TenFinal Result

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# Abstract

The COVID-19 is an infectious disease caused by the SARS-CoV-2 virus(World Health Ontario, 2022), and anybody can become infected with the virus. Those who become infected with COVID, especially older people and those with underlying medical conditions, are more likely to become critically ill and even resulting in death(World Health Ontario, 2022).

According to Global News, internal Federal polls were conducted periodically throughout the pandemic, and it seems residents of Ontario’s opinion as well as the overall Canadians’ opinion on the pandemic is dwindling as time goes on. In March 2021 roughly 71% Canadians were worried about the virus, but that percentage has dropped to 52% by November 2021(Akin, 2022). Even after 70% herd vaccination, it seems Ontario is still going through very strict COVID lockdown measures. With continuous prolonged restrictions and lockdowns, public opinions on these measures are becoming less and less supportive. Roughly 56% support the measures back in December 2021, which is down from 69% back in July 2021 & 63% in September 2021(Bricker, 2021). It seems there are increase level of frustrations and on fatigue on these measures(The Canadian Press and Berthiaume, 2022).

Based on the most recent Ontario Health’s modelling report, it states the Province must have 85% vaccination rate to avoid continuous lockdowns(Draaisma, 2021). However, Ontario is currently at 84% 1st dose vaccination and 78.5% with 2 doses(Public Health Ontario, n.d). After 2 years of the 2nd dose available, it’s safe to say there will not be a huge spike in the 2nd dose rate, hence the province reaching 85% full vaccination rate in the near future is not going to be occurring any time soon, resulting in prolonged restrictions & mandates.

However, based on recent developments, the most being the convoy protest occurring in Ottawa, and others coming out to support that movement it seems the province’s opinion on lifting the restrictions is growing. With growing support of removing the mandates, I want to predict, using Ontario vaccine data, to determine if there will be decrease of vaccine being administered across the province. The vaccine dataset begins on December 24, 2020 and gets updated on a daily basis with newer number of vaccines being administered. Currently, as newer people might still receive their first & second dosage, I want to use the time series analysis to predict the vaccine rate with decrease public support on the mandates. For this study, I will be using the ARIMA model in python to forecast the vaccination rate of the third dose. Also, I will be comparing 1 month of data for each dose of vaccine, and compare the slopes using the linear regression model in python to determine the rate of change for each 3 doses to determine if first, second or third dose will ever see an increase in vaccination rate to meet the 85% threshold.

One of the major limitations of my study would be that the data is still being collected on a daily basis, but for this study it is fixed up to February 7, 2022. This means that since the 3rd dose information became available around December 2021, I would only have 1 month of 3rd dose data for my study.

# Literature Review

The COVID-19 is an infectious disease caused by the SARS-CoV-2 virus(World Health Ontario, 2022), and those with underlying medical conditions, are more likely to become critically ill and even resulting in death(World Health Ontario, 2022). This disease first started in the province of Wuhan in China, and spread globally quickly to become a pandemic. There have been over 5.6 million deaths in result of COVID-19 and there have over 380 confirmed cases of the virus worldwide(World Health Organization, n.d).

The first case of COVID-19 in Ontario was reported on January 2020, and to prevent the spread of this virus, the Federal Government and the Provincial Government has enforced various strict measures and several lockdowns to curb the spread of the virus. During the summer months when the spread of the virus seems to decrease, the measures were relaxed but implemented again few months later as the numbers spiked again. This cycle of enforcing mandates and lifting, have been going on for 2 years in Ontario.

From the onset of the virus, many studies were conducted to predict the future confirmed cases in order to decide various mandates to curb the spread, to the vaccination modeling to determine the percentage required for herd immunity and to develop effective vaccines. Although there have been no previous studies that have studied possibility of decrease of vaccination rate, more importantly the possible decrease in 3rd dosage administered to determine future vaccination rate. But there have been few studies which measured the twitter data to determine the public opinion on vaccine mandates in US. If the public opinions on mandatory mandates are constantly falling, we can assume the opinion of Ontario will be similar. The Ontario Public Health set a threshold of 85% vaccination rate, which they say is necessary to lift all mandates in Ontario. My study will be significant because it will predict the vaccination rate of future 3rd dosage, which will help to determine if we will ever meet the threshold of 85%, especially in our current climate where the public opinion on these mandates seems to be falling around the world.

Since the beginning of 2020, COVID-19 has affected the lives of people all over the world, including the world economy. With each country going through various lockdowns to restrict the spread the of the virus and adopting various vaccination policies to curb the spread of the virus, we should start to see signs of recovery from this pandemic. Canada still has a strict COVID mandate and even with more than 70% herd immunization(Ontario, 2022), to be considered fully vaccinated individuals must have received 2 vaccinations, along with new strains of virus being discovered, the restrictions and vaccine mandates in Ontario is still in place. As time passes, it seems there is growing sentiment of frustrations about the mandates across various social media platforms. While the impact of COVID vaccination has been studied, the public opinion on various lockdown measures and mandates have not been thoroughly studied. A team of students in Western University’s Department of Statistical and Actuarial Sciences have analyzed the public opinion of lockdown and mandates across 4 Canadian cities(Vancouver, Toronto, Calgary, and Montreal) on the social media platform Twitter between Feb 24, 2020 to October 14, 2020. The students applied text mining sentimental analysis using VADER(Valence Aware Dictionary for Sentiment Reasoning) and NRC Emoticon Lexicon approaches to evaluate the sentiment intensity scores for the tweets concerning three anti-epidemic measures, masks, vaccine and lockdown and found that people have positive mood about COVID & masks, but negative opinion on mandatory vaccine and lockdowns (Zhang et al., n.d).

It was important for studies such as the one conducted by Western University group to understand the sentiment of the public and the drivers that affect the public opinion of COVID, as that will provide public officials of how to understand and navigate the social challenges in route to securing herd immunity. The internet, especially social media platforms, provides statistician another data source to analyze and solve problems, in the form of infodemiology studies in real time for public health surveillance purposes(Hu et al., 2021). Twitter has become a major source of data for health information and opinion exchange assisting people to make an informed decision(Hu et al., 2021). Analyzing Twitter’s database has helped understand the trending topic related to COVID by region utilizing geotagged tweets(Hu et al.,2021). This study however was limited to only trying to understand the public opinion using the early onset of the pandemic data, and did not cover any data from 2021 nor did it try to explore the potential drivers that may induce a change in public sentiment on vaccines, such as public announcements by political leaders(Hu et al., 2021). It was conducted by group of scientists in United States, used Twitter data from March 1, 2020 to February 28, 2021(12 months of data) and applied the sentiment and emotional analysis at national and state level(Hu et al., 2021), different to the study conducted by the Western University students. They discovered that there were indeed 3 phases where there were sharp changes of the public’s opinion, and 11 possible drivers which may have caused these changes. The 3 phases were, from March 1, 2020 to July 13, 2020 when the public was waiting for official announcements regarding the effectiveness of COVID was regarded as 1 Phase. 2nd Phase is ranging from July14, 2020 to December 13, 2020 when the news of vaccine development began to arrive. Finally the 3rd Phase was from December 14, 2020 when the 1st vaccine shots were being administered in united States(Hu et al., 2021).

During this study, they found that in Phase 1, the sentiment was relatively stable with a sharp drop on June 21, 2020 when there was a vaccine conspiracy surrounding Bill Gates(Hu et al. , 2021). The conspiracy theory was that Gates was using the vaccine as a cover for him to implant trackable microchips made by Microsoft (Hu et al., 2021). In Phase 2 & 3 the first stimulus which saw public opinion soar was when first clinical trial results of Moderna was released, but the biggest factor was when Donald Trump tweeted the good news on the vaccine on his Twitter account. It seems there is strong influence on public sentiment through public figures’ opinions than key events(Hu et al., 2021). This is an important finding because if this is true, and if more famous public figures such as celebrities or politicians come out in support of removing vaccine mandates, it will affect the public opinion of Ontario. Currently, as of February 5, 2022, there are massive protests being held in major cities across Canada in support of lifting COVID mandates, fuelled by the mandatory vaccine mandate imposed upon the transport drivers(Farooqui, 2022). With growing support of these removal of mandates, and with provinces in Canada starting to lift mandates(Heidenreich, 2022), it is imperative to predict the possibility of declining in vaccination rate to understand if Ontario will ever reach the 85% vaccination rate required to remove restrictions assuming the province will still implement restrictions and mandates until this target has been reached.

Social distancing was a new term that became popular during the onset of the pandemic. As health officials determined the social distancing, 2 meters separation from others, were required to curb the virus, one of many mandates imposed on the social population. Despite the dataset limitation, a sentimental analysis study was conducted for Canada using Twitter as the data source. The study found that 40% showed neutral sentiments towards social distancing while 35% had negative opinion on it. Only 25% had positive sentiment towards the idea of social distancing(Shofiya & Abidi, 2021).

Another mandate that was implemented was the mandatory vaccination once the vaccinations were available. The proof of vaccination(two dosages approved by Health Canada) was required to enter in door facilities such as sports arena, dining areas, concert halls etc. By examining the vaccination resistance data, we can conclude what were the driving factors of people refusing to get vaccinated when it was made a requirement to enter various indoor activities. A study, using 30 day sampling and categorizing people into no vaccine and yes to vaccine, conducted for the time period between January to May 2021 in United States looked at the vaccine hesitancy by occupation and employment to understand which category had the strongest resistance and the reason for not believing in the vaccine. Based on this study they found that the top reasons for the vaccine hesitancy were due to possible side effects, not trusting the vaccine, not believing they need it and not trusting the government (King et al., 2021). Also, they have found that those who work in blue collar jobs such as construction, maintenance, transportation etc. reported higher hesitancy towards vaccination compared to white collar jobs. There could be various factors for such a strong resistance to vaccine in these occupations, and one of the reasons are that some of the blue collar jobs’ work conditions are primarily outside or in uncrowded conditions, already social distancing, hence do not require the vaccine(King et al., 2021) much like those who work in transportation industry that are currently protesting in Canada. Although a similar study was not conducted for Canada, to understand Canadian’s reasons for not wanting to get vaccinated, but based off various sentimental analysis that has been conducted, we can presume the factors are more less than the same as our American counterparts.

Despite the growing popular support of resisting vaccine mandates & strict COVID lockdown rules imposed in Ontario, and after 2(going on 3) years of various lockdown restrictions and various mandates imposed on the population, it seems as of most recently, the government is still trying to curb the virus cases through strict measures of lockdown. As most recently as January of 2022, the lockdown was enforced yet again in Ontario. As newer variant continuously emerge, such as the Delta and Omicron, spiking the confirmed cases, governments are still trying to prevent the wide spread of the virus. Even with vaccines available, and the province achieving 78.5% full vaccination rate, the restrictions seem endless. What this virus has taught us is that, even those of us who are fully vaccinated, 2 doses based on Ministry of Health’s standards, they are still able to contract the virus. The virus only helps us become less critically ill, thus continuing to enforce strict lockdown measures will not help in the long term. We will need to start to learn to cope and live with the virus, much like the influenza virus, and move on with our lives. Now with increase protest and frustration on these restrictions, even the top Ontario doctor has recently said, we would need to learn to live with the virus(Davidson, 2022). If the province decides to change their stance on COVID opinion and not force vaccination upon the population, we could see a decrease of booster shots being administered as vaccinations will no longer become a requirement.

# Descriptive Statistics

For this study I have used Ontario’s public open source databases, Covid Vaccination data and Vaccination by Age group datasets. The Covid Vaccine data and Vaccination by Age data provides a time series label, ranging from December 24, 2020 to most recent date, February 7, 2022 and it is being updated on a daily basis until further notice. For this study I will use the data including up to February 7, 2022 information(403 records/rows of information). The data does not include any information where the consent was not provided to enter the information into CoVax. The dataset has 11 fields however, I have narrowed down to use 4 fields. The 4 fields I have decided to use captures the daily date when the vaccination information was entered into the system, the total number of individuals who were administered 1st vaccine, total number of individuals who were administered the 2nd dose, and finally the total number of individuals who were administered the 3rd dosage. The other fields were not used as it provides either total number of doses for each respective shot or the number of vaccines administered in the previous day.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Data Set** | **Field Name** | **Field Description** | **Data Type** | **Basic Stat** |
| Vaccine Doses | Report Date | Date the data was reported and entered into CoVax in regards to vaccination | Date | Min: December 24, 2020  Max: February 7, 2022 |
| Vaccine Doses | Previous\_day\_at\_least\_one | Total individuals who have been administered 1 shot of vaccination | Numerical | Mean:29988.06  Median13171  Mode12593.0  Std:37344.18  Min:204  Max:165905 |
| Vaccine Doses | Previous\_day\_fully\_vaccinated | Total number of individuals who received 2 doses | Numerical | Mean:28789.57  Median:9226  Mode:1635  Std:49956.21  Min:0  Max:244701 |
| Vaccine Doses | Previous\_day\_3doses | Total number of individuals who were administered the 3rd dosage(booster shot) | Numerical | Mean:57052.72  Median:36666  Mode:161487  Std:48873.07  Min:7021  Max:176118 |

# Approach

1) Download Covid Vaccination Data from

2)Load the Excel file into Python as Dataframe

3)Transform Data

6)Evaluation

4)Perform Descriptive Statistics

5)Perform Time Series & slope

7) Conclusion

Step 1. Download the dataset form the Ontario open source website: https://data.ontario.ca/en/dataset/covid-19-vaccine-data-in-ontario

Step 2. Load the dataset into Python as Dataframe

Step 3. Transform the Dataset

* Drop all column except, Report Date, Previous Day At Least One, Previous Day Fully Vaccinated, Previous Da 3rd Dose

Step 4. Use python to calculate, min/max, mean, median, mode and standard deviation of each field of the dataset

Step 5. Perform Time Series Analysis using the ARIMA model and compare slopes of 3 datasets

Step 6. Use Root-Mean-Square-Error also known as Root-Mean-Square Deviation to evaluate the performance

Step 7. Conclusion of the findings and summary of the study, including the limitation of this study

# Exploratory Data Analysis

Exploratory Data Analysis is a critical process of data science as it helps us to understand patterns in the dataset. The first step was to determine if there are any nulls or missing data in the dataset. This would help us determine how to triage the missing information prior to modelling. After calculating for NAs, we found there were 390 empty cells in the dataset which I would need to triage before doing any modelling. The nulls can be either omitted or given an arbitrary number for our model.

The second step of exploratory data analysis I conducted was to determine what kind of data types are in my dataset. The fields in my dataset are 1 date and 3 floats. Floats are integers and is the expected data type for the vaccine numbers. If the data types were strings, I would have to change the data type into float for my model to work correctly.

The third step was to use the describe function to understand the dataset mathematically and how it is distributed. The describe function provides the min and max value of the dataset to provide the range of the array of the dataset. The average or the mean is also provided which helps us understand the central tendency of each of the field and compile that with standard deviation, we are able to understand how much the measure deviates and varies from the average.

The describe function also provides the 25th , median(50th/) and 75th percentile values for each fields in the dataset, also known as interquartile range. This provides what the median,50th percentile, of the field is as well as the any values that lie outside the 25th & 75th percentile will be considered outliers. If there are any outliers, these will need to be removed prior to running my model. This can be visualized using the box whisker plot diagram(see below)

Chart, box and whisker chart

Description automatically generated

Circles in this visualization represents values that are considered outliers. As per the visualization, there are no outliers for the 3rd dose vaccine field, but there are lots of outliers in the 1st and 2nd vaccine field.

Also, from the describe function, we were able to calculate the average and the median of each of the field. This helps us understand if the data is skewed to the left or to the right by analyzing to average and see if it is less or greater than the median. If the average is less than the median, that means the dataset is skewing to the left and if the average is greater than the median, skewing to the right. This can also be visualized as a histogram.

Chart, waterfall chart

Description automatically generated

Once we determine if there is any skewing of the data, we would need to normalize the data using logarithmic function to ensure all variables are given equal weight/significance.

Calculating for correlation is another method in exploratory analysis. We are able to determine any strong correlations between variables and understand which one to remove if the variables are very similar to each other. This correlation matrix lets us know there is a strong positive correlation between the 1st dose and 3rd dose vaccination.

# Methods

I used ARIMA model, linear regression and auto gradient regressor model to predict vaccination rate. In order to prepare the dataset for the 3 methods, I had to subset the vaccine data into 3 datasets, one for first vaccination date, second one for the second vaccination(full vaccination) dataset and third one for the third vaccination data. I counted how many records there were in the third dataset, there were 53 records, and to compare the data equally, I had the first and second vaccination data only capture the first 53 days of the data. These new datasets were tested for outliers, and there were none, and used the ADF test to check for stationary before inputted them into the ARIMA model. For the Linear Regression and Auto Gradient Regressor models, I used the same subset data but had it split it into test and train dataset and ran it through each model to predict the outcome.

# Results

ARIMA model was used again the 3 different datasets to determine what the outcome of 3rd dose would in the future to determine if it will meet the 85% threshold. I compared the outcome of the 1st & 2nd dose to the 3rd dose to validate if the prediction is comparable. Prior to inputting the datasets into the ARIMA model, I had to ensure the data is not stationary and hypothesized the data is not stationary. To check for stationary I used the ADF test on each of the datasets and found that the 1st dose dataset is not stationary because the test statistics is less than the p-value and the p-value is greater than 0.05, which does not reject the null hypothesis, making it a non stationary data.

Text

Description automatically generated with low confidence

The second dose data was put through the same test, ADF test, and found the test statistics to be less than the p-value and the p-value to be greater than 0.05, not rejecting the null hypothesis thus non-stationary data.

Text

Description automatically generated

The third dataset, after the ADF test, rejected the null hypothesis making it a stationary data, as the p-value was less than 0.05.

Text

Description automatically generated

Another test we need to conduct prior to the ARIMA model, is understand if there are any seasonality trend in the dataset. If so, I would need to convert the data to ensure it is not seasonal. To check for seasonality I used the additive model and found there is no seasonality in any of the datasets. Also we can check for the trend of the dataset at the same time. The visuals below shows the trend and if there are any seasonal trends in each of the datasets.

Chart, line chart

Description automatically generated

Chart

Description automatically generatedTable

Description automatically generated

The first 2 datasets which were non stationary, in order to fit into to the ADF test I need to make sure that it is stationary. In order to make sure the datasets are stationary I first used logarithmic transformation to see if it will transform the data into stationary. Once the logarithmic transformation was conducted I again ran the ADF test to determine if that has resolved the issue of being stationary. The first dose logarithmic transformation dataset still tested as non stationary as the p-value is greater than 0.05, most likely due to small dataset. The second dose logarithmic transformation also turned out to be a failure in rejecting the null hypothesis. It was still stationary.

I conducted the differencing technique on the first 2 datasets to see if that helps with transforming it to stationary and found out differencing it by 1 helped changing it to stationary for both 1st dose and 2nd dose datasets. This was proven by another ADF test conducted on the differenced dataset. They both rejected the null hypothesis this time around hence became a stationary data.

Text

Description automatically generated with medium confidenceText

Description automatically generated with medium confidence

After the datasets are all stationary, I ran the autocorrelation and partial correlation function to measure the association between current and past series values and indicate which past series values are most useful in predicting future values. With this knowledge, I am able to determine the order of processes in the ARIMA model.

The ARIMA model has 3 components, AR, I, and MA. We must input these values as p,k,q into our model for it to compute our results. The “I” value is 0 because our data has been transformed into a stationary data prior and does not require any interval differencing. The “p” value represents the AR term and the “q” value represents the MA term which can both be determined by the Autocorrelation Function(ACF) and Partial Autocorrelation Function(PACF). Once this ACF and PACF has been determined, we can fit the model into the ARIMA model to predict the outcome.

The 1st vaccine dose provides me with the following results.

Table

Description automatically generated

The p value is not less than 0.05 hence the values are not significant.

The 2nd vaccine dataset of the ARIMA provided the following results,

Table

Description automatically generated

With significant values below 0.05, we can conclude they are significant.

Chart, line chart

Description automatically generated

The 2nd dose provided the figure above with prediction in comparison to the expected. With the data being significant, we can conclude the prediction is close enough to determine if the 3rd dose prediction will come to fruition.

The 3rd dose provide with significance as the p-values were below 0.05.

Table

Description automatically generated

And the results of the model were closely aligned to the actual.

Chart, line chart

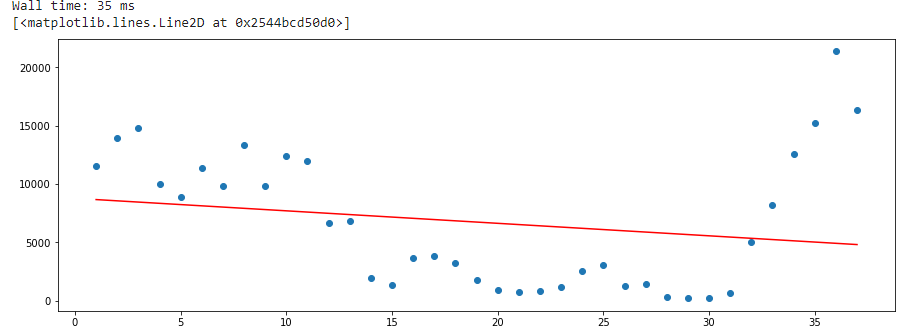
Description automatically generated

I projected the model to forecast for the next 15 days within 95% confidence interval and found this result. We can see that he forecasted vaccine number will not increase hence will not meet the threshold of 85% vaccination status the government has indicated to lift restrictions.

Chart

Description automatically generated

The second model, linear regression compares the slopes of 3 datasets to determine if the rate of change of the dataset helps to determine the prediction of the 3rd dose vaccination status. The same subset data was used for the linear regression, first 53 days of each data, to have a comparable model to the 3rd dose. I split each of the vaccination dataset into test and train dataset, and order it the test set into a chronological order prior to running it through the linear regression function. The first dose test data had a slope of -107, which means there is a negative rate of change in the first 53 days of the first vaccination rate. Although we know there was a spike in vaccination rate starting in March 2021(2 months after the vaccination was available).



You can see from the visualization that towards the end, there was a beginning of upward trend of the vaccination rate. However, the overall relationship is a weak downward trend. When the model is trained, it is resulting in decrease of vaccination rate and we know this is the opposite if used the whole dataset.

The second dose had a slope of positive value of 301 showcasing the vaccination numbers overall has a upward trend. We know for a fact there was a huge spike in vaccination numbers 6 to 7 months after the vaccines were introduced(June & July 2021). The linear regression model on the second dose predicts increase of vaccination rate. As per the visualization below, we can deduce that the linear regression prediction of the 1st dose is inaccurate as it increases until it decreases again. The second dose however provides a positive model, but if we analyze the entire data, and not just the first 53 days, we can see that there is a significant decrease of 2nd dose as well.

Chart, line chart, histogram

Description automatically generated

The third dose has a strong downward trend with a slope of -3983, showcasing a very strong negative trend, and this is also visualized in the above chart. We can conclude, based on the linear model, that the 3rd vaccination rate will continue to have a decreasing trend thus Ontario will not meet the threshold of 85% to lift the restrictions.

# Comparisons

|  |  |  |  |
| --- | --- | --- | --- |
|  | Effective | Efficiency | Stability |
| ARIMA | MAE:8268.74  MSE:156854677.14  RMSE:12524.16 | 127ms | Nan |
| 1st Linear Regression | 33950313.69 | 28ms | -29.19 |
| 2nd Linear Regression | 5918210.54 | 40ms | -2.71 |
| 3rd Linear Regression | 528047010.86 | 263ms | -36.88 |
| Gradient Boost Regressor | 138930456.34 | 59ms | 0.69 |

# Conclusions

The modelling provided that there will not be any increase in vaccination rate for either first, second or the third dosage. The ARIMA provided that there wont be any new increase in vaccination rate hence achieving the desirable 85% vaccination threshold outlined by the Ontario Government. The Linear Regression model has the lowest stability and the longest time to run the model but its effectiveness is worrisome has the mean squared errors are high compared to ARIMA. Gradient Boost Regressor has the highest mean squared error but it’s accuracy is highest compared to other models. Out of the 3, I would use the ARIMA due to the best effectiveness and it doesn’t take too long to run the model.

The Major shortcomings of this study is the restrictions are now lifted, hence no longer do we need the 85% vaccination rate to lift the mandates. Another major flaw is the lack of data as this was the most major shortcoming in this study. I was only able to dissect 1 month of data for the 3rd dose, and to compare this to the 1st and 2nd vaccine data, I had to subset 1st and 2nd vaccine data to only capture 1 month of data as well. This only provide very small sample to fit into the model.

Improvements are needed for this study, such as using larger datasets and producing cross validation results for the ARIMA model. Also, if I had a bigger test set, I would have split the data into training & test to fit into the model instead of using the entire dataset.

# Github Link

https://github.com/ericpark03/CIND820

# References

Akin, D. (2022, January 6). *Analysis: Internal government polling shows sharp shifts in attitudes on Covid-19 - National*. Global News. Retrieved January 18, 2022, from https://globalnews.ca/news/8490966/analysis-internal-government-polls-covid-19-attitudes/

Bricker, D. (2021, December 2021). *Majority (56%) of Canadians support another lockdown to* ... (n.d.). Retrieved February 2, 2022, from [https://www.ipsos.com/en-ca/news-](about:blank) polls/majority-support-another-lockdown-stop-

Davidson, S. (2022, January 27). *Ontario’s top doctor says it’s time to learn to live with COVID-19*. Toronto. https://toronto.ctvnews.ca/ontario-s-top-doctor-says-it-s-time-to-learn-to-live-with-covid-19-1.5757373

Dolgin, E. (2021). Omicron is supercharging the COVID vaccine booster debate. *Nature*, *10*.

‌Draaisma, M. (2021, September 2). *Covid-19 vaccination rate must rise above 85% to avoid fall lockdown, Ontario modelling shows | CBC News. CBCnews.* Retrieved February 2, 2022, from https://www.cbc.ca/news/canada/toronto/ontario-covid-19-vaccination-rate-1.6161726

Farooqui, S. (2022, February 6). *Trucker convoy demonstrations spread across Canada as counter-protests call for an end to disruptions*. The Globe and Mail. Retrieved February 6, 2022, from https://www.theglobeandmail.com/canada/article-trucker-convoy-demonstrators-met-with-counter-protesters-calling-for/

Heidenreich, P. (2022, February 5). *Kenney commits to lifting COVID-19 restrictions as Alberta Highway protests continue*. Global News. Retrieved February 6, 2022, from https://globalnews.ca/news/8594173/kenney-alberta-covid-restrictions-coutts-convoys/

How Ontario is responding to COVID-19. (n.d)*. https://www.ontario.ca/page/how-ontario-is-responding-covid-19*. ontario.ca. (n.d.). Retrieved January 19, 2022, from https://www.ontario.ca/page/how-ontario-is-responding-covid-19

Hu, T., Wang, S., Luo, W., Zhang, M., Huang, X., Yan, Y., Liu, R., Ly, K., Kacker, V., She, B., & Li, Z. (2021, October 9). *Revealing public opinion towards covid-19 vaccines with Twitter data in the United States: Spatiotemporal Perspective.* Journal of Medical Internet Research. Retrieved February 4, 2022, from https://www.jmir.org/2021/9/e30854/

Ontario. (2022). *https://www.ontario.ca/page/how-ontario-is-responding-covid-19*. ontario.ca. (n.d.). Retrieved January 19, 2022, from https://www.ontario.ca/page/how-ontario-is-responding-covid-19

King, W. C., Rubinstein, M., Reinhart, A., & Mejia, R. (2021, September 27). *Covid-19 vaccine hesitancy January-May 2021 among 18–64 year old US adults by employment and occupation*. Preventive Medicine Reports. Retrieved February 6, 2022, from https://www.sciencedirect.com/science/article/pii/S221133552100259X

Public Health Ontario. (n.d.). Retrieved February 2, 2022, from https://www.publichealthontario.ca/en/data-and-analysis/infectious-disease/covid-19-data-surveillance/covid-19-data-tool?tab=summary

Shofiya, C., & Abidi, S. (2021, June 3). *Sentiment analysis on covid-19-related social distancing in Canada using Twitter data*. MDPI. Retrieved February 6, 2022, from https://www.mdpi.com/1660-4601/18/11/5993/htm

Suratnoaji, C. N. (2020, August 31). *Public opinion on lockdown (PSBB) policy in overcoming COVID-19 pandemic in Indonesia: Analysis based on Big Data twitter*. Asian Journal for Public Opinion Research. Retrieved February 4, 2022, from https://www.koreascience.or.kr/article/JAKO202026964745119.page

The Canadian Press, and Lee Berthiaume*. “Coronavirus: Poll Suggests Slim Majority Support Government Lockdowns.” Coronavirus, CTV News, 11 Jan. 2022,* www.ctvnews.ca/health/coronavirus/slim-majority-support-government-lockdowns-restrictions-in-response-to-omicron-poll-1.5735159.

World Health Organization. (2022). Coronavirus disease (COVID-19). World Health Organization. https://www.who.int/health-topics/coronavirus#tab=tab\_1

World Health Organization. (n.d.). Who coronavirus (COVID-19) dashboard. World Health Organization. Retrieved February 3, 2022, from https://covid19.who.int/

Zhang, Q., Li, G. Y., Chen, L.-P., & He, W. (n.d.). *Text mining and sentiment analysis of covid-19 ... - arxiv.org*. Retrieved January 26, 2022, from https://arxiv.org/pdf/2106.15354