AN EXPLORATION OF TRAVEL BEHAVIOUR CHANGE AFTER THE IMPLEMENTATION OF CYCLE TRACKS: A CASE STUDY OF SHERBOURNE STREET IN TORONTO

by

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ABSTRACT

With the growing environmental, health and economic concerns associated with automobiles, municipalities are investing in cycling infrastructure. These new infrastructures are often assumed to facilitate a mode substitution effect, encouraging users to switch to active transportation. This study explores the impact of cycle tracks on travel behavior. A case study was conducted on Sherbourne Street, in the city of Toronto, that was redeveloped in 2012 to include cycle tracks, i.e., separated bicycle lanes. The study used a street intercept survey method to record quantitative data on retrospective cycling travel behavior. A mode substitution was observed, with 37.85% of the sample being new riders. However, this number was possibly influenced by self-selection, or a change in residency or destinations. The main reasons for switching to cycling along Sherbourne Street were listed as improved safety and efficiency. The case study provides a measure of the impact of cycle tracks, providing a justification for this infrastructure design.

Key Words: Cycling; cycle tracks; mode substitution

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Chapter 1 Introduction

Cycling is becoming more common as a mode of transportation in the city of Toronto. When I worked in a small office near City Hall for a year, I was among the few people who did not cycle, instead favoring public transit. This reflects a growing pattern of increased ridership within the city, something that municipalities have encouraged for a healthier population, particularly in response to sedimentary lifestyles. Sedimentary lifestyles may lead to a variety of health concerns, including diabetes, cardiovascular disease and most prominently obesity (Blair & Brodney, 1999). These health concerns related to sedimentary lifestyles are associated with increasing health care expenses, which can have a negative impact on the economy. For example, the overall medical care support costs of obesity within the province of Ontario have been estimated at 2.2-2.5 billion dollars annually (Ontario Medical Association, 2012; Pucher et al., 2010). Cycling is often correlated to individuals leading healthier lifestyles that meet recommended fitness levels, reducing health complications (Dill, 2009). Numerous cross sectional studies have illustrated a significant association between cycling and improved health outcomes (Larsen & El-Geneidy, 2011). Previous studies have also verified that those cycling on a daily basis are more likely to meet their daily-recommended physical activity levels (Dill, 2009; Hartog, 2010).

Multi-modal transportation networks are becoming more prominent in city planning as a means for addressing the rising health concerns related to sedimentary lifestyles. With this type of infrastructure there is growing emphasis on accommodating and encouraging sustainable modes of transportation. Major cities in North America have implemented policies and programs to encourage active transportation, and bicycle lanes remain one of the most common interventions. This is illustrated in the Portland Bicycle Plan, with a goal of making cycling more attractive than the automobile for trips 3 miles or less by 2030 (Geller & Borkowitz, 2011). The city aims to achieve this goal through, offering supporting programs to encouraging cycling and expanding the existing bicycle lane network (Geller & Borkowitz, 2011). Bicycle lanes that are commonly found within municipalities range from white bicycle lanes to shared lane pavement markings known as Sharrows (City of Toronto, 2015). White bicycle lanes are lanes along streets that are marked for cyclists by a solid painted white line, as well a bicycle and diamond symbol (City of Toronto, 2015). Sharrows are shared traffic lanes, with a suggested cycling position noted by a two white chevrons and a bicycle symbol painted in white (City of Toronto, 2015).

To encourage cycling as a primary mode of transportation, municipalities in Ontario have incorporated bicycle lanes networks (TCAT, Mitra, & Hess, 2014). To evaluate the impact of a bicycle lane in the network, many municipalities utilize bike counts. Bike counts are able to measure the increase in bicycle lane usage, but these counts can be limiting, as they do not differentiate between new riders and cyclists who changed their route.

The rationale for exploring a cycle track's ability in attracting new ridership is to provide sound evidence of their impact on travel behavior change. This would allow for a quantitative evaluation of the cycling facilities, and confirm the potential benefits that are typically assumed. The research questions for this study were as follows:

1. Who are using the recently constructed cycle tracks (separated bicycle lanes)?
2. Are cycle tracks attracting new ridership and resulting in fewer automobile trips?
3. What are the motivators for switching modes of transportation?

It was hypothesized that the cycle tracks would create a mode substitution effect, through attracting new ridership from other modes.

The above hypothesis and research questions are addressed in the context of the city of Toronto utilizing Sherbourne Street that was redeveloped in 2012 to include cycle tracks. The results from this study will provide an in-depth understanding of the mode substitution effect and the influence of cycle tracks within the city of Toronto.

Chapter 2 Literature Review

North American cities have recently witnessed the growing popularity of cycling as a mode of transportation (Bassett et al., 2008; Pucher et al., 1999); and cycling is now widely accepted as an alternative and healthier choice when compared to the automobile. Numerous Ontario provincial policies encourage and direct municipalities in creating active transportation policies, including the Growth Plan, and the Provincial Policy Statement (TCAT, Mitra, & Hess). With the increase in popularity and provincial policies, municipalities are investing in infrastructure that supports and engages users while improving cycle opportunities.

The introduction of cycling facilities has many potential benefits for an individual and society, including a safe cycling environment, reduction in travel times, improved health outcomes for users, and positive economic impacts (Clifton et al., 2013;Sztabinski, 2009). Bicycle infrastructure refers to a variety of facilities, which may include painted cycle lanes, separated bicycle lanes widely referred to as cycle tracks, their accompanying signage, and more. These types of facilities have been found to influence cycling rates and are intended to improve the safety of all road users (Dill, 2009; Dill & Carr, 2003). Choosing to cycle often correlates with increased physical activity among users, which may consequently improve an individual's health outcomes (Dill, 2009). Moreover, individuals choosing to make trips by bicycles over cars, assist in decreasing in the number of automobiles in use, which may lead to a decline in the amount of harmful emissions released (Burwell & Litman, 2011; Hartog, 2010). In addition, as a mode of transportation, cycling allows for more efficient travelling in urban contexts (Dill, 2009; Krizek, Barnes, & Thompson, 2009).

2.1 "Hard" and "Soft" Interventions to Improve Cycling

The post World War II neighbourhoods in North America are largely designed considering the needs of automobile users, making it unsafe and inconvenient for other transportation of travel such as cycling. As a result, the automobile is often viewed as being more efficient and safer in comparison to cycling (Steg, 2005). Automobiles are also perceived as a symbol of freedom and higher economic status among users (Steg, 2005). To shift from an automobile dominated environment to a bicycle friendly urban design, and change attitudes towards cycling, municipalities can implement both hard and soft interventions (Clarke, 2012). A combination of both infrastructure and programs are perhaps necessary to successfully support cycling (Clarke, 2012; Garling & Axhausen, 2003; Pucher, et al., 2010; Wright & Egan, 2000).

Soft measures are aimed at encouraging cycling through education, promotional activities, and media campaigns (Krizek, Handy, & Forsyth, 2009; Pucher et al., 2010). An example of a soft measure initiative is demonstrated in the City of Ottawa's cycling education programs, that teach cyclists of all ages how to ride safely in the city, analyze traffic situations, route planning and more (City of Ottawa, 2015). Research in this area does show a positive impact on cycling rates; for example, following the Bike-to-Work program in San Francisco, cycling counts increased by 25.4% in one month (Pucher et al., 2010). Similarly, five months after the Bike-to-Work program was introduced in Victoria, Australia, over 25% of the new cyclists continued to cycle (Rose & Marfurt, 2007). The ability of these programs to influence behaviour and perceptions is difficult to quantify, as they are often introduced alongside hard measures (Pucher et al., 2010). Nonetheless, soft measures have been reported to have a positive influence on cycling rates.

Hard measures focus on infrastructure changes that provide improved access, safety, comfort, security, and increase the attractiveness of the cycling infrastructure (Clarke, 2012;

Krizek et al., 2009). This includes, but is not limited to: painted bicycle lanes, separated paths, bicycle parking, car-free zones, et cetera. Similar interventions can be seen in the city of Toronto, with the introduction of cycle tracks along Sherbourne Street in 2012, connecting to multiple bicycle lanes in the city. The implementation of hard measure interventions can also influence individual perceptions, as road users become more aware of cyclists, increasing the safety of the road. Interventions within the built environment are intended to make cycling more appealing among users to substitute trips made by automobiles. However, this approach is associated with higher costs. Among the many benefits of healthy daily travel choices, the goal for both soft and hard measures is to change travel habits.

2.2 Evidence of Hard Measures Impacts

Increasingly, research presents a statically significant associations between higher cycling rates and the addition of cycling infrastructure such as bicycle lanes, however, knowledge on the extent of this association and its impact remain inconclusive (Buehler & Pucher, 2012; Dill & Carr, 2003; Duthie, Brady, Mills, & Machemehl, 2010; Larsen & El-Geneidy, 2011). The following subsections will discuss existing research that has examined the effects of these types of changes to the built environment on bike counts, safety, perceptions, access to cycling infrastructure and route substitution.

2.2.1 Bike Counts

Studies have illustrated that an increased supply of bicycle lanes is positively correlated with higher cycling rates (Dill & Carr, 2003; Parker, Gustat, & Rice, 2011). For example, in Minneapolis and St Paul, Minnesota Krizek et al. (2009) found that over a ten-year period, there were significant increases in cycling levels following the expansion of the cycling network. Another cross sectional study conducted on 90 major US cities established that the addition of one linear mile of a bike lane (1.6 kilometers) per square mile of city area resulted in an increase of approximately one percent in ridership (Buehler & Pucher, 2012). The addition of 3.1 miles of a bicycle lane (approximately 5 kilometers) in the downtown core of New Orleans, Louisiana, resulted in a 56.8% increase in ridership on that street (Parker et al., 2011).

The observed volume of cyclists on a street can be influenced by various factors. Research has demonstrated that the influence of bicycle infrastructure remains an important factor even when other confounding factors are taken into account. A longitudinal bicycle count study in Washington, DC, during different seasons, found weather plays a major role, with an approximate reduction of 15-25% in the number of cyclists when experiencing precipitation or temperatures below 55 degree Fahrenheit (12 degrees Celsius) (Neimeier, 1996). Infrequent and recreational users will likely cycle in more favorable conditions, and both precipitation and lower average daily temperatures result in a decreased total number of riders (Neimeier, 1996). The same study found that bicycle lanes were among the strongest predicator influencing cycle counts (Neimeier, 1996).

2.2.2 Safety

Street designs that include separated bicycle lanes, signage and painted lines, are widely considered to improve safety for cyclists and result in less injuries and fatalities (Laplante & McCann, 2008; Lynott et al., 2009). For example, between the years 1988 to 2006, there was a 45% decrease in cycling fatalities in Canada, which was found to be associated with the introduction of both cycling infrastructure and educational programs (Pucher & Buehler, 2010). These programs and supporting infrastructures are necessary to continue to improve cycling safety, and specifically, at intersections where bicycle and automobile accidents account for approximately 50-70% of all collisions (Hunter, Harkey, Stewart, & Birk, 2000). Raised medians or curbs separating bicycle lanes from automobile traffic may improve safety by reducing automobile speeds and allowing for greater distances between users. Hunter et al., (2000) reported that in Gothenburg, Sweden, a raised bicycle lane reduced automobile speeds by 35-40% turning right at intersections. The study also found this to increase bicycle speeds by 10-15%. Similarly, a study in Denmark found the addition of marked cycling paths at signalized junctions, resulted in 36% fewer cyclist-motor vehicle collisions and 57% fewer cyclist fatalities and severe injuries (Jensen, 1997).

The addition of bicycle lanes have been shown to reduce the opportunity for automobiles to encroach on cyclist's space, as it provides a greater buffer zone with the painted lines (Duthie et al., 2010). The development of painted bicycle lanes in the city of Montreal resulted in cyclists abiding by traffic signs more frequently, and resulted in a reduction of collisions (Hunter et al., 2000). In Portland, Oregon, 76% of cyclists reported feeling safer with the addition of a painted bicycle lane on a roadway (Hunter et al., 2000). However, the same study discovered that cyclists were less likely to check for nearby automobiles while using the bicycle lane. The result of the improved perceived safety, created a "false sense of security", causing cyclists to make unsafe "vehicle movements" (Hunter et al., 2000; Larsen, Patterson, & El-Geneidy, 2013, p. 302).

2.2.3 Perceptions

Separated bicycle lanes are perceived as higher risks for cyclists when compared to multi-use paths that are intended for pedestrians and cyclists only (Capital Area Metropolitan Planning Organization, 2014; Harris et al, 2013). Literature suggests that the perceived higher risk is a result of sharing the road with automobiles, which could lead to a collision. The perceived risk and dangers associated with cycling can act as a strong deterrent for attracting new users (Larsen, Patterson, & El-Geneidy, 2013).

Studies have suggested bicycle lanes over come these perceived risks and attract new inexperienced riders who have greater concerns regarding their safety (Larsen & El-Geneidy, 2011; Parkin, Wardman, & Page 2006). A study in the city of San Francisco, following cyclist's behavior using Global Positioning Systems (GPS), found that infrequent and less experienced cyclists preferred using bicycle lanes (Hood, Sall, & Charlton, 2011). Similarly an analysis of cyclists' perceptions in Dublin, Ireland noted that segregated bicycle facilities were favoured more by beginner cyclists than those more experienced (Lawson, Pakrashi, Ghosh, & Szeto, 2013), demonstrating that bicycle lanes may attract new ridership (Pucher, Komonoff, & Schimke, 1999).

Perceptions further vary by gender; women are reported as being more concerned for their safety when cycling on high traffic streets, whereas men tend to less concerned in comparison (Dill, 2009). Cycling infrastructure has been recognized as having a statistically significant association with increased female ridership. For example, in New Orleans, the addition of separated bicycle lanes found a 133% increase in average daily numbers of female riders (Parker et al., 2011). Through creating space and the supporting infrastructure: roadways, lanes and signage, municipalities are changing the perceptions of users by demonstrating that cyclists have an equal right to use streets (Lawson et al., 2013).

2.2.4 Access to Cycling Infrastructure

The distance to a bicycle lane from one's origins and the length of the lane also influence travel behaviour (Goodman, Sahlqvist, & Ogilvie, 2013). Those living near or in close proximity to cycling infrastructure report higher levels of usage, perhaps due to increased awareness (Goodman et al, 2013). A Montreal based study revealed that having a bicycle infrastructure within 400 meters of a residence or place of work increased the likelihood of using that infrastructure by 129% (Larsen, & El-Geneidy, 2011). Similarly, in the United Kingdom, living within one kilometer of the new bicycle infrastructure such as a separated or painted lanes resulted in a rise of cycling by 45 minutes weekly (Goodman et al., 2013). However, the impact is likely less for those who currently own a private automobile (Goodman et al., 2013).

A limited bicycle network may decrease the access to bicycle lanes, adding to the total travel distance and time, and would act as a barrier for users (Dill, 2009; Dill & Voros, 2007). A study conducted in Portland, Oregon, discovered that residents living near or in the downtown core who had greater access to cycle lanes and a supporting cycling network, were more likely to cycle than those outside of the downtown core (Dill & Voros, 2007). Findings such as this highlight the need to develop extensive cycling networks that allow for neighborhoods to be interconnected and improve cycling rates.

2.2.5 Route Substitution

Typically, it is assumed that cyclists are only willing to accept minor detours from the most direct path of their travel (Howard & Burns, 2001). Conversely, Howard, and Burns (2001) found that cyclists were willing to travel greater distances to use routes that offered improved safety and efficiency. Furthermore, Sener, Eluru, and Bhat (2009) established that lower travel times were considered the most important factor in route choice. This suggests that cyclists may travel greater distances to use bicycle lanes if the lanes are perceived to be safer and improve efficiency. Larsen, and El-Geneidy (2011) reported that cyclists in Montreal on average were willing to travel an additional 2.2 km to use bicycle lanes. A GPS based study conducted by Broach, Dill, and Gliebe (2012) found cyclists placed a higher value on efficient routes and cycling infrastructure improvements such as: improved neighborhood bikeways with traffic calming and off-street bike paths. For example, the study found that a cyclists commuting 1 mile (1.6km) were willing to travel an additional 9.1% to avoid left turns at un signalized intersections in Portland (Broach, Dill, & Gliebe, 2012). Cyclists were also willing to travel considerable distances to use a bicycle lane rather than a road without one (Broach, Dill, & Gliebe, 2012). Evidence such as this indicates that an observed increase in cyclists along a bicycle lane could be a result of current users altering their route to access the improved infrastructure.

2.2.6 Gaps in Current Literature

With the growing interest in cycling as a means of addressing the rising environmental and health concerns, there is a need for empirical evidence based research focused on the potential influence of bicycle lanes resulting in individuals switching modes to cycling (i.e., mode substitution effect). A common indicator used among municipalities for measuring the impacts of bicycle lanes is calculating traffic volume which is traditionally used for automobiles (TCAT et al., 2015) Traffic volume for automobiles is often calculated using Annual Average Daily Traffic, which counts the total volume of automobiles that pass through an intersection (Lowry, 2014). For pedestrians and cyclists, a similar method is used to measure the volume; however, this method only provides a snap shot of the number of users on the street at that specific time (Lowry, 2014; Nordback, & Janson, 2010). A review of current literature indicates that an observed increase in cyclists along a bicycle lane could be a result of current users altering their route to access the improved infrastructure. Some researchers have also argued that the frequency of use of bicycle lanes is a result of self selection, where individuals will chose an area to live that meets their desires and travel preference (Krizek et al., 2009). This suggests that the varying cycling rates within cities cannot be fully attributed to changes in infrastructure; rather it is partly a result of the self-selection process (Krizek, et al., 2009). In addition, it has been suggested that increased ridership may be attributed to the growing momentum of cycling in North America (Krizek et al., 2009). With the rising popularity of health and fitness, as well social media campaigns, as illustrated with the success of the Bike-to-Work programs, a cycling culture has developed (Bonham & Koth, 2010; Pucher et al., 2010). Moreover, Krizek et al (2009) argued that following Lance Armstrong’s first win of the Tour de France in 1999, cycling rapidly became popular as a mode of transportation (Krizek et al., 2009). Without strong evidence on new ridership, accounting for these factors the true impact of cycling infrastructure in enabling healthy and sustainable travel behavior remains unclear.

Chapter 3 Case Study: The Sherbourne Bike Lane, Toronto

3.1 Context and policy

In the city of Toronto cycling is becoming a popular mode of transportation for both recreational and utilitarian purposes. Cycling is also heavily promoted through governmental policies. According to the 2006 Census, those cycling increased by 30% from 2001 to 2006 in the city of Toronto (Statistics Canada, 2006), and this trend is likely to continue. Cycling has become an essential part of Toronto's transportation system, and there is a growing demand for supporting infrastructure including bicycle lanes, signs, and racks. This change has been reflected in the city of Toronto's policies and plans that have focused on improving cycling conditions in the city, including the city's Official Plan (OP) and Toronto Bike Plan.

In Toronto's OP cycling and the expansion of the network is supported in multiple sections that have specific policies directed towards enhancing the safety and supporting infrastructure. An example is policy 7 in chapter 2.4 Bringing the City Together, which states the City of Toronto will introduce policies and programs aimed to "create a safer comfortable and bicycle friendly environment that engages people of all ages to cycle for everyday transportation and enjoyment" (City of Toronto, 2010, p. 2-27). As well, policy 14 in chapter 3.1.1 Public Realm discusses that new streets will be designed to create adequate space for all modes of transportation including pedestrians, cyclists, transit and vehicles (City of Toronto, 2010).

The above policy recognizes cycling as a legitimate mode of transportation that the city aims to promote and increase the number of users by improving the bicycle network, and by implementing various programs and projects. In 2001, the city adopted the Toronto Bike Plan which sets out specific policies, programs and infrastructure designs that are intended to create a bicycle friendly city, while attracting new ridership (City of Toronto, 2001). The plan focuses on six main components: bicycle parking, bicycle friendly streets, bikeway networks, promotion, cycle and transit, as well as safety and education. The Toronto Bike Plan proposed a 1000-kilometer bicycle network within the city by 2011 as a means to foster cycling as a mode of transportation for residents in Toronto (City of Toronto, 2001).

The city is still working towards the 1000-kilometer bicycle network goal and has completed a total of 558.4 kilometers of on street bikeways, and 298.5 kilometers of multi-use trails. Of the 558.4 kilometers on street, however, 302 kilometers are signed routes that do not have bicycle lanes present or street markings other than a road sign indicating bicycles users are expected. Sherbourne Street was the first street in the city of Toronto to include a cycle track, a separated bicycle lane, making it an important project for a case study review.

Table 3.1: Toronto's Bicycle Network in 2015

On-Street Bikeway Type	Lane kilometers
Cycle tracks	15.1
White bicycles lanes	209
Yellow 'contra-flow' bicycle lanes	6.1
Lanes with shared lane pavement marking ("Sharrows")	26.2
Signed routes (no pavement markings)	302
On-Street Total	558.4
Bikeway Multi-use Trail	298.5

(City of Toronto, 2015)

3.2Sherbourne Street History and Context

Historically, Sherbourne Street has been a major transportation artery for the city, and consistently supported public transit. Streetcars were in operation from the late 19th to mid 20th century, and in 1966, the Sherbourne Subway station opened at the Bloor Street East intersection (Bow, 2014). Today, both North and South-bound buses continue to operate along the street, connecting transit riders to the Sherbourne Subway station and the waterfront. There are continuous bicycle lanes along the entire roadway that were originally developed in 1996. Based on the cycle counts completed in 2012 by the City of Toronto before the redevelopment and immediately after the redevelopment (Figure 3.3), the bicycle lanes were not used as heavily as the cycle tracks introduced.

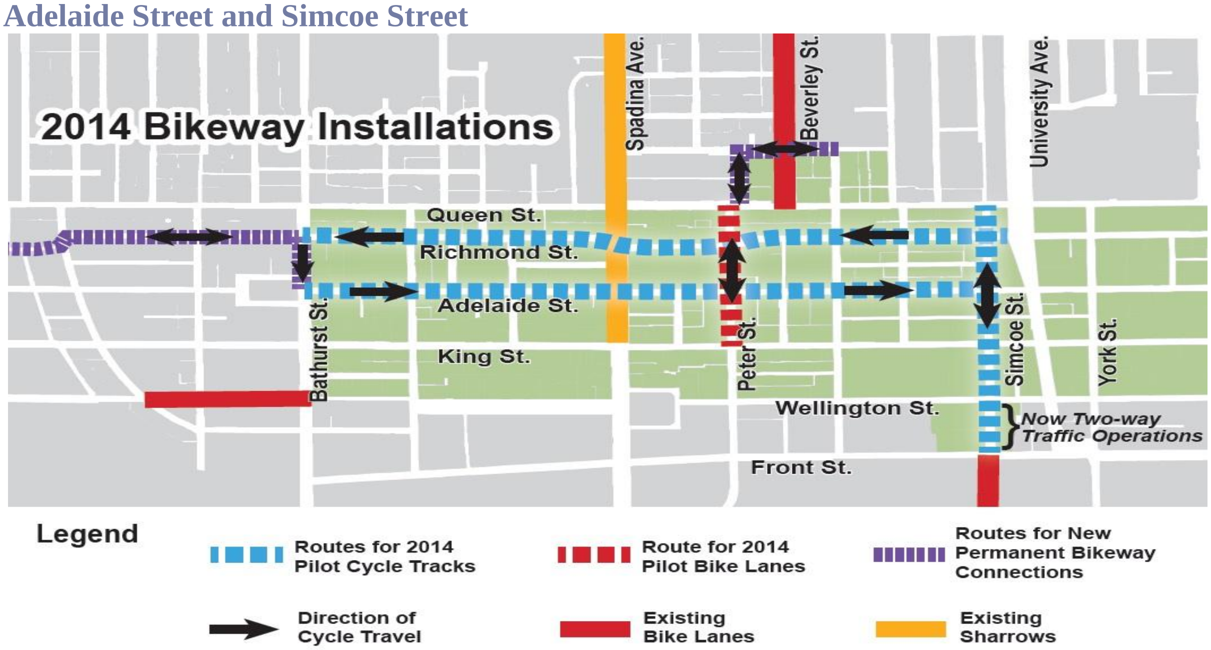
The street runs through three different neighborhoods, North St. James Town, Cabbage Town, South James Town and Moss Park. Based on Wellbeing Toronto data, the average household incomes in these neighborhoods range from $62,676 to $139,490 (City of Toronto, 2011). Therefore, this bike lane serves both low and medium income neighborhoods, while providing a direct route from the waterfront to Bloor Street East.

3.3 Sherbourne Street Redevelopment

The City of Toronto is exploring the possibility of using of cycle tracks in expanding its cycle network. The City has recently installed temporary cycle tracks as a pilot projects at Richmond Street, Adelaide Street and Simcoe Street, three major downtown streets in Toronto (Figure 3.1). Through an evaluation and online survey, the city will determine if the lanes become permanent or not. Sherbourne Street was the first road to be redeveloped with cycle tracks. The consultation and design process for its redevelopment was approved in June 2011, by Toronto city council (City of Toronto, 2015). In 2012, the city council also voted in favour of the removal of bicycle lanes on Jarvis Street and the extension of the bicycle network along Sherbourne Street (Grant, 2012). Sherbourne Street in comparison to Jarvis Street is considered more suitable for bicycle lanes, with fewer interruptions due to driveways and no automobile traffic lanes would be removed (Grant, 2012). As well, Sherbourne Street was selected based on its contribution to Toronto's existing bicycle network, where the street connects to existing bicycle lanes at Wellesley Street, Gerrard Street, Shuter Street and Bloor Street East.

Following approval of the Sherbourne Street redevelopment, the City of Toronto Transportation Services carried out extensive public consultations with stakeholders in the area, and by June 26, 2012 the city revealed their plans for a new street design (City of Toronto, 2015). The plan incorporated design features to improve both the cycling lanes as well as public transit bus stops. These design features were incorporated through the resurfacing of the street, and upgrading the current painted bicycle lanes with cycle tracks along the route.

Figure 3.1: Map of City of Toronto's Cycle Tracks Pilot Project for Richmond Street, Adelaide Street and Simcoe Street



(City of Toronto, 2014)

Sherbourne Street is the first street in the city to incorporate cycle tracks, and handicapped accessible bus stops with signage for cyclists to yield to transit users. Bicycle boxes, which are painted boxes at intersections that enable cyclist to advance first, were added to major intersections such as Wellesley Street and Sherbourne Street (City of Toronto, 2015). All on-street parking was removed, with additional spots being added on neighboring streets. (City of Toronto, 2015). The streets width of 12.2 meters is narrow in comparison to many other major roadways in Toronto, and restricts the addition of other features such as the expansion of the pedestrian space in the redevelopment (City of Toronto, 2015). Although Sherbourne Street is not considered a complete street by the city, as the redevelopment did not include an expansion of the public realm, various complete street aspects have been included in its redevelopment as seen below.

Figure 3.2: Photo of Cycle Tracks

Note: At the signalized intersection of Sherbourne Street and Wellesley Street, going Southbound.
(Ziemba, 2015)

Figure 3.3: Photo of Cycle Tracks

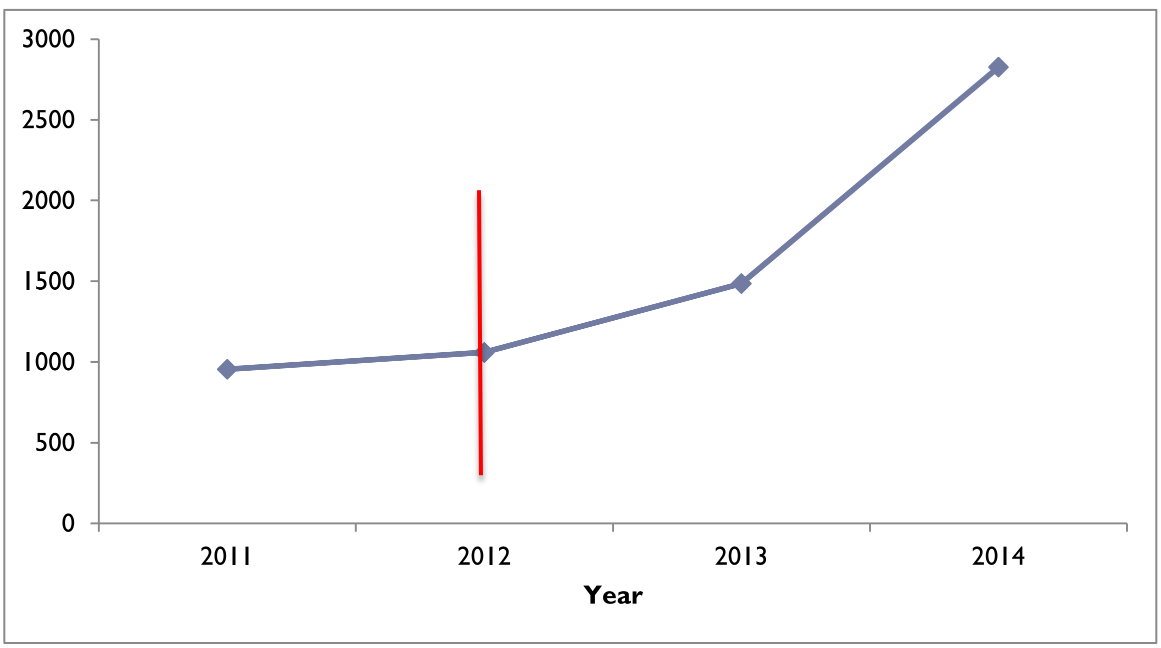
Note: At the signalized intersection of Sherbourne Street and Dundas Street East, going Northbound.
(Ziemba, 2015)

The construction was completed December 2012, and the redevelopment extended 2.5 kilometers from Bloor Street East to King Street East (City of Toronto, 2015). The cost was approximately 2.4 million dollars (CDN), which included resurfacing the street (Toronto officially opens Sherbourne Street bike lanes, 2013). Upon completion of the project, the city approved and adopted a new cycle track by-law, where those who parked or stopped in the cycle tracks would face a $150.00 fine, excluding emergency services vehicles, wheel transit services and hydro utility vehicles (City of Toronto, 2014). The city also stated that cycle tracks are only intended for bicycles, power assisted bicycles and e-scooters, where all other modes of transportation are not permitted (City of Toronto, 2014).

3.4 Cycle Usage Rates on Sherbourne Street

Bicycle counts at the intersection of Sherbourne Street and Gerrard Street were conducted by the City of Toronto before and after the redevelopment, in the months of June 2011, July 2012, October 2013, November 2013 and June 2014. This data is represented in Figure 3.3. The counts showed an upward trend in the number of cyclists using the street, especially after the implementation of the cycle tract in December 2012. In 2014, the average daily count was 2,827 compared to 995 in 2011 (Bicycle Counts, 2015).

Figure 3.4: Annual Daily Average Cyclist Counts on Sherbourne Street (at the intersection of Gerrard Street)



Notes: The red line represents the completion of the cycle tracks in December 2012.The bicycle counts for 2011 and 2012 occurred prior to the redevelopment of Sherbourne Street, where the 2013 and 2014 counts occurred after. Illustrating the increase in cyclists along this route after the introduction of cycle tracks.

Chapter 4 Methodology

This case study used primary data to explore the influence of cycling infrastructure on travel behaviour. The methodology will be discussed in three steps, beginning with the review of the data collection process, followed by a discussion of the sampling approach and population, and concluding with identifying the methods used to analyze and interpret the data, as well as the statistical tests used to evaluate the significance of the variables.

4.1 Data collection and Sites

In this study a street intercept survey was utilized to collect data documenting travel behavior and socioeconomic characteristics of those who cycle on Sherbourne Street. An intercept survey approach was adopted to provide direct access to an immediate sample of the target population, cyclists that were actively using the bicycle lane. Sites considered for conducting the intercept surveys were major intersections on Sherbourne Street between Bloor Street and King Street. Through studying the city's cycling map, sites were reviewed based on their accessibility, safety and traffic flow. The designated sites selected for recruiting participants were the intersections of Sherbourne Street and Wellesley Street and Sherbourne Street and Dundas Street East. These two sites were chosen to capture the variation in cycle track design and street connections, as a means to reach a more diverse sample of users. Both intersections include a raised and painted cycle track, however, north and south of Sherbourne Street and Wellesley Street East, the cycle tracks include a curb and poles to separate automobile traffic. While these features are not included at the Sherbourne Street and Dundas Street East intersection.

The data collection followed standard intercept survey procedures, where the researcher stood near one of the two street intersections along Sherbourne Street, utilizing the 'fixed line approach' for recruiting road users stopped at red lights (Graham et al, 2014). This method involves approaching the first road user that passed a pre-determined feature on the road, to minimize a potential selection bias (Graham et al, 2014). In this study, bus stops and poles were used as the predetermined features for approaching individuals. Those cycling along Sherbourne Street at either intersection were recruited to participate in a short two-minute survey. The researcher briefly introduced the general topic of the study, time commitments for participating, and requested their willingness to participate. This sampling method included all individuals engaged in cycling along the Sherbourne Street cycle tracks that were eighteen years or older. The survey included questions on a cyclist's socio-demographic characteristics, as well as on the trip during which he/she was being surveyed. These questions were used to determine the general characteristics of cyclists on Sherbourne Street, their travel patterns, and the potential of a travel mode switch effect after the redevelopment. The full list of survey questions can be found in Appendix 1.

4.2 Sample

The study surveyed a total of 219 cyclists at the designated intersections between the months of October and early November, 2014. Surveys were conducted on seven weekdays from 7:30am to 9:00am during the morning commute, and from 5:00pm to 6:00pm during the evening commute. Surveys were also held on three weekend afternoons from 4:30pm to 6:00pm. The data collection times indicate that the sample would be primarily comprised of utilitarian commuter trips, and would also include some other trips for recreational and social purposes, particularly during the weekends.

Street sides were alternated while surveys were conducted to include both north and south-bound cyclists in the recruitment process. Over the data collection period, a greater emphasis was placed on recruiting participants at the Sherbourne Street and Wellesley Street intersection due to the higher frequency of cyclists, and consequently, higher response rate.

Of the 219 surveyed, 214 individuals completed the survey. The distribution of the number of surveys between weekdays and weekends are summarized in Table 4.1.

Table 4.1: Surveys responses

Response to Survey	
Total Responses	219
Total Complete Responses	214
Total Weekday Responses	188
Total Complete Weekday Responses	183
Total Weekend Responses	31
Total Complete Weekend Responses	31

4.3 Methods of analysis

Data was coded into Microsoft Excel for a preliminary analysis. The frequency of each variable and percentages were calculated to summarize the characteristic of the cyclists. As well, it illustrated the key characteristics of the groups that had changed their mode of transportation. The data was further analyzed through two-way frequency tables, enabling the examination of potential relationships between variables.

A Pearson chi square test was run on this data set to examine the association between variables. The groups tested were those that switched modes of transportation versus those that did not, as well weekend versus weekday cyclists. The chi-square tests were performed to test the differences based on the variables found in table 5.2 and 5.3. A chi-square value with $\alpha<0.05$ indicated a statistically significant difference between groups (Vogt, 1993).

The data reflects two main groups of cyclists, those who regularly cycle and those who are "new" cyclists to Sherbourne Street. Those who are "new" to cycling on Sherbourne Street can be represented in four categories: individuals who switched their travel route to use the new cycle tracks, individuals who moved residence as a form of self-selecting to locate near the cycle track, individuals beginning to cycle because of cycling's rising popularity, and individuals who switched their mode of transportation due to the presence of cycle tracks.

This study aims to identify and explore those who switched their mode of transportation as a result of the cycle tracks, and the frequency of those who switched modes and those that did not. Question 5 in the survey inquired if the participant's route of travel included Sherbourne Street before the redevelopment. This question was used as a proxy question in the analysis as it controlled for those who cycled along Sherbourne Street as a result of the above mentioned four categories. For those who had not used the road and cycled, it suggested these individual may have altered their route due to the redevelopment. Self-selection may partially explain the number of individuals in the sample who switched their mode of transportation to cycling and changed their route to include Sherbourne Street after the redevelopment. Lastly, those who travelled along the road before the redevelopment and switched modes of transportation suggests that these individuals were drawn to the cycling infrastructure. This study was unable to control for those cycling as a result of growing cycle culture in Toronto (Wenzel, 2015). To control for this would require data collection on another street in the downtown core similar to Sherbourne Street without a bicycle lane. This data collection was out of the scope of this case study, and as a result this remains a potential confounding error that could not be addressed.

Chapter 5 Results

5.1 Findings

The study examined the effects of the Sherbourne Street cycle tracks on users' travel behavior, as well as the potential to attract new ridership. Chi-squares tests were conducted for each categorical question from survey (Appendix 1), enabling evaluation of the statistical significance among groups. Table 5.1 shows the summary data. Differences between weekday and weekend travel patterns are reported in table 5.2, and table 5.3 shows the differences between those who switched modes transportation and did who did not.

Table 5.1: Summary of characteristics of cyclists and cycling Trips

Variables	Percent
Demographics	
Gender (N=219):	
Male	60.73
Female	39.27
Age (Years) (N=219):	
<20	1.83
20-39	63.93
40-59	33.79
60+	0.46
Purpose and Travel Times	
Purpose of trip (N=219)	
Commuting (work)	68.95
Commuting (school)	9.59
Social (ex. Meeting with others)	15.98
Recreational (ex. Physical activity)	4.57
Other	0.91
Total time to complete trip (N=219)	
<15 mins	14.16
15-30 mins	57.99
35-45 mins	23.29
45mins-1hr	1.83
>1hr	2.74

Time spent from origins to Sherbourne Street (N=218)	
<5mins	9.17
5-15 mins	67.89
15-30 mins	16.51
30-45 mins	5.05
45 <	1.38
Time spent from Sherbourne Street to destination (N=218)	
<5mins	13.76
5-15 mins	73.39
15-30 mins	10.09
30-45 mins	0.92
45 <	1.83
Previously used the road before the redevelopment (N=217)	
Yes	37.33
No	62.67
Travel mode switch (N=214)	
Switched Mode After Redevelopment	37.85
Cycling Before Redevelopment	62.15

Within the sample, females made up 39.3% and the remaining 60.7% were males. When comparing differences between gender on weekends and weekdays the rates do not vary significantly, as illustrated with a p-value of 0.228 when a chi-square test was conducted (table 5.2).

The age distribution of cyclists showed that those 20-39 years were the largest age group of cyclists, followed by the 40-59 years age group (table 5.1). There was no statistically significant variation between weekdays and weekend (table 5.2).

Table 5.2 Comparison of Key Variables between Weekday and Weekend

	Weekday (N= 183)	Weekend (N= 31)	Statistical Test		
	Percent		Chi square	P-Value	Degrees of Freedom
Gender:			1.452	0.228	1
Male	59.56	70.97			
Female	40.44	29.03			
Age (Years)			0.974	0.807	3
<20	1.64	3.23			
20-39	62.30	67.74			
40-59	35.52	29.03			
60+	0.55	0.00			
Purpose of trip			80.66	0	4
Commuting (work)	77.60	16.13			
Commuting (school)	10.93	3.23			
Social (ex. Meeting with others)	7.65	64.52			
Recreational (ex. Physical Activity)	2.73	16.13			
Other	1.09	0.00			
Total time to complete trip			38.264	0	4
<15 mins	14.21	16.13			
15-30 mins	59.56	41.94			
35-45 mins	23.50	25.81			
45mins-1hr	2.19	0.00			
>1hr	0.55	16.13			
Time Spent from Origins to Sherbourne Street			26.848	0	4
<5mins	7.10	22.58			
5-15 mins	72.68	41.94			

15-30 mins	16.39	12.90			
30-45 mins	3.83	12.90			
45 <	0.55	9.68			
Time Spent from Sherbourne from Destination			21.771	0	4
<5mins	15.30	6.45			
5-15 mins	75.41	58.06			
15-30 mins	8.20	22.58			
30-45 mins	0.55	3.23			
45 <	0.55	9.68			
Previously used the Road Before the Redevelopment			0.257	0.612	1
Yes	37.16	41.94			
No	62.84	58.06			
Travel mode switch			0.482	0.487	1
Switched Mode After Redevelopment	38.80	32.26			
Cycling Before Redevelopment	61.20	67.74			

Overall, the majority of trips were for commuting, with 68.95% of participants traveling to work (Table 5.1). On weekends, work related commutes significantly decreased compared to weekdays (p= 0). Of the total cycling trips on weekdays, 77.60% were for commuting purposes. In contrast, 64.52% of trips made for social purposes on weekends.

With regards to trip distance, 57.99% cyclists traveled 15-30 minutes to reach their destinations, followed by 23.29% who travelled 35-45 minutes (table 5.1). The most common travel time to reach Sherbourne Street from participants' origins was listed at 5-15 minutes. (Table 5.1) Similarly 5-15 minutes was the most common time to reach one's destination from Sherbourne Street. With 5-15 minutes being the most common travel time to reach the cycle tracks and/or their destination, this suggests that users are likely locals within the immediate area. Based on the chi square result for travel times on weekdays and weekends the difference was found to be statically significant (table 5.2,), with 59.56% of the trips made on weekdays were between 15-30 minutes. There was a greater variation in travel times among weekend users, with 16.13% of cyclist traveling more than 1 hour to complete their trip.

Markedly, 37.85% of all cyclists (table 5.1) switched their mode of transportation to cycling following the redevelopment where 62.15% did not switch. This signifies that cycle tracks may attract new users. Of the sample 62.67% responded that they did not use the Sherbourne Cycle Tracks prior to the redevelopment, indicating the presence of some other confounding effects including: 1) mode substitution 2) route substitution 3) self selection 4) cycling culture.

5.2 Characteristics of New Cyclists

The most common mode previously used was public transit at 57.95%, with walking contributing 13.64%. This illustrates that the majority of individuals switching to cycling after the redevelopment previously used a sustainable mode of transportation, while 22.73% switched from the automobile, indicating some reduction in automobile trips.

Figure 5.1 Previous Mode of Transportation of those who Switched Modes

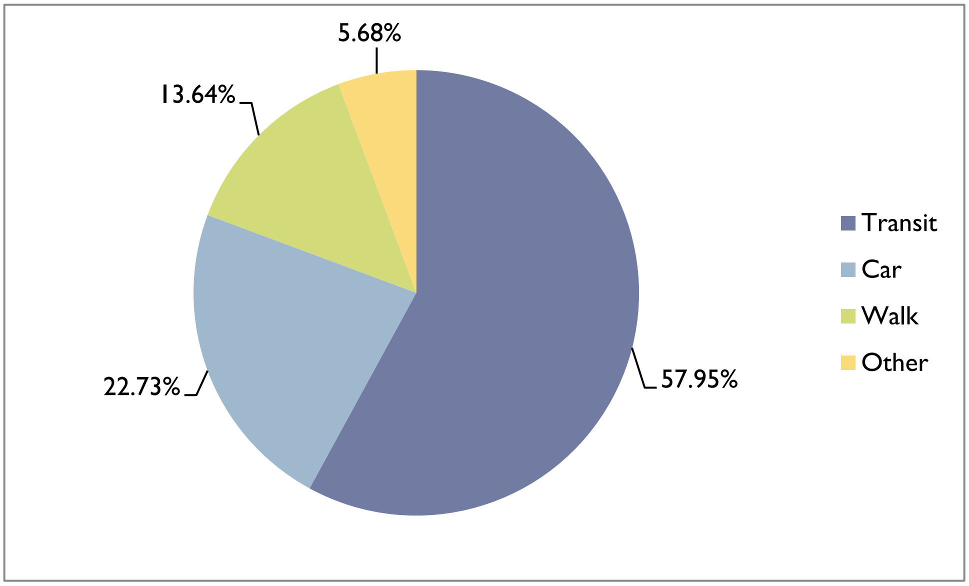


Table 5.3 Differences among those who switched their Mode and those that did not

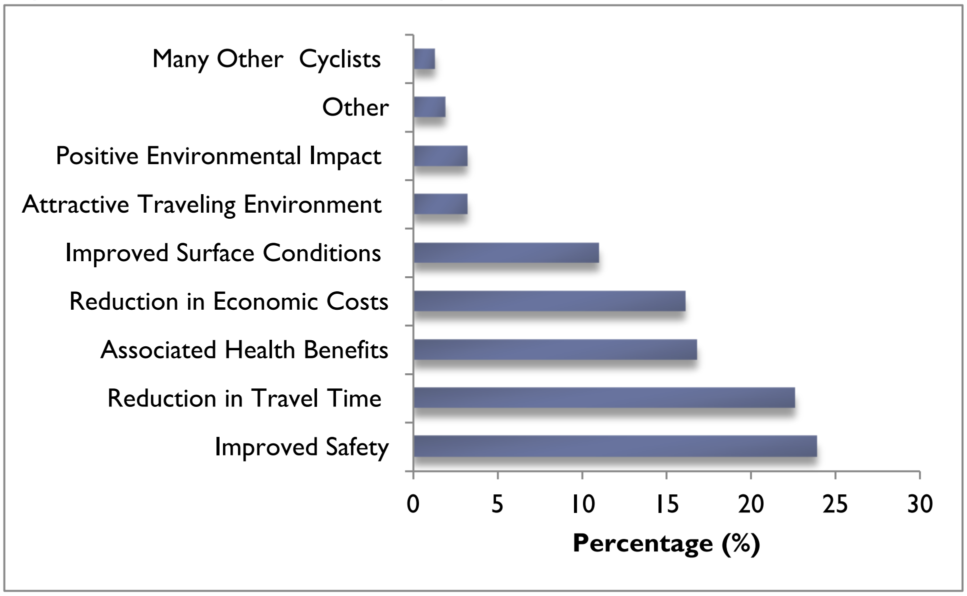
	Switched Modes (N= 81)	No modal switch (N= 133)	Statistical Test		
	Percent		Chi square	P-Value	Degrees of Freedom
Gender:			1.758	0.184	1
Male	55.56	63.04			
Female	44.44	36.96			
Age (Years)			3.59	0.309	3
<20	3.7	0.75			
20-39	65.43	61.65			
40-59	30.86	36.84			
60+	0	0.75			
Purpose of trip			2.344	0.672	4
Commuting (work)	72.84	66.17			
Commuting (school)	9.88	9.77			
Social (ex. Meeting with others)	11.11	18.8			
Recreational (ex. Physical activity)	4.94	4.51			

Other	1.23	0.75			
Total time to complete trip			0.666	0.995	4
<15 mins	16.05	13.53			
15-30 mins	56.79	57.14			
35-45 mins	22.22	24.81			
45mins-1hr	2.47	1.5			
>1hr	2.47	3.01			
Time Spent from Origins to Sherbourne Street			3.061	0.547	4
<5mins	7.41	10.53			
5-15 mins	75.31	63.91			
15-30 mins	12.35	18.05			
30-45 mins	3.7	6.02			
45 <	1.23	1.5			
Time Spent from Sherbourne from Destination			2.771	0.596	4

<5mins	13.58	14.29			
5-15 mins	76.54	70.68			
15-30 mins	7.41	12.03			
30-45 mins	2.47	1.5			
45 <	0	1.5			
<u>Previously Used the Road Before the Redevelopment</u>			43.356	0	1
Yes	9.88	53.68			
No	90.12	46.32			

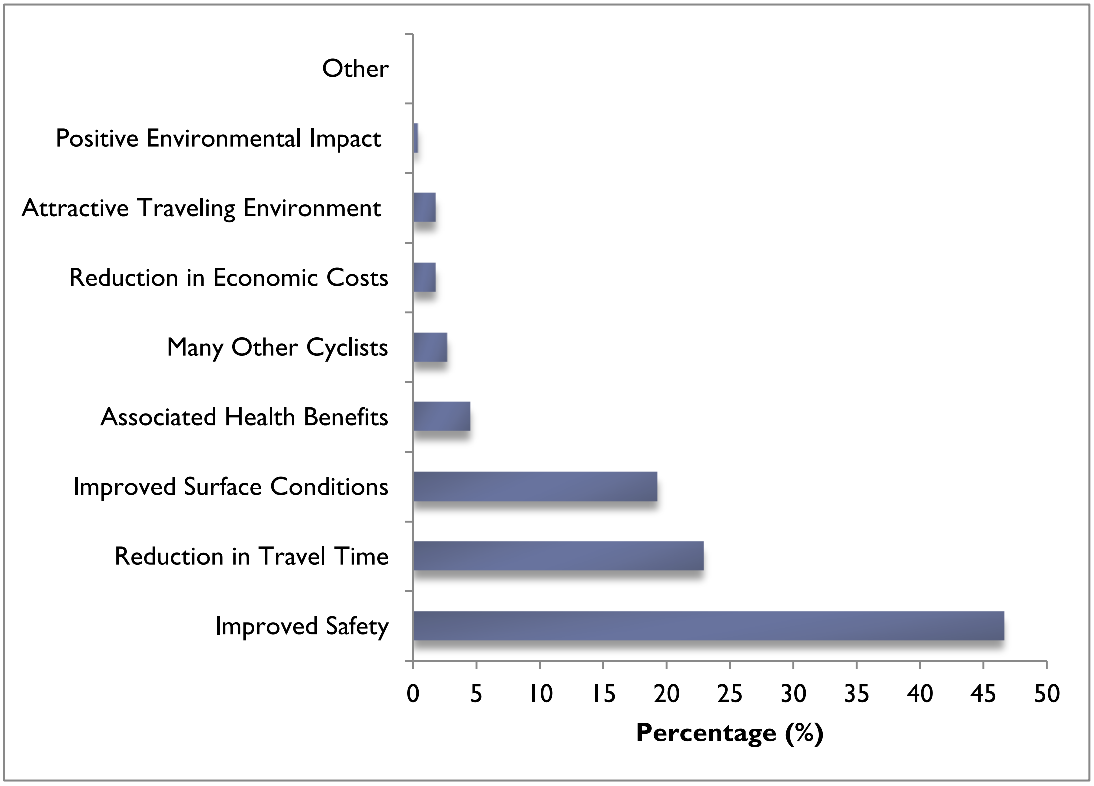
The data was further analyzed based on those that switched their modes (i.e., switched from other modes to cycle) and those that did not, presented in the table 5.3. In general there is little variation between the responses for those who switched to cycling and those that did not. The only statically significant variable in this comparison was whether or not the cyclist used the road before the redevelopment, where 90.12% of those who switched their mode of transportation indicated that they did not use the road before redevelopment. This signifies that increase in new ridership maybe be contributed by individuals that are self selecting to locate themselves near the cycle tracks, a change in route, or a cycling culture. As well 46.32% of participants who previously cycled reported they did not use the road prior to the redevelopment. This indicates that the increase in users on the Sherbourne Street cycle tracks are also likely attributed to a route substitution effect, where cyclists have altered their route to use the infrastructure.

Figure 5.2 Reasons for Switching Modes of Transportation



Reviewing the reasons for switching modes, the most frequent response listed among participants was improved safety at 23. 9%, with a reduction in travel time listed as the second most common at 22.6%, followed by the associated health benefits at 16.8% (Figure 5.2). This suggests that the cycle tracks may have addressed some of the major concerns associated with attracting new users to cycling. It has been hypothesized that cycling in groups improves safety (Robinson, 2005), however participants ranked this variable as low importance.

Figure 5.3 Observations of Cyclists Who Cycled Before the Redevelopment



When analyzing the main observation of cyclists who previously cycled before the redevelopment, the most frequently selected observation was improved safety with 46.6% (Figure 5.3). This was followed by reduction in traveling at 22.9%, and time at 19.3%. This indicates that the cycle tracks create an environment that is attractive and safer that encourages current cyclists to use Sherbourne Street.

Chapter 6 Discussion

6.1 Discussion and Findings

This case study explores cycling behaviour in the city of Toronto, specifically, the impacts of the addition of a cycle track on Sherbourne Street. This section reviews and discusses the implications of results determined in the previous chapter.

The gender split found in this study is consistent with literature on this topic, where women ridership accounted for 39.27% surveyed, and men accounting for 60.73% (table 5.1). Cycling studies on gender in countries without an established cycling culture typically report substantially lower cycling rates for women. For example, female ridership in the United States contributes to 24% of commuting (Garrard et al., 2012). Studies have reported even lower rates of women cyclists in Sydney, Australia at 17% (Pucher et al., 2010). In this case study there was little variation in the gender gap among the days of the week, and those who switched their mode of transportation and did not (table 5.2, 5.3). This suggests that the cycle tracks do not have a statically significant impact on gender.

As mentioned in the previous section, the most common age groups for cyclists on Sherbourne Street were 20-39 years, followed by 40-59 years. This aligns with commuting to work as the most frequent weekday trip, suggesting the majority of cycling trips during the week are for utilitarian purposes. These age groups were also the dominant users on weekends, where 80.65% of trips were made for social and recreational purposes. Thus in the context of the city of Toronto on Sherbourne Street, regardless of the day of the week or purposes, cycle track users were likely ages 20-39, and 40-59.

When considering distance, the most frequently selected time for completing a trip was between 15-30 minutes. Based on this travel time and the assumption that a cyclists in the city travels 15 km/hr (Alter, 2010), it can be determine that the majority of users likely travelled 3.75

km to 7.5 km, on a daily basis to work. This is finding relatively consistent with the average trip length of 5.5km to 8.6km cited for Canadian cyclist by Pucher and Buehler (2006). The data, however, contrasts with other studies addressing the distance travelled to reach a bicycle lane. Research conducted by Larsen, and El-Geneidy (2011), found those who used on street cycling infrastructure such as bicycle lanes added an addition 2.2 kilometers to their trip. Based on similar assumptions on speed, over 70% of the sample surveyed in Toronto travelled 1.25 to 3.75 kilometers to reach the cycle tracks.

This study specifically aimed to determine if cycle tracks attracted new ridership and resulted in reduced automobile trips. A notable finding of the research was that 62.67% of the sample did not use the road before the redevelopment (Table 5.1). This illustrates that the cycle tracks attracted a significant number of new users, which could be attributed to a mode substitution, a route substitution, or another confounding variable such as self selection or a cycling culture.

Another finding was that 37.85% of the sample stated they had switched their mode of transportation to cycling after the redevelopment (table 5.1). This case study confirms that bicycle lanes in particular cycle tracks may lead to mode substitution effect, which previous studies had hypothesized (Pucher et al., 1999). The chi-square test conducted in table 5.2 and 5.3 illustrates there is no statistical variation for those switching to cycling between the days of week, gender, purpose of trip and length. However, in table 5.3, it was noted that previously using the road or not was statistically significant between the participants who switched their mode of transportation to cycling and those that did not. Where individuals who did not previously cycle on Sherbourne Street before the redevelopment were more likely to switch their mode of transportation.

The key finding from this case study was that of the 37.85% who switched their mode of transportation to cycling, 90.12% indicated they did not use the road before the redevelopment. The percentage of new cyclists using Sherbourne Street after the redevelopment may be attributed to self-selection. However, self-selecting into the Sherbourne Street area may be attributed to reasons beyond the bicycle infrastructure, such as changes in lifestyle, the general attractiveness of the neighborhood, or job advancements. This finding also suggests that the rise may be a result of cyclists' destination changing, where an individual's place of work may alter resulting in using a different route and mode. As well, 46.32% of participants who did not switch their mode of transportation, listed they did not use the Sherbourne Street before the redevelopment. This signifies that the cycle tracks may also result in a route substitution effect, where cyclists altered their route to use the cycle tracks. Furthermore, this finding supports multiple studies that discuss the route substitution effect occurring after the addition of cycle lanes (Dill and Carr, 2003; Larsen and El-Geneidy, 2011).

Of the new cyclists, the most common mode to switch from was transit accounting for 57.95%, followed by the automobile at 22.73% and then walking at 13.64%. This highlights that the addition of the cycle tracks possibly reduced the number of users traveling on transit during peak hours. Similarly, with automobiles listed as second most common previous mode of transportation, it implies there was a decrease in automobiles trips made for commuting purposes in the city.

The second research question aimed to determine the primary reasons for switching ones mode or route. When analyzing the selected responses for those who switched their mode of transportation (figure 5.2), the most frequent answer was improved safety and a reduction in travel time. This suggests that the cycle track design has addressed the primary concern of safety that is considered a deterrent for new cyclists (Larsen et al., 2013). The second most common response for switching one's mode of transportation was a reduction in travel time, denoting that cycling within cities can be more efficient in comparison. With transit and automobiles listed as the two most common modes of transportation to switch from, this indicates these modes are likely becoming inefficient and individuals are willing to switch to cycling.

6.2 Implication

This study questions the assumptions behind policies related to cycling and active transportation that lack evidence. It is often assumed that investing in cycling infrastructure results in the desired outcomes such as new ridership, however little research has been conducted to confirm this. The findings of this case study provide quantitative evidence of the effects of cycle tracks, impacting future developments of active transportation policies. In many cases, active transportation policies and projects are at the mercy of politicians, as these policies are often viewed as additional, unwarranted costs. Without a clear, measurable indicator of the benefits of cycle tracks, it becomes difficult to make a case for cycle tracks or active transportation. This case study provides a measurable impact of cycle tracks on increasing new ridership, providing justifications for or against future cycling developments within urban spaces.

The City of Toronto currently has a cycle track pilot project in place, and the findings from this research will contribute to the City's evaluation of this type of cycling infrastructure. From an urban health policy perspective the study reaffirms the literature that cyclists traveling for commuting purposes meet the required 30 minutes of physical activity to maintain a healthy lifestyle (Dill, 2009). This supports policies promoting healthy communities, as this case study illustrates that the cycle tracks facilitate individuals participating in regular physical activity, and may reduce health complications (Dill, 2009).

The data from this study shows an increase in new ridership resulting in a mode substitution effect, however it was also noted that the majority of users had not used the road before the redevelopment. This indicates that the expected new ridership may not be directly a result of the cycle tracks, however a consequence of self-selection or other factors out of the scope of this project. This sheds lights onto policy assumptions related to bicycle lanes and cycle tracks indicating that it is unclear to what extent cycle tracks directly result in new ridership.

6.3 Limitation

This study has provided a starting point to review the ability of cycle tracks to result in a mode substitution. The scope of this study, however, was limited, highlighting the opportunity for future research to further address gaps in the literature. This case study focused on a particular street within the downtown of the city of Toronto meaning that the results may not be replicable or universal. While further research on other streets with cycle tracks would verify the findings and provide a stronger case, this was outside of the scope for this project. The research has shown that mode substitution effect does occur with the addition of cycle track, although it is possibly influenced by residential choice (i.e., self-selection) and route substitution. An additional limitation of the research was not controlling for a bicycle culture within the city of Toronto. Where in the recent years cycling has become more popular (Statistics Canada, 2006), contributing to the number of individuals switching their modes to cycling. To control for this would require conducting surveys on another street that connects to Toronto's bicycle network, without a bicycle lane. This would provide a clearer understanding if the mode substitution effect exhibited in this study was mainly attributed to the cycle tracks or a result of a growing cycling culture within the city. Future studies could also pursue an analysis of the socio-demographic characteristics of those that switched their mode, to gain insight of socioeconomic factors that may contribute to a mode substitution.

Chapter 7 Conclusion

This study contributes to an emerging literature on the effect of bicycle lanes on travel behaviour. Research leading up to this has often hypothesized that bicycle infrastructure leads to changes in travel behaviour, however, it has been unable to provide sound evidence in support. The purpose of this study is to address the gap in the cycling literature, through analyzing the potential mode substitution effects of the Sherbourne Street redevelopment in downtown Toronto. The two research questions that were investigated in this case study were,: 1) whether or not cycle tracks attract new ridership resulting in less automobile trips, and 2) if they do, what are the motivators for switching one's mode of transportation?

The findings illustrate that a mode substitution effect did occur along the Sherbourne Street cycle tracks, which was likely the result of a combination of improved safety, and a reduction in travel times that attracted new users. This analysis builds on current knowledge of bicycle lane studies while providing evidence that they do in fact have the ability to attract new ridership. This study found that 37.85% of the sample had switched their modes to cycling after the redevelopment. However, it should be noted of the 37.85% that switched their mode of transportation to cycling, 90.12% had not used the road prior the redevelopment. This indicates that reasons for a high modal switch could be a result of individuals switching their mode and route, or self-selection and altering their residence or destination. These findings provide a greater understanding of the impacts of cycle tracks and separated bicycle lanes, informing both street design and policy decisions within municipalities.

The study describes the measurable benefits from the implementation of cycle tracks, where an improved knowledge of indicators would aid in transportation and health planning. There are a range of benefits that arise from mode substitution caused by cycle tracks, including a reduction in automobile emissions and improved health outcomes among the population. As well, for the city of Toronto, congestion is a growing negative cost to the economy, estimated in the billions, which could be mitigated through the increase of sustainable modes of transportation (Metrolinx, 2015). Through transitioning roads from automobile dominated to supporting multiple modes of transportation, such as cycling, street uses would alter where they could become hubs for social interaction and economic conditions improving the livability of the area (Piatkowski et al., 2013). This study has presented a methodology for evaluating cycle tracks that can be applied to future research on this topic and Complete Streets that would contribute to planning for healthy communities.

Appendices

Appendix 1

An exploration of travel behavior change after the implementation of Complete Streets in Toronto

Graduate Student: Raymond Ziemba
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Supervisor: Raktim Mitra
raktim.mitra@ryerson.ca

Survey Form

Gender:

1. Male
2. Female
3. ________

Age:

1. <20
2. 20-39
3. 40-59
4. 60+

Q1. Purpose of trip?

1. Commuting (work)
2. Commuting (school)
3. Social (ex. meeting with others)
4. Recreational (ex. shopping trips, cycling or walking for enjoyment)
5. Other:_____

Q2. How long (in minutes) would it take you to complete this trip, from its origin to destination?

1. <15 mins
2. 15-30 mins
3. 30 mins-45 mins

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5. Other:_____

Q2. How long (in minutes) would it take you to complete this trip, from its origin to destination?

1. <15 mins
2. 15-30 mins
3. 30 mins-45 mins

RYERSON UNIVERSITY

An exploration of travel behavior change after the implementation of Complete Streets in Toronto

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Survey Form

Gender:

1. Male
2. Female
3. ________

Age:

1. <20
2. 20-39
3. 40-59
4. 60+

Q1. Purpose of trip?

1. Commuting (work)
2. Commuting (school)
3. Social (ex. meeting with others)
4. Recreational (ex. shopping trips, cycling or walking for enjoyment)
5. Other:_____

Q2. How long (in minutes) would it take you to complete this trip, from its origin to destination?

1. <15 mins
2. 15-30 mins
3. 30 mins-45 mins

Appendix 2

RYERSON UNIVERSITY
RESEARCH ETHICS BOARD

To: Raymond Ziemba
School of Urban and Regional Planning

Re: REB 2014-289: An exploration of travel behavior change after the implementation of Complete Streets in Toronto

Date: September 30, 2014

Dear Raymond Ziemba,

The review of your protocol REB File REB 2014-289 is now complete. The project has been approved for a one year period. Please note that before proceeding with your project, compliance with other required University approvals/certifications, institutional requirements, or governmental authorizations may be required.

This approval may be extended after one year upon request. Please be advised that if the project is not renewed, approval will expire and no more research involving humans may take place. If this is a funded project, access to research funds may also be affected.

Please note that REB approval policies require that you adhere strictly to the protocol as last reviewed by the REB and that any modifications must be approved by the Board before they can be implemented. Adverse or unexpected events must be reported to the REB as soon as possible with an indication from the Principal Investigator as to how, in the view of the Principal Investigator, these events affect the continuation of the protocol.

Finally, if research subjects are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and approvals of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research.

Please quote your REB file number (REB 2014-289) on future correspondence.

Congratulations and best of luck in conducting your research.

Lynn Lavallée, Ph.D.
Chair, Research Ethics Board

Reference Lists

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