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COVID-19 IMPACT IN CANADA WITH FOCUS ON ONTARIO AND QUEBEC PROVINCES

Business Intelligence - Final Project

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ABSTRACT

This study provides an analytical overview of the COVID-19 pandemic's trajectory in Canada, examining its ramifications across the country. In this study, the focus was on the two biggest provinces of Canada: Ontario and Quebec. We delve into a time series analysis and other relevant data to evaluate the pandemic's impact, considering provincial spread and the ratio of fatalities to total cases. The evolution of the pandemic is scrutinized, particularly in the context of Canadian policy interventions, to assess their effectiveness on case numbers. Additionally, the study explores the disparities in case distribution nationwide, offering insight into the heterogeneous nature of the pandemic's effects.

1. INTRODUCTION

Overview of COVID-19 and its global impact:

The outbreak of COVID-19, caused by coronavirus SARS-CoV-2, marked an unprecedented global health crisis. First identified in Wuhan, the capital of Hubei in China, in late 2019, the virus rapidly spread across the world, leading the World Health Organization (WHO) to declare it a pandemic by March 2020. This global health emergency has had far-reaching implications, affecting every aspect of human life.

The virus's highly infectious nature, together with its ability to cause severe respiratory illness, represented a significant challenge to healthcare systems worldwide. Countries struggled to increase hospital capacities, ensure medical supplies, and develop testing and tracing capabilities. The pandemic also required the development of a vaccine, resulting in several effective vaccines being produced at an unprecedented rhythm.

The socio-economic impact of the pandemic has been deep. Governments worldwide imposed lockdowns and travel restrictions to contain the virus's spread, leading to significant disruptions in global supply chains, businesses, and education systems. Economies faced recessions as consumer spending decreased considerably and unemployment increased. The pandemic also showed the existing inequalities among nations, with vulnerable populations that were highly disadvantaged and had the biggest impact. While in several high-income countries the ratio of total estimated cases and deaths to reported cases and deaths is low and close to 1, in some countries it may be more than 10 or even more than 100. The implementation of covid-19 surveillance methods varies widely.

COVID-19 has reshaped international relations and cooperation. The global crisis highlighted the need for collective action in areas such as vaccine distribution, economic recovery, and addressing climate change, which has been likened to a 'slow-motion pandemic'. The pandemic continues to evolve, with new variants emerging and countries adapting their strategies to balance public health concerns with economic recovery.

As we continue to navigate these challenging times, the lessons learned from the pandemic will undoubtedly shape the future of public health, international cooperation, and global preparedness for similar crises.

The primary **objective** of this study is to conduct a comprehensive analysis of Canada's COVID-19 data. This involves examining the spread of the virus across different regions, understanding the effectiveness of public health measures, and evaluating the impact of the pandemic on the healthcare system and the economy.

2. BACKGROUND

2.1 Situation of Covid-19 in Canada:

The COVID-19 pandemic's trajectory in Canada provides a unique case study. The first confirmed case of COVID-19 in Canada was reported in late January 2020, with the individual having recently returned from Wuhan, China. This initial case marked the beginning of the virus's spread within the country.

In the ensuing weeks, Canada saw a gradual increase in cases, primarily linked to international travel and community transmission. By March, the virus had spread to all provinces, requiring public health measures in all the nation. The spread patterns were initially concentrated in major urban centers like Toronto, Montreal, and Vancouver, which faced significant outbreaks.

Canada's diverse geography and population density played a critical role in the virus's spread. While urban areas experienced rapid case increases, more remote and less densely populated regions saw slower transmission rates. This disparity necessitated region-specific public health strategies.

The pandemic's first wave peaked in May 2020, followed by a more significant second wave in late 2020, driven by community transmission and the emergence of new variants. The second wave saw higher case numbers and increased hospitalizations, highlighting the virus's evolving nature and the challenge of containing its spread.

Throughout the pandemic, Canada's approach to managing COVID-19 has been characterized by a reliance on public health guidelines, regional lockdowns, and a strong emphasis on testing and contact tracing. The country's healthcare system, while strained, managed to adapt and respond to the varying demands of the pandemic, showcasing the resilience and flexibility of Canadian healthcare.

In the picture below, the confirmed deaths per 100.000 population. It was updated on May 19, 2023. As we can see Canada is one of the most affected nations.

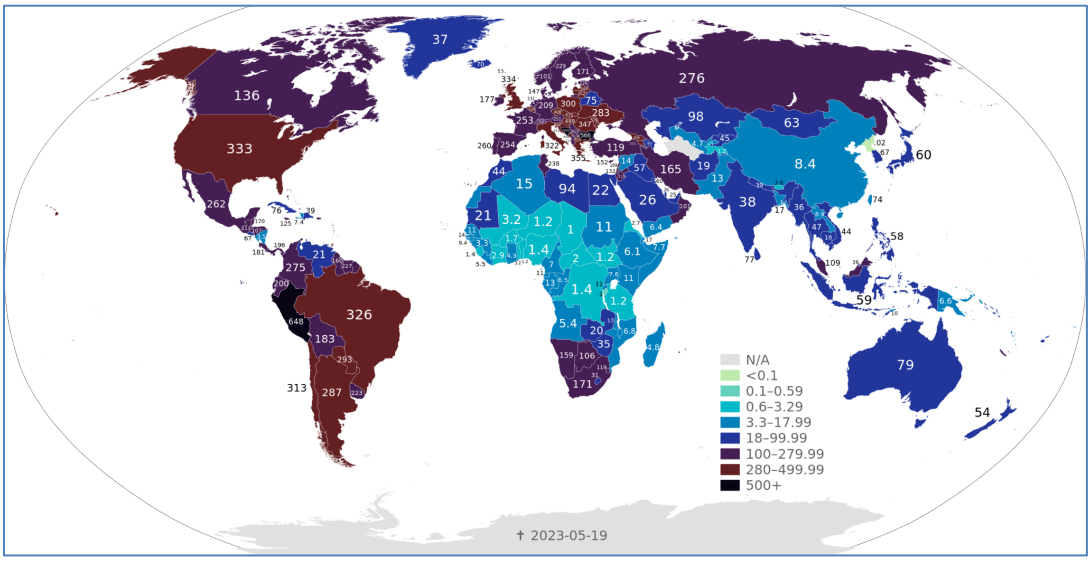

Figure 1: confirmed deaths per 100.000 population

2.2 Government responses: Lockdowns, travel restrictions, healthcare policies

With the aim to depict the whole of Canada's response to COVID-19, several stages will emerge during the path and subsequent policy shifts and adaptations. Initially, the focus was on restricting international travel, this action aimed at limiting the entry of the virus into the country. As the virus began to spread locally, provincial governments, given Canada's federal structure, took the lead in implementing measures tailored to their specific contexts. These included lockdowns, different in strictness and duration, aimed at reducing social interaction and thus the spread of the virus.

The impact of these lockdowns was big since it affected every aspect of daily life, from business operations to personal freedoms. The challenge for governments was in trying to find a balance between controlling the virus's spread and minimizing economic and social disruption. This necessitated a gradual approach, with measures being regularly adjusted in response to changing circumstances.

Considering the healthcare aspect, hospitals and healthcare workers faced unprecedented demands, asking both federal and provincial governments to improve healthcare capacity. Some of the healthcare system necessities were for example: increasing the number of beds, securing necessary equipment, and expanding the workforce. Testing and contact tracing

became fundamental in the healthcare strategy, evolving over time as there was more understanding about the virus.

The economic relapses from the pandemic and the associated public health measures was another critical area of focus. The Canadian government issued various financial aid packages to support individuals and businesses affected by the pandemic. These measures were designed to provide immediate relief to those who lost income due to lockdowns and to stimulate the economy by encouraging spending and investment.

As the pandemic progressed, the strategy shifted towards managing the long-term impacts, including planning for economic recovery and implementing a national vaccination program. The vaccination campaign became a central pillar of Canada's strategy to emerge from the pandemic, with efforts focusing on widespread vaccine distribution and ensuring hesitating people about the vaccine.

Throughout this period, the Canadian government's approach was characterized by a willingness to adapt and learn, constantly modifying policies in response to new information and changing circumstances. The pandemic response in Canada is reflecting the complexity of managing a public health crisis of this scale, requiring a delicate balance between safeguarding public health, maintaining economic stability, and respecting individual freedoms.

3. METHODOLOGY:

3.1 DATA ARCHITECTURE

The data architecture is made up of 7 parts, which can be seen in the chart below. The data was taken from COVID-19 Tracker Canada API, it was extracted using Python (pandas and request libraries in particular) and stored in CSV files. Subsequently, the data was prepared using Alteryx Designer, the process is described in the section below (paragraph 3.3 ‘’Data Preparation’’) and then it was stored in CSV files. The data was explored and visualized using Tableau and in the end, it was used to prepare dashboards.

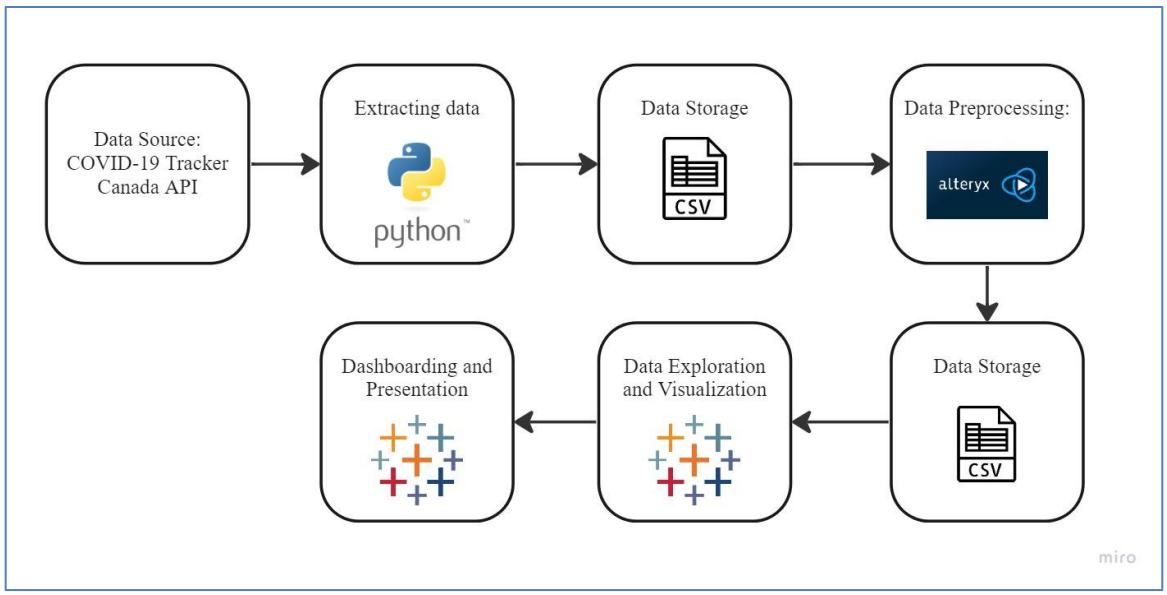

Figure 2: Data Architecture

3.2 THE DATASET

3.2.1 THE DATA SOURCE DESCRIPTION

The COVID-19 Tracker Canada API offers real-time data on the COVID-19 pandemic in Canada. It provides national summaries of cases, fatalities, tests, recoveries, and vaccinations, updated daily. The data is available under the Creative Commons Attribution 4.0 International License, with the API source under the MIT License. This API serves as a vital resource for tracking pandemic trends in Canada. For more detailed information, refer to their official documentation at [COVID-19 Tracker Canada API].

The API can return a range of different data, based on provinces and health regions, and in this project work, certain parts of it were extracted. The Summary data shows the summary of

COVID data based on the latest available information, when the request to make API, which is on December the 6th, 2023. The Provinces data provides information about provinces in Canada, which includes full name, population, area, GDP and other related information. The Report data consists of a day-to-day rolling summary of all statistics at either national level or based on province or health region. The Report data we extracted is the "National level" report, and Report of Ontario and Quebec.

3.2.2. DATA COLLECTION

Five API requests were performed using Python libraries such as Pandas and Requests to access data from the COVID-19 Tracker Canada API. These five requests were: summary based on provinces, information about provinces, general report (based at a national level), report based on Ontario and Quebec provinces.

The data were collected using two URI (Uniform Resource Identifier): /summary/split, /provinces, /reports, /reports/province/on, /reports/province/qc.

The whole list of API can be seen in the Appendix A. The Python code written to extract the data from API and save it as CSV file can be found in Appendix B.

Since the output obtained after sending the request was in Json, it was converted into a CSV file using Python.

File	**Description**	**URI of API request**
Summary based on provinces	Canada COVID-19 data summary.	/summary/split
Information about provinces	List of provinces, including the status of each province	/provinces
General report	Day-to-day rolling summary (timeseries) of all stats at the national level	/reports
Report based on Ontario provinces	Ontario province analyzed in detail	/reports/province/on
Report based on Quebec provinces	Quebec province analyzed in detail	/reports/province/qc

Table 1. five APIs

3.3 DATA PREPARATION

The data structure obtained from the API requests was too complicated and contained too much data, which was not significant. To make the data well structured, some changes were made, obtaining just two CSV files from the five previously had. The whole data preparation is divided into 3 processes: Cleaning, Joining and Output of the data.

During the Cleaning stage the unnecessary data were eliminated, the data types were changed, and the datasets were checked for unique values.

During the Joining stage, the datasets were joined to group the information together for further analysis.

During the Output stage, the final Cleaning was done. During this phase, the dataset was sorted, and the columns were renamed, and, in the end, everything was saved as csv files. The data preprocessing was conducted using Alteryx Designer.

3.3.1 Alteryx Data Cleaning

The whole Preprocessing stage was divided into 2 Alteryx workflows. The First workflow focused on getting together Summary Information based on Provinces, while the second aimed to Preprocess the total report information. Our purpose with the final data is to show COVID information on the National level, and also in Quebec and Ontario provinces especially.

3.3.1.1 Provinces Summary Workflow

The Operators that were used during both of the workflows are similar, since all the data is taken from the same data source and it has similar problems. In the beginning, the 2 csv files were joined: the summary based on provinces, and information about provinces based on province code. Later, the result dataset was checked for duplicates using Unique Operator, and then the data types were changed using Select Operator, only the important ones were chosen for analysis columns, and saved the dataset as csv file.

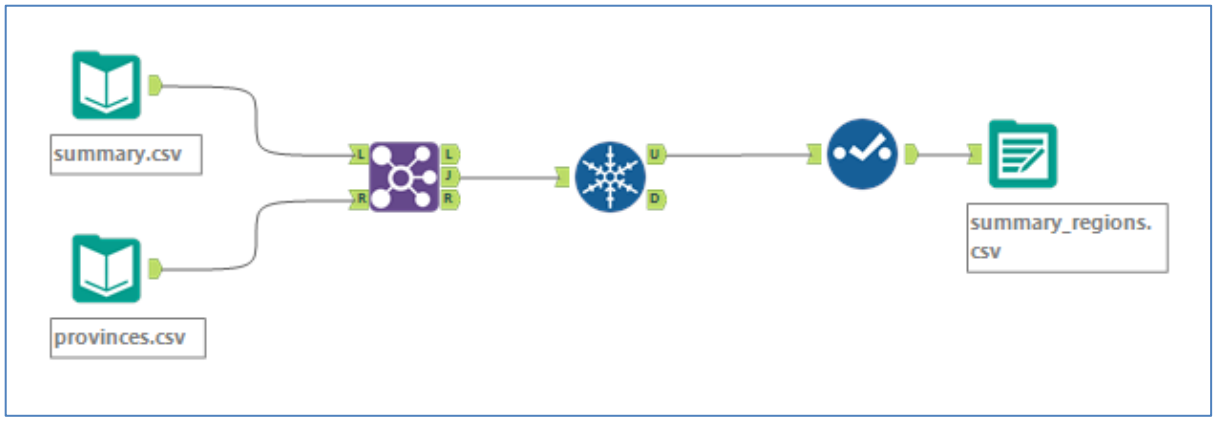

Figure 3: Summary workflow

3.3.1.2 Total Report Workflow

In the second workflow the Report data of Ontario, Quebec and of the National level were processed, in order to later analyze it all together. At the beginning, the reporting datasets were separated, as resulting from the API requests. Using the Unique Operator, duplicates were checked, and then all the unnecessary data was eliminated. Using Select Operator, the data types of the columns were changed. Each of the datasets contained a really huge amount of extensive information, which is not really needed for analysis. For this reason, a range of columns was removed and only the most important data were left. This is described in the dashboard section.

After that, all the datasets together were joined based on the "date" field, and the name of the columns were changed, in order to have a clear vision of the data shown. For instance, the word "Ontario" was added to all Ontario-related columns. Using Sort Operator, the output was sorted by date, in order to have more organized data. After that, the result were saved into a csv file.

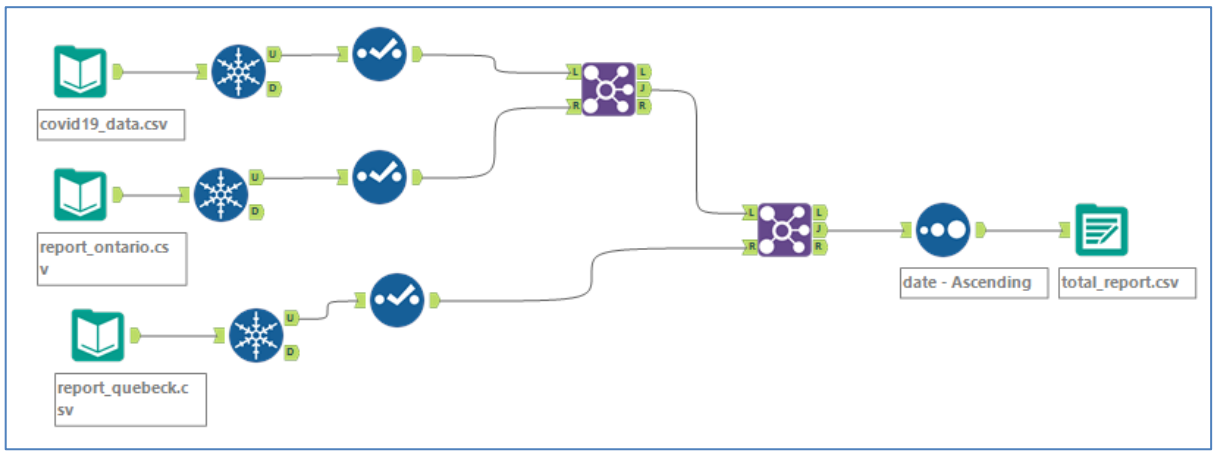

Figure 4: Total report workflow

3.3.2 Data output

The output of Data Preprocessing is 2 datasets, which contain date-dependent and date-independent information - ‘total reports’ and ‘summary regions’.

The 'total reports' dataset is a comprehensive record of COVID-19 statistics for Canada with a particular focus on the provinces of Ontario and Quebec. The dataset contains several columns, each representing different aspects of the COVID-19 data. Here's a breakdown of what each column represents:

Variable	Description
Date	The recorded date for data entry
Total Cases	Confirmed COVID-19 cases nationally
Total Fatalities	Deaths due to COVID-19 nationally
Total Tests	COVID-19 tests conducted nationally
Total Criticals	Critical COVID-19 cases nationally
Total Recoveries	Individuals recovered from COVID-19 nationally
Total Vaccinations	COVID-19 vaccine doses administered nationally
Ontario Total Cases	Confirmed COVID-19 cases in Ontario
Ontario Total Fatalities	Deaths due to COVID-19 in Ontario
Ontario Total Tests	COVID-19 tests conducted in Ontario
Ontario Total Criticals	Critical COVID-19 cases in Ontario
Ontario Total Recoveries	Individuals recovered from COVID-19 in Ontario
Ontario Total Vaccinations	COVID-19 vaccine doses administered in Ontario
Quebec Total Cases	Confirmed COVID-19 cases in Quebec
Quebec Total Fatalities	Deaths due to COVID-19 in Quebec
Quebec Total Tests	COVID-19 tests conducted in Quebec
Quebec Total Criticals	Critical COVID-19 cases in Quebec
Quebec Total Recoveries	Individuals recovered from COVID-19 in Quebec
Quebec Total Vaccinations	COVID-19 vaccine doses administered in Quebec

Table 2. Variables of total_report.csv

The dataset likely serves as a means to monitor the progress and impact of the COVID-19 pandemic over time in Canada, with particular attention to its two largest provinces by population, allowing for regional analysis as well as national. It can be used to identify trends, assess the effectiveness of public health interventions, and guide policy decisions.

The ‘summary regions’ dataset gives the last updated data related to COVID-19 about all the provinces. It also provides information about provinces, such as population and area. Here's a breakdown of what each column represents:

Variable	Description
Province	Abbreviation for the province or territory
Name	Full name of the province or territory
Population	Total population of the province or territory
Area	Total land area of the province or territory in square kilometers
Density	Population density (population divided by land area)
Total Cases	Cumulative number of confirmed COVID-19 cases
Total Fatalities	Cumulative number of deaths due to COVID-19
Total Tests	Total number of COVID-19 tests conducted
Total Criticals	Total number of critical COVID-19 cases
Total Recoveries	Total number of individuals recovered from COVID-19
Total Vaccinations	Total number of COVID-19 vaccine doses administered

Table 3. Variables of summary_regions.csv

3.4 DATA VISUALIZATION

In response to the COVID-19 pandemic, two interactive dashboards have been designed in order to present a comprehensive view of the evolving situation in Canada. The first dashboard provides a general overview of the country's COVID-19 statistics, capturing the national trajectory of the virus through the main key metrics. This high-level perspective is crucial for understanding the overall impact of the pandemic across the nation and for making comparisons with global data.

The second dashboard provides a more granular analysis, with a specific focus on the provinces of Ontario and Quebec. These provinces are of particular interest due to their significant and consistent number of COVID-19 cases, which warrant closer examination. Ontario and Quebec are the most populous provinces in Canada, and they have been central to the country's response to the pandemic. Together, they constitute a substantial proportion of the national case count, and trends within these provinces can often indicate broader patterns relevant to public health strategies.

Ontario, as Canada's most populous province and home to its largest city, Toronto, has been a focal point for monitoring the spread of COVID-19. Its dense urban centers, significant

international travel hubs, and diverse population make it a critical region for tracking the transmission dynamics of the virus.

Quebec, with its own densely populated areas, including Montreal, has faced unique challenges in managing COVID-19 cases. The province's distinct cultural and linguistic characteristics, along with its specific health system structure, add complexity to the public health response and the interpretation of data.

The dashboard facilitates a deeper understanding of regional differences in the spread of COVID-19, the effectiveness of interventions, and the progress of vaccination efforts. Users can interact with the dashboard to extract tailored insights, observe patterns over time, and make informed decisions based on the latest available data.

The two dashboards complement each other, with the first offering a national summary and the second providing in-depth regional analysis, thereby painting a full picture of the pandemic's footprint in Canada. The data-driven approach of these dashboards ensures that decisions and discussions about the pandemic response are grounded in solid evidence, reflecting both the shared and unique experiences of different regions in the country.

The Tableau dashboard we have presented offers a multi-faceted visual representation of the Canadian landscape during COVID-19 pandemic, including a breadth of data through various graphical elements. The dashboard is not merely a collection of statistics; it is a narrative told in numbers and colors, allowing the observer to comprehend the pandemic's impact on a national scale while providing the granularity needed to discern provincial nuances.

Central to the dashboard are two key metrics, presented in a clear way: the average number of COVID-19 cases and fatalities per thousand individuals. These metrics give a clear overview of the virus's impact and lethality, showing its impact on the population. By expressing the data per thousand, the dashboard achieves a normalization of scale, allowing for a comparative analysis that doesn’t consider the population size and density.

Below this, the choropleth map of Canada emerges as a visual element, its purpose twofold. Firstly, it provides a geographical context to the numbers, grounding them in the familiar shape of the nation. Secondly, and perhaps more critically, it employs color to convey the burden of cases across the provinces. The shading of each province corresponds to the total number of cases it provinces, with darker hues indicating a heavier caseload.

Complementing the map is a bar chart depicting the percentage of positive tests across the provinces. This metric, often overlooked in public discourse, sheds light on the testing efficacy and the virus's penetration within communities. The bar chart ranks the provinces, where the

stakes are the health of their populations. The vertical axis, quantifying the positivity rate, is showing us how ‘Northwest territories’ it’s experiencing a critical situation.

The second dashboard provides a visual representation of COVID-19 general statistics specifically for Ontario and Quebec provinces, with the most recent update on June 12, 2023. The dashboard is comprised of several components designed to offer insights into the pandemic's metrics within these two populous regions.

At the top, there is a straightforward presentation of vaccination and testing figures. The total number of vaccinations administered in Ontario and Quebec are displayed side by side, providing a direct comparison between the two provinces' vaccination efforts. Similarly, the total number of tests conducted in each province is also presented, offering a sense of the scale of testing relative to the spread of the virus.

Central to the dashboard is a line graph titled "Changes of Total Cases over time," which tracks the trajectory of total COVID-19 cases in both Ontario and Quebec over a multi-year period. The lines for each province are color-coded, enabling a clear distinction between the two and allowing for an easy comparison of trends over time. This temporal view illustrates the evolution of the case counts, potentially reflecting the effects of public health measures, seasonal variations, and other factors influencing the pandemic's progression.

Beside the line graph is a bar chart that compares the fatality percentage of COVID-19 cases in Ontario and Quebec to the total fatality rate, year by year. The bars are color-coordinated in the same scheme as the line graph, maintaining a visual consistency that facilitates intuitive understanding. This chart offers a perspective on the severity of the pandemic in terms of mortality within the two provinces, compared to the overall fatality rate.

Together, these visual elements create a comprehensive overview of the COVID-19 situation in Ontario and Quebec, emphasizing the dynamic nature of the pandemic and the response efforts undertaken by each province. The dashboard is designed to be informative, providing a detailed breakdown of critical data points that can inform public understanding and policy decisions.

The following figures present the two dashboards designed.

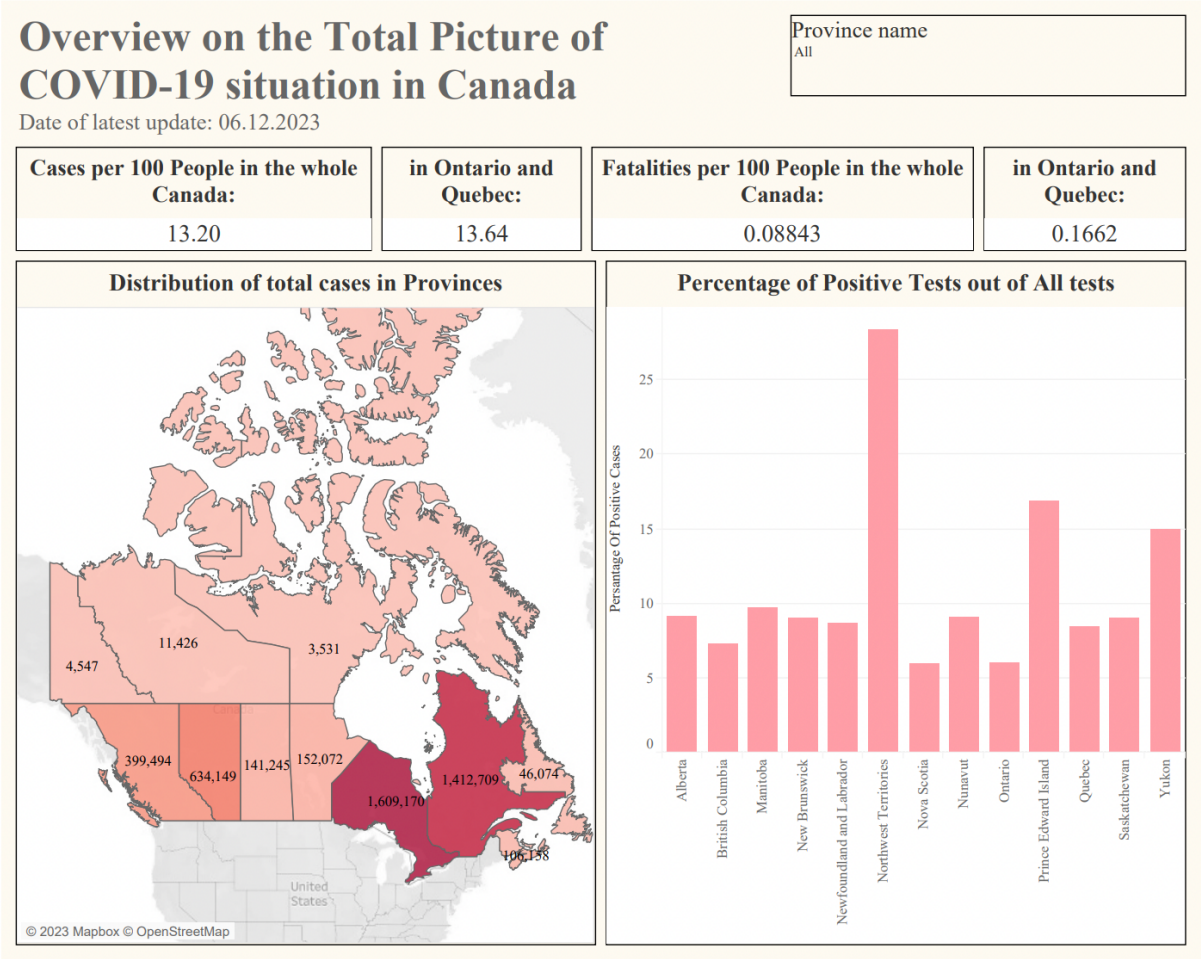

Figure 5: Dashboard 1 - Overview of the total picture of COVID-19 situation in Canada

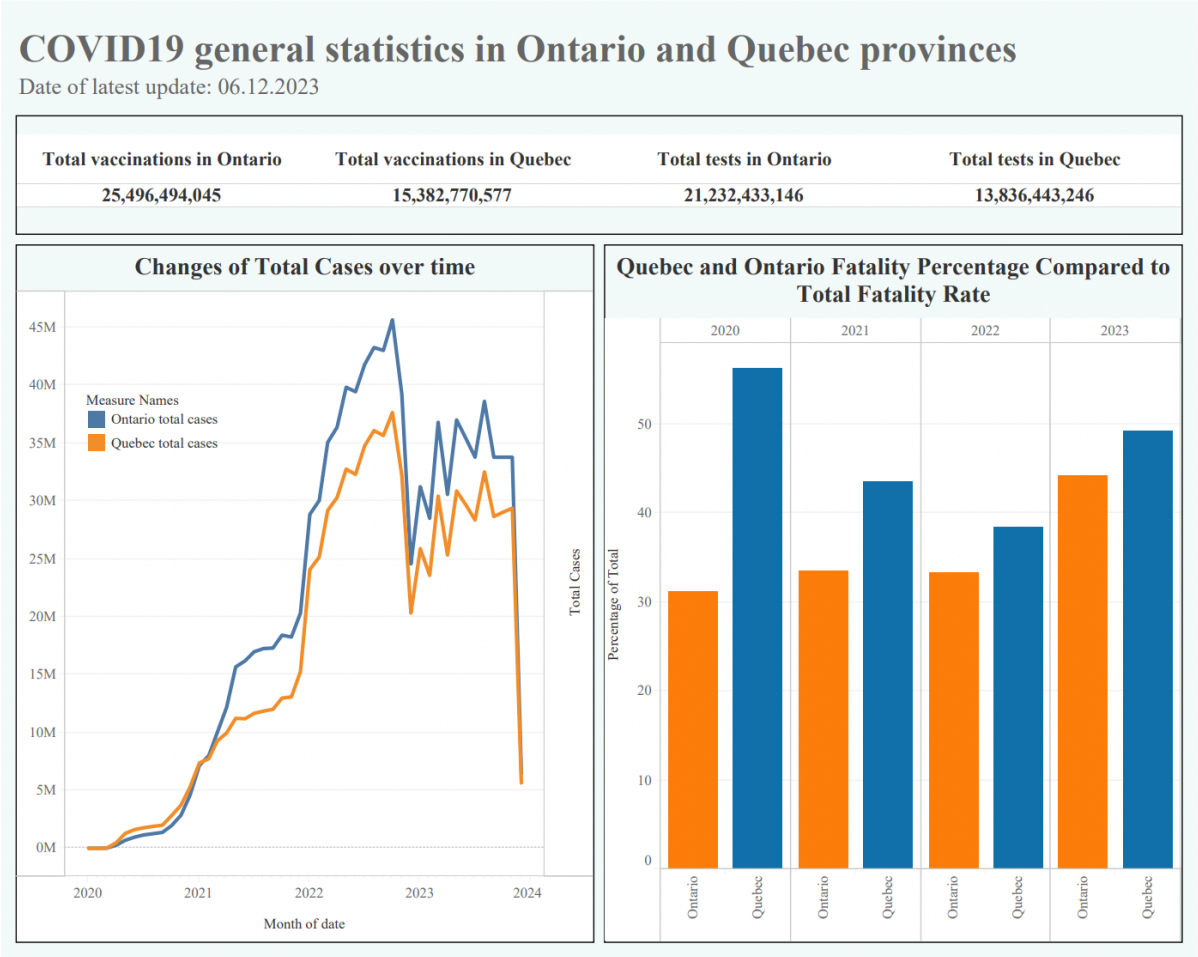

Figure 6: Dashboard 2 - COVID-19 general statistics in Ontario and Quebec provinces

3.5 Calculations

In the quantitative assessment of the COVID-19 impact across Canada, this study meticulously derived proportions from the dataset columns: *total_cases*, *total_tests*, and *total_fatalities*. The calculated metric of total cases per 100 individuals provided a proportionate representation of the infection's reach into the Canadian populace, offering a standardized metric to gauge the spread of the virus against the backdrop of the national population count. Similarly, the study computed the grim statistic of fatalities per 100 individuals, laying bare the mortality impact in a manner that directly relates to the population at large.

The analytical rigor extended to a province-wise examination, where the positivity rate — the proportion of total_cases out of the total_tests — was determined for each region. This ratio not only signifies the prevalence of the virus but also reflects the scope and scale of testing efforts across the provinces. The contrast in positivity rates across regions underscores the

variable nature of the pandemic's imprint, with each percentage point painting part of a broader epidemiological picture.

These proportions — cases and fatalities per 100 individuals, and the positivity rates — provide a multifaceted view of the pandemic's dimensions, revealing the nuances of its evolution and the heterogeneous responses it has elicited across the Canadian landscape.

Equation:

$$Percentage\ of\ positivity = \frac{total\ cases * 100}{total\ tests}$$

4. RESULTS AND CONCLUSIONS

The first Tableau dashboard, titled "Overview on the Total Picture of COVID-19 situation in Canada," updated as of December 6, 2023, provides an incisive snapshot into the state of the pandemic across Canada, with a particular focus on case and fatality rates. Across the whole of Canada, the case rate stands at 13.20 per 100 people, while the provinces of Ontario and Quebec have a slightly higher case rate of 13.64 per 100 people. The fatality rates reflect a more pronounced difference: for the whole country, the rate is 0.08843 per 100 people, which escalates to 0.1662 per 100 people when focusing on Ontario and Quebec. This suggests that the burden of severe outcomes may be more concentrated in these two provinces.

A choropleth map detailing the distribution of total cases across provinces underscores the regional disparities in case numbers. Ontario and Quebec are noticeably darker than other regions, indicating a higher concentration of reported cases. The specific case numbers are labeled on the provinces, with Quebec reporting 1,412,709 cases, which is notable in comparison to its national counterpart, Ontario, showing 1,609,170 cases. This visual representation provides a clear geographical distribution of the pandemic's impact within the country.

Complementing the geographical distribution, a bar chart illustrates the percentage of positive tests out of all tests conducted by province. The chart reveals significant variation across provinces, with Quebec showing a notably higher percentage of positive tests compared to other regions, suggesting either a higher transmission rate or possibly more targeted testing practices. This variability is critical for understanding the effectiveness of testing strategies and the actual spread of the virus within communities across Canada.

The second Tableau dashboard presents a detailed comparative analysis of COVID-19 statistics for the provinces of Ontario and Quebec, highlighting key outcomes in the progression of the pandemic. As of the latest update on June 12, 2023, Ontario has administered a total of 25,496,494,045 vaccinations, while Quebec has administered 15,382,770,577, reflecting a substantial public health response to the pandemic in terms of vaccine rollout.
When examining the total number of tests conducted, Ontario reported a higher figure, amounting to 21,232,433,146 tests, as compared to Quebec's 13,836,443,246 tests. This

disparity in testing numbers could be indicative of the differences in population size, health policy, and the response strategies employed by the two provinces.

The temporal analysis of total cases over time, as depicted in the line graph, shows a sharp increase in cases for both provinces at the onset of the pandemic, followed by fluctuations that appear to align with the waves of COVID-19 infections that have been observed globally. Notably, both Ontario and Quebec exhibit a peak in cases, with Ontario's cases reaching approximately 45 million, slightly higher than Quebec's peak, before a subsequent decline. The graph also reflects a certain degree of synchrony in the trends between the two provinces, suggesting similar patterns of transmission and possibly interconnected epidemiological dynamics.

The bar chart illustrating the Quebec and Ontario fatality percentage compared to the total fatality rate captures the annual distribution of fatalities from 2020 through to 2023. It is observed that Ontario's percentage of total fatalities was consistently higher than Quebec's in the years 2020 and 2021. However, in 2022 and 2023, Quebec's fatality percentage surpassed that of Ontario, possibly indicating a shift in the pandemic's impact or variations in the provinces' healthcare system effectiveness over time.

These results underscore the importance of regional data analysis in understanding the multifaceted nature of the COVID-19 pandemic. The temporal and quantitative insights provided by the dashboard support a nuanced interpretation of the pandemic's trajectory, the effectiveness of public health interventions, and the critical role of sustained testing and vaccination programs.

APPENDIX

A) List of all API requests made for project work:

1. https://api.covid19tracker.ca/reports
2. https://api.covid19tracker.ca/reports/province/on
3. https://api.covid19tracker.ca/reports/province/qc
4. https://api.covid19tracker.ca/summary/split
5. https://api.covid19tracker.ca/provinces

B) Python code used to make an API request and save the data as csv file (was the same for all API requests, the only difference is url):

```
import requests
import pandas as pd

# API URL
api_url = "https://api.covid19tracker.ca/reports"

# Make a request to the API
response = requests.get(api_url)

if response.status_code == 200:
    # Convert JSON data to a DataFrame
    data = response.json()
    df = pd.json_normalize(data, 'data')

    # Save the DataFrame to a CSV file
    df.to_csv('covid19_data.csv', index=False)
else:
    print("Failed to fetch data from the API")
```

Table index:

Picture index:

REFERENCES:

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