COVID-19: Medical Centres in Downtown Toronto by Neighborhood

Applied Data Science Capstone by IBM/Coursera

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Introduction: Business Problem

The COVID-19 pandemic has severely affected lives, societies, and economies around the world. In Canada, Toronto has been particularly affected as a large metropolitan city home to roughly 3 million people and countless businesses. In the Downtown Toronto area, access to nearby medical centres is not evenly distributed for each neighborhood. It is of interest to Toronto Public Health, policy makers, and community leaders to determine which Toronto neighborhoods may be lacking access to adequate medical centres (clinics, hospitals, etc.) within walking distance. This access is important in the event an individual requires medical care, testing for COVID-19, and eventually for receiving vaccinations once they become available. Intervention may be required for neighborhoods with lower medical centre availability (pop-up centres, increased transportation options, etc.). As pharmacies can also be used for testing and vaccinations, we are also interested in looking at the number of pharmacies in each neighborhood. **The goal of this project will be to segment *Downtown Toronto* neighborhoods by their number of medical centres and pharmacies present.**

Data

To group Downtown Toronto neighbourhoods by their number of medical centres and pharmacies present, the neighbourhoods will be clustered into three groups based on these metrics. This will help interested parties identify neighborhoods of greatest, medium, and least concern.

To accomplish this, the following data is required:

- A list of neighborhoods in Toronto with their corresponding latitude and longitude coordinates
- A list of the medical centres (clinics, hospitals, etc.) present in each neighborhood, within 1 km of each latitude and longitude coordinate set (a reasonable walking distance)
- A list of pharmacies present in each neighborhood, within 1 km of each latitude and longitude coordinate set (a reasonable walking distance)

Neighborhood Information

A list of Toronto neighborhoods with corresponding boroughs and postal codes are available from the Wikipedia page: \ 'List of postal codes of Canada: M' (https://en.wikipedia.org/wiki/List_of_postal_codes_of_Canada:_M).

The Wikipedia page was scraped to transfer neighborhood information to a Pandas dataframe. The latitude and longitude data for each neighbourhood was retrieved from the csv file: http://cocl.us/Geospatial_data.

After processing, the following dataframe is obtained:

Table 1: Neighborhoods and latitude and longitude coordinates of Downtown Toronto neighborhoods

	Postal Code	Borough	Neighborhood	Latitude	Longitude
0	M5A	Downtown Toronto	Regent Park, Harbourfront	43.654260	-79.360636
1	M7A	Downtown Toronto	Queen's Park, Ontario Provincial Government	43.662301	-79.389494
2	M5B	Downtown Toronto	Garden District, Ryerson	43.657162	-79.378937
3	M5C	Downtown Toronto	St. James Town	43.651494	-79.375418
4	M5E	Downtown Toronto	Berczy Park	43.644771	-79.373306
5	M5G	Downtown Toronto	Central Bay Street	43.657952	-79.387383
6	M6G	Downtown Toronto	Christie	43.669542	-79.422564
7	M5H	Downtown Toronto	Richmond, Adelaide, King	43.650571	-79.384568
8	M5J	Downtown Toronto	Harbourfront East, Union Station, Toronto Islands	43.640816	-79.381752
9	M5K	Downtown Toronto	Toronto Dominion Centre, Design Exchange	43.647177	-79.381576
10	M5L	Downtown Toronto	Commerce Court, Victoria Hotel	43.648198	-79.379817
11	M5S	Downtown Toronto	University of Toronto, Harbord	43.662696	-79.400049
12	M5T	Downtown Toronto	Kensington Market, Chinatown, Grange Park	43.653206	-79.400049
13	M5V	Downtown Toronto	CN Tower, King and Spadina, Railway Lands, Har...	43.628947	-79.394420
14	M4W	Downtown Toronto	Rosedale	43.679563	-79.377529
15	M5W	Downtown Toronto	Stn A PO Boxes	43.646435	-79.374846
16	M4X	Downtown Toronto	St. James Town, Cabbagetown	43.667967	-79.367675
17	M5X	Downtown Toronto	First Canadian Place, Underground city	43.648429	-79.382280
18	M4Y	Downtown Toronto	Church and Wellesley	43.665860	-79.383160

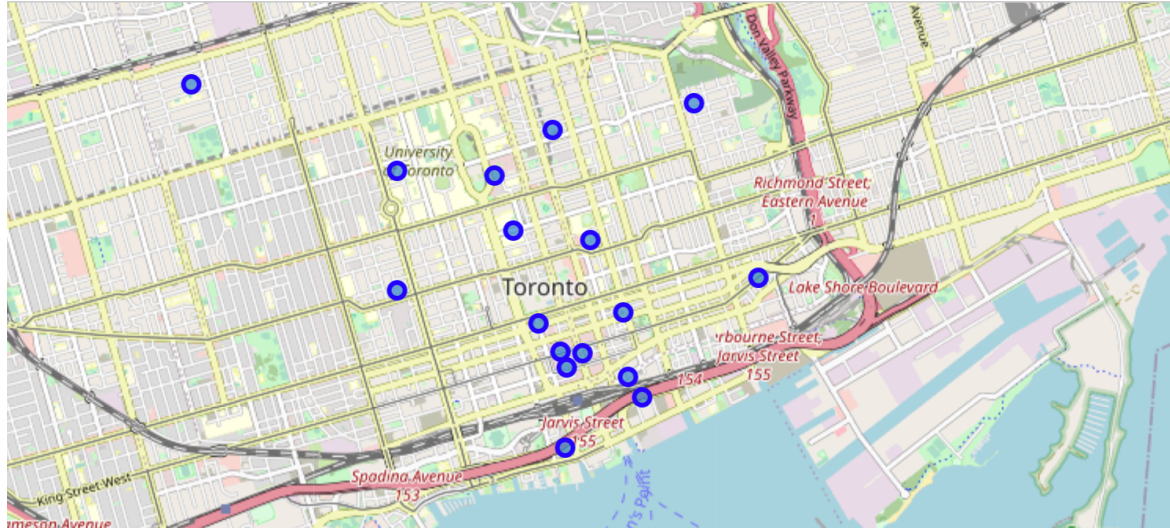The neighborhoods are visualized superimposed over a map of Toronto:

Figure 1: Downtown Toronto neighborhoods superimposed on a map of Toronto

Foursquare

Data on medical centres and pharmacies were obtained by making calls to the Foursquare API. For medical centres, the search query 'medical' was used, while 'pharmacy' was used to obtain pharmacy data. The number of query results were counted for each neighborhood and stored in columns in the dataframe. The following dataframe was obtained:

Table 2: Downtown Toronto neighborhoods with number of medical centres and pharmacies

	Postal Code	Borough	Neighborhood	Latitude	Longitude	Medical Centres	Pharmacies
0	M5A	Downtown Toronto	Regent Park, Harbourfront	43.654260	-79.360636	5	9
1	M7A	Downtown Toronto	Queen's Park, Ontario Provincial Government	43.662301	-79.389494	48	22
2	M5B	Downtown Toronto	Garden District, Ryerson	43.657162	-79.378937	48	24
3	M5C	Downtown Toronto	St. James Town	43.651494	-79.375418	34	16
4	M5E	Downtown Toronto	Berczy Park	43.644771	-79.373306	20	10
5	M5G	Downtown Toronto	Central Bay Street	43.657952	-79.387383	50	27
6	M6G	Downtown Toronto	Christie	43.669542	-79.422564	9	9
7	M5H	Downtown Toronto	Richmond, Adelaide, King	43.650571	-79.384568	48	22
8	M5J	Downtown Toronto	Harbourfront East, Union Station, Toronto Islands	43.640816	-79.381752	22	4
9	M5K	Downtown Toronto	Toronto Dominion Centre, Design Exchange	43.647177	-79.381576	36	15
10	M5L	Downtown Toronto	Commerce Court, Victoria Hotel	43.648198	-79.379817	34	16
11	M5S	Downtown Toronto	University of Toronto, Harbord	43.662696	-79.400049	38	16
12	M5T	Downtown Toronto	Kensington Market, Chinatown, Grange Park	43.653206	-79.400049	38	25
13	M5V	Downtown Toronto	CN Tower, King and Spadina, Railway Lands, Har...	43.628947	-79.394420	2	1
14	M4W	Downtown Toronto	Rosedale	43.679563	-79.377529	3	1
15	M5W	Downtown Toronto	Stn A PO Boxes	43.646435	-79.374846	23	10
16	M4X	Downtown Toronto	St. James Town, Cabbagetown	43.667967	-79.367675	8	9
17	M5X	Downtown Toronto	First Canadian Place, Underground city	43.648429	-79.382280	43	19
18	M4Y	Downtown Toronto	Church and Wellesley	43.665860	-79.383160	39	17

Methodology

After the data was collected and processed, the next step was to apply the machine learning technique **k-means** clustering to group the neighborhoods according to their number of medical centres and pharmacies present. **A value of 3 was used for k as we were looking to cluster the neighborhoods into 3 groups of greatest, medium, and least concern.**

The next step was to assign each neighborhood to a cluster based on our k-means model and add the corresponding cluster label for each neighborhood to the dataframe. Then, the clusters were superimposed and visualized on a map of Toronto using the folium library.

Results

The following dataframe contains the cluster each neighborhood belongs to:

Table 3: Downtown Toronto neighborhoods with corresponding cluster labels

	Postal Code	Borough	Neighborhood	Latitude	Longitude	Medical Centres	Pharmacies	Cluster
0	M5A	Downtown Toronto	Regent Park, Harbourfront	43.654260	-79.360636	5	9	0
1	M7A	Downtown Toronto	Queen's Park, Ontario Provincial Government	43.662301	-79.389494	48	22	2
2	M5B	Downtown Toronto	Garden District, Ryerson	43.657162	-79.378937	48	24	2
3	M5C	Downtown Toronto	St. James Town	43.651494	-79.375418	34	16	1
4	M5E	Downtown Toronto	Berczy Park	43.644771	-79.373306	20	10	0
5	M5G	Downtown Toronto	Central Bay Street	43.657952	-79.387383	50	27	2
6	M6G	Downtown Toronto	Christie	43.669542	-79.422564	9	9	0
7	M5H	Downtown Toronto	Richmond, Adelaide, King	43.650571	-79.384568	48	22	2
8	M5J	Downtown Toronto	Harbourfront East, Union Station, Toronto Islands	43.640816	-79.381752	22	4	0
9	M5K	Downtown Toronto	Toronto Dominion Centre, Design Exchange	43.647177	-79.381576	36	15	1
10	M5L	Downtown Toronto	Commerce Court, Victoria Hotel	43.648198	-79.379817	34	16	1
11	M5S	Downtown Toronto	University of Toronto, Harbord	43.662696	-79.400049	38	16	1
12	M5T	Downtown Toronto	Kensington Market, Chinatown, Grange Park	43.653206	-79.400049	38	25	2
13	M5V	Downtown Toronto	CN Tower, King and Spadina, Railway Lands, Har...	43.628947	-79.394420	2	1	0
14	M4W	Downtown Toronto	Rosedale	43.679563	-79.377529	3	1	0
15	M5W	Downtown Toronto	Stn A PO Boxes	43.646435	-79.374846	23	10	0
16	M4X	Downtown Toronto	St. James Town, Cabbagetown	43.667967	-79.367675	8	9	0
17	M5X	Downtown Toronto	First Canadian Place, Underground city	43.648429	-79.382280	43	19	1
18	M4Y	Downtown Toronto	Church and Wellesley	43.665860	-79.383160	39	17	1

The clusters were then visualized over a map of Toronto using the folium library.
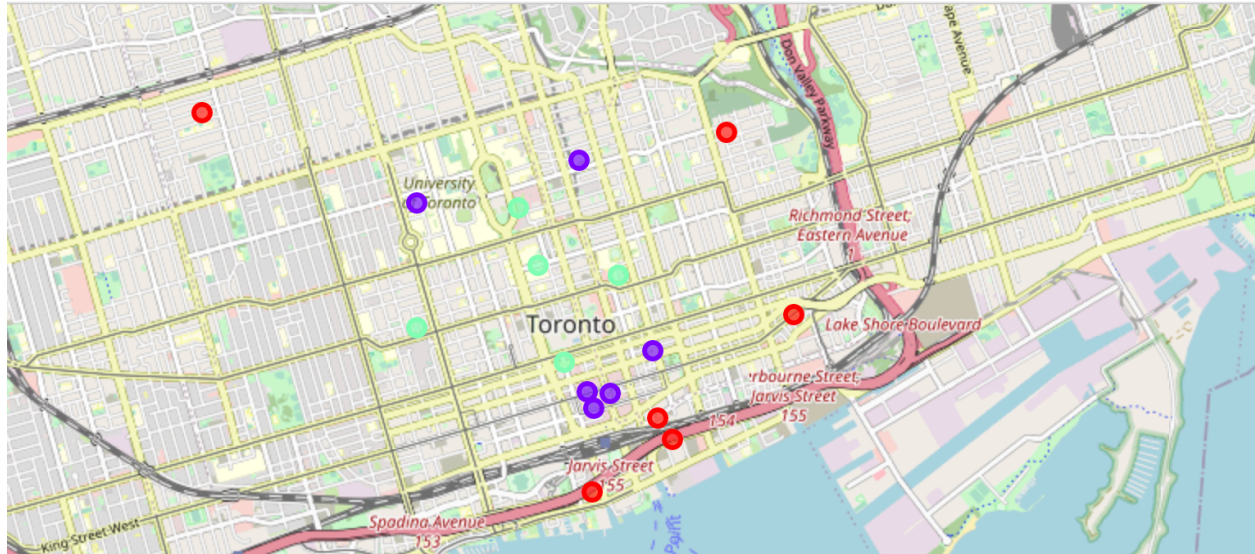
Figure 2: Downtown Toronto neighborhoods superimposed on a map of Toronto, clustered by number of medical centres and pharmacies

Discussion

Based on this analysis, we identified 3 clusters/categories:

*1) Neighborhoods of **Greatest Concern***

There are 8 neighborhoods in this category. These neighborhoods were identified to have the least number of either medical centres, pharmacies, or both. They are represented by red circles on our map of Toronto (Figure 2). These are areas where potential interventions (e.g. pop-up testing centres) may be focused by community and public health planning.

*2) Neighborhoods of **Medium Concern***

There are 6 neighborhoods in this category. These neighborhoods were identified to have a medium number of medical centres and pharmacies. They are represented by purple circles on our map of Toronto (Figure 2). These are areas where potential interventions (e.g. pop-up testing centres) may be needed but should likely not be the primary focus.

*3) Neighborhoods of **Least Concern***

There are 5 neighborhoods in this category. These neighborhoods were identified to have a high number of medical centres and pharmacies. They are represented by green circles on our map of Toronto (Figure 2). There are areas where potential interventions (pop-up centres, increased transportation options, etc.) are the least needed.

Limitations and Further Analysis Required

A major limitation of this analysis is that it did not consider the population of each neighborhood to properly assess its true medical access requirements. This is a feature that must be added for any further analysis. Some neighborhoods are also much nearer geographically to each other than others, which skews results as some venues may appear more than once while categorized under different neighborhoods. Furthermore, this study should be expanded to encompass all of Toronto and not just the downtown area.

Conclusion

The purpose of this project was to group Toronto neighborhoods into 3 categories: Greatest Concern, Medium Concern, and Least Concern on the basis of the availability of medical centres and pharmacies in each neighborhood, as a response to the COVID-19 pandemic. This information is needed by Toronto Public Health, policy makers, and community leaders to determine which Toronto neighborhoods may be lacking access to adequate medical centres within walking distance. The data was successfully extracted and clustered into the 3 categories. The number of neighborhood groups falling into each category is as follows:

- Greatest Concern: 8
- Medium Concern: 6
- Least Concern: 5

However, further analysis is required to take into the account the population of each neighborhood and to segregate geographically close neighborhoods to get the full picture of medical access in each neighborhood.