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A3_8 An Analysis of the Initial Spread of COVID-19 in the UK

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Abstract

In this paper we investigate the spread of COVID-19 in the population of the UK. We used the SIR mathematical model to analyse the rate of infection and plotted graphs using Python to visualise the results. It was found that with no preventative measures 47 million people in the UK could have contracted COVID-19 within 350 days. Assuming the same death rate as the UK currently has this would have resulted in approximately 1.7 million deaths in the UK alone.

Introduction

COVID-19, commonly known as Coronavirus, was first identified in Wuhan, China, in late 2019 [1]. This is a contagious respiratory and vascular disease that has affected hundreds of millions of people globally. This global pandemic could have been far more dangerous had preventative measures not been put into place and followed.

In this paper we analyse what could have occurred during the initial spread of COVID-19 had no lockdown measures been put in place. We use the SIR model to evaluate the spread of Coronavirus in the population if no changes had been made.

Method

In order to model the initial spread of the pandemic, a simple SIR model is used to predict the number of susceptible members of the population S, the number of infected members of the population I, and finally the number of removed people R, which includes both deaths and recoveries. This was done using three ordinary differential equations,

$$\frac{dS}{dt} = -\frac{\beta IS}{N}, \tag{1}$$

$$\frac{dI}{dt} = \frac{\beta IS}{N} - \gamma I, \tag{2}$$

$$\frac{dR}{dt} = \gamma I. \tag{3}$$

The values β and γ are the values that define different diseases. β is the number of people that a person comes into contact with per day multiplied by the probability of infecting that person. γ indicates how long a person is infectious for and is found by taking the reciprocal of the time in days that a person is infectious.

In order to compare this model to the actual COVID-19 data, a graphical method was used that simply visualises the course of the virus. In order to do this, the UK statistics were imported into Python from the government website [2]. Specifically, the number of new daily cases was plotted against time for the last 327 days. The number of daily cases predicted by the SIR model was then plotted on top of the data. This plot was formed by solving equations (1), (2) and (3) at each t value given initial input parameters for S, I and R.

Findings

In order to create a plot for the SIR model some approximations had to be made. A β value of 0.25 was used as a conservative approximation assuming an infected person comes into contact with one other person per day and has a 25% chance of infecting them. This value is used assuming a basic reproduction number R_0 of 1.75 where $R_0 = \beta/\gamma$ [4]. It becomes much harder to model the COVID-19 pandemic using this SIR model after the first lockdown began, as it would have a significant impact on the β value. A γ value of 1/7 was used as current estimates suggest that people are typically contagious with COVID-19 for about 7 days [3]. The population of the UK was used for N, which is 66 million. The graph in figure 1 provides a worrying visualisation of what could have happened had no measures been put in place to fight the virus. The SIR model almost matches the actual UK data for the first 70 days of the pandemic. The actual data stops following the model in about late March, which is when the first lockdown in the UK began. The start of the model consistently predicts higher values than the actual data, however, this could be due to the limited number of tests conducted in the early stages of the pandemic. By comparing the SIR model to the data we are able to see how impactful the first lockdown was at 'flattening the curve'. Had we waited another month before going into a full lockdown, it seems that the pandemic would have grown beyond our control. After just 157 days since the first case of COVID in the UK, the pandemic would have peaked, hitting an unfathomable number of 1.1 million cases a day, while in reality we only had about 1000 cases on that same day [2]. By late November the total number of cases would have been nearing 47 million, over 70% of the UK population. With a death rate of 3.5% this would have resulted in 1.7 million deaths due to COVID, before even considering the impact the pandemic would have had on the NHS.

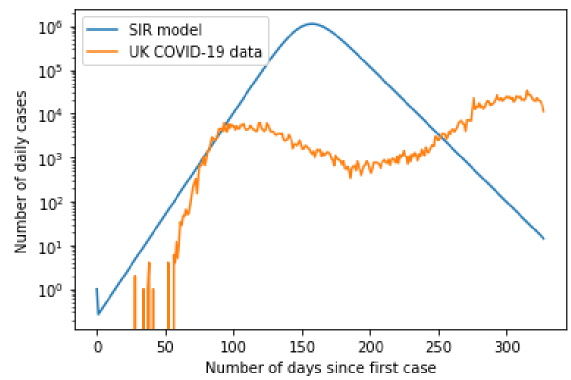

Figure 1: Graph comparing the daily number of new COVID-19 cases compared to the number of new cases predicted by an SIR model.

Conclusion

To conclude, it is clear that by using this mathematical model, and the specific parameters, that the disease did not, and most likely will not spread anywhere near as quickly as predicted in this paper. The number of infections did not increase at the same rate as predicted in this model, however, at the beginning the trajectories are scarily similar. This could be due to the fact that many activities were done as normal and little to no preventative measures were in place. If the real trajectory followed the prediction from the SIR model, then on the date this paper was written, the 25th November, we would be very close to hitting 47 million total infected, as opposed to 1.5 million in reality.

References

[1] `https://tinyurl.com/COVIDtime` [Accessed 25th November 2020]

[2] `https://coronavirus.data.gov.uk/` [Accessed 25th November 2020]

[3] `https://tinyurl.com/COVIDcontagious` [Accessed 25th November 2020]

[4] `https://tinyurl.com/reproduction8` [Accessed 9th December 2020]