Exploring Lockdown Stringency and COVID Data

Team members: Emanuel Mejia, Yixi Yang, Nadia Tantsyura

Team github: https://github.com/UC-Berkeley-I-School/Project2_Yang_Tantsyura_Mejia.git

All countries in the world were affected by the COVID-19 pandemic. However, countries dealt with the outbreak quite differently, especially in terms of lockdown stringency. Some countries were seen as strict practitioners and others lax, with a few prominent examples in each type, but there is no exact grouping for many others in the middle of the stringency spectrum. Lockdown strategy also shifted as countries balanced economic costs with public health and as vaccines became available. There is much debate on which approach is better for society, but we should be clear about how countries employed stringency over time before we attempt to evaluate the merits of the strategies.

Our main question is: how did countries use lockdowns as a pandemic response? We will answer this question through two parts: how did stringency levels look globally across different countries over time and did these exhibit any relationships with demographic factors, COVID severity, vaccines, etc.? Our primary dataset is the OWID COVID dataset made available by Our World in Data. The dataset contains many variables of interest and was made by a merge of multiple datasets from Johns Hopkins University, European CDC, the World Bank, different countries' reports, etc., and we do not foresee a need for a supplemental dataset.

The first part of our analysis focuses more on stringency level itself, and we look at how it changed over the duration of the pandemic, as a global whole, and divided into subparts, such as by continent or levels of initial stringency. The second part of our analysis focuses on the interplay between stringency level and a host of other variables. This exploration could offer clues on potential factors that governments may have considered when deciding on stringency policy, although it is not robust enough to prove the government's thought process. However, it does build a foundation for that type of research.

Data Cleaning

We went through a series of data cleaning steps to preserve data sanctity without reducing our dataset size. We first cleaned out any rows that were not about a specific country. Then, looking at the spread of data availability, we found that countries either had 500 or more observations or significantly fewer. Thus, we removed all countries with fewer than 500 observations. We then removed countries with no data in our eight variables of interest, including stringency index, new cases, new deaths, various demographic data, and hospital beds per thousand. Finally, because we are grouping countries into different stringency groups based on their policy on March 31, 2021, we took out any countries without data on that date.

After these steps we removed the columns that won't be part of our code and for those left we filled missing data (NaN) by either taking the previous values, or just filling them with zeroes.

We ended up with 144 countries after the cleaning steps, which we felt is an adequate size for analysis.

Data caveats and potential risks

There are many limitations to our study, mostly caused by data quality and availability. Most of these were due to physical limitations in countries' abilities to collect data in real-time as the pandemic shocked global health systems and overwhelmed hospitals. Thus, these would be impossible to overcome unless the global health response system was set up to be much more effective at rapid response. Most of our risks pertain to scientific validity.

First, our data are based on confirmed cases of COVID-19 that are likely to be less than actual cases and COVID-19 fatalities. This possible bias, at least in terms of case numbers, is likely to be more pronounced in countries that have had a low testing rate, either due to lack of resources or unwillingness to conduct massive testing. Some countries also did not offer free testing until much later in the pandemic.

In general, the quality of data varies by country. As mentioned in the Data section above, there are discrepancies in the speed and source of data collected by each country. Additionally, only a handful of OECD countries have ICU and hospital data while most other countries do not. Definitions of new cases and new deaths attributed to COVID could also vary across countries. Sometimes countries changed these definitions during the pandemic.

We also assume that two weeks is the average time for stringency measures to take effect. However, in reality, different variants likely had slightly different spread times.

We tried to control for intervening and moderating factors, but there is no clarity on the extent of influence these variables have on both stringency index and COVID cases and deaths. For example, many countries relaxed stringency in the summer, but cases may not have risen due to warmer weather and more activity in the outdoors. Increased stringency in the winter may be useless if indoor gatherings caused much higher surges in new cases.

Finally, stringency level is a measure of policy response, not necessarily human activity. Countries differed in how strictly stringency measures were enforced, and cultural differences may also have influenced how careful people were to actively avoid activity even beyond government mandates. For example, we have no specific data on mask-wearing, nor are we stating concretely whether this reduces transmission, but different cultural attitudes may encourage such behavior in addition to government stringency mandates, which may have an impact on COVID cases.

Due to these limitations, we may not be able to produce any definitive answer to the essential question of stringency's impact on COVID transmission and mortality. Stakeholders such as policymakers and citizens may have expected a definitive answer, and there is a risk our results could be disappointing or even misinterpreted.

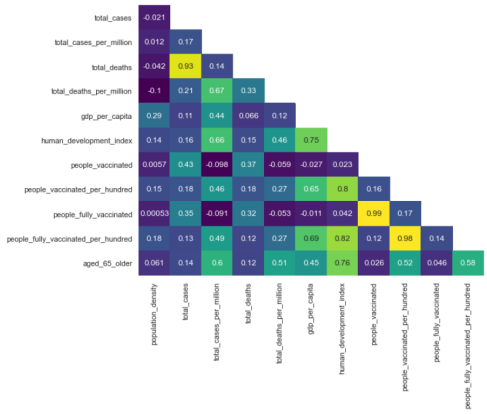
Finally, the question we study has deep implications for society. The limitations that risk the scientific validity of our results could in turn have ethical consequences in how people choose to respond to pandemics in the future or legal consequences in how new laws and systems are set up to confront future pandemics.

We aim to answer whether more stringent measures are associated with lower per capita COVID-19 cases and provide guidance for a future pandemic policy response.

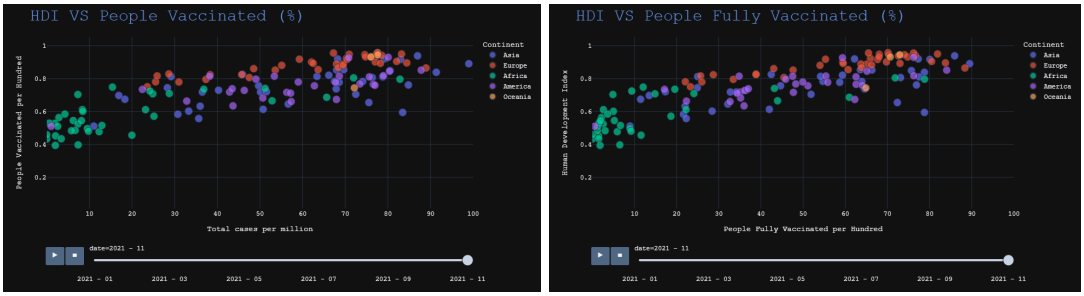
Data Exploration

In order to explore the data, and our stringency analysis, we created different grouping methods: by country, by specific dates (month endings), by continent and later by stringency group.

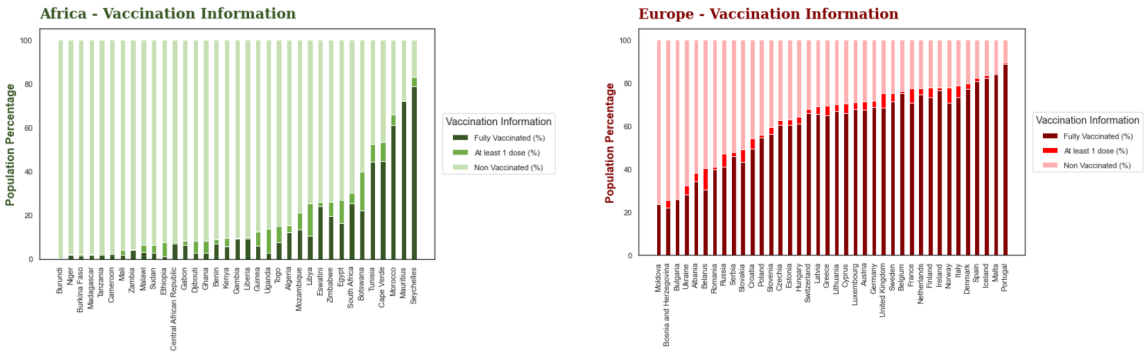
By doing this we were able to see that there were also high correlations between variables other than stringency, our main variable of interest.



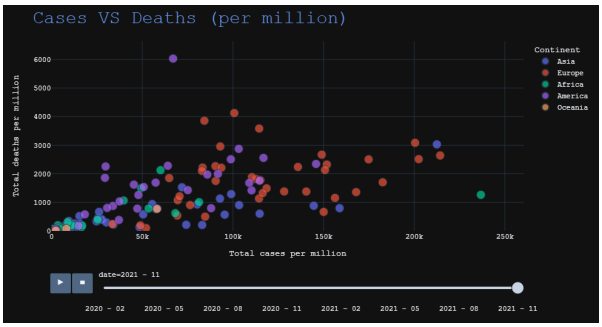
For instance, human development index (HDI) presented high correlations with people vaccinated and people fully vaccinated (per hundred).

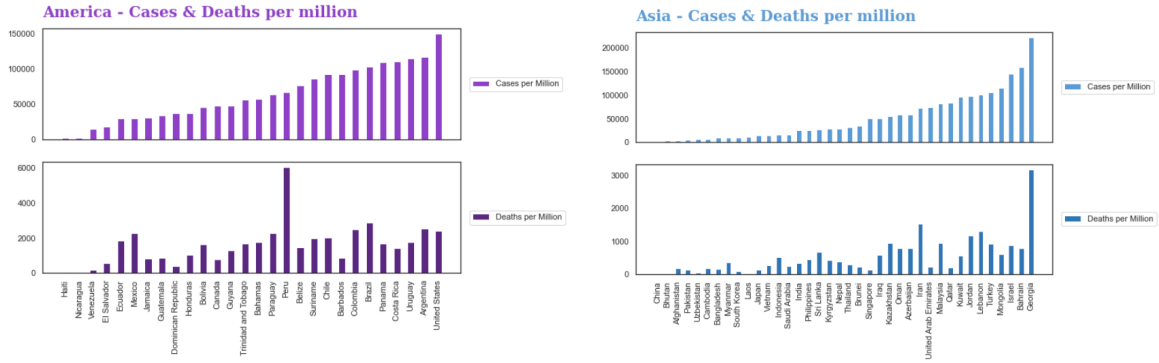


African countries (green dots) have some of the lowest HDI countries in the world while Europe (red dots) have some of the highest, and their vaccination rates are consistent with this correlation when looking closer at them (see below).

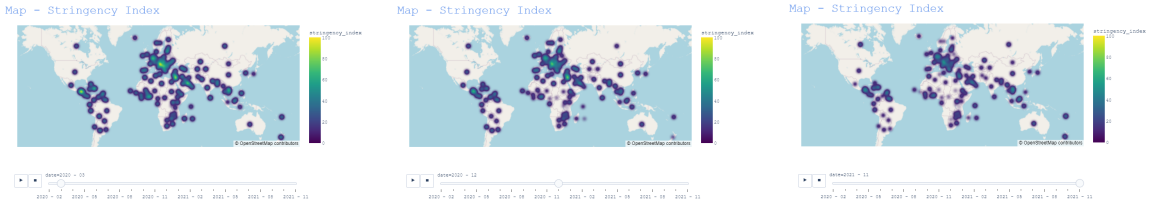


On the other hand, other variables that seemed naturally highly correlated, they were not as much as we initially thought, as total cases and total deaths (per million people).





Finally, we were also able to determine at a high level that stringency levels didn't really follow a specific pattern when looking at them by country, although, on average, it declined worldwide as time passed. But more on this analysis will come later.



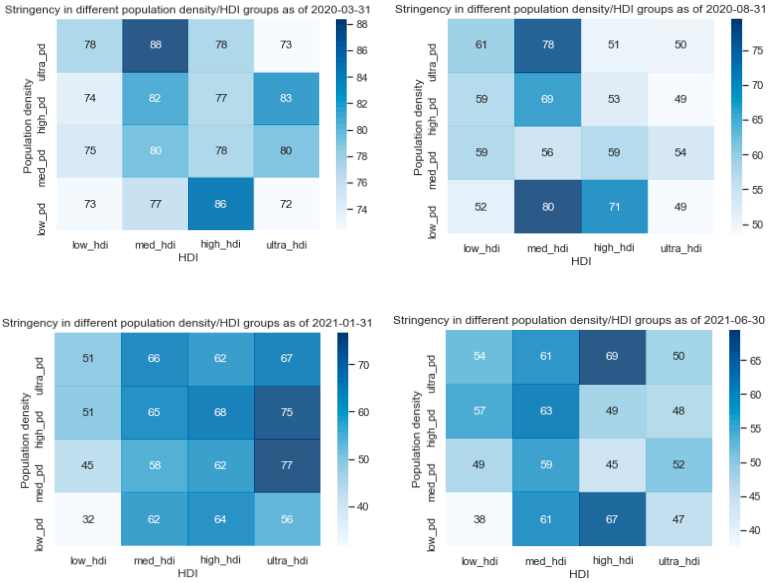
Stringency Index (Mar 2020) *Stringency Index (Dec 2020)* *Stringency Index (Nov 2021)*

Demographic Variables: population density and the human development index

We wanted to see if countries' lockdown policies were at least somewhat influenced by their population density and level of development. Both metrics are static variables for each country, so we further categorized each country into one of four quartiles for each variable. The interplay of population density, HDI, and stringency over time, shown through heat maps, show several interesting patterns.

Firstly, population density has almost no impact on stringency levels. Secondly, the least developed nations, i.e. those in the bottom quartile of the HDI index, tend to maintain the lowest stringency levels during the first year of the pandemic but actually increased relative to global peers in

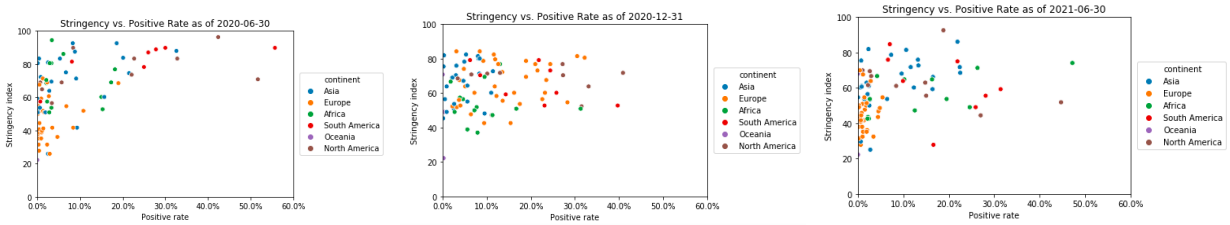
2021. The actual stringency level stayed consistently low. Countries in the highest HDI quartile exhibited the most flexibility, relaxing in the summer of 2020 then increasing relative to the globe in 2021 as delta hit. Countries in the second lower HDI quartile remained pretty stringent compared to peers throughout the pandemic, especially in 2020. This is especially true for countries with medium HDI and high population density. Note that there are only three countries with both ultra high HDI and medium population density, while all other groups have 5-13 countries.



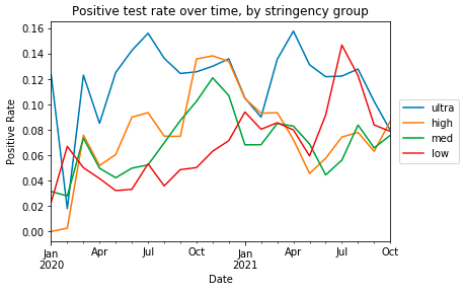
Pandemic severity: positive test rate

We also wanted to see how severity in the pandemic may have impacted government responses in stringency. Besides examining how new cases and new deaths may move with stringency, we also looked at the positive test rate. It is unclear whether governments determine stringency level based on the latest positive test rate, or whether government action would impact future positive test rate. However, we are only looking at the data descriptively to see if any patterns emerge, not to prove causality.

It does seem that countries with higher positive test rates tend to keep to higher stringency levels, especially at the early stage of the pandemic. There was more variety by the end of 2020 and even more so in 2021. Throughout the pandemic, many countries with low positive test rates also kept to high stringency levels. It seems that while most countries will not loosen restrictions when the positive rate is high, a low positive rate has not led to many relaxations.



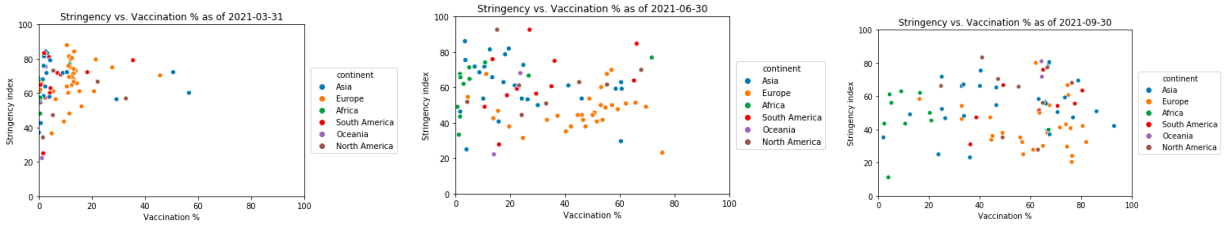
Interestingly, all countries in our dataset, regardless of their initial stringency policy, continued to see much volatility in the positive rate. In fact, the positive test rate seemed to move in sync overtime across our stringency groups. However, we caution from drawing any policy implications, as the positive rate could be due to availability of testing resources, willingness to conduct testing, and changes in stringency policy overtime which would not be captured by our stringency group categorization.



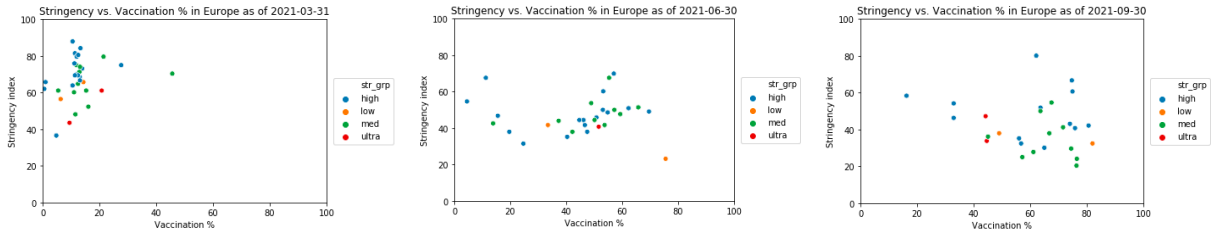
Vaccinations and Stringency

Vaccines did not become available in many countries until at least January 2021. Our available vaccination data did not start until the last few days in December. Thus, when looking at patterns of vaccinations and their effects on stringency and cases/deaths, we started in 2021. We wanted to see if the pace of vaccination seemed to affect stringency levels.

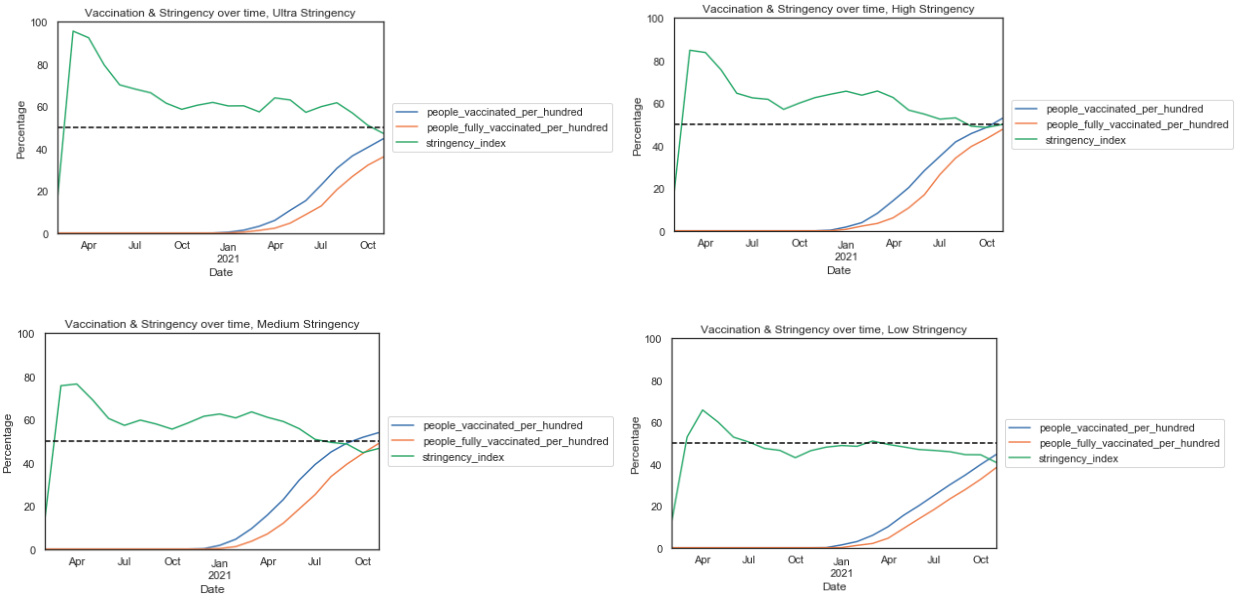
Looking at the vaccination rates, it seems that we can observe a general decline in stringency levels as vaccination rose, especially as full vaccination rose. This shows that vaccination became more and more important as an influence in government policy, as they likely weighed between health consequences and economic consequences. However, the scatterplots also show that there is a wide divergence in stringency level across countries with similar vaccination rates, especially after June 2021. This is perhaps due to more countries getting vaccines, and these countries held different lockdown philosophies than those who got vaccines first. Interestingly, the scatterplots show clearly which continents got vaccines first. Here, Europe and some North American countries stand out.



In fact, Europe also seems to be one continent where movements were broadly similar, i.e., as vaccinations increased, stringency seemed to decrease for most European countries. This is distinct from continents such as Asia or Africa, which continued to show wide divergence in stringency levels even after vaccines became more available. We thus take a closer look at Europe and track how vaccinations and stringency changed overtime for countries that were in different stringency groups at the start of the pandemic. It turns out that countries in ‘high’ levels of stringency in March 2020 were still slower to relax vs. peers that started in lower levels of stringency. Almost all ‘medium’ countries relaxed by June and more by September, while several ‘high’ countries kept up restrictions even into September.



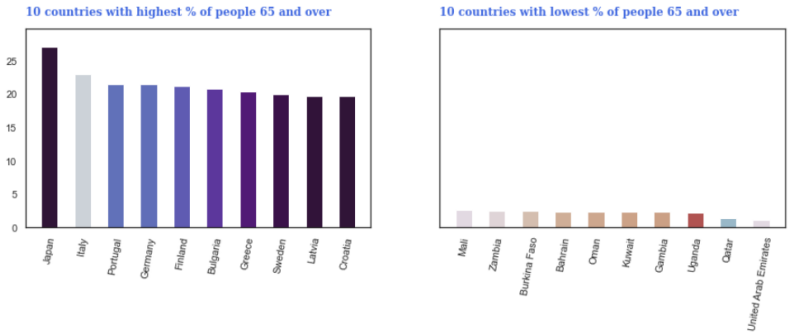
We took the approach used for Europe and applied it to the entire dataset to see globally how countries with different initial stringency policies behaved as vaccination rates rose. To simplify the visuals, we took the average stringency and vaccination rates for each stringency group on every last date of each month and checked how they changed over time. All groups showed some relaxations over time, as the percentage of population vaccinated and fully vaccinated rose. However, countries that started the pandemic with heavy restrictions do tend to relax later and to a lesser degree than others. Countries that started the pandemic in the 'medium' category saw the most relaxation. Perhaps it is because countries that started with low restrictions had little room to relax further, while those that started strictly retained the policy penchant for lockdowns. However, note that most countries already relaxed quite a bit from their heights before the vaccines arrived, so vaccination is not a key driving factor in changes in stringency policy.



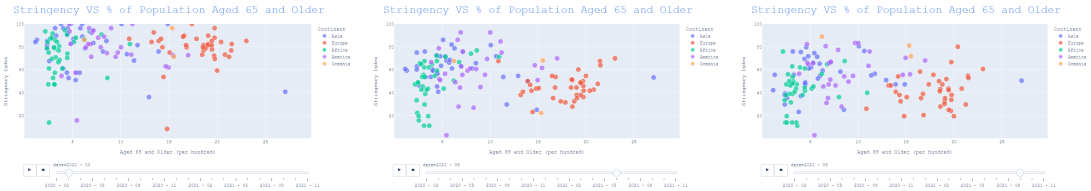
People over 65 years and Stringency

The mortality rates associated with COVID-19 are higher in individuals over 65 years of age than in younger individuals. About 8 in 10 deaths have been among people 65 and older, according to the latest demographic data available from the Centers for Disease Control and Prevention (CDC). Median age varies considerably by region and country, as does the percentage of people over 65 in any given place. Overall, Europe has the oldest population of any region, followed by Northern America and wealthy

countries in Asia, while Africa has by far the youngest. The coronavirus spread quickly in Europe in March and April 2020, with many deaths among elderly in Italy. The US has the second highest median age and one of the highest mortality rates in the world. Surprisingly, Japan, which has 29% of its population over 65 years, has unusually high life expectancies and relatively low death rate. It might be related to long life expectancy and also low diabetes and cardiovascular risks.

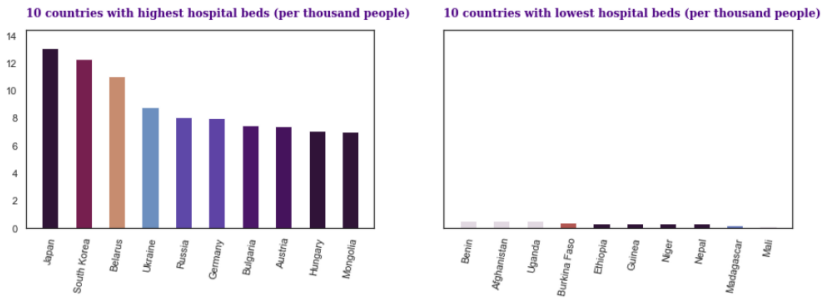


In our study we worked to determine the impact of age and stringency index in response to the COVID-19 outbreak. We wanted to see if the percentage of people 65 and older seemed to affect stringency levels. Looking at the age variable, the scatterplots show that in March 2021 the stringency levels for countries with high percentage and medium percentage of population 65 and older were about the same, however, the countries with low percentage of people over 65 years, had more relaxed policies in place. For example, many countries in Europe, Asia and America adopted strict lockdowns, while it has been more relaxed in Africa. By September 2021 the stringency levels decreased in Europe and North America, perhaps as the elderly population was vaccinated.

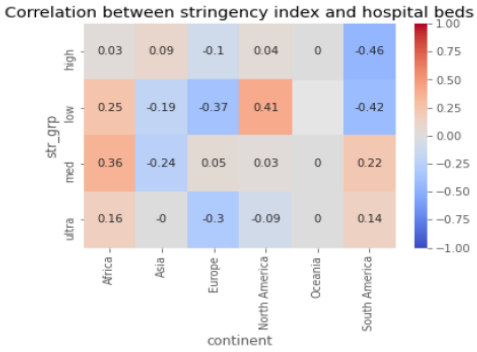


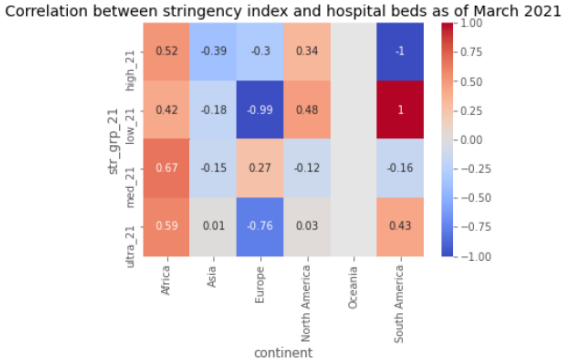
Hospital beds and Stringency

Hospital beds indicate the number of hospital beds available per 1,000 people. The number of hospital beds has a negative effect on COVID-19 deaths; Japan has the highest number of beds per 1,000 people, maybe due to the highest percentage of elderly in the country.



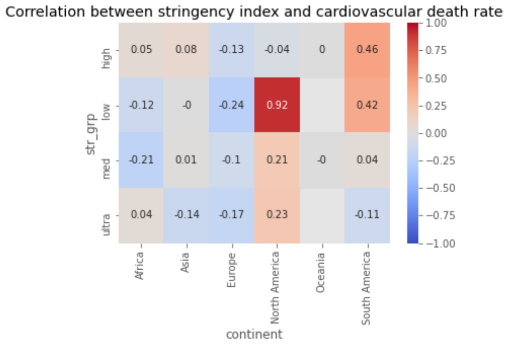
Most countries, regions, and cities were unprepared for the pandemic, with many lacking essential personal protective equipment (PPE), such as masks. In some countries, i.e. Italy, the ability of the healthcare system to respond to the coronavirus crisis was weak, which resulted in high mortality rates. At the beginning of the pandemic, there was no strong correlation between hospital beds and stringency index, as many countries adopted strict lockdowns. However, a year later, we see a strong negative correlation between the stringency index vs. the number of hospital beds in Europe and South America.

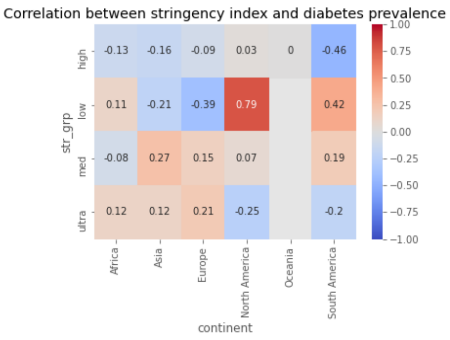




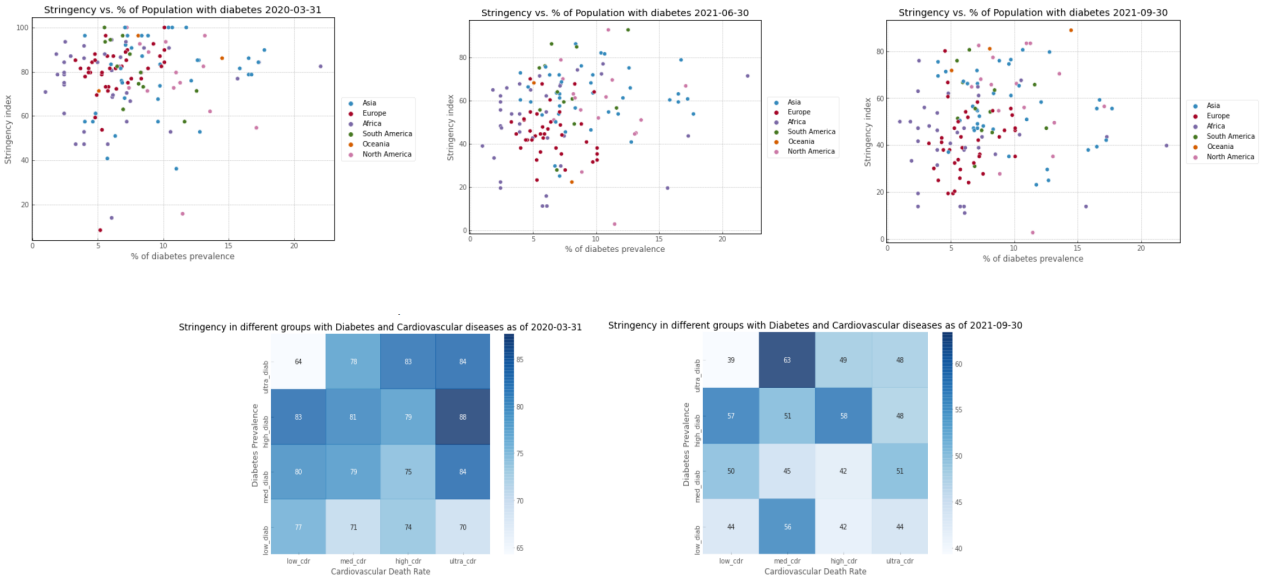
Cardiovascular death rate, diabetes prevalence and Stringency

The impact of the COVID-19 pandemic on people with chronic diseases such as hypertension, cardiac insufficiency, and diabetes is pretty pronounced. Underlying diabetes and cardiovascular diseases are considered risk factors for increased coronavirus disease severity and worse outcomes, including higher mortality. Chronic diseases are significantly higher in older adults. Evaluating the prevalence of diabetes and cardiovascular risk shows the continent with the highest rates in all age groups in North America. We found a strong correlation between stringency index and cardiovascular death rate and diabetes in North America and a weak positive correlation in South America.





The countries with a high percentage of patients with diabetes implemented strict lockdowns at the beginning of the pandemic. They relaxed the policies over time as more people became vaccinated.



Conclusion

The analysis that we have completed shows that the stringency measures are not always linear. Different regions of the world have adopted various strategies and kept changing them over time. Many countries took very aggressive approaches to the pandemic and later shifted to "stop and go" decisions on lockdowns.

However, countries with different levels of HDI exhibit different behavior through pandemic. Countries with higher levels of development showed flexibility in policy and fast responses as conditions changed. Some variables, such as percentage of people 65 and over as well as total number of vaccinations and hospital beds are related to HDI index.

Looking at the vaccination rates, it seems that we can observe a general decline in stringency levels as vaccination rose, significantly as complete vaccination increased. This shows that vaccination became more and more important as an influence in government policy, as they likely weighed between health consequences and economic consequences.

The availability of more hospital beds can reduce the number of deaths stemming from the COVID-19 epidemic; however, alone, it is not sufficient to curb the pandemic. GDP per capita did not seem to affect stringency policy, but there seems to be clear differences among countries at different levels of the human development index.

The bans and restriction regulations seem to take into account the additional risks on high-risk people (older people with chronic disease) to reduce the demand for intensive care units of healthcare systems. Vaccinating the global population against COVID-19 also seems to be the widely accepted long-term strategy to contain the coronavirus crisis and bulwark against a return to high stringency levels.