Toronto Accessibility Report

A look at the current and future of how Toronto's public transport serves the public

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Introduction

Toronto is at the centre of the fastest growing metropolitan area in North America, expected to exceed a population of 10 million people by 2030. Not only is the region building an incredible volume of housing (with more high rise construction than all of the US combined), it's also undergoing the largest public transit expansion program on the continent, with multiple new rapid transit lines and a massive regional rail modernization program set to open in the next decade.

Meanwhile, the region is facing a crippling housing crisis, a lack of transportation capacity, and the broader global climate crisis. Toronto still falls short of meeting the gravity of these various crises - particularly its slow recovery in the period after the coronavirus pandemic.

At the intersection of these issues is accessibility - the ability for residents to access jobs and opportunity. The massive growth in the city's transport network will fundamentally change its geography - completely altering land use and transportation patterns. To achieve a more livable, sustainable, and equitable city, it's crucial that the transportation network being developed for current and future residents accounts for adequate access to jobs, leisure, and education.

Research Question

From any given point within the city of Toronto, how efficiently can points of interest be accessed within a certain amount of time?

Literature Review

Numerous studies have examined the relationship between urban structure, demographics, and public transit use in Canada. A Toronto study highlighted that "people in more socially disadvantaged areas were more likely to commute by transit in any job category", and another found a strong tendency for younger generations, especially millennials, to use public transit (Newbold & Scott, 2018). These studies also underline the importance of accessibility noting that areas such as Old Toronto are more accessible in comparison to burrows. (Lamers et al., 2016). However, these factors might not fully represent affluent populations with more transportation options. Residents' attitudes also play a role, with a Montreal study showing that positive perceptions of transit increase usage (van Lierop & El-Geneidy, 2018).

The existing literature predominantly emphasises ridership and the specific user profiles and reasons, rather than conducting a comprehensive evaluation of Toronto's transit system as a cohesive entity. This study seeks to address these gaps by offering a more inclusive analysis, aiming to enhance our comprehension of the overall accessibility that the transit system in Toronto offers to its entire population.

Methodology

To gain a better understanding of how the Toronto public transport serves the different parts of Toronto, this study looks at the Toronto Transit Commission’s (TTC) coverage to points of interest (POIs), how the general population is distributed, and projected population growths in the different neighbourhoods. Specifically, the coverage of points of interest are defined as the walking duration to reach any of hospitals, pharmacies, restaurants, shops, and residential buildings within different time frames. This was accomplished with the use of isochrone maps. The distribution of population was studied via generation of population density heat maps which showed a large part of where people were likely to start their public commute. The heatmap of population density gave a good idea of how the Toronto population is distributed and the isochrones showed the coverage of access to common points of interest which in combination, allow for an analysis of commute paths to different points of interest. Lastly, logistic and linear functions were parameterized to existing population data for each neighbourhood allowing comparisons between network and population distribution and growth.

Isochrones were generated with the use of OSM street graphs downloaded via the OSMnx Python library via the Toronto bounding polygon obtained from QGIS (*OpenStreetMap*, n.d.; “OSMnx,” 2016; *Qgis/QGIS*, 2011/2023). Furthermore, the retrieval of the path network data was parameterized with the “walk” network type indicating to OSMnx to filter for all paths that are theoretically walkable. POIs were downloaded via QGIS with the QuickOSM extension where all polygonal data were converted to point data via solving for centroids and merged with the rest of the point dataset. All datasets were projected to WGS 84 / UTM Zone 17N as area of use corresponded with Toronto (*QuickOSM — QGIS Python Plugins Repository*, n.d.). Datasets were clipped to the same bounding polygon used for the street graph. Isochrone maps were generated based off the street graph where each intersection was a point and each walkable path was an edge. All TTC stations were rounded to the nearest intersection, i.e., point in the street graph and the average walking speed used for the calculations of distance travelled was 4.5km/h (Knoblauch et al., 1996). Ego graphs were then generated as subgraphs of the walking graph where the centre node of each ego graph was the node closest to a given TTC station. These ego graphs were calculated based on walk times of 5, 15, and 30 minutes. The nodes within each of these ranges were converted to polygons via convex hulling each subgraph. POIs were then integrated with the maps and the number of POIs for each of the POI types discussed within each travel distance polygon was calculated to gain an understanding of which POIs, and how many of such POIs can be walked to from a TTC station. This entire process was repeated for the planned lines for the TTC and removal of lines with a planned deprecation. The coverage proportions were compared against each other with the 10 year timeline of Metrolinx to gain insight on the growth of the TTC's coverage with respect to its growth.

To produce the heat maps, data extraction was performed using the QGIS OSM extension QuickOSM. QuickOSM facilitated the querying of our POIs, specifically focusing on hospitals, and pharmacies, which shared a common key "amenities". Supermarkets were queried using the "shop" key. Subsequently, the collected data was imported into QGIS in point format. The construction of the heatmap was achieved through the utilisation of the symbology feature in QGIS.

Population growth projections were performed for each neighbourhood utilising the 140 model. Specifically, data points obtained from the Toronto Open Data portal starting from 1996 up to 2021 in 5 year intervals (Toronto, 2017). Scipy was used to optimise parameters for logistic and linear functions. While logistic curves were prioritised, in the case that the optimization resulted in a poor covariant matrix, the linear function was fitted instead. These fitted functions were then used to estimate the population of each neighbourhood in 2030 if the current growth trend continued.

Results

Isochrone POI Accessibility Results

Results from the isochrone portion of the study indicate the accessibility of various points of interest, clinical, or otherwise (**figure 1**). Around 21.6%, 40.5%, and 70.2% of all hospitals within Toronto are accessible within a 5, 15, and 30 minute walk respectively from the nearest TTC. 17.6%, 41.2%, and 69.7% of all pharmacies are covered by the same distances respectively. Shop accessibility, including groceries, clothes, etc., 18.8%, 45.3%, and 74.6% of all shops in Toronto are covered by a 5, 15, and 30 minute walk respectively from their nearest TTC stations. Lastly, only 3.4% of residential buildings are accessible within a 5 minute walk from the nearest TTC station. Within a 15 and 30 minute walk, 43.3% and 95.2% become covered respectively.

Looking at the future TTC lines, the isochrones drastically increase the coverage of all POIs (**figure 1**). Within a 5 minute walking distance, hospital coverage does not change, however, pharmacy coverage increases to 28.1%, shop coverage to 28.6%, and residentials to 7.2%. Within a 15 minute walk from the nearest TTC of a given hospital, 64.9% of all hospitals become accessible. An increase in coverage to 59.4% is also seen in the pharmacies accessible within a 15 minute walk of the nearest station. 64.0% of Shops would be accessible within 15 minutes walking from the nearest TTC station. Regarding residential coverage, 57.0% would be accessible by a 15 minute walk from the nearest TTC. Within a 30 minute walk, 91.9% of hospitals, 88.3% of pharmacies, 89.2% of shops, and 99.3% of residentials buildings are reachable.

POI Heat Map and Population Density Results

Analysing the heat map reveals a predominant concentration of POI in close proximity to the TTC network. Moreover, within Toronto, there is a discernible correlation between areas of high population density and the clustering of POIs (**figure 2**). In fact, the concentration of POIs are significantly skewed towards downtown Toronto, meaning that access to downtown is paramount for ensuring accessibility. Viewing the population density statistics by clustering analysis instead of Neighbourhood aggregation, it becomes even more clear that much of Toronto's residential density is placed outside of the downtown core (**figure 4**). Many of these dense, suburban residential clusters are around the intersection of major suburban arterial roads, served heavily by TTC surface bus routes. This juxtaposition between downtown-centric POI concentration and comparatively more dispersed residential density creates implications for Toronto's transit trip patterns - it becomes far more necessary for people living further away to take longer commutes towards downtown to access more POIs. It's also apparent that the existing rapid transit network (currently only subways) poorly serves these residential areas, making them dependent on buses for access.

With the future rapid transit network being put in place it becomes evident that these new transit routes not only align with existing POI clusters but also coincide with areas of increased population density (**figure 3**). However, the larger implications are the dramatically expanded coverage of the rapid transit network to Toronto's dense, suburban residential areas (**figure 5**). By 2030, areas formerly served by busy bus routes will be connected directly to the rapid transit network, dramatically increasing the accessibility of a large swath of Toronto's population. The most important factor in this change will be the far shorter travel times to downtown; residents in these far-flung suburban areas will have far faster trips to downtown, dramatically increasing their access to POIs.

Population Growth Predictions

Extrapolations on the logistic curves fitted onto the individual neighbourhood populations to the year 2030 indicates a total population growth of 5.7% with an overwhelming majority concentrated in the "Waterfront Communities - The Island" neighbourhood where in 2021, there was a total of 84,990 residents of the community, while in the estimations of inhabitants based on the logistic curve extrapolation indicates 125,319 residents. The second most populated neighbourhood is the "Islington - City Centre West" community where in 2021, 47,060 individuals called the community home and in 2030, the estimated number of residents increased to 56,238. Lastly, the third most populated neighbourhood is the "Woburn" community where 53,665 residents were tallied for 2021, while the estimated population in 2030 increases to 53,638 (**figure 8** and **table 1**).

Discussion

Examining Toronto's current public transit network , it is relatively inaccessible for a vast majority of Toronto's population with over 50% of the population requiring more than a 30 minutes walk from the TTC in order to access services such as hospitals, pharmacies as well as shops. Further examination shows that currently 95.2% of residential buildings are more than a 30 minute talk from the TTC in order to even try and access POI's. Further examination into this data shows that such services that have less then a 30min walk are only accessible within Old Toronto are not inclusive of Toronto's suburban regions.

In particular, the poor accessibility to Hospitals, Pharmacies, and other healthcare facilities becomes far more apparent in existing COVID data (**figure 6**). Rates of COVID during the pandemic were disproportionately higher in suburban residential neighbourhoods, particularly in the dense areas of Northern Etobicoke and Northern Scarborough. These areas, as discussed above, are poorly served by the existing rapid transit network, and heavily bus dependent (**figure 7**). The concentration of major hospitals downtown makes accessibility to healthcare far more difficult for residents in these areas.

Development of Toronto's future transit network is seen prioritising expanding out to hospitals and other healthcare facilities. This is seen as the development of the future transit networks would make 64.9% of hospitals, 59.4% of pharmacies within a 15 minute walk to public transit. However this leaves a little under half of Toronto's population unable to access such services through the TTC. Expanding upon this we can see that a majority of these increases to services are seen within old Toronto and don't take population growth within the suburbs into consideration, as only 3.4% of residential buildings are accessible within 5 minutes of a TTC station. This is a particularly important factor to consider as Islington-City Centre West and Woburn are some of the fastest growing communities within Toronto and they're located within the suburbs which don't necessarily have the greatest accessibility via public transit.

In summary, this signifies that the future transit network is attempting to make POI's more accessible to the public. However this increase in accessibility is primarily only beneficial to areas that already possess the transit infrastructure. Although attempts to increase transit within the suburbs is already being implemented this potentially could be futile due to the vaste growth that the suburbs in particular Islington-City Centre West and Woburn are experiencing.

Development of the spatial database could be used for examining areas that could potentially be high at risk due to being far away from either a specific POI within our database or POI's overall. The database can further be used to examine where new potential transit lines can be constructed, examining where POI's are located and the relationship it has with population density. Expanding upon this the database has the potential to have the POI's to be updated, adding more specific data potentially allowing researchers to examine potential ethnic neighbourhood comprehensions as well as forecasting other things such as future ethnic comprehension as well as population growth in certain neighbourhoods.

Conclusion

Our initial findings see that Toronto's future transit network is well equipped to handle Toronto's current population density, in particular transit in and out of Toronto's downtown core, through the extension of new TTC lines as well as incorporation of the GO network.

Further examination shows that Toronto's future transit network is not well equipped to transit within the suburbs to POI's. Expanding upon this we can see that a large majority of the suburbs rely heavily upon bus networks, thus making manoeuvrability relatively more difficult due to the lack of frequency in regards to bus transit.

Toronto's accessibility to health networks is also relatively more vulnerable, with low amounts of public transport access to hospitals and pharmacies. Expanding upon this we can see that aside from the Old Toronto a majority of Toronto’s health network is only accessible by the bus network, making it inaccessible and unreliable to get to.

References

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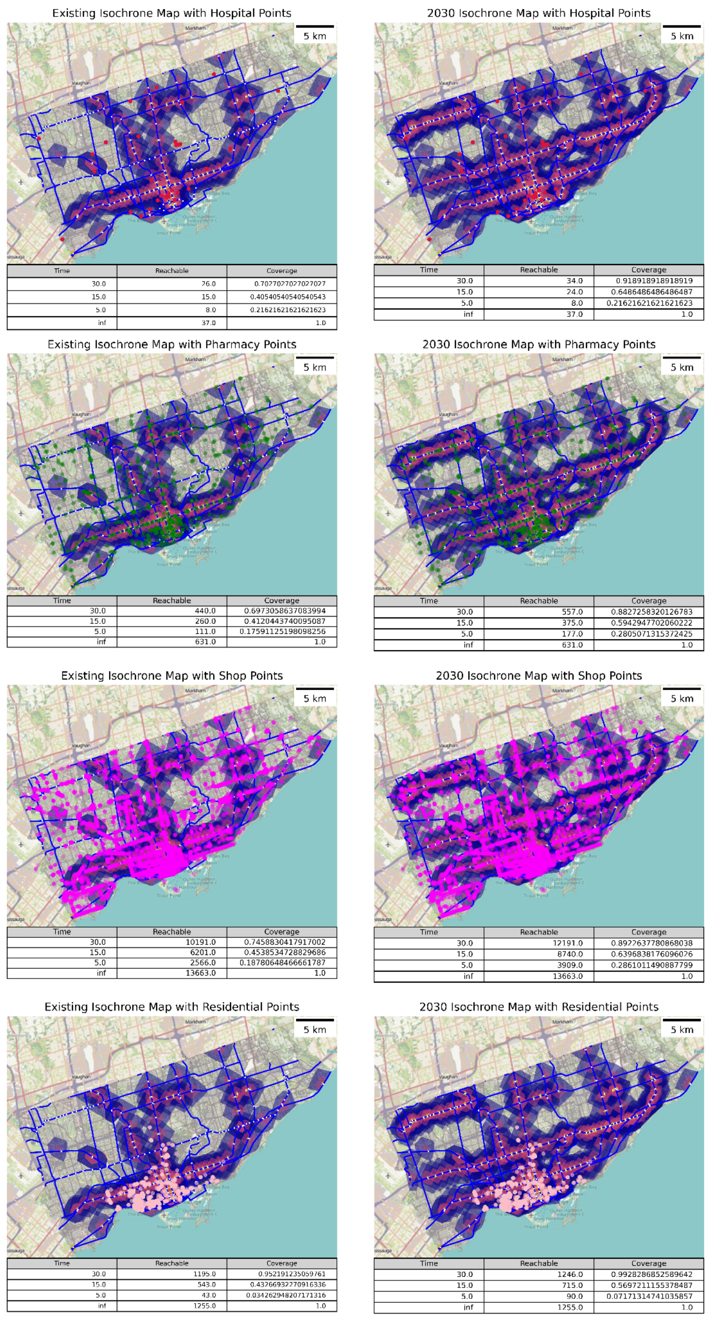
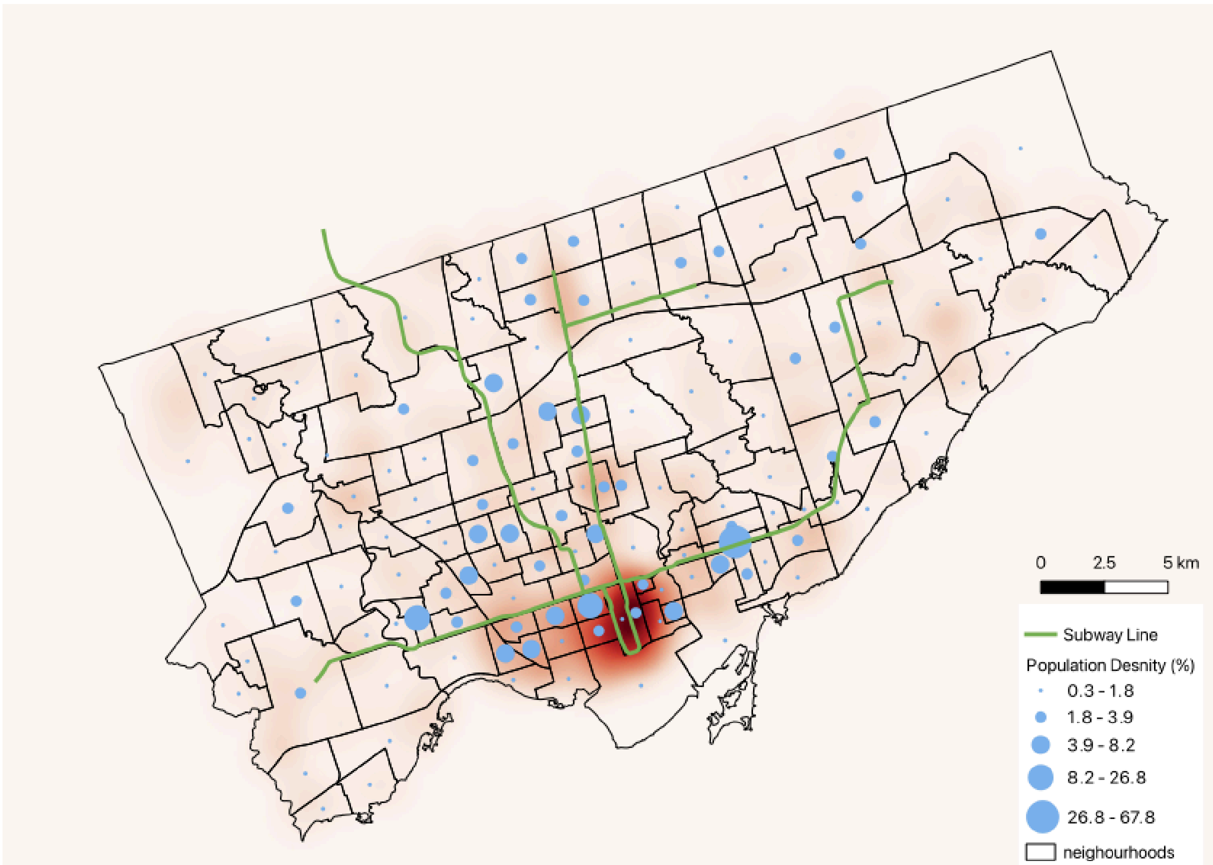
Figures

Figure 1)



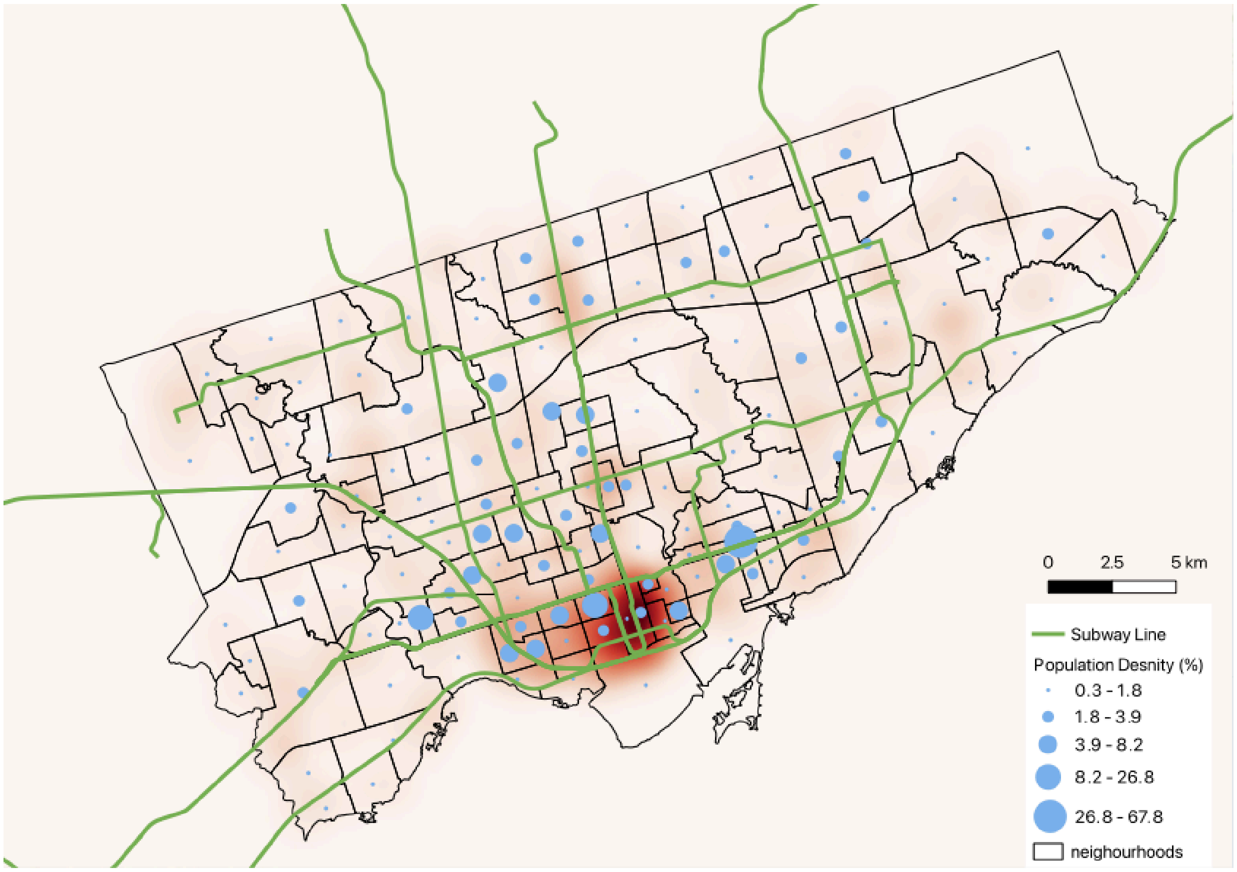
Isochrone coverage maps for respective points of interests. Tables included for coverage.

Figure 2



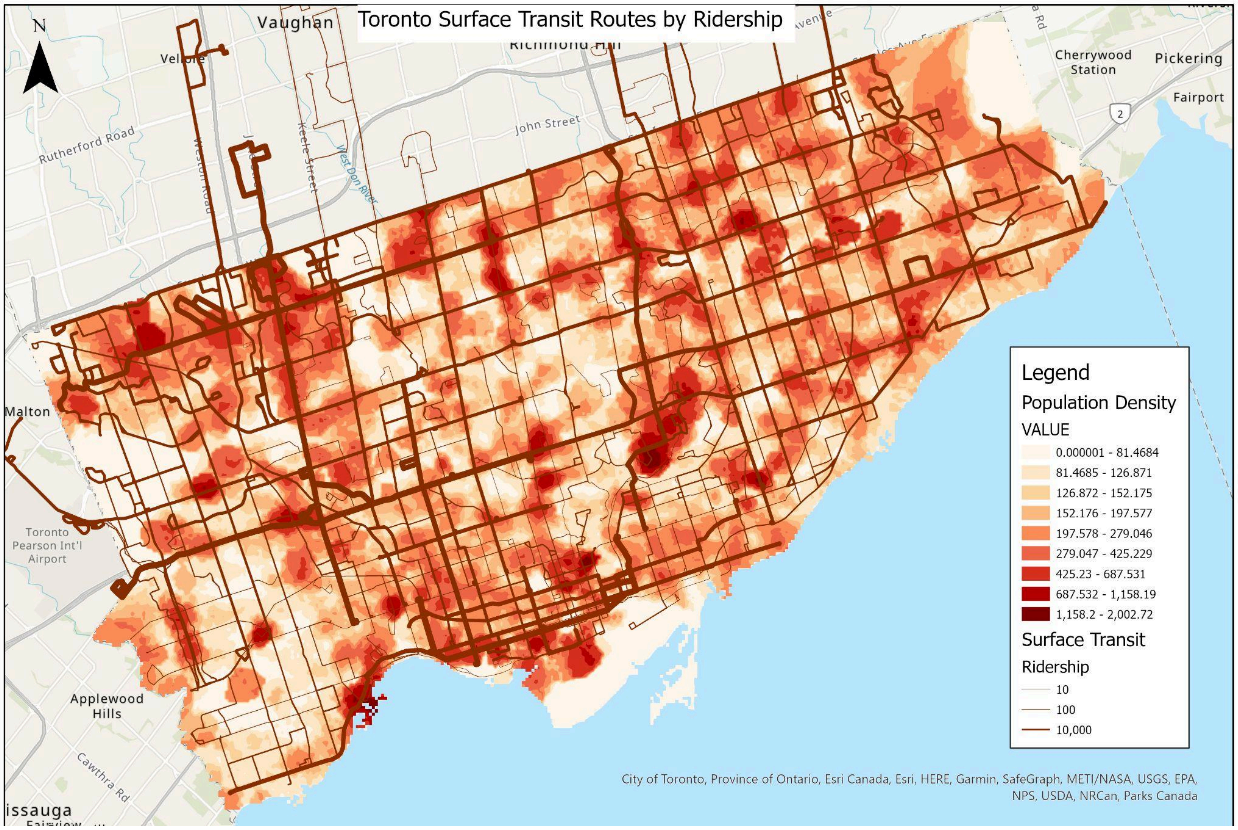
POI's heat map overlaid with population density and the current Toronto TTC network

Figure 3



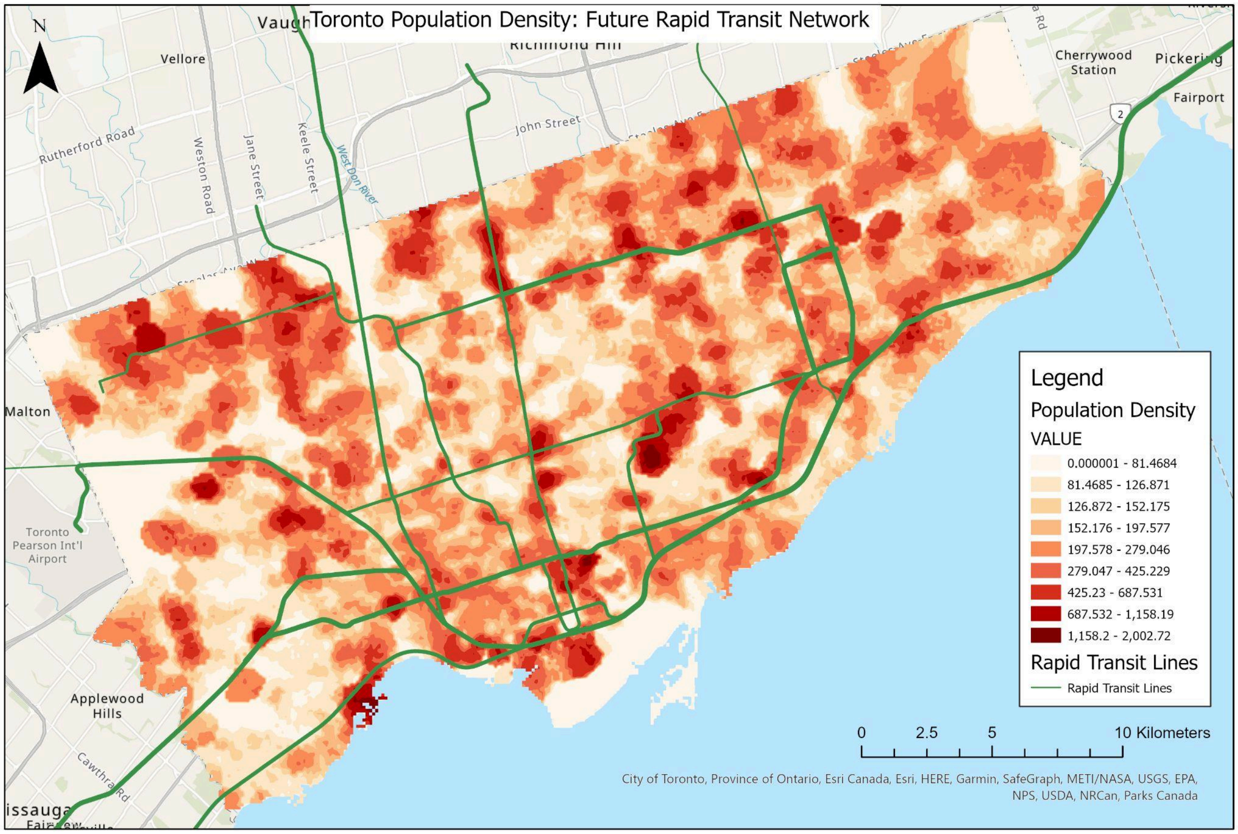
POI’s heat map overlaid with population density and the future Toronto TTC network

Figure 4



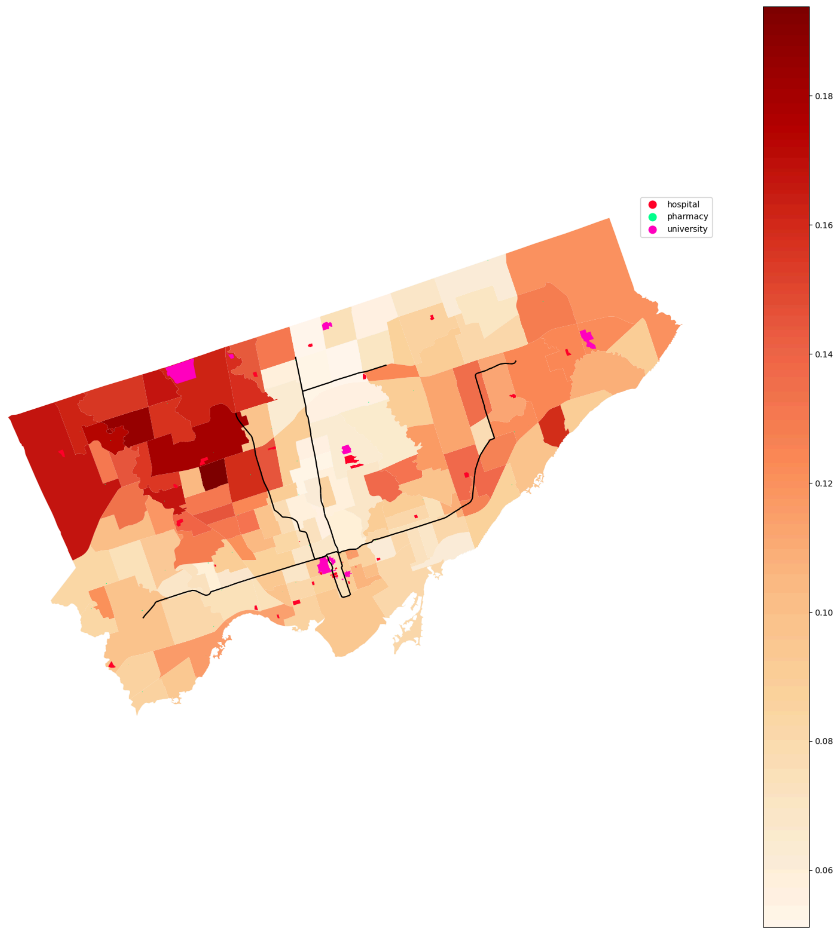
Heat Map Displaying Population Density Overlaid with Bus Transit Network

Figure 5



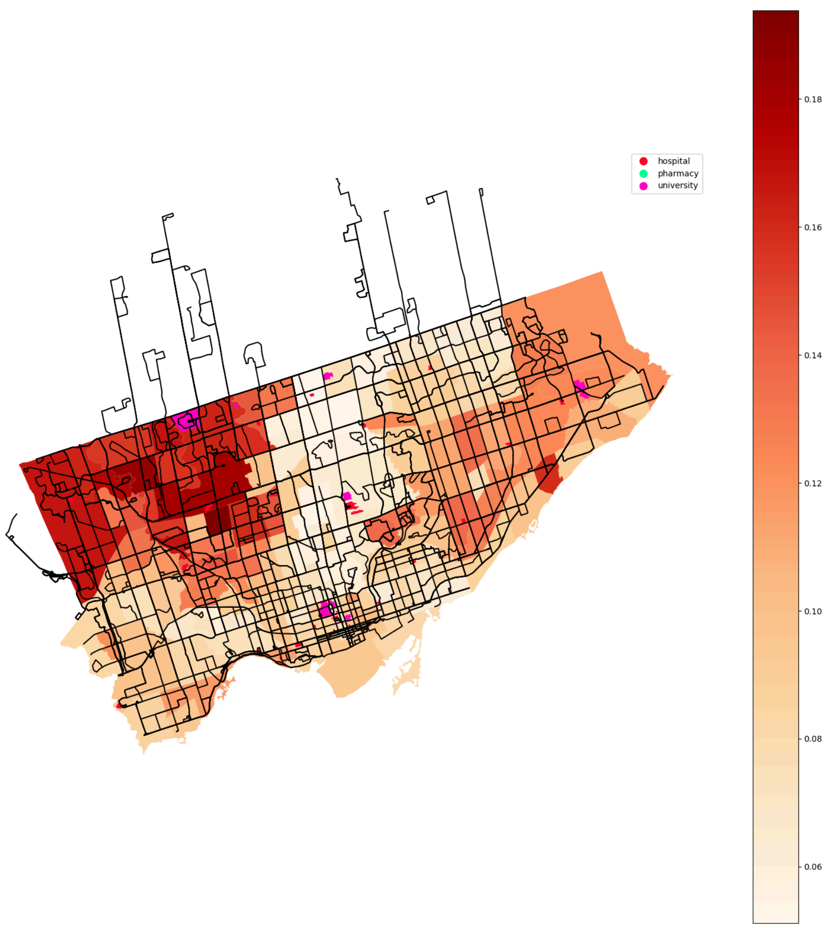
Heat Map Displaying Population Density Overlaid with Future Rapid Transit Network

Figure 6



Subway network, overlaid with healthcare and Universities POI alongside Covid-19 Infection Rate

Figure 7



Bus and Streetcar network, overlaid with healthcare and Universities POI alongside Covid-19 Infection Rate

Figure 8

Population Distribution for Year 1996

Population Distribution for Year 2021

Population Distribution for Year Estimated 2030

Top figure represents choropleth partitioned on neighbourhoods where colour gradient represents population count of 1996, **middle figure** 2021, and **bottom figure** represents choropleth on the same partition for estimated population of 2023. Data provided by Toronto Open Data.

Table 1)

Neighbourhood Name	1996	2001	2006	2011	2016	2021	Estimated 2030	Logistic	Increase from 2021
Waterfront Communities-The Island	14188	18526	26015	43361	65913	84990	125319	TRUE	1.474514649
Woburn	46483	51011	52461	53350	53485	53665	53638	TRUE	0.999496879
Willowdale East	20874	26996	41054	45041	50434	49435	51864	TRUE	1.049135228
Islington-City Centre West	30435	31431	32823	38084	43965	47060	56238	TRUE	1.195027624
Rouge	26105	28719	43191	45912	46496	45610	47957	TRUE	1.051458014
Malvern	41908	44030	44324	45086	43794	43415	44151	TRUE	1.016952666
L'Amoreaux	44290	45605	45862	44919	43993	43040	43219	TRUE	1.004158922
Church-Yonge Corridor	20229	21854	24379	28349	31340	40020	49461	TRUE	1.235907046
Mimico (includes Humber Bay Shores)	21897	24200	24973	26541	33964	39650	47981	TRUE	1.210113493
Downsview-Roding-CFB	34257	34249	32010	34659	35052	39390	39035	TRUE	0.99098756
Mount Pleasant West	20406	22836	23728	28593	29658	38620	46045	TRUE	1.192257897

A table of the top 10 most populated neighbourhoods in 2021 based on the 140 Neighbourhood model of Toronto. The logistic column indicates if the estimations were using a logistic curve fitting rather than linear. The increase from 2021 is the estimated population divided by the 2021 population.

Supplementary Materials

Github Repo

https://github.com/GGR473/toronto_poi_accessibility