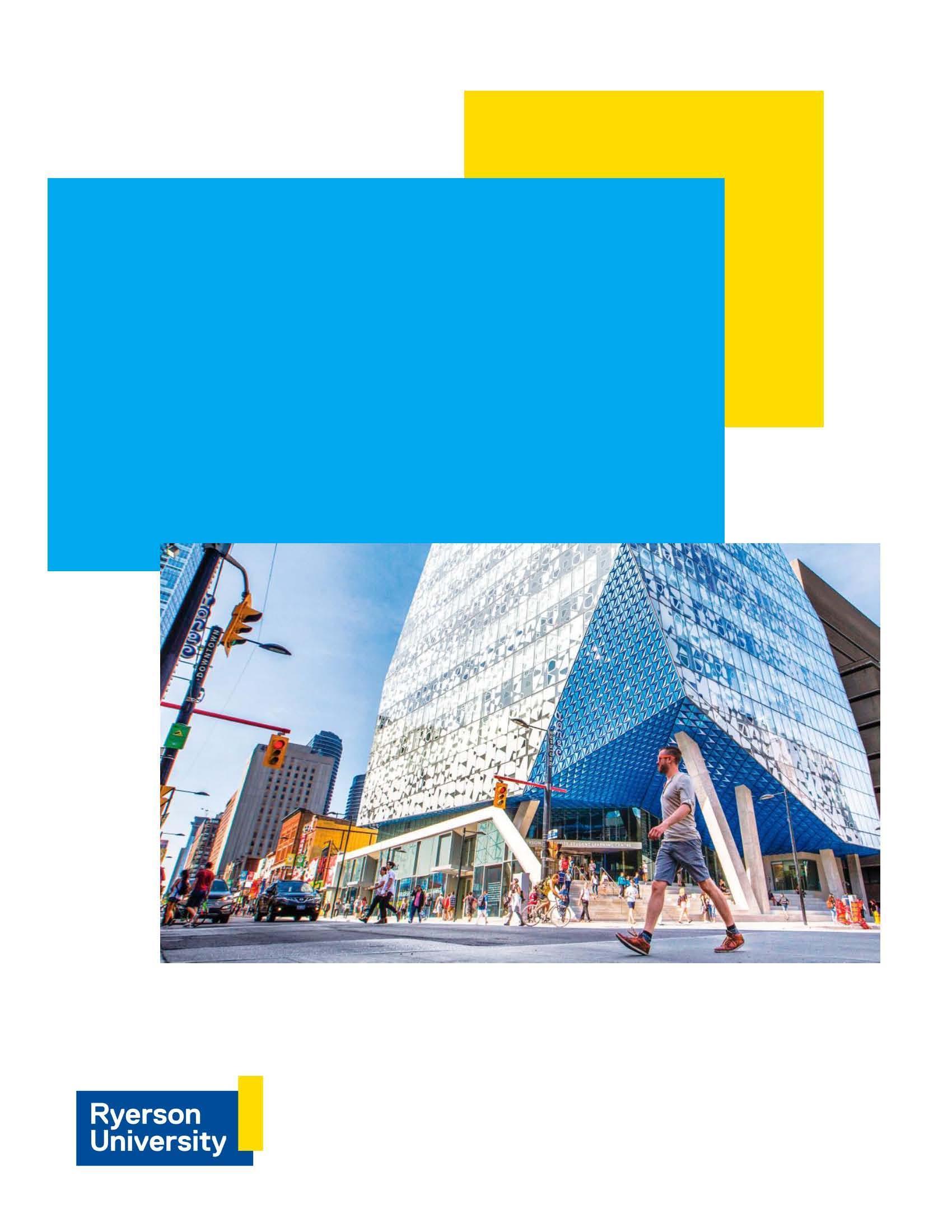
Literature Review

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Date of Submission: February 13, 2022

Date Due: February 14, 2022

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# Revised 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 opinion 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 January 7, 2021 and gets updated on a daily basis with newer number of vaccines being administered. Currently, as newer people might still receive their first & 2nd dosage, I want to use the time series analysis to predict the vaccine rate with decrease public support on the mandates. I also want to predict the possible declining of the 3rd dose using a different method, the regression model. I will be comparing 1 month of data for each dose of vaccine, and compare the slopes to determine the rate of change for each 3 doses to further validate my hypothesis and the problem.

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 27, 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 opinion 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), 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, vader and NRC 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.).

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). Another study 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 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 January 7, 2021 to most recent date, February 27, 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 |

The second data set I have used for this is also collected by Ontario Government, just like the first covid vaccination dataset, but the difference is this dataset provides vaccination information by age group starting from January 7, 2021 to February 27, 2022. Much like the first dataset, this dataset is still updating on a daily basis, however for this study I will use the data to include up to February 7, 2022 information. This second dataset has 10 fields but I will only use 6 fields out of the 10. The 4 fields I will not use are vaccination rate of 1st,2nd and 3rd dose.

| **Data Set** | **Field Name** | **Field Description** | **Data Type** | **Basic Stat** |
| --- | --- | --- | --- | --- |
| Vaccine data by Age | Date | Date the data was reported and entered into CoVax in regards to vaccination | Date | Min: December 16, 2020  Max: February 7, 2022 |
| Vaccine data by Age | AgeGroup | Category of age groups | Ordinal | 12-17yrs: 1  18-29yrs: 2  30-39yrs: 3  40-49yrs: 4  50-59yrs: 5  60-69yrs: 6  70-79yrs: 7  80+: 8  Adults 18+  Ontario 12+ |
| Vaccine data by Age | At least one dose\_cumulative | Aggregate number of people who were administered 1 dose of vaccine | Numeric | Mean:1144686.46  Median:837944.5  Mode:0  Std:1715683.52  Min:0  Max:12492618 |
| Vaccine data by Age | Second dose cumulative | Aggregate number of people who were administered 2nd dose of vaccine | Numeric | Mean:575006.65  Median:122990.5  Mode:0  Std:651718.35  Min:0  Max:1978651.0 |
| Vaccine data by Age | Third dose cumulative | Aggregate number of people who were administered 3rd dose of vaccine | Numeric | Mean:1141812.66  Median:781432.5  Mode:0  Std:1587202.54  Min:0  Max:6604028.0 |

Link to GitHub: https://github.com/ericpark03/CIND820-Descriptive-Stat/blob/main/Descriptive%20Stat.ipynb

# Approach

(Covid Vaccination Data)









First, I downloaded the dataset from the Ontario Open Database site as “xlsx” file, then load it into the Python as a dataframe. I dropped all columns except for the ones I need to use for my study, Date field, individuals with 1 dose, number of people with 2nd dose, and number of people with 3rd dose. After I will conduct descriptive statistics to define, min/max, mean, median, mode, standard deviation of all numeric fields in the dataset. And perform regression/time series analysis to predict the vaccination rate of 3rd dose in the future.

(Vaccination data by Age)







First, downloaded the dataset from the Ontario Open Database site as “xlsx” file, then load it into the Python as a dataframe. I dropped all columns except for the ones I need to use for my study, and removed the rows, Adults\_18plus, Ontario\_12plus, and Undisclosed\_or\_missing, from the dataset.

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