A STUDY OF CYCLISTS IN HAMILTON, ONTARIO

A STUDY OF CYCLISTS IN HAMILTON, ONTARIO: PERCEIVED AVAILABILITY OF CYCLING FACILITIES AND CYCLISTS' MOTIVATIONS FOR CYCLING

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JAMIE STUCKLESS, B.A.

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AUTHOR: Jamie Stuckless, B.A. (Queen's University)

SUPERVISOR: Professor Nikolaos Yiannakoulias

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ABSTRACT

Despite the many individual and community benefits to cycling, commuter cycling rates across Canada are relatively low. This research seeks to understand how this can be changed by examining the motivations and cycling behaviour of cyclists residing in Hamilton, Ontario, a mid-sized Canadian city with below average levels of commuter cycling. This thesis is divided into two separate studies of commuter cycling behaviour. The first study employs a multiple logistic regression model to explore how the perceived availability of cycling facilities influences commuter cycling. The second study uses cluster analysis to classify respondents into groups based on the factors that motivate them to cycle. This research highlights the importance of bicycle-friendly workplaces and the need for municipalities to focus on creating areas of high density, mixed-use development in order to encourage cycling. This research also discusses the potential to promote cycling by targeting specific people with positive messages about cycling that are relevant to them. The researcher argues that, in addition to encouraging non-cyclists to start cycling, municipalities need to focus on getting recreational cyclists to start commuting by bicycle and encouraging existing cyclists to cycle continuously throughout their lives. The data for this study was obtained through a revealed preference survey that was designed and administered by the researcher.

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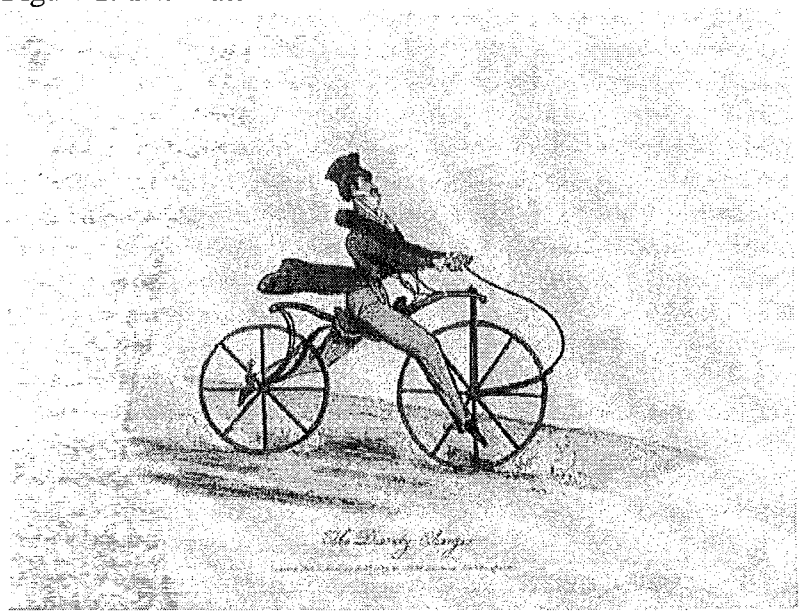
CHAPTER ONE: INTRODUCTION

1.1 RESEARCH CONTEXT

Many historians believe that cycling began in 1817 with the invention of the "velocipede", or "draisine". Although this walking machine did not yet have pedals, it was the first human powered land machine that was widely accepted by the public, marking a significant step towards the basic bicycle. The draisine was comprised of two wheels and supported by a frame to be straddled by the rider. The machine and rider were propelled forward as the rider walked their feet along the ground (Figure 1) (Herlihy 2004). Centuries of technological developments have turned the draisine into the bicycle that we recognize today. Once only affordable to the wealthy upper classes, it is now an inexpensive mode of transportation used for utilitarian and recreational purposes by cyclists of all classes.

Figure 1. The draisine



(Helihy 2004)

Cycling is often classified as being either recreational or utilitarian. Recreational journeys are those undertaken primarily for pleasure. Utilitarian cycling refers to the act of riding a bicycle with the intent of reaching a specific destination. Utilitarian cyclists, often known as "commuter

cyclists", commute by bicycle to destinations such as their place of work, for shopping trips, errands, social visits, etc. Many cyclists ride their bicycles for both recreational and utilitarian purposes, however, this paper focuses on commuter cycling.

Commuter cycling offers a number of individual and community benefits. Bicycles produce virtually no air pollution and require less space on the road, which can help to reduce traffic congestion (Doherty et al. 2000). Commuter cycling serves as a convenient way to incorporate exercise into one's daily routine and can play a role in reducing heart disease and obesity rates. Commuter cycling also has a smaller environmental impact than motorized transportation and is a more financially affordable mode of transportation. The benefits of commuter cycling are increasingly being recognized by public health officials, urban planners and policy makers and there is a growing interest in promoting commuter cycling and reducing the number of short trips being made in motor vehicles (Bergstrom and Magnusson 2003).

Bicycle modal shares range from 4-6% in the United Kingdom, Italy and France and from 20-30% in Denmark and The Netherlands (Pucher and Buehler 2005, Pucher and Dijkstra 2003). Comparatively, cycling accounts for an average of only 1.45% of all trips being made to work in Canada (Statistics Canada 2006). Despite the benefits of cycling and the rising cycling rates in many European countries, commuter cycling rates across Canada remain relatively low. Unlike in many European countries, Canada's Federal government plays a very limited role with regards to cycling policy and funding. Provincial governments differ with regards to their contributions to cycling and, with the exception of Quebec, contribute very little. Cycling is typically a municipal issue in Canada. As a result, cycling rates, policies and funding vary across the country.

1.1.1 Study Area

This research takes place in Hamilton, Ontario. Hamilton is an industrial city located on the west end of Lake Ontario, roughly 70km southwest of Toronto. It is the third largest city in Ontario and ninth largest in Canada. In January 2001, the City of Hamilton was amalgamated with the municipalities of Dundas, Ancaster, Stoney Creek, Flamborough and Glanbrook. The majority of the residential population is concentrated within the boundaries of the former City of Hamilton, however, most of the current residential development is taking place on the outskirts of the urban core, which has led to a growing reliance on automobile transportation (City of Hamilton 2007).

The City is intersected by the Niagara Escarpment, with waterfront industry, the downtown core and McMaster University located in lower Hamilton. The location of these three major employment centers requires many residents to cross the Escarpment on a daily basis. In order to facilitate cyclist access to the Escarpment there are moderately inclined multi-purpose trails on the East and West ends of the Escarpment, bike racks on all buses and staircases that allow cyclists to push their bikes up the Escarpment alongside them. Despite these efforts, the Escarpment may continue to serve as a barrier to cycling. Research has shown that the presence of hills in a city can reduce bicycle use by as much as 74% (Rietveld and Daniel 2004).

Commuter cycling levels in Hamilton are relatively low. According to the 2006 Canadian Census, 0.89% of all work trips in Hamilton are made by bicycle. This is below the national average of 1.45% of all work trips (Statistics Canada 2006). In June 2009, city council approved an updated Cycling Master Plan as part of municipal efforts to move commuters away from dependence on single occupancy vehicles (City of Hamilton 2009b). The plan focuses on developing new cycling facilities for both commuter cyclists and recreational cyclists while

connecting the gaps within the current cycling network (City of Hamilton 2009b). Efforts to implement the Cycling Master Plan have been hindered by limited funding. The funding package that was recently approved by council is significantly lower than what was recommended by city staff (City of Hamilton 2009a, City of Hamilton 2010). A cycling survey has not been conducted in Hamilton since 1997, when the City of Hamilton conducted the "Hamilton-Wentworth Community Cycling Survey" before creating the first Cycling Master Plan.

The City of Hamilton was chosen as the study area for this research because it is a mid-sized city with relatively low commuter cycling rates across the city. While many cycling studies focus on areas with moderate or high levels of commuter cycling, this study seeks to understand what influences cycling behaviour in an area with low levels of cycling. It is important to understand why a select group of people are cycling despite the barriers to cycling that exist for the overwhelming majority of residents in the area.

1.2 RESEARCH OBJECTIVES

This study was undertaken to better understand the cycling behaviour and attitudes of cyclists residing in a medium sized North American city with low levels of cycling. This study seeks to use this information to devise strategies for promoting cycling in these areas. This objective will be met by seeking to answer the following two questions:

1. Does the perceived availability of on-route or workplace cycling facilities influence bicycle commuting behaviour?
2. Are certain motivational factors for cycling associated with different socio-demographic or behavioural characteristics and, can this information be used to create target groups for

promoting cycling?

1.3 RESEARCH CONTRIBUTIONS

This thesis contributes to the existing body of literature by using a revealed preference study to understand what types of cycling facilities are being used by cyclists in a city with low levels of commuter cycling. While many studies have used aggregated data or stated preference surveys, the methods used in this research provide us with data on the current behaviour of individual cyclists. Revealed preference studies measure actual behaviour. This can be done using self-reporting, as was done in this study, or by measuring behaviour using tools such as Geographic Positioning Systems (GPS) and automatic counters. In contrast, stated preference studies measure respondents intended behaviour, or opinions. Stated preference is often employed to test interventions that do not currently exist (Pucher et al. 2010). As discussed in an international review of cycling research, revealed preference studies are generally perceived to be more reliable when measuring existing and future bicycling demand (Pucher et al. 2010) because they are based on current behaviour and not on predictions of people's anticipated behaviour. Instead of respondents speculating about which new facilities might encourage them the start cycling if provided, the revealed preference data collected in this research allows us to provide a more accurate description of the facilities that are currently being used by cyclists.

This research also helps to further our understanding of the reasons why people are cycling and the motivational factors that can be used to help promote cycling. "Transportation psychology" is a growing field of research that is primarily being undertaken in Western Europe. Studies in this field have primarily focused on how to get people out of their cars and into other modes of transportation. Cycling is rarely the focus of transportation psychology research and cycling researchers have not incorporated transportation psychology into cycling studies. This

research seeks to apply the theories and principles of transportation psychology to a study of cyclists with the objective of understanding why people cycle and how that information can be used to promote cycling in a variety of different contexts. Improving cycling conditions by providing cycling infrastructure alone will not serve to increase commuter cycling rates (Gatersleblen and Appleton 2007). It is also crucial to address people's attitudes towards transportation (Ogilvie et al. 2004).

Lastly, this study is undertaken in an area with relatively low levels of commuter cycling. Many cycling studies are undertaken in cities with moderate or high levels of commuter cycling. These studies do not provide insight into the commuting patterns of residents in cities with low levels of cycling and, as illustrated by Canada's low average commuter cycling rate, most Canadian cities do not qualify as having moderate or high levels of commuter cycling. If we want to understand cyclists and cycling conditions in Canada, it is important to conduct studies, such as this one, in areas with cycling rates that are comparable to the Canadian average instead of in areas that would qualify as "the exception".

1.4 CHAPTER OUTLINE

This thesis consists of four chapters, including this introductory chapter. The body of this thesis is comprised of Chapters 2 and 3. These two chapters are organized as separate research papers and each one seeks to address one of the questions outlined in the research objectives.

In Chapter 2, a multiple logistic regression model is presented that examines the relationship between commuter cycling behaviour and two types of cycling facilities: (1) on-route facilities and (2) workplace facilities. In this study, the availability of cycling facilities is measured based on the perceived availability of these facilities by survey respondents. This model

simultaneously evaluates the impact of cycling facilities and a number of individual cyclist characteristics.

Chapter 3 employs cluster analysis to understand whether certain motivational factors appeal more to certain groups of people. In this chapter, respondents are classified based on the rankings they gave to a list of motivational factors for cycling. The socio-demographic and behavioural characteristics of the respondents in each of the clusters formed are analyzed to create target groups for promoting cycling. This study is informed by transportation psychology research which tells us that a single strategy will not translate into widespread changes in transportation behaviour (Jensen 1999) and that the creation of target groups allows for policy measures to address the specific motives of different commuters (Steg and Tertoolen 1999, Steg 2005).

Chapter 4 concludes this thesis by looking at the important findings and policy implications of this research. In this chapter, we will also discuss the limitations and contributions of this research as well as potential future directions for cycling research.

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CHAPTER TWO: PERCEIVED AVAILABILITY OF WORKPLACE AND ON-ROUTE CYCLING FACILITIES

2.1 INTRODUCTION

In recent years, there has been a growing interest in promoting cycling as a mode of transportation. Bicycles produce virtually no air pollution and require less space on the road, which can help to reduce traffic congestion. Cycling as a means of transportation, or "commuter cycling", serves as a convenient way to incorporate exercise into one's daily routine. Despite the benefits of cycling, commuter cycling rates remain low in Canada with only 1.45% of all trips to work being made by bicycle (Statistics Canada 2006). Comparatively, bicycling modal shares range from 4-6% in the United Kingdom, Italy and France and from 20-30% in Denmark and The Netherlands (Pucher and Buehler 2005, Pucher and Dijkstra 2003).

This study seeks to understand the relationship between commuter cycling behaviour and the perception of existing cycling facilities. Throughout this study, we will focus on the provision of two types of cycling facilities, (1) on-route facilities and (2) workplace facilities. On-route facilities are those provided along the respondent's route to work such as bicycle lanes, signed cycling routes and wide shoulders. Workplace facilities are those available to respondents at their place of employment and include bicycle racks, showers and changing facilities. Other cyclist characteristics such as gender, distance to work and age will also be accounted for in our analysis. This study contributes to the existing literature by employing a revealed preference survey amongst a group of cyclists in a moderately sized North American city with relatively low levels of cycling.

The rest of this paper is organized as follows. Section 2 will explore earlier research focused on cycling facilities and describe cyclist characteristics that can confound our understanding of the relationship between commuter cycling behaviour and the perceived availability of cycling

facilities. In Section 3, we will discuss the methods of data collection and data analysis. Section 4 will explore the results of the multiple logistic regression model used to analyze our data and Sections 5 and 6 will conclude the paper by expanding on the model results and discussing the policy implications and limitations of the research.

2.2 BACKGROUND

2.2.1 Cycling Facilities and Ridership

A number of studies have found a positive association between the availability of cycling facilities and bicycle ridership (Cleary and McClintock 2000, Dill and Voros 2007, Nelson and Allen 1997, Pucher et al. 1999, Pucher and Buehler 2006, Sener et al. 2009, Xing et al. 2008). In a study of 18 cities across the United States, Nelson and Allen (1997) found a positive association between miles of bicycle pathways per 100,000 residents and the percentage of commuters who cycle (Nelson and Allen 1997). Perceived availability of bike lanes is associated with higher levels of cycling as well as with the desire to cycle more (Dill and Voros 2007). Xing et al. (2008) suggest that bicycle lanes have an indirect effect on the number of cyclists because of the psychological association between safety and bicycle lanes (Xing et al 2008). Inadequate provision of bicycle lanes is a major barrier to increasing ridership (Nelson and Allen 1997) as many people may never attempt to cycle if bicycle lanes are not available (Pucher et al 1999).

While research is often focused on bicycle lanes and other on-route facilities, the provision of cycling facilities at destinations has also been considered. The forecasting model developed by Wardman et al. (2007) suggests that showers, changing facilities and indoor parking together can serve as useful additions to on-route facilities in attempts to stimulate commuter cycling

(Wardman et al. 2007). In Nottingham, employees who reported increases in cycling cited the provision of facilities at work as a contributing factor (Cleary and McClintock 2000). A study of Texan cyclists showed that the presence of bicycle racks and showers at work was related to increases in the number of employees who cycled to work and the frequency with which they cycled (Sener et al 2009). In contrast, a similar study that surveyed residents of Canada and the United States concluded that the availability of showers and clothing lockers at work did not inspire greater cycling frequency (Stinson and Bhat 2004). The authors gave three possible explanations for their findings: (1) commuter cyclists may be comfortable with small amounts of sweating and not feel the need to shower or change, (2) workers may already have access to a place to change their clothes and (3) the extra time used to shower may be viewed as an inconvenience (Stinson and Bhat 2004).

In addition to investigating whether or not cycling infrastructure contributes to changes in cycling behaviour, researchers have also evaluated whether or not cycling facilities are being used. A cycling facility may be well used by existing cyclists, but this does not mean that general ridership levels have changed because these facilities are available. As such, it is important to distinguish between facility use and changes in cycling behaviour that occur because cycling facilities are available. Studies have shown that the cycling facilities provided will be used by cyclists. Howard and Burns (2001) found that cyclists adjust their routes to use existing facilities (Howard and Burns 2001). Using data from 43 large cities in the United States, Dill and Carr (2003) concluded that bicycle lanes in large cities would be used by commuters (Dill and Carr 2003). With regards to facilities at work, bicycle parking and showers were well used by employees when available (Cleary and McClintock 2000). These results draw attention to the utility and value of cycling facilities for cyclists.

2.2.2 Cyclist Characteristics and Cycling Facilities

Existing research has highlighted a number of cyclist characteristics that should be accounted for when examining the relationship between availability of cycling facilities and commuter cycling behaviour. Gender, distance and age have all been found to affect the way that cyclists perceive and use various cycling facilities.

Gender

Research has shown that women and men differ in terms of their cycling facility preferences. Women are more likely to prefer cycling facilities that are surrounded by less motor vehicle traffic (Dill and Gliebe 2008, Garrard et al. 2008). Dickinson et al. (2003) found that workplace initiatives, including the provision of workplace cycling facilities, were less likely to stimulate cycling amongst female employees (Dickinson et al. 2003). As such, the provision of cycling facilities at work may not effectively increase commuter cycling rates at organizations employing a high proportion of women (Dickinson et al. 2003). Cycling research has also shown that women are less likely to cycle than men (Dill and Voros 2007, Dickinson et al 2003, Garrard et al. 2008, Gatersblen and Appleton 2006, Pucher and Renne 2003, Stinson and Bhat 2004, Sener et al. 2009, Winters et al. 2007) and tend to cycle shorter distances than men (Dickinson et al. 2003, Garrard et al. 2008, Howard and Burns 2001). However, while women may be less likely to consider becoming cyclists (Gatersleben and Appleton 2006), women who are cyclists cycle as frequently as male cyclists (Howard and Burns 2001).

Distance

Distance is a way of measuring travel time, which is a crucial consideration with regards to modal choice (Bergstrom and Magnusson 2003, Pucher and Renne 2003, Rietveld and Daniel 2004, Schwanen et al 2002, Stinson and Bhat 2003, Stinson and Bhat 2004). Wardman et al.

(2007) examine the relationship between cycling facilities and probability of cycling to work by looking at the value of travel time in British pence per minute. Time spent cycling was originally valued almost three times more highly than travel time for any other mode of transportation. They predicted that the value of travel time would vary depending on the quality of facilities being offered. Their model showed that time spent cycling on high-quality facilities was valued almost the same as other modes and about 30% less than travel time on roads without cycling facilities (Wardman et al. 2007).

For many, distance is a principal deterrent to commuter cycling (Bergstrom and Magnusson 2003, Bradenburg et al. 2007, Gatersleblen and Appleton 2006, Pucher and Buehler 2005, Pucher and Dijkstra 2003, Sener et al. 2009, Stinson and Bhat 2004). More than half of the commuter cyclists surveyed in Texas were found to live within five miles of their place of work (Sener et al. 2009). Bradenburg et al. (2007) found that cyclists who live close to their destinations are more likely to cycle in poor weather conditions as it is easier for them to return home quickly (Bradenburg et al. 2007). It is unclear whether people who live close to their destinations are subsequently encouraged to cycle more, or if cyclists choose to live close to their destinations (Sener et al. 2009).

Age

Young bicyclists are more likely to have a positive perception of the cycling facilities in their community than are older cyclists (Sener et al. 2009). Sener et al. (2009) suggest that younger cyclists may simply be more accommodating and willing to accept the facilities that are available to them (Sener et al. 2009). The same study found that younger cyclists are also more likely to cycle to work and have positive perceptions of the safety of cycling (Sener et al. 2009). In North America, age is a significant predictor of cycling behaviour. A drop in cycling with age has been

observed in several North American studies (Dill and Voros 2007, Pucher et al. 1999, Pucher and Renne 2003). Unlike in Europe, very few elderly North Americans use their bicycles for transportation. Germans aged 75 and older were found to use their bicycles for 7% of daily trips and Dutch elders cycle for 25% of all trips. This is in stark contrast to cycling rates amongst Americans aged 65 and older who use their bicycles for only 0.4% of all trips (Pucher and Renne 2003).

2.2.3 Objectives

In this paper, we present a model that examines the relationship between commuter cycling and the provision of two types of cycling facilities: (1) on-route facilities and (2) workplace facilities. This paper contributes to the existing research by using a revealed preference study to simultaneously evaluate the impact of on-route facilities, workplace facilities and a number of individual cyclist characteristics. Previous studies on the impact of cycling facilities have focused on aggregate cycling data or used stated preference surveys to predict future cycling behaviour. By considering individual level factors in a revealed preference study, this research provides important information regarding the behaviour of current cyclists and their use of existing cycling facilities.

2.3 METHODOLOGY

2.3.1 Data Collection

In the summer of 2009, a structured survey was distributed online as well as in print. The target population for this survey was resident of Hamilton who currently cycle, or who used to cycle. Surveys were disseminated to prospective participants through cycling clubs, neighbourhood associations, bicycle shops and community events. Snowball sampling was also

used as participants were encouraged to circulate the survey throughout their personal network of cyclists and former cyclists. To facilitate the return of print surveys, self-addressed, stamped envelopes were enclosed with all copies. Participants were also asked to provide the first three characters of their postal code (FSA) in order to assign them to a geographic location within the study area.

Respondents were asked a series of closed-ended questions requiring them to choose from among a set of response alternatives. Questions focused on two types of journeys, (1) the journey to work/school and (2) non-work journeys such as errands, shopping trips, social visits and activities. Only the former will be examined in this research and will be referred to as "work trips" throughout the remainder of this paper. Participants were not asked any questions about recreational cycling. Respondents were also asked to provide demographic information and details regarding the availability of cycling facilities both along their route to work and at their workplace. Information collected about the availability of cycling facilities is based on perceived availability and not actual availability. This research was approved by the McMaster Research Ethics Board in the Spring of 2009.

2.3.2 Data Analysis

We used multiple logistic regression to explore the relationship between cycling to work and the perceived availability of cycling facilities. This model aims to answer the question, "does the perceived availability of cycling facilities influence bicycle commuting behaviour after controlling for a number of confounding factors"? The model used in this analysis is

$$log\left(\frac{\pi}{1-\pi}\right) = \alpha + b_1X_1 + b_2X_2 + b_3X_3 + \cdots + b_kX_k$$

where

$log\left(\frac{\pi}{1-\pi}\right)$ = log odds of the dependent variable

α = intercept

b_k = regression coefficients

X_k = independent variables

Due to the structure of the survey, the data collected is categorical. We used logistic regression because of its efficacy in describing and testing hypotheses about relationships between a dichotomous dependent variable and one or more independent variables (Peng et al 2002). Akaike's information criterion (AIC) and r-squared were used to assess goodness of fit. While an r-squared measures the proportion of the total variability explained by the model in ordinary least squares regression (OLS), this is not true for logistic regression. Because the model estimates for logistic regression are not calculated to minimize variance, the pseudo r-squared must be applied. This measure indicates the degree to which a full model with all covariates of interest is an improvement over a model with only an intercept term. Like an OLS r-squared, pseudo r-squared can range from 0 to 1, with higher values indicating a better fit.

Dependent variable

The dependent variable, cycling for work trips, was coded from the survey question "During an average week, what is your most frequent mode of transportation for your journey to work or school?". Analysis was restricted to respondents who work outside the home. From this question, a dichotomous variable (FREQMODE) was created whereby respondents either (1) cycle for work trips or (2) do not cycle for work trips.

Independent variables

Independent variables were selected based on their significance in previous cycling research (Table 1). The independent variables are coded either as dummy variables or as dichotomous variables.

Z-tests of proportions are used for univariate analyses of the independent variables. These tests are used to determine whether or not the difference between the two parts of each of the dichotomous variables is significant.

Chi-square tests were performed to determine whether or not independent variables have independent, statistically significant ($p<0.05$) associations with the dependent variable. Independent variables with statistically significant associations to the dependent variable will be included in the final model. Intuitively relevant variables are included in the model regardless of their individual statistical significance in order to control for their confounding of the relationship between the availability of cycling facilities and the likelihood of cycling for work trips (Hosmer and Lemeshow 2000).

Variables testing for interactions were created based on cycling theory. Interaction variables were constructed from original variables and plotted to test for the presence of interactions. Interaction terms were added to the main effects model to test for statistical significance. Analysis was completed using SAS 9.2 (Statistical Analysis System (SAS). Version 9.2. Cary, NC: SAS Institute 2009).

Table 1. Previous Cycling Research

Variable	Existing Research	Conclusions
Vehicle Access	Stinson and Bhat 2004	It remains an open question whether vehicle ownership influences propensity to cycle or if propensity to cycle influences vehicle ownership
	Rietveld and Daniels 2004	One additional car per capita would reduce the cycling mode share by about 26%
	Sener et al. 2009	Many commuter cyclists live in homes where they own or have access to a vehicle for their journey
	Baltes 1996, Dill and Carr 2003, Dill and Voros 2007, Pucher and Buehler 2005, Pucher and Dijkstra 2003, Pucher and Renne 2003, Rietveld and Daniel 2004, Xing et al. 2008	A negative correlation exists between vehicle ownership and propensity to cycle
Distance	Sener et al. 2009	More than half of the commuter cyclists surveyed in Texas were found to live within 5 miles of their place of work It is unclear whether people who live close to their destinations are more likely to cycle, or if cyclists choose to live closer to their destinations
	Bradenburg et al 2007	Cyclists who live close to their destinations are more likely to cycle in poor weather conditions as it is easier for them to return home quickly
	Bergstrom and Magnusson 2003, Gatersleblen and Appleton 2006, Gatersleblen and Appleton 2006, Pucher and Buehler 2005, Pucher and Dijkstra 2003, Sener et al. 2009, Stinson and Bhat 2004,	Distance is a principle deterrent to commuter cycling
Flexible Work Hours	Sener et al. 2009	50% of people who cycled to work had flexible start times, 44% had flexible end times and almost 20% of commuter cyclists travelled to work after 11am
Gender	Howard and Burns 2001	Women and men do not differ in terms of their cycling frequency
	Gatersblen and Appleton 2006	Women are less likely to consider becoming cyclists
	Dickinson et al 2003, Garrard et al 2008, Howard and Burns 2001	Women cycle shorter distances than men
	Dickinson *et al* 2003, Dill and Voros 2007, Garrard et al. 2008, Gatersblen and Appleton 2006, Pucher and Renne 2003, Sener et al. 2009, Stinson and Bhat 2003, Stinson and Bhat 2004, Winters et al. 2007	Women cycle considerably less than men
Student Status	Koth 2006	Student are more likely to cycle due to flexible arrival/departure times, financial circumstances, proximity to destinations and informal codes of dress Universities make administrative contributions that can have positive implications for regional cycling. These include; sustainability programs, courses in the environment and recreation and the potential to provide infrastructure

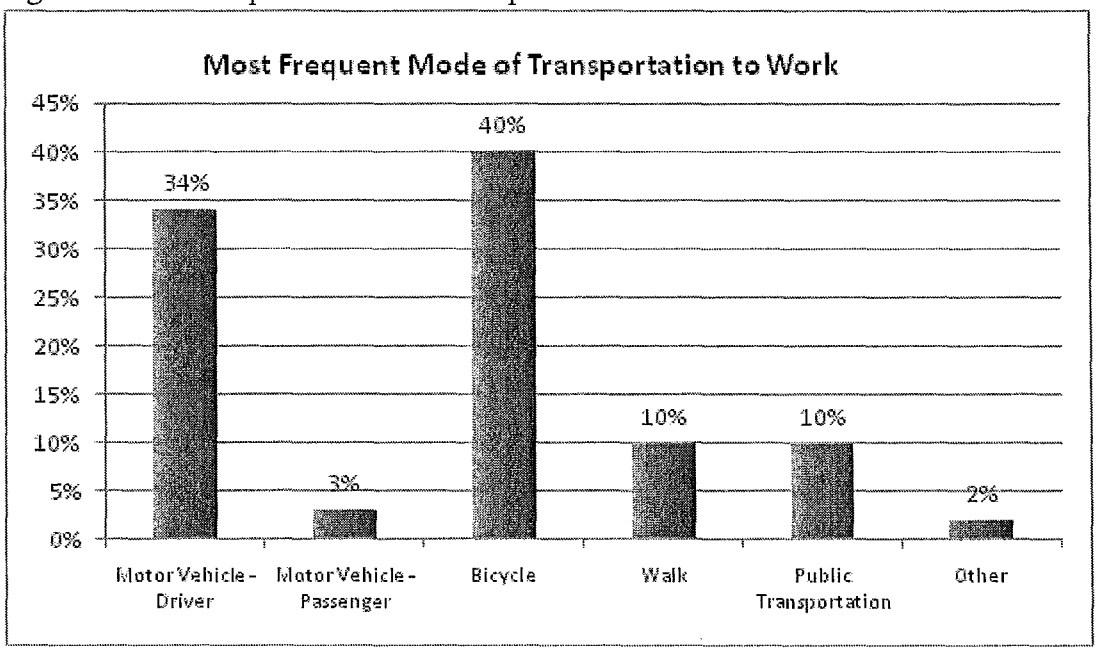
	Koth 2006, Nelson and Allen 1997, Rietveld and Daniel 2004, Winters et al. 2007,	The presence of a university or facility for higher education is widely associated with higher rates of cycling
Age	Scner et al. 2009	Younger cyclists are more likely to cycle to work and have positive perceptions of the safety of cycling
	Pucher and Renne 2003	Germans aged 75 and older were found to use their bicycles for 7% of daily trips and Dutch elders cycle for 25% of all trips. Americans 65 and older use their bicycles for only 0.4% of all trips
	Dill and Voros 2007, Pucher et al. 1999, Pucher and Renne 2003	Drop in cycling with age observed

2.4 RESULTS

2.4.1 Sample

A total of 412 responses were collected. Nine respondents identified themselves as residing outside of the study area and were not included, leaving a total of 403 responses for analysis. Significantly fewer females (35%) responded to the survey than males (63%) ($p<0.05$). The 77 respondents who do not work outside of their home were not included in this analysis, leaving a total of 326 responses. Of the respondents who commute to work, more cycle to work (40%) than drive (34%) as their most frequent mode of transportation (see Figure 2). The difference between the percentage of respondents who cycle to work versus drive is not statistically significant.

Figure 2. Most Frequent Mode of Transportation to Work



Each survey was numbered in order to determine the distribution method of returned surveys while maintaining the anonymity of respondents. The majority of surveys (62.62%) were completed online (Table 2). Paper surveys distributed at community events had the highest response rate (45%). Online respondents were not asked to identify how they came across the survey. As a result, we are unable to determine how many respondents were given paper surveys and then chose to complete the survey online.

Table 2. Responses by Distribution Method

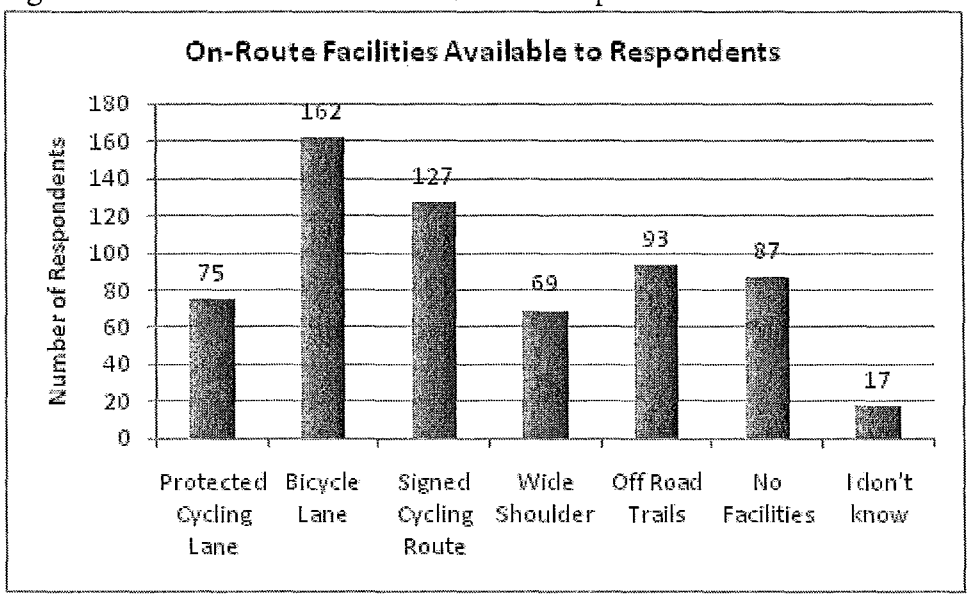
Distribution Method	Number of Surveys Distributed	Number of Surveys Received	Response Rate (%)	Percentage of Total Surveys (%)
Individual Distribution*	63	20	32	4.85
Surveys placed on handlebars of bicycles parked in public areas	106	19	18	4.61
Bicycle Shops	128	28	22	6.80
Community Centres	104	32	31	7.77
Libraries	46	7	15	1.70
Other Businesses	65	2	3	0.49
Community Events	102	46	45	11.17
Online Survey		258	Unknown	62.62
Total		**412**		

*These were surveys distributed to individuals and groups whose names are known to the researchers

2.4.2 Univariate Analysis

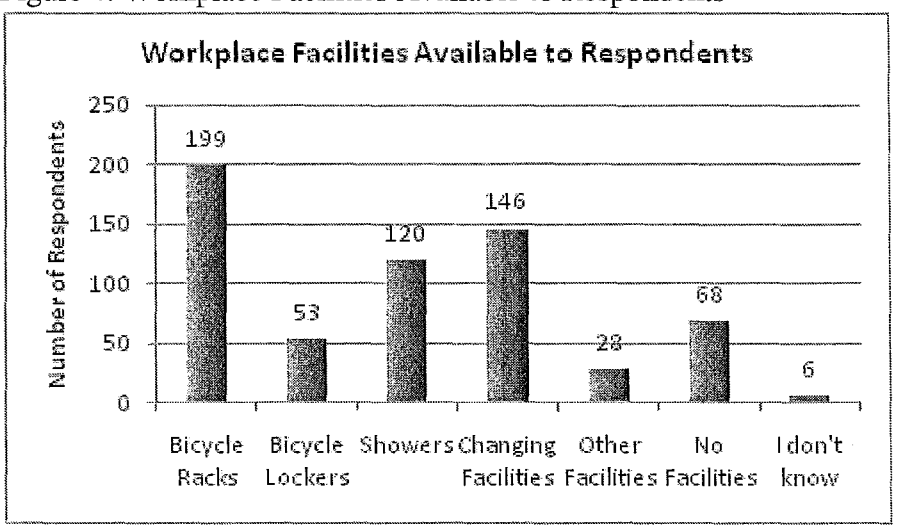
The independent variables in this study are classified as either "cycling facilities" or "cyclist characteristics". Cycling facility variables include both on-route facilities (Figure 3) and workplace facilities (Figure 4). Each of these facilities have been converted into dichotomous variables whereby the facility is either available (t=1) or not available (t=0) to respondents. Bicycle lanes (LANES) are the most commonly available on-route cycling facility and are available to 162 respondents. Signed cycling routes (ROUTE) are another commonly available facility, with 127 respondents reporting their availability. Other on-route cycling facilities are less frequently available such as protected cycling lanes (BARRIER), wide shoulders (SHOULDER) and off-road trails (TRAIL). Eighty-seven respondents reported having no facilities (NONEROUTE) available to them along their route to work.

Figure 3. On-Route Facilities Available to Respondents



At the workplace, bicycle racks (RACKS) are available to 199 respondents, making them the most widely available workplace facility. Changing facilities (CHANGE) are available to 146 respondents and showers (SHOWERS) available to 120 respondents. Bicycle lockers (LOCKERS) are available to 53 respondents. Sixty-eight respondents reported having no facilities (NONEWORK) available to them at their place of employment.

Figure 4. Workplace Facilities Available to Respondents



The second group of independent variables is cyclist characteristics. Cyclist characteristics are the socio-demographic characteristics that have been found to influence cycling behaviour in previous research. Dichotomous variables and dummy variables have been created based on these characteristics (see Figure 3). The vehicle access variable (ACCESS) distinguishes between respondents who have no access to a vehicle for their journey to work and those that do. More than half of respondents (236 respondents) have access to a vehicle for 25% or more of their trips to work.

Respondents were asked to specify how far they live from their place of employment. Nineteen respondents live within 1km of their place of employment (CLOSE), 173 respondents live between 1 to 10km away from their place of employment (ONETO10) and 131 respondents live further than 10km away (FAR). Other studies have used 5 miles (or 8km) as a reference distance for cycling (Dickinson et al. 2003, Gatersleben and Appleton 2007, Sener et al. 2009). Because distance was reported in increments of 5km, ten kilometres was chosen as the reference distance for this study.

Slightly more than half of respondents (208) indicated that they had flexible hours of work (FLEX). These respondents work, or have the option to work, outside of the 9am-5pm timeframe. The gender variable differentiates between male and female respondents (GENDER). As mentioned above, there are more male respondents than female. Of the respondents who commute to work, 115 are female and 203 are male.

Dichotomous dummy variables were created based on region of residence within the study area. FSA data provided by respondents was used to divide the City of Hamilton into three regions; Lower Hamilton (LOWER), Hamilton Mountain (MOUNTAIN) and the Outer Suburbs

(OUTER). A large proportion of respondents reside in Lower Hamilton (196 respondents). Forty-eight respondents are from the Hamilton Mountain region and 72 from the outer suburbs.

Respondents were divided into two categories depending on their age (AGE). One hundred and forty-six respondents are between the ages of 18 to 34 and 177 respondents are 35 years of age or older. Respondents were asked if they participate in sports or activities other than cycling (SPORTS). Two hundred and seventy respondents indicated that they do participate in sports other than cycling and 54 respondents do not. Similarly, respondents were asked whether or not they are members of a cycling club or group (CLUB). Only 59 respondents are members of a cycling club or group. The final cyclist characteristic variable to be examined is student status (STUDENT). A small number of respondents (80) identified themselves as full time students (Table 3).

Table 3. Cyclist Characteristics Variables

Variable	Number of Respondents	Coding
Access to a Vehicle (ACCESS)	No Access = 85 Access to a Vehicle = 236 Missing = 5	ACCESS=1 ACCESS=0
Live Close to Place of Employment (CLOSE)	Reside within 1km = 19 Reside further than 1km = 304 Missing = 3	CLOSE=1 CLOSE=0
Live Within 10km of Place of Employment (ONETO10)	Reside between 1 to 10km = 173 Reside close or far = 150 Missing = 3	ONETO10 = 1 ONETO10 = 0
Live Further than 10km from Place of Employment (FAR)	Reside further than 10km = 131 Reside within 10km = 192 Missing = 3	FAR = 1 FAR = 0
Flexible Work Hours (FLEX)	Flexible work hours = 208 Non-flexible work hours = 112 Missing = 6	FLEX=1 FLEX=0
Gender (GENDER)	Female = 115 Male = 203 Missing = 6	GENDER=1 GENDER=0
Reside in Lower Hamilton (LOWER)	Reside in Lower Hamilton = 196 Reside in Other = 120 Missing = 10	LOWER=1 LOWER=0
Reside on Mountain (MOUNTAIN)	Reside on Mountain = 48 Do not reside on Mountain = 268 Missing = 10	MOUNTAIN=1 MOUNTAIN=0
Reside in Outer Suburbs (OUTER)	Reside in Outer Suburbs = 72 Do not reside in Outer Suburbs = 244 Missing = 10	OUTER=1 OUTER=0
Age (AGE)	Between 18-34 years old = 146 35 years and older = 177 Missing = 3	AGE=1 AGE=0
Participate in Sports other than cycling (SPORTS)	Participate = 270 Do not participate = 54 Missing = 2	SPORTS=1 SPORTS=0
Member of cycling group or club (CLUB)	Member = 59 Not a member = 262 Missing = 5	CLUB=1 CLUB=0
Full time Student Status (STUDENT)	Full time Student = 80 Not a Full time Student = 241 Missing = 5	STUDENT=1 STUDENT=0

2.4.3 Bivariate Analysis

Bivariate analysis was conducted to test the relationship between the dependent variable FREQMODE (cycling to work) and each of the independent variables discussed above. Chi-square tests were used to look for homogeneity of cell frequencies and odds ratios were calculated to test for associations between the independent and dependent variables.

Independent variables with a chi-square significance level of $p<0.05$ will be included in the model.

With regards to on-route cycling facilities, the presence of protected cycling lanes (BARRIER) and signed cycling routes (ROUTES) appear to have the strongest association with one's odds of cycling to work (Table 4). Respondents with a protected cycling lane along their route to work are approximately 2.5 times more likely to cycle while the presence of a signed cycling route doubles the likelihood of cycling to work. Chi-square tests show that both BARRIER and ROUTE are significantly ($p<0.05$) related to FREQMODE and these two variables will be included in the model. The strength of association between FREQMODE and other on-route facilities is low. As such, LANES, SHOUDER, TRAILS and NONEROUTE will not be included in the model.

Of the workplace facility variables, the presence of bicycle racks (RACKS) is associated with an approximately 60% increase in the odds of cycling to work. Respondents who indicate that there are no cycling facilities available to them at work (NONEWORK) are about one third as likely to cycle to work. Chi-square tests show that RACKS and NONEWORK are significantly ($p<0.05$) related to FREQMODE and both variables will be included in the model. The strength of association between FREQMODE and the other workplace facilities (LOCKERS, SHOWERS and CHANGING) is low. As a result, RACKS and NONEWORK will be the only workplace facilities included in the model.

Table 4. Bivariate Analysis of Cycling Facility Variables

	Variable	Unadjusted Odds Ratio (Lower CI, Upper CI, 95%)	Chi-Square
Cycling to Work (FREQMODE)	BARRIER	2.5287 (1.4894, 4.2932)	0.0005
	LANE	1.3300 (0.8493, 2.0830)	0.2123
	ROUTE	2.3234 (1.4648, 3.6853)	0.0003
	SHOULDER	0.9922 (0.5754, 1.7109)	0.9776
	TRAILS	1.3662 (0.8375, 2.2285)	0.2106
	NONEROUTE	0.7075 (0.4227, 1.1841)	0.1869
	RACKS	1.6220 (1.0142, 2.5942)	0.0031
	LOCKERS	1.3871 (0.7714, 2.4942)	0.0623
	SHOWERS	1.1422 (0.7211, 1.8093)	0.5709
	CHANGING	1.0355 (0.6613, 1.6214)	0.8789
	NONEWORK	0.3683 (0.1993, 0.6807)	0.0011

Many of the cyclist characteristic variables have strong associations with cycling to work (Table 5). Respondents with no access to a vehicle for their journey to work (ACCESS) are almost three and a half times more likely to cycle to work. Respondents residing 1 to 10km away from their place of employment (ONETO10) are 4.8 times more likely to cycle to work, while those residing further than 10km away (FAR) are half as likely to cycle to work. The likelihood of cycling to work is doubled for those who report having flexible work hours (FLEX). Respondents between the ages of 18-34 years old (AGE) are more than 1.5 times more likely to cycle to work, while full time students (STUDENT) are half as likely to cycle.

All three dummy variables representing region of residence appear to be associated with cycling behaviour. Respondents residing within Lower Hamilton (LOWER) are more than 2.5 times more likely to cycle to work than persons living elsewhere in the Hamilton area. Respondents residing on the Mountain (MOUNTAIN) or in the Outer Suburbs (OUTER) are both half as likely to cycle to work. The chi-square tests for all of the above mentioned variables show that they are significantly ($p<0.05$) related to FREQMODE. As a result, ACCESS, CLOSE, FAR, FLEX, LOWER, MOUNTAIN, OUTER, AGE and STUDENT will be included in the model.

Bivariate analysis shows that GENDER, SPORTS and CLUB are not strongly associated with FREQMODE. Although GENDER is not significantly related to FREQMODE in a bivariate chi-square test, previous research has indicated that it is an important factor to consider (Dill and Voros 2007, Dickinson et al 2003, Garrard et al. 2008, Gatersblen and Appleton 2006, Howard and Burns 2001, Pucher and Renne 2003, Stinson and Bhat 2004, Sener et al. 2009, Winters et al. 2007). GENDER is the only independent variable selected for the model that is not individually significant. SPORTS and CLUB will not be included as independent variables.

Table 5. Bivariate Analysis of Cyclist Characteristic Variables

	Variable	Odds Ratio (Lower CI, Upper CI 95%)	Chi-Square
Cycling to Work (FREQMODE)	ACCESS	3.4222 (2.0235, 5.7879)	<.0001
	CLOSE	1.2984 (0.5124, 3.2897)	0.5811
	ONETO10	4.8984 (2.9833, 8.0430)	<.0001
	FAR	0.5244 (0.2790, 0.9856)	0.0427
	FLEX	2.0251 (1.2480, 3.2860)	0.0040
	GENDER	0.6895 (0.4302, 1.1052)	0.1217
	LOWER	2.6845 (1.6577, 4.3474)	<.0001
	MOUNTAIN	0.4753 (0.2406, 0.9388)	0.0296
	OUTER	0.4372 (0.2442, 0.7826)	0.0047
	AGE	1.7465 (1.1425, 2.6697)	0.0097
	SPORTS	1.0884 (0.5959, 1.9880)	0.7827
	CLUB	1.0249 (0.5684, 1.8481)	0.9349
	STUDENT	0.4810 (0.2856, 0.8100)	0.0055

2.4.4 Model Results

The results of the logistic regression model are outlined in Table 6. Akaike's information criterion (AIC) was calculated for the null model (Intercept-only) as well as for the final model, which includes the independent variables discussed above. The AIC value for the final model is lower than the AIC value of the null model. This indicates that the final model is a better fit. The r-squared value calculated for the final model is 0.2916.

Table 6. Results of Logistic Regression Model

Dependent Variable	Independent Variables	Estimate	Odds Ratio	Chi-Square
Cycling to Work (FREQMODE=1)	ACCESS	0.4894	1.631337	0.0036
	ONETO10[a]	0.9282	2.529951	<.0001
	FAR[a]	0.4567	1.578855	0.0539
	FLEX	0.3045	1.355947	0.0443
	NONEWORK	-0.5959	0.551066	0.0142
	GENDER	-0.4037	0.667844	0.0092
	MOUNTAIN[b]	-0.0307	0.969766	0.8982
	LOWER[b]	0.5014	1.651031	0.0077
	ROUTE	0.3252	1.384307	0.0268
	BARRIER	0.2389	1.269852	0.1575
	YNON[c]	-0.4892	0.613117	0.0085
	YSTUD[c]	0.00965	1.009697	0.9600
	RACKS	-0.1817	0.833851	0.3718
	AIC (Intercept only)	**427.963**		
	AIC	**345.700**		
	Pseudo R-Square	**0.2916**		

[a] CLOSE was used as the reference variable
[b] EXBURBS was used as the reference variable
[c] OLD was used as the reference variable

Interaction terms were also included in the model to test for an interaction between student status (STUDENT) and age (AGE). Although tests show that there is no statistically significant interaction between these two variables, we found that cycling behaviour varies amongst young respondents based on their student status. When the interaction is graphed, we see that the probability of cycling to work varies amongst respondents within the 18-34 years old category. The probability of cycling to work varies less amongst older respondents. As a result, respondents have been divided into 3 groups by combining the AGE and STUDENT variables, (1) young students (YSTUD), (2) young non-students (YNON) and (3) older respondents (OLD).

Once all of the independent variables are controlled for in the model, the presence of a signed cycling route is associated with a 1.5 increase in one's likelihood of cycling to work. This is the only on-route facility that is significantly associated with the odds of cycling to work. The

presence of a protected cycling lane is not statistically significant. With regards to workplace facilities, respondents who report that there are no cycling facilities available to them are half as likely to cycle to work. No specific workplace facilitics are significantly associated with the probability of cycling to work.

Many of the cyclist characteristic variables were found to influence respondents' probability of cycling to work. Respondents with no access to a vehicle are 1.6 times more likely to cycle to work. The same is true for respondents residing in Lower Hamilton. With regards to distance, living between 1 and 10km away from one's place of employment more than doubles the likelihood of cycling to work. Having flexible work hours is associated with a 1.4 odds increase of cycling to work. In contrast, females and young non-students are less likely to cycle. Residing on the Mountain was not statistically significant.

2.5 DISCUSSION

The logistic regression model presented in this study examines the relationship between commuter cycling and the provision of cycling facilities. The results of the model indicate that commuter cycling behaviour is associated with the availability of both on-route and workplace facilities. Commuter cycling behaviour is also influenced by a number of socio-demographic characteristics and the geographic location of respondents. In this section, we discuss the results of the model, the policy implications of these findings and the limitations of this research. Special attention will be given to the role that the built environment plays in encouraging commuter cycling.

2.5.1 Built Environment Correlates of Commuter Cycling

On-route cycling facilities

Signed cycling routes. Signed cycling routes are the only on-route facility with a significant positive association with commuter cycling. The perceived availability of a signed cycling route along a respondent's route to work is associated with a 50% increase in the probability of cycling to work. On the other hand, the perceived availability of bicycle lanes along one's route to work was not significantly associated with cycling to work. Bivariate analysis showed that the LANE variable was not statistically significant, therefore, it was not included in the final model. This observation differs from what has been observed elsewhere with regards to bicycle lanes and could be the result of several factors including the prominence of signed cycling routes throughout the study area, the length of bicycle lanes and the greater visibility of bicycle lanes to non-cyclists.

Firstly, signed cycling routes are more widely available to cyclists across Hamilton. The City of Hamilton has 173km of signed cycling routes in contrast to 104km of bicycle lanes. With more signed routes available throughout the city, respondents may be more likely to encounter them along their route to work. This increases the likelihood that respondents will report the availability of signed cycling routes over cycling lanes. Hamilton's network of bicycle lanes is also undeveloped and it is likely that many respondents who cycle to work do not have a bicycle lane along their route. The significance of cycling routes may be the result of their prevalence more so than their utility to commuters.

Secondly, the study area contains many bicycle lanes that are short and that are not connected to other cycling facilities. Respondents may be less likely to report the availability of bicycle lanes along their route if the bicycle lanes are short or end in high traffic areas.

Lastly, a bicycle lane marked on the pavement can be more visible to non-cyclists than dispersed signs for a cycling route. Signed cycling routes also tend to be on low-traffic streets where vehicular commuters on main arteries are less likely to see them. The ROUTE variable, like the other facility variables, is based on whether or not cycling routes are available along a respondent's route to work. Respondents were not asked to specify whether or not they actually used the facility, meaning that drivers and other non-cyclists have also identified cycling facilities along their route. For the reasons outlined above, non-cyclists may be likely to report the availability of bicycle lanes along their route to work. If non-cyclists are also reporting the presence of bicycle lanes, this decreases the association between bicycle lanes and the probability of cycling to work in this study.

Previous cycling studies have largely overlooked the role of signed cycling routes in favour of examining the importance of bicycle lanes. In this instance, it appears that commuter cycling behaviour is not significantly influenced by the presence of on-route bicycle lanes. Bicycle lanes are often an important factor in encouraging people to start cycling (Pucher et al. 1999). Respondents in this study are existing cyclists and may be comfortable with the level of protection offered by signed cycling routes. Since there are limited cycling facilities available throughout the study area, respondents may also simply be accustomed to cycling with little separation from traffic.

Protected cycling lanes. The second on-route cycling facility that has been included in this model is bicycle lanes separated by a physical barrier, or protected cycling lanes. Without controlling for gender in the model, there is a positive association between cycling to work and the perceived on-route availability of protected cycling lanes. When the model controls for gender, however, the relationship is no longer significant. This finding is consistent with

previous research, which has found that women are more likely than men to prefer facilities surrounded by less motor vehicle traffic (Dill and Gliebe 2008, Garrard et al 2008).

The non-significance of protected cycling lanes in the final model could be a result of the location and quality of the lanes themselves. The limited availability of these lanes minimizes the probability that they are available to respondents along their route to work. Once again, these lanes are also highly visible to non-cyclists and it is likely that respondents who drive or take public transit to work have reported their presence, reducing the association between protected cycling lanes and cycling to work.

Workplace cycling facilities

Our results highlight the importance of bicycle-friendly workplaces. Bivariate analysis of workplace facilities showed that the perceived availability of bicycle lockers, showers or changing facilities was not significantly associated with cycling to work. Bicycle racks (RACKS) were the only individual workplace facility that was significantly associated with cycling to work. However, the perceived availability of bicycle racks was not significant in the final model. At the same time, the final model shows that a complete lack of workplace facilities (WORKNONE) is associated with a decrease in the probability of cycling to work. As a result, efforts to increase commuter cycling should place more of an emphasis on implementing and promoting workplace facilities. Whereas on-route facilities are dependent on the municipality, workplace facilities can be initiated by individual workplaces and modified to suit the needs of employees. The findings of previous cycling studies have been mixed with regards to workplace facilities, indicating that their influence can be workplace specific. For example, the type of facilities desired by employees can be dependent on the type of work being done at the

workplace, as well as by the location of the workplace. To encourage cycling at a smaller scale, employers can implement the facilities that are deemed to be the most useful to their employees.

Geographic Location

Lower Hamilton is the only geographic region that has a statistically significant association with cycling to work. Bivariate analysis shows that respondents residing in Lower Hamilton are 2.7 times more likely to cycle to work. After adjustment, living in Lower Hamilton is associated with a 1.7 increase in the odds of cycling to work. Many of the major employment nodes are located in Lower Hamilton, including the Downtown Core, McMaster University, the steel industry and several major hospitals. Respondents residing in Lower Hamilton are less likely to cross the Niagara Escarpment on their commute to work. Roads crossing the Escarpment are very steep and have narrow shoulders, leaving little room for cyclists. Residents of Lower Hamilton may also be likely to have a shorter commute to work.

Several features of the built environment of Lower Hamilton make it more bicycle-friendly and influence the decision to commute by bicycle. Lower Hamilton is characterized by the grid-like street patterns and smaller blocks that are amenable to cycling. These characteristics allow for more direct movement and provide cyclists with multiple route options (Dill and Carr 2003, Dill and Voros 2007, Frank and Engelke 2001, Saelens et al. 2003). The mixed land use of Lower Hamilton increases the connectivity of the area with destinations in close proximity to each other. Researchers have found that cities with a diverse land use mix create a friendlier environment for cyclists (Frank and Engelke 2001, Pucher et al. 1999, Pucher and Buehler 2005, Pucher and Dijkstra 2003, Saelens et al. 2003, Sener et al. 2009, Stinson and Bhat 2004). Hamilton Mountain and the Outer-Suburbs are areas of low density sprawl, where land use mix is typically low and destinations are disconnected. The development pattern in these two regions

is not as conducive to cycling. All respondents in this study consider themselves to be cyclists, but those residing in Lower Hamilton are more likely to cycle to work.

2.5.2 Socio-Demographic Characteristics of Commuter Cyclists

The objective of this paper is to understand the relationship between commuter cycling and the provision of cycling facilities, however, it is also important to understand the influence of socio-demographic variables. Findings indicate that respondents with no access to a motor vehicle are more likely to cycle to work, as are respondents who live between 1 and 10km away from their place of employment and those with flexible work hours. Female respondents and respondents who are young non-students are less likely to cycle to work. These results are fairly consistent with previous findings, however, researchers continue to deliberate about the directionality of the relationship between these variables and commuter cycling.

Vehicle Access. Having no access to a motorized vehicle for the journey to work is associated with a 1.6 odds increase in cycling to work. Previous research has thus far been inconclusive with regards to the nature of this relationship. Some studies have found that many commuter cyclists live in homes where they own or have access to a vehicle for their journey to work (Sener et al. 2009). Others question whether low vehicle ownership causes more cycling or if car ownership is influenced by one's propensity to cycle (Stinson and Bhat 2004). If vehicle access is used as a proxy for income, the debate becomes even more unclear. Whereas some respondents have no access to a vehicle because they cannot afford one, others choose to be car-free. This gap in understanding could be examined in a study that considers respondents' level of satisfaction with vehicle access, or by controlling for income.

Distance. Living between 1 and 10km away from one's place of employment is associated with a 2.5 odds increase in the likelihood of cycling to work. This finding is consistent with

previous cycling research, which has found distance to be a principal deterrent to commuter cycling. It is difficult for researchers to determine whether people who live close to their destinations are subsequently encouraged to cycle more, or if cyclists choose to live close to their destinations (Sener et al 2009). This survey did not account for this distinction, but it could be explored in subsequent qualitative research or by distinguishing between respondents who have recently relocated and those who have not.

Gender. Previous research has largely concluded that women cycle less than men in North America. However, in a previous study of cyclists, it was found that women and men who are cyclists did not differ with regards to how much or how often they cycled (Howard and Burns 2001). Our results show that being female is associated with a 0.67 odds decrease in the likelihood of cycling to work. The relationship between gender and commuter cycling remains unclear and our findings contribute to the existing uncertainty. As discussed by Dr. Jan Garrard, the proportion of cyclists who are female can serve as a bikeability index, measuring whether or not an environment is supportive of cycling (Baker 2009). Applying this index, women are less likely to commute by bicycle than men in Hamilton and commuter cycling levels across the city are relatively low.

Age and Student Status. Model results indicate that the commuter cycling behaviour of young students differs from that of young non-students and that young non-students are less likely to cycle to work. The lifestyles of students and non-students differ greatly, therefore it is not unexpected that their commuting habits differ as well. Young non-students are likely to drive vehicles to assist with the complex travel patterns associated with having a new career and new family. As previously discussed, student life is associated with many factors that increase

one's odds of cycling to work such as flexible work hours and codes of dress (Koth 2006), increasing the odds that young students cycle to work.

2.5.3 Policy Implications

The Built Environment

Experience from regions with high levels of commuter cycling indicates that the built environment plays a crucial role in encouraging cycling. European cities in countries such as The Netherlands and Denmark have high rates of commuter cycling as well as integrated networks of cycling facilities and high density, mixed use development. Canadian cities with notably higher rates of cycling, such as Montreal and Vancouver, are making efforts to improve their cycling network and include many areas with high density and mixed use development. The results of this study indicate that the nature of the built environment may play an important role in encouraging commuter cycling. As a result, the City of Hamilton and other municipalities should focus on creating areas of high density and mixed use development in order to reduce the distance that people need to travel for goods and services, which can encourage higher commuter cycling rates.

Cycling Facilities

This study reveals a small group of dedicated cyclists who commute by bicycle despite the low perceived availability of cycling facilities. This study also points to the much larger group of self-identified cyclists who do not commute by bicycle while having access to the same facilities. As indicated by previous studies, cycling facilities are important to prospective cyclists and should be a focus for any community seeking to increase commuter cycling rates. While the current condition of the cycling network may be adequate for many experienced commuter cyclists, prospective cyclists (including those that cycle only for recreation) may be

dissuaded from cycling if the facilities available along their route are not continuous. A well maintained, integrated cycling network is an important investment for communities looking to increase their commuter cycling population and encourage new cyclists to start cycling. Future initiatives to stimulate commuter cycling should also have municipalities collaborate with individual workplaces to offer an integrated network of on-route and workplace facilities that address the specific needs of employees.

Non-Commuter Cyclists

A segment of Hamilton's population identifies themselves as cyclists but cycle only for recreational purposes. This represents a group of people who are able to cycle and are aware of the benefits of cycling, but who have not yet been convinced to commute by bicycle. Municipalities can increase their commuter cycling rates by targeting this subset of the population. While many non-cyclists need to be "won over" to cycling, non-commuter cyclists already own bicycles and enjoy cycling for recreational purposes. Previous studies have suggested that bicycling for recreational purposes precedes commuter cycling (Sener et al. 2008). Commuter cycling levels can be increased by focusing on the needs of non-commuter cyclists by implementing projects and campaigns targeted towards these needs. This approach encourages municipalities to increase ridership within an existing base of cyclists before trying to convince non-cyclists to start cycling. This can also be a factor in encouraging non-cyclists to start cycling as non-cyclists surrounded by cyclists are more likely to have contemplated cycling than non-cyclists in cities with lower cycling rates. They are also more likely to be responsive to policy interventions (Gatersleben and Appleton 2007). Higher cycling rates can serve to encourage more cycling.

2.5.4 Limitations

This study is not based on a random sample of the population, only cyclists and former cyclists were asked to participate. Survey responses are from people who already cycle and are therefore more likely to value and have positive opinions about cycling. As such, stakeholders and policy makers are not able to generalize the results of this study to the population as a whole. Because this study uses revealed preference to understand current cycling behaviour and use of existing cycling facilities, non-cyclists were not sought out as participants. Existing cycling studies have also used data derived from a cyclist-only survey (Howard and Burns 2001 and Sener et al 2009). Studies that include non-cyclists often employ stated preference research to understand what respondents think they might do if a given cycling facility or policy was put into place. This information can be speculative, given that many people who have never contemplated cycling would not cycle under any circumstances (Gatersleben and Appleton 2007). Instead of building cycling policy around the anticipated behaviour of a random sample of the population, this approach encourages policy makers to focus on encouraging existing cyclists to commuter by bicycle more.

A second limitation to this study is that, typically, cyclists are more likely than non-cyclists to be aware of cycling facilities (Dill and Voros 2007). This survey asked respondents about the perceived availability of a variety of facilities. Because we did not require respondents to give us detailed geographic information regarding their specific place of residence and place of employment, we were not able to compare these results with actual availability. Respondents who cycle to work may be more aware of the facilities that exist and be more likely to report the availability of facilities. Conversely, participants who do not cycle to work are likely to under-report the availability of cycling facilities because they feel that they are inadequate or because

they are unaware of their existence. An under-reporting bias also exists as respondents may not report facilities that exist but they do not find useful. We feel that the effect of this bias is minimal because only self-identified cyclists participated in the survey. It is probable that all respondents are more likely than the general population to notice cycling facilities.

2.6 CONCLUSION

We have presented a model that examines the relationship between commuter cycling and the provision of on-route and workplace cycling facilities. The analysis performed supports previous findings that the nature of the built environment can play an important role in encouraging commuter cycling. This research has also highlighted the importance of bicycle-friendly workplaces and the need to provide cycling facilities that meet the specific needs of employees. Lastly, we discussed the potential to stimulate commuter cycling amongst non-commuter cyclists. To better understand the association between cycling facilities and commuter cycling, future research should look at the percentage of time that cyclists spend using different cycling facilities throughout their commute. This would provide researchers with a better understanding of which cycling facilities are important to different types of cyclists. Such a study would be enhanced by comparing the perceived availability of cycling facilities with the actual availability of those facilities. Cycling research should continue to be undertaken in areas with lower levels of cycling to better understand the needs of a variety of communities.

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CHAPTER THREE: CYCLISTS' MOTIVATIONS FOR CYCLING

3.1 INTRODUCTION

In recent years, municipalities have become increasingly interested in promoting cycling as a mode of transportation. While many studies have focused on the role of cycling infrastructure in encouraging cycling, addressing some of the physical barriers to cycling with infrastructure will not in itself lead to higher cycling rates (Gatersleben and Appleton 2007). A systematic review of interventions to promote cycling has highlighted the need to address people's attitudes towards cars and bicycles (Ogilvie et al 2004). In addition to providing safer cycling conditions through infrastructure, we must also understand how people feel about cycling and how they make decisions about mode choice.

This study is informed by transportation psychology research and seeks to understand the reasons why people choose to cycle, in spite of barriers to cycling. To date, transportation psychology research has primarily been undertaken in Europe, with a specific focus on getting people out of their cars and into other modes of transportation such as walking, cycling and public transit. Although cycling is not often the focal point of these studies, their emphasis on how to change travel behaviour is relevant. Many of the strategies directed at reducing car use can be adapted to encourage commuter cycling.

This study will look at the relationship between a variety of socio-demographic and behavioural variables and the motivational factors associated with cycling. Using cluster analysis, respondents will be classified into groups based on the factors that motivate them to cycle. These groups will be used to investigate whether certain motivational factors appeal to specific groups of people. This study is unique in that it uses respondent's motivations for cycling to find broader target groups that can be used to promote cycling more effectively.

The rest of this paper is organized as follows. Section 2 will explore earlier research and outline the importance of considering motivational factors when looking at mode choice and travel behaviour. It will also explore the ways in which motivational factors have been accounted for in existing cycling studies as well as the ways in which behaviour change strategies can be applied to increase commuter cycling rates. In Section 3, we will discuss the methods of data collection and data analysis. Section 4 will explore the results of the cluster analysis and Section 5 will conclude the paper by translating the results into a number of broader policy recommendations.

3.2 BACKGROUND

3.2.1 Motivations and Mode Choice

Why Are Motivations Important?

In an effort to understand travel behaviour, many cycling studies focus on socio-demographic and geographic variables. As suggested by the theory of planned behaviour, it is also important to consider people's attitudes, or how they feel about a given behaviour (Ajzen 1991). In order to improve our understanding of transportation related decisions, we must look at the many different behavioural factors and values that motivate people when making decisions about mode choice. For example, Steg (2005) has outlined three categories of car use motives, which include (1) instrumental motives, (2) symbolic/social motives and (3) affective motives. Instrumental motives include the convenience, speed, flexibility and safety associated with driving a car. Symbolic and social motives refer to the ability of people to express themselves and their social positions through their mode choice. Thirdly, affective motives are the emotions that are evoked by driving (Steg 2005). In an effort to reduce the prevalence of driving, Steg

suggests developing an understanding of these motivations behind car use. In her research, Steg (2005) found that symbolic and affective motives played a more important role in explaining levels of car use than instrumental motives. This research implies that people are more likely to drive when they perceive the symbolic and affective functions to be favourable. Differences in mode choice are not significantly related to instrumental functions of the car (Steg 2005).

The emotional and symbolic attachments that commuters have to their cars have been examined in several studies. The car is strongly associated with feelings of independence, freedom and convenience (Tertoolen et al 1998). In a study of drivers, cyclists and public transit users, Jensen (1999) found that 80% of the respondents who drove agreed with the statement "the car is a symbol of freedom and independence". Between 50-60% of all cyclists and public transit users also agreed that the car is a symbol of freedom and independence (Jensen 1999). Strong emotional attachment to cars can lead to psychological resistance towards attempts to reduce car use (Tertoolen et al 1998). Jensen (1999) believes that our ability to reduce car use has been "limited by not capturing the emotional and/or sensual side to choosing a means of transportation" (Jensen 1999).

Why Do People Cycle?

Few cycling studies have endeavoured to account for motivational factors in their research and our understanding of people's reasons for cycling is limited. However, researchers who have included motivational factors have identified a number of reasons why people choose to cycle. While some studies include participant's motivations for cycling as descriptive information, others have included them as variables in their multivariate analysis. Previous cycling studies have noted that respondents cycle for convenience (Dickinson et al 2003, Gatersleben and Appleton 2007, Sener et al 2008), financial savings (Pucher 1988, Pucher and

Buehler 2006, Pucher and Dijkstra 2003, Sener et al 2008), pleasure (Sener et al 2008), health and fitness (Gatersleblen and Appleton 2007, Sener et al 2008), environmental values (Gatersleblen and Appleton 2007, Sener et al 2008), recreation (Sener et al 2008), avoiding vehicular traffic congestion (Sener et al 2008t), parking costs (Sener et al 2008), the thrill of cycling and (Gatersleblen and Appleton 2007) and a sense of achievement derived from cycling (Gatersleblen and Appleton 2007).

In their analysis of Texan cyclists, Sener et al (2008) found that participants who identified environmental friendliness, convenience and speed, avoiding driving in traffic and financial considerations as reasons for cycling had a high frequency of cycling to work (Sener et al 2008). Rietveld and Daniel (2004) found that speed was a significant motivator for cycling. Bicycle use increased by 3.4% when trips were 10% faster by bicycle than by car (Rietveld and Daniels 2004). Dill and Voros (2007) established a relationship between the likelihood of being a commuter cyclist and holding environmental values or disliking driving (Dill and Voros 2007).

Commuter cycling, like many other modes of transportation, can be habit forming (Stinson and Bhat 2004, de Bruijn et al 2009). Researchers have suggested that, despite the potential role of the motivational factors mentioned above, cycling may simply be habitual like much other behaviour (Garling et al 1998). In their research, de Bruijn et al (2009) explore the role of habit in commuter mode choice models. They found that adding habit strength to their model significantly increased the amount of explained variance (de Bruijn et al 2009). They concluded that habit strength was the strongest correlate of bicycle use (de Bruijn et al 2009).

3.2.2 Changing Transportation Behaviour

Transportation psychology studies have suggested several strategies to encourage more people to change modes. These strategies include, (1) changing the image of all modes of

transportation, (2) engaging people in viable alternatives to the car and (3) dividing commuters into target groups. These three behaviour change strategies will be employed throughout this research.

Image

Image can play an important role in mode choice and our perceptions of different modes affect our decisions. Currently, it is difficult for many people to picture transportation without cars (Jensen 1999). If "alternative" modes of transportation are framed as healthy, commuters may derive more of a reward from them, making it easier for them to sustain the behaviour (Nisbet and Gick 2008). In a similar manner, excessive driving needs to be viewed as undesirable (Nisbet and Gick 2008). "A marketing truism tells us that image and perceptions are as important as reality with regards to consumer choice" (Koth 2006). Creating a more positive image for cycling could help to improve cycling rates (Gatersleblen and Appleton 2007).

Alternatives

In order for people to want to change modes of transportation, a viable alternative must exist (Steg and Tertoolen 1999, Jensen 1999). This alternative must be pleasant and accessible (Nisbet and Gick 2009). Commuters must also be made to feel that there are others who are also willing to change their behaviour (Dahlstrand and Biel 1997, Jensen 1999). People who perceive a given behaviour to be common amongst their peers are likely to feel that it is ineffective or unfair to ask them to change. However, people are willing to make changes if the change is the same for everyone (Jensen 1999).

Target Groups

Classifying commuters into different transportation groups can help us to improve our understanding of commuters and target these groups with more specific and effective policy. A

single strategy will not translate into widespread changes in transportation behaviour (Jensen 1999). In Anable's research, dividing participants into transportation groups enabled a detailed interpretation of how each group thinks about their transportation choices (Anable 2005). The creation of target groups allows for policy measures to address the specific motives of commuters within each segment (Steg and Tertoolen 1999, Steg 2005). When devising strategies for change, it is important to select a target group that is likely to respond to the specific policy measures (Anable 2005).

3.2.3 Objectives

Using cluster analysis, this study will create target groups based on the factors that motivate respondents to cycle. By looking for characteristics that are common to members of each group, the target groups will be used to investigate whether certain motivational factors appeal to different types of people. Policy makers and cycling advocates can use this information to effectively promote cycling in different segments of the population by targeting people with policy measures and promotional materials that are relevant to them. This research also highlights the reasons why people choose to cycle, thereby drawing attention to cycling as a viable transportation alternative. Research has highlighted the importance of accounting for motivational factors in transportation research, however, this has rarely been the focus of cycling studies. This study is unique in that it uses respondent's motivations for cycling to find broader target groups that can be used to promote cycling more effectively.

3.3 METHODOLOGY

3.3.1 Data Collection

In the summer of 2009, a structured survey was distributed online as well as in print. Surveys were disseminated to prospective participants through cycling clubs, neighbourhood associations, bicycle shops and community events. Snowball sampling was also used as participants were encouraged to circulate the survey throughout their personal networks of cyclists and former cyclists. To facilitate the return of print surveys, self-addressed, stamped envelopes were enclosed with all copies. Participants were also asked to provide the first three characters of their postal code (FSA) in order to assign them to a geographic location within the study area.

Respondents were asked a series of closed-ended questions requiring them to choose from among a set of response alternatives. Two questions addressed motives for cycling specifically. In the first question, respondents were given a list of reasons or motives, to cycle, and asked to select each of the motivational factors that applied to them. Respondents were also given the option of selecting "other" or leaving the question blank. The second question required respondents to numerically rank the motivational factors that they had selected in the previous question. The list of motivational factors included, (1) health and fitness (HEALTH), (2) environmental sustainability (ENVIRO), (3) convenience of cycling (CONV), (4) avoiding congestion and traffic conditions (TRAFF), (5) financial savings (FINC), (6) pleasure/enjoyment derived from cycling (PLEAS), (7) being outside (OUT), (8) limited car parking facilities at destination (PARK) and (9) other (OTH). Respondents were also asked to provide demographic information and details regarding their transportation and cycling behaviour.

3.3.2 Data Analysis

Cluster Analysis

This research uses cluster analysis to classify respondents into groups based on the rankings they have given to the factors motivating them to cycle. By creating these groups, this research seeks to find commonalities amongst respondents that help to answer the question, "do certain motivational factors appeal to specific groups of people"? Respondents were asked to rank each of the nine motivational factors that apply to them. When clustering the data, these rankings will be used as the variables of interest in order to understand whether there are commonalities between respondents based on the factors that motivate them to cycle. Each variable has been ranked from 1 to 9. All nine variables will be included in the cluster analysis.

The primary purpose of cluster analysis is to measure the mathematical distance between observations based upon the variables of interest (Finch 2005). Many of the standard distance measures assume that the variables are of a continuous nature, however, the data collected in this study is categorical. As a result, standard distance measures such as Euclidean distance are inappropriate (Dillon and Goldstein 1984). Jaccard's distance is one of many metrics designed for measuring differences in non-continuous data (Finch 2005).

Jaccard's distance excludes cases where neither subject has the trait of interest (Finch 2005). Consequently, subjects are treated as similar when they have positive co-occurrences of a trait (Aldenderfer and Blashfield 1984). For example, respondents who do not to give "health and fitness" a ranking as a motivational factor, are not considered similar on this factor. Using Jaccard's distance, respondents will be identified as being similar when they provide matching rankings for one or more motivational factors. Jaccard's distance is calculated as follows;

$$J = \frac{q + r}{p + q + r}$$

where

p = the number of attributes where both cases share the same trait

q = the number of attributes that are positive for i^{th} object but negative for j^{th} object

r = the number of attributes that are negative for i^{th} object but positive for j^{th} object

Once Jaccard's distance has been calculated for the entire data set, the distance measures are combined into a matrix of distances between observations. This distance matrix is used to perform cluster analysis. In this study, we use Ward's minimum variance method. Ward's method is effective when working with distance measures derived from non-continuous data sets, such as Jaccard's distance (Hands and Everitt 1987). Ward's method seeks to maximize the similarity of cases within each hierarchical group while minimizing the loss of information, which is indicated by the error sum of squares (Ward 1963). The formula for the error sum of squares, or ESS, is

$$\mathrm{ESS} = \sum_i \sum_j \sum_k |X_{ijk} - \overline{x}_{i \cdot k}|^2,$$

where

j = the identification number of each observation

k = distance matrix value for the observation

i = the cluster to which the observation belongs

The ESS compares the value of individual cases to the cluster mean for that case. To start, there are *n* clusters, each containing one observation. At this stage, the ESS value is 0, or the distance

from each observation to its cluster centroid is 0 (Ward 1963). The distance between each of the observations is used to decrease the number of clusters by one (n-1) while also minimizing the ESS (Ward 1963). As clusters form, the distance between the cluster centroids and each observation increases. To make the second join (n-2) the ESS values for the potential joins are judged to be "equal to or better than" that of any preceding join (Ward 1963). Subsequent joins can be made by adding another observation to the first group, or by creating another pair. The grouping can continue until all observations have been united to form a single cluster (Ward 1963).

For each join, an r-squared value is calculated that indicates the proportion of variance explained by that particular clustering of observations. In Ward's minimum variance method of cluster analysis, the r-squared value is equal to the difference between the total sum of squares (TSS) and the ESS divided by the TSS and subtracted from 1. In contrast to the ESS, the TSS compares individual observations to the grand mean and not to the cluster mean. By plotting r-squared values against the number of clusters, the optimal number of clusters can be selected based on where the curve begins to flatten.

Because clustering methods seeks to maximize the separation between clusters, ordinary significance tests are not appropriate, therefore Monte Carlo methods will be used to determine the statistical significance associated with the observed clusters. There are three steps to the Monte Carlo approach. First, 999 randomly shuffled data sets are created under the null hypothesis that there is no clustering of observations based on any of the variables of interest. Each of these datasets is created by randomly shuffling the responses for each variable independently. Secondly, Jaccard's distance and Ward's minimum variance method of searching for clusters are applied to all shuffled datasets. The last step of the Monte Carlo process is to

calculate the significance of the original r-squared. To do this, all of the r-squared values from the Monte Carlo data and the r-squared of the original dataset are ranked in order from highest to lowest. The p-value is then calculated by dividing the rank of the r-squared of the original dataset by the number of simulations plus 1.

Characterizing the Clusters

Once the clusters have been identified, they will be characterized based on the variables of interest as well as socio-demographic and behavioural variables in order to understand whether certain motivational factors appeal to specific types of people. First, we will look at the motivational factors that received similar rankings from a high percentage of respondents within the cluster. Once it has been determined what the top motivational factor(s) is for each cluster, the socio-demographics and cycling behaviour of respondents within the clusters will be examined. This will be done by looking at the characteristics of the highest percentage of respondents within each cluster.

Chi-squared tests will also be performed to test whether the socio-demographic and behavioural differences between clusters are statistically significant. For each of the socio-demographic and behavioural variables, the frequencies in each individual cluster will be compared to the frequencies in all of the other clusters combined. For all cases where chi-squared tests show there to be a real difference in cell frequencies, odds ratios will be calculated.

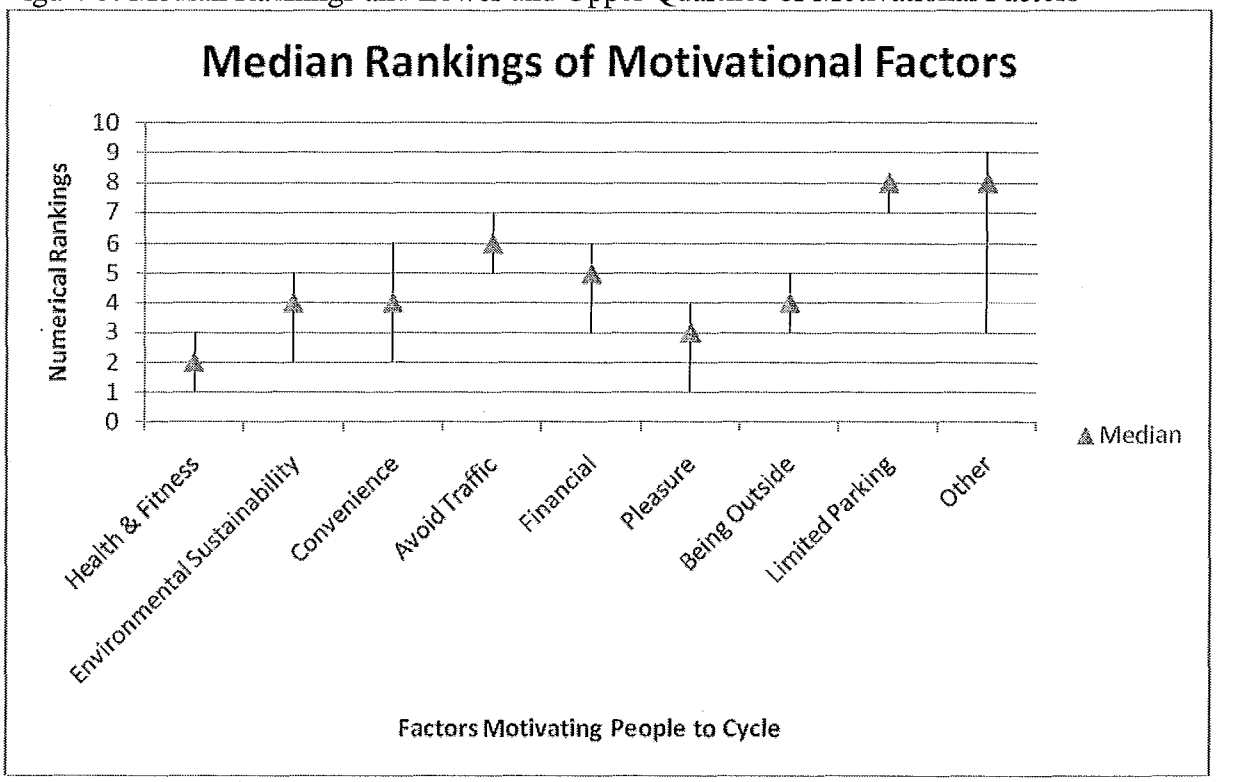
3.4 RESULTS

3.4.1 Sample

A total of 412 responses were collected. Nine respondents identified themselves as residing outside of the study area and were not included, leaving a total of 403 responses for analysis.

Respondents were asked to rank the factors that motivate them to cycle, "1" being the most important. Respondents could rank as many factors as they wanted. Figure 5 illustrates the median rankings and the lower and upper quartiles for each of the motivational factors. "Health and fitness" was the highest ranked motivational factor, with a median ranking of 2. Other factors that were ranked highly amongst respondents were "pleasure", "environmental sustainability", "convenience" and "being outside". "Limited car parking" and "other" were the lowest ranked factors, each with a median ranking of 8.

Figure 5. Median Rankings and Lower and Upper Quartiles of Motivational Factors



Respondents who provided rankings that were outside the range of 1 to 9 were deleted, as were those respondents who gave two or more factors the same ranking. Lastly, respondents who did not rank any of the motivational factors were deleted. As a result, 379 respondents were included in the cluster analysis.

3.4.2 Cluster Analysis

Using Ward's minimum variance method of cluster analysis, respondents were classified into clusters based on their rankings of the factors that motivate them to cycle. The r-squared values for the first 9 clusters are illustrated in Figure 6. Although there is no definite point at which the curve begins to flatten, the increase in r-squared values does become less rapid around the sixth cluster. With an r-squared value of 0.325 ($p<=0.001$), the 6 cluster solution accounts for about 32% of the variability amongst respondents based on respondents rankings of the factors that motivate them to cycle (Figure 7).

Figure 6. The r-squared curve

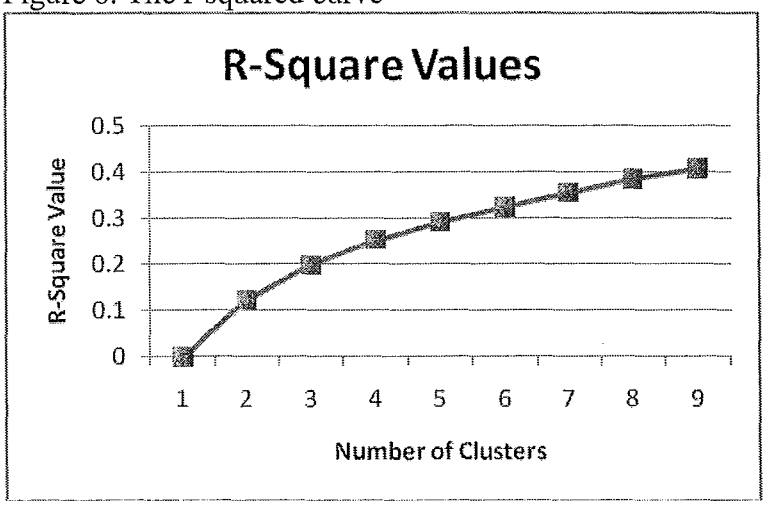
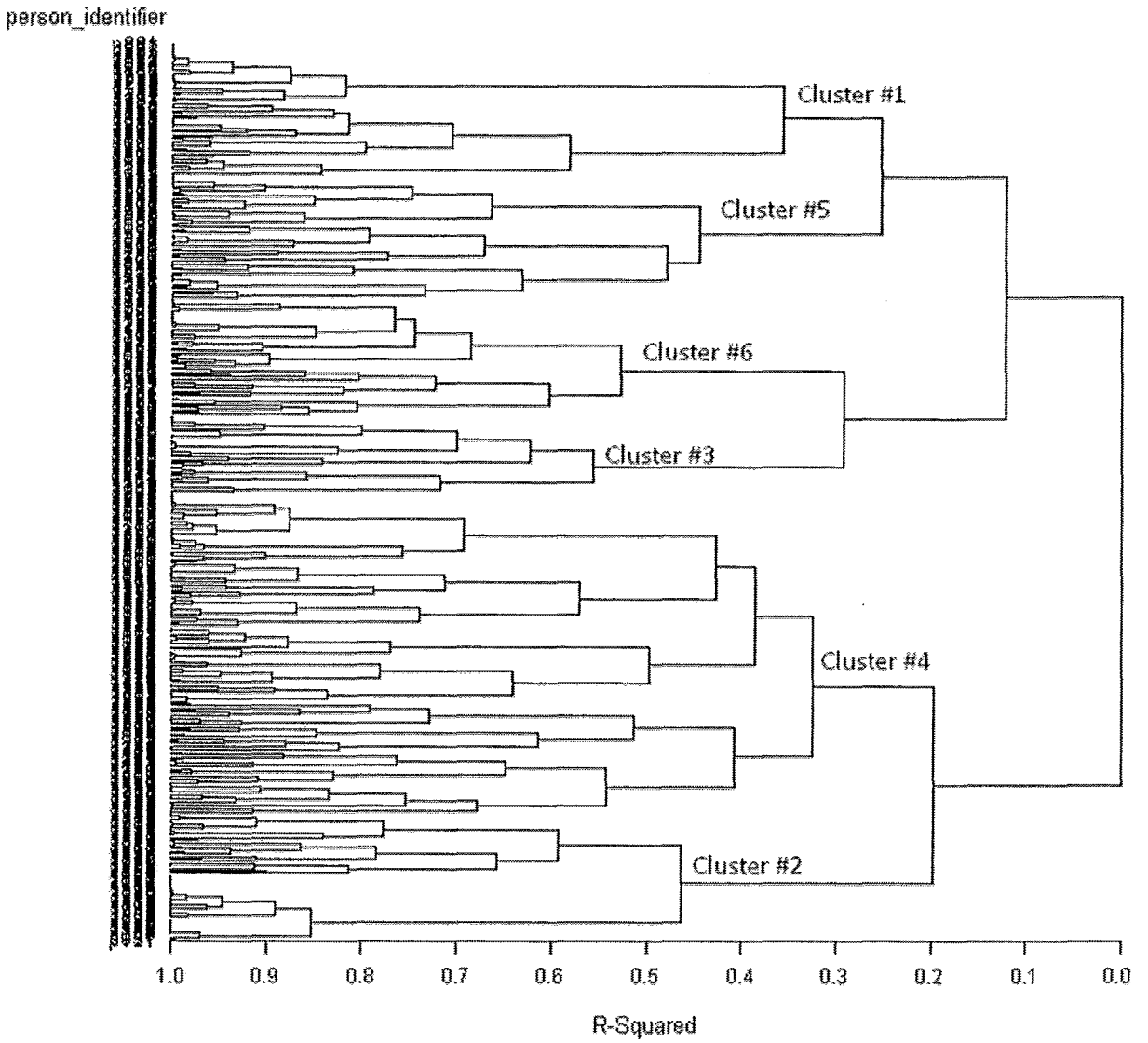


Figure 7. Results of Ward's minimum variance method of cluster analysis



3.4.3 Characterizing the Clusters

Variables of Interest

Aside from Cluster 4, the clusters are similar in size and contain 33 to 56 respondents. Cluster 4 is much larger and contains 136 respondents. Each of the six clusters is characterized based on the percentage of respondents in the cluster that have the same ranking for a particular factor (Table 7). Characterization will be based on the top ranked motivational factor in each group. Factors that have been ranked as #2 will be considered if multiple clusters have ranked

the same factor as #1, or if a high percentage of respondents in a cluster have provided the same ranking for their #2 motivation. Characterizing the clusters based on respondents' rankings of motivational factors is the first step in characterizing the clusters to understand whether or not certain motivational factors appeal to specific groups of people.

Respondents in Cluster 6 have the highest level of agreement on their #1 motivation for cycling (94%), which is "pleasure". Cluster 4 also has a high level of agreement, with 80% of respondents selecting "health and fitness" as their #1 motivation for cycling. The majority of respondents in Cluster 3 (52%) ranked "environmental sustainability" as their #1 motivation for cycling, while 40% of respondents in Cluster 5 ranked "convenience" as their #1 motivation. Because a high percentage of respondents in these four clusters have ranked the same factor as #1, these clusters are characterized based solely on the factors ranked as #1 by respondents.

"Health and fitness" and "pleasure" are popular motivations for cycling and, consequently, were ranked highly by respondents in a number of clusters. While the highest percentage of respondents to rank each of these factors as #1 are in clusters 4 and 6, a high percentage of respondents in clusters 1 and 2 have also ranked these factors as their #1 motivation for cycling. As a result, the #2 rankings provided by respondents in clusters 1 and 2 will also be considered to characterize these clusters.

Fifty-three percent of respondents in Cluster 2 have ranked "health and fitness" as their #1 motivation for cycling. A high percentage of respondents in this cluster (91%) have also ranked "pleasure" as their #2 motivation for cycling. Because of the high percentage of respondents who have ranked "pleasure" second, respondents in this cluster will be characterized as "health and pleasure cyclists". In cluster 1, 45% of respondents ranked "pleasure" as their #1 motivation for cycling, however, 43% of respondents also ranked "environmental sustainability" as #1.

Since both factors were ranked #1 by almost the same percentage of respondents, respondents in this cluster will be characterized as "pleasure and environmental cyclists". Characterizing the clusters based on the factors that motivate them to cycle gives us six different types of cyclists, (1) pleasure and environmental cyclists, (2) health and pleasure cyclists, (3) environmental cyclists, (4) health cyclists, (5) convenience cyclists and (6) pleasure cyclists.

Table 7. Respondents Overall Rankings by Cluster

Ranking	Cluster #1 "Pleasure and Enviro. Cyclists" (56 ppl.)	Cluster #2 "Health and Pleasure Cyclists" (53 ppl.)	Cluster #3 "Environmental Cyclists" (33 ppl.)	Cluster #4 "Health Cyclists" (136 ppl.)	Cluster #5 "Convenience Cyclists" (52 ppl.)	Cluster #6 "Pleasure Cyclists" (49 ppl.)
#1	PLEAS (45%) ENVIRO (43%)	HEALTH (53%) CONV (19%)	ENVIRO (52%) CONV (33%)	HEALTH (80%) ENVIRO/CONV (8%)	CONV (40%) FIN (33%)	PLEAS (94%) TRAFF (4%)
#2	HEALTH (98%)	PLEAS (91%)	FINC (33%)	ENVIRO (29%)	HEALTH (63%)	OUT (57%)
#3	OUT (52%)	OUT (79%)	HEALTH (73%)	PLEAS (27%)	ENVIRO (67%)	HEALTH (59%)
#4	ENVIRO (21%)	ENVIRO (49%)	PLEAS (33%)	OUT (26%)	PLEAS (27%)	ENVIRO (35%)
#5	CONV (20%)	CONV (32%)	OUT (24%)	ENVIRO (18%)	OUT (38%)	CONV (20%)
#6	FINC (18%)	TRAFF (23%)	TRAFF/FINC (18%)	CONV (18%)	TRAFF/PLEAS (21%)	FINC (20%)
#7	TRAFF (29%)	TRAFF (30%)	TRAFF (27%)	TRAFF (21%)	TRAFF/OUT (19%)	TRAFF (24%)
#8	PARK (34%)	PARK (48%)	PARK (36%)	PARK (40%)	PARK (54%)	PARK (47%)

Socio-Demographic and Behaviour Variables

The second step to understanding whether certain motivational factors appeal to specific groups of people is to look at the socio-demographic characteristics and cycling behaviour of respondents in each cluster. The composition of each cluster will be evaluated based on the characteristics of the highest percentage of respondents (Table 8). Looking at the characteristics of the highest percentage of respondents in each cluster gives us a better understanding of what types of people are motivated to cycle by different factors. Additionally, chi-squared tests are used to look for homogeneity of cell frequencies and odds ratios are calculated to test for associations between individual clusters and each of the twelve characteristics. The twelve socio-demographic and behavioural characteristics that will be looked at are, (1) age, (2) number of vehicles owned/leased by household, (3) geographic region of residence, (4) student status, (5) gender, (6) flexibility of work hours, (7) participation in sports other than cycling, (8) frequency of cycling to work, (9) frequency of cycling for social trips, (10) most frequent mode of transportation to work, (11) frequency of cycling throughout winter months and (12) changes in cycling frequency over the last 10 years.

Based on the characteristics of the highest percentage of respondents in each cluster, "health cyclists" are the oldest, with more respondents between the ages of 45-54 years (32%) than in any other age group. While the highest percentage of respondents in 4 of the 6 clusters are likely to own/lease 1 vehicle, a large percentage of "environmental cyclists" own no vehicles (42%) and a large percentage of "health cyclists" own 2 vehicles (40%). In 5 clusters, more people live in West Hamilton than in any other region. Respondents in the "pleasure cyclists" cluster are just as likely to live in West Hamilton as they are to live in East Hamilton, with 29% of respondents residing in each region. In all of the clusters, the majority of respondents are not full

time students. The "environmental cyclists" cluster is the only cluster where the majority of respondents are female (55%). In every cluster, more respondents have flexible work hours than non-flexible work hours.

With regards to the behaviour variables, the majority of respondents in each cluster participate in sports other than cycling. The highest percentage of respondents in all 6 clusters either cycle to work "everyday" or "never". Twenty-five percent of "pleasure and environmental cyclists" and 28% of "health and pleasure cyclists" never cycle to work. Between 22% and 30% of respondents in the remaining four clusters cycle to work every day. The highest percentages of respondents in each cluster tend to cycle for "up to 25%" of all of their social trips. Conversely, the highest percentage of "health and pleasure cyclists" cycle for 0% of their social trips (32%), while 36% of "environmental cyclists" cycle for 76-100% of social trips. In 5 clusters, more respondents use their bicycle as their most frequent mode of transportation to work than any other mode. "Health and environmental cyclists" are the only group where driving a motor vehicle to work is the most frequent mode of transportation to work (38%). "Environmental cyclists" are the only cluster where the highest percentage of respondents cycle "often" throughout the winter months (48%). The opposite is true for the other 5 clusters, where most people "never" cycle in the winter months. Lastly, respondents in all 6 clusters are more likely to have increased their cycling behaviour over the last 10 years than have decreased their cycling frequency or remained about the same.

Table 8. Socio Demographic Characteristics of the Highest Percentage of Respondents for Each Cluster

Cluster	#1 "Pleasure and Env."	#2 "Health and Pleas."	#3 "Environmen-tal"	#4 "Health"	#5 "Convenience"	#6 "Pleasure"
Age	35-44 years (29%)	35-44 years (26%)	25-34 years (42%)	45-54 years (32%)	18-24 and 25-34 yrs (23%)	25-34 years (24%)
# Vehicles	1 (43%)	1 (42%)	0 (42%)	2 (40%)	1 (35%)	1 (45%)
Region of Residence	West Ham. (39%)	West Ham. (32%)	West Ham. (42%)	West Ham. (26%)	West Ham. (52%)	W. & E. Ham. (29%)
Student Status	Non (88%)	Non (81%)	Non (61%)	Non (80%)	Non (73%)	Non (80%)
Gender	Male (59%)	Male (68%)	Female (55%)	Male (64%)	Male (71%)	Male (59%)
Flex. Work Hours	Yes (54%)	Yes (49%)	Yes (64%)	Yes (54%)	Yes (42%)	Yes (73%)
Participate in Sports	Yes (84%)	Yes (89%)	Yes (79%)	Yes (85%)	Yes (73%)	Yes (78%)
Freq. Cycle to Work	Never (25%)	Never (28%)	Everyday (30%)	Everyday (22%)	Everyday (25%)	Everyday (27%)
Freq. Cycle Social	Up to 25% (36%)	0% (32%)	76-100% (36%)	Up to 25% (35%)	Up to 25% (31%)	Up to 25% (31%)
Freq. Mode to Work	Driver (38%)	Bicycle (28%)	Bicycle (42%)	Bicycle (34%)	Bicycle (38%)	Bicycle (37%)
Winter Cycling	Never (50%)	Never (42%)	Often (48%)	Never (40%)	Never (42%)	Never (41%)
Cycling Freq. Change	Increase (57%)	Increase (49%)	Increase (42%)	Increase (61%)	Increase (58%)	Increase (51%)

Using chi-squared tests, we see that there are no statistically significant differences between clusters based on flexibility of work hours, cycling to work 3 or more times a week, using a bicycle as one's most frequent mode of transportation to work, frequency of cycling in the winter or increasing one's general cycling frequency. Significant differences between clusters were

found for other socio-demographic and behavioural variables. "Environmental cyclists" differ from respondents in all other clusters most often (Table 9).

Table 9. Bivariate Analysis of Socio-Demographic and Behavioural Variables by Cluster

Variable	Cluster	Chi-Square	Unadjusted Odds Ratio
18-24 years of age	Cluster 1	0.4702	0.8029 (0.4421, 1.4581)
	Cluster 2*	0.0558	0.5344 (0.2791, 1.0231)
	Cluster 3*	<.0001	5.8854 (2.5757, 13.4481)
	Cluster 4*	0.0466	0.6392 (0.4107, 0.9946)
	Cluster 5	0.2073	1.4593 (0.8092, 2.6315)
	Cluster 6	0.6930	1.1310 (0.6136, 2.0849)
Cycle in the Winter "Often" or "Sometimes"	Cluster 1	0.0920	0.6145 (0.3475, 1.0864)
	Cluster 2	0.7801	1.0875 (0.6036, 1.9590)
	Cluster 3	0.4019	1.3711 (0.6539, 2.8749)
	Cluster 4	0.8543	1.0405 (0.6809, 1.5900)
	Cluster 5	0.8799	1.0467 (0.5790, 1.8920)
	Cluster 6	0.7101	1.1226 (0.6101, 2.0657)
Own/Lease No Vehicles	Cluster 1	0.1381	0.5357 (0.2322, 1.2359)
	Cluster 2	0.5741	1.2218 (0.6070, 2.4594)
	Cluster 3*	0.0006	3.4426 (1.6365, 7.2420)
	Cluster 4*	0.0166	0.4978 (0.2793, 0.8872)
	Cluster 5*	0.0119	2.2527 (1.1817, 4.2944)
	Cluster 6	0.3001	0.6422 (0.2763, 1.4926)
Reside in West or East Hamilton (Lower Hamilton)	Cluster 1	0.7574	1.0957 (0.6134, 1.9573)
	Cluster 2	0.2079	0.6888 (0.3847, 1.2331)
	Cluster 3*	0.0050	3.4439 (1.3865, 8.5541)
	Cluster 4*	0.0165	0.5952 (0.3889, 0.9109)
	Cluster 5*	0.0247	2.0834 (1.0869, 3.9933)
	Cluster 6	0.7960	0.9231 (0.5031, 1.6935)
Cycle to Work "3-4 days a week" or "Everyday"	Cluster 1	0.1599	0.6419 (0.3448, 1.1953)
	Cluster 2	0.0870	0.5698 (0.2974, 1.0916)
	Cluster 3	0.0694	1.9263 (0.9402, 3.9469)
	Cluster 4	0.9580	0.9884 (0.6397, 1.5271)
	Cluster 5	0.3879	1.2989 (0.7167, 2.3541)
	Cluster 6	0.3577	1.3298 (0.7234, 2.4445)
"Never" Cycle to Work	Cluster 1	0.1930	1.5556 (0.7967, 3.0372)
	Cluster 2*	0.0542	1.9032 (0.9804, 3.6946)
	Cluster 3	0.5810	0.7576 (0.2819, 2.0361)
	Cluster 4	0.6851	0.8936 (0.5188, 1.5393)
	Cluster 5	0.2942	0.6392 (0.2754, 1.4835)
	Cluster 6	0.2122	0.5689 (0.2322, 1.3939)
Cycling for 51% or more of social trips	Cluster 1	0.2829	0.7019 (0.3670, 1.3423)
	Cluster 2	0.1499	0.6075 (0.3066, 1.2036)
	Cluster 3*	0.0006	3.3860 (1.6339, 7.0168)
	Cluster 4	0.3152	0.7901 (0.4986, 1.2519)
	Cluster 5	0.2193	1.4605 (0.7962, 2.6791)
	Cluster 6	0.9326	0.9723 (0.5073, 1.8637)
"Never" Cycle for Social Trips	Cluster 1	0.6559	1.1714 (0.5837, 2.3506)
	Cluster 2*	0.0108	2.2768 (1.1950, 4.3378)
	Cluster 3*	0.0442	0.2499 (0.0584, 1.0691)
	Cluster 4	0.7455	0.9150 (0.5350, 1.5649)
	Cluster 5*	0.0576	0.4052 (0.1552, 1.0581)
	Cluster 6	0.3199	1.4302 (0.7046, 2.9031)

"Bicycle" is Most Frequent Mode of Transportation to Work	Cluster 1	0.1439	0.6195 (0.3245, 1.1826)
	Cluster 2	0.3865	0.7542 (0.3977, 1.4302)
	Cluster 3	0.2562	1.5193 (0.7351, 3.1401)
	Cluster 4	0.9227	1.0222 (0.6556, 1.5939)
	Cluster 5	0.4154	1.2850 (0.7020, 2.3522)
	Cluster 6	0.6082	1.1773 (0.6305, 2.1983)
"Motor Vehicle – Driver" is Most Frequent Mode of Transportation to Work	Cluster 1	0.0760	1.7071 (0.9412, 3.0963)
	Cluster 2	0.8211	0.9270 (0.4806, 1.7880)
	Cluster 3*	0.0036	0.1522 (0.0358, 0.6478)
	Cluster 4	0.0798	1.5082 (0.9511, 2.3918)
	Cluster 5	0.1416	0.5815 (0.2803, 1.2063)
	Cluster 6	0.8440	0.9342 (0.4741, 1.8409)
Full Time Student	Cluster 1	0.3408	0.6921 (0.3234, 1.4809)
	Cluster 2	0.7025	0.8662 (0.4142, 1.8112)
	Cluster 3*	0.0216	2.3795 (1.1153, 5.0766)
	Cluster 4	0.2516	0.7325 (0.4296, 1.2488)
	Cluster 5	0.2453	1.4850 (0.7597, 2.9029)
	Cluster 6	0.9358	0.9699 (0.4611, 2.0403)
Female	Cluster 1	0.7503	1.1000 (0.6115, 1.9788)
	Cluster 2	0.2302	0.6776 (0.3578, 1.2834)
	Cluster 3*	0.0175	2.3487 (1.1427, 4.8278)
	Cluster 4	0.9210	0.9781 (0.6307, 1.5167)
	Cluster 5	0.0851	0.5601 (0.2876, 1.0908)
	Cluster 6	0.4156	1.2894 (0.6984, 2.3802)
Participate in Sports Other than Cycling	Cluster 1	0.7328	1.1430 (0.5304, 2.4628)
	Cluster 2	0.1908	1.8031 (0.7374, 4.4091)
	Cluster 3	0.5775	0.7792 (0.3233, 1.8782)
	Cluster 4	0.2565	1.3908 (0.7854, 2.4629)
	Cluster 5*	0.0599	0.5250 (0.2661, 1.0360)
	Cluster 6	0.3482	0.7060 (0.3402, 1.4651)
Flexible Work Hours	Cluster 1	0.8965	1.0385 (0.5880, 1.8340)
	Cluster 2	0.5593	0.8412 (0.4706, 1.5037)
	Cluster 3	0.1907	1.6327 (0.7790, 3.4218)
	Cluster 4	0.6321	1.1083 (0.7275, 1.6884)
	Cluster 5	0.1037	0.6139 (0.3397, 1.1092)
	Cluster 6	0.7261	1.1138 (0.6094, 2.0355)
Cycling Frequency Remained About the Same	Cluster 1	0.4277	0.7519 (0.3710, 1.5239)
	Cluster 2	0.1276	1.6301 (0.8657, 3.0696)
	Cluster 3	0.7883	0.8872 (0.3703, 2.1256)
	Cluster 4	0.3939	0.8042 (0.4865, 1.3293)
	Cluster 5	0.5703	1.2119 (0.6236, 2.3551)
	Cluster 6	0.9046	1.0437 (0.5188, 2.0994)
Cycling Frequency Decreased	Cluster 1	0.6053	1.1953 (0.6071, 2.3534)
	Cluster 2	0.7317	0.8789 (0.4201, 1.8389)
	Cluster 3*	0.0447	2.1812 (1.0032, 4.7427)
	Cluster 4	0.2819	0.7460 (0.4370, 1.2735)
	Cluster 5	0.3137	0.6649 (0.2993, 1.4774)
	Cluster 6	0.4748	1.2924 (0.6387, 2.6151)
Cycling Frequency Increased	Cluster 1	0.7956	1.0787 (0.6082, 1.0132)
	Cluster 2	0.3045	0.7379 (0.4125, 1.3200)
	Cluster 3	0.1601	0.5952 (0.2868, 1.2353)
	Cluster 4	0.1084	1.4181 (0.9251, 2.1736)
	Cluster 5	0.7385	1.1061 (0.6120, 1.9991)
	Cluster 6	0.4935	0.8108 (0.4445, 1.4788)

* $p<0.05$

3.5 DISCUSSION

Clustering respondents based on the factors that motivate them to cycle has revealed six types of cyclists, (1) pleasure and environmental cyclists, (2) health and pleasure cyclists, (3) environmental cyclists, (4) health cyclists, (5) convenience cyclists and (6) pleasure cyclists. By classifying respondents into these groups, we are able to see that certain motivational factors appeal more to different types of people. In this section, we will discuss the socio-demographic and behavioural characteristics associated with different motivational clusters, as well as the policy implications of these findings and the limitations of this research. Special attention will be given to the characteristics of both the smallest and the largest clusters; environmental cyclists and health cyclists.

3.5.1 Associations Between Individual Characteristics and Motivational Clusters

Environmental Cyclists

Environmental values have been linked to reductions in car use by researchers in previous transportation studies (Steg and Vlek 1997, Nilsson and Kueller 2000). Researchers who have divided participants into behavioural groups have found a segment of respondents who are aware of the connection between environmental pollution and driving and who, as a result, do not drive, or drive less (Anable 2005, Jensen 1999). Respondents in the "environmental cyclists" cluster in this study are likely to cycle more than respondents in other clusters and possess many of the socio-demographic characteristics associated with higher cycling rates. Although it is difficult to determine whether respondents in this cluster are influenced to cycle because of their socio-demographics or because of their environmental values, it is likely that the two are linked.

The "environmental cyclists" cluster contains 33 respondents and is the smallest of the six clusters. However, based on bivariate analysis of the socio-demographic and behavioural

characteristics of the clusters, this is also the most unique group of respondents. Environmental cyclists are almost six times more likely to be young than respondents in other clusters and are the only cluster where the majority of respondents are female. Respondents in this cluster are more than twice as likely to be full time students as other respondents and are three times more likely not to live in households that own or lease any motor vehicles. Environmental cyclists are almost four times more likely to reside in Lower Hamilton. This area of the city is characterized by high density, mixed use developments and increased street connectivity.

Previous research has found that young people, students, people without vehicles and those living in high density, mixed use areas are more likely to cycle (Koth 2006, Sener et al. 2009, Pucher and Renne 2003, Pucher et al. 1999, Baltes 1996, Dill and Voros 2007, Pucher and Buehler 2005, Pucher and Dijkstra 2003, Xing et al. 2008, Dill and Carr 2003, Frank and Engelke 2001, Saelens et al. 2003). Young people and students are often more likely to be environmentally conscious (Koth 2006, Sener et al 2009) and respondents in this group may choose not to own a vehicle because of the environmental values that they espouse. With regards to the high proportion of women in this group, women may be less likely to be cyclists than men (Dill and Voros 2007,Dickinson et al 2003, Garrard et al. 2008, Gatersblen and Appleton 2006,Pucher and Renne 2003,Stinson and Bhat 2004,Sener et al. 2009, Winters et al. 2007), but researchers have found that women who are cyclists cycle just as frequently as male cyclists (Howard and Burns 2001).

Not only do environmental cyclist's posses many of the socio-demographic characteristics associated with higher rates of cycling, they are also more likely than other cyclists to cycle for both social and work trips. Environmental cyclists are more than three times more likely than other respondents to cycle for 51% or more of their social trips and are the only group of cyclists

with a high percentage of respondents who cycle often throughout the winter months. Environmental cyclists are the least likely group of respondents to drive a motor vehicle as their most frequent mode of transportation to work. On the other hand, environmental cyclists are twice as likely to report a decrease in their overall cycling frequency over the last ten years. This can likely be explained by the fact that environmental cyclists tend to cycle more than respondents in other clusters and likely cannot cycle more than they currently do. In statistics, this phenomenon is known as "regression to the mean", but the concept can also be applied to cases such as this one. Since cyclists in this cluster are at the extremely high end of the distribution of cycling rates, they can only decrease their cycling frequencies.

This study suggests that youth, students, urban residents and females may be more effectively targeted with information about the environmental benefits of cycling than other people. Results also suggest that those who are primarily motivated to cycle because of environmental sustainability may be more likely to be commuter cyclists than those motivated by other factors. Environmental sustainability is generally a more common motivation for commuter cycling than for recreational cycling (Sener et al. 2009), therefore, environmental sustainability may be an effective motivational factor to promote when seeking to increase commuter cycling rates.

It is important to note that, although environmental cyclists are associated with higher commuter cycling rates and reduced levels of driving, this does not mean that information about the environmental benefits of cycling will lead to increases in commuter cycling. For many people, driving is simply the easiest form of transportation and information about the harmful effects of driving will not be enough to effect large scale changes in transportation behaviour (Jensen 1999). Anable (2005) suggests that environmental concern does account for some of the variations in people's transportation attitudes, intentions and behaviours but these environmental

beliefs need to be combined with the belief that one has the ability to control their own behaviour (Anable 2005). This study reveals two clusters in which respondents have given high rankings to environmental sustainability. In one cluster (environmental cyclists) respondents are likely to commute by bicycle, but in the other (pleasure and environmental cyclists), respondents commute by bicycle less often. Information about the environmental benefits of cycling may not always encourage large scale reductions in driving, but may be useful in stimulating cycling amongst select target groups.

Health Cyclists

Researchers have suggested that the link between health and cycling be emphasized to encourage cycling (Pucher et al. 2010). Health professionals encourage moderate physical activities such as walking and cycling as "lifestyle interventions", which can allow people to achieve healthy levels of physical activity on a daily basis (Frank and Engelke 2001). A review conducted by the Surgeon General of the United States highlights the positive health outcomes that can be derived from 30 minutes of regular brisk walking or cycling (US Department of Health and Human Services 1996). Others have encouraged moderate forms of physical activity because people are more likely to maintain these activities than they are more vigorous forms of exercise such as jogging (Frank and Engelke 2001). Although cycling and walking are often discussed collectively under the title "active transportation", cycling may be a more likely substitute for driving since it allows commuters to cover greater distances in a shorter time period than they would be able to cover by walking (Dill 2009). Studies have shown that people who cycle regularly are able to achieve the weekly recommended level of physical activity (Dill 2009).

With a median ranking of 2, "health and fitness" is the most highly ranked motivation for

cycling amongst survey respondents. Not surprisingly, the "health cyclists" cluster is the largest cluster with 136 respondents, 80% of whom ranked "health and fitness" as their #1 motivation for cycling. In this study, health cyclists are half as likely to be young, more likely to own multiple vehicles and to live outside of the Lower Hamilton region. In contrast to the socio-demographic characteristics of environmental cyclists, the socio-demographics of health cyclists have been associated with lower levels of cycling in previous studies. There are no statistical associations between respondents in this cluster and any of the cycling behaviour variables. This is consistent with previous findings that have suggested that health-minded cyclists are likely to be moderate cyclists as opposed to frequent cyclists since they are likely to pursue fitness activities unrelated to cycling (Xing et al. 2008). In fact, 85% of respondents in this cluster report participating in sports other than cycling. On the other hand, this cluster contains the highest percentage of respondents who report increasing their cycling frequency over the last 10 years (61%). A large percentage of health cyclists also report cycling to work every day (35%) and for up to 25% of their social trips (35%). This may be because of people's increasing awareness of the health benefits of cycling.

The results of this study suggest that a wide audience of people may be attracted to cycling because of the health benefits. Older residents living in suburban areas who are interested in improving their physical activity and willing to consider cycling for a portion of their journeys or for recreational purposes may be a particularly effective target group when promoting the health benefits of cycling. Unlike information about the environmental impact of driving, the health benefits of cycling can help to convince people that they will benefit personally from cycling instead of driving (Pucher and Dijkstra 2003). Because the benefits are personal, it may be easier for health cyclists to rationalize driving for more journeys than it is for environmental

cyclists. Individuals who bicycle for health reasons are likely to cycle more often for recreation than for commuting purposes (Sener et al. 2008), therefore, health and fitness may be an effective motivational factor to promote when seeking to encourage moderate levels of both recreational and commuter cycling.

Other Cyclists

Many cyclists have also identified "pleasure derived from cycling" and "convenience" as their #1 motivation for cycling. The remaining four clusters are characterized by either of these motivations. With a median ranking of 3, "pleasure derived from cycling", is the second most highly ranked motivational factor behind "health and fitness". Pleasure is also one of the motivational factors characterizing three of the six clusters, (1) pleasure and environmental cyclists, (2) health and pleasure cyclists and (3) pleasure cyclists. While bivariate analysis shows that "health and pleasure cyclists" are twice as likely never to cycle to work or for social trips, there are no statistical associations between socio-demographic or behavioural variables and either "pleasure and environmental cyclists" or "pleasure cyclists". Pleasure is a common motivating factor for cycling (Stinson and Bhat 2004), however, there are no clear associations between pleasure and commuter cycling behaviour or socio-demographic characteristics. The pleasure benefits of cycling are perhaps not as visible or as easy to pinpoint as the environmental and health benefits of cycling. As a result, while many people cycle because they enjoy the activity, this may not lead them to cycle regularly, or when other modes of transportation are readily available. Because pleasure is an important motivational factor for multiple groups, it is difficult to determine a specific target group to whom cycling should be advertised as pleasurable.

3.5.2 Policy Implications

Municipal Promotion of Commuter Cycling

In cities across North America "Cycling Master Plans" have been produced to guide the development and implementation of cycling infrastructure and policies. Much like grassroots advocacy efforts, these Master Plans are primarily focused on the provision of cycling facilities. Sections of Cycling Master Plans dealing with proposed cycling facilities are very detailed and are often subject to thorough public scrutiny, as was the case with the City of Hamilton's most recent update to its Cycling Master Plan. On the other hand, details about educational and promotional strategies tend to remain vague, with few specific policy proposals. As has been discussed in this paper, we need to change people's attitudes towards bicycles (Ogilvie et al 2004) and give them a reason to use the cycling facilities being built.

The need to change people's attitudes towards cycling has been addressed by some cities in their Cycling Master Plans (City of Toronto 2001). Similarly, others have outlined the need to facilitate community acceptance of commuter cycling (City of Victoria 1995) as well as the importance of promoting the advantages of commuting by bicycle (City of Hamilton 2009, City of Victoria 1995, City of Toronto 2001, City of Ottawa 2008). However, the strategies to change people's attitudes towards bicycling have been focused on convincing people that cycling is a safe mode of transportation. This is done by educating residents about the rights of cyclists and motorists on the road and by training them on safe cycling practices. While the importance of cycling safety should not be ignored, the tendency of policy makers to focus on the need for safer cycling facilities and practices serves to draw even more attention towards the potential dangers of cycling. Efforts to change people's attitudes towards bicycles need to extend beyond convincing residents that it can be a safe mode of transportation. Over the last decade, cities

have made strides in providing residents with the necessary means for safe cycling (bicycle lanes, safety training, etc), but residents also need to be provided with compelling reasons for cycling beyond it being safe, and this is where municipal promotional strategies often fall short.

As an example, consider the Cycling Master Plan recently approved by the City of Hamilton's city council. While the "Cycling Education" section is limited to safety, the "Cycling Promotion" section focuses on the "production and dissemination of information to encourage people to start or increase the amount of cycling they do (...)" (City of Hamilton 2009). In this section, eleven of the city's current promotional strategies are outlined and include the distribution of cycling maps and cycling safety pamphlets, providing cycling information on the city website, sending out positive messages about cycling using various types of media, working with volunteers to present information about cycling and festivals, and adding cycling logos to street name signage on streets with cycling infrastructure (City of Hamilton 2009).

Many of these promotional strategies are focused on cycling safety and way-finding. In this regard, the City of Hamilton produces and disseminates excellent cycling maps and safety pamphlets. "Positive messages about cycling" is included in this list of promotional strategies, however, there are no specific proposals outlining the kinds of positive messages this includes. This ambiguous promotional strategy is in stark contrast to the detail with which proposed cycling facilities are outlined. Earlier in the Master Plan, a profile is presented for each ward of the city wherein a detailed map of all proposed cycling facilities is provided in addition to a table that summarizes the length, overall ranking, location and environmental assessment status of each proposed facility. Cycling infrastructure is the primary focus of Cycling Master Plans across North America and cycling facilities should continue to be evaluated in detail by both policy makers and the general public. However, this research highlights the need to compliment

carefully planned cycling infrastructure with detailed strategies aimed at changing people's attitudes towards cycling. The target groups outlined in this study can be employed as part of more specific municipal promotional efforts.

Fostering Lifelong Cyclists through the Cross Promotion of Motivational Messages

The target groups created in this research help us to understand how to effectively target people with positive information about cycling that is relevant to them as individuals. Transportation psychology research tells us that a single motivation or strategy will not translate into widespread changes in transportation behaviour (Jensen 1999) and that it is important to select a target group of people likely to respond to specific policy measures (Anable 2005). As evidenced in the above discussion, certain segments of the population will be more receptive audiences for information about the health, environmental and convenience advantages of cycling. The statistical associations between socio-demographic variables and individual motivational factors also makes it clear that people's priorities change over the course of their lives, as do their cycling habits, and this has important policy implications.

A good example of this is age. In North America, age and cycling have an inverse relationship (Dill and Voros 2007, Pucher et al. 1999, Pucher and Renne 2003). As they age, cyclists are likely to decrease their cycling frequency or stop cycling. There are many reasons why people may choose to stop cycling, including, an injury or physical inability to cycle, professional and familial responsibilities that create more complex trip patterns, the perception that commuter cycling is only for young people and vehicle ownership. This study suggests that people should be targeted with different types of positive messages about cycling over the course of their changing lives. Adapting the message(s) to the person's lifestyle could help to remind people of the reasons why cycling could be of benefit to them and encourage people to maintain

their cycling habits for as long as they are physically able to cycle.

Looking at the two motivational clusters in this study with statistical associations to age, environmental cyclists are likely to be young (18-24 years of age) and, with 32% of health cyclists between the ages of 45-54 years old, health cyclists are statistically unlikely to be young. Environmental cyclists are likely to report decreases their cycling frequency, as was previously discussed, and health cyclists are likely to report increases in their cycling frequency. Given that a high percentage of respondents in the health cyclist cluster are older, it seems counter-intuitive that they would be cycling more than they used to. However, in 2001, Velo Quebec released a report indicating that, even though younger age groups continue to have the highest cycling rates, most of the growth in cycling that had occurred since 1981 was amongst middle-aged and older residents (Velo Quebec 2001). This trend could be related to a growing awareness of the health benefits of cycling amongst this age group.

Trying to encourage non-cyclists to start cycling is a difficult task given that many people who have never contemplated cycling would not cycle under any circumstances (Gatersleben and Appleton 2007). To increase cycling rates, we also need to focus on minimizing the rate with which people stop cycling as they age. While this study indicates that environmental sustainability and the health benefits of cycling each have significant statistical associations with different age groups, the convenience, potential for financial savings and pleasurable nature of cycling do not. As they age, cyclists may become less idealistic about cycling as they acquire professional and familial responsibilities. During this stage, the convenience of bicycles over motor vehicles in certain situations as well as the ability to simply enjoy one's commute may be appealing motivational factors to help sustain their cycling behaviour over time. Additionally, people who are aware of several different advantages of cycling may be more likely to cycle

often and for a variety of different trips. While many cities mention the environmental, health and economic benefits of cycling in their Cycling Master Plans, the pleasurable nature of cycling is often limited to recreational cycling or one-time cycling events such as Bike Week. Over and above its many advantages, cycling is a fun activity and mode of transportation. Promoting this aspect of cycling to a variety of different target groups may serve to compliment other motivational factors while providing residents with a compelling reason to become lifelong cyclists.

3.5.3 Limitations

This study is not based on a random sample of the population, only cyclists and former cyclists were asked to participate. Survey responses are from people who already cycle and are therefore more likely to value and have positive opinions about cycling. As such, stakeholders and policy makers are not able to generalize the results of this study to the population as a whole. Because this study seeks to understand the reasons that are effective in motivating different people to cycle, it is appropriate that only cyclists were asked to participate. Previous cycling studies have also used data derived from cyclist-only surveys (Howard and Burns 2001, Sener et al. 2008). Although it is also difficult to generalize these results to other cities because people's motivations for cycling change depending on the context, the importance of focusing on the psychology of mode choice and using target groups to promote cycling is an important promotional strategy that can be applied in other areas.

A second limitation to this study is that respondents' motivations for cycling are based on the rankings they gave to a list of motivational factors. Rankings can be challenging for both respondents and researchers and the answers can become less reliable as the number of items being ranked increases. More detailed clusters could have been formed if respondents were

asked to answer multiple Likert scale questions about each motivational factor. This method would have given us a better sense of respondents' overall values and reasons for cycling. Despite the disadvantages of rankings, this method allowed us to associate respondents with a single motivational factor that they considered to be most important (#1) in a way that would not have been possible using Likert scale questions about each motivational factor.

Lastly, it is difficult to determine whether respondents in the same cluster displayed cycling behaviours that can be linked to motivational factors or if these associations are the result of the socio-demographic composition of the cluster. Employing the Likert scale questions mentioned above would have helped to address this limitation by allowing us to associate respondents with specific values as opposed to only a ranking. However, it is likely that motivational factors and socio-demographic characteristics are linked and that certain people are likely to be attracted to motivational factors because of who they are. An example of this comes from the environmental cyclists cluster. It is unclear whether environmental cyclists are more likely to cycle because of their environmental values, or because they are also likely to be young and young people tend to cycle more than old people. It is likely that respondents in this cluster value environmental sustainability because they are young.

3.6 CONCLUSION

Few studies have sought to understand the reasons why cyclists cycle. In this study, we used cluster analysis to group respondents based on the factors that motivate them to cycle. Analysis of the composition of these clusters indicates that certain motivational factors may be more appealing to different groups of people, but that different motivational factors serve to encourage different types of cycling activity. Although it is difficult to change people's transportation

behaviour, promoting specific motivational factors to receptive target groups may help to encourage more cycling by addressing the specific needs of commuters. Transportation psychology research has suggested that cycling needs to have a more positive image and be seen as a viable mode of transportation successfully used by others before commuters will willingly switch modes (Jensen 1999, Koth 2006, Steg and Tertoolen 1999). Focusing on the factors that motivate people to cycle can accomplish both of these aims by improving our perceptions of cycling while identifying the reasons why other people view cycling as a viable mode of transportation. In addition to guiding the implementation of cycling facilities, the Cycling Master Plans produced by North American cities need to focus more on outlining specific strategies for motivating residents to cycle. The pleasurable nature of both recreational and commuter cycling and the convenience of cycling should be highlighted during these promotional efforts.

Future research should continue to focus on the reasons why people cycle and how this information can be used to promote cycling in different communities. This research would benefit from including the broader values of respondents and the emotions that they ascribe to their mode of transportation. Information about the benefits of cycling alone will not result in wide scale increases in commuter cycling rates and should be used in conjunction with other legislative and infrastructural changes. Municipalities need to focus on finding the right balance of physical infrastructure improvements and educational or promotional strategies that will help to increase cycling rates by providing residents with a safe cycling environment as well as with compelling reasons to cycle.

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CHAPTER FOUR: CONCLUSION

4.1 INTRODUCTION

This thesis presents the results of two studies exploring the behaviour of cyclists in Hamilton, Ontario. This research is based on data collected through a survey of self-identified cyclists that was designed and administered by the student researcher. The overall objective of this research was to understand the behaviour and motivations of cyclists in a mid-sized North American city with relatively low levels of cycling. This objective was met by addressing two specific research questions:

1. Does the perceived availability of on-route or workplace cycling facilities influence bicycle commuting behaviour?
2. Are certain motivational factors for cycling associated with different socio-demographic or behavioural characteristics and, can this information be used to create target groups for promoting cycling?

Multiple logistic regression and cluster analysis were used to address each of these questions respectively and the results of these analyses are outlined in chapters 2 and 3. In this concluding chapter, a summary of the major findings of this research will be presented, along with the limitations, contributions and potential future directions for this research.

4.2 SUMMARY OF MAJOR FINDINGS

4.2.1 Cycling Facilities and Cycling to Work

In the first paper, a multiple logistic regression model is presented to analyze the relationship between the perceived availability of on-route and workplace facilities and the likelihood of cycling to work. This study reveals a small group of dedicated cyclists who commute by bicycle

despite the low perceived availability of cycling facilities. Three main policy implications are discussed based on the results of the model.

First, cities should seek to encourage high density, mixed used developments in order to reduce the distance that people need to travel for goods and services. In this study, respondents residing in Lower Hamilton are more likely than other residents to cycle to work. This area of the city is characterized by many of the built-environment characteristics that have been found to create friendlier cycling environments. This includes grid-like street patterns, smaller blocks and destinations in closer proximity to each other (Dill and Carr 2003, Dill and Voros 2007, Frank and Engelke 2001, Saelens et al. 2003).

Secondly, municipalities and individual workplaces need to collaborate to offer an integrated network of cycling facilities that address the specific needs of employees. Previous studies have been inconclusive with regards to the relationship between a number of individual workplace facilities and one's likelihood of cycling to work. Consistent with these findings, the perceived availability of bicycle lockers, showers and changing facilities were not significantly associated with cycling to work in this study. On the other hand, the presence of no cycling facilities was associated with a decrease in one's likelihood of cycling to work. This study highlights the importance of bicycle-friendly workplaces, however, because the needs of employees differ based on the location of the workplace and the type of work being performed, there is no individual facility that can be implemented at all workplaces to stimulate cycling.

Lastly, efforts should be made to promote commuter cycling amongst self-identified cyclists who cycle only for recreational purposes. This research reveals a high proportion of cyclists who are presently able to cycle and aware of the benefits of cycling, but who have not yet been convinced to commute by bicycle. By promoting commuter cycling amongst this group of

people, municipalities can perhaps increase their commuter cycling rates with more ease than when trying to convince non-cyclists to start cycling. Additionally, previous research has indicated that non-cyclists surrounded by cyclists can be more responsive to policy interventions and more likely to consider cycling themselves (Gatersleben and Appleton 2007).

4.2.2 Motivations for Cycling

In the second paper, cluster analysis is used to create target groups based on respondents' motivations for cycling. This is done to identify segments of the population that will be receptive to promotional strategies advertising the various advantages of cycling. Six motivational clusters have been formed, (1) pleasure and environmental cyclists, (2) health and pleasure cyclists, (3) environmental cyclists, (4) health cyclists, (5) convenience cyclists and (6) pleasure cyclists. The results of this cluster analysis show that different motivational factors are more appealing to certain groups of people and that different motivational factors can encourage different types of cycling behaviour. There are two important policy implications that arise from these results: (1) the Cycling Master Plans and other municipal cycling policy documents produced by cities to govern cycling policy need to outline detailed promotional strategies to help change people's attitudes towards cycling and (2) targeting people with different positive messages about cycling throughout their lives can help to foster lifelong cyclists by minimizing the rate with which people stop cycling as they age.

Currently, municipal Cycling Master Plans contain comprehensive details about proposed cycling facilities and very few specific strategies regarding the promotion of cycling. Those strategies that are aimed at changing people's attitudes towards cycling are directed towards safety concerns. This research highlights the need to devise strategies for promoting cycling and changing people's attitudes that extend beyond convincing residents that it can be a safe mode of

transportation. The target groups outlined in this study can be used to more effectively target segments of the population with positive messages about cycling. By promoting different motivational factors to different groups of people the message will be more relevant to its audience.

The second policy recommendation stemming from this research is that people need to be targeted with multiple different motivational factors for cycling at different times in their lives. In North America, cycling rates decrease with age, meaning that people who were once cyclists stop cycling, or decrease the frequency with which they cycle. The promotional messages outlined in this paper can be used to minimize decreases in cycling frequency over time by providing people with compelling reasons to cycle that are relevant to their changing lifestyle. While promoting the environmental benefits of cycling can be effective when the target audience is young, the health benefits of cycling are relevant to an older segment of the population. This research suggests that positive messages about the pleasurable nature, convenience of cycling and the potential financial savings should be used in order to encourage people to cycling during the time period between these two different life stages. Without this decrease in cycling, cycling rates can be increased.

4.3 LIMITATIONS

This study is not based on a random sample of the population. Only self-identified cyclists were asked to participate. As a result, survey responses are from residents who already cycle and are more likely to value and have positive opinions about cycling. This means that the results cannot be generalized to the population as a whole by policy makers and other stakeholders. As mentioned in both papers, the goal of this study is to understand the characteristics and behaviour

of cyclists, therefore it is appropriate that only cyclists were asked to participate. Previous cycling studies have also been based on data derived from cyclist-only surveys (Howard and Burns 2001, Sener et al 2008). As opposed to many previous cycling studies which have looked at cities with higher levels of cycling, this study was undertaken in a city with low levels of cycling. This research is specific to the City of Hamilton, however, the findings of this research can hopefully be applied to other cities with similar characteristics across North America. Although the availability of cycling facilities, support for cycling and motivations for cycling differ from place to place, the general promotional strategies outlined in this research can be applied and explored in other cities looking to increase cycling rates. This includes the importance of focusing on the built environment and workplace specific measures as well as the need to focus on the psychology of mode choice.

While not necessarily a limitation, data about recreational cycling was not collected. The purpose of this study is to examine commuter cycling behaviour, therefore a lack of data about recreational cycling does not limit this research. On the other hand, asking respondents about their recreational cycling habits would have painted a better picture of respondents - especially those who cycle only for recreation. Because these respondents report low commuter cycling rates, their cycling behaviour is not accurately represented if they are avid recreational cyclists. Also, potential respondents who cycle only for recreational purposes may have been discouraged from completing the survey upon seeing that they were only able to report commuter cycling trips.

In addition to the limitations discussed in chapters 2 and 3 and the data collection limitations outlined in Appendix A, this study was only administered in English. Because surveys were not translated into any other languages, cyclists who do not speak English were unable to participate.

This effect is minimized by the fact that English is the mother-tongue for more than 75% of Hamilton residents (Statistics Canada 2006).

4.4 RESEARCH CONTRIBUTIONS

The overall goal of this research is to understand how cycling rates can be increased in cities with relatively low levels of commuter cycling. Cycling studies are often focused on the features and policies of regions with moderate or high levels of commuter cycling, however, cycling rates in Canadian cities are low and it is important to understand why. This study looks at some of the strategies and messages that residents in areas with low levels of cycling might respond to.

This study also contributes to the existing body of cycling literature by highlighting the importance of encouraging commuter cycling amongst recreational cyclists. This study also contributes to the existing literature by incorporating theories from transportation psychology in an effort to understand how to effectively change people's attitudes about cycling. It is not enough for people to be warned about the harmful effects of driving motor vehicles. Positive messages about the advantages of cycling and the individual and community benefits that can be derived from it must also be promoted if more people are going to start cycling.

4.5 CONCLUSIONS AND FUTURE RESEARCH

Despite the individual and community benefits that can be derived from commuter cycling, cycling accounts for an average of only 1.45% of all trips to work across Canada. Many municipalities endorse cycling and produce Cycling Master Plans to guide the development and implementation of cycling facilities and policies. As is the case in Hamilton, cycling initiatives are often met with public dissent and cycling rates remain low. To increase cycling rates,

municipalities need to focus on changing people's attitudes towards cycling and encouraging recreational cyclists to start commuting by bicycle. While the current objective of many municipalities is to implement a network of on-route cycling facilities, substantial efforts must be made to promote cycling as an attractive and viable mode of transportation. If more residents support cycling, it will be easier for municipalities to approve and acquire funding for cycling facilities. In turn, people will also have compelling reasons to use those facilities.

Cycling research should continue to be conducted in study areas with varying levels of support for cycling. To better understand associations between on-route cycling facilities and commuter cycling rates, future studies should look at the percentage of time cyclists spend using each facility during their commute. Such studies would be enhanced by including measures that compare the perceived availability of facilities with actual availability. Transportation psychology research should be consulted more often in cycling studies to gain a better understanding of how cycling can effectively be promoted to different people in different contexts. Such research would benefit from including the broader values of respondents as well as the emotions that they ascribe to their mode of transportation.

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APPENDIX A: ABOUT THE SURVEY

Introduction: Why conduct a new cycling survey?

In the summer of 2009, cyclists residing in Hamilton, Ontario were asked to participate in a structure survey. The purpose of the survey was to collect data about the perceived availability of cycling facilities in Hamilton and the reasons why people cycle. The most recent cycling survey conducted in the area prior to 2009 was undertaken by the City of Hamilton in 1997. Both cyclists and non cyclists participated in this survey and the data collected was used to create Hamilton's first Cycling Master Plan, known as "Shifting Gears". Since this last survey was conducted, the City of Hamilton has hired a full time Alternative Transportation Manager to oversee the implementation of the Cycling Master Plan, a number of cycling lanes and routes have been installed across the city and bicycle racks have been installed on all city buses. It is clear that the cycling landscape has changed significantly since residents were last surveyed on the topic.

Previous cycling surveys, such as the one undertaken by the City in 1997, have included both cyclists and non-cyclists and focused on the factors that prevent them from cycling. In addition to obtaining up to date cycling data, this survey was conducted to obtain new data regarding why Hamiltonians cycle. The City of Hamilton has very low commuter cycling rates and this survey seeks to collect data that will help us understand why a select group of people cycle despite the barriers to cycling that exist for the overwhelming majority of residents in the area.

Structure of the Survey

Survey questions were divided into six sections, (1) demographic information, (2) the journey to work, (3) travel for non-work purposes, (4) overall cycling activity, (5) changes in cycling behaviour and (6) use of Hamilton Street Railway (HSR). After conducting a review of the

cycling literature, a number of research objectives were established. These research objectives were used to develop the survey questions. The wording of questions was carefully considered in order to receive the most accurate answers from respondents while minimizing any discomfort that respondents may have while completing the survey.

Section I: Demographic Information

In the first section, respondents were asked to provide demographic and residential information. Many of the questions asked in this section were asked to obtain information that has been found to be important in previous cycling studies. Respondents were asked to provide information such as their age, gender, student status, the length of their residency in Hamilton and how many vehicles and bicycles are owned by members of their household. Because vehicle ownership was reported at the household level in this survey, respondents were also asked whether or not they had a valid driver's license. This was done to determine whether or not they actually have access to any motor vehicles that may be owned by members of their household. This may have been a sensitive topic for respondents whose license has been revoked, or for those unable to acquire a driver's license, however, respondents were able to skip any questions that felt uncomfortable answering.

To determine the geographic location of respondents, respondents were asked to provide the first three characters of their postal code, also known as their forward sortation area (FSA). Because of the potentially small sample size for this survey, respondents were not asked to provide their full postal code. Since respondents may have felt hesitant to provide their full postal code, only their FSA was required in order to collect geographic information from as many respondents as possible.

Section II: The Journey to Work

The first question in this section asked respondents whether or not they "work outside of their home". In order to obtain data about the journey to work, it was necessary to ascertain whether or not respondents work outside of their home. The question is worded so that a response of "No" does not insinuate being unemployed, as it also includes those who telecommute or have home offices. Participants who do not work outside of the home were directed to the next set of questions.

In this section, respondents were also asked to indicate the percentage of work trips for which they have access to a motor vehicle. Ownership and access are different and, while many respondents may live in households that own or lease a motor vehicle, we wanted to be able to distinguish between those respondents who are able to drive that vehicle to work, and those for whom the vehicle is not available for their journey to work. In this question, respondents have access to a motor vehicle for (1) 0% of their journeys to work/school, (2) up to 25% of their journeys to work/school, (3) 26-50% of their journeys to work/school, (4) 51-75% of their journeys to work/school or (5) 76-100% of their journeys to work/school. Because respondents' vehicle access can be irregular, increments of 25% were used to denote vehicle access.

Respondents were also asked how often they cycle to work. Since the typical work week consists of 5 days on which respondents travel to and from work, respondents were asked to indicate the number of days per week, or month, that they cycle to work. Additional questions in this section were about the flexibility of respondents' work hours, their most frequent mode of transportation to work and the cycling facilities available to them on-route and at their workplace.

Section III: Travel for Non-Work Purposes

The questions in Section III were very similar to those in Section II, except that they dealt with travel for non-work purposes. Travel for non-work purposes, or "social trips", include trips to run errands, go shopping, visit friends or commute to social activities. It was made clear to respondents that recreational cycling trips were not to be included in this section. As in Section II, respondents were asked about their access to a motor vehicle for social trips and how often they cycle for social trips. In this section, both questions were answered in terms of percentages because it is difficult to determine how often people run errands, an activity that is not as regulated as commuting to work 5 days a week. Asking respondents to identify the number of times that they cycle for social trips would not have been appropriate and would have provided us with data that is difficult to interpret and compare. Lastly, respondents were asked to indicate the cycling facilities that they perceive to be in close proximity to their home. Unlike work trips, where the respondent generally travels to and from the same location, social trips can be to a variety of different locations. Social trips often begin at home, therefore this seemed like the most appropriate way to ascertain data about the availability of cycling facilities for social trips.

Section IV: Overall Cycling Activity

In this section, respondents were asked questions about their overall cycling habits. This includes both work and social trips. Because surveys are distributed through bicycling groups, networks and stores, it was important to determine whether or not a response bias existed towards people who are members of cycling clubs and groups. Theoretically, these people may be more "serious" about cycling. Respondents were asked whether they are members of a cycling club or group in a "yes" or "no" question. They were not asked to report what type of club or the name of the club in order to maintain the anonymity of respondents.

This research seeks to understand the factors that motivate respondents' to cycle, therefore, respondents were asked to rank a number of motivational factors that were provided on the survey. This list includes, (1) health and fitness, (2) environmental sustainability, (3) convenience of cycling, (4) avoiding congestion and traffic conditions, (5) financial savings, (6) pleasure/enjoyment derived from cycling, (7) being outside, (8) limited parking facilities at destination and (9) other – please specify. The motivational factors included on the list have been discussed in previous cycling studies. The wording for the "financial savings" option was chosen so that choosing it does not insinuate a lack of funds. Financial savings is also relevant to participants who cycle to save money on gas, bus passes and car payments, regardless of their actual income.

Section V: Changes in Cycling Behaviour

Another research objective for this study was to understand why respondent's who had decreased their cycling frequency had done so. Respondents who indicated that their cycling frequency had decreased were asked to indicate how often they cycled to work and for social trips prior to the decrease. They were also asked to select a number of response alternatives about why they had decreased their cycling frequency. These alternatives included changing jobs or place of residence, the need to transport children, injury or illness, gaining access to a motor vehicle, etc. Respondents who indicated that their cycling frequency had remained about the same or increased were asked to proceed to the next set of questions.

Section VI: Use of the Hamilton Street Railway (HSR)

In the last section, respondents were asked questions about their use of the bicycle racks provided on every HSR bus in Hamilton. Respondents were asked whether or not they had ever used the racks, how often they used the racks as well as the reasons why they used the racks, if

they did. Response options for why respondents used the racks included inclement weather, being too tired to bike, illness or injury, mechanical problems with the bike, the presence of steep hills, etc. Respondents were encouraged to select any and all of the options that pertained to them.

Survey Distribution

The survey was distributed online as well as in print from May to August 2009. Paper surveys were made available to prospective participants at a number of locations across the study area, (1) bicycle shops and sports stores, (2) libraries, (3) gyms and community centers and (4) grocery stores and other local businesses. Posters advertising the online survey were also available at these locations. Consent was received from each location before surveys were made available. Surveys were also distributed by the researcher at a number of community events. These events included the McMaster Commuter Challenge Event, the City of Hamilton Transportation Fair, weekly farmer's markets and neighbourhood association meetings. Near the end of the summer, surveys were placed on the handle bars of bicycles parked in public places around the city.

In addition to the survey itself, all paper copies of the survey included a poster with the researcher's contact information and the address of the online survey, a letter of consent outlining the goals of the research and a self-addressed stamped envelope. The online survey was hosted by McMaster University (cyclingsurvey.mcmaster.ca) and was available to participants from the beginning of May to the end of August. All data received through the online survey was stored by FHS Surveys 1.86+. The online survey and the paper survey contained the same questions and the same information was collected from all respondents.

Each paper survey was numbered in order to determine the distribution method of returned

surveys while maintaining the anonymity of respondents. The majority of surveys (62.62%) were completed online (see Table 1). Online respondents were not asked to identify how they came across the survey. As a result, we were unable to determine how many respondents were given paper surveys and then chose to complete the survey online. Of the paper surveys, those distributed at community events had the highest response rate (45%). This was likely the result of the personal interaction that was possible at community events. Speaking with prospective participants about the survey and about the research may have increased the likelihood that they completed the survey. Participants were also able to complete surveys immediately at community events. This eliminated the possibility of them losing the survey, forgetting about it or completing it online and being registered as an online participant.

Response rates were also high amongst surveys distributed at community centers and through "individual distribution". Surveys that were included in "individual distribution" are those that were distributed to individuals and groups whose names were known to the researchers. The response rate from surveys placed on the handlebars of bikes (18%), was not as high as originally expected, however, recipients may have completed the survey online. This method was also employed at the end of the summer when cyclists may have already completed the survey after receiving it through other means. The lowest response rate came from surveys distributed at "other businesses". These businesses were not directly related to cycling, and therefore may not have attracted as many cyclists interested in participating in a cycling survey.

Table 1. Responses by Distribution Method

Distribution Method	*Number of Surveys Distributed*	*Number of Surveys Received*	*Response Rate (%)*	*Percentage of Total Surveys (%)*
Individual Distribution*	63	20	32	4.85
Surveys placed on handlebars of bicycles parked in public areas	106	19	18	4.61
Bicycle Shops	128	28	22	6.80
Community Centres	104	32	31	7.77
Libraries	46	7	15	1.70
Other Businesses	65	2	3	0.49
Community Events	102	46	45	11.17
Online Survey		258	Unknown	62.62
Total		**412**		

Description of Sample Population

The survey was completed by 412 respondents. Nine respondents identified themselves as residing outside of the study area and were not included, leaving 403 respondents. Of these respondents, 140 were female (36%) and 254 male (64%). The large majority of respondents have been cyclists for 10 years or more (71.5%) and have lived in Hamilton for 6 or more years (75%). As expected, a very small percentage of respondents (5%) identified themselves as being 65 years of age or older. Efforts were made by the researcher to include residents in this age group by distributing surveys at senior's activity centers and by participating in a seniors cycling group. Most respondents were middle aged, with 23% of respondents between the ages of 25-44 years, 20% of respondents between the ages of 45-54 years and 14% of respondents between the ages of 55-64 years. The two youngest age groups, 18-24 and 25-34, contained 15% and 23% of respondents, respectively.

A small proportion of respondents (5%) work in a job that is related to cycling and 19% of respondents are members of a cycling club or group. On the other hand, the majority of

respondents (81%) participate in sports other than cycling. More than half (55%) of respondents indicated that, over the last 10 years, their cycling frequency had increased. With regards to their most frequent mode of transportation to work, the highest percentage of respondents indicated that they bicycled to work most often (40%). Next were drivers of motor vehicles, with 34% of respondents. Walkers and public transit users both accounted for 10% of survey respondents, while motor vehicle passengers and "other" accounted for 2% of respondents.

Respondents were also asked to provide their FSA data in order to assign each respondent to a geographic region within the study area. The study area was divided into seven regions, (1) Dundas, (2) Ancaster, (3) Stoney Creek, (4) the Mountain, (5) West Hamilton, (6) East Hamilton and (7) Rural. Most participants reside in either West or East Hamilton, with 35% and 26% of respondents residing in each region, respectively. Sixteen percent of respondents reside on the Mountain and 11% reside in Dundas. Ancaster, Stoney Creek and the Rural region account for the smallest percentage of respondents, with 6%, 2% and 4% residing in each region, respectively. Prior to the amalgamation that occurred in 2001, Hamilton was comprised of the Mountain, West Hamilton and East Hamilton. Together, these three regions are home to 77% of survey respondents. Although this is high, it is representative of the general population. According to Statistics Canada, the former City of Hamilton region is home to about 68% of the population of the study area. Ancaster, which is home to 6% of respondents, is home to 6% of the population of the study area. While 2% of respondents reside in Stoney Creek, that region is home to 11.7% of the general population. Representation is also low amongst Rural residents, who account for 4% of respondents, but 10% of the general population. On the other hand, 11% of respondents reside in Dundas, but the region is home to 5% of the general population. Due to the urban nature of cycling, these results are to be expected.

Limitations

Survey Structure and Distribution

The distribution methods and structure of the survey resulted in limitations to this study. Two of these limitations are (1) the calculation of response rates and (2) analyzing categorical data. As previously mentioned, it is difficult to calculate response rates for each of the distribution methods because online respondents were not asked to indicate where they first came across the study. A respondent could have collected a survey at a community centre and then completed the survey online. This information would be useful when evaluating the success of each of the different distribution methods, however, it does not impact the results of the study. We are also unable to calculate precise response rates because we are unable to know whether all of the surveys delivered to distribution locations were actually displayed. For example, all materials displayed at public libraries are subject to the approval of management. There were many surveys delivered to libraries and, although some branches approved the surveys for display, others may not have. The researcher followed up with each of the locations where surveys had been delivered, however, could not confirm the status of all of the surveys.

The second limitation of this survey is that all of the data collected is categorical. Although we were able to analyze the data, non-categorical responses would have resulted in more accurate data in some instances. This is especially true for the questions related to respondents' motivations for cycling (questions 15 and 16). Instead of asking respondents to rank motivational factors in the order in which they are important to them, it would have been effective to ask a series of likert scale questions about respondents' values. Previous studies in the transportation psychology field have employed the likert scale in similar situations.

Survey Response

Due to a lack of response data, we were unable to analyze two particular questions of interest, (1) why respondents have decreased their cycling frequency and (2) why respondents are using the bicycle racks provided on public buses. Eighty-three respondents (21%) indicated that their cycling frequency had decreased. This was lower than originally expected. Respondents who indicated that their cycling frequency had decreased were asked to respond to additional questions that asked why their cycling frequency had decreased. Respondents were given 11 options to choose from. Since the 83 respondents were then spread out over 11 different response options, there was not enough data on which to perform statistical analysis tests such as chi-square significance tests or logistic regression analysis.

The last section of the survey asked respondent questions about their use of public transit (HSR) and how often and why they used the bicycle racks provided on the front of every bus. Two hundred and ninety-four respondents (74%) indicated that they had never used the bicycle racks on the front of buses in Hamilton. Because so few respondents had actually used the bicycle racks, limited data was provided in subsequent questions that asked respondents why they use the racks. As a result, this data could not be used in statistical analysis tests.

APPENDIX B: THE SURVEY

Section I. First, I would like to ask you some questions to obtain some residential and demographic information.

Age 18-24 25-34 35-44 45-54 55-64 65 and over

Gender: Female Male

Are you a full time student? Yes No

Do you possess a valid driver's license? Yes No

How many people live in your household (including yourself)? 1 2 3 4 5 6 or more

How many members of your household are under 18 years of age?
0 1 2 3 4 5 6 or more

How many motorized vehicles does your household own/lease? 0 1 2 3 4 or more

How many bicycles does your household own? 0 1 2 3 4 or more

How long have you lived in the Hamilton region?
(a) less than 6 months
(b) 6 months – 1 year
(c) 2 – 3 years
(d) 4 – 5 years
(e) 6 or more years

Please provide the first 3 characters of your postal code (e.g. **L8P** 5T2): [ ] [ ] [ ]

Have you ridden a bicycle 1 or more times in the last 12 months? Yes No

Do you participate in any sports or fitness activities other than cycling? Yes No

Section II. Now, I would like to ask you some questions about your journey to and from work or school.

1. Do you work and or attend school **outside** of your home? Yes No
   (if your response to this question is no, please proceed to Section III)
2. Approximately how far do you travel to get to work or school from your place of residence?
   (a) Less than 1 km
   (b) 1-5 km
   (c) 6-10 km
   (d) 11-15 km
   (e) 16-20 km
   (f) More than 20 km
3. Does your work/school allow you to have flexible work hours (outside of 9am-5pm)?
   Yes No
4. During an average week, what is your most frequent mode of transportation for your journey to work or school?
   (a) Motor vehicle – driver
   (b) Motor vehicle – passenger
   (c) Bicycle
   (d) Walk
   (e) Public transportation
   (f) Other (please specify)

5. During an average week, how often do you have access to a motorized vehicle for the journey to work or school?
    (a) 0% of my journeys to work/school
    (b) up to 25% of my journeys to work/school
    (c) 26-50% of my journeys to work/school
    (d) 51-75% of my journeys to work/school
    (e) 76-100% of my journeys to work/school
6. On average, how often do you cycle to work or school (**weather permitting**)?
    (a) I never cycle to work and or school
    (b) Less than once a month
    (c) 1-5 days a month
    (d) 1-2 days a week
    (e) 3-4 days a week
    (f) I cycle to school/work every day
7. What facilities are available to you at your work or school (select all that apply)?
    (a) Bicycle racks
    (b) Bicycle lockers
    (c) Showers
    (d) Changing facilities
    (e) Other (please specify)
    (f) There are no bicycle facilities at my work/school
    (g) I don't know
8. What cycling facilities are available along your route to work or school (select all that apply)?
    (a) Bicycle lanes separated from traffic with a physical barrier (ex. Cement or pylon)
    (b) Bicycle lanes separated from traffic with pavement markings
    (c) Bicycle route signage
    (d) Wide shoulder
    (e) Off-road bike trails
    (f) There are no cycling facilities along my route to work/school
    (g) I don't know

Section III. Now I will present you with some questions regarding your travel to destinations in Hamilton-Wentworth **other** than work or school.

9. During an average week, how often do you have access to a motorized vehicle to run errands, go shopping, visit friends, commute to social activities, etc?
    (a) 0% of these journeys
    (b) Up to 25% of these journeys
    (c) 26-50% of these journeys
    (d) 51-75% of these journeys
    (e) 76-100% of these journeys

10. During an average week, how often do you cycle for errands, shopping trips, social visits and activities, etc (**weather permitting**)?
    (a) 0% of these journeys
    (b) Up to 25% of these journeys
    (c) 26-50% of these journeys
    (d) 51-75% of these journeys
    (e) 76-100% of these journeys
11. What cycling facilities are available in close proximity to your place of residence (select all that apply)?
    (a) Bicycle lanes separated from traffic with a physical barrier (ex. Cement or pylon)
    (b) Bicycle lanes separated from traffic with pavement markings
    (c) Bicycle route signage
    (d) Wide shoulder
    (e) Off-road bike trails
    (f) There are no cycling facilities in close proximity to my house
    (g) I don't know

Section IV. Now I will present you with some questions about your cycling activity in general.

12. Are you a member of a cycling group or club? Yes No
13. Do you work in a job that is related to cycling? Yes No
14. For how long have you been a cyclist?
    (a) Less than 1 year
    (b) 1-2 years
    (c) 3-5 years
    (d) 5-10 years
    (e) More than 10 years
15. What factors **motivate** you to cycle (select all that apply)?
    (a) Health and fitness
    (b) Environmental sustainability
    (c) Convenience of cycling
    (d) Avoiding congestion and traffic conditions
    (e) Financial savings
    (f) Pleasure/enjoyment derived from cycling
    (g) Being outside
    (h) Limited parking facilities at destination
    (i) Other (please specify)

16. Please numerically rank the following factors in order of importance to you when making the decision to cycle:
    ( ) Health and fitness
    ( ) Environmental sustainability
    ( ) Convenience of cycling
    ( ) Avoiding congestion and traffic conditions
    ( ) Financial savings
    ( ) Pleasure/enjoyment derived from cycling
    ( ) Being outside
    ( ) Limited parking facilities at destination
    ( ) Other (please specify)
17. Do you cycle during the winter months (December through February)?
    (a) Often – once a week, or more
    (b) Sometimes – less than once a week
    (c) Never

Section V. Now I will ask you some questions about any changes in your cycling activity.

18. Over the last 10 years, your cycling frequency has;
    (a) remained about the same
    (b) decreased
    (c) increased
    (If you answered **remained about the same** or **increased** please proceed to Section VI.. If you answered **decreased**, please answer the following questions)
19. Prior to any decrease in your cycling frequency, how often did you cycle to work or school (**weather permitting**)?
    (a) I never cycled to work or school
    (b) Less than once a month
    (c) 1-5 days a month
    (d) 1-2 days a week
    (e) 3-4 days a week
    (f) I cycled to school/work every day
20. During an average week, how often did you cycle for errands, shopping trips, social visits and activities, etc prior to any decreases in your cycling frequency (**weather permitting**)?
    (a) 0% of these journeys
    (b) Up to 25% of my these journeys
    (c) 26-50% of these journeys
    (d) 51-75% of these journeys
    (e) 76-100% of my these journeys

21. Please indicate which of the following factors have influenced any decreases in your cycling frequency (select all that apply):
    (a) Changed jobs or changed place of residence
    (b) Transportation of children
    (c) Injury/illness
    (d) Stopped cycling upon moving to Hamilton-Wentworth
    (e) Time of journey
    (f) Complex trip patterns (ex. going to the grocery store, running errands)
    (g) Gained access to a motor vehicle
    (h) Switch to public transportation
    (i) Graduation from university
    (j) Involvement in another physical activity
    (k) Other (please specify)
22. If your cycling frequency decreased because of changing jobs or changing your place of residence, which of the following may have explained this decrease (select all that apply);
    (a) Change in work hours
    (b) Greater distance to work
    (c) No cycling facilities on new route to work (ex. bicycle lane, bicycle route)
    (d) Inadequate facilities at workplace (ex. shower, bike storage)
    (e) Strict dress code or social climate towards cycling
    (f) None of the above

<u>Section VI. Lastly, I will ask you a few questions about your use of the Hamilton Street Railway (HSR) bus system. These questions should be answered with regards to ALL cycling trips, regardless of the destination.</u>

1. Is your work or school accessible by public transportation? Yes No N/A
2. Do you currently have an HSR bus pass? Yes No
3. Have you used the Hamilton Street Railway (HSR) in the past month? Yes No
4. Have you ever used the bicycle racks provided on the front of every HSR bus? Yes No
5. Where you aware that all HSR buses were equipped with bike racks? Yes No
6. How would you characterize your use of the HSR bike racks?
    (a) I have not previously used the HSR bike racks
    (b) I use the HSR bike racks 1-5 times a year
    (c) I use the HSR bike racks 6-10 times a year
    (d) I use the HSR bike racks 1-3 times each month
    (e) I use the HSR bike racks at least once each week
    (f) I use the HSR bike racks 5 or more days a week

7. Which of the following factors have led you to use the HSR bike racks (select all that apply):
   (a) Distance
   (b) Inclement weather
   (c) Too tired to bike
   (d) Illness/injury
   (e) Mechanical problems with the bike
   (f) Landscape features (ex. steep hill)
   (g) Traffic/congestion
   (h) Ease and convenience
   (i) Other (please specify)
   (j) Not applicable

Thank-you for taking the time to complete this cycling survey. If you know other Hamilton-Wentworth cyclists, or residents who used to cycle, please direct them to our online survey at cyclingsurvey.mcmaster.ca. Your assistance is greatly appreciated!