CSC110 Project Report:
Power of the Media: Correlational Analysis of Immunization Rates to Vaccine Media Representation

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December 13, 2021

Problem Description and Research Question

Vaccines have been an important topic in the COVID-19 pandemic, more specifically the push for a safe vaccine and a widely vaccinated population has been a goal for many countries. However, as statistical data shows (Ritchie et al., 2020), not all populations are vaccinated equally. While a lack of access to vaccines may account for these differences in second or third world countries, it does not explain the variability that we see in first world countries. Take the USA and Canada for example. In Canada, 78% of the population is partially or fully vaccinated with 74% of the population being fully vaccinated. Compare this to the United States where 66% of the population is partially or fully vaccinated with only 57% of the population being fully vaccinated. The USA produces vaccines and is in no shortage of them. In fact, Canada purchases its vaccines from the United States, so what could be causing these differences in vaccination?

Information on the vaccine is not hard to come by as although it is a pandemic, informed medical consent is still needed for vaccination in Canada. However, not all of this information is viewed equally. The average person may not have the time or knowledge to read a scientific paper on the various side effects of a vaccine or make an informed decision based on the foreign concoction of words listed on the ingredients for a Pfizer-BioNTech COVID-19 Vaccine (CDC, 2021). As a result, much information on COVID-19 vaccines is consumed second-hand through a variety of news sources. These news sources report on a wide variety of topics relating to the COVID-19 vaccine, each with their own, often political, perspective. Furthermore, these perspectives do not always paint the COVID-19 vaccines in a positive light. If a person were to see an interview of a top medical official urging citizens to get vaccinated (Osman, 2021), they may feel more inclined to be vaccinated. However, perhaps another person in the same country sees an article on the issue of potential blood clots in AstraZeneca vaccines (Tasker, 2021). This person may decide to hold off on getting vaccinated.

For our CSC110 project, we would like to use our learned knowledge of Computer Science to answer this Sociological/Psychological question of **whether the consumption of the varying media reports on the COVID 19 vaccine has any correclation with the vaccination rate of a country?**

Dataset Description

Our project consists of two categories of datasets. For the first dataset, we accumulated news articles in a text format from numerous popular media sources around the world, namely: The National Post, Toronto Star, and Vancouver Sun from Canada and CNN, Politico, and Fox News from the US. The National Post, Toronto Star and Vancouver Sun have daily circulation averages of over 130,000 each, for a total daily average circulation of over 640,000 across the three sources (Daily Newspaper Circulation Report 2015, 2015). CNN ("CNN Worldwide Fact Sheet," 2021), Politico ("Politico Fast Facts," 2018), and Fox News' online editions have at least 26 million unique visitors monthly ("FOX News Digital Claims Number One Spot in Multiplatform Minutes and Multiplatform Views During July," 2021), for a total of 314 million unique visitors across the three sources. These articles present varying views on the topic of immunization and are widely read. We collected one article from each source from December 2020 to December 2021 to use as our dataset.

For the second dataset, we collected global immunization data from Our World in Data, a non-profit organization whose COVID-19 datasets compile official numbers published by governments and health ministries worldwide. Through this organization, we have open access to CSV files containing statistics on total vaccinations, people vaccinated, and people fully vaccinated by date per country for hundreds of countries around the world. The Total

Vaccinations metric is a cumulative count of the total number of doses administered by a certain date; People Vaccinated is the cumulative count of people vaccinated with at least one dose (it does not increase when a partially vaccinated person receives another dose); People Fully Vaccinated is cumulative total of people who received all doses prescribed by vaccination protocol. For Canada, these statistics come from COVID-19 Tracker Canada (https://covid19tracker.ca/vaccinationtracker.html. For the US, the data set comes statistics published in America's Centers for Disease Control and Prevention website (COVID-19 Vaccination Trends in the United States,National and Jurisdictional — Data — Centers for Disease Control and Prevention (cdc.gov)).

Computational Plan

For our project, we extracted text from articles from different countries and parsed through them to perform sentiment analysis and compared the results to the vaccination rate of the country using graphical representation.

First, we extracted the textual data of various articles related to COVID-19 vaccinations from the news sources mentioned above using the Scrapy library. In our project, we used the Scrapy library to extract the headline, date, and body text from each news article and saved it as a CSV file to perform sentiment analysis on. Scrapy is an application framework for extracting structured data from websites. Scrapy uses the class Spider which stores a list of URLs in the variable start_urls and defines the function parse(). This function 'crawls' through each URL in start_urls and is able to extract certain parts of the text and create a CSV file to store it in. This helps us extract the article texts in a readable format that we can then run our sentiment analysis program on. Without a library such as this, we would have to sort through each article manually as well as judge these articles ourselves which may lead to inconsistencies.

We then transferred each article from a CSV file to an Article dataclass that kept track of the articles title, date, and text. These articles were then computed using our VaderSentiment class which utilizes the vaderSentiment python library to calculate the articles compound sentiment score as well as the positive, negative, and neutral ratio. The neutral score tells us to what degree the text is polarizing or emotional. This allows us to figure out if an article is more objective (news report) or subjective (opinion article).

After that, we programmed a sentiment analysis algorithm that analyzes each article's text and computes an average sentiment value for the article based on the presence of specific keywords that represent the article's overall view on COVID-19 vaccines. We created our own lexicon for the sentiment analysis algorithm, based on common terms found in news articles implying support or opposition in the context of the COVID-19 vaccines. For example, although the term 'conspiracy theories' is usually negative in connotation, we assigned it a positive value as articles that use this term are often against anti-vaccine groups, implying support for the vaccine. Utilizing this algorithm and the neutral score we are able to quantify to what degree an article is in support of the Covid Vaccine.

Once we compiled a dataset of the average sentiment towards vaccines in the media by month for each country, we plotted a dual-axis line chart with two graphs for each country. One graph is of the vaccination rate of the country over time while the other is of the average sentiment towards vaccines in the media in the country over the same time period. We used the Plotly library to display the graphs, with time as the x-axis, the vaccination rate as the first y-axis, and the average sentiment towards vaccines as the second y-axis.

Using the Python CSV library, we were able to write code to read, write and edit the CSV files containing our data. Using the csv.reader() and csv.writer() functions, we were able to create Writer and Reader objects to enable csv file manipulation (with the writerows() and reader() functions). Using the Pandas and Plotly Express libraries together, our graph-plotting functions can transform csv files into dataframes that Plotly can plot into line graphs and bar graphs.

After cleaning the raw CSV files in `clean_raw_csv` so that the columns of the raw Canada and United States data sets match, the total_vaccinations, poeple_vaccinated, and people_fully_vaccinated metrics can be graphed with `vacc_plot_bar` using Plotly Express's bar() function. Since we want to determine whether there is a correlation between vaccine media representation and people's willingness to get vaccinated, we calculate the daily percent change of the three vaccination metrics in `raw_data_reader_per_day` which outputs the data in a list of lists - with each list representing a row and each element representing a column. The formula we use to calculate percent change is $\frac{\text{count on day 2}}{\text{count on day 1}} - 1.0$. Since the percent growth from a metric of '0' people/vaccinations to a larger count is undefined, the initial days with vaccination/people counts of 0 are omitted. This manipulated data is transformed from a nested list table to a csv file in `csv_writer` which is then graphed into a line graph in `vacc_plot_line` with the Plotly Express line() function. The VADER sentiment analysis data dictionaries (`canada_average_cvac`, `usa_average_cvac`) and the vaccine sentiment analysis data dictionaries `canada_average_compound`, etc...) are transformed into csv files through `vader_dict_to_csv` and `vaccine_dict_to_csv` respectively. These functions use list.append() and list.sort() to transform the dictionary to the desired nested list table format, and then CSV's writerows() function to transform

the data into a csv file. These files can then be graphed using Pandas's read_csv() function and Plotly Express's line() function.

In total, the data analysis code creates 7 new CSV files in the file directory and plots 7 interactive graphs in the computer's default browser. The scale of each graph can be adjusted in the browser (to zoom in and out) and hovering over bars or lines shows precise data points.

Instructions

Required Files and Libraries:

Installing Pandas: In Pycharm, access the terminal (Alt+F12 or View ¿ Tool Windows ¿ Terminal) and then install Pandas with `pip install pandas`. https://pandas.pydata.org/docs/getting_started/install.html

Installing Scrapy: In Pycharm, access the terminal (Alt+F12 or View ¿ Tool Windows ¿ Terminal) and then install Pandas with `pip install scrapy`. https://docs.scrapy.org/en/latest/intro/install.html

Installing vaderSentiment: In Pycharm, access the terminal (Alt+F12 or View ¿ Tool Windows ¿ Terminal) and then install Pandas with `pip install vaderSentiment`. https://github.com/cjhutto/vaderSentiment

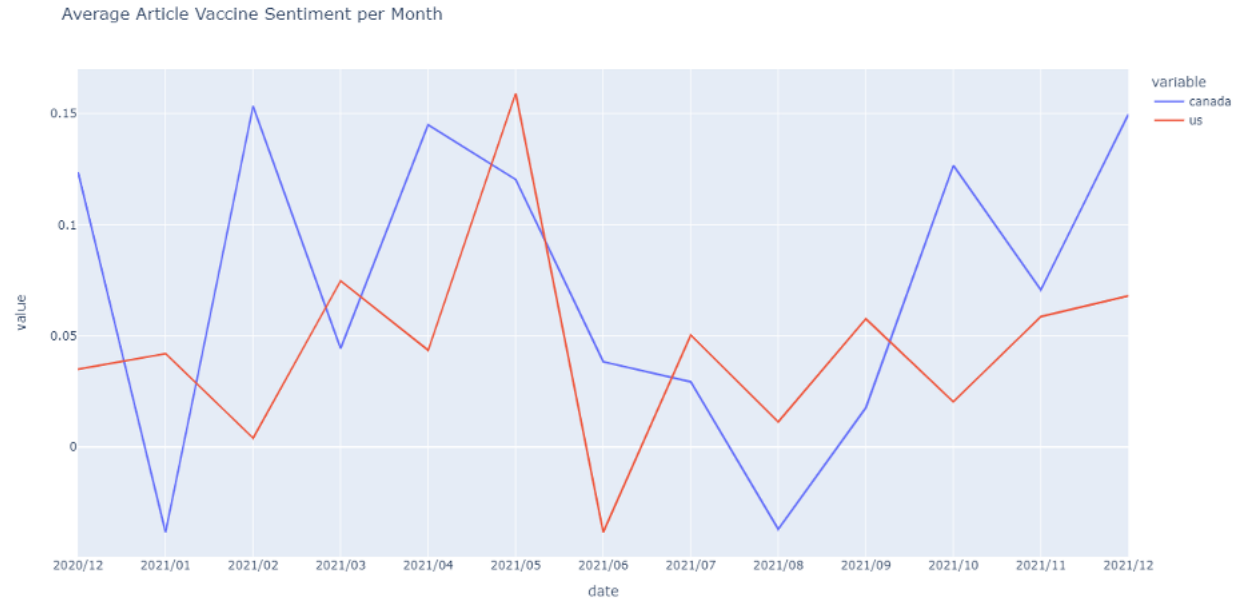
Installing Plotly: In Pycharm, access the terminal (Alt+F12 or View ¿ Tool Windows ¿ Terminal) and then install Pandas with `pip install plotly`. https://plotly.com/python/getting-started/

Download the vaccine datasets: For Canada: https://github.com/owid/covid-19-data/blob/master/public/data/vaccinations/country_data/Canada.csv (click 'Raw" and then 'Save As' into the project folder) Make sure to save the csv file in the project directory and ensure that it is named 'Canada.csv'.

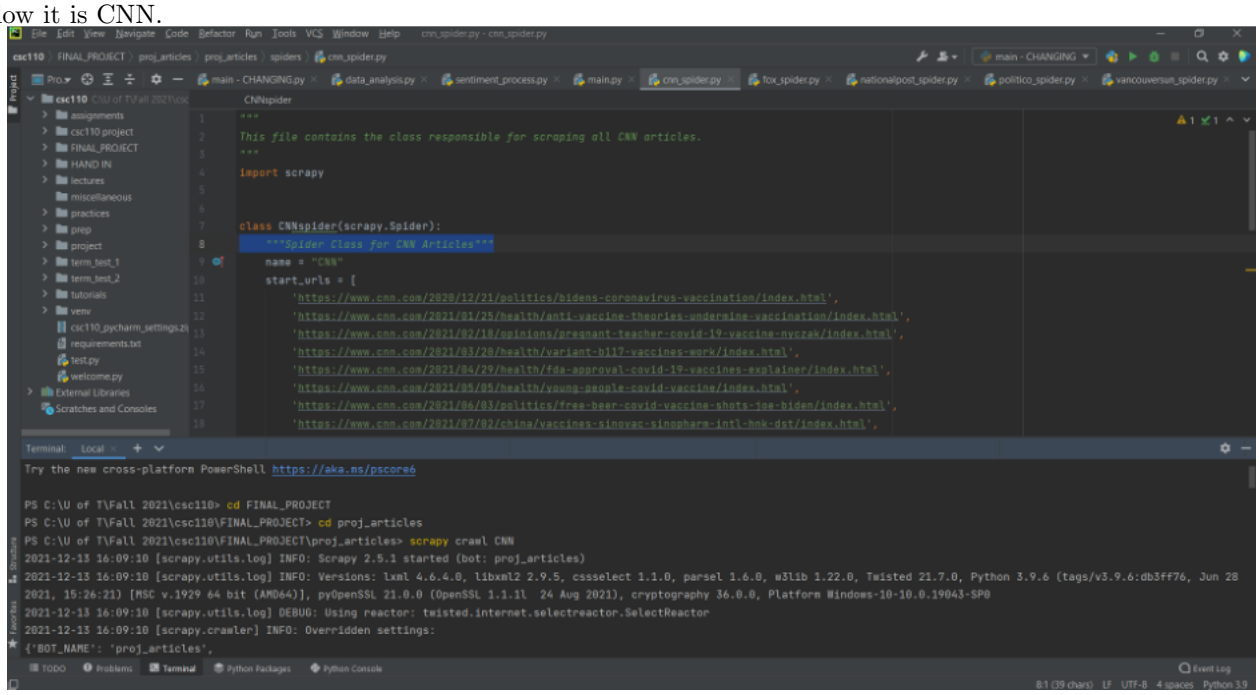
For the United States: https://github.com/owid/covid-19-data/blob/master/public/data/vaccinations/ country_data/UnitedMake sure to save the csv file in the project directory and ensure that it is named 'United States.csv'

TO RUN MAIN.PY ALL CSV FILES MUST BE IN THE SAME DIRECTORY. This includes all the articles and the 2 two vaccine data sets ('United States.csv' and 'Canada.csv'). If for any reason the above do not work this link should have a copy of all required files (files in "VACCINE DATA" and "PROCESSED ARTICLES" must be moved to same directory as 'main.py': https://drive.google.com/drive/folders/1kGCbNRu-09Kza7VZ6K1_aHI646LSiLyy?usp=sharing

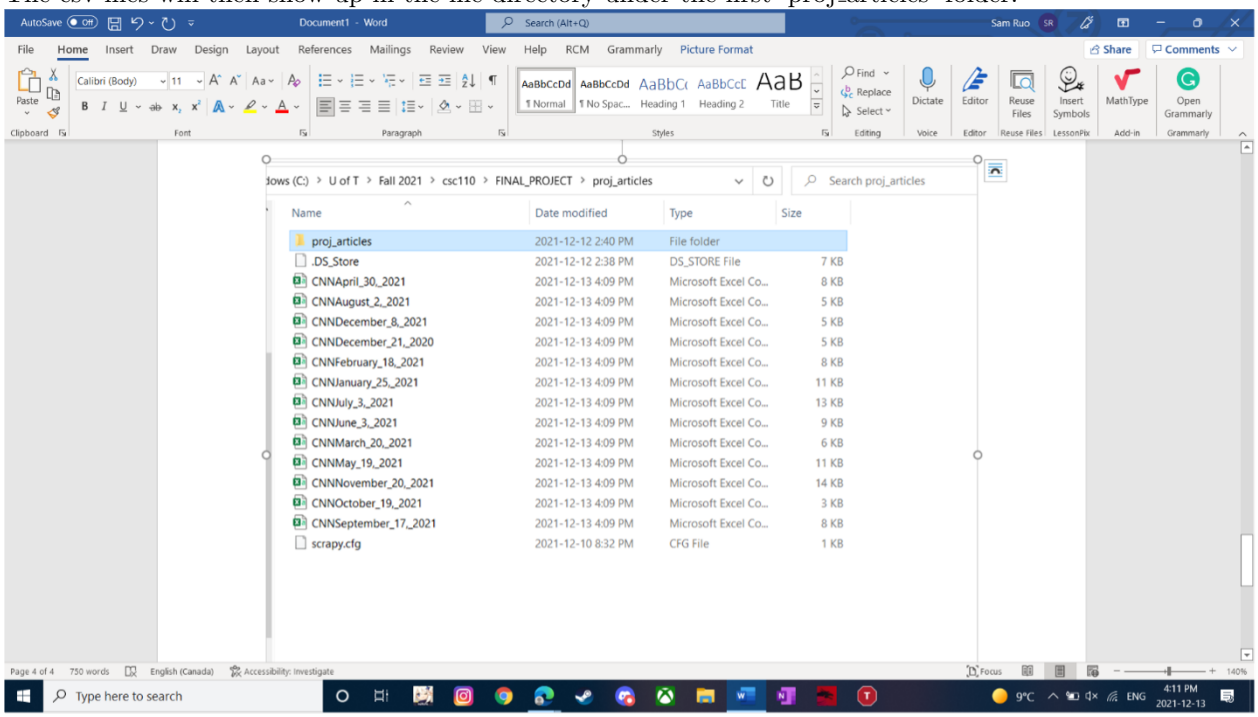
Running 'main.py' should yield the 7 graphs discussed in the computation plan. These graphs should open automatically in a web browser. An 'html' file for each graph will also show up in the same directory which can be used to access the graphs if they do not automatically show up. Each graph is interactive and the tools to do so are located in the top right of the page. Zoom allows you to create a box on the graph to zoom in. This may allow the user to see changes in the graphs that are hard to see with the original scale. 'Reset axes' allows the user to return to the original scale. Other tools include box select, lasso select, pan, zoom in/out, auto scale, and downloading the graphs as a 'PNG'.



The file (main.py) may take a moment to run however the user should be shown what percentage the file is done loading in the console. When the file is done running the console should also display a prompt to look in the browser for the graphs. The console will also display all the titles and dates of the articles, as well as their corresponding list locations. Finally, the console will also display an example call to 'sp.VaderSentiment().fullanalysis()' and 'sp.covid_vac_sentiment()' using the first article in the list canada_articles. Each section of the code has been separated and labeled to show what each part is doing. Scrapy is not used in 'main.py' as we are not able to access and run it as a function. This is why the articles must be downloaded separately. To see how we utilized web scraping in this project first go to 'spiders' folder located in the 'proj_articles' folder which is within another folder called 'proj_articles'. In the file click any of the 'x_spider.py' files. To run the file, open the python terminal, then type 'cd *folder_name*' wherever the route directory is located, in the example below this name is 'FINAL_PROJECT'. Then type 'cd proj_articles'. Finally, type scrapy crawl x, where x is the name of the spider class, in the example below it is CNN.



The csv files will then show up in the file directory under the first 'proj_articles' folder.



Changes

In our proposal, our research question was "whether the consumption of the varying media reports on the COVID 19 vaccine can predict (or have an influence) on the vaccination rate of a country" but we have since changed it to "whether the consumption of the varying media reports on the COVID-19 vaccine has any correlation with the vaccination rate of a country" because we changed our project focus from prediction to correlation. We had also planned to collect articles from many countries around the world, however, we have sicne reduced our dataset to only one article per month for each of the six news sources: three from Canada and three from the US. Our original plan did not involve using the vaderSentiment library, however we adjusted our Vaccine Sentiment algorithm to compute and utilize the neutral score produced by this library. In addition to this, we used this library to find the compound score, positive/negative ratios for each article and graphed the results to perform a better analysis and gain another perceptive in our study.

Discussion

Before we discuss our findings, we must first discuss some limitations that may have had an effect on our results. The first limitation is the size of our dataset. We utilized a rule/lexicon-based sentiment analysis which requires the lexicon to be created by a user. Due to time constraints, we were not able to find or utilize a bigger sample to create or test our lexicon which means it may be as accurate as it could be. The lexicon is also in English and abides by the grammar rules of English which means it may not be accurate in analyzing articles outside of North America. Scrapy also proved to have some limitations as we were not able to completely automate the process of running through the article links, as such processing the articles must take place separately and before main.py is run. The article data set also contributed to this issue as for each publisher the data location of the title, date, and text are different for each website, meaning they were located under different class names and containers. As such we had to create a different spider for each publisher, and our web scraping was limited to these publishers. This restricted the size of our article data set.

The results of our study showed that there is not a strong correlation between the sentiment of vaccine articles and the daily percentage change in vaccination for a country. In fact, throughout the pandemic there does not seem to be a strong trend up or down in article sentiment for either country. Therefore the answer to our research question "Does a country's varying media reports on the COVID 19 vaccine have any correlation with can predict (or have an influence) on the vaccination rate of that country?", put shortly is "no". However, this is not to say there is no connection between the two data sets.

Studying the results of the graph "Average Article Vaccine Sentiment per Month" we can see that overall Canada rated higher than the USA. In the months where Canada rates lower than America, the articles share a commonality. That commonality is criticizing the government/authority, which is reflected in an article by the star, 'Should COVID-19 vaccines be mandatory? Inside our contentious history with forced immunization', which was published on 2021/08. Expanding on this point we see that while in some cases negative article sentiment reflects negative side effects of the vaccine or reports of misinformation, more often they reflect criticism of the ruling power/authority. In many cases, this may be criticizing a government's slow rollout of vaccines, information, or policy on vaccination. This would explain why Canada rates higher overall "Average Article Vaccine Sentiment per Month" as the news articles may reflect how Canadians are more trusting or less critical of the government compared to Americans.

This trust in government would better explain the difference in overall vaccination. While the mass majority of Canadians and Americans may have a strong sense of trust with the government, there are groups in each that do not support the government and their actions. Putting this all together, countries that have a lower total vaccination rate may also have a larger group of individuals with less trust in the ruling authority or government. In the United States, this may be reflected in many supporters of the Republican party who are often opposed to the ruling Democrats and their policies. Republican ideology also reflects more individualistic beliefs which are widespread across America compared to Canada which has parties that reflect more collectivist beliefs. Countries in East Asia such as Japan and South Korea which hold even stronger collectivist beliefs, also have high vaccination rates further affirming this point. This finding of vaccination rate and government trust gives us some insight on the next steps that could be performed in this project.

First, news articles do not give the best reflection of trust in the government as they represent one person writing an article for many to read. Instead, comments on articles or the type of articles shared would give us a better sense of how the general populace of a country reacts to articles. As such, performing sentiment analysis on social media comments on the pandemic, specifically the government's reactions to it, on platforms such as Twitter may help us explore whether or not vaccination is truly correlated with government trust. Second, utilizing a larger data set such as social media comments would also help us gain a more accurate model to compute sentiment scores. With

a larger data set machine learning can be used to perform sentiment analysis which has advantages not attainable using human made lexicons/rules.

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