

# No Evidence of Discrimination Accessing COVID-19 Immunization Clinics Across the City of Toronto\*

Christina Wei

March 28, 2023

COVID-19 immunization clinic and ward profile datasets were used in the assessment of vaccine access across the City of Toronto. Based on the analysis of number of clinics and household income, no systematic discrimination was discovered as there is no correlation found between the two variables. There is a slightly positive correlation between number of clinics and population, supporting the hypothesis that COVID-19 clinic location is related to the the number of residents within its proximity. Further analysis should be performed to analyze utilization data alongside COVID-19 clinic access.

## Table of contents

<b>1</b>	<b>Introduction</b>	<b>2</b>
<b>2</b>	<b>Data</b>	<b>3</b>
2.1	COVID-19 Immunization Clinics . . . . .	3
2.2	Ward Profiles, 2018 (25-Ward Model) . . . . .	4
2.3	City Wards . . . . .	4
2.4	Combining Ward Data . . . . .	5
<b>3</b>	<b>Results</b>	<b>5</b>
3.1	COVID-19 Immunization Clinic Statistics . . . . .	5
3.2	Ward Profile Based on 2016 Census Data . . . . .	5
3.3	Comparing Number of Clinics with Ward Population . . . . .	7

---

\*Code and data supporting this analysis is available at: <https://github.com/christina-wei/INF3014-1-Covid-Clinics.git>

3.4 Comparing COVID-19 Clinics with Ward Income . . . . .	7
<b>4 Discussion</b>	<b>7</b>
<b>5 Conclusion</b>	<b>9</b>
<b>Reference</b>	<b>10</b>

## 1 Introduction

The new coronavirus (COVID-19) outbreak was deemed a global pandemic by the World Health Organization (WHO) on March 11, 2020 (WHO 2020). Shortly after the announcement, many countries implemented lock downs in order to control the spread of the disease. At the same time, scientists around the world worked tirelessly to develop vaccines against this new virus. By the end of 2020, both Pfizer and Moderna have developed effective vaccines providing protection against COVID-19 virus (Brothers 2020). As vaccines became widely available in early 2021, Canada started to implement strategies to make vaccines accessible to the general public. Specifically in the City of Toronto, the government opened various immunization clinics across the city, as well as partnered with hospitals and pharmacies to provide access to vaccines. However, there are some criticism against the government for inequitable vaccine distribution, discriminating against vulnerable populations (CBC 2021). As the vaccine roll out progresses, there are also concerns that high-risk individuals in Ontario are lagging in vaccinations (Ogilvie 2022).

One of the factors that may contribute to discrimination of COVID-19 vaccines is the accessibility to receive the immunizations. In this paper, I used the COVID-19 clinic location data as the estimand for immunization accessibility. A snapshot of COVID-19 immunization clinic data as of January 22, 2023 alongside 2016 Census data were used as data sources. To evaluate access equality, I analyzed the distribution of immunization clinics across the city, as well as investigating social factors such as income and population that may influence the availability of clinic sites. My findings showed that there is a slightly positive correlation between population and the availability of clinics. However, it did not show systematic discrimination for the availability of COVID-19 clinics based on household income levels. As such, this paper did not find any evidence that the distribution of clinics across the city contributed to the inequitable access to vaccines.

In the Data section, different data sources used for analysis are discussed, as well as the data cleaning process applied to these datasets. The following Results section presents trends and correlations discovered in analysis. The Discussion section shares additional insights into the data findings, as well as discussing measurement errors and limitations of this analysis. Finally the paper wraps up with the Conclusion section summarizing the main discoveries from this paper.

Table 1: Sample of cleaned Covid-19 clinic data

ID	Name	Type	Ward Name
153	Metro Toronto Convention Centre	City	Spadina-Fort York
157	Scarborough Town Centre	City	Scarborough Centre
158	Cloverdale Mall	City	Etobicoke-Lakeshore
650	Woodbine Mall	City	Etobicoke North
150	Mitchell Field Community Centre	City	Willowdale

## 2 Data

Data used in this paper are retrieved from Open Data Toronto Portal through the library `opendatatoronto` (Gelfand 2022). Three different data sources were leveraged to analyze COVID-19 immunization clinics across Toronto: `COVID-19 Immunization Clinics` (Data 2023), `Ward Profiles, 2018 (25-Ward Model)` (Data 2021), and `City Wards` (Data 2022). Data was cleaned and analyzed using the open source statistically programming language R (R Core Team 2022), using functionalities from `tidyverse` (Wickham et al. 2019), `ggplot2` (Wickham 2016), `dplyr` (Wickham et al. 2022), `readr` (Wickham, Hester, and Bryan 2022), `tibble` (Müller and Wickham 2022), `janitor` (Firke 2021), `kableExtra` (Zhu 2021) and `knitr` (Xie 2014). Details of the data extraction and cleaning processes are discussed in the subsections below.

### 2.1 COVID-19 Immunization Clinics

This dataset published by Toronto Public Health (Data 2023) captures information about COVID-19 immunization clinics across the City of Toronto and is refreshed on a daily basis. The data used for analysis in this paper is captured as of January 22, 2023. Based on the data features described on the portal, the data should include information on clinic location, date added, contact information, eligibility criteria, availability and appointment booking details. Upon further inspection, data elements are not recorded properly for appointment, availability and eligibility related information as the columns designed to capture these data are not populated. Instead, information are typed in as free form comments in the `info` column, making it difficult to systematically extract details from this field. As a result, only columns with reasonable data are kept in the data cleaning process (see Table 1). Basic data cleaning was applied to the column values to shorten the description of different types of clinics for readability.

Table 2: Sample of cleaned ward profile data

Ward Code	Popluation	Income
1	118040	73374
2	118020	128448
3	129080	105994
4	108805	99784
5	116685	67954

## 2.2 Ward Profiles, 2018 (25-Ward Model)

Ward profiles such as income and population would be interesting factors to analyze alongside COVID-19 immunization clinics. Therefore, the dataset for ward profiles (Data 2021) based on 2016 census data has been included in analysis as well. This dataset is published by City Planning, and was last updated on February 11, 2021. The 25-ward model was chosen over the 47-ward model because it is matching the ward classification in the COVID-19 immunization clinic data. This dataset contains demographic, social and economic information for each ward, such as income and population.

Ward profile data is stored in an Excel file with multiple tabs. The relevant data to be used for this paper’s analysis is included the first tab, `2016 Census One Variable`. As such, only data for this tab was downloaded for analysis. Further data cleaning was performed to transpose the data and only keeping information relevant to income and population level for each ward (see Table 2).

Based on the Open Data Toronto Portal, there is a CSV file in the package, `25 Ward Names and Numbers`, that contains the mapping between ward codes and ward names. Unfortunately this particular resource does not download properly through the `opentorontodata` library (Gelfand 2022). As such, another dataset, `City Wards` (Data 2022), has been identified to fill in this gap.

## 2.3 City Wards

The city wards dataset (Data 2022) is published by City Clerk’s Office, and was last updated on November 29, 2022. It contains information regarding the codes, names, and boundaries of Toronto’s 25 wards. Data elements of ward code and ward name are selected from this dataset. Also the columns have been renamed to match the naming conventions in the other datasets.

## 2.4 Combining Ward Data

Using the `merge` function, ward profiles data and city ward data are combined into one dataset containing information on ward code, ward name, population, and average income. COVID-19 immunization clinic data can be summarized by each ward name and the number of clinics per ward. This data is then injected into the combined ward profile dataset. Please see Table 3 for a snapshot of the combined data.

## 3 Results

### 3.1 COVID-19 Immunization Clinic Statistics

As of January 22, 2023, there are 434 COVID-19 immunization clinics across the City of Toronto. Further breakdown shows that there are 5 clinics that are city operated, 16 clinics that are run by hospitals, and 415 are offered in local pharmacies. On average, there are 17 clinics per ward in Toronto, with standard deviation of 6. The wards with the highest number of clinics are: Toronto Center (Ward 13) with 29 clinics, Etobicoke-Lakeshore (Ward 3) with 28 clinics, and University-Rosedale (Ward 11) with 28 clinics. The wards with the lowest number of clinics are: Humber River-Black Creek (Ward 7) with 9 clinics, Davenport (Ward 9) with 12 clinics, Scarborough Southwest (Ward 20) with 12 clinics, Scarborough-Agincourt (Ward 22) with 12 clinics, and Scarborough-Rouge Park (Ward 25) with 12 clinics.

### 3.2 Ward Profile Based on 2016 Census Data

There are 25 wards in the City of Toronto. Based 2016 census data, the average population per ward is 109,263, with standard deviation of 7,472. The wards with the highest population are: Etobicoke-Lakeshore (Ward 3) at 129,080, Willowdale (Ward 18) at 118,800, and Etobicoke North (Ward 1) at 118,040. The wards with the lowest population are: Don Valley East (Ward 16) at 94,580, Scarborough North (Ward 23) at 98,800, and Scarborough-Rouge Park (Ward 25) at 102,275.

Average household income level per ward is \$101,161, with standard deviation of \$37,772. The wards with the highest household income are: Don Valley West (Ward 15) at \$216,158, University-Rosedale (Ward 11) at \$104,310, and Eglinton-Lawrence (Ward 8) at \$162,674. The wards with the lowest household income are: Humber River-Black Creek (Ward 7) at \$65,458, York South-Weston (Ward 5) at \$67,964, and Scarborough Centre (Ward 21) at \$70,624.

Table 3: Ward profile details

Ward Code	Ward Name	Number of Clinics	Population	Income
0	NA	2	NA	NA
1	Etobicoke North	11	118040	73374
2	Etobicoke Centre	14	118020	128448
3	Etobicoke-Lakeshore	28	129080	105994
4	Parkdale-High Park	18	108805	99784
5	York South-Weston	19	116685	67954
6	York Centre	19	104320	86717
7	Humber River-Black Creek	9	108035	65458
8	Eglinton-Lawrence	15	114395	162674
9	Davenport	12	108470	80807
10	Spadina-Fort York	27	115510	103047
11	University-Rosedale	28	104310	170832
12	Toronto-St. Paul's	14	107900	155470
13	Toronto Centre	29	103805	75382
14	Toronto-Danforth	17	106875	101323
15	Don Valley West	13	102510	216158
16	Don Valley East	14	94580	80648
17	Don Valley North	15	110080	87491
18	Willowdale	17	118800	87416
19	Beaches-East York	22	109465	104123
20	Scarborough Southwest	12	110280	78561
21	Scarborough Centre	27	112605	70624
22	Scarborough-Agincourt	12	105540	75768
23	Scarborough North	15	98800	78984
24	Scarborough-Guildwood	15	102390	72289
25	Scarborough-Rouge Park	12	102275	99715

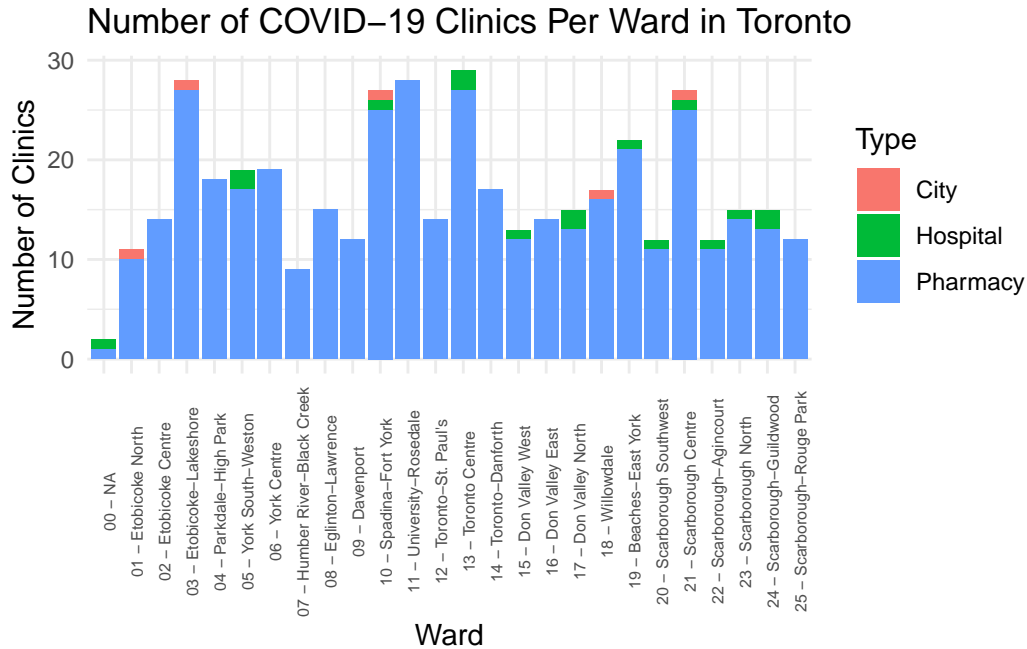


Figure 1: Number of COVID-19 clinics per ward in Toronto

### 3.3 Comparing Number of Clinics with Ward Population

As seen in Figure 2, there is a slightly positive correlation between the number of clinics and the average population in a ward, with correlation coefficient of 0.26. The top three wards with the highest population levels, Etobicoke-Lakeshore (Ward 3), Willowdale (Ward 18) and Etobicoke North (Ward 1) have a wide spread of number of clinics, with 28, 17, 11 clinics respectively. The bottom three wards with lowest population, Don Valley East (Ward 16), Scarborough North (Ward 23) and Scarborough-Rouge Park (Ward 25), have average number of clinics per ward, with 14, 15, and 12 clinics respectively.

### 3.4 Comparing COVID-19 Clinics with Ward Income

As shown in Figure 3, there is no observable correlation between the number of clinics and the average household income in a ward, with correlation coefficient of 0.06.

## 4 Discussion

Overall there is a slightly positive relationship between the number of COVID-19 immunization clinics and population within each ward, which is matching to the expectation that clinic

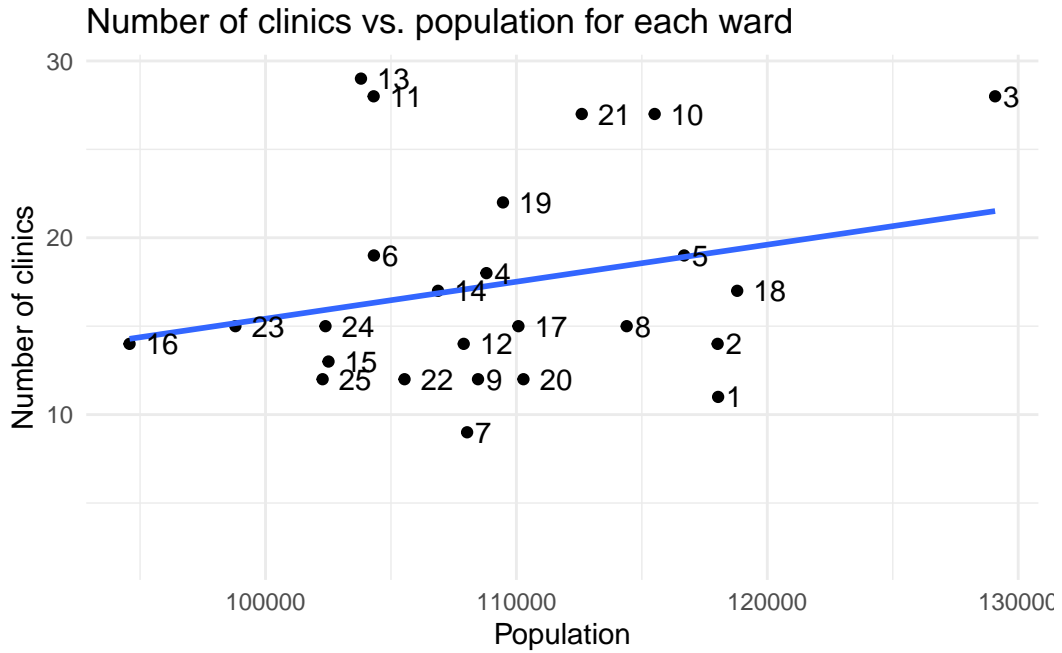


Figure 2: Correlations between number of clinics vs. population

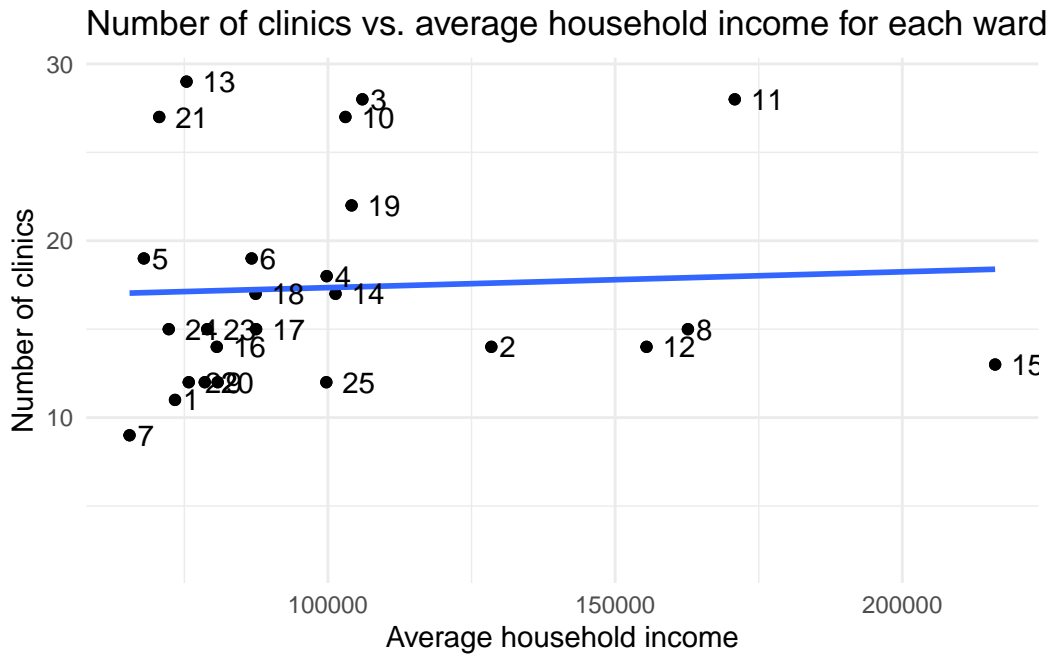


Figure 3: Correlations between number of clinics vs. average household income



sites are established based on the number of individuals residing within proximity of the clinic. There is no correlation found between number of clinics and household income levels. Therefore, this paper did not find any evidence of systematic discrimination against vaccine access based on income.

Based on Figure 1, most of the currently active COVID-19 clinics (96%) are operated through local pharmacies like Shoppers Drug Mart or Rexall. As such, this analysis may be a reflection of the existing pharmacy infrastructure across Toronto instead. The results above demonstrated that existing pharmacy network is reasonable equitable across Toronto, therefore it is a good infrastructure to provide access to COVID-19 to the general public.

There are potential measurement errors in the datasets used for this analysis. First, with regards to the measurement of COVID-19 immunization clinics, the data is not inclusive of all vaccine site, such as doctor’s offices or pop-up sites. There is also the possibilities of human error in data entry. As an example, two immunization sites are wrongfully categorized to “NA”, while they belonged to specific wards within Toronto. Third, even though the dataset itself is listed as being refreshed daily, the reliability of data sources and frequency of data updates is unknown. There are also various errors that may exist in census data (“Guide to the Census of Population, 2021 / Chapter 9 – Data Quality Evaluation” 2021): *coverage errors* when data is incorrectly processed like omissions or misclassifications; *non-response errors* when respondent did not provide full information; *response errors* when a problem was not understood properly by the respondent; *processing errors* as information is entered incorrectly; and *sampling errors* where the sample selected for census does not represent the general population.

There are several limitations to this analysis. As the COVID-19 immunization clinic dataset is a snapshot as of a point in time, it is not possible to analyze the changes in clinic availability over time. Also, the dataset only records which locations offer COVID-19 vaccines, but does not properly contain information with regards to opening hours or eligibility, which are also important factors to assess availability. Another limitation of the analysis is that this paper used ward profile data based on 2016 Census. The data may not accurately reflect current social conditions. Lastly, it would have been useful to include the utilization rates for each clinic for better assessment of public needs. Unfortunately this dataset is not available on the Open Data Toronto Portal (Gelfand 2022).

## 5 Conclusion

This paper investigates the accessibility of COVID-19 vaccines by analyzing immunization clinic data to assess whether there is equitable access to vaccines across City of Toronto. Our data analysis showed that there is a slightly positive correlation between the number of clinics and the population in wards. There is no evidence of systematic discrimination in the distribution of clinic sites as there is no correlation between the number of clinics and household incomes in wards. As most COVID-19 vaccines are offered through major pharmacy chains,

this analysis can also be extended to indicate that there is a reasonably equitable access to pharmacies across the city. Future analysis with newer census data, clinic distribution over time, as well as including clinic utilization rate in analysis will be useful to continue investigate into the access to COVID-19 vaccines within the City of Toronto.

## Reference

- Brothers, Will. 2020. “A Timeline of COVID-19 Vaccine Development.” <https://www.biospace.com/article/a-timeline-of-covid-19-vaccine-development/>.
- CBC. 2021. “Ontario Court Tosses Lawsuit Claiming Province’s COVID-19 Vaccination Rollout Was Discriminatory.” <https://www.cbc.ca/news/canada/toronto/covid-vaccine-discrimination-court-challenge-1.6014892>.
- Data, Toronto Open. 2021. “Ward Profiles, 2018 (25-Ward Model).” <https://open.toronto.ca/dataset/ward-profiles-2018-25-ward-model/>.
- . 2022. “CityWards.” <https://open.toronto.ca/dataset/city-wards/>.
- . 2023. “COVID-19 Immunization Clinics.” <https://open.toronto.ca/dataset/covid-19-immunization-clinics/>.
- Firke, Sam. 2021. *Janitor: Simple Tools for Examining and Cleaning Dirty Data*. <https://CRAN.R-project.org/package=janitor>.
- Gelfand, Sharla. 2022. *Opendatatoronto: Access the City of Toronto Open Data Portal*. <https://CRAN.R-project.org/package=opendatatoronto>.
- “Guide to the Census of Population, 2021 / Chapter 9 – Data Quality Evaluation.” 2021. <https://www12.statcan.gc.ca/census-recensement/2021/ref/98-304/2021001/chap9-eng.cfm>.
- Müller, Kirill, and Hadley Wickham. 2022. *Tibble: Simple Data Frames*. <https://CRAN.R-project.org/package=tibble>.
- Ogilvie, Megan. 2022. “High-Risk Ontarians Lagging on Third Doses of COVID Vaccine.” <https://www.thestar.com/news/gta/2022/01/21/high-risk-ontarians-lagging-on-third-doses-of-covid-vaccine.html>.
- R Core Team. 2022. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.
- WHO. 2020. “WHO Director-General’s Opening Remarks at the Media Briefing on COVID-19 - 11 March 2020.” <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>.
- Wickham, Hadley. 2016. *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. <https://ggplot2.tidyverse.org>.
- Wickham, Hadley, Mara Averick, Jennifer Bryan, Winston Chang, Lucy D’Agostino McGowan, Romain François, Garrett Grolemund, et al. 2019. “Welcome to the tidyverse.” *Journal of Open Source Software* 4 (43): 1686. <https://doi.org/10.21105/joss.01686>.
- Wickham, Hadley, Romain François, Lionel Henry, and Kirill Müller. 2022. *Dplyr: A Grammar of Data Manipulation*. <https://CRAN.R-project.org/package=dplyr>.
- Wickham, Hadley, Jim Hester, and Jennifer Bryan. 2022. *Readr: Read Rectangular Text Data*. <https://CRAN.R-project.org/package=readr>.

- Xie, Yihui. 2014. “Knitr: A Comprehensive Tool for Reproducible Research in R.” In *Implementing Reproducible Computational Research*, edited by Victoria Stodden, Friedrich Leisch, and Roger D. Peng. Chapman; Hall/CRC. <http://www.crcpress.com/product/isbn/9781466561595>.
- Zhu, Hao. 2021. *kableExtra: Construct Complex Table with 'Kable' and Pipe Syntax*. <https://CRAN.R-project.org/package=kableExtra>.