

Holistic Research Report of COVID-19 Pandemic

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ABSTRACT

The SARS-CoV-2 (COVID-19) pandemic has left no one untouched, impacting the lives of billions of people. Due to the variance in socio-economic, political, and even belief systems around the world, different geographies have chosen to combat the virus in very different ways. The objective of our independent research was to identify what factors played a role in certain countries having a “better” response than others during the COVID-19 pandemic and then to relate that back to the political and cultural characteristics of those countries. We first researched coronavirus characteristics and compared them to those of previous pandemics to understand, physically, why the virus is hard to stop. Our research finds that COVID-19 has relatively “average” characteristics for infection and case fatality rates, but the difficulty lies in the time delay from more extended incubation periods and testing results turnaround times. That, along with the disproportionate effect on people with weak immune systems and pre-existing conditions, has made the virus hard to prevent without strict lockdowns of large parts of individual economies. Using this knowledge as a baseline, we analyzed what factors led to some countries adopting more effective responses than others by examining the general government response timelines of six countries: Germany, France, South Korea, Australia, the United Kingdom, and the United States. Our analysis finds that the differing effectiveness of a country's COVID-19 response can be narrowed down to three main factors: reaction time, protective policy enforcement, and testing rates. Moreover, we find that the responses often mirror the social and political climate of the country.

Hypotheses

We approached this investigation recognizing that there was a lot of data and analysis in the public domain, but perhaps an absence of fundamental understanding of the underlying root causes versus the effects. We had four incoming hypotheses:

1. The “average” physical characteristics of COVID-19 make it particularly challenging for a modern, democratic, interconnected nation to combat.

2. Addressing the pandemic involves balancing the need to protect lives and livelihoods, and countries optimize this calculus differently.

3. Of all the levers available to governments, testing is the most foundational measure that all governments should practice. Without that baseline data, other levers are hard to make effective.

4. After testing, countries follow different approaches that often mirror their past experience addressing crises, their political and socio-economic situation, and their geographical setting.

Our work set about proving or disproving these hypotheses, with a particular focus on the testing hypothesis in number 3.

Methods

To understand why COVID-19 has become so challenging for governments to deal with, we did a comprehensive review of past viruses and pandemics to analyze how their impacts varied as a function of their different physical characteristics. Specifically, we looked at the common cold, SARS, MERS, chickenpox, polio, measles, and Ebola.

Data selection

One of the challenges when analyzing epidemiological phenomena is finding reliable, consistent data sets and being able to clarify which causes correspond to which effects. For example, when looking at death rates, one has to consider how a state of lockdown reduces the number of deaths from car accidents (due to there being fewer people on the roads) while increasing the number of deaths of people with pre-existing conditions. Therefore analyzing the right data sets is critical.

Our primary data source came from a database called Our World in Data, as well as Johns Hopkins University & Medicine's Coronavirus Resource Center. It was quite challenging to find reliable data, especially as when we began the study, data for specific countries were not available. Several other data sources had not been adequately vetted, so we leveraged our advisory board to steer us toward reliable sources.

Country selection

We selected a range of countries from all over the world of varying sizes and social environments (North America, Europe, Asia, Oceania) in order to reflect the different approaches different nations had. We focused the majority of our research on Germany, South Korea, The United Kingdom, China, and the United States for this reason, believing that these countries encompassed a diverse range of strategies, social climates, and legislative action. We also examined Australia, Canada, and France, although not quite to the same depth. It was challenging to find good data from certain countries, namely China, which kept most of their case statistics and testing rates from the public domain. For cases like China, most of our conclusions are based upon what we have read, instead of raw data (that was not available to analyze).

Advisory board

We set up an advisory board of experts with a variety of backgrounds and capabilities to give us valuable advice on general methodology, and reliable data sources to use. Specifically, the board was comprised of:

- **Byron Philhour** (Dean of Academics at San Francisco University High School) - overall direction and simulation.
- **Emma Hartmann** (Infectious Disease teacher at San Francisco University High School) - overall direction and looking specifically at the characteristics of COVID-19 compared to other viruses.
- **Mihir Mysore** - Expert Partner, McKinsey, co-leader of McKinsey's COVID-19 Response Center - refining and testing initial hypothesis, provided general advice about ways to think about country response.
- **Anthony Ramirez** - McKinsey, Solution Leader, Data Science Center of Excellence - provided insight into factors of virus, general simulating advice.

See appendix for interview guides of [Mihir Mysore](#) and [Anthony Ramirez](#) to get a better understanding of the topics we covered.

Results

1. The characteristics of COVID-19 make it particularly challenging for a modern interconnected world to combat.

In regards to two of the physical attributes most often used to characterize a virus – the reproduction number, R_0 , and the case fatality ratio, CFR (as shown in Figure.1 for a selection of viruses) – the COVID-19 virus seems to lie in the middle of the pack. So, what is it about COVID-19 that makes it so hard for societies to deal with?

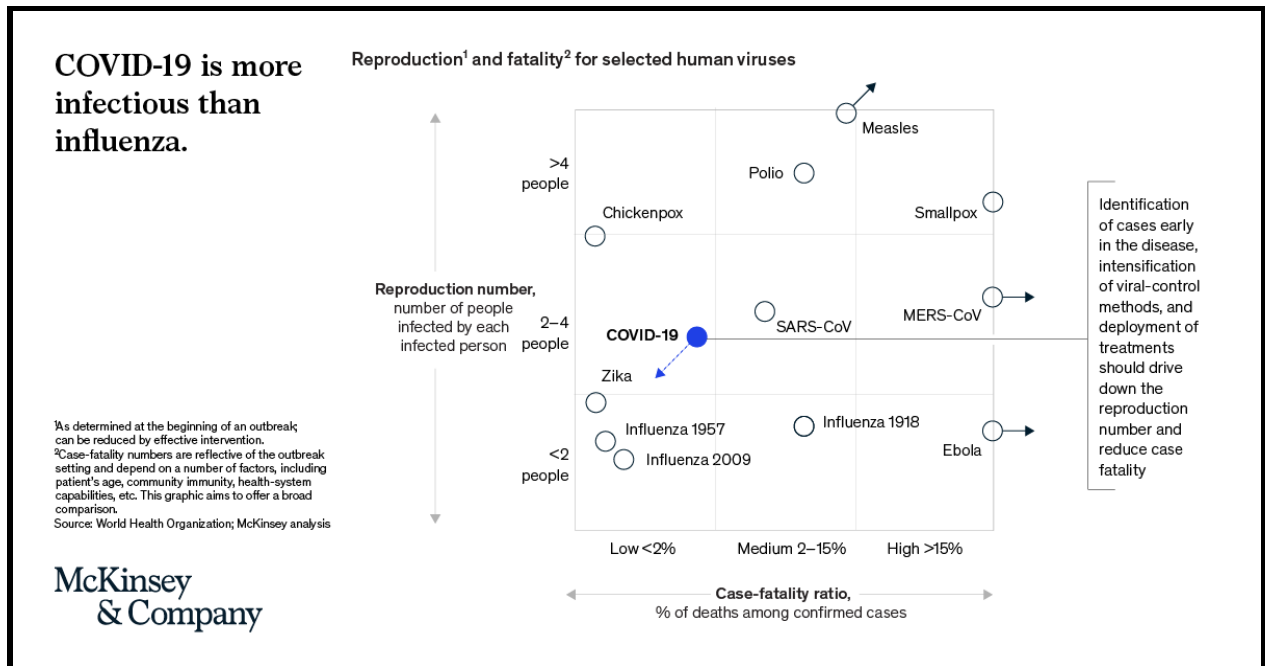


Figure 1. McKinsey Comparison of Reproduction and Fatality for Selected Viruses and Pandemics

We found that this can be explained by noting that COVID-19 has:

- A relatively high transmission high rate; considerably more infectious than influenza, but much less than measles or polio.
- A mortality rate that is higher than influenza, but much lower than Ebola. People with Ebola die so fast that the disease only wipes out a small group of people.
- An increased morbidity rate for people with pre-existing conditions and/or weak immune systems
- 1–2-week asymptomatic period, during which symptoms are not displayed, but the individual is infected (and infectious).
- A relatively long test turnaround time from 1 day to 2 weeks (e.g., as compared to instant infrared testing that is used to test for SARS).

It is interesting to note that COVID-19 has relatively “average” characteristics for transmission and mortality rate. Starting with the R_0 rate, COVID-19 is quite infectious, although nowhere near as transmissible as chickenpox or measles. As can be seen by both Figure 1 above and Table 2 below, in comparison to other viruses, COVID-19 has an R_0 rate of approximately 2 - 2.5, which means that the virus can spread relatively quickly from person to person.

Still, these R_0 rates are much lower than that of measles (~14). COVID-19 also disproportionately impacts people with weak immune systems and/or pre-existing conditions but is still not as deadly as previous epidemics like Ebola or MERS. This lower fatality rate allows the virus to spread faster than those other viruses as the newly infected host likely will not die and is, therefore, able to infect many other people. That being said, both of these characteristics are certainly not outstanding compared to previous pandemics.

A more important difference is the long incubation period and longer test turnaround times. As shown by Table 2, COVID-19 has a much more extended incubation period than that of SARS or MERS. This results in infected asymptomatic individuals spreading the virus for a longer period of time (up to 2 weeks) than would be possible from infected people with Ebola or measles. The longer the virus can spread undetected, the more difficult it is for countries to track where the virus has been and where it is going, which has resulted in many countries struggling to contain the spread. When you consider that these physical characteristics are all working together, it's easy to see why the COVID-19 virus has been extremely challenging and complicated to contain.

Table 2 below reinforces the most important differences between COVID-19 and other viruses; although COVID-19 is relatively average for most categories, the highlighted sections for the incubation period or detection time have made it difficult for many countries to manage.

Disease:	Flu (vaccine)	COVID-19	SARS	MERS	Ebola	Measles (vaccine)
R_0 Rate	1.3	2.0 - 2.5	3	0.3 - 0.8	1.0 - 1.5	14.0 - 14.5
CFR	0.05 - 0.1%	~3.0 - 3.5%	9.6 - 11%	34.4%	60.0 - 90.0%	14.0 - 15.0%
Incubation Period	1 - 4 days	4 - 14 days	2 - 7 days	6 days	2 - 8 days	3 - 14 days
Hospitalization Rates	2%	~19%	Most cases	Most cases	Most cases	Most cases
Detection method	Swab	Swab or anti-body	Temperature	PCR or anti-body	Test	Swab
Detection time	Couple of days	1 day - 2 weeks	Instant	Couple of days	Instant	Couple of days

Table 2. General Comparison of COVID-19, Flu, Sars and Mers

Source: Johns Hopkins Medicine, CDC, Yale University, BioRender, OurWorldinData

2. Addressing the pandemic involves balancing the need to protect ‘lives and livelihoods’, and countries optimize this calculus differently

In our research we attempted to compare these relative response timelines between six major countries: South Korea, Australia, Germany, France, The United Kingdom, and The United States. We did so by investigating and plotting the dates for the start of lockdown, the implementation of travel restrictions and mask mandates, the reopening of the economy, and any significant shifts in testing rate. We divided the graphs into three groups of two countries with similar response characteristics.

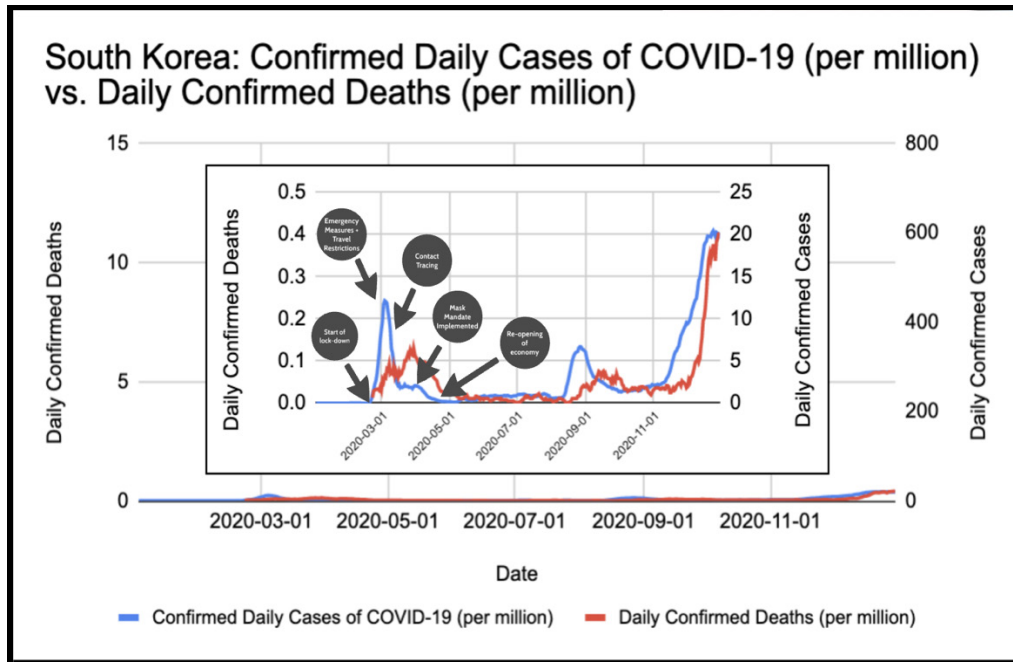


Figure 3. COVID-19 Response Timeline: South Korea KR

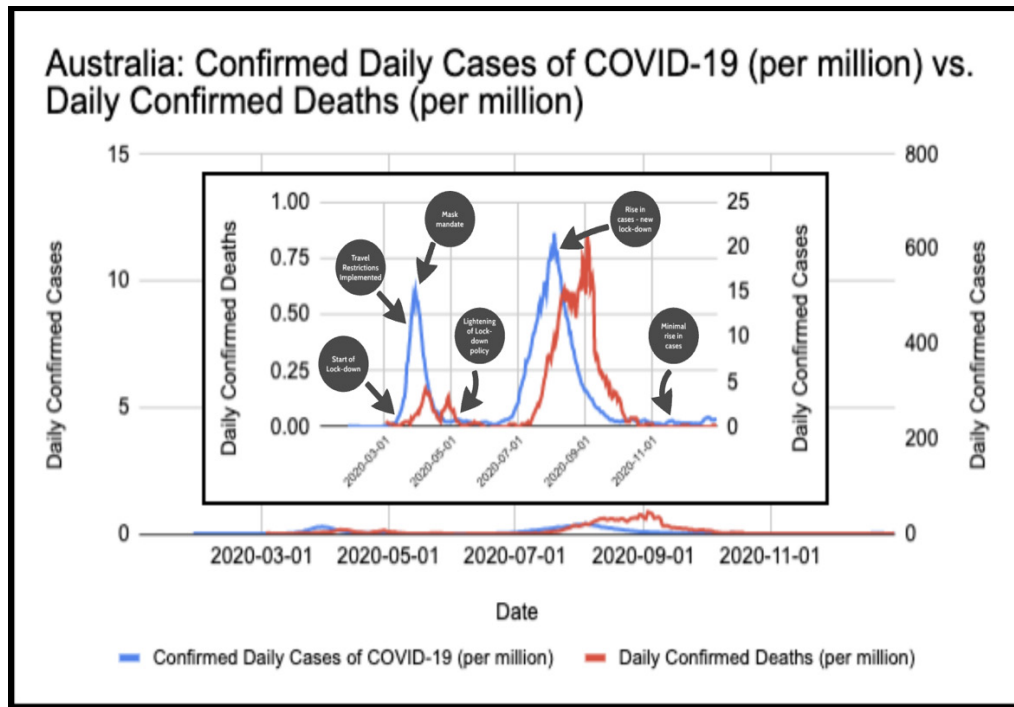


Figure 4. COVID-19 Response Timeline: Australia AU

This first group consists of South Korea and Australia, both of which have had almost impeccable COVID-19 responses. As seen from the timelines, the confirmed case trends for Australia and South Korea are similar during the first phase, spiking during March and April and decreasing until August, when cases rise again due to the relaxation of policies going into summer. Both governments were then quick to address the second spike in cases and recovered shortly after. These responses were characterized by quick lockdown enforcements and strong mask-wearing, traveling and social distancing policies. Both countries managed to keep their daily confirmed cases far below the normed range of 0-800 for cases and 0-15 for deaths, so we added an inset graph for a scale of 25 people per million, emphasizing how effective their responses were.

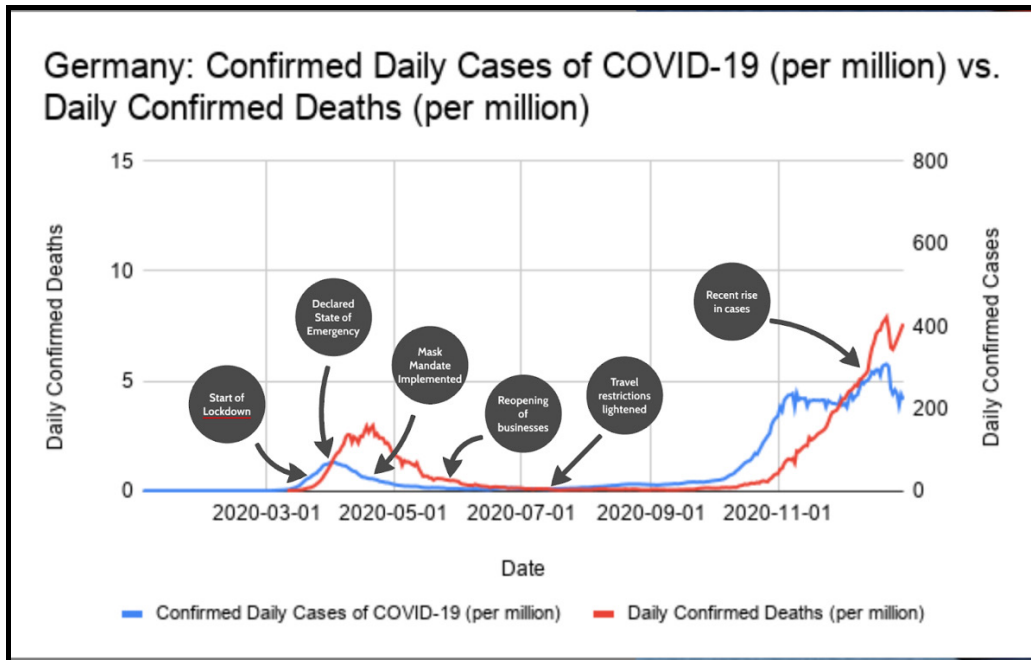


Figure 5. COVID-19 Response Timeline: Germany DE

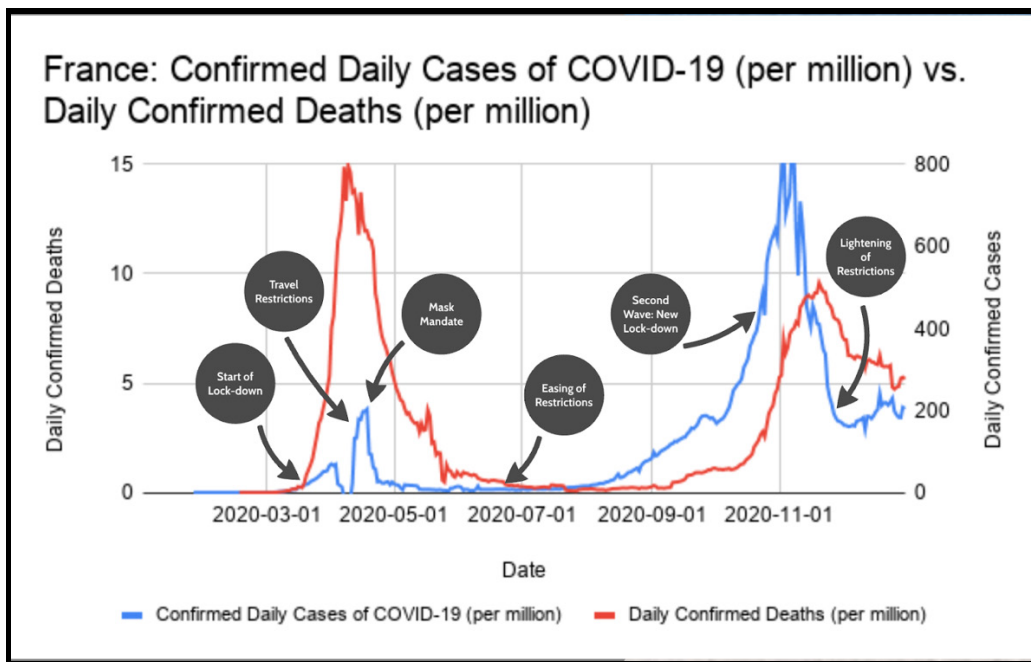


Figure 6. COVID-19 Response Timeline: France FR

Germany and France had relatively similar responses and results to each other from March through to September. France then experienced a dramatic increase in cases during October and November. This comparison is interesting because both countries are geographically next to one another. Compared to Germany's gradual increase, France's rapid case spike shows a response difference between the two. That being said, both countries saw a rise in cases during September and October (France's was more severe than Germany's) but ultimately managed to control

the spread. These responses were not as effective as those of South Korea or Australia, but by no means terrible, with both countries locking down at the same time and taking the proper steps to slow the virus.

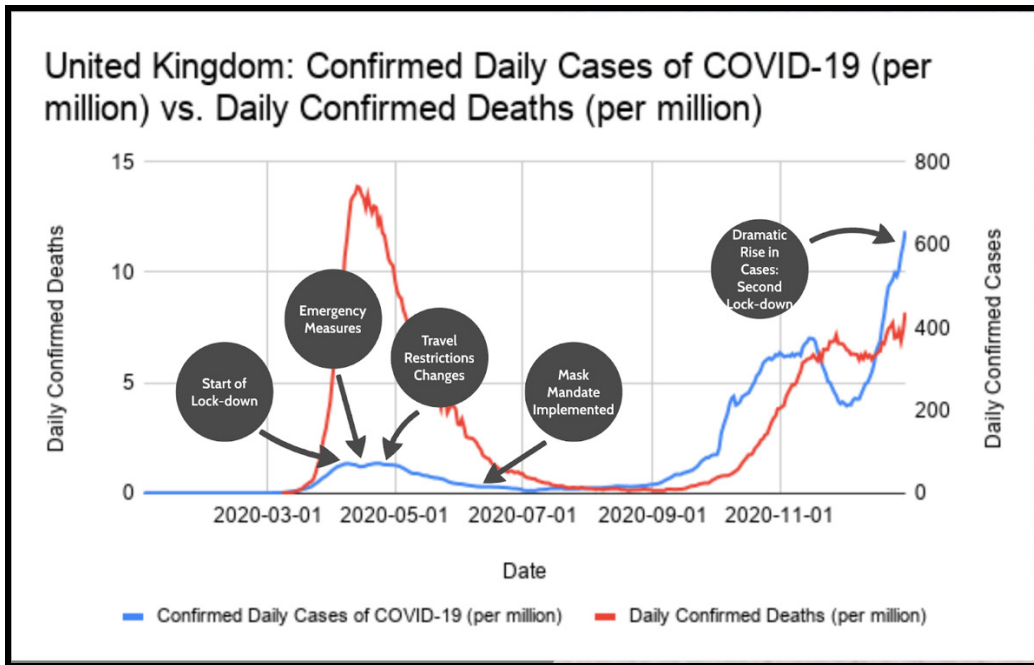


Figure 7. COVID-19 Response Timeline: United Kingdom GB

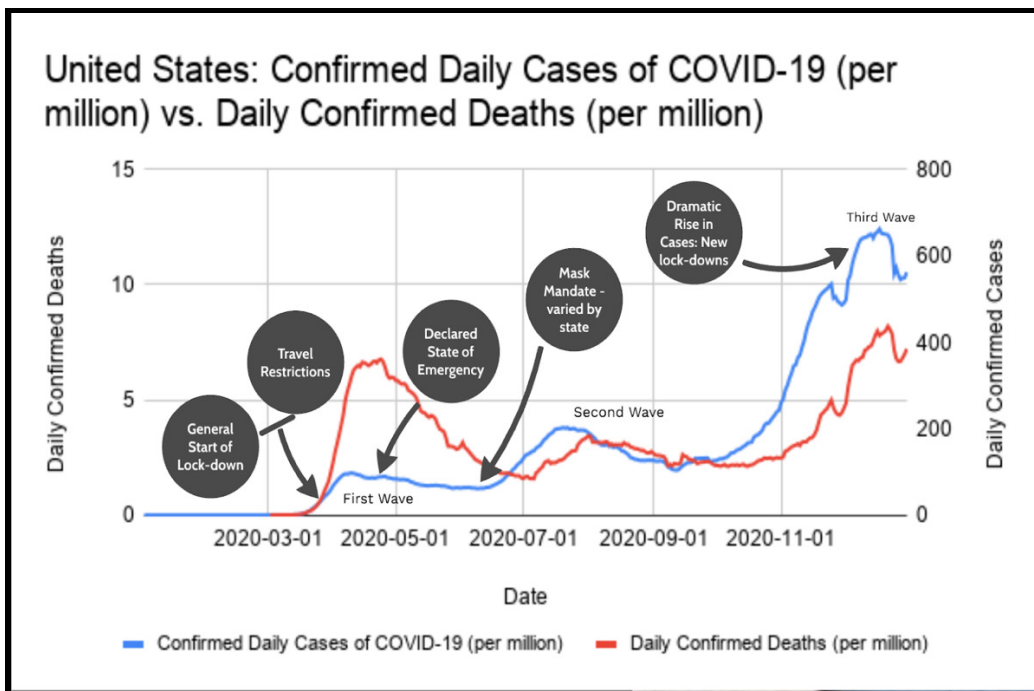


Figure 8. COVID-19 Response Timeline: United States us

Finally, we see that the U.S. and the U.K. had similar patterns during the first wave, both taking longer to get the wave under control. The U.S. then encountered a second wave in July, and both the U.S. and U.K. saw an even steeper rise in October. The United Kingdom's response was initially marked by a late lockdown implementation (late March/early April), but the country managed to gain a pretty strong foothold over the virus until September, when the opening of schools, universities, and businesses allowed for rapid spread. The U.S. made most of the right moves on paper (similar lockdown and travel restriction dates to Germany, for example), but were never able to gain complete control over the first wave before lightening restrictions, and have therefore struggled to contain the spread ever since. Both the United States and the United Kingdom are currently experiencing a considerable rise in cases, entering a second or even third lockdown and social restrictions throughout the countries.

After comparing the timelines of these countries in more depth, we found that countries had a more successful response to the pandemic if they went into lockdown earlier and took the proper administrative steps to handle the virus, including creating capacity in hospital ICUs, preparing clinics with tests, and enforcing protective policies like mask-wearing and social distancing. For example, comparing the start of lockdown for South Korea (approx. February 20-28) to that of the United Kingdom (March 26-30) can at least partially explain why South Korea's cases have lowered while the cases in the U.K. continues to surge, with the country entering a second lockdown in major cities.

Looking more specifically at the lockdown period, during our interview with Mihir Mysore at McKinsey, we discussed how lockdown acts as a timestamp, which gives around 6-8 weeks for countries to develop a plan to ensure a safe transition back to normality. Future containment is driven by what plans the governments put in place during that 6-8 week period, as continued lockdown beyond that stretch of time is socioeconomically unrealistic.

Nearly every country went into some sort of lockdown as the number of COVID-19 cases began to rise, but these lockdowns varied greatly, both in their length and their general nature. The efficacy of these lockdowns depended on a series of factors; namely, the specific provisions of the lockdown, the social climate, and the governmental response after the lockdown. Unsurprisingly, countries with stricter lockdown measures had fewer cases, both during and after the lockdown. China had notoriously stringent regulations during lockdown; on February 1, Chinese province Hubei issued a ruling that completely prevented people from exiting their houses. One member of each household was permitted to leave and purchase essential goods every two days. Many provinces followed suit soon after, implementing a similar curfew. While this was quite the rigorous statute (as shown by Figure 9 below), it allowed China to reduce viral transmission drastically. Thus, when lockdown ended, they were able to cautiously begin reopening the country without seeing a sudden spike in cases.

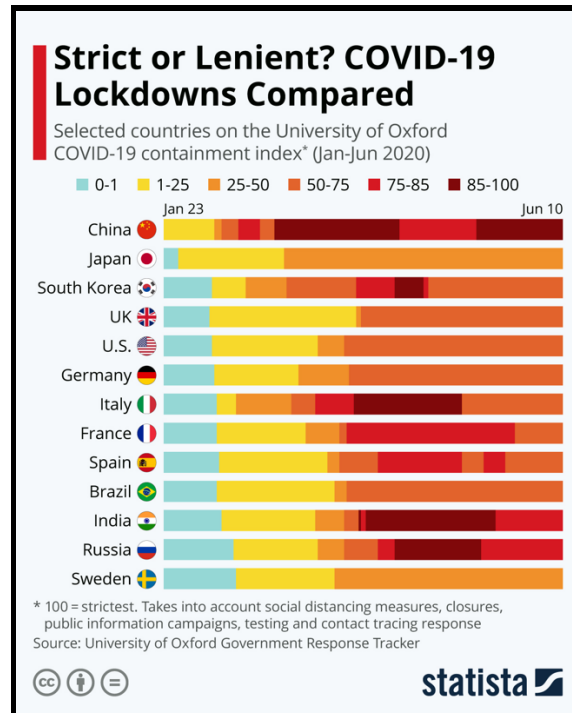


Figure 9. Statista Comparison of Lockdown Strength

Overall, at the start of the pandemic, countries that were effective in locking down the country and limiting social interaction managed to minimize the virus's spread. That being said, lockdown only serves as a temporary fix, and as seen from Figure 9, most countries did not have the same intensity level of lockdown as China and therefore needed to find other ways to ensure a safe transition to their economy. The initial lockdown period can only last for around 6-8 weeks before people need to leave their homes and return to work, so during that time, countries had several options to lower physical spread:

- Tracking the disease and preventing spread
 - Increasing testing rates: easily the most effective to stop any dramatic spread of the virus.
 - Knowing who has, and does not have the virus will allow the majority of businesses to reopen - eventually want everyone tested.
 - Enforcing strict protective protocols: mask mandate, social distancing, travel restrictions (fines for each if caught).
 - Implementing contact tracing: knowing who has the virus, and where they have been can help to limit further spread.
- Limiting Mortalities
 - Developing therapeutics: helps to make people feel better, but does not go about the actual problem.
 - Developing a vaccine: takes the longest, but obviously once it is achieved will eliminate most spread of the virus if easily accessible to the public.

Table 10. below relatively shows how different countries used the lockdown period, with corresponding grades on execution:

Country:	Lever:				Type of strategy:	Grade:
	Test- ing	Protective Poli- cies	Contact Trac- ing	Therapeutics/vac- cines		
United King- dom	X	X	X	✓	Suppression	C
China	✓	✓	✓	✓	Elimination	A
Germany	✓	✓	X	X	Suppression	A
United States	✓	X	X	✓	Control	D
South Korea	✓	✓	✓	X	Elimination	A
France	✓	✓	X	X	Suppression	B
Australia	✓	✓	X	X	Elimination	A

Table 10. Hamilton Lane Country Strategy Comparison
 Source: Hamilton Lane

3. Testing is the most foundational lever all governments should practice. Without that baseline data, other levers are hard to make effective.

Taking a step back, it is important to ask why some countries saw an increase in cases post-lockdown and others a decrease. There is no single answer to this question, but something we can tangibly point to is the amount of testing each country conducted during and after lockdown. Lockdown typically served as a temporary fix to the pandemic, not a solution, providing a way for countries to stall the spread of cases while simultaneously developing strategies to combat it. Arguably the most effective of these strategies was the development of an aggressive, consistent testing system. Testing was crucial because it allowed the country to generally track the virus, helping local governments and cities to react to outbreaks and enforce restrictions accordingly. Of course, countries can't report cases without testing, but countries want to get to a stage where they test so much the number of positive cases is low. We found that countries that tested more *after* their main lockdown were able to maintain their lockdown-induced case suppression, while countries that did not make a concrete or substantial effort to increase testing (e.g., the U.S. and U.K) tended to

see the case count creep back up. Without the testing baseline data, all other levers available are hard to make effective.

We attempted to prove this with six graphs below for South Korea, Australia, Germany, France, the United Kingdom, and the United States, where we found that countries with similar response strategies (as seen from Figure 3 – Figure 8 above) also had similar trends with testing.

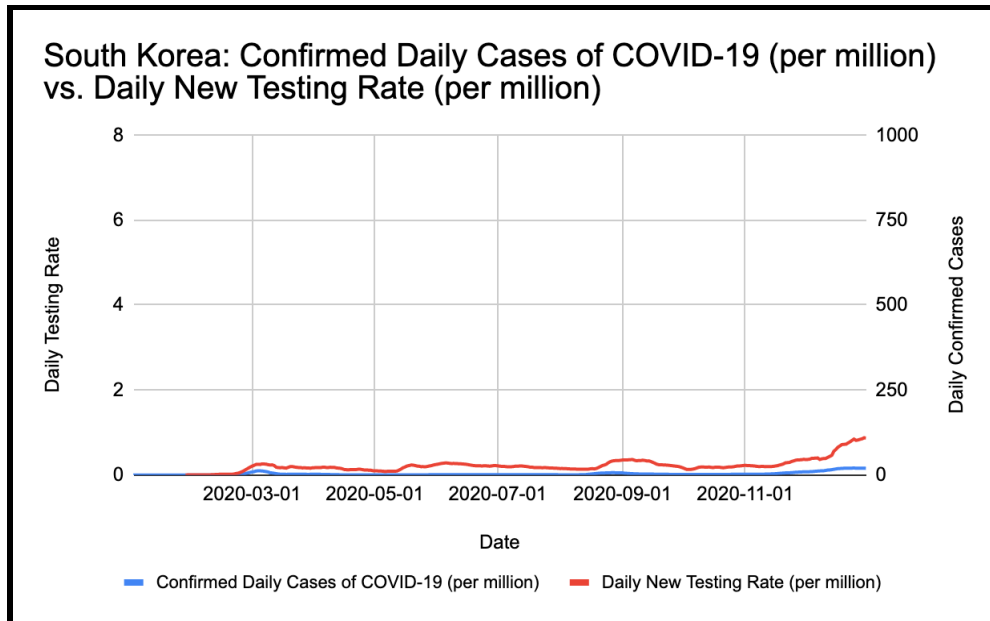


Figure 11. Testing Rate vs. Daily Confirmed Cases: South Korea KR

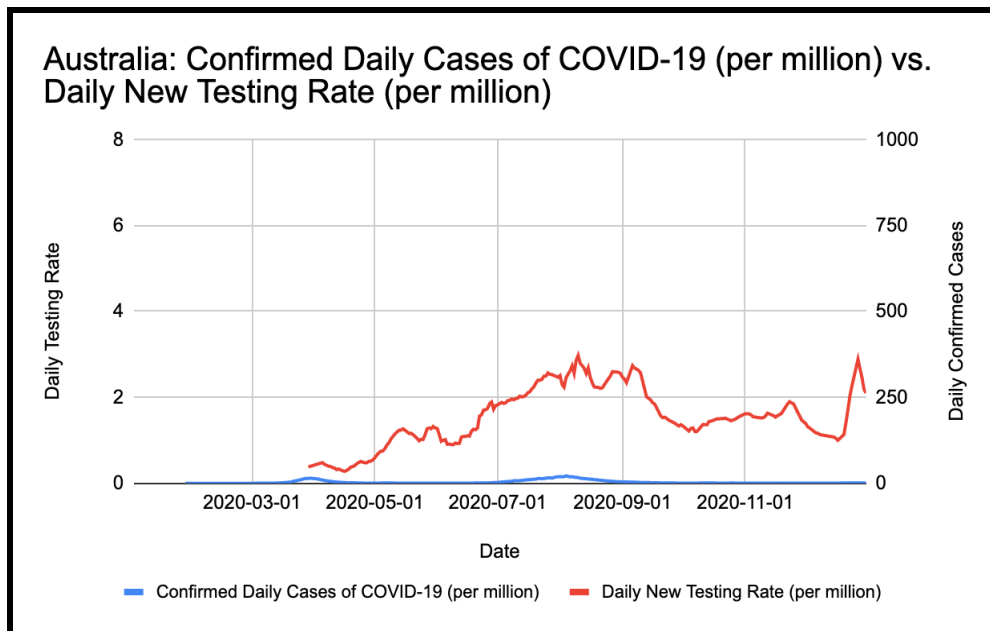


Figure 12. Testing Rate vs. Daily Confirmed Cases: Australia AU

Like before, South Korea and Australia both managed to keep their cases low while also increasing testing. A case in point here is Australia, which increased testing rates above the likes of Germany and South Korea while seeing no spike in cases. Getting testing rates this high allows the government to know who has and does not have the virus, and they can therefore adjust accordingly.

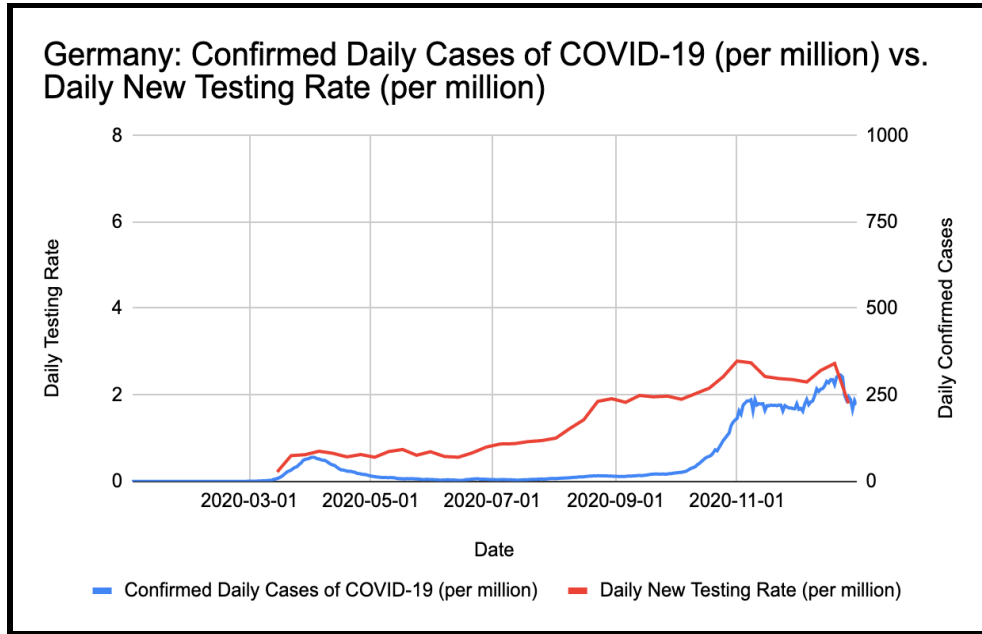


Figure 13. Testing Rate vs. Daily Confirmed Cases: Germany DE

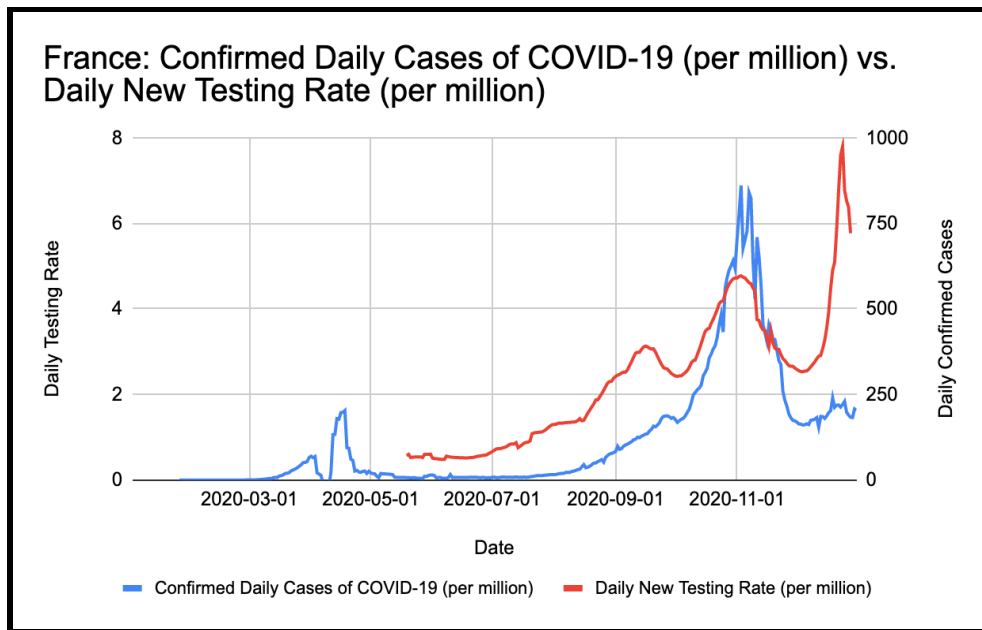


Figure 14. Testing Rate vs. Daily Confirmed Cases: France FR

As we have already seen, both Germany and France experienced a spike in cases over the last two or three months, but both countries managed to get a hold of the spike while maintaining steady testing rates. Looking at France in particular, after the dramatic increase in cases during October and November, the government reacted in the right way by a) enforcing strict lockdowns and protective policies and b) increasing the testing rate (more than any other country we examined) while seeing a decrease in cases.

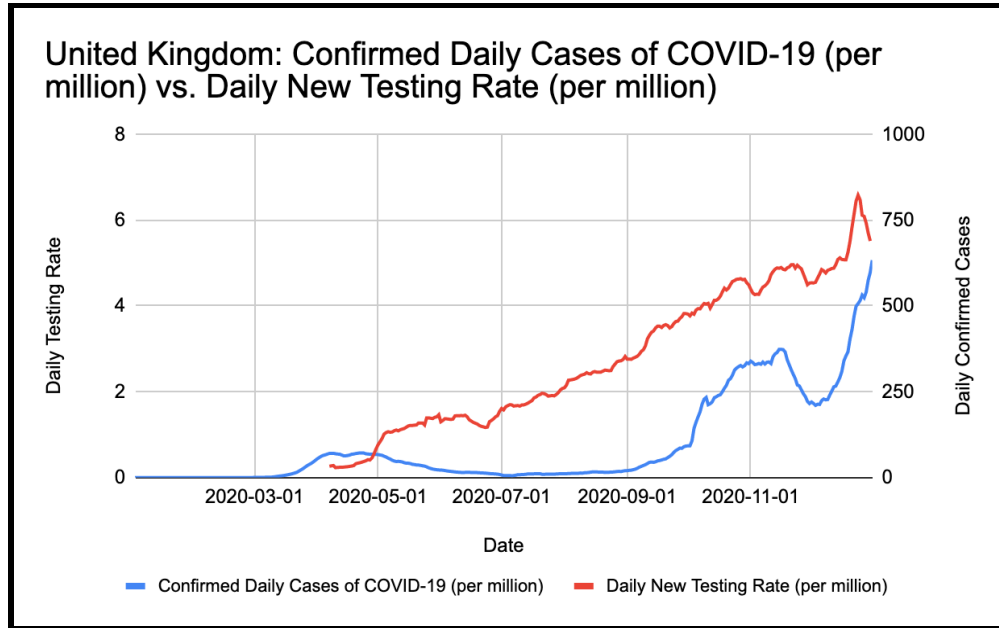


Figure 15. Testing Rate vs. Daily Confirmed Cases: United Kingdom GB

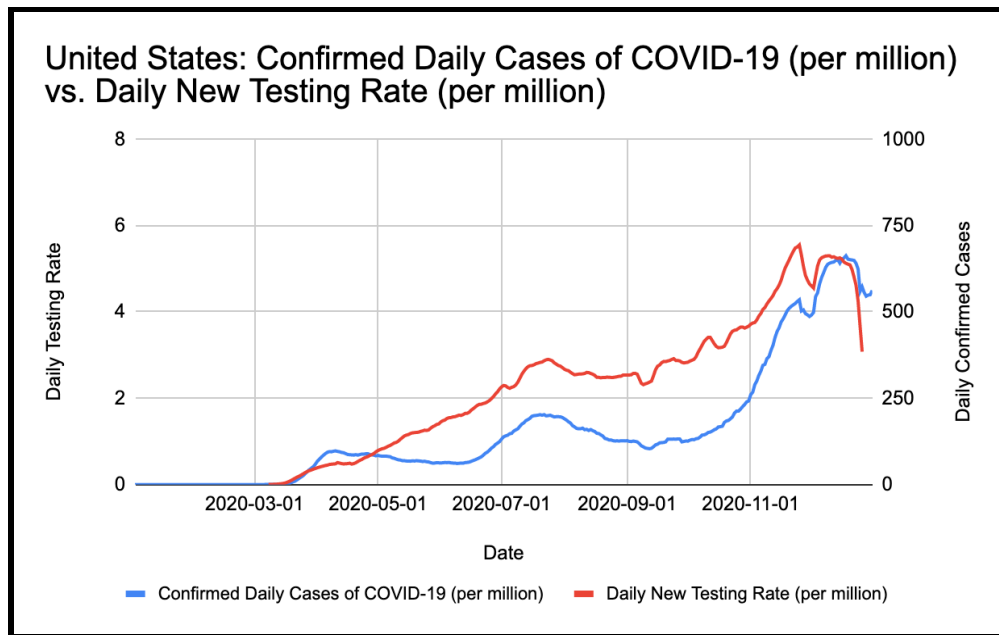


Figure 16. Testing Rate vs. Daily Confirmed Cases: United States US

Meanwhile, while the United Kingdom and the United States have both done a solid job at increasing the testing rate as of late, they have not been able to keep the number of cases fixed in a plateau the way countries like South Korea and Australia have. This is not a bad thing in and of itself; actually, it should be expected. Nevertheless, it is important to look at the context of both countries as a whole. Currently, the U.S. and the U.K. are stuck. Both are developed, technologically advanced countries, and yet the virus continues to ravage populations. Hundreds of thousands are dead, hospital beds are filling up, and millions are having trouble paying their bills. In the state that these countries are in, they need to ramp up the testing to where the cases do not increase so severely when they do so. Unfortunately, that does not seem to be the case as of right now.

Taking a step back, testing is crucial because it is both the beginning and the end of the cycle of case prevention. Once a country increases its testing rates, testing shifts gradually from an action taken when one strongly suspects they have the virus to an action taken routinely, even if one doubts they will test positive. This makes it easier for countries to catch cases before the viral carriers have a chance to spread it to others. Furthermore, in making tests more widely available, countries allow schools and jobs to reopen again. The economy can begin to recover, and the government can invest in even more testing, thus restarting the cycle. Countries like Australia and New Zealand (not represented in the graphs above) have successfully completed this cycle, and they have nearly eradicated the virus within themselves altogether. This concept can be demonstrated in Figure 17 below.

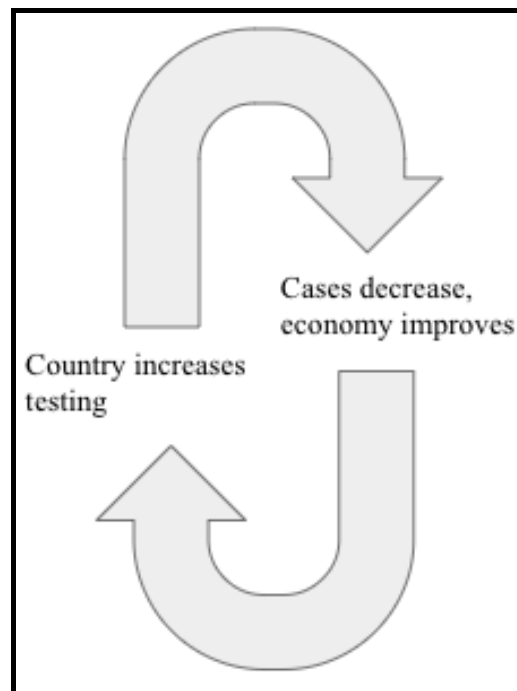


Figure 17 Cause and Effect Chart of Testing

4. Addressing the pandemic involves balancing “lives and livelihoods,” finally concluding that countries’ responses to the pandemic reflect their cultures and socioeconomic situations.

Back in March, McKinsey coined the phrase “lives and livelihoods,” claiming that addressing this pandemic involves addressing the significant risk that this pandemic poses to both. Essentially, governments are faced with a tough choice between enforcing lengthy, restrictive lockdowns, which hurts the economy and people’s jobs, or “livelihoods,” and sacrificing the “lives” of many (particularly more vulnerable parts of the population) to a deadly virus. As we know, based on the characteristics of COVID-19, the only proven way of effectively containing the virus (absent a vaccine)

is by enforcing pro-longed lockdowns. At the same time, countries knew that restrictive lockdowns would halt their economies and were therefore also focused on ways to limit economic impact during the lockdown phase. This was highlighted in more depth in a paper by McKinsey and Company at the very beginning of this pandemic, on March 23, 2020.

In this article, the authors suggest that “to avoid permanent damage to our livelihoods, we need to “timebox” this event: we must think about how to suppress the virus and shorten the duration of the economic shock.” This level of thinking can be demonstrated by the graph below, which argues that the first phase of the pandemic should be directed towards suppressing the virus *and* helping local businesses:

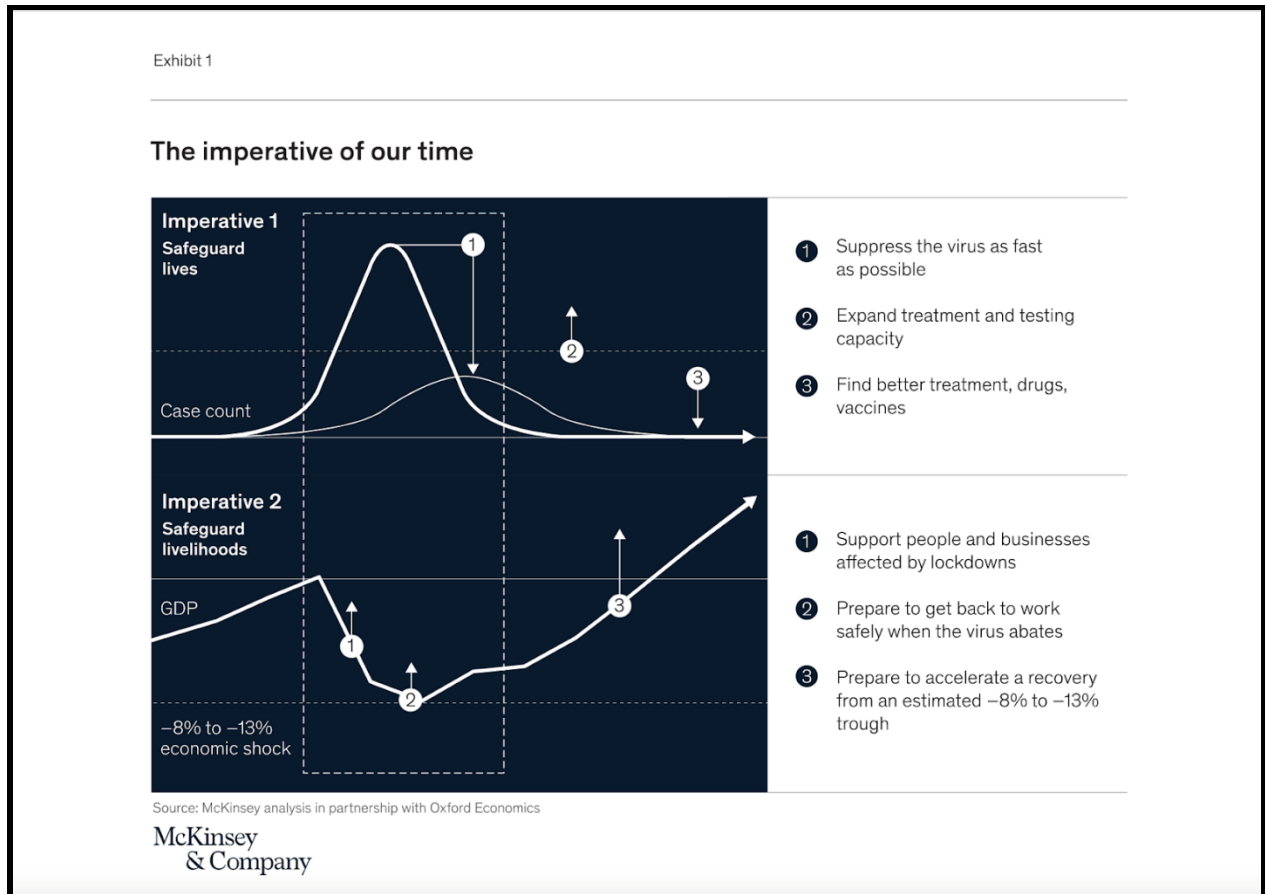


Figure 18. McKinsey “Timebox” Graph for Lives and Livelihoods

We categorized the differing reactions for each of the lives and livelihoods responses.

In order to save lives, countries needed to:

- Quarantine, isolate and enforce pro-longed lockdown
- Launch and aggressive testing program
- Make sure hospitals have capacity (e.g., ICU beds), and are properly equipped with supplies (beds, tests, etc.)
- Develop therapeutics and vaccines

In order to ensure the safety of livelihoods, countries needed to:

- Implement legislative acts and public-policy responses
 - Furlough Scheme (UK)
 - Stimulus bills (US, Europe)
 - Reduce or delay rental payments

We found that although all countries wanted to balance both “lives and livelihoods,” certain countries took more steps towards a particular direction. For example, countries like Germany, South Korea, New Zealand, and Australia focused more on the ‘lives’ side of the coin, enforcing strict lockdown measures and supplying hospitals with the necessary resources. These strategies have been categorized as “elimination” or “suppression,” attempting to completely eliminate the virus through rigorous testing, contact tracing, border restrictions, and protective measures such as mask mandates and social distancing. By contrast, although countries like the United States certainly focused on saving millions of lives, they also focused heavily on the economy and business community, enforcing public-policy responses like stimulus bills to keep the economy ticking. This response strategy is categorized as “control,” as countries often aim to control spread (without eliminating) while maintaining their economy. Figure 19 below shows the comparative stimulus bills by major countries during the pandemic, and although the United States has the lowest total package, the country has the highest immediate fiscal impulse, showing the desire to limit the current economic downturn.

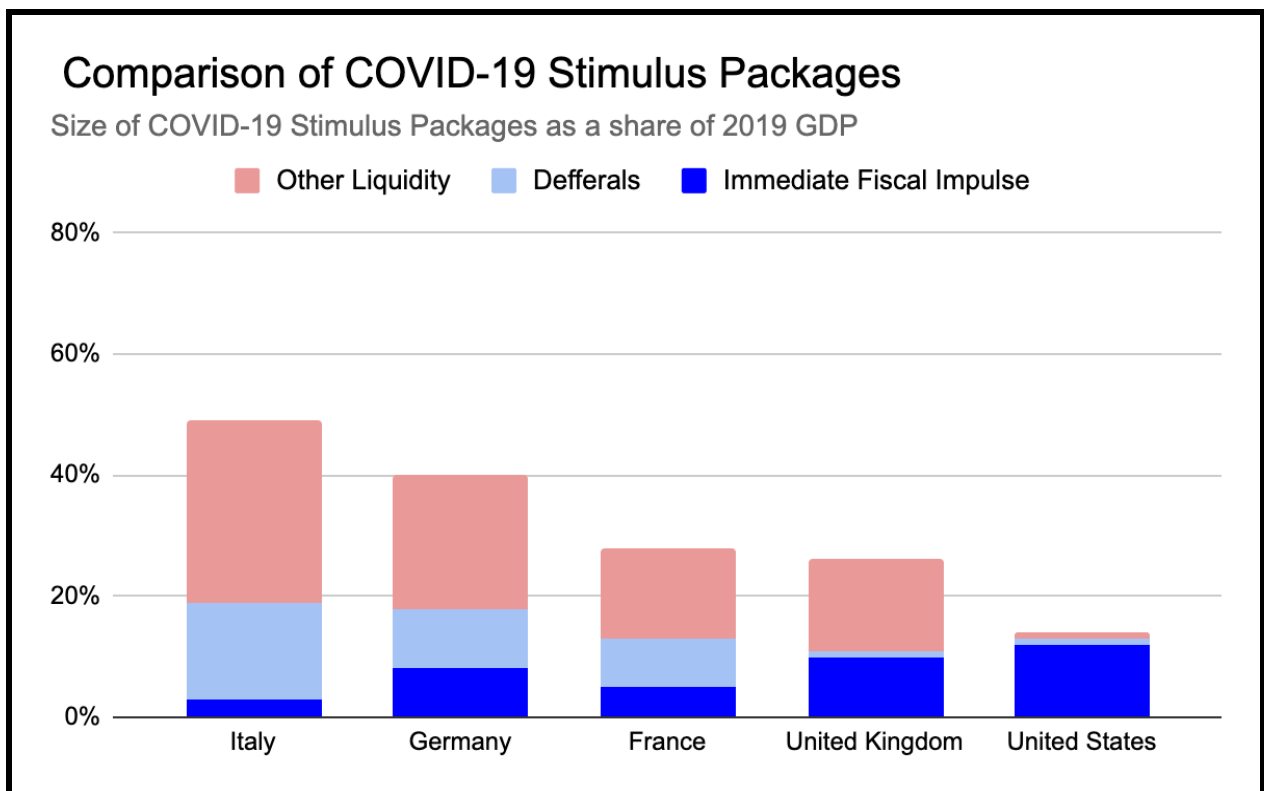


Figure 19. Statista Comparison of COVID-19 Stimulus Packages

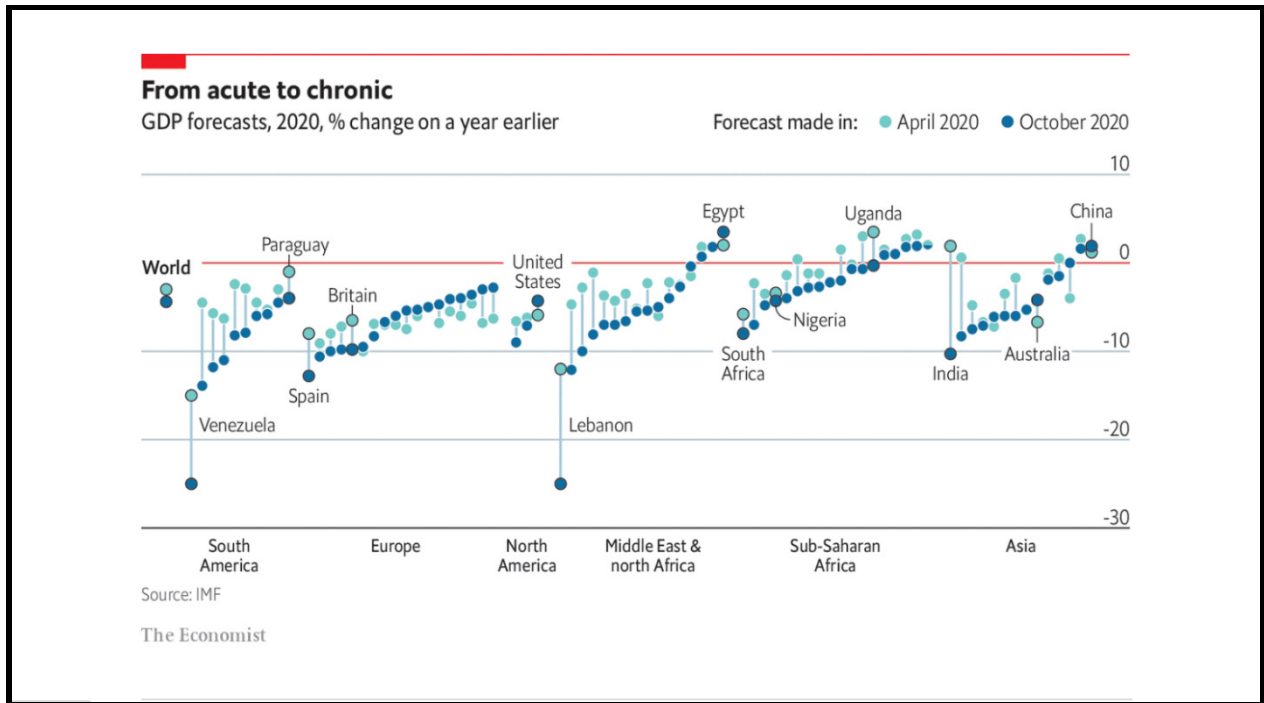


Figure 20. Economist Chart Comparing Predicted vs. Actual GDP Change

Figure 20 also reinforces this point, as the United States is one of the few countries to have overachieved their expected 2020 GDP forecast back in April, one month or so after the pandemic hit. Looking at round estimates, the US was meant to have a growth of around -6% and ended up around -4%, which is a feat few others managed. This was accomplished through some of the evidence shown in Figure 19, where the US government added lots of immediate fiscal impulse to stop the economy from hurting. Looking at Britain as a comparison, they saw similar projections to the US in April but ended the year around the -10% mark, showing the difference in COVID-19 response focus between the two countries. That being said, although the country managed the pandemic effectively in an economic sense, the case-death statistics are still quite damning and should not be acceptable under any circumstances.

This leads to the second point of the country analysis: countries with experience of a crisis responded well to that particular element. For example, South Korea had prior knowledge, a “playbook” even, of what to do during a pandemic, having an outbreak of another coronavirus back in 2015, understanding that the sooner the country went into lockdown and enforced mask mandates, the sooner they could limit the spread of the virus. The other key example here is the United States, which went into an economic depression in 2008 after the collapse of the housing market, and were therefore very careful not to make the same mistake again, adding enormous amounts of immediate fiscal stimulus to help their economy.

It should be recognized that other factors also play into the number and spread of cases beyond response time and protective policy enforcement, such as the social behavior/climate, type of government, population size, etc. Countries with larger populations were always going to have a more challenging time ensuring that their people were following the new regulations, but the social climate and type of government differentiate the effectiveness of country response. For example, we find that countries with a typically more individualistic social body, like the United States, had a tougher time enforcing policies like mask-wearing, social distancing, and lockdowns. The United States also has a strong partisan and sectional divide throughout the country, making the task even more difficult for state governments to handle. The physical response to the virus was decentralized to individual states to decide, leading to a cacophony of different responses. Without control of state borders and allowing largely free movement of people, this led to a very challenging situation. By contrast, the US’s fiscal response (to protect livelihoods) was done at the federal

level and was one of the most effective that any country undertook. On the other hand, typically cooperative social bodies from South Korea or Germany were able to follow the lockdown and mask-wearing policies very well, easing the government's pressure to come up with a plan during lockdown.

Conclusion

Our investigation highlights several fundamental and critical lessons from the COVID-19 pandemic. **First and foremost is the importance of listening to the science.** Countries that heeded the recommendations from scientists, who understand this virus's characteristics best, have been able to manage a more successful response. This meant acknowledging the importance of speed and small numbers; countries who listened to their scientific advisors were told that a quick response would help limit exponential spread. The quicker governments responded to the pandemic, the sooner they could halt the spread of the virus. A prompt government response that included strict lockdown and widespread testing gave a country the best chance of limiting spread and deaths. This leads to the next lesson. After triggering the first lockdown in March 2020, successful countries used the time to develop a rigorous and well-implemented plan to ensure a safe transition back to normality, recognizing that further lockdowns were likely to be harder to enforce, both politically and socioeconomically. Populations would tolerate a first lockdown, but a second would be a much tougher sell to the population. Our analysis shows that successful lockdown strategies included widespread testing, strict protective policy enforcement (mask-wearing, social distancing), and an effective economic response to help protect jobs. The initial lockdowns that countries implemented were quite beneficial towards halting the spread, but we found that only the countries (South Korea, Australia, Germany) that are currently sitting in a good position are the ones that had a plan for what to do after those eight weeks. Countries with ineffective strategies for handling people returning to work (U.K. and U.S.), on the other hand, are still struggling to contain spread, forcing further lockdown implementation.

Secondly, our analysis highlights the importance of reliable, fast, and widespread testing. Testing provides countries with significant, fundamental, and functional data on how to respond to a pandemic. Quick identification of cases allowed local governments to respond with treatment and isolation in order to prevent further spread. We found a positive correlation between countries implementing effective testing and limiting the rise in cases. The national testing in countries like South Korea and Australia helped their governments respond to regions of spread quickly, while the lack of sufficient testing in the U.S. and U.K. did not enable early containment. Countries that did not test enough at the start of the pandemic often had a more challenging time tracking spread, and therefore casualties began to rise.

Thirdly, we found that countries with prior experience with certain crises often responded well to that aspect of the pandemic. It would have been beneficial for countries to learn from each other. For example, if other countries had sought advice from South Korea on how to manage a pandemic, as they had a previous outbreak in 2015, they could have learned some valuable lessons in regards to testing and lockdown regulations. Likewise, countries who wanted to protect livelihoods could and should have looked to the United States for assistance, as their experience with the financial housing crisis in 2008 played a significant role in their desire to protect against a loss of jobs around the country. If countries had found a way to collaborate on response strategies, both physical and fiscal, it is possible that we would not be in the dire position we are today.

Finally, our analysis shows that there is no "right" answer to this pandemic. This pandemic has been one of the most challenging adversaries many governments have had to deal with. We found that the governments' response to the pandemic had to be both culturally and politically acceptable to their specific situations. For example, in a democratic nation, forcibly locking people in their homes is much harder to enforce in an individualistic society like that in the US, despite it being shown by China to be an effective way to limit spread.

COVID-19 has stressed governments and people around the world, impacting significant loss of life and socioeconomic hardship. We hope these findings can provide useful insights for policy and law makers as they inevitably face the many more challenges that this pandemic will inevitably bring before it is fully under control, but also

for dealing with future global situations that are yet to unfold, such as the physical and economic impacts posed by climate change.

Limitations

There are several areas where further research could compensate for this study's limitations. First of all, the time at which we conducted the research for this project didn't have the opportunity to consider a variety of factors. When we first set out on organizing and interpreting data for different countries, there was, and continues to be limited information available from China, whether that is testing data, casualties, or lockdown policy. This meant that we could not effectively interpret the response from the origin of the virus itself, which of course is a key piece of missing information and analysis. Additionally, because we finished the report in December of 2020, the vaccines for COVID-19 were yet to be released to the public, and therefore this report also lacks both vaccine data for distribution, and the positive or negative impacts for varying countries (e.g., in terms of economics, testing, etc.). This report also lacks a comprehensive code or simulation work which could aid in visualizing the impacts of this virus compared with others, especially when examining the impacts of quarantine, lockdown, or increased/decreased transmission rates.

From a bigger perspective, it is quite hard to really determine cause and effect in a simplistic manner. There are so many variables that determine an outcome to this pandemic, and although we attempted to single out some (testing rate and response time), it is very difficult to distinguish an isolated cause that leads to any given effect for a concept as complex as this pandemic.

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