

Natalie Mosqueda, Stephanie Younes, Eric Por
 Data Science CS 3753
 Jianhua Ruan
 December 8, 2021

COVID-19 Vaccine Efficiency

Abstract

This paper offers a new method in analyzing the efficiency of the COVID-19 vaccine has on countries around the world and its people. Without dependency on which vaccine taken, an analysis has been done using three different methods: comparing country's vaccination data to number of day- to-day cases data from March 2021 to October 2021 to analyze how the vaccine impacts covid cases, comparing the vaccination count to the virus' daily mortality rate of these countries, and lastly seeing the impact the vaccine has on the hospitalization rate of countries. Our main results show that the vaccine has affected these countries differently. It is proven the vaccine has highly decreased the mortality rate but according to our second method, the vaccine only decreased cases slightly. Our third method also proves that the vaccine slowed down the hospital admissions for most countries, although some did not seem to be affected by this at all. With these results, we can conclude the vaccine has impacted these countries for the better, but some more significant than the others.

Covid-19 has impacted so many countries and its people around the world for the past year and half. Having a lot of misinformation, it is important to know how our world has changed and if it has gotten better with all the medicine coming out due to the virus. With the vaccine rolling out, by analyzing its efficiency, we can see the difference it has made on millions of people to really get to know how well the Covid-19 vaccine has changed our lives to the better. The goal for this analysis is to examine three different ways the vaccine could have made country's Covid-19 plummet. To reach this goal, we pulled data from Our World in Data(<https://ourworldindata.org/coronavirus-source-data>) which provided a day to day file of most all countries in the world including information about their new vaccinations, population, median age, new deaths, life expectancy, and much more. The first and main method implementing this data is comparing country's vaccination data to number of day-to-day cases data. Our first method we'll will be comparing the daily vaccination rate with new cases of each country. By comparing the sample data set, we will be able to analyze if the vaccine has effectively played a role in preventing new cases. Our second method following this data we will be comparing the vaccination count to the virus' day to day mortality rate of these countries. With the use of multiple bar graphs, we can see how the vaccine has impacted countries, some more drastically than the others, for the better. Each bar graph includes the countries day to day cases, deaths, as well as vaccinations. Our final method used when implementing our data is to compare the weekly hospital rates to the number of vaccinations. This data was compared between six countries and displayed through bar graphs to see if there was a correlation between the two data sets. Throughout history, vaccine has been tested and proven to help human fight against viruses and diseases. In this analysis, we'll be comparing each data set to help us conclude was the Covid-19 vaccine able to help on preventing new cases in each country.

To complete our goal, we implemented data extraction, plotting, correlation analysis, as well as statistical testing. The data extracted from Our World in Data was used for all three methods in the research done. This source is actually updated daily. The data get its confirmed day to day cases and deaths pulled from Join Hopkins University which updates its data multiple times a day. In order to get this data, JHU sources from governments, national and subnational agencies around the world.

After pre-processing this data, we were left with a little less than 30 columns of information. A couple main columns include, iso_code, continent, location, total_cases, new_cases, total_deaths, new deaths, new_vaccinations_smoothed, and population. Our three methods use this one data file. Even after some pre-processing, the data includes almost 56,000 lines of data of almost every country in the world with detailed information surrounding the country's important numbers on all things surrounding the virus. As seen in *Fig. 1*, it is shown the number of rows and columns the csv includes as well as the number of days represented by a couple of the main countries used in our research.

```
In [5]: runfile('/Users/stephaniyounes/Desktop/Data Science/FinalProject/VaccineEfficiency/
FinalProject.py', wdir='/Users/stephaniyounes/Desktop/Data Science/FinalProject/
VaccineEfficiency')
Rows in file: 55814
Columns in file: 26
USA days represented 261
China days represented 261
Brazil days represented 261
Italy days represented 261
Jordan days represented 261
```

Figure. 1. Python script print out of information taken from data portraying number of rows, columns, and days represented for a couple of countries

To complete visuals for the research done, multiple types of matplotlib graphs were used. For example, in order to implement the statistical correlation of day-to-day deaths compared to vaccinations, a couple bar graphs were used to show statistics in the same graph. This will be shown later in our results. When implementing the statistical correlation of hospital admission rates compared to vaccinations, further pre-processing had to be done. The reason for this is that the dates of which the hospital admission rates were recorded are weekly, so the overall data was further condensed to 920 rows. After this was done, it was clear that not all countries we were previously looking at had data for hospital admissions. To accommodate this, the countries for this method were changed slightly and chosen from North America, Asia, and different parts of Europe.

With the results being clear, our methods show how the vaccine was deliberately able to decrease the number of cases in many different countries around the world. For our methods, we used many different countries to depict the influence the vaccine which will be shown and discussed in the next few paragraphs alongside the visuals created.

When we compare the data between number of vaccinated and new cases, it will help us determine on the effectiveness of the vaccine on lowering the infection rate of Covid-19. Our analysis was done by selecting one country from each continent. For the first country, we have USA as shown in *Fig 2*. The graph has shown us that new cases corresponding with number of vaccinated. With the consideration of vaccine help preventing after obtaining the shot. We can see that the new cases are lower when there is higher rate of vaccination of the previous dates.

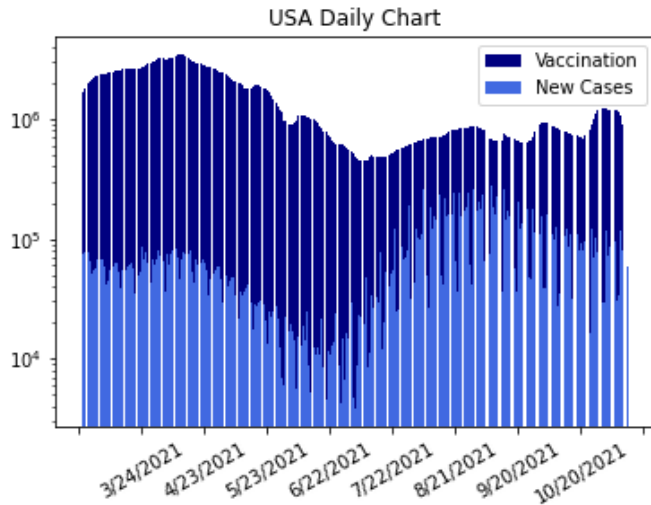
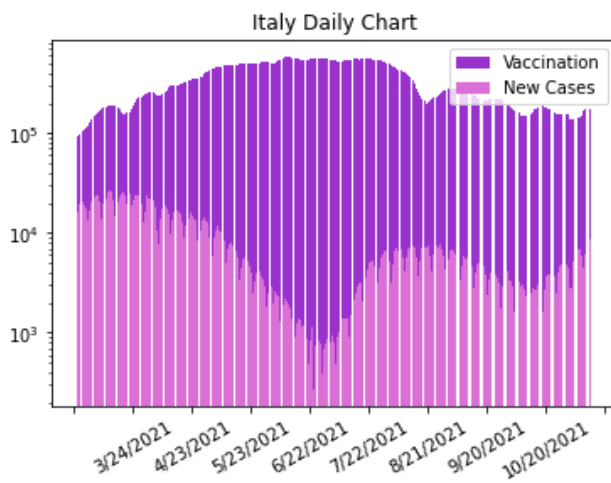


Fig 3. Bar graph of Brazil Daily graph comparing vaccination rate and new cases. Data set from March 2021 – October 2021.

Following by Italy as shown in Fig 4, while the graph does have a significant drop of new cases occurring in the middle of the year. We have to considered the fact that Italy's government also announced the whole country will be on reinforced lockdown during the time frame. As the graph displayed after Italy has lifted the lockdown. We then see the corresponding between vaccination and new cases.



maintaining with the low infection rate.

Fig 2. Bar graph of USA Daily chart comparing vaccination and new cases. Data set from March 2021 – October 2021.

Next, we have Brazil as shown in Fig 3, this is a good example of the effectiveness of the vaccine. As the graph has shown, each spike of graph corresponds with lower new cases reported on the following dates. This incident occurs throughout the time frame of the data set. During the time frame, as the number of vaccinated increased we can see that the number of new cases is also steadily decreasing.

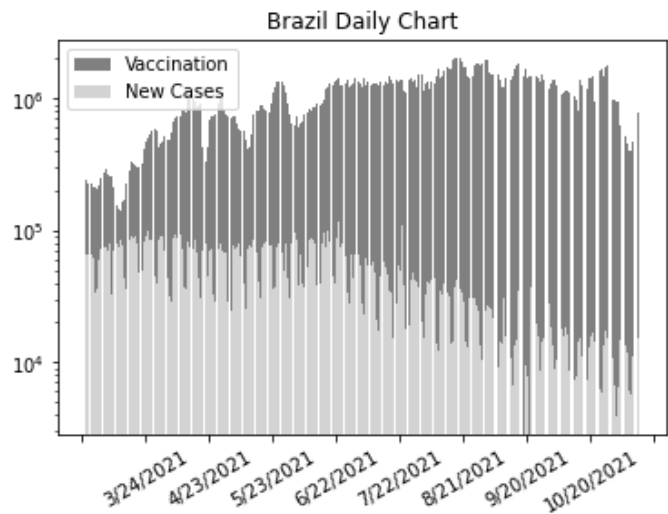


Fig 4 - Bar graph of Italy Daily graph comparing vaccination rate and new cases. Data set from March 2021 – October 2021.

Follow by the next country, we know that China was the original country where Covid-19 had discovered and China was able to adapt and implement preventive measurements during the time frame of the data set. As the graph has shown in Fig 5, China has the lowest daily new cases rate comparing to other countries of our analysis and with the help of vaccine, we can determine that the vaccine has also help with

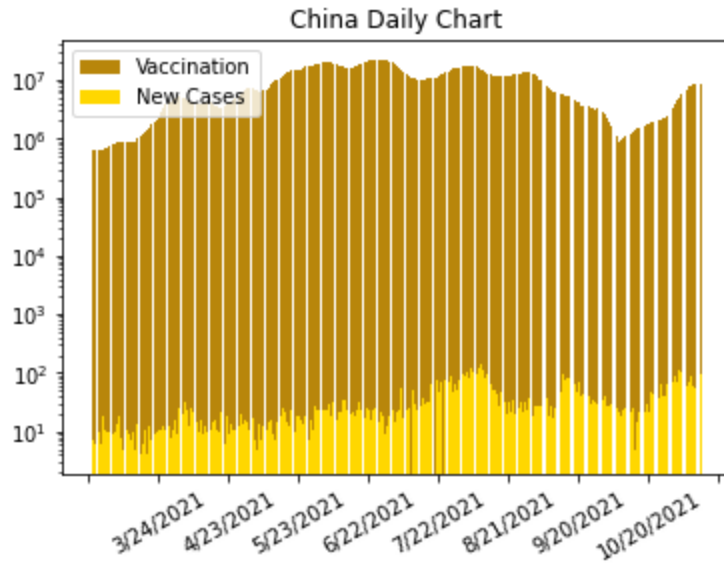


Fig 6 - Bar graph of Mexico Daily graph comparing vaccination rate and new cases. Data set from March 2021 – October 2021.

Lastly, we have Jordan as our last country. Given with the consideration of Jordan being a third world country with limited access of vaccine. As shown in *Fig 7*, in the beginning there are a significant spike in new cases with the lack of availability for vaccine but as more population are getting vaccinated, we can see that there is a steady decrease in new cases reported.

Fig 5 - Bar graph of China Daily graph comparing vaccination rate and new cases. Data set from March 2021 – October 2021.

Mexico was the only data set that did not fully correspond with our analysis towards the end of the time frame. In the beginning even though Mexico's vaccination rate is not as high as our other selected countries. We can see that there is a decrease in new cases followed by a spike in rise of new cases, even with the increasing vaccination rate.

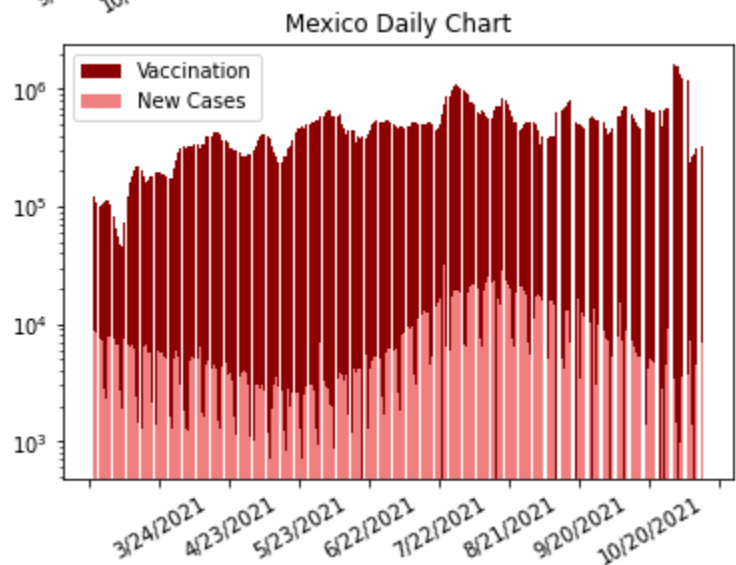


Fig 7 - Bar graph of Jordan Daily graph comparing vaccination rate and new cases. Data set from March 2021 – October 2021.

When graphing the correlation between the number of deaths compared to vaccine count daily, the effectiveness of the vaccine is shown. For this method our research is done on the United States, China, Brazil, Italy, and Jordan; including at least one country in almost every part of the world to get a fair result. For starters, China showed the clearest insight into the way the vaccine greatly decreases death rate. As show in *Fig 2*, due to the great number of vaccines (compared to many different countries), the mortality rate is near 0 almost every day from March 2021 to October 2021. This is a great example to how the vaccine can do better for countries

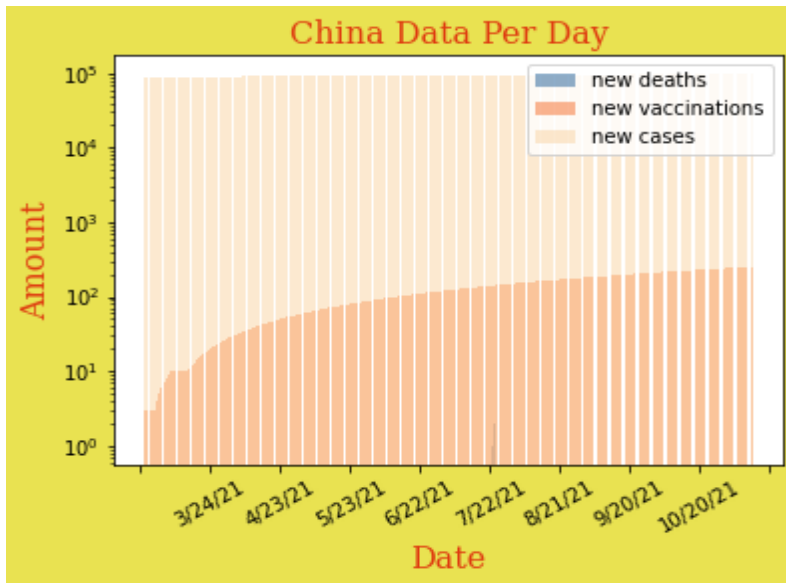
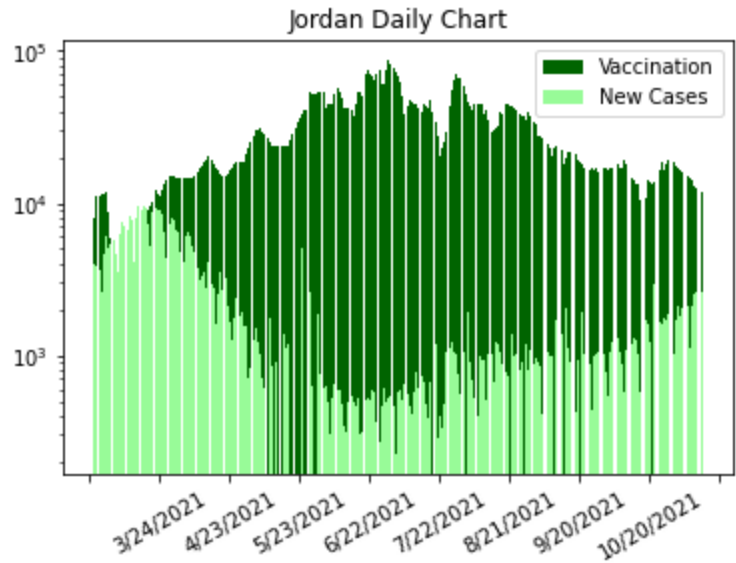
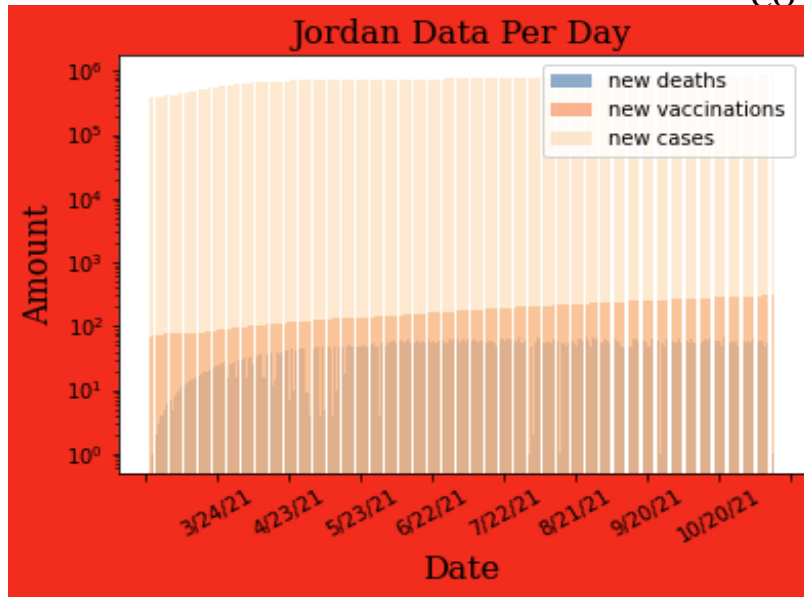


Figure 2. Bar graph depicting China's day-to-day new deaths, new vaccinations, and new cases from March 2021 to October 2021.

than harm to those struggling with the corona virus. As you can see from the graph, the higher the vaccination number, the smaller number of cases as well. Out of all the countries studied in the research done, China had the most amount of vaccines, the most gradual growth of vaccines leading to the least amount of death in 2021.

Moving onto Jordan, as shown in *Figure 3*, it is visibly shown how the vaccines per day increased as the deaths per day decrease. Although the cases do not show too many signs of decreasing. After China, Jordan seems to have the second-best gradual increase in vaccinations compared to the other countries looked at in this method. With Jordan having a great spike in the beginning of 2021, the bar graph shows the great change the vaccine made on those living in Jordan.

Figure 3, Depiction of



Jordan's day-to-day new deaths, new vaccinations, and new cases from March 2021 to October 2021.

Though the cases do not seem too impacted, Jordan is a prime example of the way the vaccine has proved to decrease the mortality rate of countries.

Moving onto the United States, as shown in Figure 4, the vaccination did not have too much of an increase leading to not much of a change in the mortality rate.

Not only was the mortality rate not changed but nor were the cases. This shows that in order to make a drastic change in the mortality rate of the virus in a country, it is best to have an

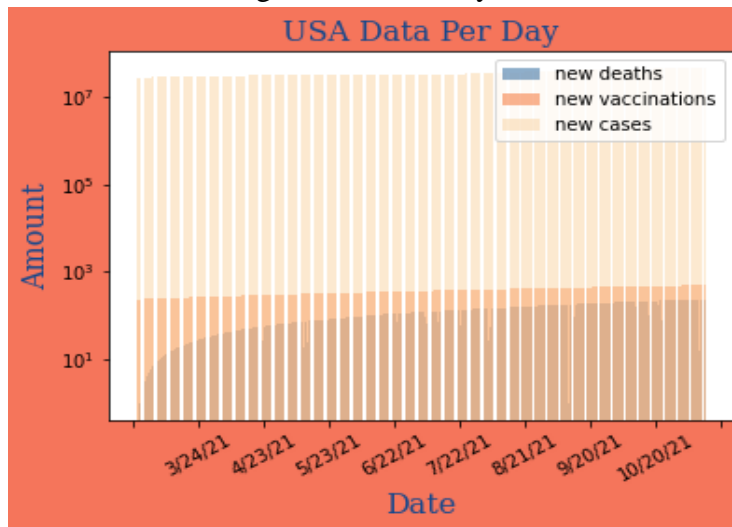


Figure 4, Depiction of the United States day-to-day new deaths, new vaccinations, and new cases from March 2021 to October 2021.

an exponential amount of people vaccinated to see the actual difference, like Jordan.

Due to the United States lack of mass vaccinations, both the daily number of cases and new deaths do not seem to be impacted by the vaccine.

The next country studied; Italy also shows the way mass vaccinations are the main way the mortality rate can actually decrease.

In the beginning of the bar chart as shown in Figure 5, it is seen that while people were being vaccinated, the mortality rate was not decreasing. Towards the end of the bar graph, once the vaccinations start to increase drastically is when the daily number of deaths start to show a change for the better and make their way down. The daily cases show to increase but many factors come into that besides vaccinations.

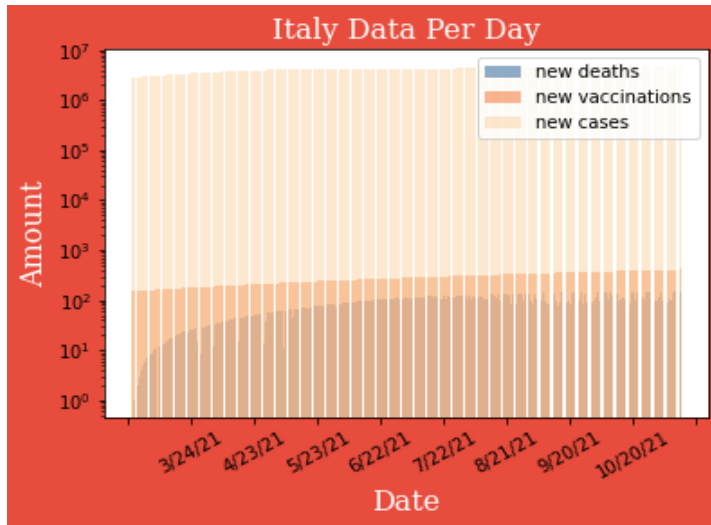


Figure 5, Depiction of Italy's day-to-day new deaths, new vaccinations, and new cases from March 2021 to October 2021.

Moving on to Mexico, as shown in Figure 6, the same dilemma the United States that was seen is shown here as well. Because the country did not vaccinate people at a high rate like China, the mortality rate does not decrease much but rather increases due to spikes and then ends up neutralizing. As for the cases shown in Mexico,

The vaccine seems to not impact that

either as the cases were high almost every day.

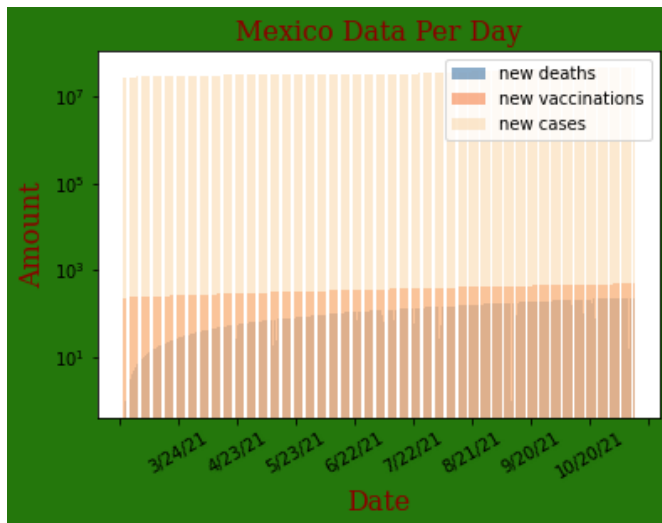


Figure 6, Depiction of Mexico's day-to-day new deaths, new vaccinations, and new cases from March 2021 to October 2021.

The last country studied in our second method is Brazil. As shown in Figure 7, Brazil's pattern of new vaccinations compared to new deaths is similar to Mexico. One difference that is seen are multiple gaps in new deaths on a couple of days. Because this information is gathered from these country's governments, the data is not always transferred correctly to the database and can cause these errors in our predictions.

With that being said, due to Brazil's lack of

constant vaccinations, the mortality rate is not decreased and might take an effect months after getting this data.

Due to our second method, this report can conclude that in order to get a grand decrease in the virus' mortality rate in a country, there needs to be an exponential number of vaccines for a constant amount of time. Two good examples done in this research are Jordan and China; Jordan being able to greatly decrease the mortality rate of the virus and China who almost completely demolished it. While countries like Brazil, Mexico, and the United States struggled with declining the mortality rate because vaccinations were not done at a great number.

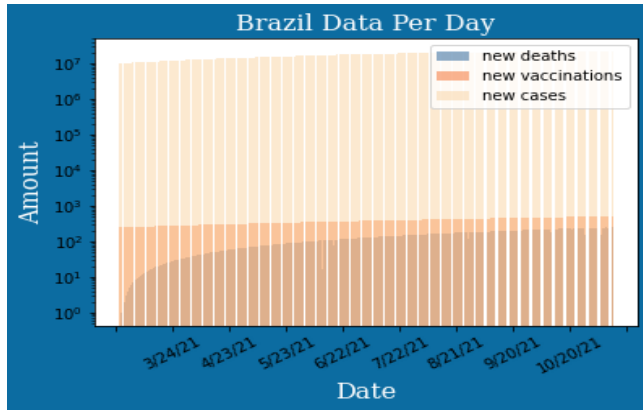


Figure 6, Depiction of Brazil's day-to-day new deaths, new vaccinations, and new cases from March 2021 to October 2021.

Our main reason for graphing the hospitalization vs. vaccinations data was to see if more vaccines would correlate to less people being admitted to the hospital due to the COVID-19 virus. Interestingly, a few countries seemed to go against our expectations while the others followed what we originally thought would happen. We're going to look at six countries: United States,

Israel, Denmark, Portugal, Italy, and Latvia. As stated before, these countries were switched from our previous data because of the lack of hospital admission numbers for countries of Brazil, China, and Jordan. Since most of the hospital admissions data came from Europe, we made sure that the countries chosen were geographically father apart as to get more diverse data. Let's start with United States and Denmark, as these countries graphs showed a clear insight into how the vaccines were affecting the hospitals. As can be viewed in Figure 4, Denmark's hospital admissions started declining at the same time that the vaccination rate was steadily increasing. On the opposite end, once the vaccination rate took a steep drop, the hospital admission rate begins gradually increasing once more (although with a small hiccup around the end weeks of August). Now looking at the United States data in Figure 2, the lower number of hospital admissions is towards the left of the graph, which is where the highest vaccination numbers can be seen. Then as we move towards the later months, the hospital rates increase significantly as the vaccinations declined, and then stayed more or less at a steady pace. These two countries stuck out the most when determining if vaccinations would slow the amount of people being admitted to hospitals.

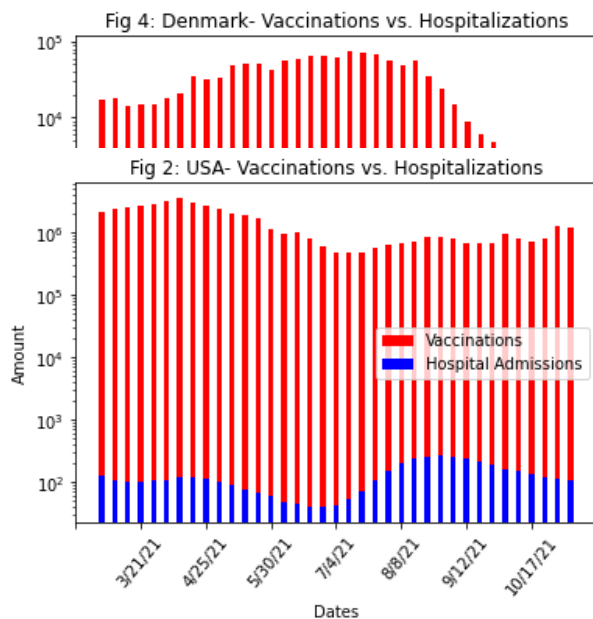


Figure 4. A bar graph depicting the number of vaccinations and hospital admissions per week for Denmark. The x axis goes from the dates February 28, 2021 to November 7, 2021.

Figure 2. A bar graph depicting the number of vaccinations and hospital admissions per week for the United States of America. The x axis goes from the dates February 28, 2021 to November 7, 2021.

Next, we will discuss Italy, Portugal, and Latvia. These countries graphs had parts of their data conform to the trend of lower vaccination rates and higher hospitalizations. Although not all of the data could be contributed to this trend, it still is interesting that during some weeks that was the case. During the first few months of the recorded data, Portugal had declining hospital admissions

as the vaccination rates increased, but around July with increasing hospital admissions was a dramatic change compared to the vaccination rates which didn't start declining swiftly until around September.

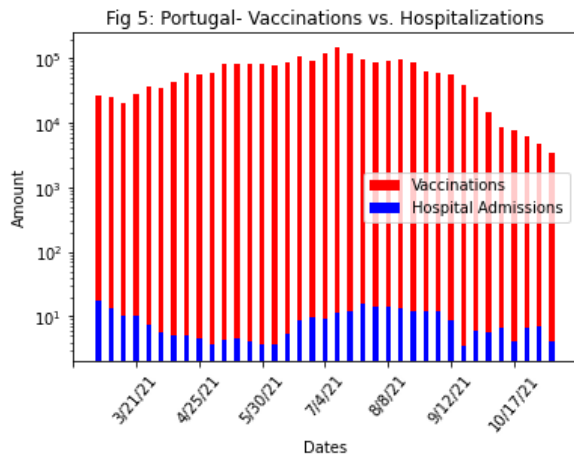


Figure 5. A bar graph depicting the number of vaccinations and hospital admissions per week for Portugal. The x axis goes from the dates February 28, 2021 to November 7, 2021.

Analyzing the graph trend in Figure 6, it is clear that the decrease in the hospital admissions can be attributed to the steady increase of vaccinations. Although, the hospital admission rate seems to fluctuate towards the end of the year despite the vaccinations only decreasing slightly. There is also a large divot in the data during the month of July, which shows the lowest hospital admission number throughout the entire

graph. This was an interesting discovery and could be attributed to the linear number of vaccinations between May and the beginning of August.

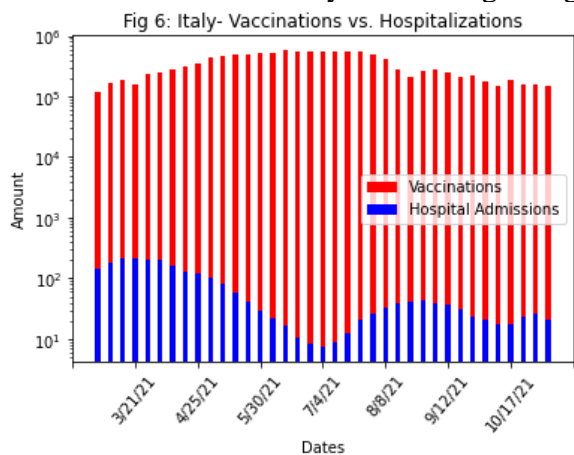


Figure 6. A bar graph depicting the number of vaccinations and hospital admissions per week for Italy. The x axis goes from the dates February 28, 2021 to November 7, 2021

Latvia had the most interesting graph out of the six as it seemed to fluctuate throughout the entire timeline. The hospital admission rates seemed to stay linear until the months of May to September where a parabola occurred as shown in Figure 7. During May and June is when the vaccination rate was at its highest, which could lead to some reasoning behind the vast decrease in admission rates during the later month. Also, the vaccination

rates declining during August and September could contribute to the increase of those same months for the hospitalization rates. Latvia is definitely one of the more neutral countries when it comes to analyzing the correlation between vaccination and hospitalizations.

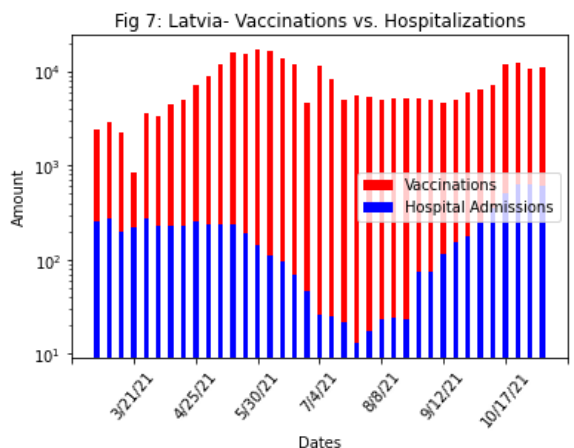


Figure 7. A bar graph depicting the number of vaccinations and hospital admissions per week for Latvia. The x axis goes from the dates February 28, 2021 to November 7, 2021.

Lastly, we'll look at Israel as it seemed to be the outlier of the bunch. Figure 3 shows Israel's hospitalization rates were almost in sync with the vaccination rates. They seemed to parallel each other, as when one went down, so did the other and vice versa. This was unexpected and it is unclear on why this was the case for this country. The reasons could be due to outside

influences going on in the country at the time. There could be other countries like this, and it would be interesting to know how many are and the cause of this phenomenon.

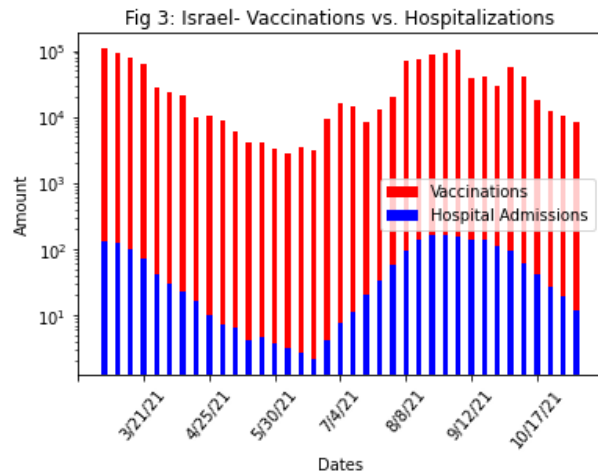


Figure 3. A bar graph depicting the number of vaccinations and hospital admissions per week for Israel. The x axis goes from the dates February 28, 2021 to November 7, 2021.

Comparing our data of vaccinations vs hospitalizations as a whole, we can see that the greater number of vaccinations has meant a decline in the number of people admitted into the hospital, whether that be to a small degree or large one. We acknowledge that some data from a few countries wasn't 100% on par with this conclusion, and that one country out of six was going completely against this conclusion.

Despite this, it is safe to say that the majority of our analysis can be used to support this claim. Although more analysis from many more countries would be done before we could reach a definitive answer.

In conclusion in our analysis, we find that vaccine does play a significant role in various aspects regarding COVID-19. Such as lowering the infecting rate, reducing mortality rate as well as the severity of the symptoms. We hope through this analysis, we can further educate the population on the misinformation and uncertainty of the vaccine.

The contributions made by EP were brainstorming ideas about the subject we wanted to do, found data, as well as finding our final data. EP worked on the code and report for the first method implemented in our research, comparing number of cases to number of vaccinated daily in a couple of countries around the world. The contributions made by NM were brainstorming ideas and helping process our final data. Alongside that NM worked on the code as well as the report for the third method implemented for our research; data of those vaccinated compared to those hospitalized daily in a couple of countries. Lastly SY contributed to brainstorming and finding data as well as processing our csv file to the columns needed. SY focused on the second method for our research; daily vaccinations compared to daily mortality rate of the virus in a couple of countries. All members contributed to the Abstract, Introduction, Materials and Methods, and Results and Discussion.

References

Ritchie, Hannah, et al. "Coronavirus Source Data." Our World in Data, 5 Mar. 2020,
<https://ourworldindata.org/coronavirus-source-data>.

CSSEGISandData. "CSSEGISANDDATA/Covid-19: Novel Coronavirus (COVID-19) Cases,
Provided by JHU CSSE." *GitHub*, <https://github.com/CSSEGISandData/COVID-19>.