Policy Advice for Future Pandemics

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Introduction

The objective of this report is to model and analyse the spread of the COVID-19 epidemic in the United States and provide policy advice to mitigate the impact of a future pandemic. The report is split into two parts. First section is a virus contagion simulation of 1000 people. The time taken for the full population to be infected by the virus is simulated. Further analysis takes place with introduction of vaccines in the simulation period. Part two pertains to analysis on 2020 COVID-19 data sourced from the US Department of Health. Here, the investigation focuses on the states and sections of US society most devastated by the virus. Infections and fatalities are measured against policy decisions such as ICU beds per capita, demographics per state and population density. It is intended that this report will be used to make better policy decisions should a similar airborne virus pandemic occur.

COVID Virus Model

The COVID virus contagion simulation model was created via python. The total population in this model is 1000 people. Each person has the ability to infect 3 other individuals per day with a probability of 5%. 10 people are initially infected. In Figure 1, you can see the simulation estimates that during the first 3 days just 3 other people are going to be infected, bringing the total from 10 to 13 persons.

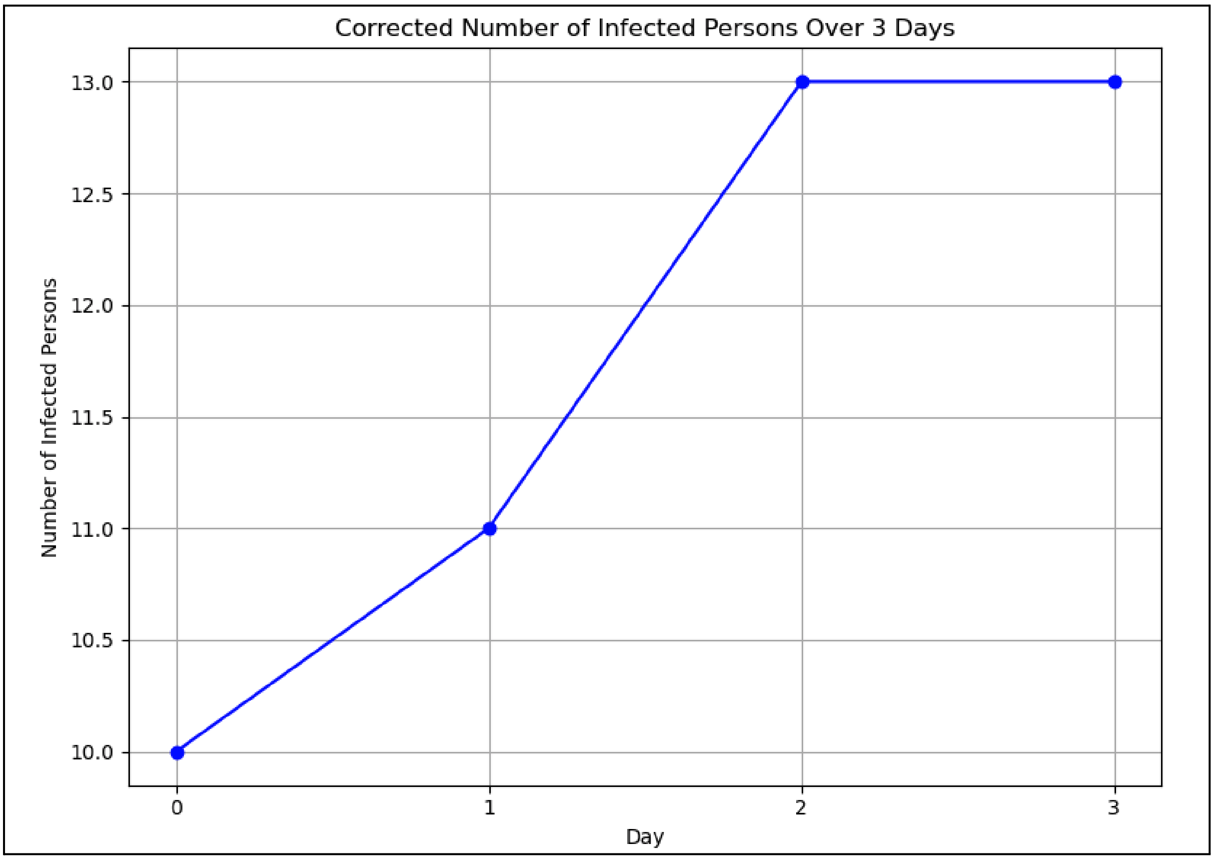

Figure 1: Corrected Number of Infected Persons Over 3 Days

The graph in Figure 2 displays how many days it will take for the full population to be infected without a vaccination. COVID-19 cases exponentially increase taking 48 days until the total population of 1000 people is infected.

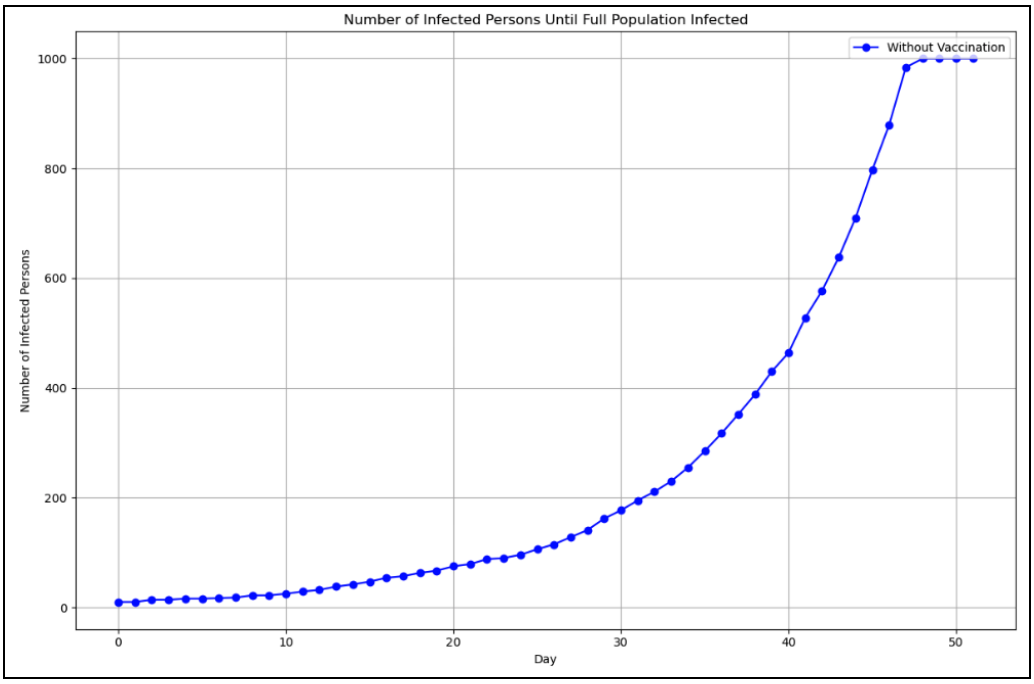

Figure 2: Number of Infected Persons Until Full Population Infected

Figure 3 shows the positive impact of the COVID vaccine. If the population is vaccinated, it takes a further 9 days for the total population to be infected. For policymakers it is clear vaccination buys time. Medical resources will be less stretched and therefore lockdown measures can be less severe.

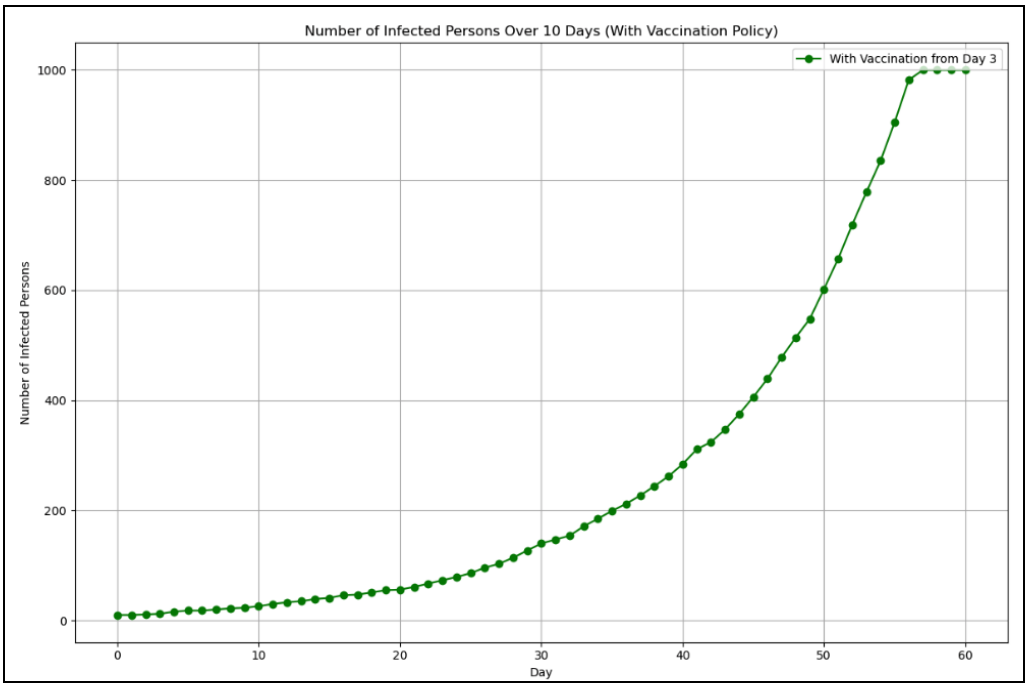

Figure 3: Number of Infected Persons Over 10 Days (With Vaccination Policy)

2020 US COVID Response

The United States suffered the highest incidence of cases and deaths in the COVID-19 pandemic. There is concern that policymakers have not reflected on the mistakes in the early days of the pandemic. In the period of this study, there were no COVID vaccines available. In the critical early stage of another pandemic, vaccines are unlikely to be obtainable. By May 27th 2020, 100 000 Americans had died from COVID-19. This report examines this period in detail and attempts to propose policy improvements.

Figure 4 is a line plot showing the rapid increase of COVID-19 cases in the United States from February to December 2020. The graph shows exponential growth of positive cases of COVID 19 increasing further into the year. This graph shows how vital prevention policy measures are early on in the epidemic to slow down the spread of the disease. The first policy change is that lockdown procedures need to be introduced around the 60 day mark in order to lower the infection rate and minimise exponential increase in cases.

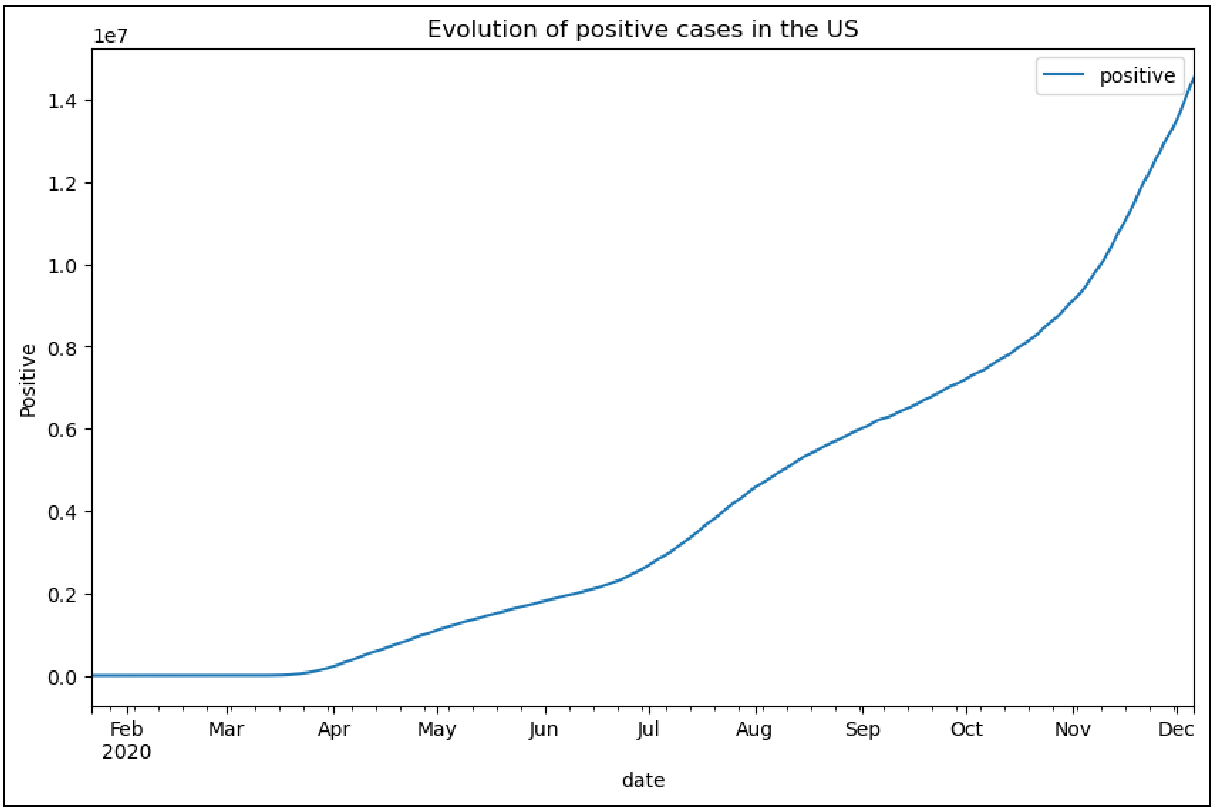

Figure 4: Line Chart of Positives Over Time in the US

Figure 5 is an in depth representation of figure 4. Figure 5 shows the evolution of positive cases broken down state-by-state. 5 states stand out with an exponential growth between April and July. However, these states are the most populated states so their exponential growth is not much of a surprise. To investigate the states in which the infection rate is the highest, the values of each state were normalised. Figure 6. shows the normalised infection rate of the 5 highest growing states and the 4 lowest growing states. The 5th lowest growing state AS (American Samoa) was not taken into consideration as they did not have a single positive case in the dataset. The 5 states which standed out in the figure 5. are not represented in the 5 highest growing states from figure 6, which show that the population density had no impact on the infection rate.

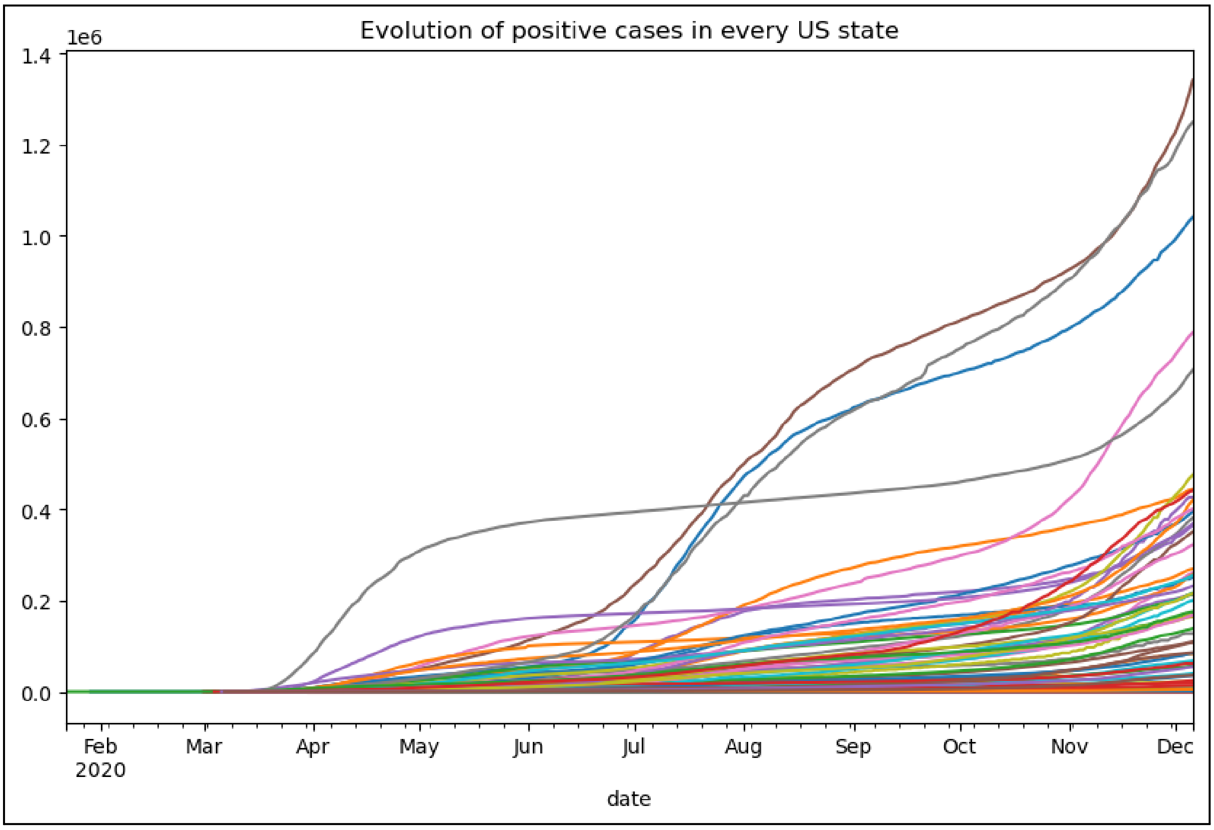

Figure 5: Line Chart of the evolution of positive cases in each state

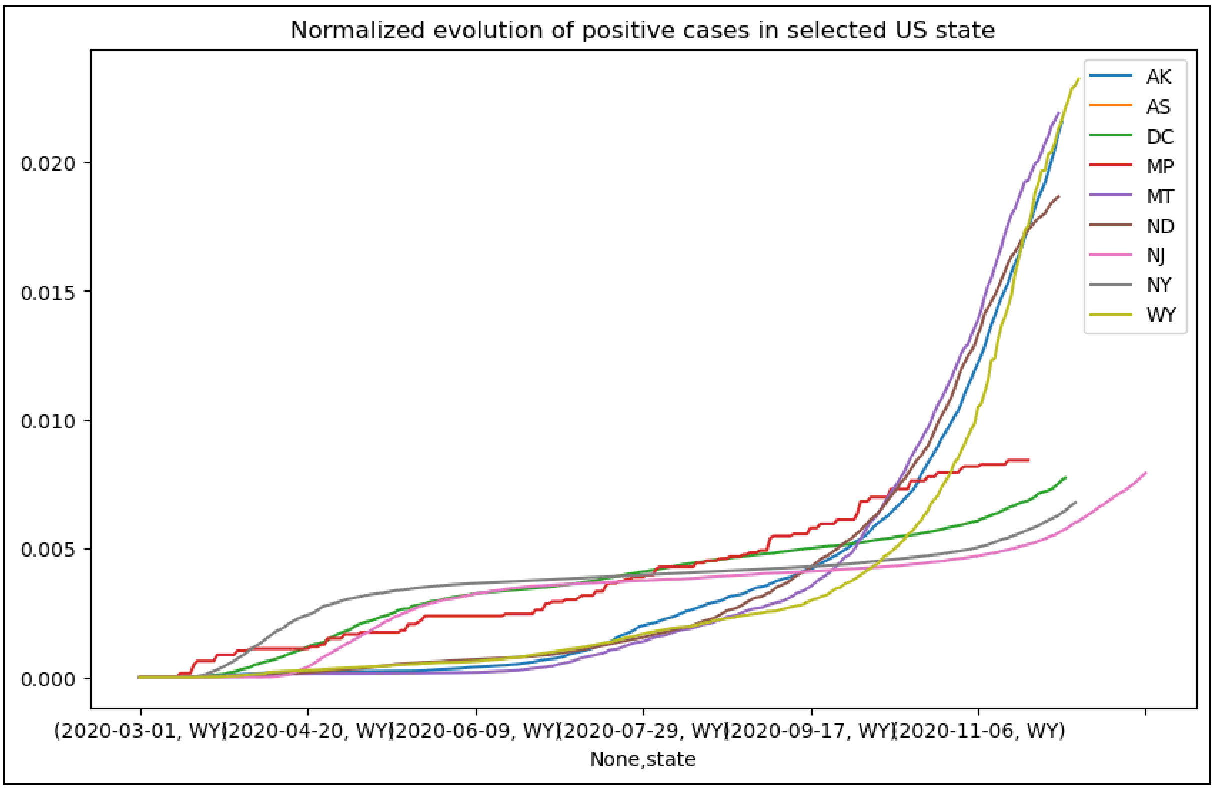

Figure 6: Line Chart of the normalized evolution of positive cases in selected US states

A series of tests were run in order to better understand the various subgroups of society most affected by the pandemic. Several factors were examined such as sex, population density, smoking rate, income, unemployment, age, temperature, etc. Since there wasn't a visible influence of the smoking rate or the unemployment rate to the percentage of death, these graphs are not mentioned in this paper. The following test results were concluded. Males having a larger death count compared to females (Fig: 7), states with higher population density had a tendency of more deaths compared to lower populated states (Fig: 8) and states with larger incomes saw an increase in deaths compared to lower income states (Fig: 9).

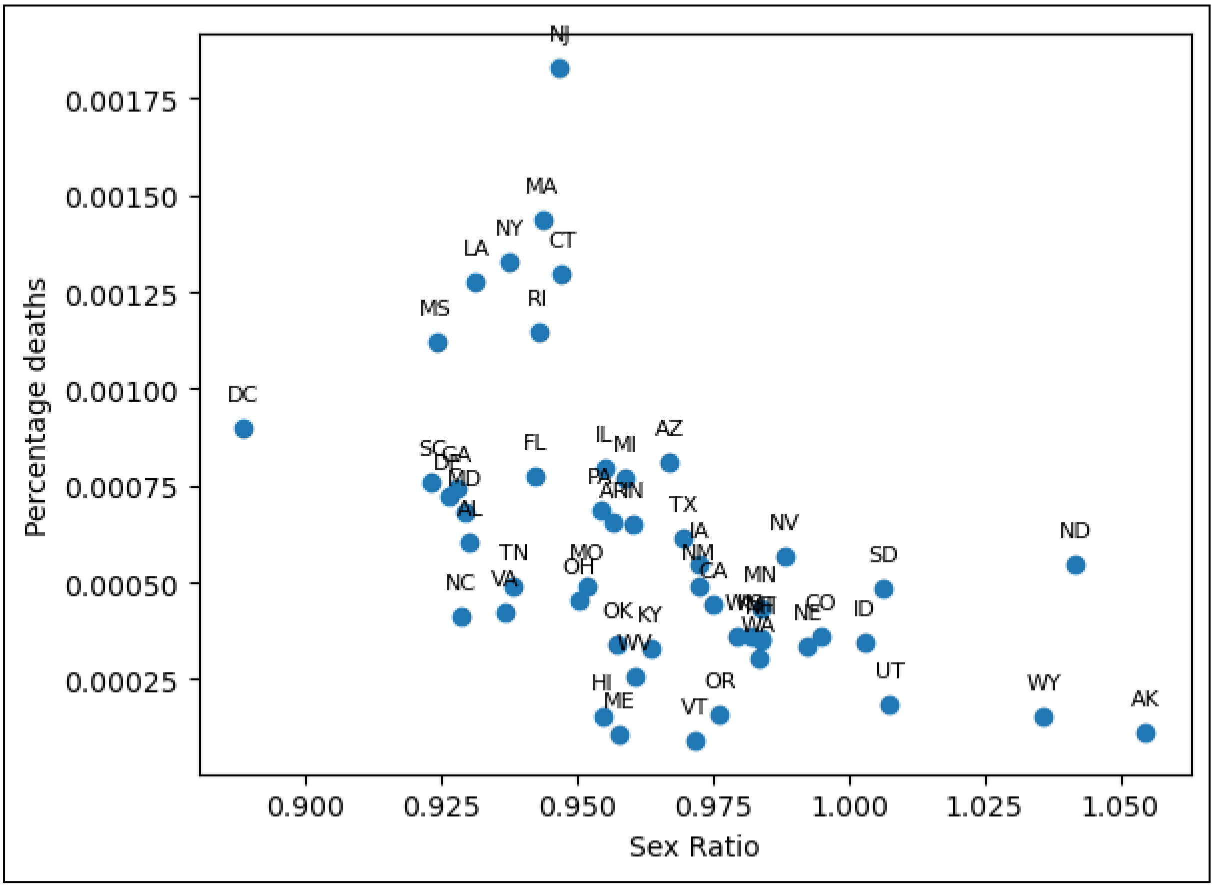

Figure 7: Scatter plot, deaths in relationship to sex

When looking at the income effect on death, it is important to consider that the Federal Government does not provide free healthcare to its citizens. This likely allowed those more financially able to get tested and treated for COVID 19. We also observed that younger people between ages of 0-25 had higher percentages of infection (Fig: 10). This age group has a lower probability of severe infection but contribute to the overall spread of the virus.

Looking at the average temperature breakdown in each state, it is evident that states with higher average temperatures had higher infection rates (Fig:11). It is inferred that citizens in these states were complacent thinking that hotter weather mitigates the spread of airborne particles.

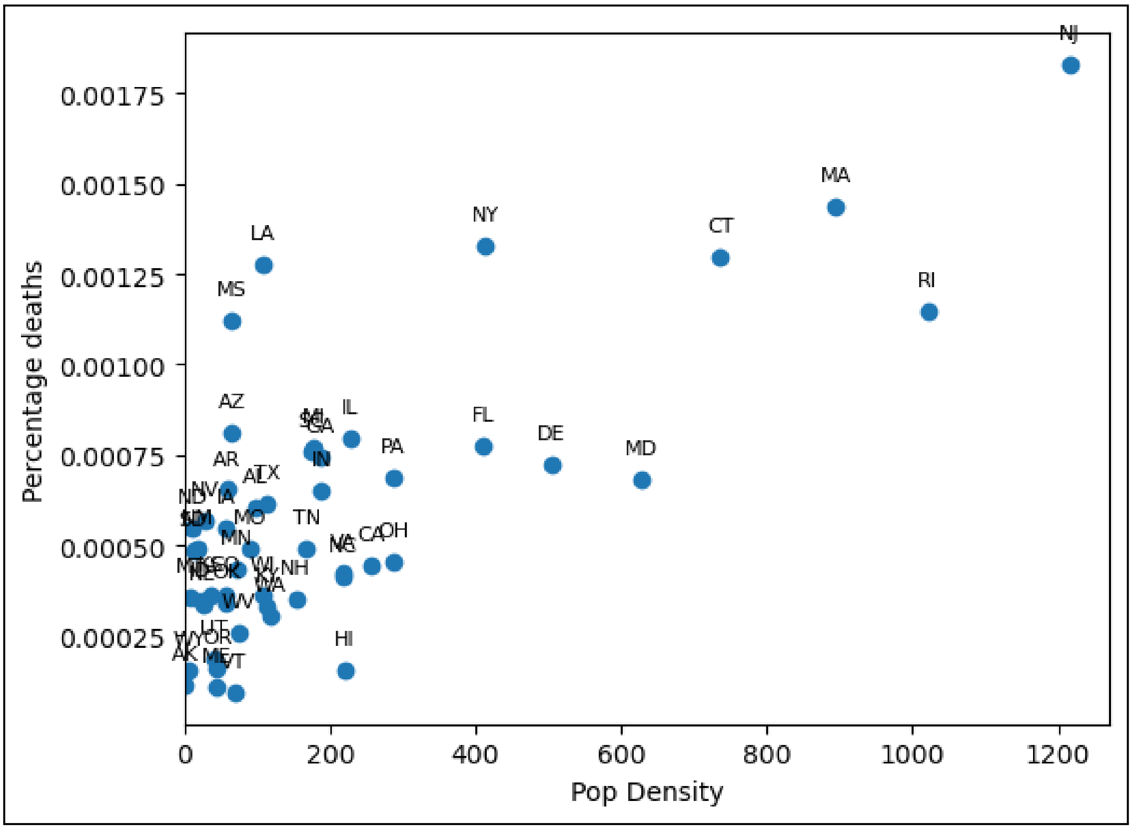

Figure 8: Scatter plot, deaths in relationship to population density

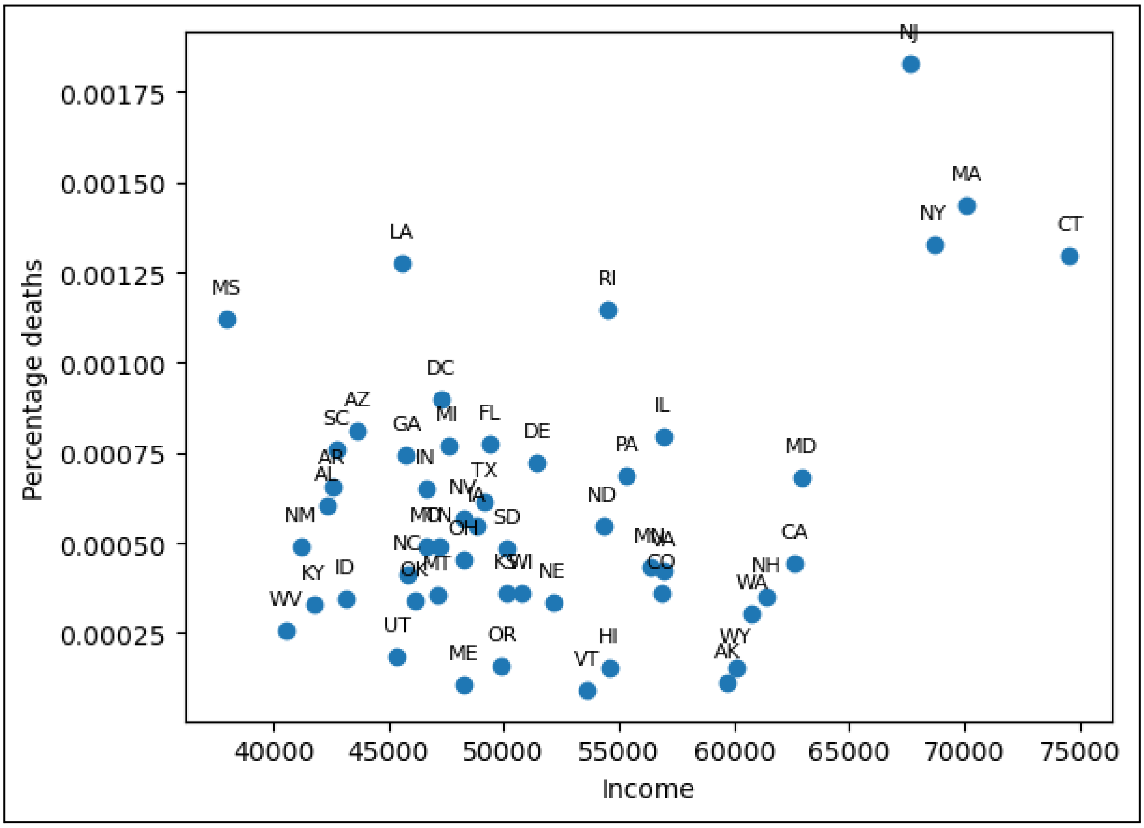

Figure 9: Scatter plot, deaths in relationship to the average income in the state

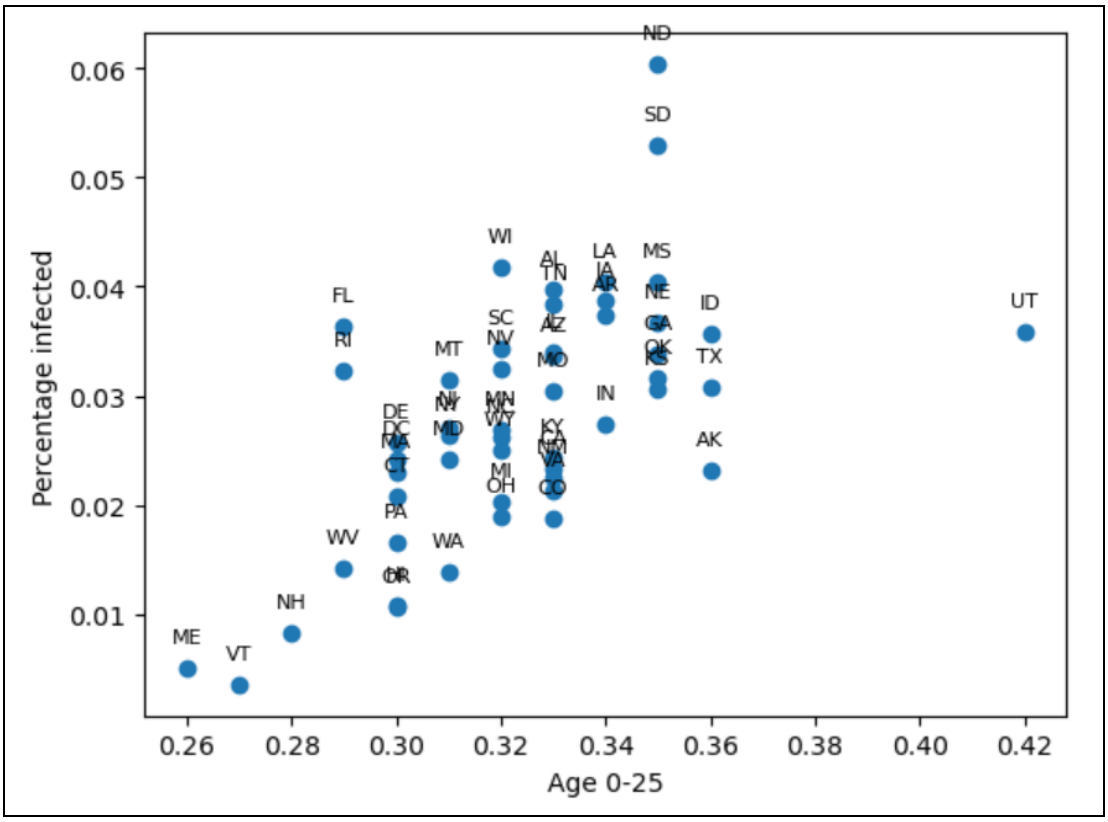

Figure 10: Scatter plot, infections in relationship to the portion of young people in the state

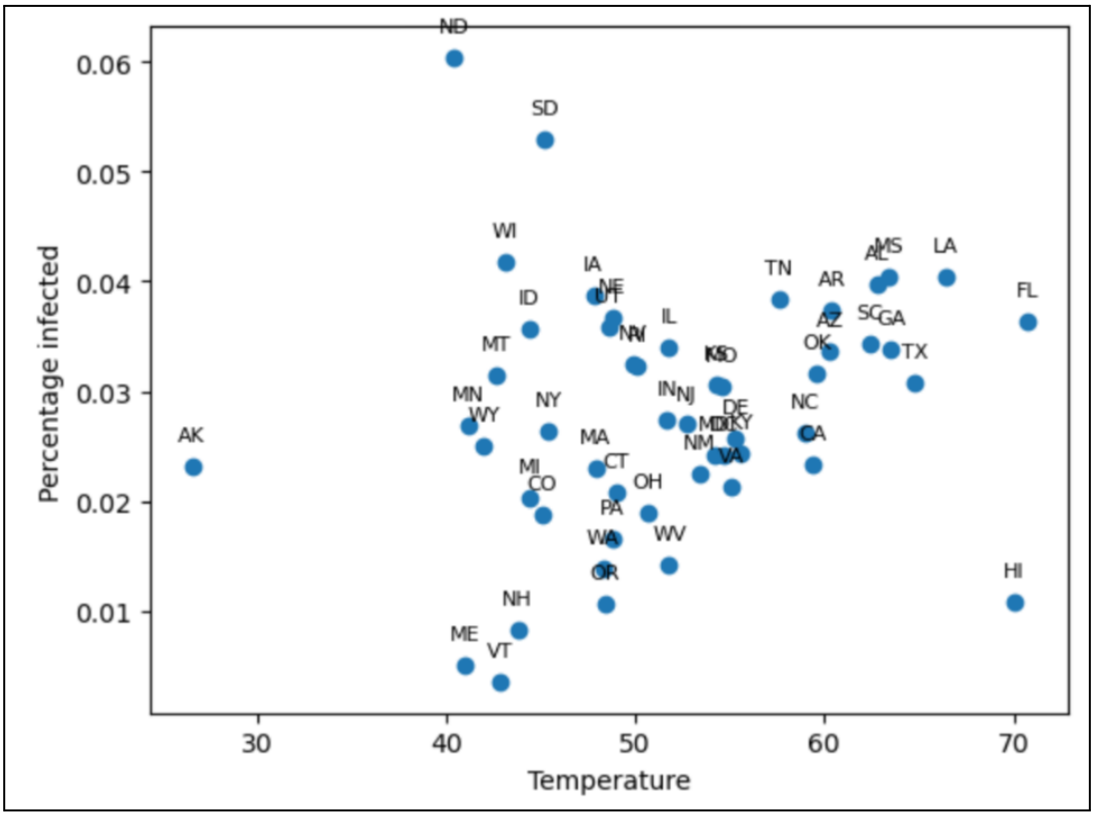

Figure 11: Scatter plot, infections in relationship to the average temperature in the state

Report Conclusion

The COVID-19 pandemic was a health event not seen since the Great Influenza epidemic of 1918. Policymakers had a very difficult job, minimising the spread of the virus, while keeping the economy and the health system afloat. Unlike the influenza epidemic of 1918, we have a vast amount of data stored about COVID-19. Our job as data scientists is to harness this data and create as best as possible, an emergency user manual for policy makers to tackle a future pandemic.

The conclusion of the virus contagion simulation is straightforward. Airborne virus cases have a tendency to increase rapidly in a short period of time. And vaccines buy more time. The nine days difference between the total population being infected with or without a vaccine allows the government to adjust resources in the health system and softens economic impact due to less strict lockdowns.

The US COVID response report concludes that lockdown restrictions need to be implemented once there is evidence of exponential growth in cases. Particular attention needs to be paid to the behaviour of young people, particularly males during lockdown restrictions. States with higher temperatures had higher infection rates. Areas with a dense population also suffered the highest positive cases. Because of these varying factors this report advises policy to be made at city or county level as far as possible. These policymakers will need to coordinate closely with officials in the state & federal government because they have the ability to allocate funds and sophisticated material where needed most.

Annex

Github Repository: https://github.com/SBoxho/Final_Project