How to Slow Down the Spread of COVID-19

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Contents

Introduction

For this paper I will put myself in the context that it is still January 1st, 2021, at the start of the COVID-19 pandemic. This means that all data and knowledge I have access to is capped at May 1st of 2020. I will not use my knowledge of the future of the pandemic to make assumptions or alter conclusions.

As the COVID-19 disease has continued to spread throughout the world there are still many unanswered questions about it. The main question that everyone is asking is how long will this pandemic last. The only way to truly answer this question is with time. However, we can model disease spread and analyze how variables affect the spread. Seeing what affects the spread of the disease the most could help us figure out the most effective ways to stop the spread.

Overview

The simulations will be tailored towards Indiana as the initial data used will be from Indiana. However, general conclusions can be applied to any location dealing with the COVID-19 outbreak. The variables that will be altered and analyzed include transmission rate, recovery rate, and waning immunity time.

Data

The initial total population data was taken from the 2020 census. The total Indiana population from the census is 6,785,528 people [1]. The initial infectious population data was taken from a May 1st report from the John Hopkins COVID-19 database. The confirmed active number of COVID cases from this report is 17,432 [2].

Modelling

The model I utilized for every simulation is a SIRS model. This model splits the population into three different categories: Susceptible, Infectious, Recovered. Each individual can move between these three different categories. Most individuals will start as susceptible while some will begin as infectious. Susceptible individuals can become infectious based on the transmission rate. Infectious individuals can recover based on the recovery rate. Finally, recovered individuals will go back to susceptible based on the waning immunity time. I am using this model since it can be used for diseases where immunity is not lifelong and can go away after a certain time [3].

Results

Running the SIRS model with varying values for transmission rate, recovery rate and waning immunity rate resulted in the graphs located in the references section of this document. Transmission rate represents number of new infections / number of exposed individuals. The transmission rates I utilized were 1/10, 3/10, and 5/10. Recovery rate represents 1 / days to recover. The recovery rates I utilized were 1/7 and 1/14 (1 week to recover and 2 weeks to recover). The waning immunity rate represents 1 / days until immunity is lost. The waning immunity rates I utilized were 1/90 and 1/180 (3 months until immunity is lost and 6 months until immunity is lost). I ran the model with combinations of these parameters to see how they each affected the length and peek of the disease spread. Every run utilized a total population of 6,785,528 and a starting infectious population of 17,432. The simulation assumed 0 people were already immune to the virus. Additionally, every simulation was run over a two-year timespan.

Analysis

Throughout all of the simulations the number of infected individuals peaked in less than fifty days and the total length of significant infection mostly lasted less than 100 days. The remainder of the two years simulation contained a small number of baseline infected individuals with some small spikes. The following three sections contain a detailed analysis of how each variable affected the results.

I. Transmission Rate

Altering the transmission rate had a large impact on the peek number of infected individuals. Figure 1 was the only simulation run with a transmission rate of 0.1 (1 new infection from 10 exposed individuals). It was run with a two week recovery time and 6 month waning immunity length. The graph displays an extremely low peak of infected individuals and the disease was barely spread. All other simulations were run with 0.3 and 0.5 transmission rates so that there was more of a disease spread. Running the simulation with a 0.5 transmission rate consistently resulted in a higher peak of infected individuals compared to a 0.3 rate. However, the length of time where there was a significant number of infected individuals remained around the same with a 0.3 and 0.5 transmission rate.

II. Recovery Rate

Altering the recovery rate effected both the peek number of infected individuals and the length of the pandemic. Comparing figure 2 with figure 4 and figure 3 with figure 5 show how changing the recovery rate from 1/14 (Infected individual recovers after 14 days) to 1/7 significantly impacts the simulation. Both the peek number of infected individuals and the length of the pandemic seem to be almost halved due to this change. Increasing the recovery rate also resulted in the gap between number of susceptible individuals and number of recovered individuals to be much smaller.

III. Waning Immunity Rate

Altering the waning immunity rate did not have a big impact on the peak number of infected individuals or the length of the pandemic. However, it did increase the number of infected individuals after the pandemic was over. As you can see from comparing figure 3 and figure 6, changing the waning immunity rate from 1/180 (180 days of immunity after recovering) to 1/90 results in a higher baseline of infected individuals after the main spike of the pandemic. This theme remains consistent when altering recovery rates and transmission rates.

Recommendations

After analyzing the data, it is clear that all three of the variables affected the spread of the disease in different ways. As we try to fight against the COVID-19 pandemic we can use the gathered information to effectively do so. Transmission rate is one of the easiest variables that we can quickly alter, and it drastically lowers the peak number of infected individuals. Utilizing masks and quarantining can lower the transmission rate by keeping infected individuals away from those who are susceptible. Additionally, it is clear that increasing the recovery rate is able to both shorten the duration of the pandemic and lower the peak number of infected individuals. In order to this for COVID research would need to be down to find medicines that are able to effectively fight back against the virus. This is not something that can be actively done by the majority of the population. Finally, altering the waning immunity rate was able to lower the baseline number of infected individuals. To implement this a vaccine or immunity booster would need to be created to temporarily or permanently grant individuals immunity to the disease. This is also something that should be researched; However, it is also not something that can be done by the majority of the population.

Conclusion

From our results we see that there are a few potential ways we can fight against the spread of COVID-19. One of the most effective methods that is discussed and that we already use involves wearing masks and quarantining. This lowers the transmission rate which helps a lot with decreasing the spread of a disease. One avenue that does need more research and should be looked into is finding or creating a medicine that can aid in fighting off the virus. This would increase the recovery rate and could shorten both the peak and length of the pandemic. Finally, finding a vaccine is a long-term solution that should be researched. Once we are out of the pandemic this will significantly lower the baseline infections. I believe that out of these three the most effective measure given the results from the simulations would be to focus on finding or creating a medicine that could fight against COVID. However, utilizing all three methods would obviously be the most effective for stopping the spread of COVID.

References

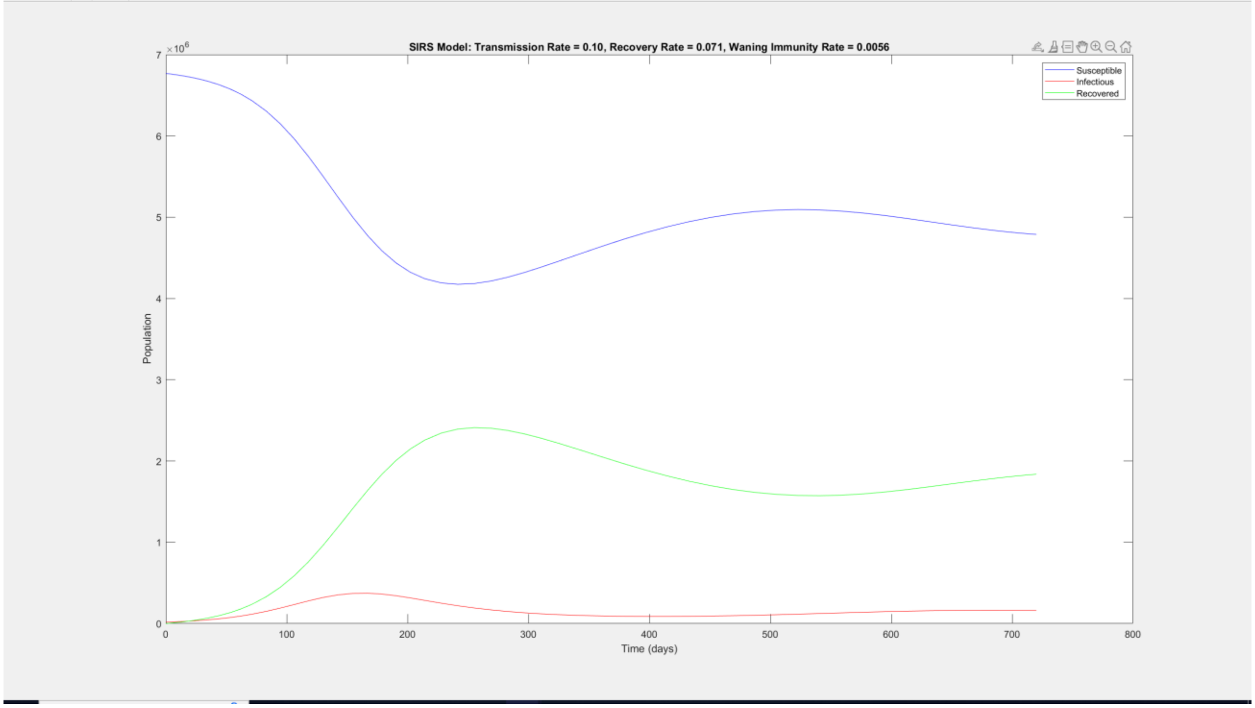

Figure 1: SIRS Model (1/10 transmission rate, 1/14 recovery rate, 1/180 waning immunity rate)

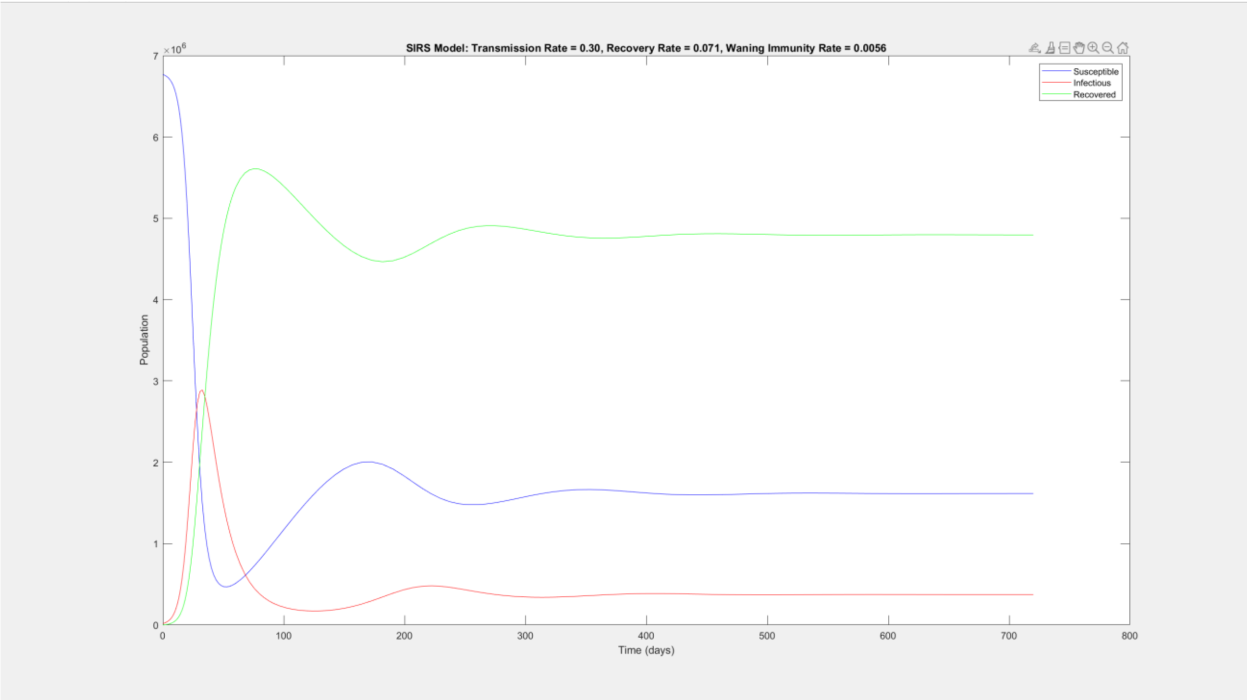

Figure 2: SIRS Model (3/10 transmission rate, 1/14 recovery rate, 1/180 waning immunity rate)

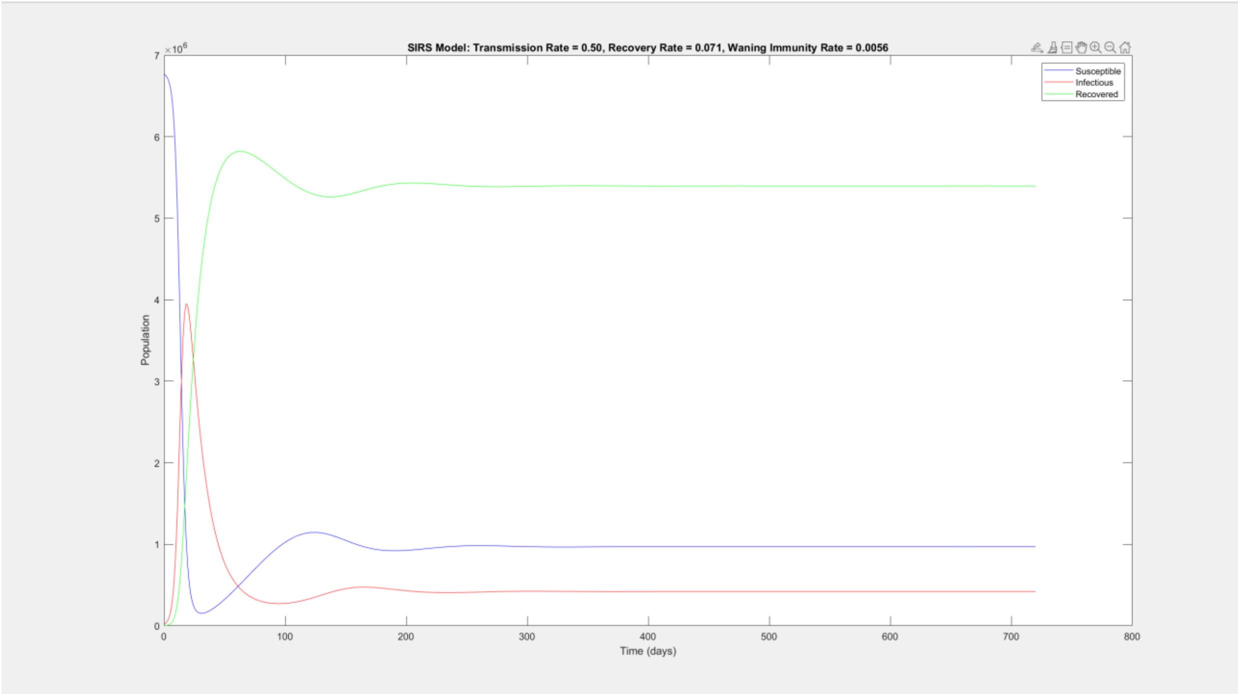

Figure 3: SIRS Model (5/10 transmission rate, 1/14 recovery rate, 1/180 waning immunity rate)

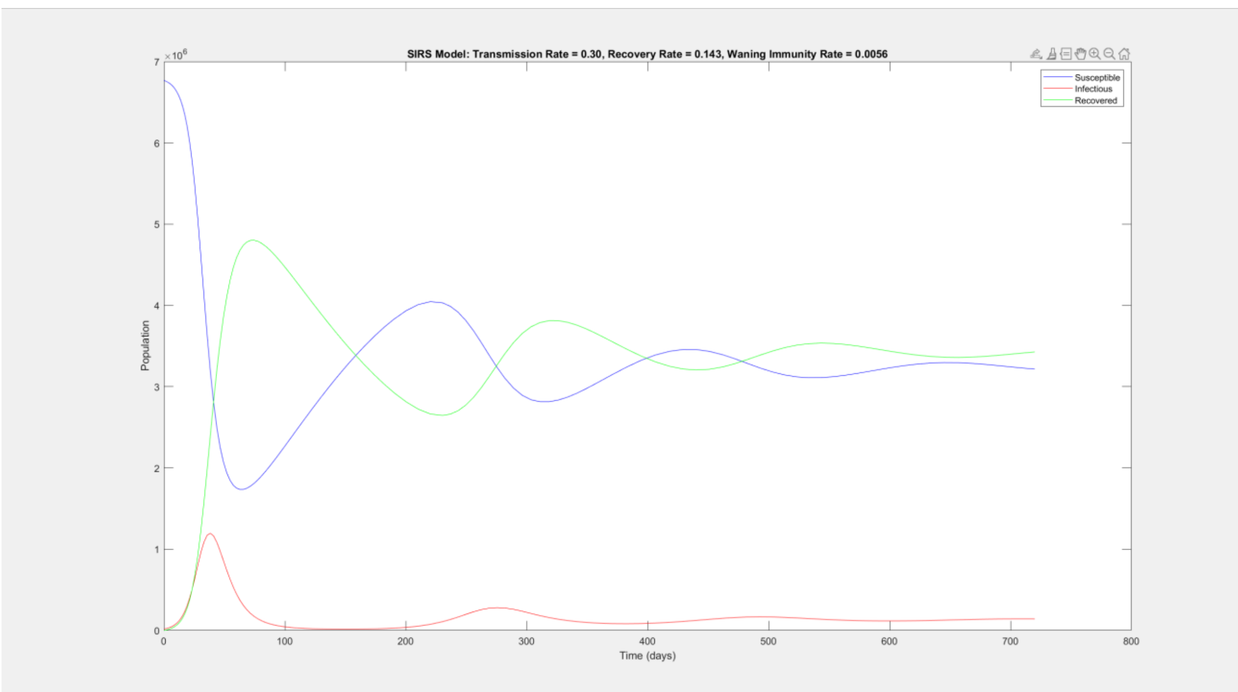

Figure 4: SIRS Model (3/10 transmission rate, 1/7 recovery rate, 1/180 waning immunity rate)

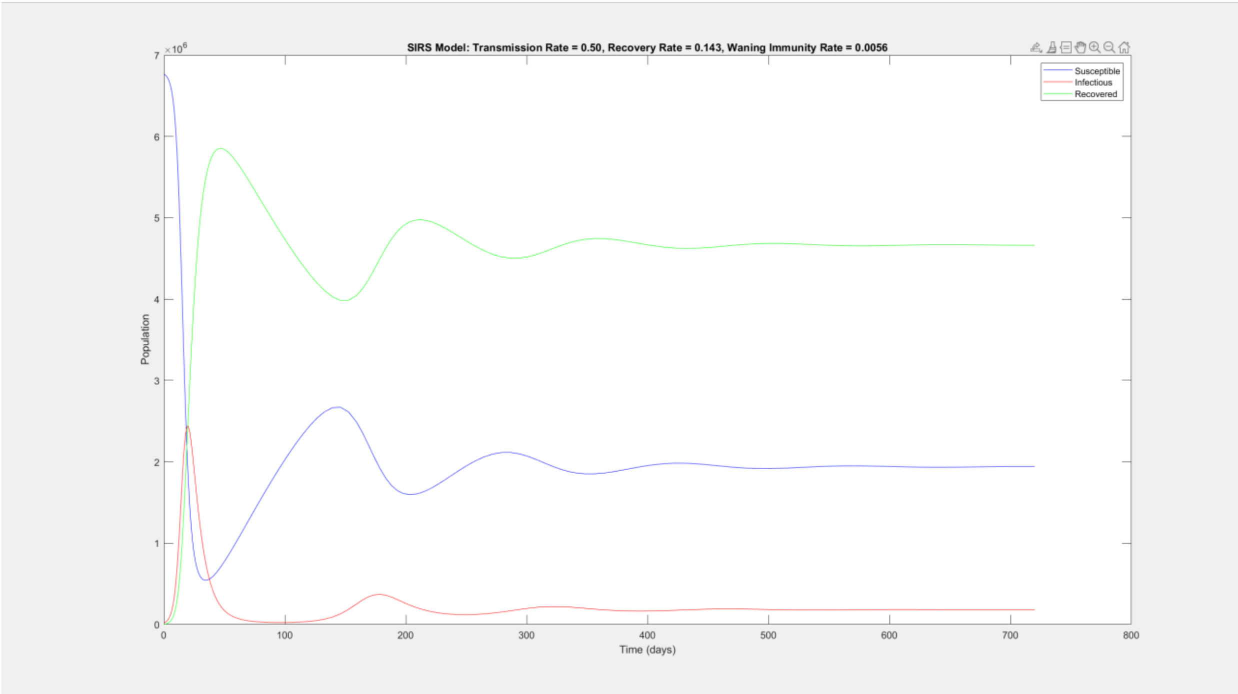

Figure 5: SIRS Model (5/10 transmission rate, 1/7 recovery rate, 1/180 waning immunity rate)

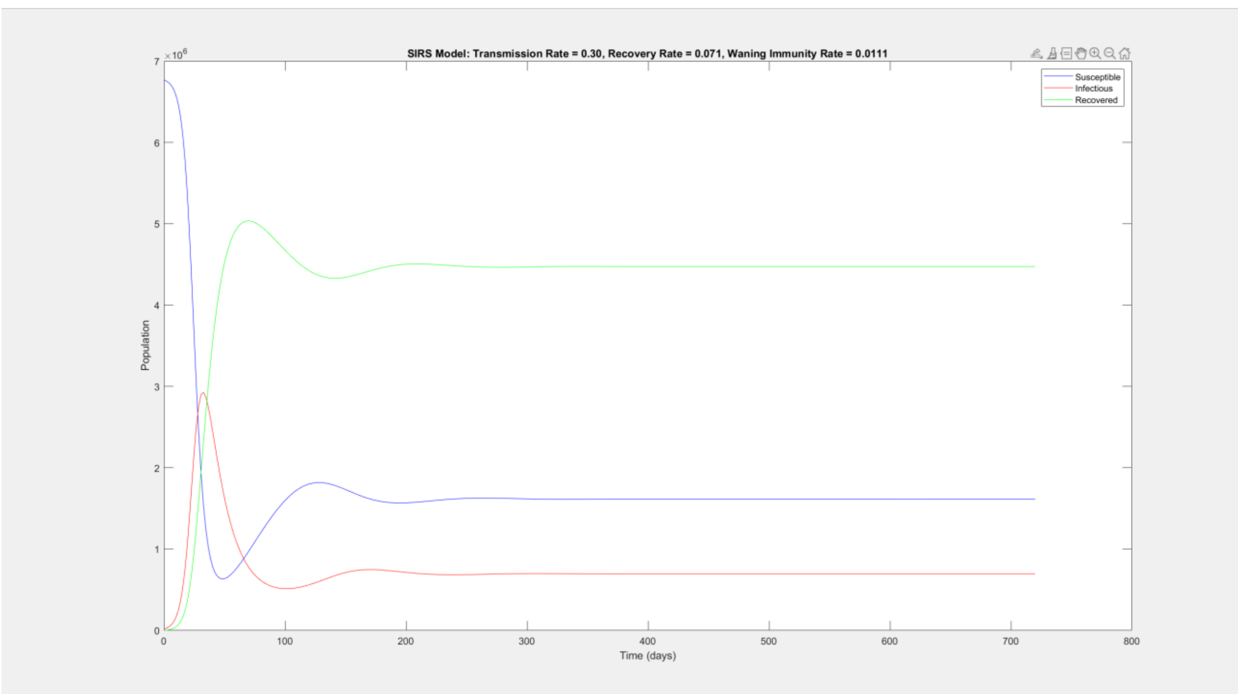

Figure 6: SIRS Model (3/10 transmission rate, 1/14 recovery rate, 1/90 waning immunity rate)

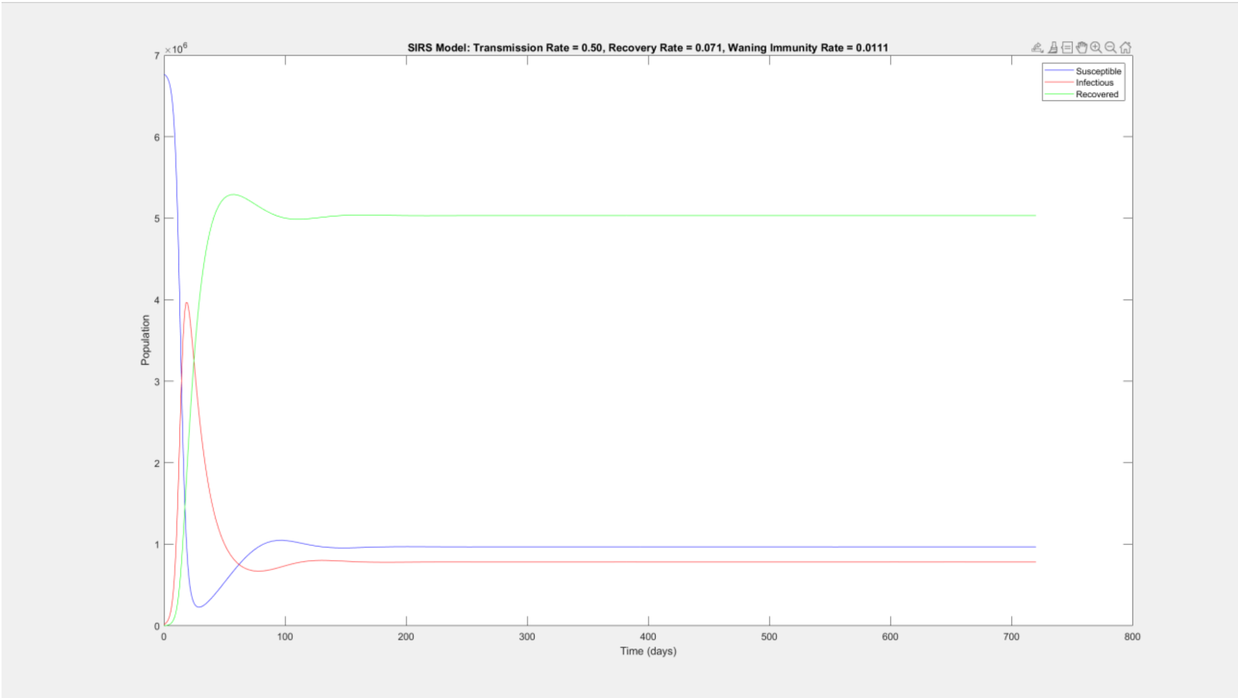

Figure 7: SIRS Model (5/10 transmission rate, 1/14 recovery rate, 1/90 waning immunity rate)

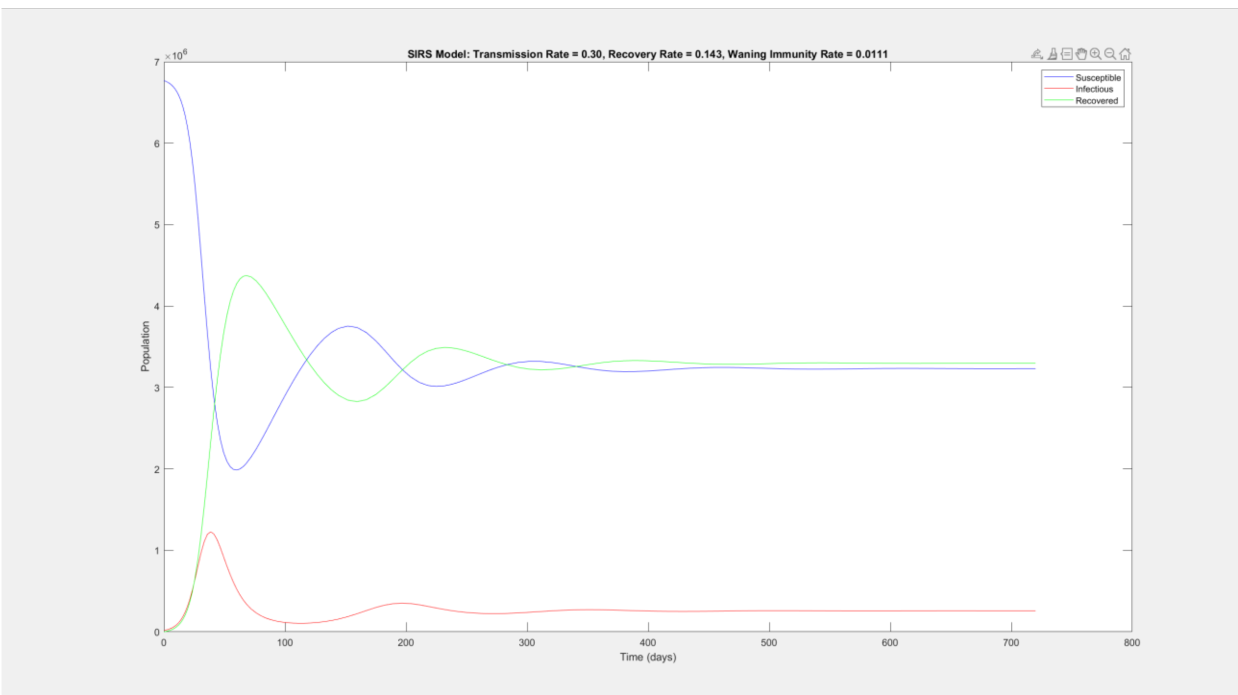

Figure 8: SIRS Model (3/10 transmission rate, 1/7 recovery rate, 1/90 waning immunity rate)

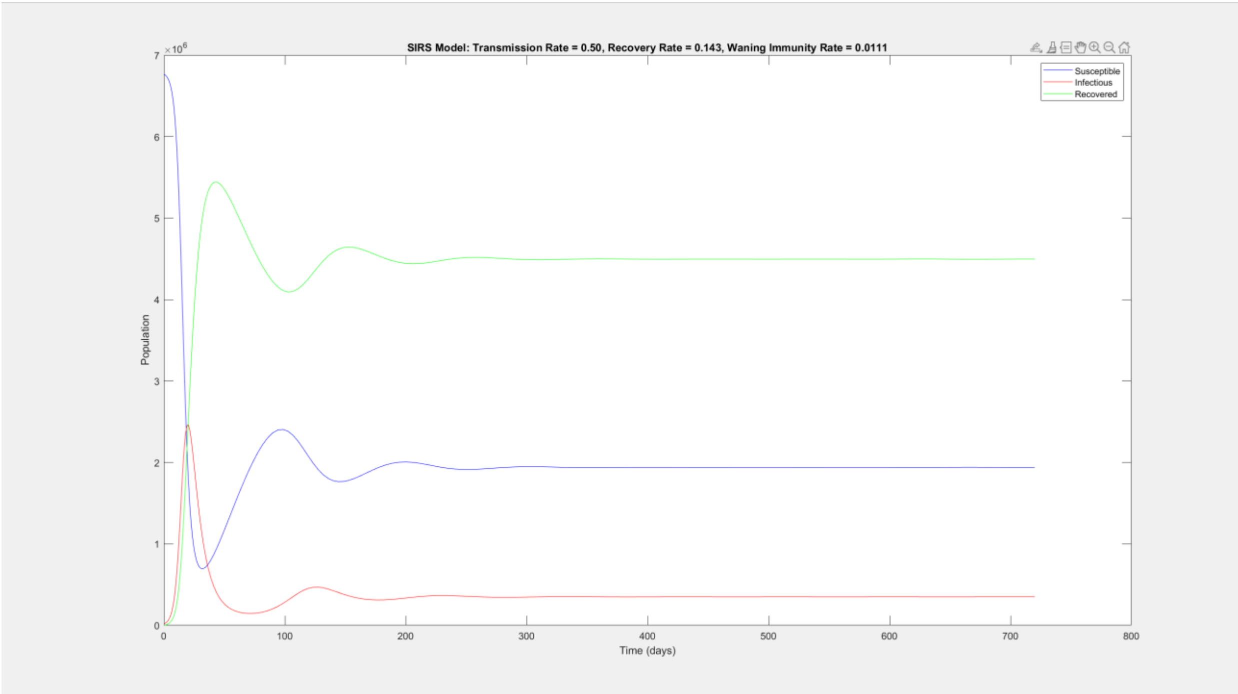

Figure 9: SIRS Model (5/10 transmission rate, 1/7 recovery rate, 1/90 waning immunity rate)

Works Cited

[1] https://www.census.gov/quickfacts/fact/table/IN/PST045222

[2] https://github.com/CSSEGISandData/COVID-19/

[3] https://docs.idmod.org/projects/emod-generic/en/latest/model-sir.html#sirs-without-vital-dynamics