The Effect On Excessive Death of COVID-19 In Quebec

0.1 Summary

This study investigates the impact of the ongoing COVID-19 diseases based on the death counts data in Quebec, Canada. By using the non-parametric model and simulation the excessive death counts from 2020 to 2022. We could conclude that COVID-19 increase the mortality rate hugely starting from 2020, and elderly people have the highest risk of being infected and passing away. The vaccination is an effective way to protect people.

0.2 Introduction

The COVID-19 disease has become an ongoing pandemic since the end of 2019. Some scientific research points out that this virus is age-specific and causes high mortality rate in old people, while some believe that COVID-19 isn't the direct cause of death as elderly might already suffer from the chronic diseases such as heart disease and diabetes. Therefore, we want to examine the whether the COVID-19 is targeted on the elderly by comparing excessive deaths without COVID-19 and mortality rate of the COVID-19, plus the effect of vaccination by using the data from Quebec, Canada.

0.3 Method

0.3.1 Data Visualization

Figure 1 displays the death counts of COVID-19 in Quebec from 2010 to 2020 on a yearly and weekly basis. We could observe the overall increasing trend with the seasonal effects over the decade, and the death counts peak at the beginning of 2020 which corresponds to the outbreak of COVID-19. The same trend can be observed in Figure 1(b), where the purple line representing the high death counts around the 18^{th} week, 2020.

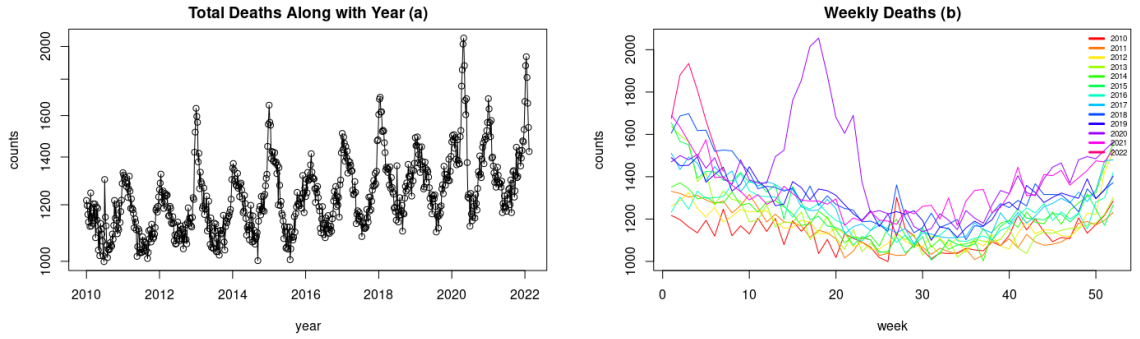

Figure 1: Time Series Plot for Death Counts on the Yearly and Weekly Basis in Quebec

Figure 2 shows the death counts within different age groups. The upper line is the total death counts, and the second wave is people aged above 70 which accounts for over 50% percent of the total death

counts from 2012 to 2020 with the seasonal cycle with might due to the influenza. Followed by people aged between 50-69 years old. Therefore, we need to compute further analysis to examine where COVID-19 is age-specific.

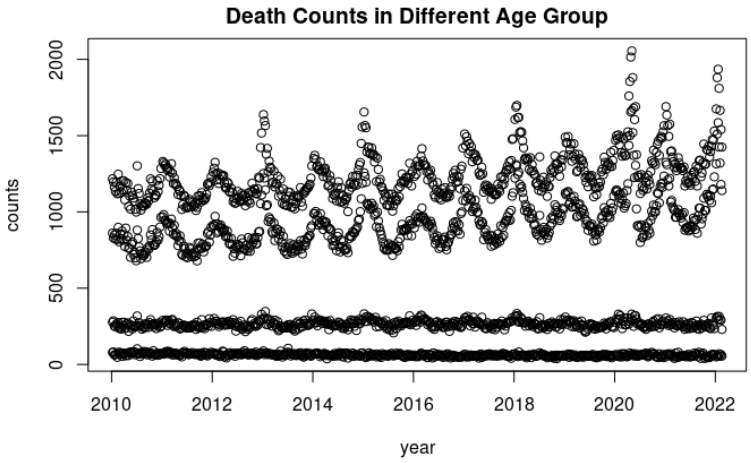

Figure 2: Total Death Counts For People of Different Age Groups

0.3.2 Model

The dataset consists of morality counts over the last decades in Quebec, which is positive and discrete. Therefore, we can make the assumption that the death counts for people in Ontario follows Poisson distribution. In addiction, there is seasonal pattern in the data, so we can fit a non-parametric model with the Bayesian Inference approach:

$$Y_i \sim Poisson(\lambda_i)$$

$$\log(\lambda_i) = X_i\beta + U_{t_i} + V_i$$

where Y_i is the real daily death counts in Quebec, λ_i is average expected death counts. X_i is the covariates of all sinusoidal seasonal fixed effects and β is vector of parameters corresponding to all fixed effects, and we use the default prior for β_0 with normal distribution of mean 0 and standard deviation ∞, and $\beta_1, \beta_2, ...\beta_n$ with normal distribution of mean 0 and standard deviation 1000:

$$\beta_0 \sim N(0, \infty)$$

$$\beta_1, \beta_2, ...\beta_n \sim N(0, 1000)$$

U_{t_i} is the second-order random walk for the smoothing purpose, and V_i is the overdispersion term. There are four sinusoidal functions for the fixed seasonal effects with the frequency of 12 month and 6 month, they are written as follow:

$$X_{i1} = cos12 = cos(2\pi t_i/365.25)$$

$$X_{i2} = cos6 = sin(2\pi t_i/182.625)$$

$$X_{i3} = sin12 = sin(2\pi t_i/365.25)$$

$$X_{i4} = sin6 = sin(2\pi t_i/182.625)$$

where t_i is the number of days since the orginate date and divide by 365.25, the number of days it takes for the earth to go around the sun. The second-order random walk U_{t_i} is applied with a penalized term and the overdispersion term V_i follows Normal distribution with penalized prior:

$$[U_1...U_T]^T \sim RW2(0, \sigma_u^2)$$

$$Prob(\sigma_u > log(1.5)) = 0.5$$

$$V_i \sim Normal(log(1.5), \sigma_v^2)$$

$$Prob(\sigma_v > 0.05) = 0.55$$

0.4 Result Analysis

Figure 3 displays the excessive deaths during the COVID-19 pandemic, where we used the total death counts to subtract average death counts before thee pandemic. We could see that people aged 70 have the largest amount of excessive death counts in Quebec. Vaccination started at the end of the year 2021, where the number of excessive death counts increases especially in elder group which reflects that the vaccination is effective and less people die of COVID-19.

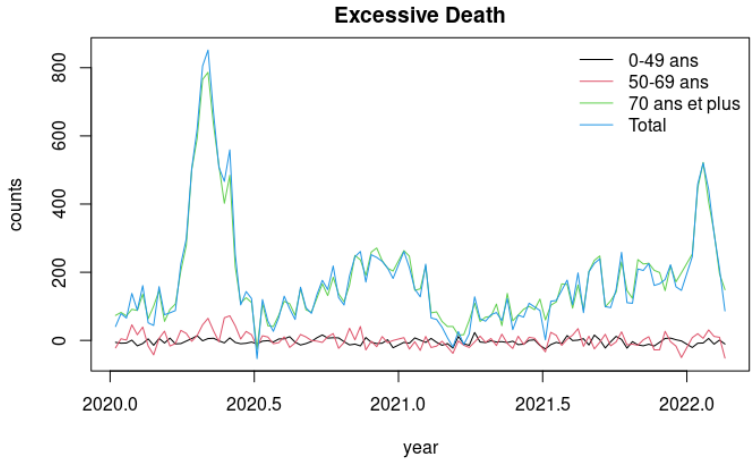

Figure 3: Excessive Deaths During COVID-19

Then we start the simulation and prediction for the death counts without the impact of COVID-19. The black line from Figure 4 is the predicted death counts, dash line is the 80% credible interval where the red dot is the actual death counts under the affect of COVID-19 in Quebec. We could see

that almost all dots lie above the predicted line and even about the credible interval. It shows that COVID-19 did raise the mortality rate to a great extent.

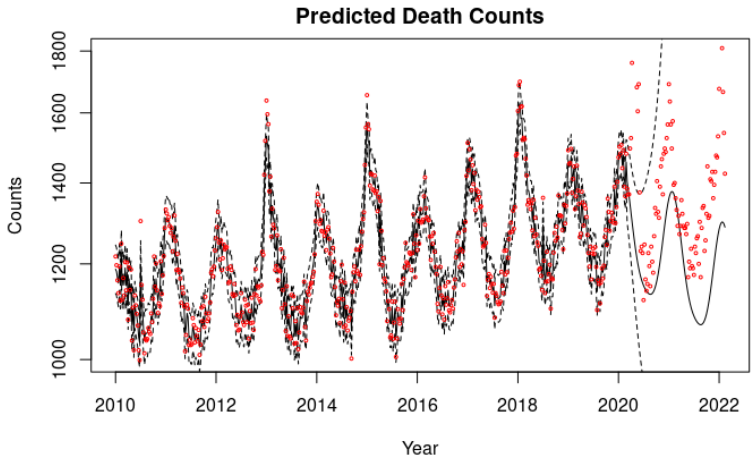

Figure 4: Predicted and Actual Death Counts Comparison Plot

According to Figure 5, there is a upward trend starting from 2020 based on the fitted value and its credible interval. The trend can be observed clearly in the right where the red dots increase tremendously. The increasing trend outweighs the prediction over the outbreak of COVID-19. Therefore, it further enhance our hypothesis that the COVID-19 has impact on the death counts.

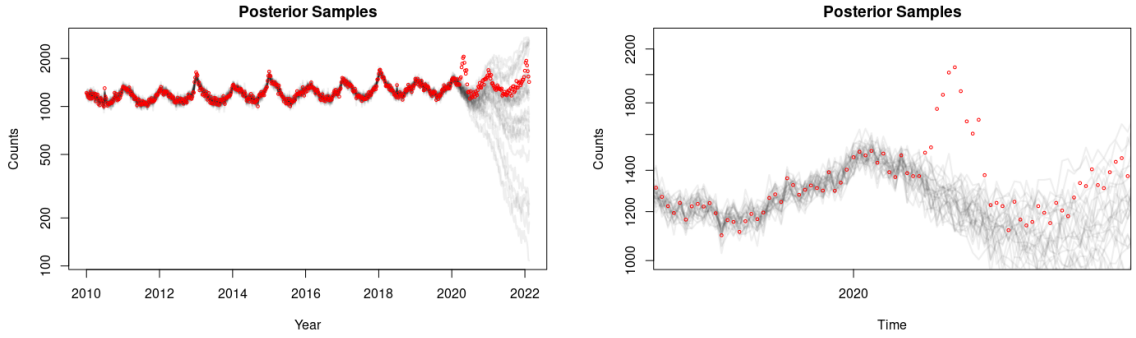

Figure 5: Posterior Samples of Death Counts Over the Last Decade and The Year 2020

Figure 5 shows the total death counts of the simulation. By comparing the real data and the simulation results, where the death counts in 2020 reach to the peak and is more than the excessive death.

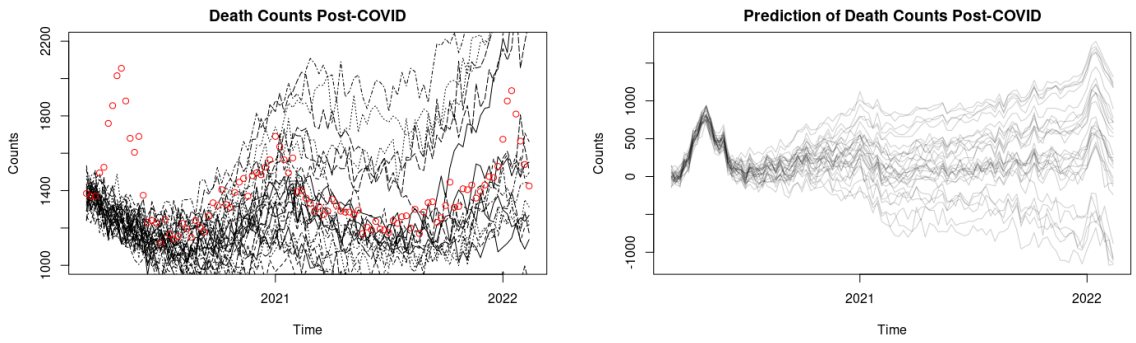

Figure 6: Death Counts Post-COVID 19

0.5 Conclusion and Discussion

According to the data analysis, we could see that COVID-19 cause a high mortality compare to the pre-pandemic period starting from the beginning of 2020. By grouping the people by their ages, we found that elderly people (especially above 70) accounts for the highest death counts no matter excessive death or death due to COVID-19. Through the simulation during the period between 2020 to 2022, the predicted value is lower than the actual death values under the COVID-19. Therefore, we can conclude that COVID-19 is age-specific to people above 70, while the appearance of vaccination effectively decrease the number of death counts in Quebec. The public sector should still advocate people to get vaccinated. Noted that the study is conducted on the data in Quebec where the weather is extremely cold during the winter, and the effect of COVID-19 could be stronger in other tropical regions. AS the result, the conclusion may not be representative on the world-wide basis. Also, there might be other factors influencing the excessive death rates. For example, during the peak of COVID-19, the medical care system could be overloaded, and people with other disease cannot get proper treatment in time.