Combining Mass Rapid Transit and Active Transportation for Physical Activity Promotion

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Executive Summary

Active transportation percentages in Canada are very low. Driving has the advantage of direct transportation from home to destination, but often the disadvantage of traffic congestion and parking. Public transit, including light rail, subways, and bus rapid transit are often undeterred by traffic congestion. However, there are often multiple legs to a trip (e.g., walking to a bus stop, waiting for a bus, travelling to a station), which make transit use longer than driving. Cycling to transit stations to replace the local bus portion of trips, may reduce some of the trip time and increase physical activity levels.

The purpose of this analysis was to compare travel distance and physical activity amounts attained from point-to-point travel by automobile, public transit only, bicycle only, and bicycle to public transit to downtown areas in select Canadian cities.

Methods

Six cities were chosen (Ottawa, Montreal, Toronto, Vancouver, Edmonton, and Calgary). Two stations were selected for each city. Each station was selected based on distance from the city center and proximity to a transit station. The downtown destinations selected were either art galleries or libraries as generally accessed public spaces in each city. Twenty five street addresses were randomly selected within a 5km buffer around the two stations. Commute times and distances to the downtown central business districts were calculated. All of the code are available for the analysis https://github.com/walkabilly/phac_routing.

Results

On average across all modes the trip duration was 48 minutes with a mean distance of 22.2km. On average, car trips were the fastest at 30 minutes with a mean distance of 22.1km. The next fastest trip mode was cycling to transit with an average time of 36 minutes and distance of 25.3km. Transit and cycling the entire distance had similar times with average travel times of 72 minutes. Cycling to transit would represent an 18 minute per day bicycle commute. That 18 minutes per day, 5 days per week to and from work, would contribute 180 minutes of weekly physical activity. This would represent 120 percent of the recommended 150 minutes of physical activity per week.

Discussion

This analysis examined trips across 6 large Canadian cities and the results suggest that cycling to transit is an excellent means to include more physical activity into the day as well as significantly reduce commute times for non-drivers. On average, cycling to transit adds 6 minutes (30 minutes by driving compared to 36 minutes cycling and using transit) to the time of a commute compared to other modes, including driving the entire trip. In many cases, cycling to transit is very competitive to driving and is usually the second fastest form of travel, usually faster than transit only trips.

Introduction

Active transportation (AT) is one of the four domains of physical activity and is associated with higher levels of total physical activity. Consequently, it is an important behaviour to target for health promotion and chronic disease prevention. AT is particularly attractive as a target for physical activity promotion, given that individuals generally travel to various destinations throughout the day. By replacing sedentary forms of transportation (such as motor vehicle use) with active forms of transportation (such as cycling or walking), Canadians can increase their physical activity levels. Moreover, walking and especially cycling for transportation are often carried out at intensities of physical activity (i.e., moderate-to-vigorous intensity) that contribute towards meeting the physical activity recommendation from the Canadian 24-Hour Movement Guidelines.

Typically, people opt for active modes of transportation for travelling shorter distances (i.e. to and from a local shop or public transit stop). Using origin-destination survey data in Montreal, it was found that the 85th percentile of trip distance for walking to various destinations was under 2 kilometers, and for cycling it was less than 6.5 kilometers (Yasmin, F. et. al., 2010, Larsen J, 2010). This is an important consideration for the promotion of AT. Although within smaller cities, large portions of the population live within these distances of frequently visited destinations, in larger cities, there are often substantial numbers of residents living much further from these destinations in the central business district (CBD). Promoting AT to cover large distances is unlikely to be successful if the messaging suggests that they should walk or bike the entire trip. However, many recent investments in Canada have been made to expand mass rapid transit (MRT) systems (including subways, light rail and bus rapid transit). This expansion has brought higher speed transit and stations closer to suburban neighbourhoods and is often faster than the stop and start nature of typical bus routes.

In many countries with more mature MRT systems, it is common to see bikes parked at transit stations with commuters continuing their journey by bus or rail. Theoretically, such transportation choices are becoming increasingly available to more Canadians as new commuter rail, subway, Light Rapid Transit, and Bus Rapid Transit become available in large Canadian cities. Some of the supporting infrastructure of secure bike parking and easy walking and cycling sidewalks and bikeways to make such trips safe and comfortable for users of all ages and abilities are not yet available. However, those infrastructure expenses are a fraction of the cost of the MRT projects themselves and could be added if AT to transit was a competitive mode of travel from a time perspective. Therefore, a key question to consider before developing policy aimed at getting people to use more AT, is how do trips incorporating AT to MRT compare to those completed entirely by car and/or entirely by transit? To determine this, it is important to understand how the duration of trips to MRT by walking or cycling compare to trips taken entirely by transit or entirely by driving.

Driving has the advantage of direct transportation from home to destination, but often the disadvantage of traffic congestion and the costs of operating a vehicle and parking. While MRT is often undeterred by traffic congestion, there are often multiple legs to a trip, e.g. walking to a bus stop, waiting for a bus, travelling to a MRT station, which can make transit use a longer trip than driving. However, by investigating the potential of taking AT to the MRT to replace the local bus portion of trips, we may see that this can reduce some of the time taken by some of the legs of the trip in cases where individuals can walk to the station, or cycle to it from a few kilometers away, and increase physical activity levels.

Objective

To compare travel distance and physical activity amounts attained from point-to-point travel by automobile, transit, cycling, or cycling to transit, to a specific location in the CBD (e.g., central library).

Methods

All of the code and a detailed read me file are available for the analysis https://github.com/walkabilly/phac_routing. Sufficient detail is provided to replicate the analysis. This work used the Google Route API implemented in the googleway R package to compare travel time, travel distance, and estimated physical activity contribution of trips from 25 randomly selected street addresses within a 5km buffer of these two stations to the downtown central business districts (CBD) of 6 major Canadian cities. The Google Routing API for bicycles assumes pedal bikes (rather than e-bikes) and creates routes using both roads and cycleways (https://developers.google.com/maps/documentation/routes/reference/rest/v2/RouteTravelMode). The modes of transportation used for the trip calculations were:

- Transit Only
  - Time and distance calculations include walking to and from stations
- Cycle only
  - Assuming a pedal bike and not a e-bike
- Cycle + Transit
  - Cycle to main station and transit to destination
  - Assuming a pedal bike and not a e-bike
- Drive

A full data dictionary for all data is available here: https://github.com/walkabilly/phac_routing/blob/main/data_dictionary.xlsx

Origin - Station Selection

Each station was selected based on distance from the city center, proximity to a transit station, and discussion with staff at PHAC. This was not an exact science but meant to represent a selection of 2 stations per city to provide a sense of travel times and distances for different modes of transportation. The selected stations are as follows:

1. Ottawa
   - Blair Station
   - Barrhaven

2. Montreal
   - Brossard Station
   - Rivière-des-Prairies Station
3. Toronto
   - Vaughan Metropolitan Centre Stations
   - Scarborough GO Station
4. Vancouver
   - Surrey Central Station
   - Bridgeport Station
5. Edmonton
   - Heritage Valley Station
   - Nakî Transit Centre & Park and Ride
6. Calgary
   - North Pointe Transit Terminal
   - McKenzie Towne

Destination - City center

Destinations were selected for each city. Each destination was either a major Art Gallery or Library located in the CBD of each city. These locations were selected because they are public, are located downtown, and draw considerable numbers of people. The destination locations are as follows:

1. Ottawa
   - National Gallery of Canada
2. Montreal
   - Musee d'art contemporain de Montreal
3. Toronto
   - Art Gallery of Ontario
4. Vancouver
   - Vancouver Art Gallery
5. Edmonton
   - Edmonton Public Library - Stanley A. Milner Library
6. Calgary
   - Calgary Public Library - Central Library

Buffer and Home Selection

For each origin at a station, a 5km diameter buffer was drawn around the station. Within that 5km buffer, 25 points (i.e.., latitude and longitude coordinates) were randomly selected using a seed to ensure reproducibility. A different seed was used for each station. Below is an example of the buffer and 25 points selected for the Ottawa Barrhaven Station.

Figure 1. 5km buffer around Barrhaven Station in Ottawa.

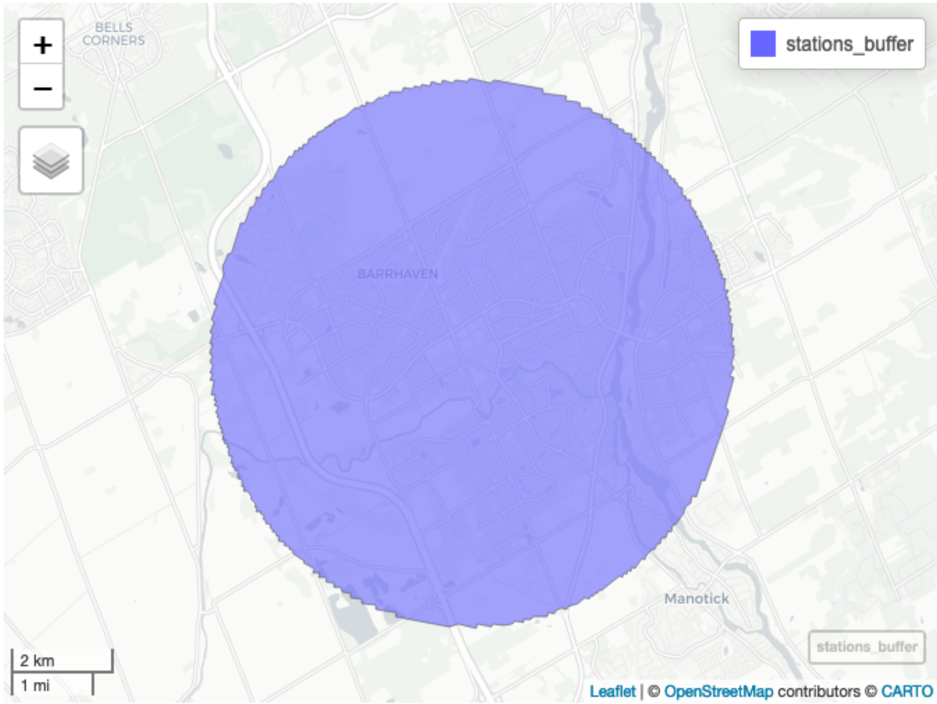
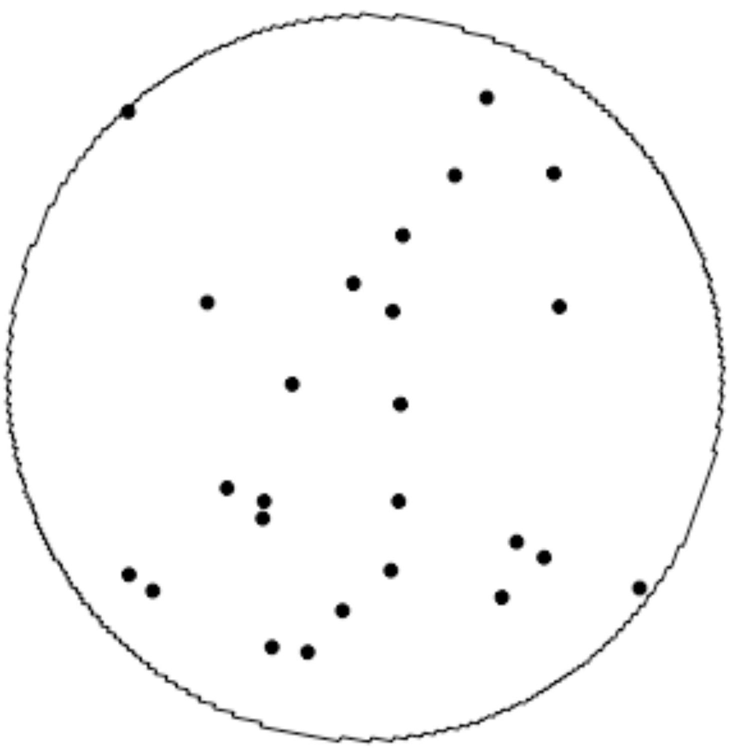
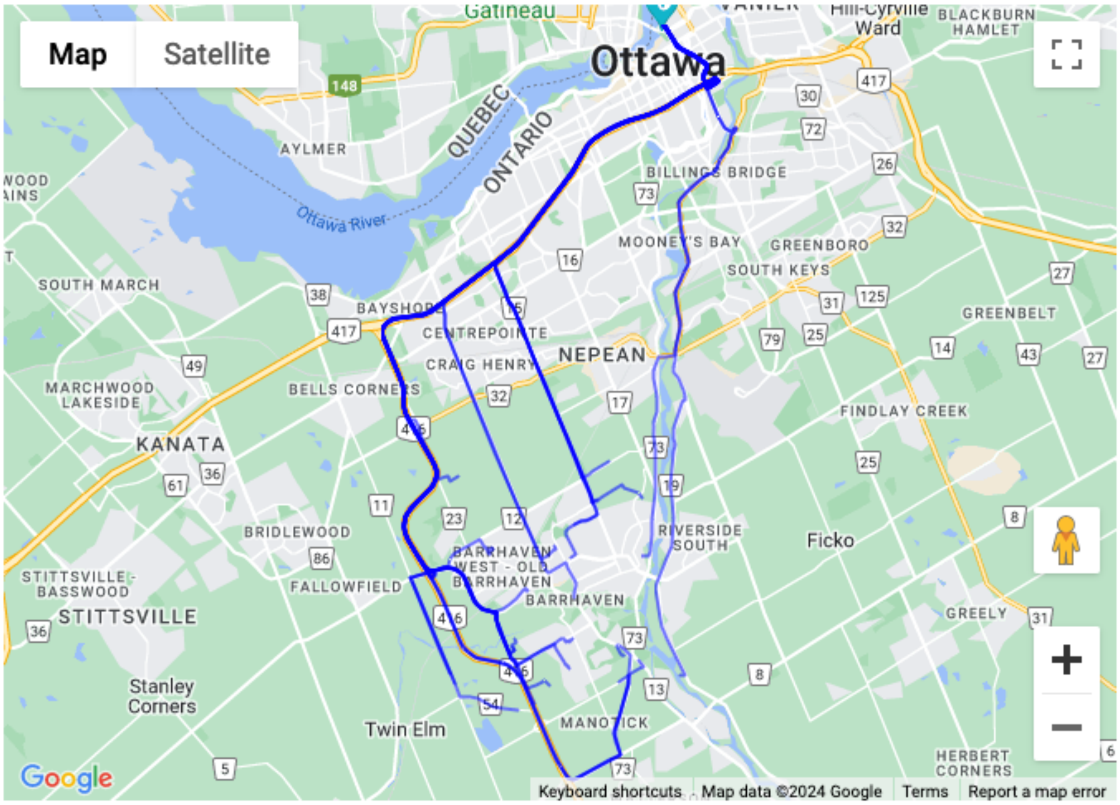


Figure 2. Randomly selected points within the 5km buffer around Barrhaven station.



For each trip type (i.e., Transit Only, Bike, Bike + Transit, and Drive), the `googleway` R package was used to generate trips from the randomly generated points to the destination. All trips were scheduled to arrive at the destination at 8:30am on either Tuesday June 11th or Tuesday June 25th. For the Bike + Transit trips, two trips were generated. First, a trip from the randomly selected point to the station of interest by bicycle, then a trip from the station of interest to the destination by transit.

Figure 3. Googleway transit routes from randomly selected points to destination.



Once all of the routes were calculated the travel time and travel distance elements were extracted from each trip type and each route and organized into a tidy dataset. On average there were 25 routes per trip type, however, on some occasions some routes failed to geocode. Table 1 presents the city, station, and trip type sample sizes for all cities.

Figure 1. Number of observations per station

Station	Number of observations
Barrhaven Center Station, Ottawa, Canada	88
Blair Station, Ottawa, Canada	96
Bridgeport Station, Vancouver, Canada	96
Surrey Central Station, Surrey, Canada	96
Heritage Valley Station, Edmonton, Canada	96
Naki Transit Centre, Edmonton, Canada	96
North Pointe Transit Terminal, Calgary, Canada	96
McKenzie Towne, Calgary, Canada	96
Brossard Station, Montreal, Canada	80
Riviere-des-Prairies Station, Montreal, Canada	100
Scarborough GO Station, Toronto, Canada	92
Vaughan Metropolitan Centre Station, Toronto, Canada	100

Analysis

Descriptive analyses were conducted to describe the trip time and distance for all stations and cities together, then separately for individual cities. No statistical tests were performed.

Table 2. Descriptive statistics for travel time for all modes by station

	Full Sample (n=1132)	Barrhaven Center (n=88)	Blair (n=96)	Bridgeport (n=96)	Brossard (n=80)	Heritage Valley (n=96)	McKenzie Towne (n=96)
distance km							
Mean (sd)	22.2 (7.8)	28.1 (4.3)	11.5 (3.4)	14.0 (3.6)	22.4 (5.0)	22.1 (4.2)	25.2 (4.3)
Median (Q1,Q3)	21.6 (16.6, 27.3)	28.1 (25.1, 30.7)	11.4 (8.9, 14.7)	15.1 (12.0, 16.3)	21.9 (18.9, 25.6)	21.9 (19.8, 23.9)	25.7 (22.3, 28.3)
duration hours							
Mean (sd)	0.8 (0.5)	0.9 (0.5)	0.6 (0.4)	0.7 (0.4)	0.8 (0.4)	0.9 (0.6)	1.0 (0.6)
Median (Q1,Q3)	0.7 (0.5, 1.1)	0.9 (0.5, 1.4)	0.6 (0.3, 0.7)	0.6 (0.5, 0.8)	0.8 (0.4, 1.1)	0.8 (0.5, 1.1)	0.9 (0.5, 1.2)

	Naki Transit (n=96)	North Pointe Transit (n=96)	Riviere-des-Prairies (n=100)	Scarborough GO (n=92)	Surrey Central (n=96)	Vaughan Metropolitan (n=100)
distance km	17.5 (4.1)	20.3 (4.9)	24.5 (5.2)	17.8 (3.5)	33.6 (5.7)	29.5 (7.0)
Mean (sd)	18.7 (15.1, 20.2)	19.9 (16.5, 23.8)	24.6 (20.3, 27.5)	18.5 (15.0, 19.9)	33.2 (29.7, 38.1)	28.2 (24.4, 33.2)
Median (Q1,Q3)						
duration hours	0.8 (0.3)	0.8 (0.4)	1.0 (0.5)	0.8 (0.3)	1.1 (0.6)	0.9 (0.4)
Mean (sd)	0.8 (0.5, 1.0)	0.8 (0.4, 1.1)	0.9 (0.6, 1.3)	0.7 (0.6, 1.0)	1.0 (0.7, 1.4)	0.8 (0.6, 1.3)
Median (Q1,Q3)						

Note. Full results for the analysis are available here:
https://github.com/walkabilly/phac_routing/blob/main/data_analysis.md

Across all of the stations the longest travel time on average was Surrey Central Station with an average travel time of 66 minutes. The travel time from Surrey central ranged between 42 and 84 minutes. McKenzie Town in Calgary and Riviere-des-Prairies in Montreal also had average travel times of 60 minutes. The shortest average travel times were Blair Station in Ottawa and Brossard Station in Montreal with average travel times being 36 minutes. It should be noted that the stations we selected were chosen to be relatively far from downtown, with an average distance of 22.2km and a range of 5.3km to 46.4km.

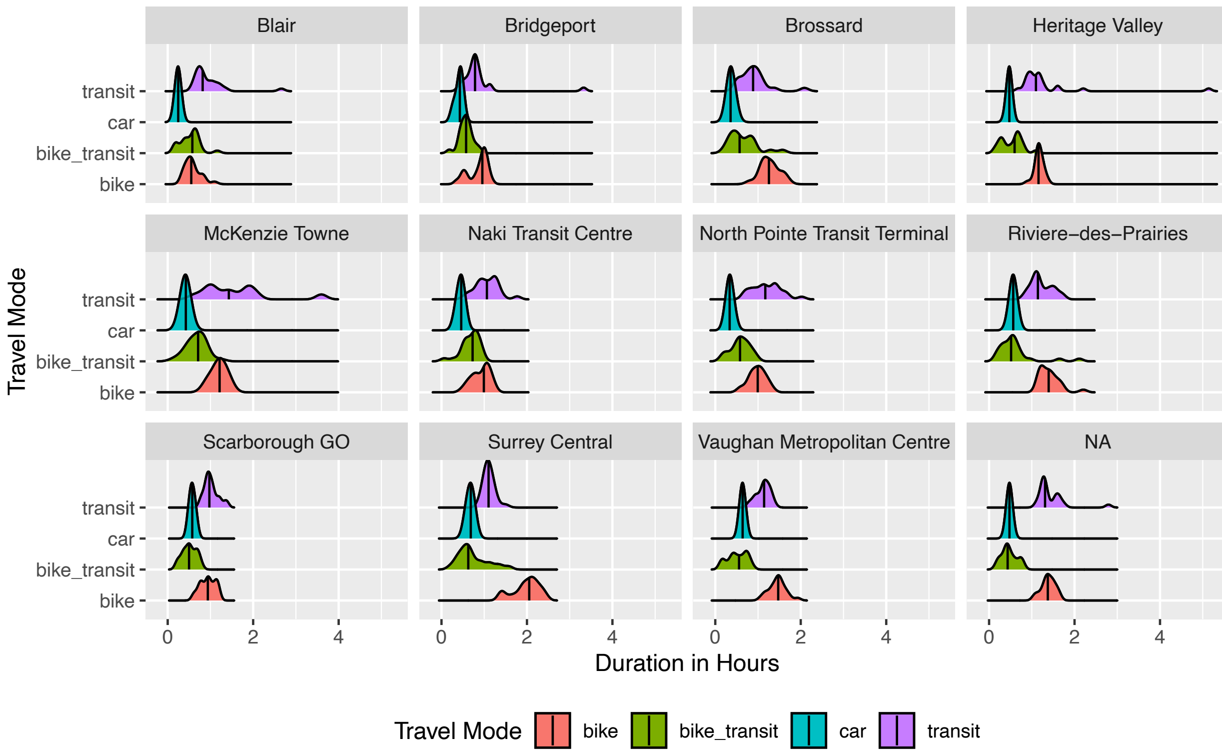
Table 3. Descriptive statistics for travel time and mode by trip type

	Full Sample (n=1132)	bicycle only (n=283)	bicycle + transit (n=283)	Car only (n=283)	Transit only (n=283)
distance km					
Mean (sd)	22.2 (7.8)	20.6 (7.0)	25.3 (7.3)	22.1 (9.1)	21.0 (6.8)
Median (Q1,Q3)	21.6 (16.6, 27.3)	20.0 (16.2, 25.2)	25.5 (19.9, 29.2)	20.3 (15.5, 28.2)	20.6 (16.2, 26.0)
duration hours					
Mean (sd)	0.8 (0.5)	1.2 (0.4)	0.6 (0.3)	0.5 (0.1)	1.2 (0.5)
Median (Q1,Q3)	0.7 (0.5, 1.1)	1.2 (0.9, 1.4)	0.6 (0.4, 0.7)	0.5 (0.4, 0.6)	1.1 (0.9, 1.3)

On average, across all modes, the trip duration was 48 minutes with a mean distance of 22.2km. On average car trips were the fastest at 30 minutes and a mean distance of 22.1km. The next fastest trip mode was cycling to transit with an average time of 36 minutes and distance of 25.3km. Transit and cycling the entire distance had similar times with average travel times of 72 minutes.

On average, the bike to the transit station was 18 minutes long with an interquartile range of 12 minutes to 24 minutes. An 18 minute per day bicycle commute, 5 days per week to and from work, would contribute 180 minutes of weekly physical activity. This would represent 120 percent of the recommended 150 minutes of physical activity per week. There would also be additional contributions of walking to the destination from the station.

Figure 4. Visualization of travel time by mode and city



The `joy plot` shows a histogram for travel time for each travel mode and each station. In general, the car travel mode has the shortest travel time and the narrowest range of the distribution. This suggests that driving is the fastest travel mode and the most consistent in terms of time. The next fastest travel mode was bicycle + transit, which was generally similar in travel time to driving except for the McKenzie Towne (Calgary), Blair (Ottawa), and Naki Transit Center (Calgary) stations. The distribution of the cycling + transit travel times was wider for cycling + transit compared to driving. Taking transit only was rarely competitive with driving or cycling + transit. The closest transit time between cycling, cycling + transit, and car was Surrey Central station. For transit use, the distribution was very wide, particularly for McKenzie Towne and Heritage Valley. Finally, simply cycling the entire distance was often time competitive with public transit and half of the time of driving.

While this analysis did not consider whether there was presence of key AT supporting infrastructure, it does suggest that if this infrastructure is built, a combination of cycling and transit can be very competitive with driving for suburban trips. Such investments in supportive infrastructure to make trips safe and comfortable could support higher levels of physical activity, lower greenhouse gas emissions and road congestion, and higher transit ridership.

Limitations

There are a number of limitations to this work. The limitations mostly relate to the default settings in the Google Routing API, the random selection of points, and the time of day chosen for the analysis.

1. This analysis did not consider whether key AT supporting infrastructure or policy exists on these for the cycling trips. In many of the areas around the origin stations, cycling infrastructure is likely lacking. Improving cycling infrastructure around transit stations could support more cycling to transit, as many cyclists may not cycle in areas with poor infrastructure.
2. The transit routing uses the default settings in the Google Maps API for each of the modes. The transit options include potential alternate routing preferences including `less_walking` and `fewer_transfers`. We did not test each of the different transit routing options as sensitivity analyses.
3. The bicycle routing analysis includes the default Google bikeway analysis. The Google Routes API clearly states that `bicycling routes are in beta and might sometimes be missing clear sidewalks, pedestrian paths, or bicycling paths`. If there were paths that were more direct from residential areas to transit, this would make the bike trip shorter, and we are assuming that we are routing the bikes along roadways only. The cycling to transit and transit trips may be slowed a bit because we are routing all those trips to a certain station, but in fact there may be a closer station to downtown that we are not accounting for. In those cases, we are modelling commuters back-tracking to the station of interest.
4. Related to point number 2, because the 25 points within the 5km buffer around the station were randomly generated, it sometimes happens that points are located in areas were a route is not able to be created (e.g., on water). This means that not all stations have 25 points. However, for a given station, the seed (i.e., where the points are generated) is the same, which means that all travel modes have the same number of points for a given station.
5. For this work, we set the arrival time to Tuesday mornings at 8:30am (either on June 11 or June 18, 2024). Travel times vary over the morning and afternoon peak periods, and we did not model trips across a variety of travel times.

Future Directions

There are several future directions for this work. First, examining a wider set of cities and stations would improve the generalizability of the findings for more cities. Second, examining whether AT supportive infrastructure is available around the selected stations would help cities design and plan for potentially highly impactful AT infrastructure around MRT stations. Third, including travel time estimates for micro-mobility (including e-bikes and e-scooters) could provide additional support for travel time savings and physical benefits.

Conclusion

Based on the analysis, overall cycling plus using transit to get from suburban areas appears to be competitive with driving and is faster than taking transit only or cycling the entire distance. The time difference across all cities was approximately 6 minutes slower for cycling to transit compared to driving, however, the distribution was wider for cycling to transit compared to driving. Based on the findings, today in Canada, it is time efficient to ride your bike to transit stations from suburban homes. There is considerable potential for infrastructure to improve the cycling experience including bike lanes and protected bike lockers at stations. These improvements would create important physical activity and environmental benefits.

References

- Yasmin, Farhana & Larsen, Jacob & El-Geneidy, Ahmed. (2010). Examining travel distances by walking and cycling, Montréal, Canada. https://www.researchgate.net/publication/258405294_Examining_travel_distances_by_walking_and_cycling_Montreal_Canada Accessed February 13, 2024.
- Larsen J., El-Geneidy A. Beyond the quarter mile: Re-examining travel distances by active transportation (2010) Canadian Journal of Urban Research, 19 (1 SUPPL.), pp. 70 - 88