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**Overcoming barriers to cycling: Understanding frequency of cycling in a University setting
and the factors preventing commuters from cycling on a regular basis**

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42 **ABSTRACT**

43 Much local and regional transport policy is attempting to increase cycling as an everyday mode
44 of travel through infrastructure changes, education initiatives, and safety campaigns. While
45 considerable research has examined the influence of the built form on cycling, less research has
46 examined the barriers that prevent people who wish to cycle more (as part of their routine) from
47 doing so. This study examines several factors influencing the frequency by which people do (and
48 do not) cycle in a campus setting in a large metropolitan area. Mixed methods reveal differences
49 between barriers to cycling as well as the relative strength of these barriers across categories of
50 age, sex, and current mode used. A multinomial logit model, which controls for residential self-
51 selection effects, predicts whether and how often a respondent cycles based on socio-
52 demographic and trip characteristics. The presence of cycle paths is found to be strongly
53 associated with a higher frequency of cycling commutes. Additionally, an analysis of stated
54 barriers reveals effort and a lack of safety as the most important barriers to potential cyclists.
55 Finally, a qualitative analysis of respondents' open-ended responses confirms the influence of
56 bicycle paths, but reveals other factors such as the importance of improved interactions among
57 various street users. Findings from this research can be of benefit to transportation engineers and
58 planners who are aiming to increase the use of cycling among various groups of commuters.

59 **Keywords:** Barriers, Active Transportation, Cycling, Mixed methods, Mode choice, Cyclist
60 types

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63   **1.0 INTRODUCTION**

64   Recent decades have seen an increase in urban policy geared toward increasing active
65   transportation as well as a heightened awareness of its importance in terms of public health, the
66   environment, and congestion alleviation. Therefore a substantial amount of research in the fields
67   of transportation, health, and psychology has sought to identify factors influencing the uptake of
68   cycling as a mode of transportation. Many have recognized spatial and built environment factors
69   as influencing transport mode choice, especially how they affect cycling (Dill & Voros, 2007;
70   Jensen, 1999). Others have identified socio-economic and demographic factors associated with
71   active transport (Jensen, 1999; Kaczynski, Bopp, & Wittman, 2010; Larsen, El-Geneidy, &
72   Yasmin, 2010; Manaugh & El-Geneidy, 2011; Titze, Stronegger, Janschitz, & Oja, 2008). In
73   addition to looking at determinants of cycling, research has also turned to barriers to cycling, that
74   is the factors that prevent people from cycling, such as safety, effort and comfort concerns.
75   However, most of these studies do not gage the relative importance of these barriers in
76   preventing potential users from adopting active modes (Forman et al., 2008; Yeung, Wearing, &
77   Hills, 2008).
78   Furthermore, few examples of past research focus explicitly on barriers to active
79   transportation for those who in fact intend or would like to use active modes on a regular basis
80   but who currently do not. Thus, this study seeks to understand current cycle use and to answer
81   the following research questions: What are the most important barriers preventing commuters
82   from adopting cycling as a routine mode of transport? How do these barriers differ by spatial and
83   socio-economic characteristics? This study examines commuters from a large University travel
84   survey and aims to identify, measure, and compare the presence and relative importance of
85   barriers for different socio-economic groups, based on actual cycling frequency as well as stated
86   elements. This study contributes to the literature by using actual travel behavior and
87   incorporating mixed methods. Also, by focusing on the commuters who wish to cycle more, this
88   research can aid policy makers tapping into this latent demand for active transportation.
89   This paper is structured as follows: we briefly introduce key concepts and findings from
90   the existing literature on motivators and barriers to cycling. Next, the data and methods are
91   described, followed by our results and analysis. We conclude with a discussion of what these
92   findings imply for policy.
93
94   **2.0 LITERATURE REVIEW**

95   Barriers to cycling are defined in the literature as factors that prevent commuters who wish to
96   cycle more from doing so and can be classified in three broad categories: individual factors,
97   social and cultural factors, and built environment factors. A large body of literature has looked at
98   correlates, barriers, and facilitators to cycling (Bauman et al., 2008; Daley & Rissel, 2011;
99   Gatersleben & Appleton, 2007; Titze et al., 2008). Yet, many of these studies focus on the
100   physical infrastructure. As such, the lack of bicycle lanes and traffic characteristics have been
101   found to be major barriers to cycling. To a lesser extent, some studies have also addressed the
102   social- and individual-level factors (Gatersleben & Appleton, 2007). Winters *et al.* (2011) looked
103   at 197 "potential" and 107 "regular" cyclists (the former having expressed willingness to cycle
104   and the latter having claimed to cycle at least once a week) and found differences in the barriers
105   to cycling. For example, while a distance of 10-20 km was identified as a barrier for potential
106   cyclists, it did not influence regular cyclists. In addition, Heesch *et al.* (2012) found gender
107   differences in how recreational cyclists perceive environmental constraints for cycling.

108 Furthermore, Willis, Manaugh, and El-Geneidy (2013) found that cyclists' characteristics had
109 more influence on trip satisfaction than built environment factors.
110   Recent studies have highlighted the need to go beyond quantitative methods to uncover
111 social and individual barriers to cycling. Based on in-depth interviews, Schneider (2013)
112 examined the thought processes of mode choice decision making; interview respondents
113 provided rich detail on reasons why they do and do not use active transport. Recent work by
114 Pooley and colleagues has taken a mixed method approach to investigate factors preventing from
115 cycling. In a study examining the role of household level factors, 437 households responded to
116 an online survey and eight households agreed to a more in-depth ethnographic interview. Among
117 many findings, the authors explore the importance of time constraints, views, and perceptions
118 about cycling for everyday activities as well as issues such as the need to plan ahead in order to
119 make active trips cycle (wardrobe, choice of shoes etc.)(Pooley et al., 2011). A later study with
120 respondents from four British towns identified several important aspects such as respondents
121 believing that cycling would be a good way to save money, have health benefits, and be good for
122 the environment, but that it would not be "enjoyable" (Pooley et al., 2013).
123   Gatersleben and Appleton (2007), in a mixed-methods study addressing barriers to
124 cycling, categorized survey respondents by how frequently they cycled. Perceived constraints
125 were compared between these groups in terms of "preparedness for cycling", on a scale from
126 "pre-contemplation" to "maintenance". In a similar vein, much work in recent years has
127 examined types of cyclists (Bergstrom & Magnusson, 2003; Damant-Sirois, Grimsrud, & El-
128 Geneidy, 2014; Dill & McNeil, 2013; Geller, 2006). This body of literature is vital in
129 understanding how different people will respond to policy, cycling infrastructure, and land use
130 changes. The classification of people into cycling categories in the present paper most closely
131 resembles the approach of Bergstrom and Magnussum (2003).
132   Although research has sought to identify the existence of barriers to active transportation,
133 few evaluate their actual effect on commuters' actual use of active transportation (Shannon et al.,
134 2006). In addition, relatively few have used a mixed-methods approach when doing so. This
135 paper is among the first to both model the likelihood of cycling as well as to focus on the
136 experienced barriers that prevent people from becoming cyclists or increase the frequency of
137 bicycle commuting.
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140 **3.0 METHODS AND RESEARCH FRAMEWORK**

141 This research was motivated by the desire to understand not only the correlates of current cycling
142 behavior, but the factors that could be related to a change in cycling frequency. The stages of
143 change model, an approach long used in behavioral change research (Prochaska & DiClemente,
144 1983), has recently been used in cycling research. This approach guides our research framework,
145 design, and analysis here; we are interested in what physical and psychological factors may
146 influence a person to move along a continuum from a "non-cyclist" to a regular commuting
147 cyclist.
148   Using a large sample of cyclists and non-cyclists, four groups of cyclists were identified
149 based on their cycling frequency. Then, acknowledging that one's frequency can either increase
150 or decrease over time, we identified barriers to increased cycling, by comparing the cyclists with
151 high and low frequency of cycling. After grouping commuters into four cycling frequency
152 categories, statistical modeling allowed assessing the influence of the factors (socio-economic
153 and built environment) associated with an increased frequency in cycling (from never to rarely,

154 usually or always). The barriers were then further investigated through an analysis of the stated
155 barriers and the respondents' open-ended responses.
156   The sample includes students, faculty and staff at McGill University in Montreal,
157 Canada. Data for this study were collected using a survey that was active for 35 days in March
158 and April 2013. A total of 20,851 survey invitations were distributed. Roughly 6600 people filled
159 the survey (response rate of 31.7%). After data cleaning, 4,944 surveys were kept as usable
160 responses for this study. In addition to socio-economic information (age, sex, employment or
161 student status, household structure and income) and details of current travel patterns, respondents
162 were asked to what degree they intend to use the modes of transportation they currently do not
163 use. They were also asked to rate the barriers they faced for the mode that they were "least
164 likely" to use again. Questions on barriers to mode use were asked as likert-type questions. The
165 question was phrased, "Please specify why you don't cycle more often during your commute to
166 McGill. Please choose the appropriate response for each item: Strongly disagree, somewhat
167 disagree, neutral, somewhat agree, and strongly agree". The factors were: distance, effort,
168 comfort, cost, safety, and availability of bicycle parking.
169   Respondents were asked to place a pin on an online map to represent their home location
170 as well as the building on campus where they spend most of their time. This allowed for the
171 calculation of the shortest network distance, elevation change, distance to cycling facilities, and
172 presence of dedicated cycling infrastructure along the route to campus. Actual paths used by
173 respondents were not available to the researchers; while this would have been ideal, the shortest
174 path arguably better captures the variance in respondents' perception of their potential commute
175 to work. Also, as the "never" cyclists would not have an observed path, this method does not
176 introduce any biases or assumptions in regards to how far the respondents might be willing to
177 divert from the shortest path distance (Gliebe and Dill, 2008).
178   Also, to account for issues of residential self-selection, respondents were asked to rate the
179 importance of various home location factors (for example the desire to live close to campus or in
180 close proximity to public transit). Respondents were also given the opportunity to respond to the
181 following open-ended question: "Do you have any suggestions to encourage the use of
182 sustainable transportation (cycling, walking, and public transit) to McGill?" All authors
183 examined each open-ended response to code into a general theme, allowing us to measure the
184 frequency of concepts mentioned. Quotes that illustrate important themes are presented in
185 Section 4.
186   It is important to mention that while the sample is drawn from a University setting and so
187 may not be representative of the region as a whole, an effort was made to oversample faculty and
188 staff (itself a diverse category including technicians, janitors, and administrative assistants).
189 Students make up 48% of the sample; the average age is 34.9.
190   Based on information given in response to questions that asked respondents to describe
191 their typical "warm dry" and "cold snowy" commute, as well as what modes they had used in the
192 past year, respondents were divided into four categories of cycling types. These are "never"
193 (have never cycled from their current home location to campus), "rarely" (had cycled at least
194 once in the past year, but most often commute by other modes), "usual" (those that cycle as main
195 mode during "warm dry" periods) and "always" (year-round cyclists).
196   After separating respondents into one of the four cycling categories, a multinomial
197 logistic regression is used, as part of the mixed-methods analysis, to understand and quantify the
198 effects of socio-demographic factors, route characteristics, and residential choice factors on the
199 likelihood of falling into one of the four categories. After this, we focus on the "potential"

200 cyclists (these are defined as people who are currently not cycling regularly ("never" or "rarely")
201 but have expressed a desire to do so) and their expressed reasons for not cycling more often
202 (both likert-type and open-ended questions). This approach allows us to capture nuances not only
203 in what objective physical factors (age, presence of hills and bicycle paths) may influence
204 cycling, but also to explore what reasons and perceptions respondents give to why they do not
205 regularly cycle.
206
207 **3.1 Area of Study**

208 The City of Montreal has recently invested heavily in cycling infrastructure. The latest budget
209 includes $10 million CAD per year for new and upgrading cycling infrastructure (Ville de
210 Montreal, 2013). Figure 1 shows the location and type of dedicated cycling lanes in the city, the
211 inset map shows a close-up of the McGill University campus, giving a sense of how well the
212 campus is connected to cycle paths. The city currently has roughly 650 km of cycle paths, of
213 which 41% is off street, although some of this, particularly in parks, is more used for recreation
214 than for commuting. This is a higher than average amount for a North American city. For
215 simplicity's sake, several different types of cycling infrastructure have been consolidated into the
216 "on-street" category, these include, "sharrows", as well as lanes separated by a line of paint.

217 **FIGURE 1 CYCLING INFRASTRUCTURE IN MONTREAL**

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220 **4.0 RESULTS & ANALYSIS**

221 **4.1 Quantitative Results and Analysis**

222 To begin, basic descriptive statistics for our subsamples of current cyclists and non-cyclists are
223 presented in Table 1. Respondents are described in terms of age, gender, university status, and
224 distance from destination. Similar to past research, we see that the vast majority fall into the
225 "never" category (71%), and only 1.4% are in the "always" category. 13% of the respondents fall
226 in the "rarely" category and 15% in the "usually" category.
227 　　　　ANOVA and Chi-square tests examine whether socio-demographic and physical
228 characteristics are significantly different across groups. ANOVA post-tests allowed for the
229 determination of which specific groups were different. We see that, for example, distance
230 between home and destination is significantly longer for "never" cyclists. However, there is no
231 significant difference among the other three groups of cyclists. Being male, on the other hand, is
232 only statistically significant for the "always" cyclists. The "other" mode used by "rarely" and
233 "usual" cyclists is also noteworthy; 41% of "rarely" cyclists walk as their most common mode;
234 this speaks to the fact that many respondents live close enough to their destination that walking is
235 a viable option. "Never" cyclists are also more likely to be automobile drivers than the other
236 categories. The proportion of dedicated cycle path along the actual or potential cycling route is
237 significantly different and as expected, higher proportion of cycle path availability is associated
238 with higher levels of cycling.
239 　　　　The average elevation change is consistent across groups, although when expressed as a
240 percentage of respondents with an elevation change of more than 30 meters, more "never"
241 cyclists fit into this category. Lastly, roughly 75% of "rarely" and "usual" cyclists express the
242 desire to cycle more often. This "latent demand" is important and points toward the value of
243 understanding the barriers to cycling.

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256   **Table 1: Description of subsamples by frequency of cycling**

	Never	Rarely	Usual	Always
Socio-Demographics				
Count	3502	642	731	69
Age	35.5	32.2	34.6	32.8
Male	33.4%	46.4%	43.5%	75.4%*
Staff	37.3%*	24.1%	28.9%	21.7%
Faculty	17.3%	19.0%	24.5%	21.7%
Student	45.4%	56.9%	46.7%	56.5%
Current Mode[1]				
Cycling	0%	0%	0%	100%
Automobile	19%*	8%	6%	0%
Park and Ride	11%	2%	1%	0%
Transit	49%	49%	68%*	0%
Walking	21%	41%*	25%	0%
Trip Characteristics				
Distance (m)	10865.0*	4972.4	5582.3	4947.5
Length of bike path (m)	2600.1	1541.4	2541.5	2147.9
Share of bike path	29.1%*	37.4%*	50.8%*	44.0%*
Elevation change (m)	59.0	58.4	59.2	58.7
Presence of Hill	62.7%*	54.4%	59.1%	52.2%
Mode Change Intention				
Percent who wish to cycle more	38.2%	74.9%	75.0%	43.5%

257   * Significantly different across groups (based on Tukey and LSD procedures)
258   [1] For "usual" cyclists, this refers to the "cold wet" mode.
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261   **4.1.1 Multinomial Regression Results**
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263   Table 2 presents the results of the multinomial logistic regression with the Relative Risk Ratio
264   (RRR), this is similar to an odds ratio in a binary logistic regression and can be interpreted in a
265   similar manner. In other words, the RRR represents the probability associated with a unit change
266   in a given variable relative to the reference case ("never cycle for commuting purposes"). Other
267   variables (including interaction terms gender*distance, and age*distance) were tested but were
268   not significant in the models. Also, other variables commonly used in travel behavior research
269   such as possession of a driver's license and car ownership were dropped from the model; over
270   80% of respondents possess a driver's license. While other modeling approaches were
271   considered (such as a binary never/rarely and usual/always), the multinomial better captures the
272   progression from a non-cyclist to a year-round cyclist which lies at the heart of the theoretical
273   approach here. In other words, the MNL attempts to answer the question, what factors could
274   convince a non-cyclist to sometimes, often, or always cycle.
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Table 2 Multinomial Regression Results

		Rarely[1]	Usual	Always
Socio-Demographics	Faculty	1.441***	1.760***	1.225***
	Staff[2]	1.042	1.153***	0.878
	Male	1.694***	1.434***	5.934***
	Age	1.044	1.159***	1.104
	Age squared	0.999	0.998***	0.999
Trip Characteristics	Length (km)	0.918***	0.948***	0.918
	Percent Cycle path	1.008***	1.033***	1.019***
	Hill (>20 meters)	0.847**	0.983	0.822
Home Location Factors	Proximity to campus	0.959	0.917**	1.046
	Proximity to Transit	1.005	1.023	0.703***
	Desire to not use non-motorized transport	1.066*	1.166***	1.346**

[1] Reference case is "Never cycled from current home to work"
[2] Reference category is "student"
***= p<0.001, ** p<0.01, *p<0.1
Pseudo R square 0.135 McFadden
N=4944

Socio-demographic characteristics
The model has a reasonable explanatory power compared to previous research and most variables are significant with intuitively signed coefficients. Being male is significant in all models but the difference among the groups is striking. On average, the effect of age is positive, older respondents are more likely to cycle than younger respondents. Plotting the age and age squared terms shows that age has a positive effect on the likelihood of cycling until the age of 45. It is important to note, however, that given the characteristics of the sample, this may be due to the fact that many younger respondents live close to or on campus, potentially making walking a more attractive mode than cycling. Being a staff or faculty member is, on average more associated with being a cyclist than being a student.

Trip characteristics
The most interesting aspect in terms of potential infrastructure and policy change is the share of bike path along the respondent's potential route. For a unit change in the increase of the proportion of designated cycle path, the associated RRR is 1.033 for a "usual" cyclist, and 1.019 for an "always" cyclist relative to a "never" cyclist. In other words, each percentage increase in cycle path coverage is associated with an increase of 3.3% and 1.9% respectively for being a "usual" or "always" cyclist. While the presence of elevation change has a small effect between being a "never" and a "rarely" cyclist, the effect is not significant for the other categories.

Home location factors
Distance from home to campus is significant in each of the model iterations, although the magnitude does not vary by cycling outcomes. The residential choice factors test the "self-

303 selection" issue by attempting to control for the fact that some respondents may live in their
304 current home location in order to use desired modes of transport. The associated coefficients
305 show the importance of these factors. The "desire to use non-motorized transport" is positively
306 associated with cycling, while controlling for trip characteristics. As would be expected, the
307 effect of this attitude is increasingly important for each level of cycling use, being associated
308 with a 34% increase in the likelihood of being an "always" cyclist. Having chosen the current
309 home location based on "proximity to public transit" is significantly and negatively associated
310 with being an "always" cyclist.
311
312 **4.2 Barriers to cycling on a regular basis**
313
314 The regression analysis sheds some light on the factors that determine what type of cyclist a
315 respondent is. However, a more nuanced examination will allow us to make more informed
316 recommendations as to policy and infrastructure changes. This is accomplished in three ways:
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318   • A sensitivity analysis using the outputs of the logistic regression.
319   • An examination of "potential cyclists'" stated reasons for not cycling.
320   • An analysis of open-ended responses.
321
322 *4.2.1 Sensitivity Analysis*
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324 To better understand the effects of socio-demographic, spatial, and infrastructure elements on the
325 likelihood and frequency of cycle commuting, a sensitivity analysis was done. This was
326 performed by predicting the likelihood of falling into each of the four cycling types given
327 changing variables concerning age, distance, and proportion of potential path which is a cycle
328 lane. Table 4 shows simplified results of this analysis with only three distances shown (3, 5, and
329 7 kilometers). Each row of the table shows the relative probability of a 34 year-old male of being
330 in each of the cycling categories given changing distance and cycle path characteristics. It is
331 important to reiterate that as year-round cycling is such an uncommon outcome, the model rarely
332 predicts this outcome. This has important implications for the potential of mode shift, the model
333 predicts that even under favorable conditions (3 km trip with 50% cycle path availability) 48% of
334 the population will still fall into the "never" cycle category. In other words, this finding presents
335 a realistic idea of how many people will cycle given these ideal conditions without exaggerating
336 the potential market for cycling. The area of most interest is in examining at which thresholds the
337 probability becomes higher to be "usual" cyclist than a "never" or "rarely" cyclist.
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Table 3 Sensitivity Analysis

Distance (km)	Share of bicycle path	Never	Rarely	Usually	Always
3	0.33	0.57	0.21	0.19	0.03
	0.5	0.48	0.2	0.28	0.04
	0.75	0.35	0.17	0.44	0.04
5	0.33	0.6	0.19	0.18	0.03
	0.5	0.52	0.18	0.27	0.04
	0.75	0.38	0.16	0.43	0.04
7	0.33	0.63	0.16	0.17	0.03
	0.5	0.55	0.16	0.26	0.03
	0.75	0.41	0.14	0.41	0.04

The most striking aspect is the power of the presence of a bicycle lane. While the probability of "usually" cycling three kilometers (less than the average overall cycling commuting distance) with 33% cycle path coverage for a 34-year-old male is relatively low (19%), increasing the amount of coverage to 75% increases the probability to 44%. Interestingly, this stays roughly the same even with a much longer commute, 41% for a seven kilometer commute with 75% bicycle path availability. Similarly, a 5 km commute with 50% bicycle path coverage predicts a higher probability of "usually" cycling than being a "rarely" cyclist.

4.2.2 Barriers identified by potential cyclists

This section of the analysis focuses on "potential" cyclists and their expressed barriers to not cycling more regularly. This section uses data from both likert-type questions on the importance of different barriers and open-ended questions. This section is derived only from the responses of people who are not currently regularly cycling but have expressed a strong desire to do so (these respondents are drawn from both the "never" and "rarely" categories), this is a subsample of 295 people. Two key reasons make it important to perform this analysis in addition to the multinomial regression model. Firstly, many potentially important factors (secure bike parking, showers, for example) cannot be variables in the model (as there is no variance across respondents in the sample). Secondly, we are interested in knowing respondents' perceptions about their reasons for not cycling. The model could easily lead us to overstate the importance of distance of (lack of) cycle paths, for example, as deterrents to cycling in the absence of corroborating evidence from respondents.

The survey asked respondents to rate the importance of elements that have been found to discourage cycling: distance, effort, comfort, safety, cost, and presence of bicycle parking. Table 4 presents these findings stratified by age, distance, and most common mode used.

Safety and effort were the most commonly cited barriers with the availability of bicycle parking following closely behind. Lack of safety was more prevalent among potential cyclists, being a concern for roughly half of them. The importance of safety in influencing cycling has effectively been shown in past literature (Gatersleben & Appleton, 2007; Heesch et al., 2012; Timperio et al., 2006).

383 Table 4: Barriers to Cycling as cited by Potential Cyclists (expressed in percentages)

Barrier	Length	Effort	Comfort	Cost	Safety	Parking	N
Average (out of 5)	**2.3**	**2.9**	**2.5**	**1.6**	**3.1**	**3.1**	**295**
Overall (%)	25.0	43.0	29.4	7.8	48.4	41.6	295
Age							
<25	20.9	41.9	24.7	11.4	52.3	46.6	105
25-34	25.8	52.8	37.1	7.8	44.9	35.9	89
35-44	21.7	43.4	19.5	6.5	34.7	47.8	46
45-54	30.4	17.3	21.7	4.3	65.2	43.4	23
55-64	45.8[1]	41.6	45.83[1]	0	58.3	33.3	24
>65	12.5	25	37.5	0	37.5	25	8
Sex							
Female	24.6	48.1[1]	28.5	9.1	48.1	45.4[1]	154
Male	24.6	38.8	30.6	5.9	50	36.5	134
Distance (km)							
<2.5	3.9	38.1	26.9	10.3	50	39.6	126
2.5-5	20.2	50.7	31.8	5.8	43.4	42.0	69
5.01-7.5	42	44	24	4	36	42	50
7.51-10	68.4[1]	52.6	36.8	10.53	57.8	42.1	19
>10	67.7	38.7	38.7	6.45	67.7[1]	48.3	31
Main mode of transportation							
Drivers	47.6	38.1	38.1	0	52.3	42.8	21
Transit users	45.0	48.8	32.1	6.8	45.8	39.6	131
Pedestrian	3.5[1]	38.4	25.8	9.8	50.3	43.4	143

384 [1] Statistically significant across comparison (vertical) category chi test (p<0.05)

385

386 It is not surprising that the perception of distance as a deterrent to cycling increases with
387 actual distance. However, the importance of distance as a barrier to cycling increased and
388 plateaued at different distances for men and women. While overall distance is a barrier for both
389 men and women, the actual distance at which people state it as a barrier varies by sex. Starting at
390 around 7.5 km, the difference in the proportion of men and women who cite distance as a major
391 barrier to cycling increases, with 63% of women 'agreeing' or strongly agreeing' that distance is
392 a barrier to cycling at this distance, compared to roughly 50% for men at the same distance.
393 While distance and elevation were determining factors for predicting cycling frequency, length
394 of commute was the second least important barrier after cost according to the survey responses.
395 This echoes the small effect of distance on cycling frequency, as found in the MNL. Yet, lack of
396 bicycle parking and cost of cycling were generally higher for those living closer to their
397 destination.
398 The importance of certain barriers differ by age group. Safety as a barrier to cycling
399 increases in importance as age increases whereas discomfort remains fairly consistent across age
400 groups (Table 4). Effort differs significantly by age group, with the youngest and oldest agreeing
401 most with the presence of this barrier (p<0.05). Youth are also overrepresented among those

402 perceiving cost as a barrier to cycling (p<0.05), a finding that contrasts with other studies that
403 cite the low cost of cycling as a motivator for youth (Shannon et al., 2006).
404   The importance of certain barriers also varies by gender, as mentioned above. Despite
405 being important for both females and males, effort and lack of safety stood out among females as
406 being significantly more important as a barrier to cycling (p<0.05, p<0.1). A majority of cyclists
407 would like to cycle more, further suggesting a relatively high potential and opportunity for
408 growth in cycling among potential and even current users (Heesch et al., 2012).
409
410 *4.2.2 Open-ended questions on barriers to cycling*
411 In order to gain an understanding beyond what is provided by a structured survey questions, an
412 analysis of open-ended questions was conducted. Both authors and a research assistant read each
413 comment and coded according to general theme. This was done iteratively until both authors
414 agreed on the proper category. We present basic percentages by theme and provide illustrative
415 quotes in this section.
416   Somewhat surprisingly, weather conditions were not a prevalent concern among potential
417 cyclists. The most common response (28%) concerns path infrastructure. For example, a 46 year-
418 old male responded: *"1) Have bike paths put in practical places -- not impractical places like [a*
419 *busy street]. 2) Enforce safety regulations for bike paths, ie: get cyclists to obey traffic signals,*
420 *get pedestrians to look both ways on bike paths."* A 33-year male suggests *"[…] having bicycle*
421 *lanes that are separated from traffic,"* would impact his sense of safety. Several others listed
422 specific streets that they would like to see cycling infrastructure.
423   Other frequent responses relate to the bicycle facilities, such as parking, showers and
424 BIXI stations. Bicycle parking and concerns of theft are quite common for potential cyclists;
425 24% of comments concern the availability and security of bicycle parking as a main deterrent of
426 use. For example, a 27-year-old male pedestrian says, *"I worry about the safety of my bicycle*
427 *locked outside. I've heard many stories of people losing their bikes to thieves."* Another was
428 more direct*, "I would bike to school more if I had a cheap bike. The reason I do not bike to*
429 *school is because I'm afraid my bike (or parts of it) will get stolen even if I lock it up." (32 year-*
430 *old female). "*Shower and changing facilities were another theme (10% of comments). A 45-year
431 male and current car driver says. "*Provide showers and secure/supervised bicycle parking.*"
432 Another surprising outcome has to do with the frequency by which BIXI (the local bicycle-
433 sharing network) is mentioned (12%). The comments concern the number and location of
434 stations, as well as the number of available bicycles. For example, a 28 year male responds,
435 "*More BIXI stations around campus, especially [in the northern part of campus].*
436   Interactions between different mode users also came up. Interestingly, some mentioned
437 not only driver, but also cyclists' behavior *"Educate and regulate young bikers. Feelings of*
438 *road entitlement work both ways"* (34 year-old male). Another (31 year-old female) mentions,
439 "*jay-walkers downtown are very dangerous to bikers on paths.* Regarding the trip characteristics,
440 elevation was a prevalent theme among potential cyclists with words like "mountain" and "hill"
441 coming up fairly often, cited by 8.8% of the potential cyclists. Also, a 20 year-old female who
442 lives 500 meters from her most common destination on campus wrote, "*I'd rather walk*" pointing
443 out the importance of personal taste as well as the fact that trips that are *too* short may be
444 difficult to convert to cycling trips (it is also debatable whether converting walking trips to
445 cycling trips is a desirable goal). Another (30 year-old male student) pointed out *"I'm close*
446 *enough that it would be insane to do anything other than walk".*

447   Finally, while they represent a smaller percentage, several people pointed out the effect
448 that dropping children at daycare facilities. "*I have to bring my children to daycare at McGill*
449 *and to school so there is no way to take a bike! If I were commuting without children, I would*
450 *consider biking*" (38 year-old male student). *"I have to drop off a child at daycare on the way to*
451 *work and I live too far away. That's why I don't bike"* (31 year-old female staff).
452   These results help to reinforce the model results and point to where policy can play a
453 role. For example, cycle path coverage and the location of BIXI stations are under control of city
454 transportation planners, while concerns of elevation change are, of course, not. Other comments
455 and barriers are directly under the control of University policy such as showers, parking and
456 change facilities. More importantly, many of the comments deal with factors that are difficult to
457 capture and model in a mode choice model, such as the location of a child's daycare.
458 Furthermore, while certain elements, such as elevation, were not significant—or had a smaller
459 than expected effect sizes in the statistical models—the written comments allow us to capture the
460 importance of this element for particular respondents. The variation in the distance and elevation
461 change of people citing these factors also points toward the subjectivity of these elements, some
462 people will perceive a given travel distance as acceptable while others will not.
463
464 **5.0 DISCUSSION AND CONCLUSION**

465 By examining current and desired travel patterns as well as barriers to change, this research
466 identified four distinct groups of cyclists and has drawn attention to the latent demand for
467 cycling among a large sample of commuters in Montreal, Canada. By better understanding the
468 barriers experienced by those who wish to engage in active modes of transportation, public
469 policy can be more appropriately oriented to affect behavior and mode switch. Since active
470 modes have important public health, environmental and social benefits, it is a central goal of
471 many regions, cities, and institutions to improve conditions for these modes.
472   Potential cyclists are affected by a complex array of barriers. The multinomial choice
473 model and comparison of expressed barriers, revealed the importance of cycle paths, safety, and
474 secure parking facilities. Comments and suggestions also confirmed and elucidated the
475 importance of connected bicycle paths and proper intersection design, accompanied by a need for
476 more secure and available bicycle parking.
477   This study reveals latent demand to take up or increase the frequency of cycling as a
478 regular commuting mode among both cyclists and non-cyclists, roughly 75% of "rarely" cyclists
479 and 38% of "never" cyclists wish to cycle more often. It is, however, also important to note that
480 the model results as well as the responses to open-ended questions suggest that many people will
481 never become "usual" or "always" cyclists although in many cases they are within a reasonable
482 cycling distance. Furthermore, while it is important to bear in mind that the authors cannot with
483 certainty claim that respondents would begin to cycle or increase the frequency at which they
484 cycle, readers should be reminded that these barriers constitute expressed reasons preventing
485 potential cyclists from changing modes. Most respondents in these subgroups explicitly said they
486 would like to cycle more. Therefore, these findings have relevant implications for where active
487 transportation policy needs to be oriented.
488   The findings concerning the relationship between perceived distance and objectively
489 measured elevation change deserve more careful examination in the future. Future research
490 should look further into distance perception and how it differs by a variety of factors that were
491 unexplored in this study. Other important factors that were not explicitly explored in this study
492 include: variance in the propensity to cycle by time of day (darkness and traffic levels), and

493 influence of peer groups. Finally, the qualitative findings presented here point toward the
494 usefulness of continuing to look beyond traditional travel survey methods to capture and
495 understand what may be preventing desired travel behaviors.

496

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