

Should our city adopt a bicycle rideshare program?

# Bike Sharing Analysis

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## Introduction/Business Problem

Your mythical town board has asked you to help advise them on the feasibility establishing a bicycle ride sharing program in your community. They have received proposals from two vendors, and believe it would be wise public policy to offer such a program to help alleviate air pollution in the area. However, they wish to get a sense of how an existing program operates in another city of similar size, and what lessons might be learned to help decide if this should be a go-no go program.

**Among the questions for which the town board wishes information:**

- Is ridership widespread or concentrated in certain areas?
- Are most trips within a small radius or far-ranging?
- Are there any interesting demographic keys associated with ridership?
- For how long do riders rent their bikes?

- How prevalent is bike theft in the city?

This report intends to answer these questions by analyzing information from such a program in Toronto, Canada. Toronto is of similar size and of a similar climate and has had an active program for several years.

## **Data Analyzed**

### Primary Sources

[2018 Bike Share Ridership Statistics](#) Toronto's link to each of the 1.8 million trips taken in 2018. It also links to prior years, but only 2018 is used in this analysis. Source: City of Toronto Open Data Portal

[Toronto Neighbourhood Geodata](#) Mapping data showing the boundaries of all Toronto neighborhoods. Source: City of Toronto Open Data Portal

[Toronto Bicycle Thefts](#) Bicycle thefts in Toronto during 2018. Analysis will assist in assessing risk of bike share bikes being vulnerable. Source: Bicycle Thefts, Toronto Police Service, Public Safety Data Portal

[Geocoded list of Bike Share stations in Toronto](#) Lats and Longs were not readily available for the 270 bike share stations in Toronto proper, so this dataset was built by the author using Google Map's service. Geopy.geocoders.Nominatim was tried for this, but it was not working properly with the long list of station names. Source: City of Toronto Open Data Portal

[Toronto Neighbourhood Profiles](#) Demographic data for the official Toronto Neighborhoods. Data includes population, income and other data of lesser interest for this project. Source: City of Toronto Open Data Portal

[WellBeing Toronto](#) Population, Income, Education and Crime data by Neighbourhood. Source: City of Toronto

### Media Stories

[Despite losses, city set to pump more money into Bike Share](#) Source: Michael Smee - CBC News Posted: Mar 03, 2018 4:00 AM ET

[Bike Share Toronto gets \\$7.5-million expansion despite operating losses](#) Source: The Star, By Jennifer Pagliaro City Hall Bureau, Feb. 28, 2019

[Bike Share 2019 Expansion: 105 More Stations, 1,250 New Bikes](#) Source: Urban Toronto, Ryan Deberge, Mar. 01, 2019

### Websites

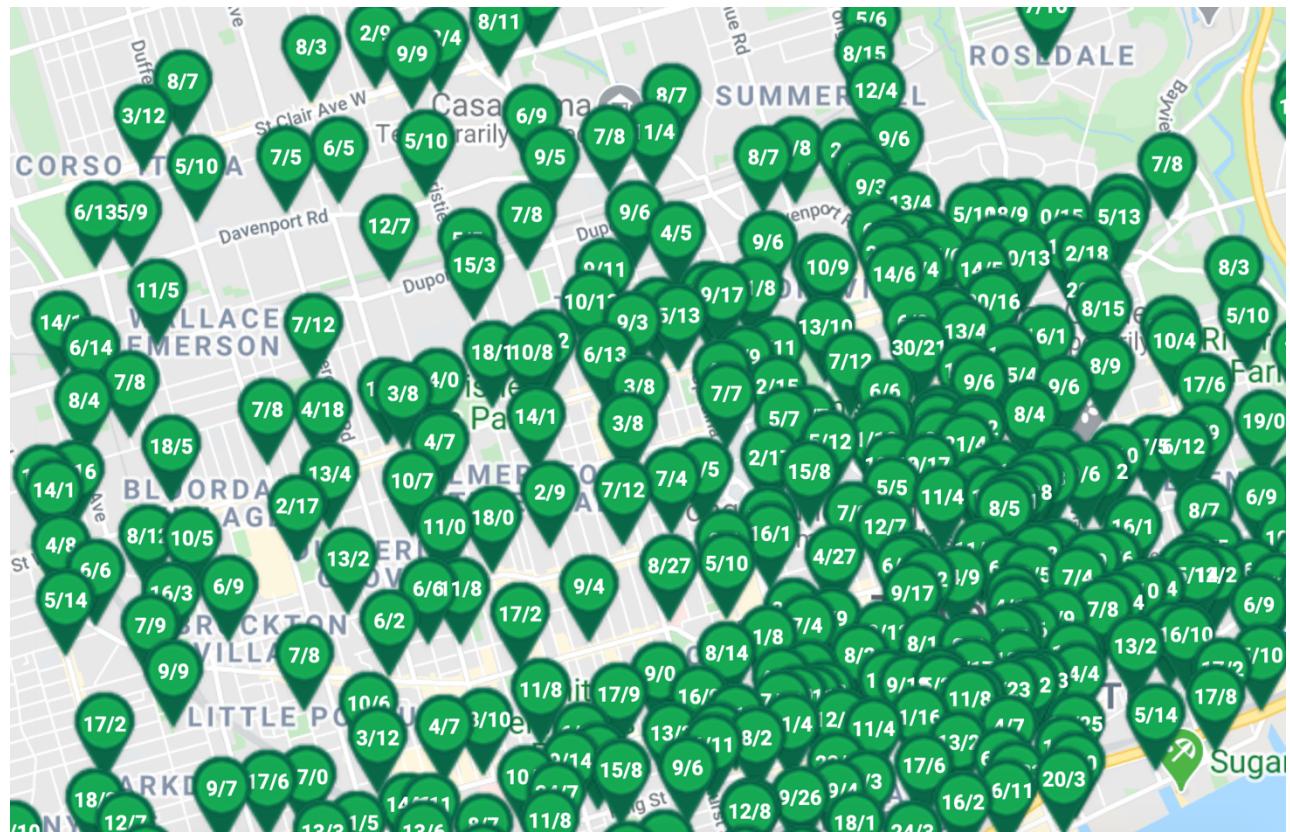
[Bike Share Toronto](#)

## Background on Toronto Bike Share Program

Toronto has had a bike share program for a number of years. Electronics has made it possible to maintain data on trip departures and arrivals by time and location. This analysis reviews over 1.7 million trips made in 2018 to and from 270 bike stations located around parts of the city. As mentioned, Toronto seemed a good location to analyze as it shared many of the characteristics as our mythical city and has detailed information available for analysis. According to news accounts, the program continues to grow even though it runs a deficit.

The purpose of the program as stated in the FAQ on its website, “Bike share was created for quick trips and getting from Point A to Point B. Rides are limited to 30 minutes to ensure bike availability for all riders to “share.” This encourages riders to use bike share for quick trips and return the bike to any station within 30 minutes.”

Each station has a certain number of locking stalls. This is a screenshot from their website which shows real-time availability of bikes and empty stalls by some of the stations:



Rentals can be controlled at a station kiosk or a phone app. The map allows you to see where there are empty stalls where a bike can be returned.

## The Five Questions To be Answered in this Report

Is ridership widespread or concentrated in certain areas?

Are most trips within a small radius or far-ranging?

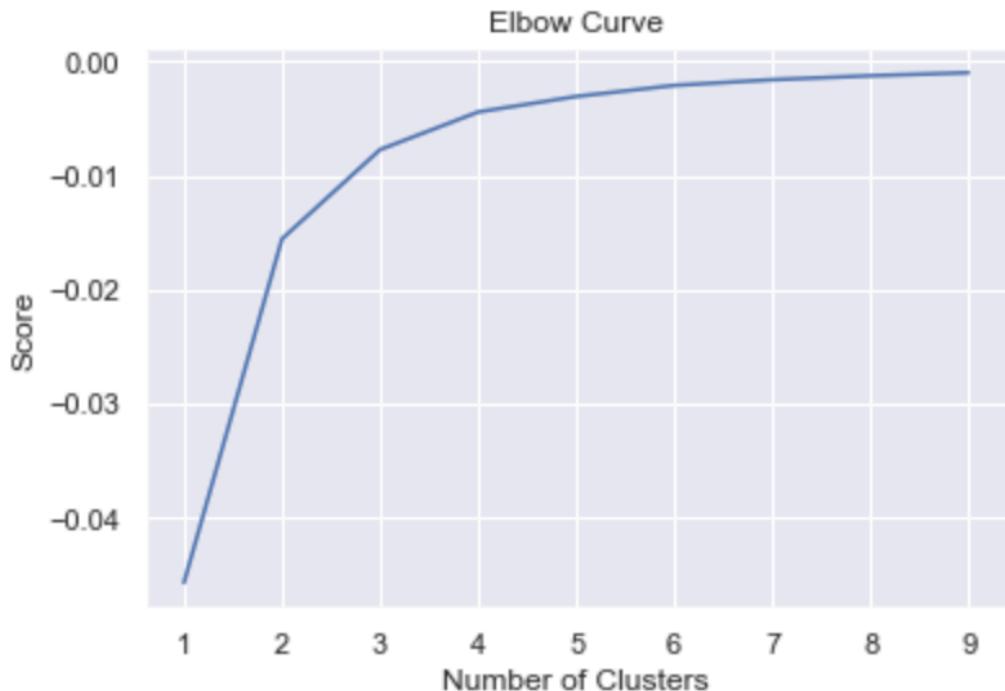
Are there any interesting demographic keys associated with ridership?

For how long do riders rent their bikes?

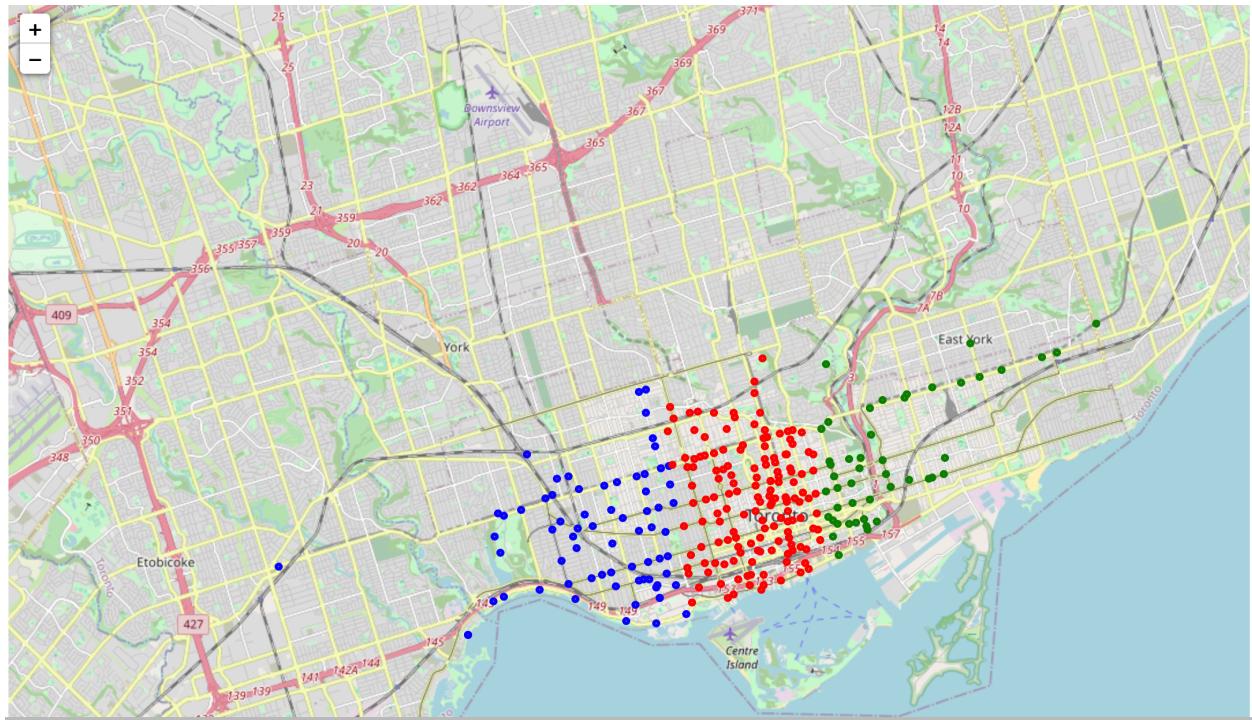
How prevalent is bike theft in the city?

## Methodology

The initial analysis of the data indicated there was an incredible amount of data to process, and it might not be in useful shape to evaluate trip characterizations. It was decided to do a K-Means test on the data to see what might be the optimal number of clusters in which to place the 270 bike stations for trip analysis. The generated elbow curve suggested three clusters would be optimal.



The model generated the three groups based on the geocodes of each station. These geocodes were not readily available, so each station name was run through the Google Maps API. All 270 stations returned geocodes. As a result, each station could be mapped and assigned to a group.



Cluster 0 is represented by the red dots, which mainly represents the downtown part of Toronto. Blue dots are Cluster 1, and green dots are Cluster 2. Once the station and trip datasets were both geocoded, much of the cleaning was done. Time to answer the five questions.

## Is ridership widespread or concentrated in certain areas?

To answer this question, the data was stratified by cluster, after grouping the data by the “to cluster code” and the “from cluster code”. Here are couple of findings:

- Over 1.3 million trips in 2018 took place within a single cluster out of a total of 1.7+ million total trips.
- Downtown trips were far and away the most taken.

The chart that demonstrates the findings is here.

## Trips To, From and Within Clusters

to_cluster_label	from_cluster_label	
0	0	1022538
	1	153748
	2	102139
1	0	157826
	1	103604
	2	13515
2	0	105774
	1	14380
	2	43512

Are most trips within a small radius or far-ranging?

## Unique Routes Travelled in 2018

from_station_name	to_station_name	
Bay St / Queens Quay W (Ferry Terminal)	Bay St / Queens Quay W (Ferry Terminal)	3697
Humber Bay Shores Park West	Humber Bay Shores Park West	2232
Bathurst St/Queens Quay(Billy Bishop Airport)	York St / Queens Quay W	2034
Front St W / Blue Jays Way	Union Station	1997
York St / Queens Quay W	York St / Queens Quay W	1997
	...	
Mortimer Ave / Coxwell Ave	King St W / Spadina Ave	1
King St E / Jarvis St	Kendal Ave / Spadina Rd	1
Wright / Sorauren (Sorauren Park) - SMART	Queen St E / Sackville St	1
Mortimer Ave / Coxwell Ave	King St E / Jarvis St	1
John St / Mercer St - SMART	Parliament St / Bloor St E	1
Length: 57648, dtype: int64		

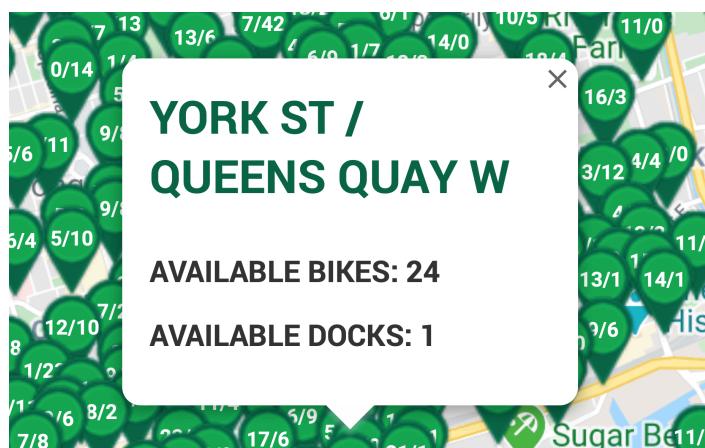
- Over the course of 2018, 57,648 unique trip routes were recorded.
- The top two routes ended where they began, as did three of the top five.
- The top five routes represent one out of six total routes.

Another interesting piece of the analysis relates to the total number of trips to specific destinations. This chart will show the top five destinations during the course of 2018.

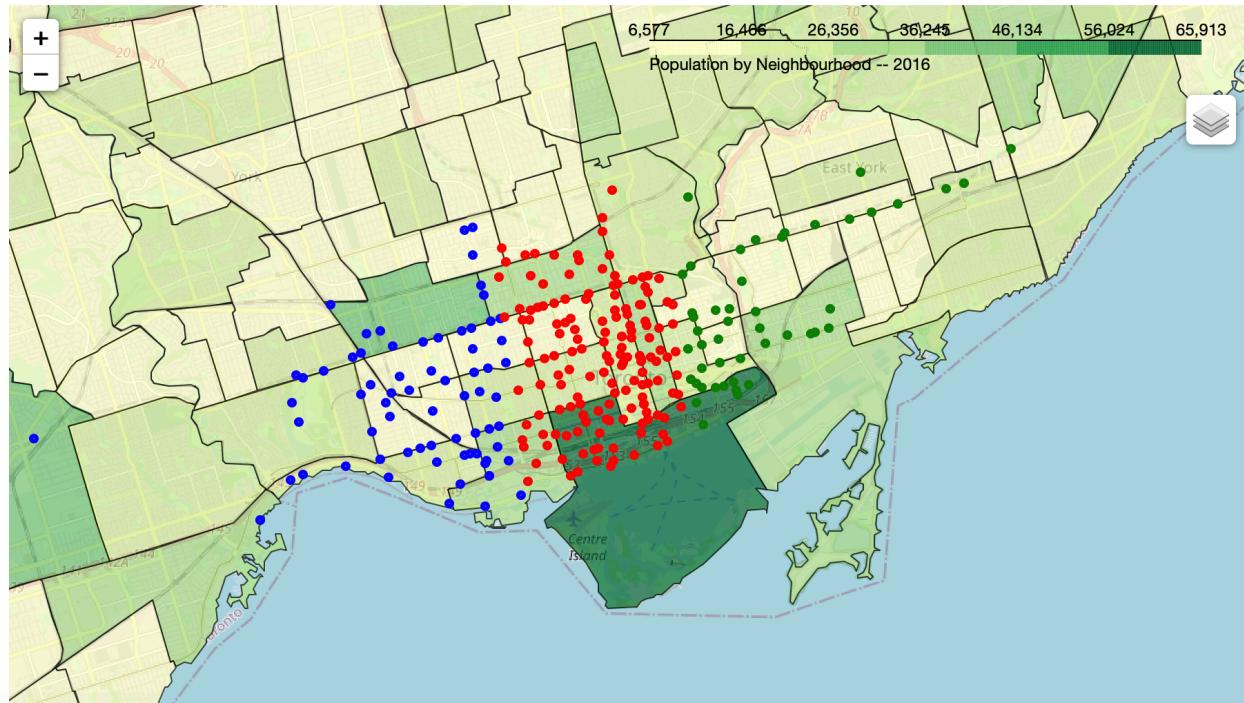
## Top Five Destinations

<b>Popular Destinations</b>	<b>Trip Length</b>	<b>Minutes</b>
<b>to_station_name</b>		
<b>York St / Queens Quay W</b>	25060	1514.277534
<b>Union Station</b>	24843	767.342752
<b>Bay St / Queens Quay W (Ferry Terminal)</b>	23733	2787.766359
<b>Princess St / Adelaide St E</b>	18942	721.300443
<b>Dundas St W / Yonge St</b>	18267	827.349318

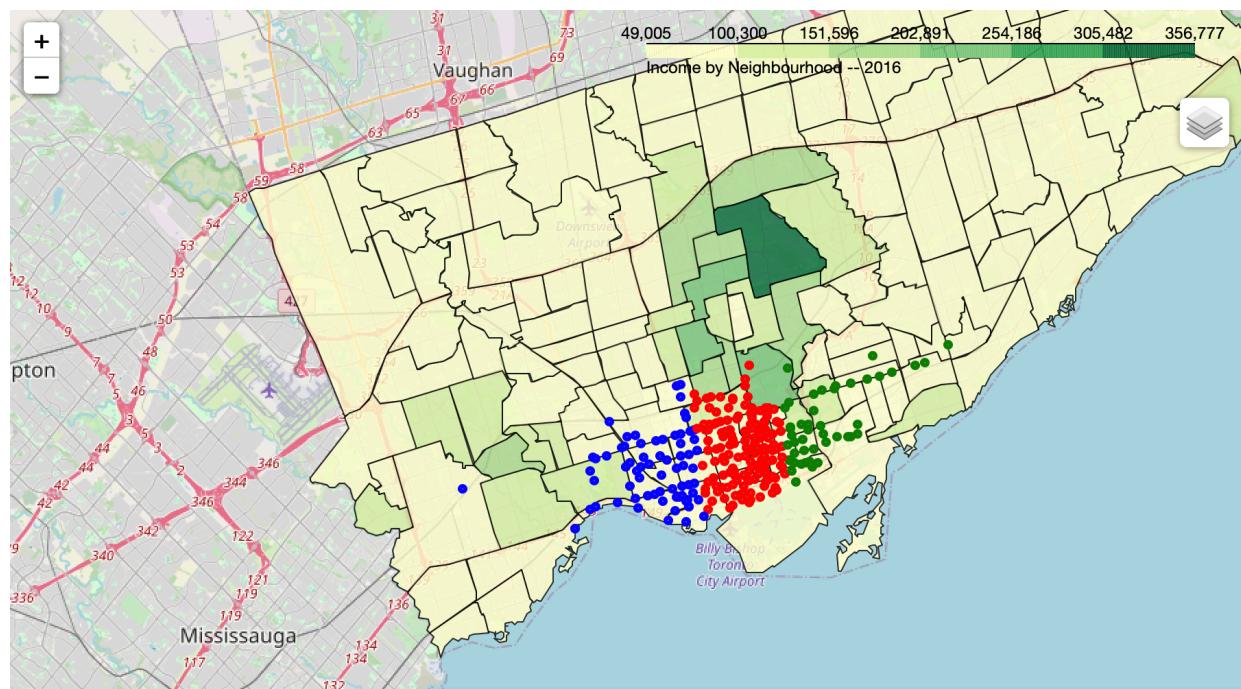
Here Trip Length is the average trip time to reach the destination measured in seconds, which is how it is tracked in the dataset. Minutes is simply the data conversion. For York St / Queens Quay Way, that's about 70 arrivals per day. This particular station has 25 docks.



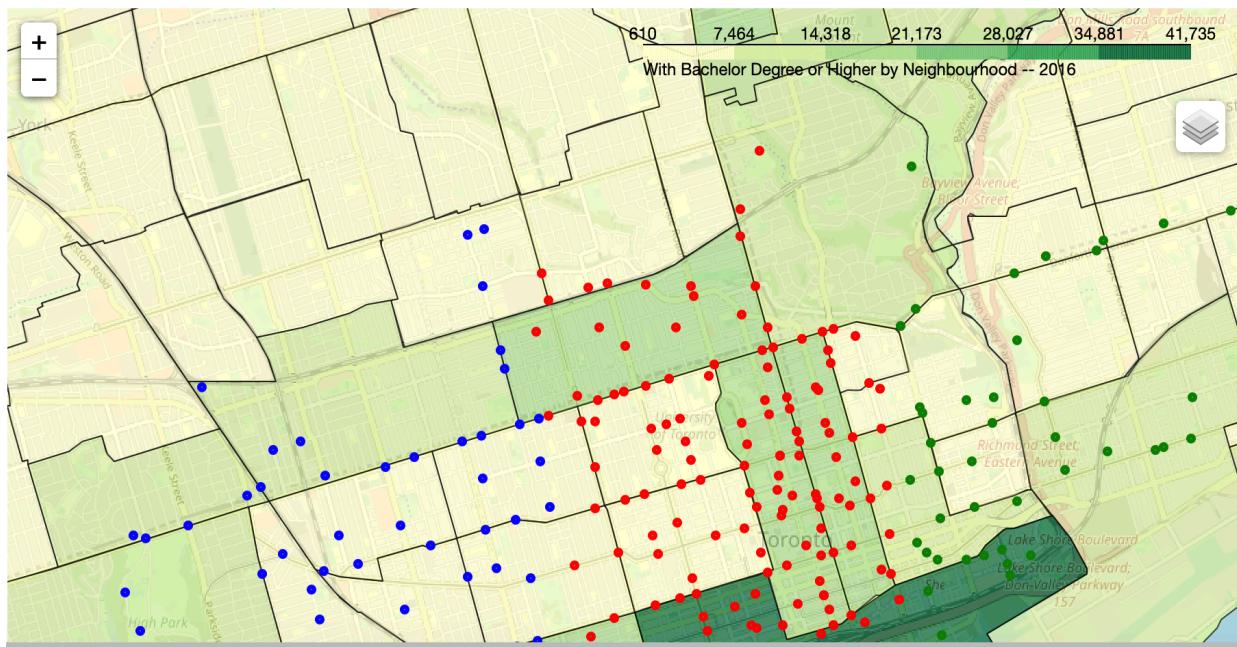
## Are there any interesting demographic keys associated with ridership?



Choropleth of Population by Neighbourhood



Choropleth of Average Family Income



Choropleth of College Graduates by Neighbourhood

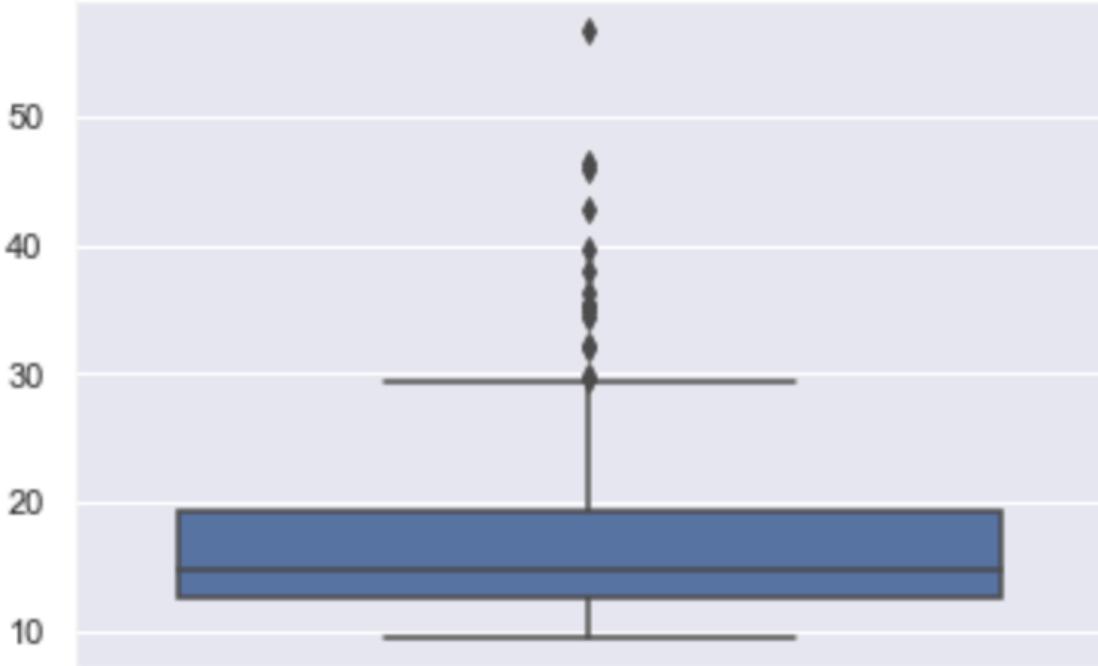
Three neighbourhood demographic statistics were compared to the locations of bike stations to see if anything appeared to be an influential demographic, either in terms of station location or ridership. High volume stations like York St / Queens Quay and Union Station fall in neighbourhoods with higher populations and more college graduates, but wealthier neighbourhoods trend mostly north of where stations are located. None of these findings seem surprising.

## For how long do riders rent their bikes?

This question well frames the policy the city of Toronto has laid out for its bike share program. The following can be found in a FAQ on their website:

“Bike share was created for quick trips and getting from Point A to Point B. Rides are limited to 30 minutes to ensure bike availability for all riders to “share.” This encourages riders to use bike share for quick trips and return the bike to any station within 30 minutes.”

The requirement that a bike be re-docked within 30 minutes under penalty of fees beyond the price of a second rental seems to mesh with rider behavior.

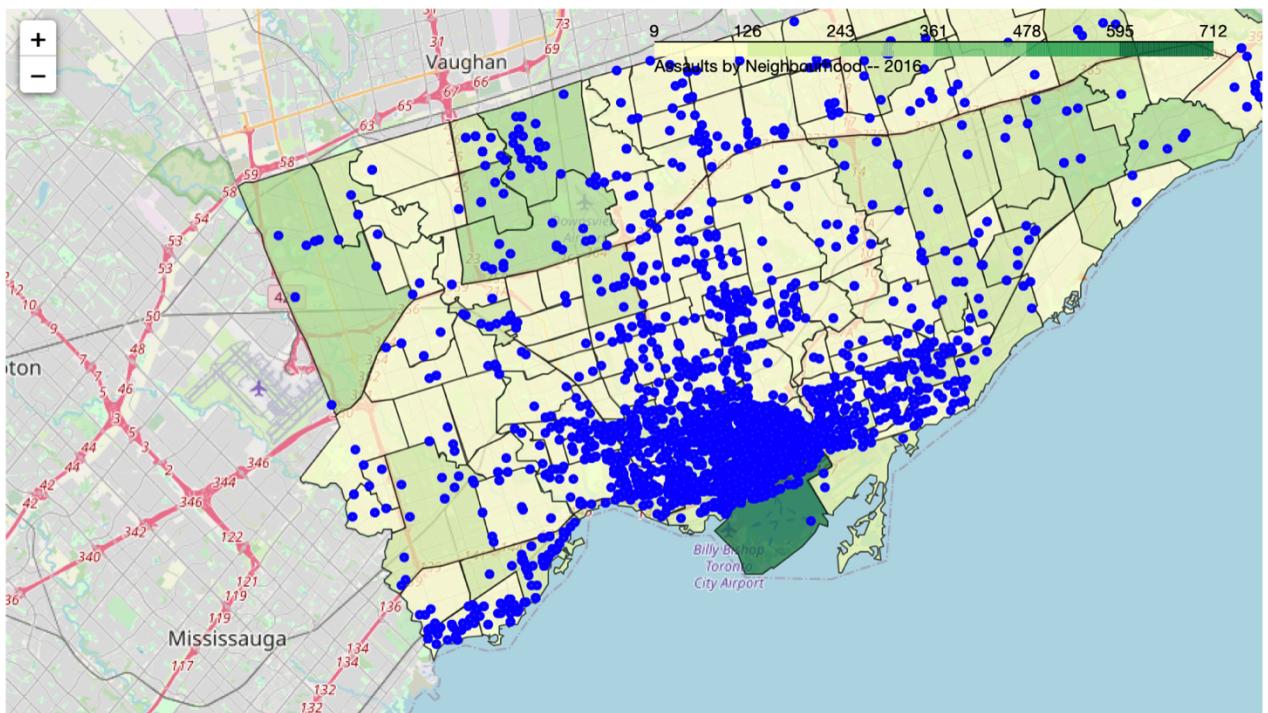


## Ridership by Rental Duration (Minutes)

Seventy-five percent of all rentals were of 30 minutes or less. Almost all rides were of 50 minutes or less. Because the program requires re-docking, there is a degree of control over asset dispersion. There have been other bike rental programs that allowed riders to leave their bikes anywhere once they were finished. This led to some ill-will when bikes were strewn all over the neighbourhood. The Toronto program, by having re-docking requirements, alleviates this problem. The tricky part is to find a stall before your time is up, if traveling to a different station than the one you started from. Fortunately, the website has a map showing available stalls by station. As the chart shows, most rides are of a duration of 20 minutes or less, which would seem to indicate the bikes are being used for their intended purpose.

## How prevalent is bike theft in the city?

As a responsible program operator, you need to take steps to ensure the well-being of your customers, and safekeeping of your assets. It is important to remember that riders frequently have to walk to a station, and the placement of stations in a way that minimizes things like assault risk is important.



## Crime in Toronto

### Bike Theft Overlay (2018) on Assault Rates by Neighbourhood (2016)

The bikes used by the Toronto program cost \$1,100 apiece. Minimizing the risk of theft of these bikes should be a management priority. The *Crime in Toronto* map shows there is a greater concentration of bike thefts and assaults in the same area where there is a higher concentration of ridership. This would suggest higher rider and management vigilance. The locking stalls likely act as a deterrent to theft. It is doubtful it has any effect on vandalism during hours when ridership would be considered very low and no one would be around the station.

# Results

As a refresher, these are the five questions in search of answers:

Is ridership widespread or concentrated in certain areas?

Are most trips within a small radius or far-ranging?

Are there any interesting demographic keys associated with ridership?

For how long do riders rent their bikes?

How prevalent is bike theft in the city?

**Answer 1:** Ridership is mostly concentrated within clusters identified during the analysis, with most rides starting and ending within the same cluster, and downtown trips being the most concentrated.

**Answer 2:** With over 59,000 combinations of trips taken between different stations, there are a lot of different ways Toronto riders chose to arrive at a particular destination. However, the top five destination locations represent one in six total destination locations and concentrate downtown.

**Answer 3:** Demographic data on population, income and education were considered as predictors of the location of stations. Nothing proved surprising. Higher population and well-educated neighbourhoods were found downtown where there is higher ridership, and few stations have been located in higher income neighbourhoods.

**Answer 4:** Most rides are shorter than city-mandated 30-minute limit. In fact, most riders get to where they're going in 20 minutes or less.

**Answer 5:** Crime is an issue in Toronto as it is everywhere else, and it appears crime corresponds to areas with people and things. Bike Share Toronto seems to have taken some steps to help protect its riders and bikes, with measures such as station siting and a locking stall system.

# Discussion



The above chart lists some of the questions and observations the board may want to consider before moving ahead with this project.

**Data:** There was sufficient data available to do this analysis and the results were interesting. There was little to any missing information from the data analyzed which made the analysis easier. However, this analysis might have been more informative by analyzing some additional factors, such as time of day ridership, ridership by day of the week, and weather's influence.

**Policy:** It's easy to say, "Hey, Toronto has a program like this, so why don't we?". Committing to a program like this will require an investment of people, time and money. While the optics are good for a program like this, it is still important to ensure sound management, good neighbourhood relations, monetized benefit demonstration of things like pollution reduction that counterbalance likely operation deficits, and good program design.

Toronto's program has continually run a deficit and relies heavily on funding from provincial and federal funding. In 2018, each ride was subsidized to the tune of \$1.14.

The program began as a privately-run business called BIXI in 2011, and was taken over by the city in 2013. A private sponsor helped with the program for a while before pulling out, so it is likely the city will have to manage the program.

**Intangibles:** Any program that involves neighbourhoods needs their support. If stations attract undesirable elements, or stations become eyesores, then the program will have a harder time achieving acceptance.

See media links for sourcing of some statistics.

## Feasibility

- Identify subsidy sources
- Environment v. Expenditure

## Accessibility

- High Density Areas to Start
- Right Place, Right Time

## Desirability

- Public perception
- Rider motivation

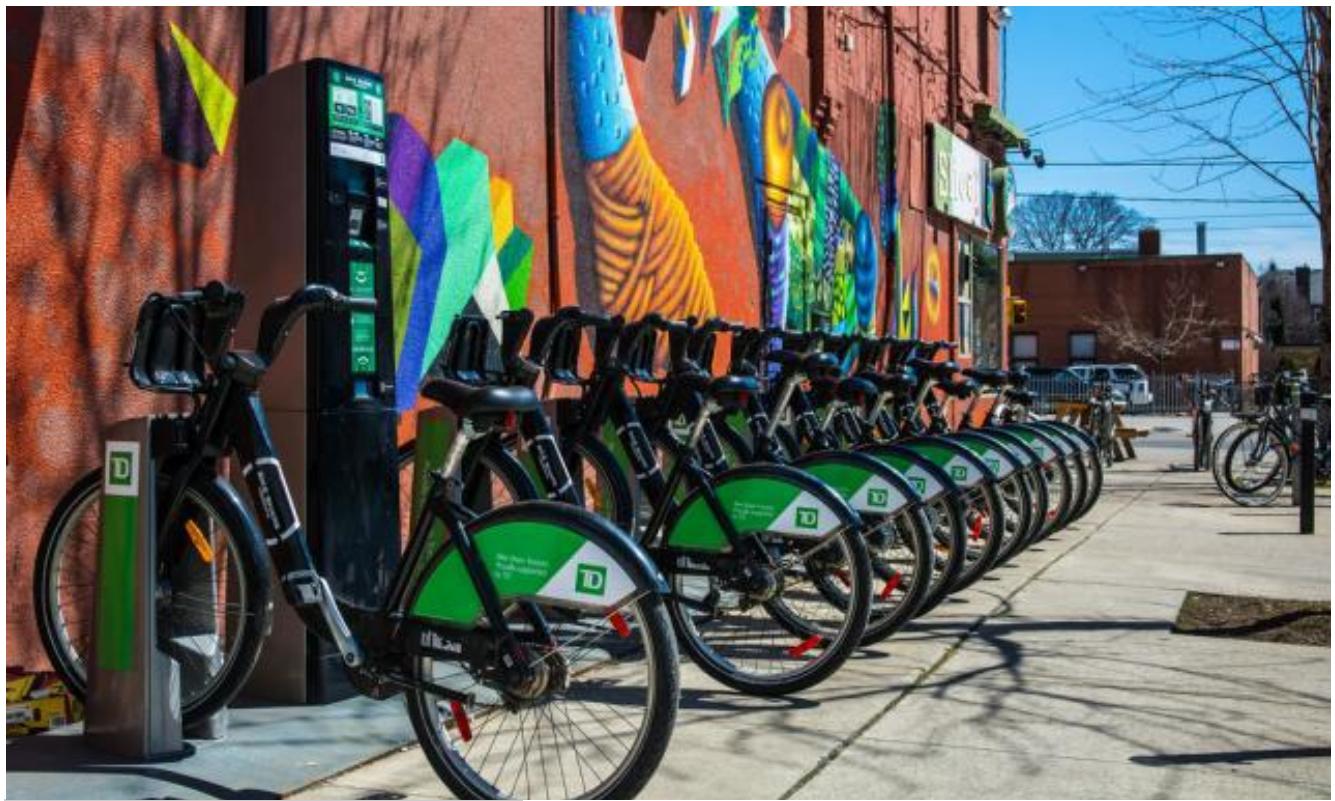
## Conclusions

**Feasibility:** The Toronto program has been around for a number of years, and appears well-managed, and ridership has grown every year. Still, it runs deficits of around \$400,000 a year and relies heavily on other government sources for funding. Toronto believes it will need four million trips a year to break into the black. The board will likely face similar challenges. It should also consult with the state environmental agency to identify how much the total bike miles ridden displace pollution emissions every year. This would be a good talking point for the city.

**Accessibility:** To show early success, the board should locate its first wave of stations in the downtown area where ridership is likely to be the heaviest. A well thought out station location system will help with public acceptance by ensuring there are some stations that always have too many bikes, and those that never have any.

**Desirability:** Programs need constituencies. The board will have to exercise oversight into the development of a program the public views as a positive for the community, and potential riders see as a viable alternative to other public transportation modes, such as subways and busses.

**Happy Riding!**



A bike station, image courtesy of Biking Toronto