Proximity to bike routes and mode share: An analysis of the Metro Vancouver Area

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Abstract

We studied census-tract level commuting cycling mode share for the Vancouver Census Metropolitan Area. We examined whether variations in mode share, for all commuters and female and male commuters separately, were related to proximity to any bikeway, and proximity to four comfort-based bikeway classifications. Cycling commute mode shares at the census-tract level varied from 0 to 18.3%. A one-kilometer closer proximity to any bikeway was associated with five times higher cycling mode share. Proximity to a “Comfortable for Most” bikeway had a stronger association with mode share than any bikeway, and no other bikeway type was associated with mode share. Our results suggest that only bikeways considered Comfortable for Most, including protected bike lanes, off street paths, and traffic calmed local streets, are associated with higher cycling commute mode shares.

Introduction

There is consistent evidence that bike infrastructure in general is associated with more cycling[1,2], and that safety concerns are a major deterrent for potential cyclists[3,4]. Safety is highly linked to exposure to motor vehicle traffic[5,6], however not all separated bikeways provide the same level of comfort and safety for riders, and some on street bikeways with low vehicle speeds and volumes may provide similar benefits to off street routes[5]. To provide a consistent framework for describing bikeways across the region, HUB Cycling (a cycling advocacy organization in the Vancouver area) and TransLink (the public transportation authority in the region) completed a benchmarking report[7], which categorized all bikeways in the region based on cyclist comfort, as a supplement to data on infrastructure type.

In 2017, a previous study by Teschke, Chinn, and Brauer[8] investigated the relationship between commuter cycling mode share at the neighborhood (census tract) level and proximity to bikeways in

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[1] Nelson, A., & Allen, D. (1997). If You Build Them, Commuters Will Use Them: Association Between Bicycle Facilities and Bicycle Commuting. *Transportation Research Record: Journal of the Transportation Research Board*, 1578, 79–83.
[2] Dill, J., & Carr, T. (2003). Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them. *Transportation Research Record: Journal of the Transportation Research Board*, 1828, 116–123.
[3] Noland, R. B. (1995). Perceived risk and modal choice: Risk compensation in transportation systems. *Accident Analysis & Prevention*, 27(4), 503–521.
[4] Winters, M., Davidson, G., Kao, D., & Teschke, K. (2011). Motivators and Deterrents of Bicycling: Comparing Influences on Decisions to Ride. *Transportation*, 38(1), 153–168.
[5] Teschke, K., Harris, M. A., Reynolds, C. C., et al. (2012). Route Infrastructure and the Risk of Injuries to Bicyclists: A Case-Crossover Study. *Am J Public Health*. 102(12), 2336-43.
[6] Winters, M., Babul, S., Becker, H.J., et al. (2012). Safe Cycling: How Do Risk Perceptions Compare with Observed Risk? *Can J Public Health*. 103(3), S42-S47.
[7] HUB Cycling & TransLink (2020). Benchmarking the State of Cycling in Metro Vancouver. *TransLink.*
[8] Teschke K., Chinn, A., & Brauer, M. (2017). Proximity to Four Bikeway Types and Neighborhood-Level Cycling Mode Share of Male And Female Commuters. *The Journal of Transportation and Land Use*, 10 (1), 695–713.

Vancouver and Montréal. This study found a that one-kilometer closer proximity to any bikeway was associated with four times higher cycling mode share, but associations between specific facility types and mode share differed between the two cities. This study applies the same methodology but uses bikeway comfort classification instead of facility type and considers the entire Vancouver Census Metropolitan area. We investigate whether mode shares are higher when bikeways are closer to homes, and whether comfort classification of bikeways makes a difference. Additionally, as cycling is much more common among men than women in Canada[9], and because women express stronger route preferences[10,11,12], we examined whether associations differed for female and male commuters.

Methods

This study used 2016 Census data on commuting to work and spatial data on the shortest routes from residential parcels to bikeways. The geographic boundaries of the study were defined as the Vancouver Census Metropolitan Area, which comprises 23 jurisdictions. Figure 1 shows the study area.

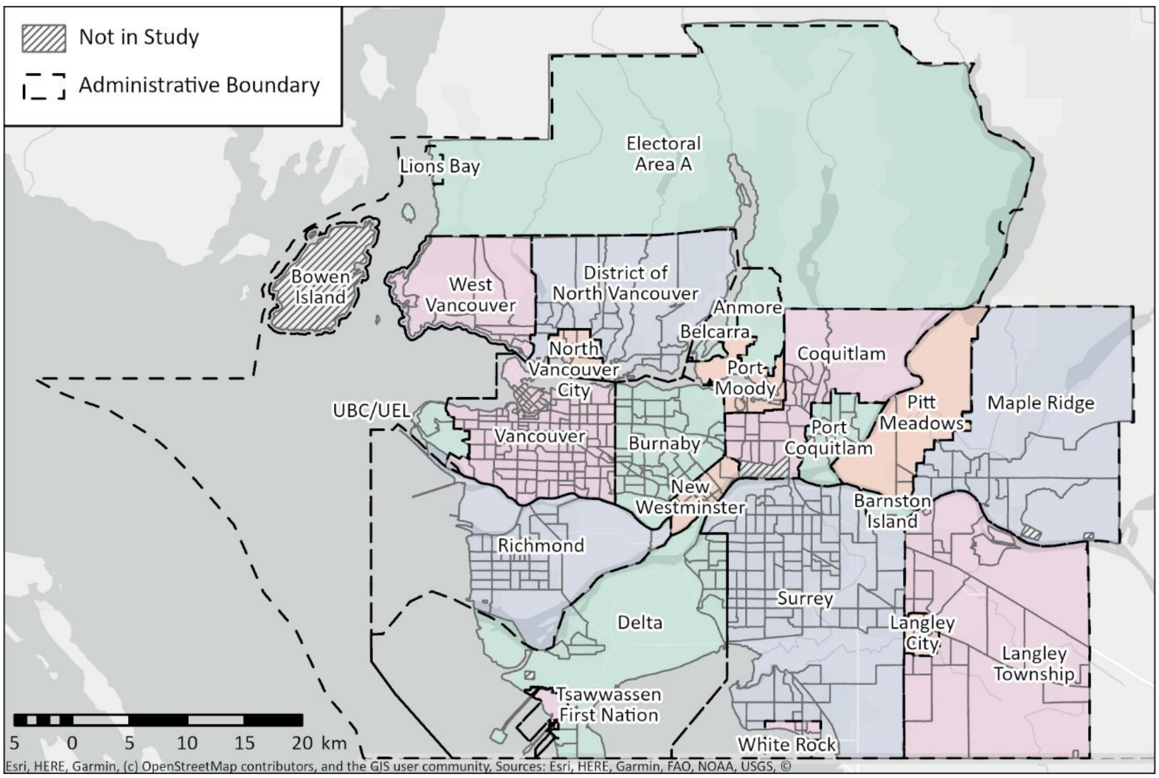

FIGURE 1: STUDY AREA

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[9] Buehler, R., & Pucher, J. (2012). Walking and Cycling in Western Europe and the United States: Trends, Policies, and Lessons. *TR News*, 280, 34–42.

[10] Aldred, R., Elliott, B., Woodcock J. & Goodman A. (2017) Cycling Provision Separated from Motor Traffic: A Systematic Review Exploring Whether Stated Preferences Vary by Gender and Age. *Transport Reviews*, 37:1, 29-55

[11] Akar, G., Fischer, N., & Namgung, M. (2013). Bicycling Choice and Gender Case Study: The Ohio State University. *International Journal of Sustainable Transportation*, 7(5), 347–365.

[12] Winters, M., & Teschke, K. (2010). Route Preferences Among Adults in the Near Market for Bicycling: Findings of the Cycling in Cities Study. *American Journal of Health Promotion*, 25(1), 40–47.

Census tracts[13] were used as the unit of analysis. The study area comprises 478 census tracts, but nine were not included because they were uninhabited (n=4), did not have any commuting population (n=2), or because data quality or small reporting samples meant commuting data were not released (n=2). The census tract comprising Bowen Island was also removed from the study as it did not have any bike facilities in 2016; the nearest cycling facility would only be reachable by ferry. The 469 census tracts had a mean population of 5,200 (interquartile range: 4,000 to 6,500). Table 1 lists the number of census tracts in each administrative area.

TABLE 1: NUMBER OF CENSUS TRACTS IN EACH ADMINISTRATIVE AREA

Name	Number of Census Tracts	Name	Number of Census Tracts
Anmore, Belcarra, Lions Bay, and Electoral Area A*	1	Pitt Meadows	5
Barnston Island**	1	Port Coquitlam	9
Burnaby	42	Port Moody	8
Coquitlam	24	Richmond	39
Delta	19	Surrey	96
Langley City	6	Tsawwassen First Nation	1
Langley Township	26	Vancouver	118
Maple Ridge	15	West Vancouver	9
New Westminster	13	White Rock	5
North Vancouver City	10	University of British Columbia and University Endowment Lands**	2
District of North Vancouver	20		

*Except Barnston Island and UBC/UEL **Part of Electoral Area A

Commute data

Commuting data was taken from the public release dataset of the 2016 Census of Population, conducted from May 2 to 10, 2016[14]. The sampling frame was 25% of households randomly selected from the 2016 Census of Population dwelling list. The Vancouver Area census subdivisions had a global non-response rate of 5.7%[15]. Commuting questions were restricted to the population aged 15 years and over in private households who worked at some time since January 1, 2015, and who indicated that they either had no fixed workplace address or specified a usual workplace address. Commuting questions referred to the job held during the week of May 1-7, 2015. However, if the person did not work that week, the questions were asked about the job held longest since January 1, 2015.

For each census tract, data was collected for the total number of commuters and the number of commuters usually cycling to work. For each census tract, cycling commute mode share (the proportion of commuters who reported usually cycling to work) was calculated. Commute data was also tabulated for females and males separately (female and male were the only sex options for the 2016 census; the 2021 Census was the first year to allow respondents to write in their own gender)[16].

[13] Statistics Canada (2017a). Dictionary, Census of Population, 2016. *Statistics Canada*. Catalogue no. 98-301-X.
[14] Statistics Canada (2017b). Guide to the Census. *Statistics Canada*. Catalogue no. 98-304-X2016001.
[15] Statistics Canada (2017c). Focus on Geography Series, 2016 Census, Census Metropolitan Area of Vancouver. *Statistics Canada*. Catalogue no. 98-404-X2016001.
[16] Statistics Canada (2021). Dictionary, Census of Population, 2021. *Statistics Canada*. Catalogue no. 98-301-X.

Route to bikeway data

Table 2 details the spatial data layers used to calculate distances from homes to bikeways. ESRI Shapefiles and Feature Classes were used to perform Geographic Information Systems (GIS) analyses and all GIS analysis was done using ArcGIS Pro 2.5 and ArcGIS Desktop 10.8 (Esri Canada, Toronto, ON). The data were projected using the NAD83 Zone 10N coordinate systems. Property parcel polygon centroids were created by calculating polygon centroid geometry and using this to generate an XY point feature class. Parcels within exclusively industrially or commercially zoned areas were removed from the dataset, leaving only those at which people would be expected to live. The parcels were not weighted to account for those that have many households or those that may not be inhabited at all.

TABLE 2: SPATIAL DATA FORMAT AND SOURCES

Data	Format	Source
Canadian Census Tracts	Polygon	Statistics Canada
Administrative Boundaries	Polygon	Metro Vancouver
Parcels	Polygon	Government of British Columbia Data Catalog
BC Digital Roads Atlas	Polyline	Government of British Columbia Data Catalog
Cycling Routes	Polyline	HUB Cycling/TransLink
Anmore Zoning	Polygon	Village of Anmore
Belcarra Zoning*	Polygon	Village of Belcarra
Burnaby Zoning	Polygon	City of Burnaby
Coquitlam Zoning	Polygon	City of Coquitlam
Delta Zoning*	Polygon	City of Delta
Electoral Area A Zoning*	Polygon	Metro Vancouver
Langley City Zoning	Polygon	City of Langley
Langley Township Zoning	Polygon	Township of Langley
Lions Bay Zoning*	Polygon	Village of Lions Bay
Maple Ridge Zoning	Polygon	City of Maple Ridge
New Westminster Zoning	Polygon	City of New Westminster
North Vancouver City Zoning	Polygon	City of North Vancouver
District of North Vancouver Zoning	Polygon	District of North Vancouver
Pitt Meadows Zoning	Polygon	City of Pitt Meadows
Port Coquitlam Zoning	Polygon	City of Port Coquitlam
Port Moody Zoning	Polygon	City of Port Moody
Richmond Zoning	Polygon	City of Richmond
Surrey Zoning	Polygon	City of Surrey
Tsawwassen First Nation Zoning*	Polygon	Tsawwassen First Nation
University of British Columbia Zoning	Polygon	University of British Columbia
University Endowment Lands Zoning*	Polygon	University Endowment Lands
Vancouver Zoning	Polygon	City of Vancouver
West Vancouver Zoning	Polygon	District of West Vancouver
White Rock Zoning	Polygon	City of White Rock

*Polygon features created manually from PDF maps

HUB Cycling/TransLink provided a bikeway polyline network of the Metro Vancouver region that represented the bikeways network as of 2019. Bikeways were classified into four comfort-based categories: “Comfortable for Most,” “Comfortable for Some,” “Comfortable for Few,” and “Comfortable for Very Few.” Comfortable for Most bikeways included most infrastructure where cyclists are separated from vehicles – dedicated bike paths, on street protected bike lanes (also called cycle tracks), and paved and unpaved multi-use paths. Additionally, local street bikeways were included in this category if they had speed limits of 30 km/hr or lower, volumes under 2,000 vehicles per day, and an effective roadway width (excluding on-street parking) of at least three meters. Photos showing examples of each bikeway type in the Comfortable for Most category are provided in Figure 2.

Dedicated Bike Path | On-Street Protected Bike Lane | Traffic Calmed Local Street Bikeway

Paved Multi-Use Path | Unpaved Multi-Use Path

FIGURE 2: COMFORTABLE FOR MOST BIKEWAY TYPES (PHOTO CREDITS: GOOGLE STREET VIEW)

Comfortable for Some, Few, and Very Few bikeways consisted of painted bike lanes (adjacent to curb or parking lane), bike accessible shoulders (painted lanes with no curb), and shared roadways with posted speed limits greater than 30 km/hr and/or volumes greater than 2,000 vehicles per day. These bikeway types are shown in Figure 3. The specific classification depended on posted speed limit, vehicle traffic, facility width, and presence of parking. Additionally, some narrow or inadequately separated off-street facilities next to higher speed traffic were included in these categories.

Painted Bike Lane | Bike Accessible Shoulder | Shared Major Road

FIGURE 3: COMFORTABLE FOR SOME, FEW, AND VERY FEW BIKEWAY TYPES (PHOTO CREDITS: GOOGLE STREET VIEW)

This bikeway network was modified for this study to match the 2016 TransLink cycling map published in December 2016[17,18]. Historical Google Street View imagery was used to manually reclassify bikeways that had been upgraded between 2016 and 2019. Vertices at bikeways end points were generated to represent points of access at roadway intersections; vertices were generated at 50-meter along bikeway polylines to a represent immediate access of those living along a bikeway. Separate layers were generated for all bikeways and for each of the four comfort classifications.

The street network dataset for the region was built using the BC Digital Road Atlas. Routes where cycling is not permitted (parts of Highways 1, 91, 91A, and 99) were excluded from the network, and the bike network was modified to ensure connectivity between it and the road network.

Data analyses

All data analyses were conducted using JMP 15 (SAS Institute, Cary NC). Cycling commute mode share and distance to bikeway variables were linked via census tract, the unit of analysis. Descriptive statistics (mean, median, SD, maximum, minimum, interquartile range) were calculated for each variable to summarize the data. Histograms of each variable and scatterplots of bivariate relationships between each independent variable and cycling mode share were examined to make decisions about variable transformation or categorization. Models were developed to examine the associations between cycling mode share and proximity to any bikeway and proximities to each of the four bikeway types. These analyses were repeated for female and male commuters separately.

Modelling was done using the generalized linear model with Poisson distribution and log link, and variance estimates were corrected for overdispersion (quasi-Poisson). The model for female commuters and Comfortable for Most bikeways was overdispersed so a Negative Binomial model was used instead. Exponentiated coefficients represent the relative rate (i.e., the ratio of cycling commute mode shares) for each unit or category change in the independent variable.

Results

Table 3 outlines characteristics of the included census tracts of the Vancouver Census Metropolitan Area at the time of the 2016 Census of Population.

TABLE 3: CHARACTERISTICS OF THE STUDY AREA AND THE FIVE LARGEST JURISDICTIONS IN 2016

	All	Vancouver	Surrey	Burnaby	Richmond	Coquitlam
Number of Census Tracts	469	118	96	42	39	24
Total population	2,459,598	633,138	518,007	232,755	198,309	139,284
Commuter population	1,157,670	315,950	238,960	108,295	86,275	64,420
Percentage of Commuters who were female	48%	49%	47%	48%	49%	47%
Bicycle Mode Share (All Commuters)	2.4%	6.1%	0.4%	1.1%	1.3%	0.6%
Bicycle Mode Share (Female Commuters)	1.7%	4.8%	0.2%	0.5%	0.8%	0.3%
Bicycle Mode Share (Male Commuters)	2.9%	7.4%	0.5%	1.6%	2.0%	0.8%

[17] TransLink, (2017). TransLink Regional Cycling Map East. *TransLink*.
[18] TransLink, (2017). TransLink Regional Cycling Map West. *TransLink*.

Commuting

In 2016, the study area had an overall cycling commute mode share of 2.4%, with a broad range across census tracts, from 0.0% to 18.3% (Table 3, Figure 4). At 6.1% Vancouver had the highest cycling mode share of any jurisdiction, with the exception of the University of British Columbia and Endowment Lands, two census tracts with a combined mode share of 8.7%. 35% of cycling commuters were female, though this also varied a great deal by census tract, from 0 to 100%. Figure 5 shows histograms and box plots of cycling mode share for all commuters and for female and male commuters.

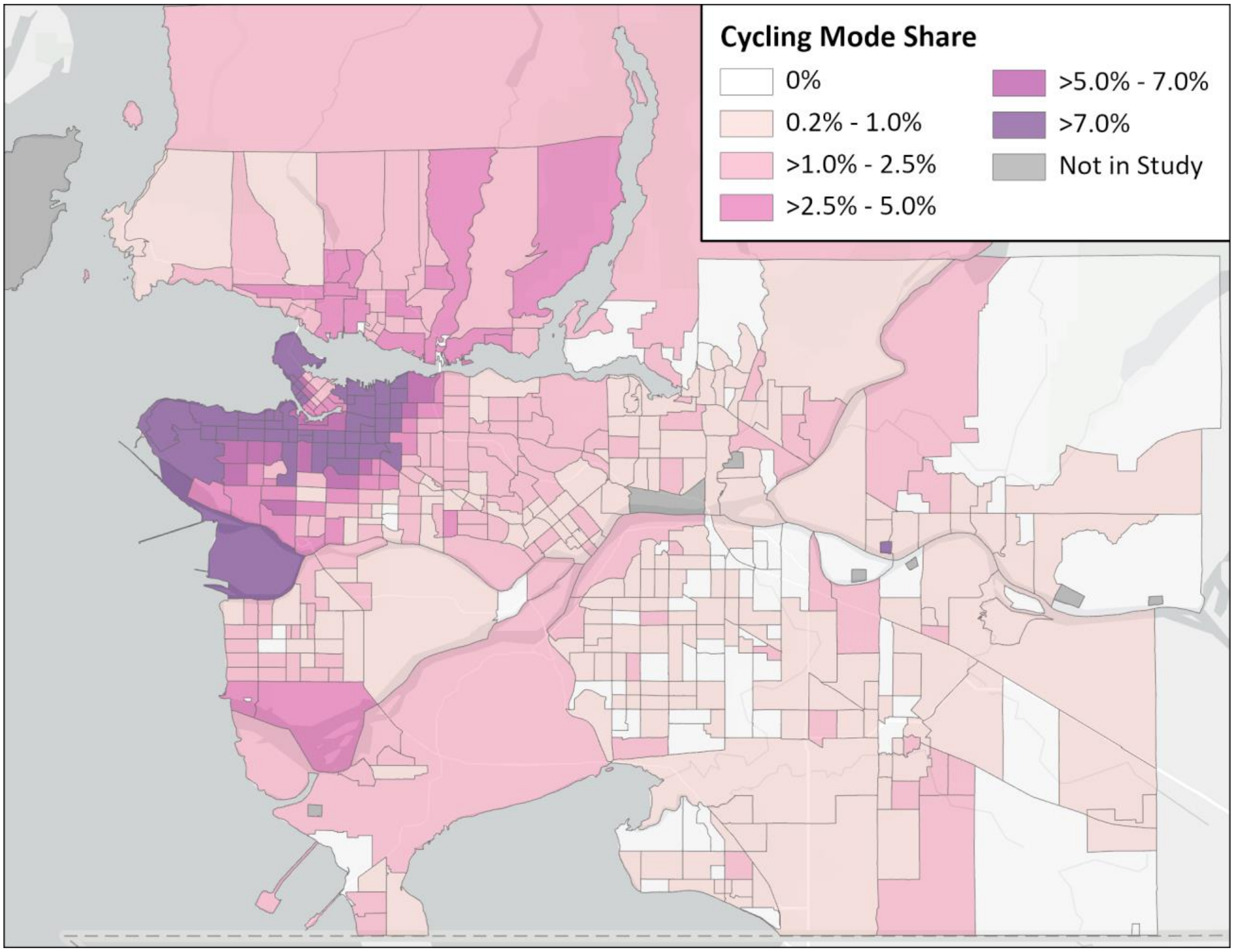
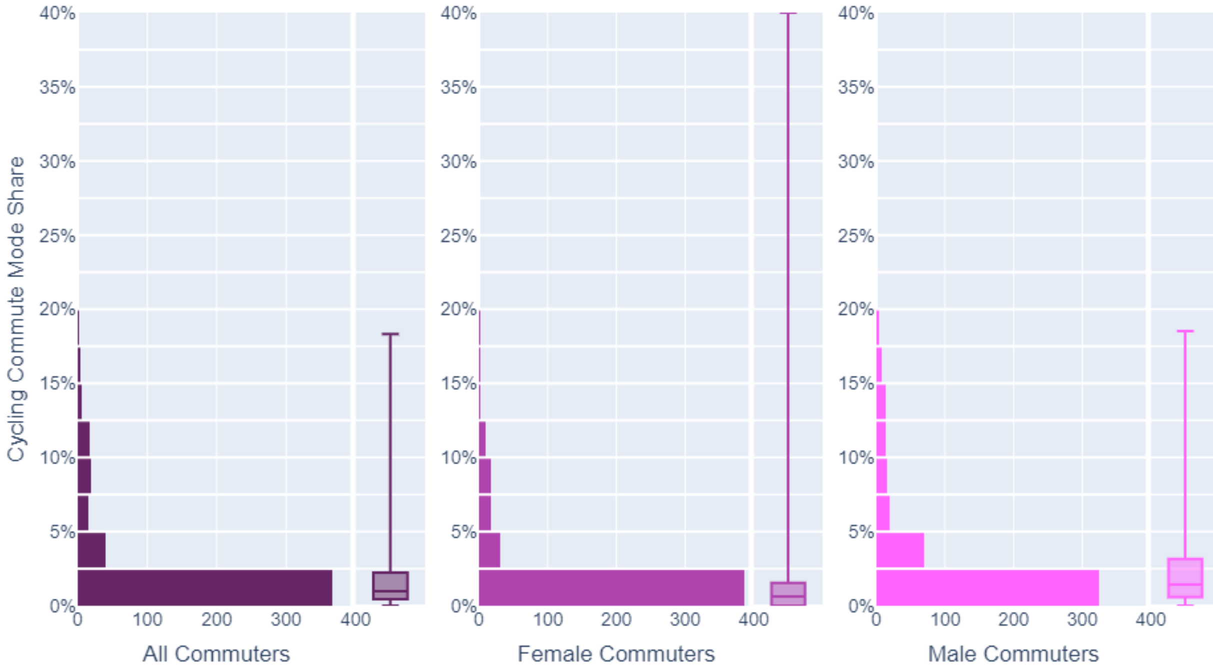


FIGURE 4: CYCLING COMMUTE MODE SHARE BY CENSUS TRACT



Left side of each graph displays a histogram showing the number of census tracts in each mode share range. Right side displays a box plot with the centreline equal to the median mode share, and the bottom and top of each box equal to the 25th and 75th percentiles, respectively. The bottom whisker shows the minimum of the data, and the top the maximum.

FIGURE 5: DISTRIBUTION OF CYCLING COMMUTE MODE SHARE OF CENSUS TRACTS FOR ALL COMMUTERS AND FEMALE AND MALE COMMUTERS

Routes to bikeways

Figure 6 shows the bicycle network in the study area as of 2016. Table 4 indicates the lengths of the four bikeway classifications available in the study area and the five largest jurisdictions. The distribution of bikeway types varies widely based on jurisdiction – nearly 75% of bikeways in Vancouver are classified as Comfortable for Most, compared to less than 20% in Surrey. Burnaby, Richmond, and Coquitlam all had about 40% of their bikeways categorized as Comfortable for Most, more than any other type.

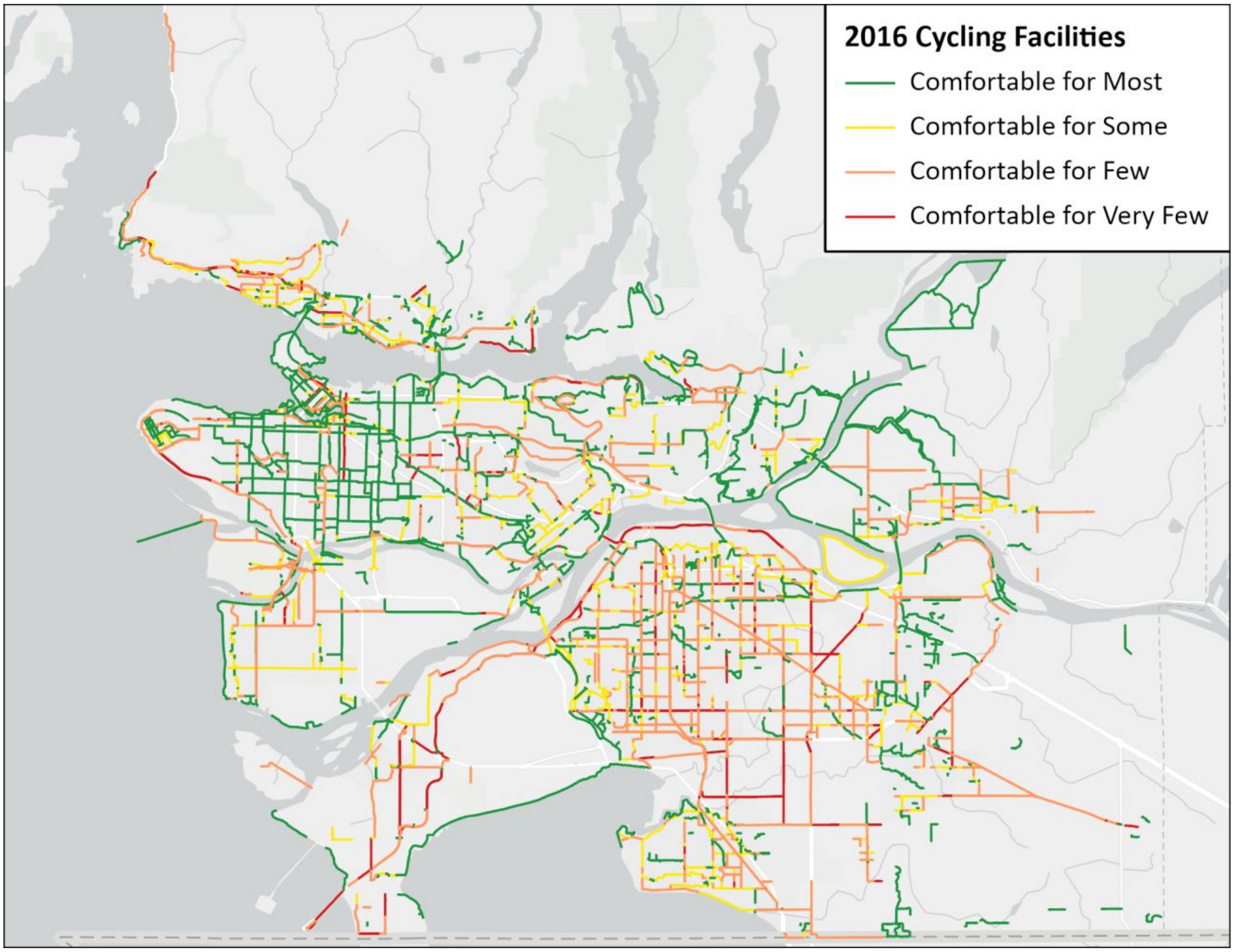
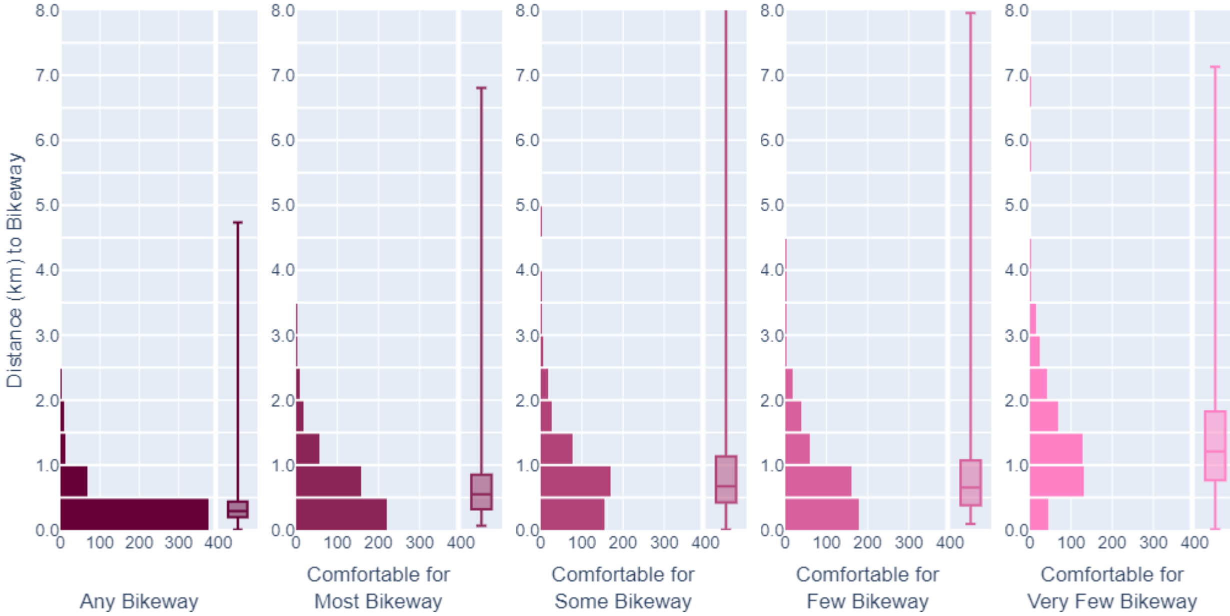


FIGURE 6: BIKEWAYS WITHIN THE STUDY AREA CLASSIFIED BY COMFORT (2016)

TABLE 4: LENGTH OF BIKEWAYS IN THE STUDY AREA AND FIVE LARGEST JURISDICTIONS IN 2016

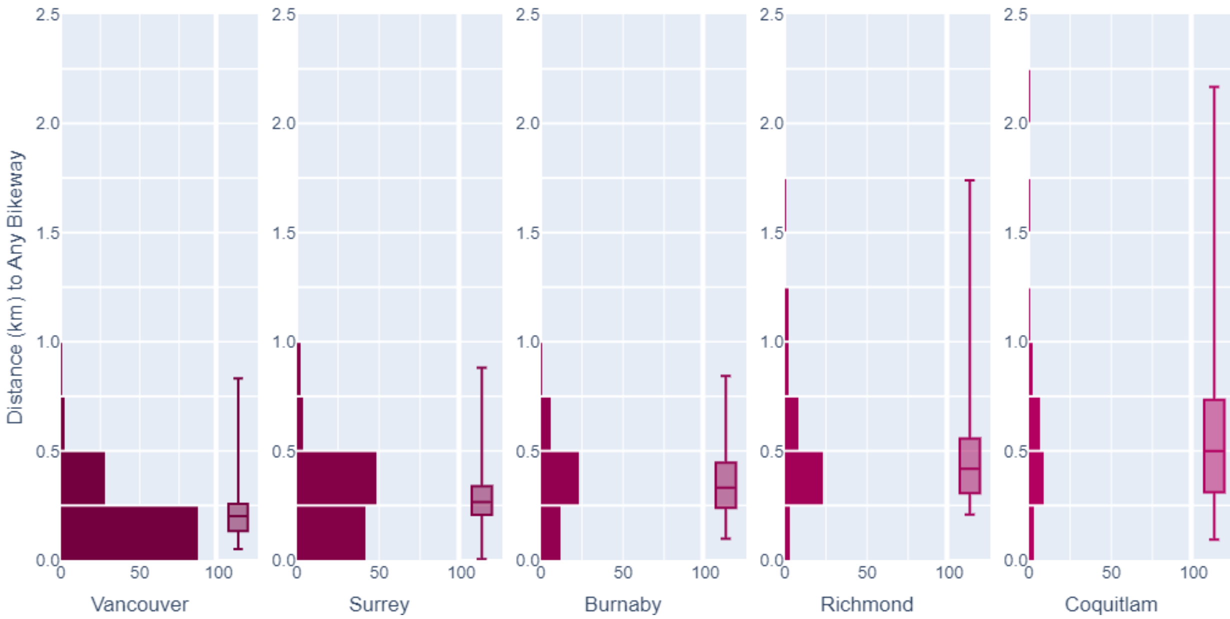
Bikeway Classification	Centreline km (Percent of total)					
	All	Vancouver	Surrey	Burnaby	Richmond	Coquitlam
Comfortable for Most	909.9 (40%)	226.2 (73%)	119.1 (19%)	72.3 (39%)	62.1 (38%)	31.5 (41%)
Comfortable for Some	363.6 (16%)	19.2 (6.2%)	100.5 (16%)	30.1 (16%)	37.0 (23%)	14.6 (20%)
Comfortable for Few	754.2 (33%)	46.7 (15%)	293.0 (48%)	67.8 (36%)	59.0 (37%)	29.3 (38%)
Comfortable for Very Few	253.2 (11%)	19.0 (6.1%)	99.3 (16%)	16.1 8.6%)	3.5 (2.1%)	0.6 (0.8%)
Total	**2,276**	**311.2**	**611.8**	**186.2**	**161.5**	**76.4**

Figure 7 shows the distributions of the mean distances within census tracts from residential parcels to any bikeway and to each bikeway classification. Overall, the median distance (among census tracts) to any bikeway was 0.29 km. The distance to each bikeway type was greater: Comfortable for Most 0.55 km, Comfortable for Some 0.67 km, Comfortable for Few 0.65 km, and Comfortable for Very Few 1.2 km. Distances to bikeways varied widely between jurisdictions; Figure 8 shows the distance to any bikeway for the five largest jurisdictions in the study area.



Left side of each graph displays a histogram showing the number of census tracts in each distance range. Right side displays a box plot with the centreline equal to the mean distance, and the bottom and top of each box is equal to the 25th and 75th percentile, respectively. The bottom whisker shows the minimum of the data, and the top the maximum. Comfortable for Some bikeways had six values outside the limits shown in the graphs.

FIGURE 7: BOX PLOTS SHOWING THE DISTRIBUTION OF THE MEAN DISTANCES FROM RESIDENTIAL PARCELS TO ANY BIKEWAY AND BIKEWAY COMFORT CLASSIFICATIONS



Left side of each graph displays a histogram showing the number of census tracts in each distance range. Right side displays a box plot with the centreline equal to the mean distance, and the bottom and top of each box is equal to the 25th and 75th percentile, respectively. The bottom whisker shows the minimum of the data, and the top the maximum.

FIGURE 8: BOX PLOTS SHOWING THE DISTRIBUTION OF THE MEAN DISTANCES FROM RESIDENTIAL PARCELS TO ANY BIKEWAY WITHIN THE FIVE LARGEST JURISDICTIONS

Associations between distance to bikeways and cycling commute mode share

Table 5 provides descriptive data for six categories of cycling commute mode share. In census tracts with higher cycling mode shares, the proportions of bike commuters who were female were considerably higher. Census tracts with mode shares higher than 5% had consistently closer mean proximities to any bikeway and to Comfortable for Most bikeways.

TABLE 5: CENSUS TRACTS CATEGORIZED BY CYCLING COMMUTE MODE SHARE: DESCRIPTIVES FOR VARIOUS CHARACTERISTICS

	Cycling Commute Mode Share					
	0%	0.2% to -1%	1% to 2.5%	2.5% to 5%	5% to 7%	>7%
Number of Census Tracts	63	173	130	40	14	49
% of Bike Commuters who were female	-	24%	27%	31%	34%	42%
Mean Distance to Any Bikeway (km)	0.51	0.41	0.41	0.39	0.19	0.21
Mean Distance to Comfortable for Most Bikeway (km)	0.99	0.79	0.74	0.52	0.22	0.24
Mean Distance to Comfortable for Some Bikeway (km)	1.3	1.0	0.94	0.97	1.0	0.82
Mean Distance to Comfortable for Few Bikeway (km)	0.97	0.79	0.88	0.96	0.79	0.92
Mean Distance to Comfortable for Very Few Bikeway (km)	1.8	1.5	1.5	1.3	1.3	1.0

Table 6 shows the results of inferential analyses of the associations between cycling commute mode share and distance to bikeways for all commuters, and female and male commuters separately. In bivariate analyses, only distance to any bikeway and distance to a Comfortable for Most bikeway showed a statistically significant association with mode share. A multivariate analysis including variables for distances to each of the four bikeway comfort classifications was performed, but again only distance Comfortable for Most bikeways was significant (data not shown). Models for female and male commuters separately showed the same pattern, with females having a much stronger associations for both any bikeway and for Comfortable for Most bikeways. The relative rates (RR) indicate the increase in cycling mode share per kilometer increase in bikeway proximity (decrease in distance). For example, for all commuters, a 1 km decrease in distance to Comfortable for Most bikeways was associated with 6.6-fold increase in cycling mode share.

TABLE 6: ASSOCIATION BETWEEN CYCLING COMMUTE MODE SHARE AND PROXIMITY TO BIKEWAYS

	All Commuters		Female Commuter		Male Commuters	
Closer Proximity (1m km) to:	**RR**	**β (SE)**	**RR**	**β (SE)**	**RR**	**β (SE)**
Any Bikeway	**5.0**	-1.6 (0.3)**	**13.6**	-2.6 (0.6)**	**3.9**	-1.4 (0.3)**
Comfortable for Most Bikeway	**6.6**	-1.9 (0.8)*	**11.1**	-2.4 (0.5)**	**5.3**	-1.7 (0.5)**

N = 469 census tracts
RR = e^{β} = relative rate (ratio of cycling commute mode shares) for each one-unit change or category change in the independent variable
β = coefficient
SE = standard error of the coefficient
Statistically significant: * $p < 0.01$; ** $p < 0.001$
Bold indicates RR that are in the hypothesized direction and statistically significant

Discussion

Our analysis found that in neighborhoods where homes were more proximate to bikeways, cycling mode shares were considerably higher. The association was strong, but even stronger was the association with bikeways classified as Comfortable for Most. These bikeways, which include separated bike infrastructure as well as shared local streets with low speeds and volumes, made up about 40% of the Metro Vancouver bike network in 2016. Routes classified as Comfortable for Some, Few, or Very Few had no association with cycling commute mode share.

We investigated cycling mode share for female and male commuters separately. Though almost half the commuters were female, only about one-third of cycling commuters were, echoing the common finding in low-cycling countries that men are much more likely to use this transport mode[9]. The proportion of bike commuters who were female was not stable across census tracts. Where mode shares were low (less than 1%), the proportion female was only 24%; but where mode shares were high (greater than 7%), the proportion female was 42%—approaching parity with males. This dramatic difference in the proportions of women cycling underscores how important providing cycling facilities where women feel comfortable is to achieve high cycling mode shares.

These results are consistent with the results from Teschke, Chinn, and Brauer's 2017 study of proximity to bike routes and mode share in Montréal and Vancouver[8]. They found that a one kilometer closer proximity to any bikeway was associated with four times higher mode share. In Vancouver, only cycle tracks (protected bike lanes) and residential street bikeways were associated with higher mode shares, and the associations were lower than for any bikeway. This led the authors to speculate that the network formed by multiple bikeway types was more important than specific type of bikeway.

In our study, while the association between distance to any bikeway was similar, the association with Comfortable for Most bikeways was stronger. As Comfortable for Most bikeways includes most cycle tracks and residential street bikeways, the network formed by multiple bikeway types is contained within this classification. Of the Comfortable for Some, Few, and Very Few bikeways, consisting primarily of painted bike lanes and shoulders as well as shared roads with high speed and vehicle traffic, only painted bike lanes were investigated in the 2017 study. The researchers did not find an association between painted bike lanes and mode share in Vancouver. In our study, none of these bikeways had an association with mode share, and including these bikeways in the network for the distance to any bikeway reduced the association between distance to bikeways and mode share as compared to only Comfortable for Most bikeways.

Strengths and limitations

This study investigated neighborhood-level commuter cycling mode share in third largest Census Metropolitan Area in Canada with diverse cycling infrastructure and high (for North America) cycling mode share. It used large-sample national survey data, with input from households with approximately 625,000 residents (a 25% random sample of the 2.5 million Vancouver Metro Area population). It examined the potential influence not only of bikeway provision, but of cyclist comfort, as classified in the 2020 State of Cycling report[7]. It also examined female and male commuters separately.

While this study benefitted from the large size of the survey sample, it was also limited by the questions asked and the data publicly released. The survey queried the usual mode of transport to work, not all modes used or the frequency of travelling by each mode. It did not consider the modes used for non-commute trips. The survey was conducted in May 2016 and the time of year may have affected the usual mode of travel reported.

This study used data from a single census year, so no claim can be made about a temporal direction of effect. Although it is reasonable to expect that greater availability of bikeways leads to more people cycling share, it is possible that cities install more infrastructure where cycling is already higher. This cross-sectional data also cannot determine whether new bikeways increase cycling among existing local residents or people who cycle or want to cycle move to areas with new bikeways. A valuable follow-up to our study would examine whether implementing new cycling infrastructure or upgrading existing bikeways are associated with changes in neighborhood cycling mode shares, for example in the 2021 census.

Zoning data was used to limit the origin points for analysis, restricting the area only to places where residential uses are permitted. This does not take into account the different populations on different parcels – many parcels in residential areas are used for parks, school, or other non-residential uses, while others may have apartment towers with hundreds of households. An alternative methodology would be to use Census Blocks as origin points instead of parcels, and to weight them by the number of residents.

The State of Cycling data used in this study, which classifies bikeways by comfort, only looks at road segment conditions and not at intersections. An improvement to this data would be to look at intersection conditions and use this to inform the overall classification of a bikeway. Additionally, this study did not consider intersections in the analysis of the shortest distance from each parcel to a bikeway. A future analysis could include information on intersections to ensure that the routes to bikeways cross major streets at signals, or avoid some intersections all together.

Lastly, this study only investigates the distance from homes to bikeways, and not the distance from destinations to bikeways, or whether there is a continuous bikeway from one to the other. Future analysis could attempt to include this by including a measure of cycling network connectivity, and by excluding or penalizing bikeways that have limited connections to other bike facilities.

Conclusions

In the Metro Vancouver region, which had an overall cycling commute mode share of 2.4%, there was substantial variation in cycling at the neighborhood (census tract) level: 0.0% to 18.3%. The variation in cycle commuting was associated with the proximity to any bikeway and with proximity to bikeways considered Comfortable for Most. No other bikeway classification had an association with mode share. This study suggests that cycling infrastructure that is considered comfortable for only some, few or very few people, including painted bike lanes, bike accessible shoulders, and shared roads with high speeds and volumes, is not effective at encouraging more cycling.

In neighborhoods where cycle commuting was more common, the proportion of cycle commuters who were female approached parity with males. Proximity to a Comfortable for Most bikeway had stronger associations with cycling mode share in women than men. These results underscore the importance of building this type of infrastructure to ensure cycling is a more equitable transport option.

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