Difference Between Different Waves of COVID-19

Introduction

Covid-19 , spreading around the world, has mutated rapidly and has developed into different variants. Cases were first reported back in December 2019. The variants include Alpha, Beta, Gamma as well as the more recent Delta and Omicron variants. The Delta variant was first reported in India in October, 2020 and Omicron documented in November, 2021 (WHO, 2021). According to CDC (2022), the variants have different characteristics, specifically, the infectious rate and incubation rate varies across different variants of Covid-19. It's hypothesized that the waves that came later in time are narrower than the prior waves in Covid-19. To better understand the variation in Covid-19 variants, the concept of the successive waves becoming "narrower" in Maharashtra state, New York, Belgium, and London using the SIR model will be further explored.

Methods

The datasets for Maharashtra state, New York, Belgium, and London were cleaned inorder to visualize the cases with respect to time. For each data set, the case count after January 1st, 2020 was taken. Then, the difference in cases between dates was taken for the data set that doesn't include new daily cases and days where the number of cases is greater than 150000 or less than 1 were removed from the data sets. Next, cases for each region were plotted with time to visualize the time period for the wave for each variant. Before fitting the model, the cases were converted to a proportion with respect to the population, the population was divided by 10 to account for the under report of cases. Finally, SIR model initialized with S of 0.5, I of 0.001, beta of 0.25, and gamma of 0.005 was fitted through the data points for the Delta and Omicron wave for each region separately. Parameters for transmission rate and recovery rate were optimized.

Results

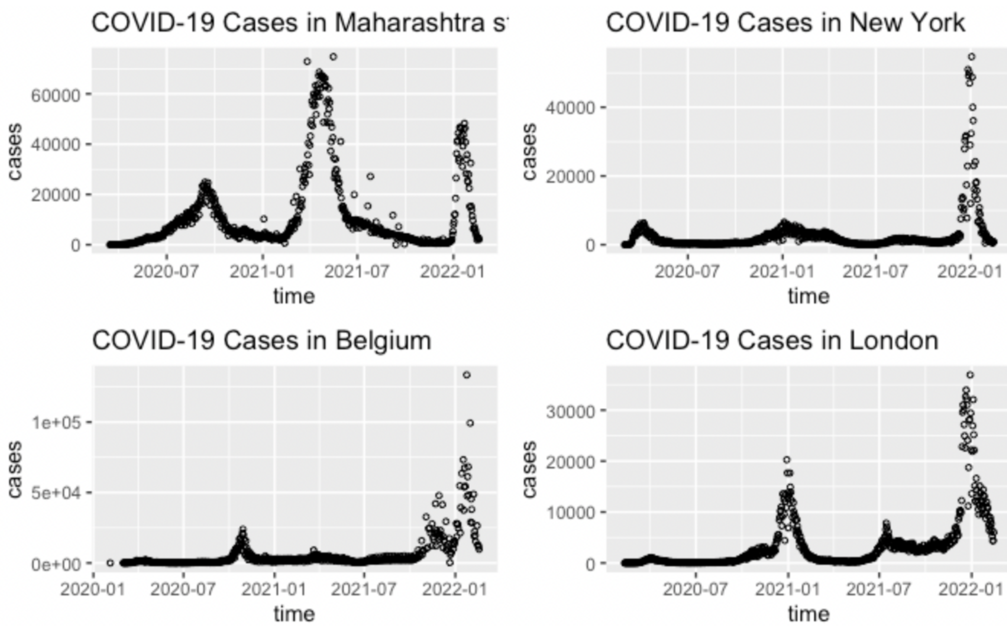

Figure 1. 1 Covid Cases since Jan 2020 for Regions of Interest

Figure 1.1 shows the case count for Maharashtra state, New York, Belgium, and London since January 2020. The increase in cases caused by the variants is clearly shown in the plots, where the middle wave is caused by Delta and the wave that happened around beginning of 2022 is caused by Omicron. In Maharashtra, London, and New York, it shows a clear trend that the Omicron wave is narrower than the Delta wave. However, this trend is not as clear in Belgium.

	Delta Wave β	Delta Wave γ	Omicron Wave β	Omicron Wave γ
Maharashtra	0.3248	0.1936	2.1803	0.2252
New York City	0.0802	0.0321	0.2108	0

Belgium	0.0954	0	0.2422	0
London	0.1424	0.0921	0.1611	0.0180

Table 1. 1 Transmission Rate and Recovery Rate Output from SIR Model

As presented in Table 1.1, for all four regions, the $\boldsymbol{\beta}$ parameter estimated from the Omicron wave is higher than the Delta Wave. This represent that the transmission rate for the Omicron Waves is higher than the Delta wave. Yet, the trend in the $\boldsymbol{\gamma}$ parameter representing recovery rate varies across the regions. In Maharashtra State, the recovery rate for the Omicron wave was higher than the Delta wave. In New York and London, however, the recovery rate for the Omicron wave was lower than the Delta wave.

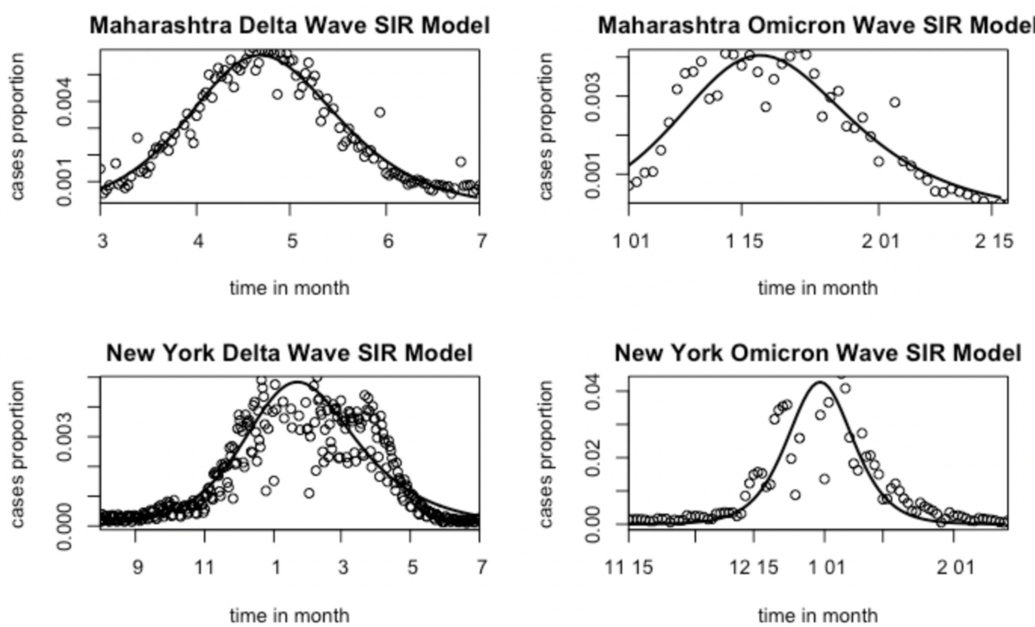

Figure 1. 2 SIR Models for Maharashtra and New York

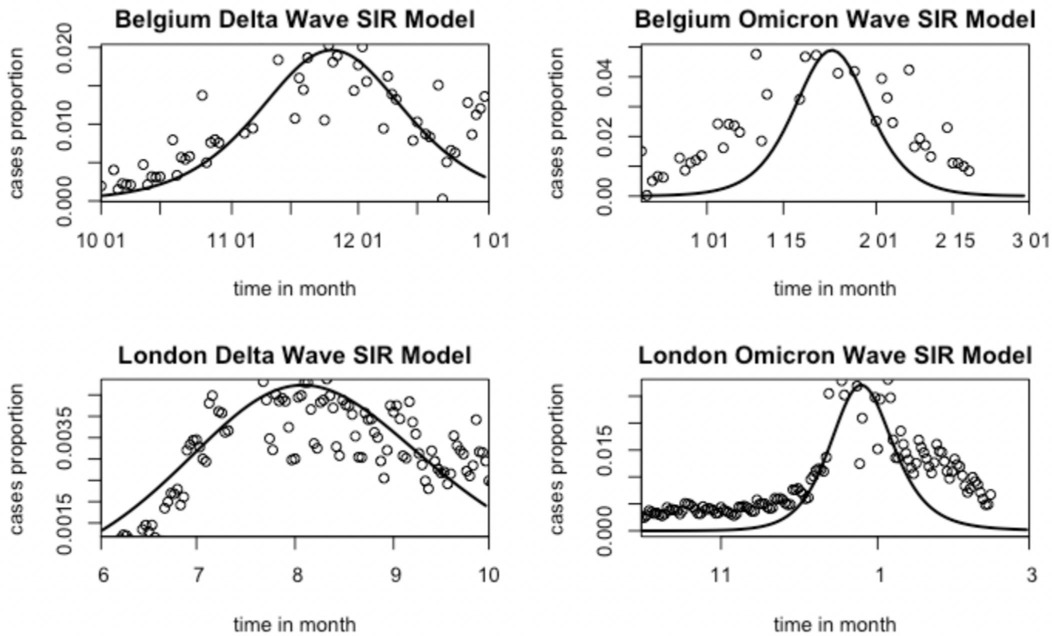

Figure 1. 3 SIR Models for Belgium and London

Discussion

The estimated parameters from the SIR models together with the case count scatterplot shows that the increase in transmission rate is the main factor contributing to the successive waves becoming “narrower” in the selected region. Nonetheless, there are a few limitations to these results. As presented in Figure 3, although we tried to optimize the parameters to fit the data, the model for the Belgium Omicron wave is still not fitted smoothly. This could affect accuracy of our parameter estimation. Furthermore, since Covid-19 haven’t been around for a long time, the amount of data is relatively small. In the datasets used, only three waves were observed. Therefore, the data is insufficient to thoroughly test the hypothesis that “successive waves of COVID-19 are becoming narrower”.

References

Centers for Disease Control and Prevention. (n.d.). What you need to know about variants. Centers for Disease Control and Prevention. Retrieved February 20, 2022, from https://www.cdc.gov/coronavirus/2019-ncov/variants/about-variants.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fvariants%2Fdelta-variant.html

World Health Organization. (n.d.). Tracking sars-COV-2 variants. World Health Organization. Retrieved February 20, 2022, from https://www.who.int/en/activities/tracking-SARS-CoV-2-variants/

Covid-19 Reporting Delay

Introduction

Covid-19 cases are subject to reporting delay, and this delay affect analysis of Covid-19. Since the delay varies for every individual, it's t difficult to be informed about it. In this question, the impact of reporting delays on SIR models will be explored.

Methods

The delay time of 0, 2, and 5 days was chosen. 3 pandemics was simulated using SINR with 500 people. Distributions for the delay periods were Γ (0, 0.25), Γ (0.5, 0.25), and Γ (1.25, 0.25) , with means of 0, 2, 5, respectively. The transmission rate was set to 0.3248, which is the transmission rate estimated from the Delta wave in Maharashtra state.

Next, Markov Chain Monte Carlo (MCMC) is used to estimate the posterior distribution for the 3 simulated pandemic. The prior of 0.1424 rate was picked for transmission rate from Delta wave in London, since London has population size closest to Maharashtra state from Question 1. According to CDC (2021), COVID-19 has "a median time of 4-5 days from exposure to symptoms onset." Thus, Γ (1, 4) with an average of 0.25 was chosen as the prior distribution for incubation period rate. A low spark value was chosen since a minimum number of infections not accounted by the SINR model is desired. Finally, MCMC with 500 iterations was executed for each delay time.

Results

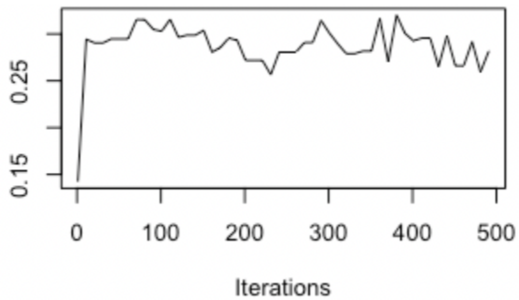

Figure 2. 1 Beta Trace Plot for 500 Iterations using MCMC

	No Delay	2-Day Delay	5-Day Delay
95% CI	(0.0134, 0.0192)	(0.2932, 0.3533)	(0.2775, 0.3343)

Table 2. 1 95% Confidence Interval for Transmission Rate from MCMC

The 95% confidence intervals for transmission rate shown in Table 2.1. The posterior of 0.3248 is only captured by the 2-day and 5-day delay confidence interval. Looking at the length of the intervals for 0-day, 2-day, and 5-day, they were 0.0058, 0.06, and 0.057, respectively. Interestingly, the length of the interval was observed to huge increase from half-day to 2-day, but then slightly decreased as delay period went from 2 days to 5 days.

Discussion

From the results, it's shown that estimating the model parameters gets harder when there is a delay between infection and reporting. However, comparing the interval length between 2-day and 5-day delay, it does not get harder to estimate as reporting delay gets bigger. There are still some limitations to these results. Due to technical constraint, only

500 iterations of MCMC were ran and this is a relatively small number. The results would probably be more accurate if more iterations were done.

Reference

Centers for Disease Control and Prevention. (n.d.). *Management of patients with confirmed 2019-ncov*. Centers for Disease Control and Prevention. Retrieved February 20, 2022, from https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html