Biking Infrastructure and Human Behaviour

The impact of adding 2700 km of bikeways in Metro Vancouver

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EXECUTIVE SUMMARY

In July 2015, Metro Vancouver residents reviewed and rejected a future transportation proposal, which included the addition of 2700 km of bikeways, at the transit and transportation referendum (CBCNews, 2015). To gain more insights into the impacts of adding the proposed 2700 km of bikeways, this project worked with the HUB Cycling organization to answer the following questions:

1. Would the number of people cycling in Metro Vancouver increase?
2. How many fewer vehicle trips in kilometers would result?
3. How would greenhouse gas emissions be affected?
4. What factors prevent people from cycling more?

To answer our objectives, we surveyed 205 Metro Vancouver residents, who were 19 years or older, through an online and in-person questionnaire. Participants were asked to estimate the average distance from where they travelled most (work/school) and where they ran errands, along with the types of transportation they used to get there and how often they would use it now and after 2700 km of bikeways are added. They were also asked how often they would cycle for recreation before and after 2700 km of bikeways and reasons why they don’t cycle more. Using this information we calculated the change in participants who would go from non-cyclists to cyclists after the addition of 2700 km of bikeways and calculated the change in the amount of kilometers driven and greenhouse gas emissions produced. From our sample size (n=205), we projected our data onto the population of Metro Vancouver. We were also able to gather valuable information on what prevents people from cycling.
The results collected from this project suggest that biking infrastructure, the addition of 2700 km of bikeways, would benefit Metro Vancouver:

- The overall number of participants biking in Metro Vancouver would significantly increase for all types of destinations: work (68 to 94 participants), errands (57 to 91 participants), and recreation (119 to 151 participants). In addition, the change varied between gender and age range.
  - For age range, the greatest change, amongst our participants, was found in age group of 60-69, which had a 25 percentage increase after implementation of additional 2700 km bikeways.
  - For gender, the greatest change, amongst our participants, was found in female, which had a 16 percentage increase.
- From projecting the findings onto the Metro Vancouver Population, about 665 million km/year of travel would be converted from cars to bicycles, saving around 144 million kg of greenhouse gases per year.
- Information gathered on what prevents people from cycling supports the concept that biking infrastructure is indeed a preventing factor, and addressing this issue could increase the population of Metro Vancouver cyclists.
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INTRODUCTION

Currently, about 24% of all motorized trips in the Metro Vancouver region are capable of being biked with nearly two thirds of all trips in Metro Vancouver within a comfortable cycling distance (NNCA, 2013). Despite this, only 2.2% of these trips are made by bicycle. Why the lack of cycling? Translink suggests that the lack of bike infrastructure, in particular lack of safer and more convenient bikeways, is the cause for the low percentage of cycling trips (NNCA, 2013). This statement is supported by Pucher & Buehler’s (2008) study, which found that countries with more extensive cycling infrastructure, such as Germany and Netherlands, were found to have the highest percentage in total trips by bike at 15-30%. Biking infrastructures are structures and facilities used by cyclists, such as on-street and off-street bikeways, cycle tracks and designated painted areas on the road where cyclists can safely share the roads with drivers (Newhall, 2013).

With the demand in transportation ever increasing in the Metro Vancouver region, Translink (NNCA, 2013) and the Mayors’ Council (2015) proposed a vision for future transportation to counteract this, which included the addition of 2700 km of bikeways. With the implementation of the bikeways, Translink’s two primary goals were to increase the number of cycling trips and improve cycling safety. However, in July 2015, Metro Vancouver residents reviewed and rejected the proposal at the transit and transportation referendum, which is a regional district vote, which would have funded these major transportation projects (CBCNews, 2015).

Although this proposal was rejected, it is still important to gain more insights into the impacts of adding the proposed 2700 km of bikeways for future transportation proposals. To explore this topic we worked with the HUB Cycling Organization, Metro Vancouver’s most recognized cycling representation organization whose aim is to get people cycling more often. Through educating, communicating and encouraging people of all demographics about the advantages of cycling, HUB Cycling motivates many people to know more about cycling and to use cycling as one of their forms of transportation (HUB, 2015). HUB Cycling can use this report as one of their supportive arguments on whether the additional 2700 km bikeways is an effective method to achieve their goal of promoting cycling with their project on UnGapTheMap (Figure 1). UnGapTheMap is a project
supported by HUB Cycling to connect Metro Vancouver’s current cycling network. This provides HUB Cycling with a master plan for defining and prioritizing the infrastructure improvements that are still needed to connect the regional cycling network and realize the original vision for cycling (HUB, 2015).

Working alongside HUB Cycling, this project will aim to look at the impacts of adding the proposed 2700 km of bikeways by answer the following research questions:

1. Would the number of people cycling in Metro Vancouver increase?
2. How many fewer vehicle trips in kilometers would result?
3. How would greenhouse gas emissions be affected?
4. What factors prevent people from cycling more?

METHODS

DATA COLLECTION

Based on the objectives of this project, we created a questionnaire (Appendix) to gain insight on whether people would adjust their mode of transportation based on the addition of 2700 km of bikeways. The questionnaire focused primarily on the Metro Vancouver region. The questions asked information about an individual’s distance travelled, the number of trips they travelled, and the mode of transportation they used for two categories: 1) Where they travelled most (eg. work/school), 2) Where they ran errands (e.g. grocery shopping, entertainment, church, soccer, etc.). Information about an individual’s recreational cycling as well as their age and gender demographics were gathered. In addition, reasons for why participants did not cycle were collected to gain knowledge on how big an issue biking infrastructure is in preventing people from cycling. Once this information on an individual’s mode of transportation was collected, they were asked the same questions with the addition and knowledge of UnGapTheMap (Figure 1). The participants were shown a map with the new potential bikeways that could have been added if the 2700 km proposal was accepted. After looking at this map, participants would estimate their new or same mode of transportation and number of trips. This information was then compared with their original answers of their current transportation habits.
Figure 1: This is UnGapTheMap, a map showing the gaps in the current bikeway system in Metro Vancouver. The grey lines show the current bikeways and the pink lines show the gaps or potential new bikeways if the 2700 km were built. The blue stars indicate the nearest cross-intersections to where participants of the questionnaire live. The purple stars indicate the locations where in-person questionnaires were implemented. Sample size = 205.

The questionnaire was released online on January 11, 2016 and was open until February 11, 2016 where 153 completed questionnaires were collected (Table 1). While the online questionnaire was live, in-person questionnaires took place at four locations on four different days around the Metro Vancouver region. These locations were chosen based on two requirements: 1) Proximity to locations of new potential bikeways; 2) Density of people from different areas of Metro Vancouver. The four locations we chose were: 1) Commercial-Broadway Station, 2) Richmond Centre, 3) Metrotown, 4) UBC Nest. A total of 52 completed in-person questionnaires were collected.

<table>
<thead>
<tr>
<th>Location</th>
<th>Dates</th>
<th>Completed Questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial-Broadway Station</td>
<td>Jan 11</td>
<td>13</td>
</tr>
<tr>
<td>Richmond Centre</td>
<td>Jan 16</td>
<td>14</td>
</tr>
<tr>
<td>Metrotown</td>
<td>Jan 23</td>
<td>12</td>
</tr>
<tr>
<td>UBC Nest</td>
<td>Jan 27</td>
<td>13</td>
</tr>
<tr>
<td>Online</td>
<td>Jan 11 - Feb 11</td>
<td>153</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>205</strong></td>
</tr>
</tbody>
</table>

Table 1: Summary of data collection locations and time.
DATA ANALYSIS

We transformed all the raw questionnaire data into units of km/year for all modes of transportation. To determine whether there was a statistical significance, we used a chi squared contingency test. From our sample size (n=205), we projected our questionnaire results onto the population of Metro Vancouver. To do this, we used population data found on the government website (Statistics Canada, 2016). We are aware that our sample size is not directly representative of the whole Metro Vancouver region, so to minimize further misrepresentation, we applied age and gender data from our questionnaire to the age and gender distributions in Metro Vancouver as shown in Table 2. Statistics Canada organized their data by gender and ages in increments of 5 years. Because the population size for 19 years old was in the 15-19 age category, the population size was divided by five to get the population of 19 year olds. We also used this population size to project how much gas emissions would be saved based on our sample size.

ASSUMPTIONS

In the analysis of our data, we assumed that the estimate participants gave on their future transportation habits is accurate to what they would actually do if the 2700 km of bikeways were built. However, because of response bias, our results are likely an upper bound quantity. Also, the assumption that people interested in biking were more likely to fill out a questionnaire targeting cycling would contribute to the likeliness of our results being an upper bound quantity. In our data, there was a small amount of blanks that were not filled out by the participants. We assumed that if a participant left the distance or number of trips blank, we filled it in as “0”. If a participant left the unit blank (per day/week/month/year), we assumed it to be “per year”. We assumed this because it would assume the least that the participant would have had as an answer, rather than more. Because there were not many blanks, this did not significantly effect our data. We also made the assumption that the in-person questionnaires are equivalent in validity compared to the online questionnaires. Lastly, we assumed that all participants, who checked off cycling as one of their modes of transportation for work, errands, or recreation, are to be considered cyclists.
RESULTS

OVERALL CHANGE IN PARTICIPANTS WHO CYCLE

We found that, of the 205 questionnaire participants, the overall number of participants who currently cycle was 68 for work, 57 for errands and 119 for recreation. Based on the questionnaire responses, these numbers would increase to 94 participants for work, 91 for errands, and 151 for recreation after the addition of the 2700 km of bikeways (Figure 2). We then used the chi squared contingency test to determine whether our dataset had any significance, with an alpha value of 0.05 as our cutoff for significance. Any p-value less than 0.05 suggests a significance in the data. Using the chi squared contingency test to compare our observed cyclist results from the expected theoretical cyclist results, we found that for work, the chi-squared value was 6.88 and the p-value was 0.009. The chi-squared value and p-value for errands was 12.19 and 0.0005 respectively, and 11.00 and 0.0009 for recreation.

Figure 2: The number of questionnaire participants who currently bike (blue; before 2700 km of bikeways added) and who would be potential bikers (purple; after 2700 km of bikeways added) for each type of destination (Work; Errands; Recreation). Sample size = 205. *p < 0.05.
**Change in Cycling based on Age Range**

From our data analysis, we found that, from before to after additional 2700 km bikeways, the age range of 20-49, and 60-69 all have a positive percentage increase from non bikers to bikers, while ages 50-59 and 70+ have a zero percentage change before and after adding 2700 km more bikeways (Table 2).

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Percent of all participants</th>
<th>Before additional of 2700 km bikeways</th>
<th>After additional of 2700 km bikeways</th>
<th>Difference (n)</th>
<th>Total number within the range (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-29</td>
<td>61.5</td>
<td>83</td>
<td>94</td>
<td>+11(+13.3%)</td>
<td>126</td>
</tr>
<tr>
<td>30-39</td>
<td>18.5</td>
<td>23</td>
<td>29</td>
<td>+6(+16%)</td>
<td>38</td>
</tr>
<tr>
<td>40-49</td>
<td>7.31</td>
<td>14</td>
<td>15</td>
<td>+1(+7%)</td>
<td>15</td>
</tr>
<tr>
<td>50-59</td>
<td>10.2</td>
<td>17</td>
<td>17</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>60-69</td>
<td>1.95</td>
<td>2</td>
<td>3</td>
<td>+1(+25%)</td>
<td>4</td>
</tr>
<tr>
<td>70+</td>
<td>0.49</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2: Age distribution of all participants and all participants who are bikers. Bikers were classified as all participants who checked off cycling as one of their modes of transportation for work, errands, or recreation. Sample size = 205.

**Change in Cycling based on Gender**

In Table 3, male cyclist will have around 7 percent increase and female cyclists will have around 25 percent increase after the addition of 2700 km bikeways. One participant, who wrote gender as other, will have no change of habit in cycling before and after the construction of additional 2700 km bikeways.
<table>
<thead>
<tr>
<th>Gender</th>
<th>All participants (%)</th>
<th>All participants who are bikers (n)</th>
<th>Difference (n)</th>
<th>Total number (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>42.0</td>
<td>59</td>
<td>+4 (+6.78%)</td>
<td>86</td>
</tr>
<tr>
<td>Female</td>
<td>57.6</td>
<td>77</td>
<td>+18 (+23.4%)</td>
<td>118</td>
</tr>
<tr>
<td>Other</td>
<td>0.49</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Before additional of 2700 km bikeways | After additional of 2700 km bikeways

Table 3: Gender distribution of all participants and all participants who are bikers. Bikers were classified as all participants who checked off cycling as one of their modes of transportation for work, errands, or recreation. Sample size = 205.

**Change in Participants who Cycle to Work**

We expanded these changes found for participants who cycle to work by looking at the number of participants who would cycle, before and after, for each gender and age range, as shown in Table 4. In the work category, for each gender from ages 19-49, we found an increase in the number of cyclists from before and after the addition of 2700 km of bikeways. In particular, the greatest overall change in participants going from non-bikers to bikers was in the 20-29 age range for females. The number of 50-59 aged participants and the 60-69 aged male participants that currently cycle at all would not change, regardless of the additional bikeways. The number of 60-69 female participants would increase and none of our participants aged 70+ currently cycle nor would they decide to cycle with the addition of 2700 km of bikeways. Percentage-wise, the greatest increase after 2700 km was found in females aged 60-69.

**Change in Participants who Cycle to Run Errands**

In the errands category, there would be an increase in cyclists for all genders who are 19-59, after the addition of 2700 km of bikeways (Table 4). There are no current 50-59 female participants who cycle, but the number would also increase. None of the 70-79 aged participants would cycle regardless of the additional bikeways. The greatest overall change,
number-wise, was found in 19-29 year old females and, percentage-wise, in all genders aged 60-69%.

**CHANGE IN PARTICIPANTS WHO CYCLE FOR RECREATION**

As shown in Table 4, an increase in all genders aged 19-49 and males aged 50-59, who would cycle, was found in the recreation section. No change was found among the 50-59 year old females. The amount of 60-69 year old participants who cycle would increase after the addition of 2700 km of bikeways, while there are no current cyclists nor would there be any change among the 70+ aged participants.

**PROJECTIONS OF SAMPLE SIZE ONTO METRO VANCOUVER’S POPULATION**

Using the percentage increase based on our sample size of 205 and the Metro Vancouver population from Statistics Canada (2016) we were able to project the potential number of cyclists resulting from the addition of 2700 km of bikeways (Table 4). Approximately 193,000 citizens would go from non-biking to biking for work, 306,000 for errands and 292,000 for recreation.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Gender</th>
<th>Metro Vancouver Pop’n</th>
<th>Participant Pop’n</th>
<th>Estimated Number of Cyclists</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-29</td>
<td>M</td>
<td>171,689</td>
<td>49</td>
<td>16 8.2% 14,015</td>
</tr>
<tr>
<td>19-29</td>
<td>F</td>
<td>171,142</td>
<td>76</td>
<td>22 15.8% 27,022</td>
</tr>
<tr>
<td>30-39</td>
<td>M</td>
<td>148,615</td>
<td>15</td>
<td>6 13.3% 19,815</td>
</tr>
<tr>
<td>30-39</td>
<td>F</td>
<td>160,075</td>
<td>23</td>
<td>6 17.4% 27,839</td>
</tr>
<tr>
<td>40-49</td>
<td>M</td>
<td>171,410</td>
<td>7</td>
<td>3 14.3% 24,487</td>
</tr>
<tr>
<td>40-49</td>
<td>F</td>
<td>183,100</td>
<td>8</td>
<td>4 12.5% 22,888</td>
</tr>
<tr>
<td>50-59</td>
<td>M</td>
<td>158,530</td>
<td>13</td>
<td>0 0.0% 0</td>
</tr>
<tr>
<td>50-59</td>
<td>F</td>
<td>166,855</td>
<td>8</td>
<td>3 0.0% 0</td>
</tr>
<tr>
<td>60-69</td>
<td>M</td>
<td>107,840</td>
<td>2</td>
<td>2 0.0% 0</td>
</tr>
<tr>
<td>60-69</td>
<td>F</td>
<td>113,300</td>
<td>2</td>
<td>0 50.0% 56,650</td>
</tr>
<tr>
<td>70+</td>
<td>M</td>
<td>94,605</td>
<td>0</td>
<td>0 0.0% 0</td>
</tr>
<tr>
<td>70+</td>
<td>F</td>
<td>116,895</td>
<td>1</td>
<td>0 0.0% 0</td>
</tr>
</tbody>
</table>

Table 4: This Table shows the percentage increase in the number of cyclists after the 2700 km bikeways are added and is projected onto the population of Metro Vancouver (19 years or older; Statistics Canada, 2016). The column in pink font, gives the estimated increase of cyclists per each age/gender category. Sample size = 204; 1 participant specified their gender as other, which we do not have Metro Vancouver population data for.
The 205 participants estimated their current driving habits. Among these participants, a total of 486,687 km are being driven to work and 217,379 km being driven to run errands, for a total of 704,066 km (Figure 3). After the 2700 km of bikeways are added, the number of kilometers driven to work and to run errands would decrease to 446,534 km and 180,195 km respectively, for a total of 626,729 km. We used the "Kilograms of Greenhouse Gases Saved" constant (0.2168 kg greenhouse gases saved/year), which was calculated by HUB Cycling based on an average of vehicle size/model’s emissions per kilometre driven, to determine the amount of greenhouse gases that would be saved per year. Using this model, 8,705 kg of greenhouse gases would be saved from decreased driving to work and 8061 kg of greenhouse gases would be saved from decreased driving to run errands leading to an overall 16,767 kg of greenhouse gases saved per year, among our 205 participants who currently drive. Projecting these numbers onto the population of Metro Vancouver using the data from Statistics Canada (2016), it is estimated that about 75 million kg of greenhouse gases would be saved from decreased driving to work and about 69 million kg of greenhouse gases would be saved from decreased driving to run errands (Figure 4). This would lead to approximately 665 million km/year of travel being converted from cars to bicycles, saving about 144 million kg of greenhouse gases per year for the city of Metro Vancouver.

From this we can also see a shift in the number of individuals who drive. Before the 2700 km of bikeways are added 117 individuals drive to work and 120 individuals drive to run errands. After the 2700 km of bikeways are added the number of individuals driving decrease to 98 and 107 respectively.
Figure 3: Distance travelled in kilometers by questionnaire participants who drive a vehicle. The results before 2700 km of bikeways are added in blue and the potential driving distance travelled after 2700 km of bikeways is added in purple. Sample size = 205.

Figure 4: The amount of estimated greenhouse gas emissions that could be saved in kilograms per year from reduced driving as a result of adding 2700 km of bikeways. This data is based on the sample size of 205 participants and projected onto the population of Metro Vancouver (19 years and older), giving an estimate of the potential greenhouse gases that could be saved with the addition of 2700 km of bikeways.
FACTORS PREVENTING CYCLING

At the end of our questionnaire, we asked the participants, regardless of how much they cycle now, what prevents them from cycling more. We found the most popular answer out of our 205 participants was “Weather or darkness” (Table 5). 134 respondents chose this as one of the main factors that prevents them from cycling. Several participants (n=68) chose “lack of safe bikeways”. The participants also had the option to choose “Other” where they then had a text box they could fill out with the factor that prevented them from cycling. 11 individuals expressed their concerns of safety, 20 individuals do not have a usable bike, and 8 people expressed their lack of time in the “Other” category.

Table 5: Question 11 on the questionnaire: Regardless of how much you cycle now, what prevents you from cycling more? The left column is the factors that prevent people from cycling. The right column is the number of participants who checked off the factors that prevent them from cycling. If they checked off “other”, they wrote a statement describing what prevented them from cycling more. Some of the factors people wrote in the other category included: Not owning a usable bike; Not knowing how to bike; Not interested in cycling; Safety related; Health related; Lack of time. Sample size = 205.
DISCUSSION

CYCLISTS AND BIKING INFRASTRUCTURE

The results from Figure 2 suggests that the addition of 2700 km of bikeways would increase the overall percentage of participants who would bike for work, errands and recreation. Based on the chi-squared contingency test, all three destinations have a p-value less than 0.05, showing a statistical significance for each destination. We can say that the additional bikeways would significantly increase the number of people who would cycle in Metro Vancouver. A similar study done by Dill and Carr (2003) found that in 35 major US cities, there was a strong and significant relationship between biking rates and the amount of biking infrastructure available within the community. Cities with higher levels of biking infrastructure were positively correlated with higher rates of cycling usage. Some limitations mentioned in their study were addressed in ours, such as including people who cycle to run errands or for recreation and considering anyone who has biked at least once to be a cyclist. Since our study found a significant increase after the addition of 2700 km of bikeways, it further supports Dill and Carr’s findings that additional biking infrastructure would encourage more people to cycle. In addition, the significant increase was found after participants were shown the map with potential locations for new bikeways (Figure 1), suggesting that the connectivity of biking infrastructure networks and the location of infrastructure near commuting routes are some of the factors that influence a person’s willingness to cycle (Douma and Cleaveland, 2008). Therefore, our results also supports Krizek et al.’s (2009) study, which found a small but consistent and statically significant increase in bicycle commute share especially near areas surrounding biking facilities, suggesting that biking infrastructure significantly impacts levels of bicycle commutes.

GREENHOUSE GAS EMISSIONS

From Figure 3, of our 205 participants, it was found that the total kilometers driven decreased by about 77,300 km translating to 16,800 kg of greenhouse gas emissions saved. According to the Integrated Air Quality and Greenhouse Gas Management Plan Progress Report (IAQGGMP, 2014), the goal is to have 33% reduction of greenhouse gas emissions from 2007 levels by 2020 and 80% reduction by 2050. Metro Vancouver estimates that per
vehicle emissions decline will be part of reaching these goals. In 2007, just under 4000 kg of \( \text{CO}_2 \) emissions were emitted per vehicle (IAQGGMP, 2014). A 33% decrease would suggest that per vehicle emissions decline by 1320 kg. If about 16,800 kg of greenhouse gas emissions are saved based on 111 participants who drive (average number of participants who drive before and after 2700 km of bikeways are added), it is estimated that about 151 kg would be saved per vehicle based on the addition of 2700 km. Thus, the 2700 km bikeway addition would contribute to the greenhouse gas emission goals set by Metro Vancouver, but only slightly.

**AGE AND GENDER DEMOGRAPHICS AND CYCLING**

From Table 2, we can see all age groups will have an increased amount of participants who change from non-bikers to bikers except at age 50-59. The highest percentage increase of bikers was from the age range 60-69 followed by 30-39 and 19-29. The least amount of percentage change was at age 40-49. There is no clear reason on explaining why age 60-69 had the highest percentage increase in cyclist population nor why there was a higher percentage increase at age 30-39 than at age 19-29, but we assume it might be due to the fact that our participants at age 60-69 and 30-39 had a much smaller sample size than at age 19-29. Especially, due to limited time and resources, we were unable to gather more data on participants at age 60-69 so we could not make an accurate conclusion that the additional bikeways would affect people at this age. This result shows us an interesting possibility that the general public’s perception that younger generations tend to have more interest in cycling than older generation might not be true. In order to gather more information on which age group would be impacted the most by the additional bikeways, more data will be needed, especially data on older generations. For age 50-59 and 70 above, there was not any percentage change before and after the implementation of the additional 2700 km bikeways. According to participants at age 50-59, 13 out of 21 participants answered that weather or darkness prevented them from cycling more regardless of how much they cycle now. Therefore, we might able to infer that the reason why the additional 2700 km bikeways would not convince them to bike more is because the additional bikeways would not solve their concern on weathers and darkness. There was only one female participant in the group of age 70 and her reason for not biking more was
because she did not know how to bike, which is another thing that additional bikeways alone could not solve.

According to Table 3, females had a higher percentage increase in participants (+23.4%) who would switch from non-bikers to bikers compared to males (+6.78%), while for the gender: other, the participant would continue to be a biker before and after additional bikeways. This result agrees with the study from Pucher et al. (2011) that in Canada, specifically Vancouver, there is a higher percent of female who commute by bike than the male. However Pucher et al. (2011) found that in USA, there was a much higher percentage in male share of all bike trips than female. Males comprised 67% of bike commuters and females only comprised the remaining 33% of bike commuters in USA. His paper cannot suggest a valid reason for explaining why the percentage of female daily cyclists was different in USA than in Canada, but Pucher et al. (2011) concluded that it was most likely not due to the labor force structure between the two countries, since they both share a relatively similar amount of female labor force of 47% in Canada and 46% in the USA (Statistics Canada 2010, USDOC, 2010a,b). Therefore this phenomenon of higher female cyclist percentage might be due to our higher number of female participants from our questionnaire and might due to the fact that there are overall more females living in Vancouver than males (Statistics Canada 2016).

Table 4 shows that there was a consistent increase for all genders in the 19-49 age range for each type destination, with an overall greater number of cyclists for both before and after. In comparison, the older ages varied between each type destination yet had the highest percentage change despite having the lowest number of cyclists before and after. This may be due to the fact that we only collected questionnaires from a few participants who ranged from 60+. Therefore, one participant who would potentially change from non-biking to biking would greatly increase the change in percentage. Since more questionnaires were collected from the 19-49 age range, with an especially high range in 19-29, it is a more accurate representation of how Metro Vancouver citizens would change their biking habits after the addition of 2700 km of bikeways, compared to the older age ranges. In addition, because of the number of questionnaires collected for 19-29’s, there was a greater overall difference in participants who went from non-biking to biking. Due to
our sample population being quite a small sample size compared to the actual Metro Vancouver population, our results are an estimation rather than a direct representative projection of Metro Vancouver.

**FACTORS PREVENTING CYCLING**

When asked what prevented participants from cycling more, the top answer was “weather and darkness”, which correlates with Dill and Carr’s (2003) findings that the six cities with the lowest bicycle commuting rate are the cities that have over 100 days of rain. As Vancouver on average has around 168 days of precipitation per year (Current Results, 2016), we acknowledge that this is a factor that the addition of bike infrastructure may not be able to change unless it included some sort of overtop cover that protects cyclists from the rain or snow. However, darkness could be linked to the “lack of safe bikeways”, our second most popular answer, as some participants commented that if there were more safe bikeways, such as bikeways that separate cyclists from car traffic, they would feel more confident and safer cycling in the dark. Many people do not cycle more because they feel that there is not enough safe bikeways in Metro Vancouver. To support this claim, a study done by Cripton et al. (2015) found that out of 414 injured cyclists surveyed in Vancouver, one third of the bicycles crashes were collisions with motor vehicles. The severity of the injury for these types of crashes were the most severe amongst all types of bicycle crashes. With biking infrastructure in place, it would help cyclists have safer trips and potentially reduce crashes and injury severity after a crash (Cripton et al., 2015).

**FUTURE PLANS OF ACTIONS**

According to Environment and Climate Change Canada, emissions from transportation were the second largest contributor to Canada’s GHG emissions, which represents 24% of total GHG emissions among all other economic sector. The largest contributor (25%) is Oil and Gas “related to production, transmission, processing, refining and distribution of oil and gas products”. Since 2005, GHG emissions on transportation have been quite stable, 168 Mt CO\textsubscript{2} eq on 2005, 167 Mt CO\textsubscript{2} eq on 2010, 166 Mt CO\textsubscript{2} eq on 2011 and 165 Mt CO\textsubscript{2} eq on 2012. Environment and Climate Change Canada explained that the effect of increased population that puts more vehicles on the road have been offset
by the increasing fuel efficiency of light-duty vehicles. In 2014, Environment Canada suggested a Canada’s Emission Trends 2014 report and set up a Canadian target of 611 Mt of CO₂ equivalent in 2020. In the report, Environment Canada indicated that Canada’s annual GHG emissions will be 857 Mt of CO₂ equivalent if there are no actions have been taken to reduce CO₂ emissions, while with current measures, while CO₂ can only been reduced to 727 Mt of CO₂ equivalent with current measures and actions.

That means if Canada wants to achieve the goal of 611 Mt of CO₂ equivalent in 2020, there have to be some more new measures to help further reduce Canada’s annual CO₂ equivalent emissions. From our results, the addition of 2700 km of bikeways could put a dent in this number. If the additional 2700 km of additional bikeways were to be implemented, each year 144 million kg of CO₂ which is equal to 0.14Mt of CO₂ could be saved in the Metro Vancouver region inside the sector on transportation and this would help Canada be one step closer to achieving their GHG emission goal of annual 611 Mt of CO₂ equivalent at the year of 2020.

Additionally, the City of Vancouver plan on launching a public bike-share program operated by CycleHop Canada that will have 1,500 bicycles operating out of 100 stations covering from downtown to 16th Avenue and from Main Street to Arbutus Street summer of 2016 (CTV news, The Vancouver Sun). This bike-share program could help solve the problem for people who do not have access to a bike. This would provide a solution for those in our study who specified that they do not cycle because they do not have access to a bike. Therefore, if the government could combine the bike-share program with the additional bikeways, more people would likely to switch to cycling and would be cycling more often.

**CONCLUSION**

Based on the results found from our study, the overall number of participants who bike would significantly increase by 26 participants for work, by 34 for errands and by 32 for recreation with the additional 2700 km of bikeways. In particular, all genders from 20-49 would increase in all types of destinations, while 50+ would vary in change based on the type of destination. There was a decrease in the total kilometers driven for work and
errands after the additional bikeways and thus a decrease in total greenhouse gas emissions from cars per year. Lastly, females and the age group 60-69 had the highest percentage increase in participants who would go from non-bikers to bikers. When asked what prevents them from biking more, the most popular answer was due to weather and darkness, followed by lack of safe bikeways demonstrating the correlation of biking infrastructure and people’s willingness to cycle. Overall, the results gathered from this project suggest that biking infrastructure, the addition of 2700 km of bikeways, would benefit the city of Metro Vancouver. The two primary goals of Translink’s plan, to increase cycling trips and improve cycling safety, the addition of 2700 km of bikeways would impact Metro Vancouver and its residents.

ACKNOWLEDGMENTS

With the help from our community partner HUB Cycling and its representative Erin O’Melinn; and our ENVR 400 instructors, Dr. Sara Harris and Dr. Tara Ivanochko, we were able to create concise objectives, meaningful questionnaire questions, and insightful data analysis in order to answer our main question on how would people’s decisions to bike in Metro Vancouver be impacted by the addition of 2700 km of bikeways.

REFERENCES


Please read the following consent form before participating in the questionnaire.

1. What city do you live in?

2. What is the nearest intersection to your residence?
   e.g. Green Street and West 15th Avenue
3. What is the distance (one way) from your residence to where you travel most? e.g. work or school.

Please refer to Google Maps if you are unsure of your distance.


4. How often do you use each of these transportation modes to where you travel most (e.g. work or school)?

1 trip is one-way, e.g. home to work to home is 2 trips. Please give an answer for each mode of transportation.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Trips</th>
<th>per ___ (choose day/week/month/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk/Run</td>
<td></td>
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<tr>
<td>Cycling</td>
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<tr>
<td>Transit (Bus/Skytrain/SeaBus)</td>
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<td></td>
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<tr>
<td>Driving (Personal/Taxi/Car-Share)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This is "ungapthemap", the grey lines show the current bikeways, and the pink lines show potential new bikeways.

5. Looking at ungapthemap, if all the pink lines were built as safe bikeways, how often would you use each of these transportation modes to where you travel most (e.g. work or school)?

1 trip is one-way, e.g. home to work to home is 2 trips. (Please make sure your total trips for this section equal the same number of trips in question 4.)

<table>
<thead>
<tr>
<th>Mode</th>
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<tr>
<td>Other</td>
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</tbody>
</table>
6. What is the average distance (one way) you travel from your residence to where you run errands and/or attend weekly commitments? E.g. grocery shopping, entertainment, church, soccer, etc.
Please refer to Google Maps if you are unsure of your distance.

7. How often do you use each of these transportation modes to run errands and/or attend weekly commitments? (E.g. grocery shopping, entertainment, church, soccer, etc.)

<table>
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<tr>
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<td>---</td>
</tr>
</tbody>
</table>

This is "ungapthemap", the grey lines show the current bikeways, and the pink lines show potential new bikeways.

8. Looking at ungapthemap, if all the pink lines were built as safe bikeways, how often would you use each of these transportation modes to run errands and/or attend weekly commitments (E.g. grocery shopping, entertainment, church, soccer, etc.)?

<table>
<thead>
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<tbody>
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<td>Other</td>
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</table>

1 trip is one-way, e.g. home to work to home is 2 trips. (Please make sure your total trips for this section equal the same number of trips in question 7.)
9. How often do you cycle for recreation? (e.g. exercise, health or fitness)

1 trip is 1 bike ride, e.g. home to home is 1 trip.

<table>
<thead>
<tr>
<th></th>
<th>Trips</th>
<th>per ___ (choose day/week/month/year)</th>
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</thead>
<tbody>
<tr>
<td>Recreational Cycling</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This is "ungapthemap", the grey lines show the current bikeways, and the pink lines show potential new bikeways.

10. Looking at ungapthemap, if all the pink lines were built as safe bikeways, how often would you cycle for recreation?

1 trip is 1 bike ride, e.g. home to home is 1 trip.

<table>
<thead>
<tr>
<th></th>
<th>Trips</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Recreational Cycling</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11. Regardless of how much you cycle now, what prevents you from cycling more?

- Lack of safe bike lanes
- Lack of bikeways near my residence or work
- Lack of secure bike parking
- Weather or darkness
- Need to transport equipment or kids
- Too far
- Too trolly
- Other, please specify...

12. What is your gender?

- Female
- Male
- Other

13. What is your age?

- 10
- 20-29
- 30-39
- 40-49
- 50-69
- 60-69
- 70 or over

Question for Survey Investigators ONLY:

Do you use In-person Survey?

- Yes
- No