outbreaks.

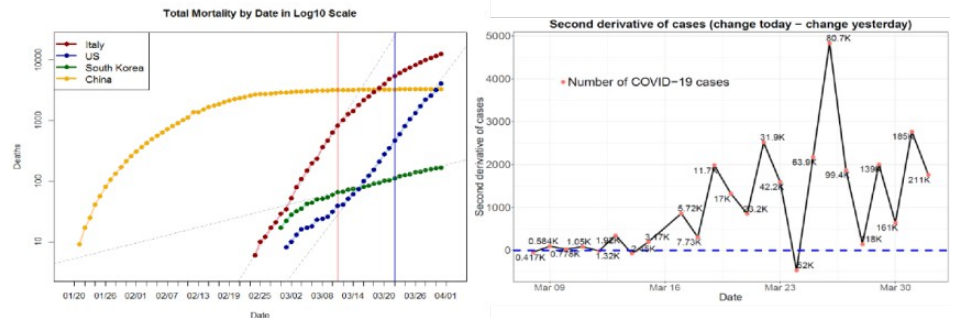
Exhibit 3: Reported cases for each country since the reporting of at least 100 cases (left) and comparison between US and Italy cases (right).



Source: Morgan Stanley Research, JHU CSSE

- US mortality/cases are not slowing despite social distancing** – Mortality is increasing at an exponential rate in the US at a slightly lower slope than Italy prior to its lockdown (Exhibit 4, left panel). While mortality will lag new cases, other countries have been able to slow from exponential growth after lockdowns. Further, although variable, the 2nd derivative of the US cases (defined as *new cases today - new cases yesterday*) demonstrates an increasing trend, diverging from the value of 0 (spread stabilization), indicating that the US case growth is not slowing (Exhibit 4, right panel).

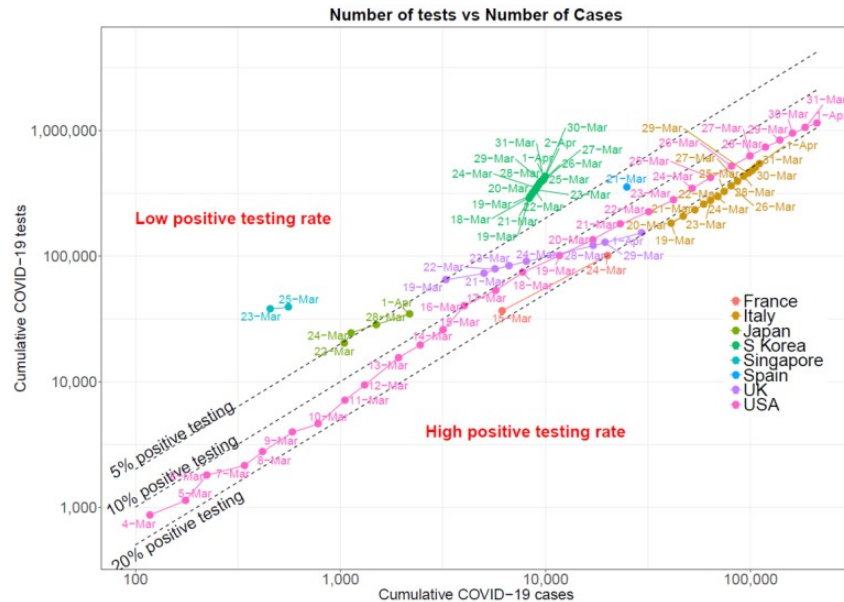
Exhibit 4: Mortality in 4 key countries (left) and second derivative of COVID-19 cases in the US (right). Right panel: The black line corresponds to the values of the 2nd derivative while the numbers on the red circles refer to the number of COVID-19 cases at the respective timepoint. The blue dashed line shows the point at which the 2nd derivative equals zero, reflecting spread stabilization.



Source: Morgan Stanley Research, JHU CSSE, The COVID Tracking Project, Tencent News, <https://coronavirus.1point3acres.com/en>.

- New cases are growing faster than testing capacity** – Per Exhibit 5, the rates of testing positivity (cumulative positivity rate currently at ~20%) continue to trend higher across the US as testing rates lag other countries and cases are growing faster than tests, suggesting the US continues to lack enough testing capacity (see our recent analysis [COVID-19 Cases Growing Faster Than Tests As US Capacity Is Still Too Low](#))

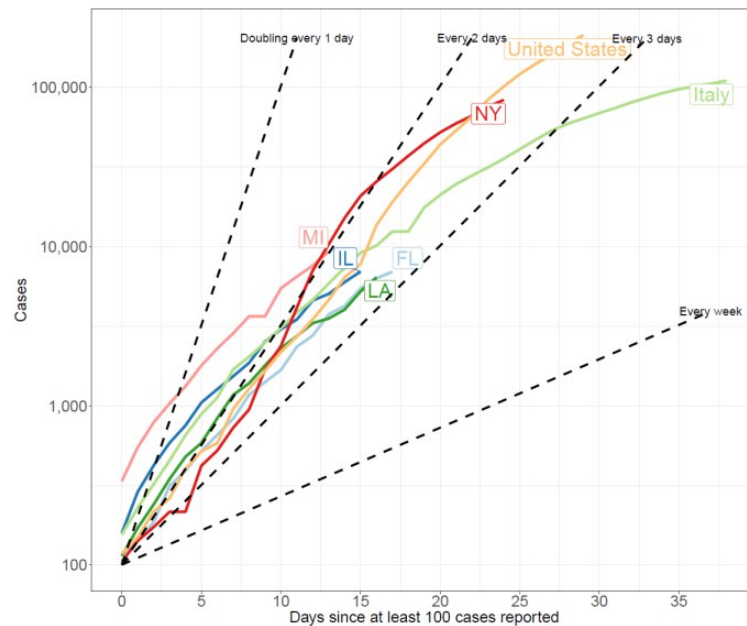
Exhibit 5: Covid-19 cases versus testing capacity for 8 countries. The cutoff date is April 1st. Note that tests with pending results in the US are not taken into account and the positivity rate refers to cumulative (not daily) positivity rate.



Source: Morgan Stanley Research, JHU CSSE, The COVID Tracking Project, Wikipedia, South Korea CDC.

- **New "hot spots" are exhibiting growth above other regions** – Case rates for emerging US "hot spots", such as the 5 States presented in Exhibit 6, are growing at rates faster than all other countries or US states. This suggests new US cases could continue to accelerate.

Exhibit 6: Number of cases in US, Italy, and 5 key US States. The data cutoff is April 1st.



Source: Morgan Stanley Research, JHU CSSE, The COVID Tracking Project.

- **Social distancing measures remain not as strict as other countries** – The US has more limited quarantine measures compared to Italy or China (see timing and scope of the measures in Exhibit 7). Italy, which is now exhibiting stabilization, will likely reach peak ~15 days after China. This represents a time to peak that is 2x China and

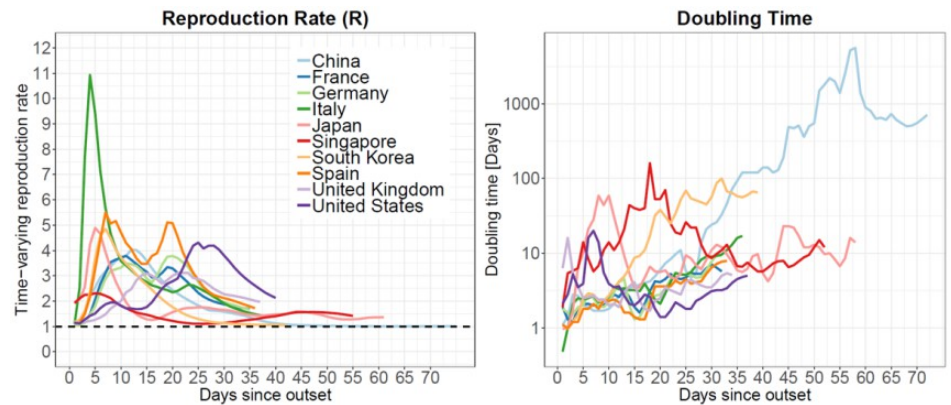
3x South Korea. With the US potentially trending worse than Italy, we would expect more social distancing to reduce the risk of tracking significantly worse than Italy. Exhibit 8 indicates faster spreading with the reproduction number (R) of US (2.1) higher than Italy (1.36), suggesting that the spreading rate is higher in the US compared to Italy, while the doubling time of cases in the US (~5 days) is lower than Italy (17 days), pointing to a significantly faster elevation of case numbers in the US than Italy. We highlight that today's R and doubling time in the US are similar to those of Italy on March 22nd (our note [here](#)), which is a signal that the spread rate in the US lags Italy by ~10 days. As a reference, it took China ~25 days to attenuate its R value from ~2.1 (today's R in US) to 1 (indicates control of spreading), which is a soft indicator of the time required for COVID-19 containment under social distancing measures similar to China.

Exhibit 7: US Social Distancing Measures By State

State	Non-Essential Services Closed (1)	Stay at Home Order	Educational Facilities Closed	Travel Severely Limited
California	3/19/2020	3/19/2020	3/19/2020	N/A
Nevada	3/20/2020	4/1/2020	3/16/2020	N/A
New York	3/20/2020	3/22/2020	3/18/2020	N/A
Illinois	3/21/2020	3/21/2020	3/17/2020	N/A
New Jersey	3/21/2020	3/21/2020	3/18/2020	N/A
Louisiana	3/22/2020	3/23/2020	3/16/2020	N/A
Connecticut	3/23/2020	N/A	3/17/2020	N/A
Maryland	3/23/2020	3/30/2020	3/16/2020	N/A
Michigan	3/23/2020	3/24/2020	3/16/2020	N/A
Ohio	3/23/2020	3/23/2020	3/16/2020	N/A
Pennsylvania	3/23/2020	4/1/2020	3/17/2020	N/A
Delaware	3/24/2020	3/24/2020	3/16/2020	N/A
Indiana	3/24/2020	3/25/2020	3/19/2020	N/A
Massachusetts	3/24/2020	N/A	3/17/2020	N/A
New Mexico	3/24/2020	N/A	3/13/2020	N/A
West Virginia	3/24/2020	3/25/2020	3/14/2020	N/A
DC	3/25/2020	3/30/2020	3/16/2020	N/A
Hawaii	3/25/2020	3/25/2020	3/19/2020	N/A
Idaho	3/25/2020	3/25/2020	3/23/2020	N/A
Maine	3/25/2020	4/2/2020	3/16/2020	N/A
Vermont	3/25/2020	3/24/2020	3/18/2020	N/A
Washington	3/25/2020	3/23/2020	3/13/2020	N/A
Wisconsin	3/25/2020	3/25/2020	3/18/2020	N/A
Colorado	3/26/2020	3/26/2020	3/23/2020	N/A
Kentucky	3/26/2020	N/A	3/20/2020	N/A
Montana	3/26/2020	3/26/2020	3/15/2020	N/A
New Hampshire	3/27/2020	3/27/2020	3/16/2020	N/A
Alabama	3/28/2020	N/A	3/19/2020	N/A
Alaska	3/28/2020	3/28/2020	3/16/2020	3/28/2020
North Carolina	3/30/2020	3/30/2020	3/14/2020	N/A
Tennessee	3/30/2020	N/A	3/20/2020	N/A
Mississippi	4/3/2020*	4/3/2020*	3/19/2020	N/A
Arizona	N/A	3/30/2020	3/16/2020	N/A
Arkansas	N/A	N/A	3/17/2020	N/A
Florida	N/A	4/3/2020*	3/17/2020	N/A
Georgia	N/A	N/A	3/18/2020	N/A
Iowa	N/A	N/A	N/A	N/A
Kansas	N/A	3/30/2020	3/17/2020	N/A
Minnesota	N/A	3/27/2020	3/18/2020	N/A
Missouri	N/A	N/A	3/23/2020	N/A
Nebraska	N/A	N/A	N/A	N/A
North Dakota	N/A	N/A	3/16/2020	N/A
Oklahoma	N/A	N/A	3/17/2020	N/A
Oregon	N/A	3/23/2020	3/16/2020	N/A
Rhode Island	N/A	3/28/2020	3/16/2020	N/A
South Carolina	N/A	N/A	3/16/2020	N/A
South Dakota	N/A	N/A	3/16/2020	N/A
Texas	N/A	N/A	3/19/2020	N/A
Utah	N/A	N/A	3/16/2020	N/A
Virginia	N/A	3/30/2020	3/16/2020	N/A
Wyoming	N/A	N/A	3/19/2020	N/A

*announced/planned; N/A = not announced.
Source: Morgan Stanley Research, <https://covid19.healthdata.org/projections>

Exhibit 8: Time-varying reproduction rate R and doubling time of COVID-19 cases. Note that the R in the plots refers to the time-varying effective R, which differs from the basic reproduction number (R0) that reflects R under ideal transmission conditions without any intervention. We also caution that our calculations are based on daily reported data and may be confounded by testing capacity, reporting timing, and different sources of data.

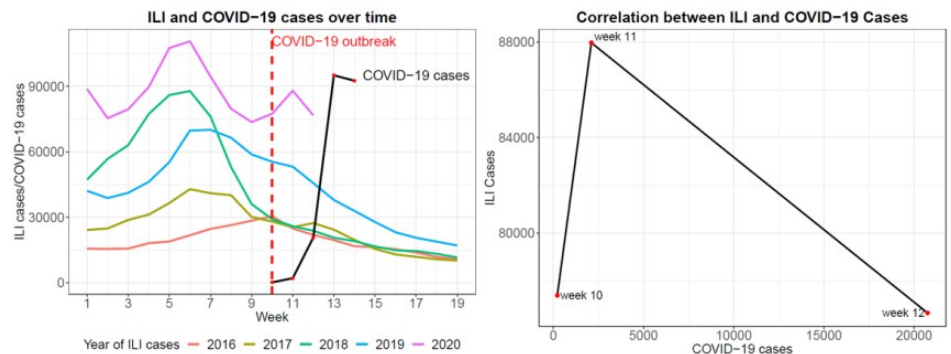


Source: Morgan Stanley Research, Johns Hopkins CSSE

What can we learn from Influenza Like Illness (ILI) reported data?

In Exhibit 9 we present weekly ILI data in the US during 2016-2020 (left) and the correlation of the weekly 2020 ILI cases with the weekly COVID-19 cases (right). We highlight two main observations: (1) Unlike all previous 4 past years (2016-2019), wherein the number of ILI cases following week 9 is declining, in 2020 (pink line in Exhibit 9, left panel) we observe an increase in the number of ILI cases at week 9 that continues until week 11 followed by a drop in the number of cases; (2) At week 10, i.e., one week after the number of ILI cases began to raise, the first COVID-19 cases were reported and their number increased significantly until week 13 when it was slightly attenuated (black line Exhibit 9, left panel). The correlation between the number of ILI cases and COVID-19 cases is illustrated in the right side of Exhibit 9. **Taken together, this data suggests that the trajectory of the ILI cases may constitute a leading factor for the COVID-19 cases trajectory**, although additional data is needed to validate this. We note that we observed the same pattern between the number of ILI cases and the number of deaths/hospitalizations/tests related to COVID-19. We will continue to monitor how the ILI-COVID19 correlation is evolving throughout the pandemic.

Exhibit 9: Data showing the ILI cases over the past 5 years and the COVID-19 cases over the past weeks (left) as well as the correlation between the ILI and COVID-19 cases (right).



Source: The COVID Tracking Project, CDC.

What Do Governor's Need To See To Start Relaxing Social Distancing Measures?

Peak in New Cases Precedes Peak in Cumulative Mortality Rate

We expect the US to experience two peaks associated with new COVID-19 cases starting with the coastal regions, followed by the interior of the country. These assumptions are based on initial hotspots, population density and projections based on individual state models. California/Washington and New York/New Jersey were the first states to report significant cases of COVID-19 and consequently they were some of the first states to issue "stay at home" orders. We expect new cases in these regions to peak in ~1-2 weeks, based on current testing capacity and positivity/mortality rates. We then project a second wave from interior regions of the country. These assumptions push the ultimate US peak in new cases to mid-May, followed by a peak in cumulative mortality rates. Ultimately, we believe Governors will begin considering relaxing social distancing measures once cumulative mortality rates peak, which lags new cases by ~20 days. This means that some resumption in activity will occur in the coastal regional areas prior to the full US peak, followed by other states that have experienced a similar trajectory in peak new cases and cumulative mortality. Ultimately, based on our projections we do not expect to see significant resumptions in activity for ~70 days.

Are hospital facilities able to handle new cases?

The most immediate challenge facing states is their ability to properly supply and equip hospitals and medical personnel with necessary equipment to confront the potential influx of COVID-19 patients. It is estimated that 5% of COVID-19 cases are critical and require ventilation, which implies ~30k ICU admissions in the US over the coming months. Private companies have begun manufacturing and shipping PPE and ventilators to at-risk states and the federal government is prepared to step-in with what is left of the national stockpile of medical supplies. To gauge the potential impact to hospitals, New York City could be a leading indicator as new cases continue to climb and their hospital capacity is pressured in the coming weeks. To address the anticipated surge in new cases, New York State has requested additional ventilators and PPE. Based on IHME projections, New York State expects to need 9,427 ventilators and 11,064 additional ICU beds to deal with the potential peak in hospitalized patients over the next 1-2 weeks. We expect other states to face similar capacity issues as the interior of the country experiences a peak in new cases. Assuming Governors feel their states have been adequately supplied to address their peak cases and that they have secured recurring shipments of goods, their view of the immediate risk could recede somewhat. Thus, we see hospital surge capacity as a key first step to considering relaxing social distancing.

Robust Public Health Infrastructure

Governors will be required to rely on their public health infrastructure when they decide to relax social distancing measures to determine who is immune and who is still

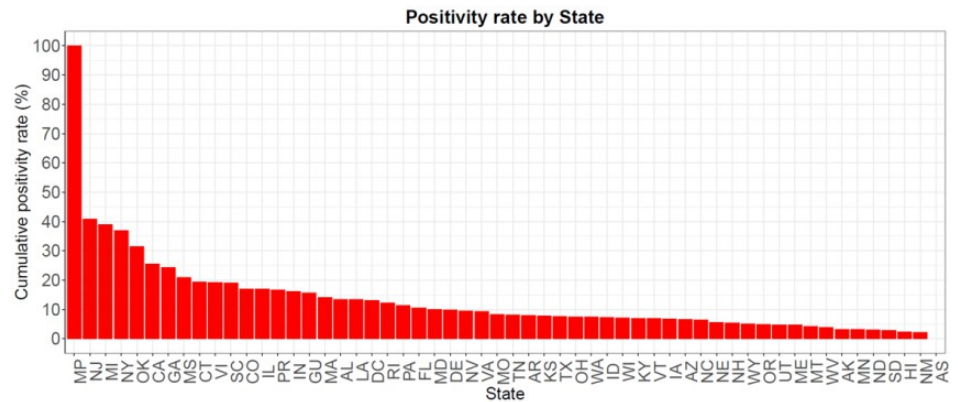
vulnerable to contracting COVID-19. China and South Korea have begun to restart their economies based on their ability to evaluate individuals that are currently infected with COVID-19 and others who have overcome the virus and have measurable protective antibodies. This vital infrastructure is in place because these countries had previous experiences with other outbreaks of respiratory syndromes, including SARS and MERS. Given these experiences, both countries have effectively quarantined people who could be spreading the disease and are able to monitor protected individuals that can go back to work. This means that the US will need to create a similar system to monitor the spread of COVID-19 and whether specific regions need to reinstitute social distancing measures to combat a second peak in new cases. Dr. Scott Gottlieb, the former commissioner of the FDA, proposed that the US needs a National Sentinel Surveillance System to track and actively monitor COVID-19 cases before we are able to really relax social distancing measures. This system could be modeled off our current ILINet, which is designed to track the spread of influenza across the country. This would require significant investment in the public-health infrastructure to monitor testing (for the presence of the virus and immunity) with same-day point-of-care diagnostic testing. Dr. Gottlieb argues that states can start reducing social distancing measures when there is a sustained reduction in cases for at least 14 days. Overall, we believe the US has to invest in a centralized surveillance system along with increasing testing capacity before states can confidently relax social distancing measures.

Testing Capacity

Testing capacity is currently the greatest limiting factor driving uncertainty related to the potential spread of COVID-19 and when states could potentially relax social distancing measures. Currently, the positivity rate of testing in the majority of states is still >5%, which indicates that the current testing rate is not sufficient to accurately address the outbreak. The US is currently able to test ~100,000 people per day, but we believe national testing capacity for active infections needs to increase to ~500,000 per day to accurately account for all potential cases. We believe this can be achieved by the end of April with a combination of high-throughput and point-of-care testing. We are closer to this goal with the recent approval of Abbott Labs' five-minute COVID-19 test, but we note that it only runs one patient sample at a time. Both public and private labs will need to implement high-throughput strategies to keep up with demand. The second phase of the testing strategy includes serology, which is designed to determine if someone has been exposed to COVID-19 and generated potentially protective antibodies against the virus. This is a critical part of the surveillance strategy allowing Governors to confidently relax social distancing measures and allow certain people back to work. There are a significant number of companies developing immunoassays to test for the presence of antibodies (IgG/IgM) against SARS-CoV-2 and a complete list of known assays in development can be found [here](#). Currently, companies are focused on developing either a rapid point-of-care test (similar to Abbott Labs' test) or a high-throughput ELISA assay that takes longer to run. The FDA recently announced that they will not object to companies distributing validated serology tests, but noted that negative results do not rule out SARS-CoV-2 infection. We highlight that the validation of these tests have not been reviewed by the FDA. We note that this policy does not apply to home testing, which the UK is currently evaluating. The list of commercial companies that have notified the FDA and are offering serology tests can be found [here](#). Regarding rapid tests, BioMedomics (~15 minute test) and BodySphere (~2 minute test) have received emergency use authorization (EUA). BioMedomics plans to supply one

million tests in the coming months and BodySphere announced that they expect to ship five million test kits in the new few weeks. These tests can works at point-of-care facilities, but we believe ELISA assays are more accurate, previously validated and potentially better designed to handle the high demand. We highlight recent United Biomedical (and subsidiary c19) partnership with San Miguel County, CO to test the entire county as a small scale example of what needs to be done on a national level (press release [here](#)). The UBI/c19 ELISA antibody test has been validated in China, Taiwan and California and can obtain results within a "couple hours." We would also like to highlight that serology testing is less technically challenging than q-RT-PCR, which means more companies may be inclined to develop these assays. We note that this could pose challenges regarding the reliability of serology testing across different platforms and supply chain concerns if multiple companies are sourcing similar reagents. **Overall, we believe states need a centralized surveillance system to identify and contain the spread of COVID-19 based on viral and serology testing. The required scale to supply the necessary tests represents a challenge, but we believe states will rely on testing and new case/mortality trajectories before they being to relax social distancing measures. We believe sufficient testing capacity could be available by June.**

Exhibit 10: Positivity rate of COVID-19 testing in each US state.



Source: The COVID Tracking Project.

How Long Will It Take To Get Back To Work and When Can Full Economic Activity Resume?

The federalist nature of American governance further supports the notion that the US economy is likely to reopen in stages as opposed to abruptly. Three points to consider:

- **It is unlikely the President can force States to abandon their quarantine orders:** While authorities granted to the CDC appear to give the executive branch broad authority to quarantine and restrict travel even if States have not done so, we're not aware of any such authority to force States to loosen quarantine measures.
- **Political incentives suggest local officials are more likely to react to facts on the ground than messaging from the White House:** In our view, it's easy to prioritize economic activity over health risks when a threat is distant. It's more difficult when the risk is present. Hospital capacity is a key variable. Without appropriate capacity, not only in terms of beds but also critical equipment like ventilators, Governors who choose not to social distance could be inviting a crisis whereby there is an insufficient supply of medical treatment for those who need it. Even if one thought the risk of such a humanitarian crisis were not enough to incentivize social distancing orders, the politics of such an outcome almost certainly are. Hence, it's not surprising that many state governors continue to state that they will follow their own timeline, rather than the White House's, for scaling back social distancing.
- **States run the risk of greater fiscal and political strain by underreacting:** States may be unsure of which risk is greater: the short term economic pain of asking citizens to disengage from the economy by sheltering in place OR the economic pain of having an engaged workforce that is subject to a fast-spreading illness and the human cost of having insufficient hospital capacity to treat illness. Mitigation measures for the latter may also be undesirable. Tracking and regular fever-checking could be costly and politically challenging, particularly at a time when states are already starting to run substantial deficits to cope with the crisis. Hence, we think states are likely to play it safe and order social distancing until sufficient healthcare infrastructure (i.e., hospital beds, widely available testing & treatment, and sufficient ventilator capacity) is available as a proper mitigant to the risks of scaling back social distancing.

Below are the milestones we think are required before a region of the country can start to open up while minimizing human and economic casualties:

- **Peak in new cases and deaths:** The first milestone is a peak in new cases and deaths. To guard against the risk that a large outbreak could reignite, new cases and deaths should be trending downwards, particularly a sustained reduction in cases for at least 14 days (i.e., one incubation period of the virus) should occur.
- **Fully staffed and equipped hospitals:** Hospitals in the region must safely be able to treat all patients requiring hospitalization without resorting to crisis standards of care. Indeed, hospitals must have sufficient staff and capacity, such as acute-care beds and ventilators, for the predicted level of demand.

- **Widely available high-capacity testing and surveillance:** Although the U.S. has increased its testing capacity in the last couple of weeks, more capacity is needed. That increased testing capacity would allow for a new focus on identifying individual cases, including those with asymptomatic or mild infections. To support this focus on case-based interventions, sufficient capacity to support contact tracing also needs to be developed in parallel. We do not expect to reach this milestone, though, until the end of May at the earliest.

Once these milestones are met, individual regions can begin to slowly relax physical distancing measures, allowing the appropriate time between each adjustment to carefully monitor for any outbreaks.

Once this stage is reached, we identify the following steps and events that would allow people to begin to go back to work and to school:

- **Determine who is immune:** A serological assay can be used to identify evidence of immunity in someone who has recovered from COVID-19. With serological testing, people who are immune – and thus no longer vulnerable to SARS-CoV-2 – can be identified. Those who are immune could be allowed to return to work. And those who are immune could serve in roles where the risk of being infected is high – such as front-line health care workers and contact tracers. Moreover, accurate and widely available serological testing could further reduce the uncertainty around the case fatality ratio, which may affect people's view on risk associated with the relaxing of physical distancing measures. For example, if serological testing identifies a large proportion of the population as having been infected but with mild or asymptomatic infections, the case fatality ratio could be lower than expected while those with immunity could be higher.
- **Identify those who are immune and allow those who are low-risk to return to work:** With widely available serological testing, a portion of workers can be tested. Those who are immune and the young and healthy could be allowed back to work. At work, physical distancing measures can be incrementally eased. For those who are neither immune nor part of a low-risk population, teleworking could continue where possible.
- **Allow children back to school:** Newly opened schools should continue to review and implement physical distancing measures with input from local officials. We recommend that schools increase social hygiene measures and cleaning of shared surfaces. However, because the virus appears to have a low impact on children and children do not appear to be major spreaders of the disease, we believe it is prudent to re-open schools.
- **Increase surveillance for and containment of new cases:** South Korea has implemented rapid and extensive testing, combined with high-tech monitoring and public notifications, to identify and contain new cases. This approach has allowed those who are infected to be isolated, while allowing healthy people to go about their lives. The U.S. should emulate this style of response to new cases.
- **Accelerate development and distribution of therapeutic treatments:** Because therapeutics can reduce the burden on the healthcare system and reduce the risk in people returning to work and school, the development of new therapeutics and the distribution of FDA-approved ones should be prioritized. A safe and efficacious therapeutic could receive emergency use authorization or approval as early as the

late-spring or summer. Converting severe cases into mild cases could further reduce the strain on hospitals and allow a greater proportion of the employees back to work.

- **Prioritize vaccine research and development until mass vaccination possible:** When a safe and effective vaccine starts to become available, which we do not expect until the 2021 season, the vaccine should be made available to prioritized groups of people, such as front-line health care workers. Implementing mass vaccination should occur when supply is abundant. To achieve this, governments need to be partners in development. We believe governments should invest with companies to develop at-risk infrastructure to support wide availability of a vaccine. While some of this effort will produce unusable plants as some vaccines will fail, it is necessary to have the greatest near-term impact.

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(as of March 31, 2020)

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STOCK RATING CATEGORY	COVERAGE UNIVERSE		INVESTMENT BANKING CLIENTS (IBC)			OTHER MATERIAL INVESTMENT SERVICES CLIENTS (MISC)	
	COUNT	% OF TOTAL	COUNT	% OF TOTAL IBC	% OF RATING CATEGORY	COUNT	% OF TOTAL OTHER MISC
Overweight/Buy	1228	38%	306	44%	25%	543	37%
Equal-weight/Hold	1437	45%	322	46%	22%	702	48%
Not-Rated/Hold	2	0%	0	0%	0%	2	0%
Underweight/Sell	543	17%	72	10%	13%	212	15%
TOTAL	3,210		700			1459	

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COMPANY (TICKER)	RATING (AS OF)	PRICE* (04/02/2020)
David N Lebowitz, CFA, MPH		
Akebia Therapeutics Inc (AKBA.O)	E (09/07/2018)	\$7.07
Anylam Pharmaceuticals Inc (ALNY.O)	O (03/05/2019)	\$104.21
Ascendis Pharma A/S (ASND.O)	O (10/11/2019)	\$110.87
AVROBIO Inc (AVRO.O)	O (07/16/2018)	\$13.34
Blueprint Medicines Corporation (BPMC.O)	O (04/03/2019)	\$60.39
Epizyme Inc (EPZM.O)	O (12/05/2019)	\$14.26
Ionis Pharmaceuticals Inc (IONS.O)	U (11/07/2019)	\$49.01
Ironwood Pharmaceuticals, Inc. (IRWD.O)	E (03/27/2019)	\$10.10
MacroGenics Inc (MGNX.O)	U (11/21/2019)	\$5.41
Nabriva Therapeutics PLC (NBRV.O)	E (03/17/2020)	\$0.53
Rhythm Pharmaceuticals Inc (RYTM.O)	O (09/07/2018)	\$15.04
Schrodinger Inc. (SDGR.O)	E (03/02/2020)	\$37.95
Syndax Pharmaceuticals Inc (SNDX.O)	E (10/29/2018)	\$9.74
Zealand Pharma A/S (ZEAL.O)	O (09/12/2018)	\$31.72
Jeffrey Hung		
Acceleron Pharma Inc (XLRN.O)	O (02/03/2020)	\$83.60
Aprea Therapeutics Inc (APRE.O)	E (10/28/2019)	\$32.50
Cytokinetics Inc (CYTK.O)	E (09/10/2018)	\$12.05
Exelixis Inc. (EXEL.O)	E (03/18/2019)	\$16.65
MyoKardia Inc (MYOK.O)	O (09/10/2018)	\$46.40
Neurocrine Biosciences Inc (NBIX.O)	O (09/10/2018)	\$86.31
NextCure Inc. (NXTC.O)	O (06/03/2019)	\$35.88
Prevail Therapeutics Inc (PRVL.O)	O (07/15/2019)	\$12.11
Ultragenyx Pharmaceutical Inc (RARE.O)	O (03/27/2019)	\$50.02
Viebia Bio (VE.O)	O (10/28/2019)	\$31.99
Voyager Therapeutics Inc (VYGR.O)	E (09/10/2018)	\$8.70
Matthew Harrison		

Alector Inc (ALEC.O)	O (03/04/2019)	\$22.75
Alexion Pharmaceuticals (ALXN.O)	E (12/17/2019)	\$90.35
Amgen Inc. (AMGN.O)	O (12/17/2019)	\$208.88
argenx SE (ARGX.O)	O (01/04/2019)	\$133.31
BeiGene Ltd (6160.HK)		HK\$74.50
BeiGene Ltd (BGNE.O)	O (01/17/2020)	\$136.36
Biogen Inc (BIIB.O)	U (03/22/2019)	\$304.47
Biohaven Pharmaceutical Holding Company (BHMN.N)	E (04/09/2019)	\$30.30
Biomarin Pharmaceutical Inc (BMRN.O)	O (02/07/2017)	\$86.06
Bluebird Bio Inc (BLUE.O)	E (11/03/2017)	\$42.61
Cabaletta Bio Inc (CABAO)	O (11/19/2019)	\$6.82
Denali Therapeutics Inc (DNLI.O)	O (01/02/2018)	\$17.44
Editas Medicine (EDIT.O)	E (02/29/2016)	\$19.98
Evelo Biosciences Inc (EVLO.O)	O (06/04/2018)	\$3.70
Forty Seven Inc. (FTSV.O)	E (03/03/2020)	\$95.43
Fulcrum Therapeutics Inc (FULC.O)	O (08/12/2019)	\$10.43
Galapagos NV (GLPG.O)	E (12/17/2019)	\$190.01
Genmab A/S (GMAB.CO)	O (08/12/2019)	Dkr 1,379.00
Genmab A/S (GMAB.O)	O (08/12/2019)	\$20.30
Gilead Sciences Inc. (GILD.O)	E (10/01/2015)	\$76.98
Global Blood Therapeutics Inc (GBT.O)	E (03/21/2018)	\$50.56
Immunomedics Inc (IMMU.O)	E (01/22/2019)	\$10.65
Innoviva Inc (INVAO)	U (08/14/2014)	\$12.12
Insmed Inc (INSMO)	O (03/21/2018)	\$15.11
Kaleido Biosciences Inc. (KLDO.O)	O (03/25/2019)	\$5.35
Kodiak Sciences Inc (KOD.O)	O (10/29/2018)	\$43.72
Moderna Inc (MRNA.O)	O (01/02/2019)	\$33.20
Regeneron Pharmaceuticals Inc. (REGN.O)	E (10/01/2015)	\$498.75
Regenxbio Inc (RGNXO)	O (11/09/2017)	\$29.43
Rubius Therapeutics Inc. (RUBY.O)	E (03/13/2020)	\$4.25
SAGE Therapeutics Inc (SAGE.O)	O (02/26/2018)	\$26.75
Sarepta Therapeutics Inc (SRPT.O)	O (08/01/2018)	\$95.98
Seattle Genetics Inc. (SGEN.O)	E (12/10/2019)	\$118.67
Unity Biotechnology Inc. (UBX.O)	O (05/29/2018)	\$5.82
Vertex Pharmaceuticals (VRTX.O)	O (10/01/2015)	\$242.16

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DBV Technologies SA (DBVT.O)	E (10/23/2017)	\$3.91
Incyte Corp (INCY.O)	O (04/01/2020)	\$77.07
Neon Therapeutics Inc (NTGN.O)	E (01/16/2020)	\$2.60
Portola Pharmaceuticals Inc (PTLA.O)	E (09/05/2019)	\$7.13
Radius Health Inc (RDUS.O)	O (09/05/2019)	\$12.53
Unum Therapeutics Inc (UMRXO)	E (03/03/2020)	\$0.35

Stock Ratings are subject to change. Please see latest research for each company.

* Historical prices are not split adjusted.