Safety and school travel: How does the built environment relate to correlates of safety, mode of travel and physical activity levels to and from school

By

Kristian Larsen

A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy

Program in Planning, Department of Geography University of Toronto

© Copyright by Kristian Larsen 2014
Safety and school travel: How does the built environment relate to correlates of safety, mode of travel and physical activity levels to and from school

Kristian Larsen

Doctor of Philosophy

Program in Planning, Department of Geography University of Toronto

2014

Abstract

Many children do not meet the physical activity targets necessary to accrue health benefits. Declines in active school travel over the past half century are one example of how opportunities for daily physical activity for children have been lost. Adult safety concerns may partially relate to the recent decreases in active school travel. This dissertation examines the connection between safety, the built environment and school travel behaviour. A mixed methods study design explores the links between safety, the environment, physical activity and school transport.

Findings from the first results chapter suggest that safety in general is a concern for both parents and children but safety concerns are not uniform. Both parents and children were worried about strangers, while children identified additional concerns such as dogs and bullies. Traffic safety concerns related to street crossings, incomplete sidewalks and traffic around the school.

Further analysis determined that objective measures of the environment such as street crossings, sidewalk, traffic and parking relate to mode of travel. Perceptions regarding the presence of strangers, street crossings and living in a safe neighbourhood, were also important
factors. Differences were observed across the to/from school models, with more environmental features influencing mode choice during the trip to school.

Concerning children’s health, findings suggest that the environment may relate to healthier body weights along with encouraging walking and minutes of physical activity. Longer distances, mode of travel and traffic calming features along the route to school related to an increase the number of minutes of activity before school.

There is evidence that safety is an important factor in determining travel behaviour and features of the built environment may influence these decisions. Current policies aimed at curbing bullying at both the school and provincial level should continue and be expanded. Further work should look at reducing the number of vehicles around the school to increase walking rates. More time walking translates into more physical activity and may assist children in achieving daily physical activity targets.
Acknowledgments

As my graduate student tenure winds down, I would like to thank all of the great professors who helped me along the way. A special thanks to my advisors (Ron Buliung and Paul Hess) and committee members (Guy Faulkner, Matthew Roorda and Jim Dunn) for their assistance with the completion of this dissertation. I also wish to thank my reviewers Matti Siemiatycki and Kelly Clifton for taking the time to review and examine my dissertation. I also owe gratitude to Jason Gilliland for encouraging me to continue with my studies, while helping me along the way.

Ron and Guy, it has been great to work with both of you over the past five years. I have learned a great deal through my involvement with the BEAT project. I hope that we can continue to work together for the years to come. I would also like to thank the entire BEAT team for their assistance and contributions to the larger study. Raktim and Michelle, I really appreciate all of the assistance and advice you gave me over the past five years.

Financial support was provided by the Canadian Institutes of Health Research, Public Health Agency of Canada, the CIHR Training Grant in Population Intervention for Chronic Disease Prevention: A Pan-Canadian Program (Grant #53893), and the Canadian Transportation Research Forum Scholarship provided by Transport Canada Scholarship in Safety and Security/Sustainable Transportation. Furthermore, additional support was provided through the “Built Environment and Active Transport (BEAT)” project funded by the Heart and Stroke Foundation and the CIHR. A special thanks to these agencies for supporting my work.

I would like to thank my wife Lindsay for allowing me to become a “professional” student, but also for the encouragement over the past ten years. Finally, I would like to thank my parents and brother for their continued support throughout my post-secondary adventure.

# Table of contents

## Contents

Abstract ........................................................................................................................................... ii  
Acknowledgments.......................................................................................................................... iv  
Table of contents ............................................................................................................................. v  
List of tables ................................................................................................................................... viii  
List of figures ................................................................................................................................ viii  
List of appendices ........................................................................................................................... x  
Chapter 1 Introduction .................................................................................................................... 1  
  Outline ......................................................................................................................................... 3  
  Literature review ......................................................................................................................... 5  
    Decline in active travel ............................................................................................................. 5  
    Increasing prevalence of obesity ............................................................................................ 6  
    The environment and health ................................................................................................. 8  
    Pedestrian injury ...................................................................................................................... 11  
    Factors associated with AST ............................................................................................... 14  
    The environment, safety and mode choice ........................................................................... 15  
    The intrapersonal .................................................................................................................... 19  
    Household resources ............................................................................................................. 20  
    Overview, critical appraisal and dissertation contributions ................................................. 20  
Study area ..................................................................................................................................... 24  
Chapter 2 Child and parent perspectives on how safety influences the journey to school .......... 32  
  Introduction ............................................................................................................................... 32  
  Conceptual framework .............................................................................................................. 33  
  Background ............................................................................................................................... 35  
  Methods ..................................................................................................................................... 37  
  Results ....................................................................................................................................... 43  
    Personal security concerns .................................................................................................... 44  
    Traffic safety .......................................................................................................................... 52  
Discussion and conclusion ............................................................................................................. 61
Context in relation to previous work ........................................................................................................... 66

Chapter 3  Safety and school travel: How does the environment along the route relate to safety and mode choice? ................................................................................................................................. 68
Introduction .................................................................................................................................................. 68
Conceptual framework .................................................................................................................................. 69
Methods ....................................................................................................................................................... 72
  Study area and data ...................................................................................................................................... 72
  Built environment ........................................................................................................................................ 77
  Socio-economic variables .......................................................................................................................... 83
  Traffic environment .................................................................................................................................... 84
  Individual characteristics ............................................................................................................................ 90
Empirical Analysis and Modeling .................................................................................................................. 92
Model specification and structure .................................................................................................................. 96
Results .......................................................................................................................................................... 97
  Regression models ........................................................................................................................................ 99
Discussion .................................................................................................................................................... 103
  Traffic volume and vehicle fleet ................................................................................................................ 103
  The objective environment ........................................................................................................................ 106
  The perceived environment ........................................................................................................................ 110
  Individual characteristics ............................................................................................................................ 112
Differences in trips to and from school .......................................................................................................... 115
Conclusion .................................................................................................................................................... 117

Chapter 4 Physical activity and school travel: Assessing how traffic safety and the built environment relate to physical activity levels before and after school ........................................................................... 119
Introduction .................................................................................................................................................. 119
Background ................................................................................................................................................... 121
Conceptual framework ................................................................................................................................... 125
Methods ....................................................................................................................................................... 126
  Exploratory spatial data analysis of the street network around schools ..................................................... 128
  Detailed assessment of the routes to and from school ............................................................................... 129
  Traffic counts .............................................................................................................................................. 133
List of tables

Table 2.1 - Descriptive statistics for participants................................................................. 40
Table 3.1 - Ecological model and the levels of influence....................................................... 71
Table 3.2 - Pedestrian safety multiplier for car equivalency .................................................. 87
Table 3.3 - Independent variables examined in the models and the predicted relationship to walking .................................................................................................................. 92
Table 3.4 - Significance of correlations in preliminary analysis .............................................. 94
Table 3.5 - Descriptive statistics for participants routes...................................................... 98
Table 3.6 - Logistic regression estimation results with walk as the dependent variable ....... 100
Table 4.1 - Variables examined in the models and the predicted relationship to physical activity ......................................................................................................................... 136
Table 4.2 - Pearson correlation with light, moderate and vigorous physical activity .......... 137
Table 4.3 - Mode of travel to school by gender and neighbourhood type ............................ 143
Table 4.4 - Body weight breakdown by gender and neighbourhood type ............................ 144
Table 4.5 - Average minutes of light, moderate and vigorous physical activity during the journey to school by gender and neighbourhood type .................................................. 148
Table 4.6 - Descriptive statistics for participant routes ...................................................... 150
Table 4.7 - Multiple linear regression analysis with light, moderate and vigorous physical activity as the dependent variable during the school travel time-period ............ 152
Table 5.1 - Summary of results and research questions......................................................... 172
List of figures

Figure 1.1 - Major arterial roadways in the (a) central city and (b) inner suburbs ....................... 26
Figure 1.2 - Minor arterial roadways in the (a) central city and (b) inner suburbs ....................... 27
Figure 1.3 - Local residential street in the (a) central city and (b) inner suburbs example 1 ...... 28
Figure 1.4 - Local residential street in the (a) central city and (b) inner suburbs example 2 ...... 29
Figure 1.5 - Sample of school neighbourhoods and street design ................................................ 31
Figure 2.1 - Example of broad neighbourhood classification types in the City of Toronto ........... 38
Figure 2.2 - Flow chart describing themes related to safety for children and parents ................. 42
Figure 2.3 - Flow chart illustrating neighbourhood differences in themes related to safety ........ 44
Figure 3.1 - An adaptation of an ecological model used to explain physical activity and walking ............................................................................................................................ 72
Figure 3.2 - Example of a map drawn by a parent and their child.............................................. 77
Figure 3.3 - Example of traffic count locations and vehicle counts, 8:00-8:45 A.M. ................... 89
Figure 3.4 - Example of traffic count locations and vehicle mix, higher values represent more passenger vehicles, 8:00-8:45 A.M. .............................................................. 89
Figure 4.1 - Street design around each of the sampled school and characteristics of the environment .......................................................................................................................... 140
Figure 4.2 - Percentage of students walking to school for each of the neighbourhood types .... 142
Figure 4.3 - Percentage of overweight and obese students by neighbourhood type................. 146
Figure 4.4 - Average minutes light, moderate and vigorous physical activity before school..... 148
List of appendices

Appendix: A - Charting of data from qualitative study .............................................................. 229

Appendix: B - Traffic counting instruments ............................................................................... 237
Chapter 1

Introduction

The purpose of this dissertation is to examine how safety relates to mode of travel and physical activity levels for journeys between home and school (to and from) in the City of Toronto, Ontario, Canada. The safety, convenience and enjoyment of pedestrian travel is important for everyone, as we are all pedestrians at some point during the day. Even for those who travel by automobile or public transit, for those who are physically able, every journey starts and ends on foot. Improvements to pedestrian safety and infrastructure will benefit the entire population of individuals who are physically able to walk, not just those people who regularly travel on foot. While pedestrian travel is an important aspect of everyday life, the amount of walking for transport people do has significantly dropped in recent years. Rates for active travel, such as walking and cycling to and from school have decreased, while more students are travelling by private motor vehicle (McDonald 2007; Ham et al. 2008; Buliung et al. 2009; McDonald et al. 2011). Over the same period of time (50 years), where fewer children are walking to school, the prevalence of overweight and obese children has also increased dramatically (Tremblay et al. 2002; Shields 2006; Wang 2011). Decreases in rates of children walking to and from school may be one of many factors influencing the current childhood obesity trend.

Distance between home and school, perceptions of convenience, and safety concerns are all common factors related to active school travel (AST) (Ewing et al. 2004; Schlossberg et al. 2006; McDonald and Aalborg 2009; Faulkner et al. 2010). The concept of child safety is twofold; it consists of both issues of personal security, like social fears or threats to the body or mind from strangers, bullies or animals, while safety from traffic is another concern. Personal
security can relate to both objective and/or perceived risks. Common personal security concerns relate to the risk of abduction, interaction with strangers or fear of crime (Greves et al. 2007; McDonald and Aalborg 2009). Objective and perceived measures of vehicle speed, traffic volume, fleet characteristics, sidewalks and street crossings are key traffic safety issues (Collins and Kearns 2002; Boarnet et al. 2005). Although it seems fair to assume that safety concerns directly relate to physical activity levels, this dissertation tests that hypothesis. Much of the previous literature indicates the importance of safety in school travel decisions, but does not fully examine how parents and their children might talk about and perceive safety differently. Previous work also does not provide clarity on how the objective environment relates to perceptions, nor do studies of school travel mode choice use measured traffic counts around the school when children are actually walking to and from school.

Recent policy recommendations at the Canadian, provincial and federal levels of government indicate recent public policy interest in active travel promotion and use as a way forward to achieving longer run sustainable transport goals and objectives, while enhancing children’s health (Metrolinx 2008; OPPI 2009; Stepping It Up 2012; Active Healthy Kids Canada 2013). Many of these recommendations address concerns related to pedestrian safety, advocating for with complete sidewalk networks, and improved neighbourhood walkability. This recent policy attention also suggests that it may be important to develop a better understanding of how the traffic environment and perceptions of safety relate to school travel for children.

This dissertation aims to provide a better understanding of the correlates related to perceptions of safety, the built environment and school travel for elementary students in the City of Toronto, Canada. This dissertation contributes a mixed-methods analysis of the relationship between safety, the built environment, school travel and children’s physical activity. Specific
contributions include: a qualitative study comparing parent and child perspectives on school travel safety; quantitative objective measurement and analysis of the relationship between school traffic environments (traffic volume, and fleet mix), school travel and physical activity and perceptions of safety. Novel contributions with regard to the research methods include: use of reported/mapped school travel routes and the development of traffic survey methods extended to examine vehicle fleet characteristics directly around the school.

The primary research question this dissertation addresses is, what are the dimensions of safety and the traffic environment that relate to mode of travel to and from school? There are three sub-questions associated with this research that each of the three studies within the dissertation explore: 1) what are the differences and similarities between parent and child safety perceptions?; 2) how do environmental features along the route between home and school, as well as perceptions of safety, relate to school travel mode?; and 3) how does the traffic environment relate to a child’s physical activity levels?

**Outline**

This introductory chapter provides the primary objectives guiding the research, a review of current literature related to AST and child safety that ultimately exposes limitations in the literature and knowledge gaps. The literature review is broken into several sections, aimed to highlight some of the important aspects related to this dissertation. Sub-headings indicate to the reader what the next section will entail. A description of the research setting is also offered. This dissertation consists of three empirical studies that examine links between perceptions and correlates of safety, the built and social environments, physical activity levels and school transport.
The first empirical chapter is a qualitative assessment examining how traffic safety and personal safety may relate to mode of travel for grade 5 and 6 students. It examines how perceptions of safety relate to mode choice for both parents and children in neighbourhoods of contrasting built and social environments. Much of the previous literature regarding safety concerns only examines the views of the parent (Joshi and MacLean 1995; Ahlport et al. 2007; Greves et al. 2007; Baslington et al. 2008; Lang et al. 2011; Price et al. 2011; Zuniga et al. 2012). The first study of this dissertation purposefully examines the differences between child and parent concerns, rather than merely adopting the views of the parent. This piece also investigates how the gender of the child is related to safety concerns. For the purpose of this dissertation, gender is defined as, “the array of socially constructed roles and relationships, personality traits, attitudes, behaviours, values, relative power and influence that society ascribes to the two sexes on a differential basis. Gender is relational and refers not simply to girls or boys but to the relationship between them” (Health Canada, 2000).

The second empirical results chapter (chapter three) builds off the findings of the first qualitative study. It is a quantitative mode choice piece that explores how characteristics along a child’s route to and from school relate to mode of travel and how these findings relate to their perceptions. This chapter offers many methodological contributions through the examination of the objective environment along the reported and mapped route travelled (to and from school), but also by using actual recorded traffic counts around the school, which not only include traffic volume but also fleet characteristics. The final empirical chapter examines whether a relationship exists between safety, the environment and a child’s health, by assessing how objective physical activity levels relate to the built environment during travel to and from school. Researchers commonly state that certain environmental characteristics such as the presence of
sidewalks or street design may relate to activity levels, but little knowledge exists regarding safety and school travel. An assumption exists that when an environment encourages walking it directly relates to physical activity levels. The final study of the dissertation tests the hypothesis that characteristics of the environment directly relate to children’s health behaviour when travelling to and from school. The concluding chapter ties together the findings from the dissertations three main studies; highlighting key findings, contributions and goals for future research.

**Literature review**

*Decline in active travel*

Over the last half century, the mode share for active travel for trips to and from school has declined in many countries. In the United States (U.S.), nationwide statistics show a significant drop in the number of students walking to and from school. Trends in the U.S. are more drastic than reported rates in Canada and the United Kingdom (U.K.). In 1969, nearly half (49%) of U.S. children aged 5 to 14 (Kindergarten to grade 8) actively travelled to school, but by 2009, only 13% engaged in AST (McDonald et al. 2011). In the U.K., 75% of children aged 5 to 10 walked or biked to school in 1975, while only 55% were doing so in 2001 (Pooley et al. 2005). No known data exists at the nationwide level in Canada, but in Toronto rates have also decreased over time. In 1986, almost 56% of children aged 11 to 13 walked to school; by 2006, the rate dropped to 48% (Buliung et al. 2009). These trends highlight how mode of travel has changed considerably over the past 30 to 40 years, and how several countries or cities are affected.

Walking dominates the active mode share. Cycling typically accounts for only 1 to 3% of school trips and these rates have remained fairly stable over the past half-century (Pooley et al.
Decline in walking activity is therefore, responsible for the decline in AST. Rates of walking to school have decreased in recent decades, and the mode share for automobile travel has increased. School transport by private motor vehicle has seen the most significant gain for school travel over the past 40 years (Buliung et al. 2009; McDonald et al. 2011).

**Increasing prevalence of obesity**

While AST in parts of Canada and the U.S. has been in decline, the prevalence of obesity in children has increased (Ogden et al. 2002; Tremblay et al. 2002; Shields 2006; Wang 2011; Ogden et al. 2012). In Canada, for children aged 2 to 17, only 4% of boys were obese in 1979, but by 2004 rates increased to 9% (Shields 2006). Rates also increased from 3% to 7% for Canadian girls over the same period of time (Shields 2006). For children aged 2 to 19 living in the U.S., similar trends exist; 5% were obese in 1971, but 16% of boys and 15% of girls were obese by 2006 (Ogden et al. 2011).

When examining combined rates of overweight and obesity, the situation is even more troubling. Once again, there has been a drastic increase in rates for children in both Canada and the United States. In Canada, overweight and obesity rates for children aged 2 to 17 increased from 15% in 1979 to 26% in 2004 (Shields 2006). Both boys and girls have seen the same rate of increase (10%) over the 25-year time span. Only 17% of boys were overweight or obese in 1979, while 27% were classified as overweight or obese in 2004. For girls, rates increased from 15% to 25% in the same time frame (Shields 2006). In the U.S., trends were similar; for individuals aged between 2 and 19, rates doubled between 1971 and 2006 for boys (15% to 31%), and for girls (15% to 30%) (Ogden et al. 2011).
Current studies may over or under estimate actual rates of overweight and obesity depending on the type of measurement employed. A few studies use actual measurements for height and weight to calculate body mass index (BMI), while most others rely on self-reported data. BMI is an indicator of body fatness and is a reliable measure of fatness for children (CDC 2011), while its use for adults is less useful. The calculation of BMI takes the weight in kilograms over the height in metres squared. For adults, being overweight means having a BMI greater than 25 whereas obesity is when BMI is greater than 30 (Cole et al., 2000). Due to the rapid growth of children, these types of cut-offs do not apply. Overweight and obesity classification for children varies by age of the child in months and by gender. Being overweight for children, youth and young adults (ages 0 to 20) means having a BMI at or above the 85th percentile, while obesity is greater than the 95th percentile (CDC 2011).

The contributing factors to obesity are genetics, dietary intake and energy expenditure (Hill and Peters 1998; Andersen 2000; Tremblay and Willms 2003). One factor that may be associated with the recent obesity epidemic relates to the high levels of inactivity in people of all ages (Luke et al. 2004). Walking is the most common form of physical activity (Saelens et al. 2003), and changes in travel patterns from active to less active modes can contribute to higher levels of inactivity and obesity. Though the trip to and from school is not expected to fulfill all daily physical activity needs of children or solve the obesity epidemic, it does present an opportunity to increase levels of daily physical activity through the use of active modes of transport such as walking and cycling (Tudor-Locke et al. 2002; Cooper et al. 2003; Cooper et al. 2005; Murtagh and Murphy 2011; Owen et al. 2012). Aside from the physical activity benefits active transport provides, walking associates with increased academic achievement, improved heart health, reduced stress, provides social opportunities and reduces vehicular emissions and
greenhouse gases (Friedman et al. 2001; Rissotto and Tonucci 2002; Lambaise et al. 2010; Voss and Sandercock 2010; Andersen et al. 2011; Martinez-Gomez et al. 2011; Larouche 2012).

Potential health benefits from the use of active modes exist for children travelling by all modes. For children who already walk or bike, it is important to maintain the use of these travel modes, while for those currently driven to and from school, shifting to an active mode can increase daily levels of physical activity. People who are active as children are more likely to remain physically active as adults (Vanreusel et al. 2001; Conroy et al. 2005; Telama et al. 2005), thus, to create healthier habits later in life, it is important to expose children to physical activity at a young age.

**The environment and health**

Throughout history, people have been learning about and attempting to control certain elements of the environment in order to improve community health. Previous generations, for example, learned the importance of clean drinking water, leading to the separation of drinking water from human waste and other pollutants. The diseases and ill-health of past generations provides knowledge on how to improve the living conditions for today’s communities.

While in Canada, infectious disease remains problematic in some areas (most notably, aboriginal and remote communities), chronic diseases such as cancer and circulatory system diseases (e.g., heart disease and stroke) have become increasingly important and are the leading killers in Canada today (Government of Canada 2005). Some of these deaths are preventable and can be minimized by reducing risk factors such as hypertension, unhealthy diets, physical inactivity, high blood glucose and many other factors. For children, the most common cause of
death is unintentional injury, which includes a variety of incidents such as drowning and pedestrian vehicle collisions (Government of Canada 2005).

The built environment can be defined as everything within the physical environment that was made or modified by people, including transportation systems (streets and sidewalks), buildings, land uses and parks or open spaces (Northridge et al. 2003). The physical environment consists of both the built and natural environment. Within cities, entirely natural environments are exceedingly rare. For example, people build or modify parks along with the waterfronts of rivers, lakes and oceans (Health Canada 1997). Certain neighbourhood characteristics may relate to levels of physical activity, diet and pedestrian injury, but little work has explored the relationship between various correlates of safety and travel decisions and, subsequently, levels of physical activity and/or inactivity. There is evidence that both the built and the social environment may affect one’s health (Humpel et al. 2002; Evans 2003; Lee and Moudon 2004).

The social environment includes social relationships, income, religion, inequity, culture, arts and beliefs about place (Barnett and Casper 2001). The built and social environments are not independent of one another and there is constant interaction and development over time; thus, it is important to understand and study both aspects of the environment in relation to health.

There are several ways neighbourhoods can potentially influence health. One relates to food access, as affordable and healthy food (most notably fruits and vegetables) is a necessity for all citizens, but some disadvantaged neighbourhoods have poor access to supermarkets (Curtis and McClellan 1995; Weinberg 2000; Morland et al. 2002; Larsen and Gilliland 2008). Research has also determined that certain characteristics of one’s surroundings can influence mental health (Evans 2003). High-rise housing, poor quality housing or crowding can all lead to
various mental health problems (Evans 2003). Neighbourhood-level factors can also affect other health behaviours. Recent research suggests that the density of outlets selling tobacco (Henriksen et al. 2008), and other neighbourhood-level characteristics may relate to both smoking behaviour (Diez Roux et al. 2003) and the use of alcohol (Freisthler et al. 2003).

Another aspect of how the environment can influence one’s health relates to transportation and pollution from automobiles. Motor vehicle exhaust can account for a large proportion of benzene, nitrogen dioxide, small particulates and carbon monoxide within cities (Hirsh et al. 1999). For children with asthma, air pollution from vehicles can cause an onset of symptoms (Pekkanen et al. 1997; Nicolai et al. 2003), but not the actual disease. Children living within 100 metres of a highway are more commonly diagnosed with asthma than those who live farther away from major roads (van Vliet et al. 1997; Gordian et al. 2006).

Although relatively under studied, there may be a link between noise and one’s health. Researchers found a connection between road traffic noise and reading comprehension for elementary school children (Evans and Lepore 1993; Evans and Maxwell 1997), although a more recent study found no relationship (Clark et al. 2006). For people of all ages, noise can cause several ill health effects such as annoyance, stress, sleep deprivation and cardiovascular diseases (Ouis 2001; Evans 2003). Pollution and noise from roadway traffic will influence the health of different neighbourhoods at varying degrees, based on the street design. The built environment can play a very important role in controlling the noise and pollution associated with transportation infrastructure.

The built environment can affect both levels of physical activity and pedestrian safety. Certain characteristics of neighbourhoods can promote and hinder rates of physical activity (Humpel et al. 2002; Lee and Moudon 2004). Parks, recreation centres, pools and health clubs
can support and encourage physical activity if they are easily accessible in one’s neighbourhood (Sallis et al. 1997; Gordon-Larsen et al. 2000; Brownson et al. 2001; Huston et al. 2003; Molnar et al. 2004; Norman et al. 2006; Motl et al. 2007). Prior research indicates that neighbourhood features such as sidewalks, street connectivity, residential density, retail space, and land use mix influence walking behaviours in adults (Frank et al. 2003; Humpel et al. 2004; Owen et al. 2004; Li et al. 2005; Frank et al. 2006), but more work is needed to understand the influence on children. Other neighbourhood characteristics such as street design, traffic volume and speeds can also relate to the risk of pedestrian injury (Carlin et al. 1997; LaScala et al. 2000; Posner et al. 2002; Retting et al. 2003; Garder 2004; LaScala et al. 2004), but again children and adults may view and interact with the environment in different ways. The following section discusses in more detail the connection among neighbourhood features, active travel and pedestrian safety for children.

**Pedestrian injury**

Traffic collisions are a major cause of childhood injury and death throughout the world (Gallagher et al. 1984; Runyan et al. 1985; Waller et al. 1989; Macpherson et al. 1998; Durkin 1999; Transport Canada 2004). Walking has become one of the most dangerous modes of travel, as the death rate for walking is much higher than for other modes (McCann and Delille 2000). Walkers of all ages are at a risk of fatality 50 times greater than those travelling by automobile (McCann and Delille 2000). In the United States, pedestrian injuries are the number one cause trauma related death for children aged 5 to 9 years and the second leading cause of death for children of all ages (NSC 1988). In Canada, pedestrians struck by motor vehicles comprise 14% of fatalities and 13% of serious injuries, but no age breakdown was reported (Transport Canada
The risk of injury obviously varies by mode of travel. Children who are driven to school are susceptible to vehicle occupant injury, but obviously their risk for pedestrian injury is limited (Roberts et al. 1996). Children who primarily travel in a motor vehicle to and from school still have to navigate the streets on foot when travelling between the vehicle and the school, but their overall time at risk of pedestrian injury is shorter than for most walkers. In Canada, pedestrian injury, drowning and motor vehicle occupant crashes are the three leading causes of injury related death among children (Safe Kids Canada 2006).

The time of day is also associated with pedestrian injury. Rates for pedestrian fatalities among children are greater in the afternoon than in the morning as the highest occurrence of injury takes place between 3p.m. and 6p.m., while almost half of all deaths occur just after school has finished between 3p.m. and 4p.m. (U.S. Department of Transportation 1998; Transport Canada 2004). This suggests that most pedestrian collisions take place when rates of AST are at their highest, while children are travelling home from school. Most studies report higher rates of AST during the trip home from school, than the trip to school (Schlossberg et al. 2006; Mitra et al. 2010; Larsen et al. 2012), thus more pedestrian collisions are likely to occur when more children are walking or exposed to motor vehicles.

General traffic safety concerns are evident in the AST literature (Schlossberg et al. 2006; McMillan 2007; Ahlport et al. 2008), however; none of these studies examined how specific traffic features such as measured traffic volume or vehicle fleet characteristics influence mode choice for school travel. This is one area where this dissertation aims to improve the analysis, by including data on traffic volume around the school and vehicle fleet characteristics. For pedestrians of all ages, the likelihood of being struck by a motor vehicle decreases as the number of walkers increases (LaScala et al. 2000), while a greater number of vehicles on the roadway
elevates risk of pedestrian collision (LaScala et al. 2000; Posner et al. 2002; LaScala et al. 2004; Carlin et al. 1997). Automobiles travelling at a faster speed also increases the risk of severe injury and fatality for the pedestrian (Baker et al. 1992). There also appears to be a link between higher traffic volumes and the risk of injury for both adults (Sze and Wong 2007; Harwood et al. 2008; Zegeer and Bushell 2012) and children (Lee and Abdel-Aty 2005; Zegeer and Bushell 2012). Other factors that appear to associate with child pedestrian injuries include higher traffic volume, but also having more streets to cross and lack of adult accompaniment (Roberts et al. 1995; Stevenson et al. 1995; Retting et al. 2003). In a case control study examining modifiable environmental risk factors for injury to child pedestrians, speeds over 40 km/h increased the risk of injury and death (rates of increase were: 1.8 univariate or 2.7 adjusted) (Roberts et al. 1995). Similarly, higher speeds and wider roads (which can lead to driving faster) were both associated with increased risk of pedestrian injury for adults (Garder 2004).

The type of vehicle or fleet characteristics may influence one’s perception of safety, but as previously stated the literature has yet to examine this subject, so relationships between vehicle type, fleet mix, safety and pedestrian travel remain unknown. People may view certain types of vehicles as more dangerous than others; large trucks versus passenger cars for example. From an injury standpoint, larger vehicles put pedestrians of all ages at a risk of more severe injuries (Al-Ghamdi 2002; Lefler and Gabler 2004). It is unknown exactly, however, how vehicle type influences perceptions of safety or mode choice for school travel, here I hypothesise that differences in risk perception emerge in the presence of varied vehicle fleet characteristics. The inclusion of vehicle fleet characteristics aims to fill gaps in the current literature, by adding an additional dimension of the traffic environment.
Certain characteristics of the social environment also play a role in pedestrian safety. Low-income neighbourhoods commonly have a higher rate of child pedestrian injury (Rivera 1985; Calhoun et al. 1998). This likely relates to lower automobile ownership, and therefore more walking, as rates of pedestrian accidents are also higher among households with low car ownership (Rivera 1985). There is commonly a relationship between automobile ownership and income (Schimek 1996). Families with fewer cars typically walk more and have to cross a greater number of streets (Roberts et al. 1996; Roberts et al. 1997), putting them at an increased risk of injury. Children who grow up in low-income families without an automobile do not reap any of the benefits auto-mobility offers, but rather absorb a greater share of the risks.

Factors associated with AST

Distance between home and school is one of the most common reasons why people do not walk or cycle to and from school (Ewing et al. 2004, Merom et al. 2006; McMillan 2007, McDonald 2008; Larsen et al. 2009; Mitra et al. 2010; Mitra and Buliung 2012). Most studies have found a significant association between distance and rates of AST; as the distance increases the probability of walking decreases. While distance is indeed important, other aspects such as convenience and safety also influence AST. Even at short distances, recent studies have found that parents are simply driving their children to school as it is more convenient, easier to structure into daily activities and can potentially (or is perceived to) save time (Ewing et al. 2004; Schlossberg et al. 2006; McDonald and Aalborg 2009; Faulkner et al. 2010).

Concern about child safety is another reason parents drive children to and from school (DiGuiseppi et al. 1998; Collins and Kearns 2002; McMillan 2007; Ahlport et al. 2008; Wen et al. 2008). As previously stated, child safety consists of both personal security and safety from
traffic. Personal security in children can relate to both objective risks and risks perceived by either the parent or the child. Common concerns for parents relate to the risk of abduction, interaction with strangers (‘stranger danger’) and the fear of crime (DiGuiseppi et al. 1998; Eyler et al. 2007; Greves et al. 2007; McDonald and Aalborg 2009). Children are also concerned about strangers, but have additional fears which relate to bullying, teenagers or older kids (as they are more likely to be bullies) and stray animals (Greves et al. 2007; Ahlport et al. 2008). For traffic safety, both objective and perceived measures of vehicle speed, traffic volume, sidewalks and street crossings may influence safety concerns (Collins and Kearns 2001; Boarnet et al. 2005; McMillan 2005).

The environment, safety and mode choice

Several studies examining pedestrian safety and the built environment have found a connection between neighbourhood characteristics and risk and severity of injury (Retting et al. 2003; Graham and Glaister 2003; Clifton and Kreamer-Futs 2007; Clifton et al. 2009). This association between the environment and pedestrian injury suggests that certain neighbourhood characteristics may also influence safety and school travel. Empirical evidence about the relationship between the environment, safety and mode choice is quite mixed. For example, research regarding environmental features such as intersection density, types of street crossing and sidewalk coverage has generated inconsistent findings (Braza et al. 2004; Timperio et al. 2004; Boarnet et al. 2005; Fulton et al. 2005; Schlossberg et al. 2006; Frank, et al. 2007; Kerr et al. 2007; McMillan 2007; Ulfarsson and Shankar 2008; Dalton et al. 2011; Larsen et al. 2012). Many of these inconsistencies may relate to how the environment is measured. Most studies examining school travel use aggregate data of either the home or school neighbourhood (Braza et
al. 2004; Kerr et al. 2006; Frank et al. 2007; McMillan 2007; Larsen et al. 2009). In these situations the school or home are the centre point and a simple straight-line or network buffer of a given distance defines the boundaries of the home or school neighbourhood. The entire environment within this neighbourhood buffer is examined for each child or school. This aggregated approach will capture characteristics along the environment a child travels, but also other features, which may be unrelated to their school trip. A few recent studies have aimed to improve the methods applied by examining characteristics along the shortest path between home and school (Scholossberg et al. 2006; Timperio et al. 2006; Larsen et al. 2012). Although this is a methodological improvement, errors are still introduced as children do not always travel along the shortest path (Buliung et al. 2013). This dissertation aims to use methodological improvements to not only improve the methods used within the literature, but also the empirical findings. Through more accurate representations of the environment, the findings should also be more conclusive. Slight discrepancies such as drawing or memory errors while completing the mapping exercise may exist between the mapped routes and actual routes travelled, furthermore people may take different routes on different days; however, overall route-based analysis should be a more accurate representation of the environment a child engages with during his/her travels to and from school.

Current findings related to safety and mode choice suggests that a more connected street network may be supportive of active travel for adult pedestrians (Frumkin et al. 2004). A connected street network creates more route options, which can increase the number of possible destinations; however, an increased number of street crossings may also increase perceptions of danger for children and parents as crossing an increased number of streets may increase the likelihood of a child being struck by an automobile. Thus, a higher number of street crossings
could be a deterrent where children are concerned. No consistent finding has been observed to date, however; some studies have found that a higher density of intersections relates to an increase in walking to school (Braza et al. 2004; Schlossberg et al. 2006; Frank, et al. 2007; Kerr et al. 2007), while others have found the opposite relationship (Timperio et al. 2004; Ulfarsson and Shankar 2008). From a traffic safety standpoint, crossing more streets may negatively influence walking, but it is important to continue to study street connectivity to understand its connection to children’s travel.

The type of street crossing may also be an important factor. A major intersection could be more difficult (or perceived as more dangerous) to cross than local neighbourhood streets. An Australian study reported that parents drive children to school because of dangerous road crossings (Wen et al. 2008), while a U.S. study found no relationship between major street crossings and school travel (Schlossberg et al. 2006). More recently, Larsen et al. reported that this particular factor only influenced mode choice for the trip home from school (2012). While major roads may have more vehicles and wider lanes, they commonly have traffic lights to assist with street crossings, which may explain the mixed results. Regardless of current findings, further study would create a better understanding of this relationship as no clear understanding exists between street crossings or intersection density and child travel.

The presence of a good and complete sidewalk network also relates to perceptions of traffic safety (Frumkin et al. 2004) and has been positively associated with higher rates of AST in some studies (Boarnet et al. 2005; Fulton et al. 2005; Dalton et al. 2011), while others report no association (McMillan 2007; Larsen et al. 2012). Many AST studies to date do not even examine sidewalks as one of the variables that may or may not relate to mode of travel. This may relate to the fact that sidewalk data are difficult to construct or obtain. It may also relate to
how researchers perceive sidewalk infrastructure in their study area. In Toronto, most areas of
the city have a complete sidewalk network; however, there are certain places within the city that
do not. Thus, is it important to understand whether this environmental feature may relate to mode
of travel for students in these neighbourhoods. A connected sidewalk network gives pedestrians
their own space away from moving vehicles. Although the association between sidewalks and
mode of travel to and from school is mixed, findings are more consistent in the pedestrian safety
literature than those assessing AST. Several studies examining pedestrian accidents have found
that neighbourhoods with complete sidewalk networks experience a reduced objective risk of
pedestrian injury, especially for children and older people (Harwood et al. 2008; Zegeer and
Bushell 2012). While sidewalks may improve safety, the mixed findings in the AST literature
suggest that further exploration is necessary.

Income is a common indicator of the social environment. Some studies examine
individual household income, while others rely on more aggregated census level data for the
neighbourhood. Households or neighbourhoods with higher household income commonly have
lower rates of active travel on the journey between home and school (McMillan et al. 2005;
Vovsha and Petersen, 2005; Frank et al. 2007; Chillon et al.2009; Dalton et al. 2011; Larsen et
al. 2012). Although rates of AST are higher for lower income respondents, the risk of pedestrian
injury is higher in their neighbourhoods (Rivera and Barber 1985; Calhoun et al. 1998;
DiMaggio and Li 2012), signifying that income may not only relate to mode choice, but also
safety.
The intrapersonal

Many studies report a connection between the gender of a child and active travel, as AST is commonly more prevalent in boys (Evenson et al. 2003; Fulton et al. 2005; Merom et al. 2006; Yarlagadda and Srinivasan 2008; Mitra et al. 2010; McDonald 2011; Larsen et al. 2012). McMillan et al. also discovered that girls were 40% less likely to walk/bike to school in California (2006). More recently in a nationwide study examining school travel trends in the United States, McDonald found that while boys walked more than girls, the differences for walking rates were modest (2011). Significant differences in cycling rates were found, as rates for boys were nearly three times that of girls (McDonald 2011). Although gender is commonly important in quantitative assessments of mode choice (McMillan et al. 2006 McDonald et al. 2011; Larsen et al. 2012), few studies to date have examined how boys and girls perceive safety and their walk to school differently. Since gender is such an important factor related to AST, it is important to obtain a better understanding as to what is shaping these decisions for children and their parents. In the first of the three empirical chapters, gender differences are examined to obtain a better understanding at to what the important factors are for boy versus girls, but also for parents with a son versus a daughter. This looks beyond the previous work, which mostly looks at the difference in rates of AST for boys and girls (Fulton et al. 2005; Merom et al. 2006; Yarlagadda and Srinivasan 2008; Mitra et al. 2010; Larsen et al. 2012). The age of the child may also relate to mode of travel at the elementary school level. Recent studies have found that as the age of the child increases, so does the likelihood of walking (McDonald 2008b; Mitra et al. 2010).
**Household resources**

The availability of automobiles also plays a role in determining mode of travel. If a vehicle simply does not exist within a household, it is not possible to drive the child to school. Mixed results exist regarding mode choice and vehicle ownership (Vovsha and Petersen, 2005; Schlossberg et al. 2006; Mitra et al. 2010). Vovsha and Petersen found vehicle ownership to relate to escort decisions for parents (2005), but Schlossberg et al. found no relationship between mode of travel and automobile ownership (2006). Recent work in Toronto has found a negative association between the number of vehicles per licensed driver and walking (Mitra et al. 2010). These mixed findings may relate to the higher than average automobile ownership rates in North America.

**Overview, critical appraisal and dissertation contributions**

Findings to date are consistently presenting evidence of a decline in AST over the past half-century in Canada, the United States and the United Kingdom (Pooley et al. 2005; Buliung et al. 2009; McDonald et al. 2011). Over this time period rates of overweight and obesity have also increased in both Canada and the United States (Ogden et al. 2002; Tremblay et al. 2002; Shields 2006; Wang 2011; Ogden et al. 2012). Concerning correlates of AST, gender and distance are both commonly identified (Ewing et al. 2004; Fulton et al. 2005; Merom et al. 2006; Schlossberg et al. 2006; Yarlagadda and Srinivasan 2008; Mitra et al. 2010; McDonald 2011; Larsen et al. 2012). Parents also commonly identify safety concerns as a correlate of AST (Joshi and MacLean 1995; Fesperman et al. 2007; Greves et al. 2007; Baslington 2008; Eyler et al. 2008; Lang et al. 2011; Price et al. 2011; Zuniga 2012); however, this is where the consistency in the
findings stop. As previously stated, much of the AST literature has produced inconclusive or inconsistent findings related to mode of travel, safety and the environment.

Boys have higher rates of walking than girls (Evenson et al. 2003; Fulton et al. 2005; Merom et al. 2006; Yarlagadda and Srinivasan 2008; Mitra et al. 2010; McDonald 2011; Larsen et al. 2012), but this work aims to provide more knowledge on how gender differences relate to safety concerns among boys and girls. Furthermore, the majority of work to date examines how parents or adults perceive safety (Joshi and MacLean 1995; Fesperman et al. 2007; Greves et al. 2007; Baslington 2008; Eyler et al. 2008; Lang et al. 2011; Price et al. 2011; Zuniga 2012), but does not look at how the child perceives their environment while travelling to or from school. Much of the literature likely examines the fears of the parent, as parents commonly make many of the decisions determining mode of travel for their child (McMillan 2005). However, there is likely a disconnect between how parents and children perceive their environment. In turn, a knowledge gap exists regarding parent and child differences of environmental perceptions and risk, while travelling to or from school. This dissertation will look at the perceptions of both the parent and their child to get a better understanding at how their ideas are similar or different.

How the environment it measured, will likely relate to the findings associated with spatial or travel behaviour. The conceptual validity of a measurement tool relates to how well a method or tool represents reality. Geographic Information Systems (GIS) is often used in combination with environmental data, as a tool to measure characteristics of the objective built environment in school travel research; however, there are many ways to use GIS to measure neighbourhood characteristics. As previously stated, previous work commonly applies the use of straight-line (Braza et al., 2004; Kerr et al., 2006; Frank et al., 2007; McMillan, 2007: Larsen et al. 2009) or network buffers (Kerr et al., 2006; Frank et al. 2007). A buffer simply examines the
characteristics of the environment around one’s home address, school or shortest path. Buffers use a set distance to proxy neighbourhood characteristics children may interact with when traveling between home and school. A straight-line buffer calculates distance ‘as the crow flies’, while a network buffer calculates walking distance along the street network.

There are many problems with this approach. First, it is unknown what buffer size or shape influences decisions regarding travel behaviour, and these kinds of analytical choices likely differ on a person-to-person basis. What I consider my neighbourhood may differ significantly from what my neighbour perceives was their neighbourhood. By applying a buffer of a set distance, one is assuming that perceptions of the environment are similarly constructed by multiple respondents, while in reality how one perceives their neighbourhood is likely unique. Furthermore, the use of different sized buffers will influence the results. Little work to date studies ‘how to measure the environment’ or what buffer size is acceptable, as most studies simply adopt methods applied in previous research, essentially compounding the problem. Buffers of the child’s home or school captures features, which may contribute to neighbourhood perceptions, but they may also capture attributes that do not relate to the school trip. This aggregated approach also includes several features children may not interact with, which may be an inaccurate representation of the objective environment and once again lead to inaccurate results. Finally, buffers assume that children or their parents have perfect knowledge of the entire neighbourhood buffer, which is likely not the case for many people. Since all features within the buffer are weighted the same, this suggests each individual knows all of the features within the defined neighbourhood and that they are all influencing travel behaviour.

More recently, a few studies have examined characteristics along the shortest path between home and school (Scholossberg et al. 2006; Timperio et al. 2006; Larsen et al. 2012).
Although this is a methodological improvement over aggregated buffers of the home or school, errors are still introduced as children do not always travel along the shortest path (Buliung et al. 2013). Furthermore, these shortest path buffers are of varying sizes (Schlossberg et al. 2006: 400 metres; Larsen et al. 2012: 100 metres), which can influence the results and the association between environmental features. This dissertation adopts a route-based analysis, which is a methodological improvement itself, but also should be a more accurate representation of the environment.

Parental concerns are commonly associated with safety from traffic (Schlossberg et al., 2006; McMillan, 2007; Ahlport et al., 2008), yet the AST literature has very little on how actual traffic volumes or conditions affect mode of travel. One recent Canadian study used average daily counts on nearby streets as a proxy for traffic volume (Larsen et al. 2012), but the child may not actually interact with this nearby street, or traffic conditions could differ when travelling to or from school versus the daily average. The pedestrian safety literature commonly collects traffic data near the site of an injury (Roberts et al. 1995; Stevenson et al. 1995), which is an improvement over daily averages, but again the traffic conditions when an automobile physically struck the child are unknown. This dissertation aims to obtain a better understanding as to how the traffic environment relates to AST through the manual collection of traffic conditions directly around the school when children are travelling to and from school. The fleet characteristics around a school may also relate to perceptions of safety; however, as previously stated the literature has yet to examine this subject. A study by Lefler et al. (2004) reported that risk of pedestrian death was two to three times higher when struck by a light-truck or van, then when struck by a car. This finding relates to the size of vehicles and how vehicle type may related to both pedestrian safety and injury. Although it is unknown how or if vehicle type relates to safety
and mode of travel, this dissertation will aim to further the understanding of the traffic environment and school travel literature through the examination of this variable.

**Study area**

This dissertation examines how safety and the environment relate to mode of travel to and from school and the corresponding levels of physical activity in the City of Toronto. Toronto is the largest city in Canada with a population of approximately 2 600 000 people (Statistics Canada, 2011). Toronto has been developing as a city since the mid-19th century. Over this time, development patterns, the built environment, and the city’s social and political geography have changed considerably, creating city populated by a variety of neighbourhood types. The variability within the city represents an excellent opportunity to explore how different environments can affect mode of travel.

The City of Toronto can be classified into two broad neighbourhood types with unique but similar environmental characteristics, the central city and inner suburbs. A big difference between these neighbourhood types was the era of development. The majority of the central city was built prior to the Second World War and before formal planning was implemented. The opposite is true for the inner suburbs, as many of these areas are recent developments created under modern planning principles aimed at controlling land uses and transportation networks to construct organized developments. These areas offer contrasting transportation options, built environments and social characteristics, factors that may relate to mode of travel, safety and physical activity levels. The central city includes the downtown core along with other inner-city neighbourhoods, while the inner suburbs are early automobile suburbs constructed after the Second World War (Lee and Leigh 2005). Within each of these two broad classification
schemes, environmental differences also exist and by no means are neighbourhoods within the central city (or within the inner suburbs) identical; however, this method of categorization provides a degree of variability within the environment and helps to ensure the examination of multiple neighbourhood types. Targeting each neighbourhood type within the sampling frame of this dissertation allows for the possibility of developing a sample with sufficient variability in neighbourhood design features – a necessary condition for the travel and physical activity models. Government agencies such as the Canada Mortgage and Housing Corporation (CMHC) also uses this broad classification scheme to compare neighbourhood differences across the region. Finally, the large size of the central city and inner suburbs also provides researchers with an abundance of eligible schools within each region, increasing the odds of reaching the required number of participating schools.

In the central city, neighbourhoods typically have a higher residential density, mixed land uses, more connected street networks (gridded), a higher density of intersections and short straight blocks. In the inner suburbs, the streets are typically curvilinear as the road system hierarchy pushes traffic to the arterials, there is more open space, residential densities are much lower, and land uses are segregated. A series of photographs illustrates the characteristics of the neighbourhood types. The purpose of these images is to assist with the understanding of the neighbourhood characteristics within the sample school neighbourhoods in the central city and inner suburbs. To maintain anonymity, these pictures are not directly in front of the sample schools, but within the school neighbourhoods. Where the photos display arterial roadways, the sample schools were actually located a few blocks from the road depicted. The local streets shown are within a few blocks of their associated school. These photographs demonstrate features of the environment children interact with on their way to and from school. The images
on the left of the page are from the central city, while the right side represents the inner suburban neighbourhoods. I took all of these images while conducting field work and/or field surveys to validate datasets obtained from the City of Toronto. The photographs help to display certain environmental characteristics within the sampled neighbourhoods.

Figure 1.1 illustrates the differences between major arterial roadways in the central city and inner suburbs. Both streets have four lanes of traffic, but in the central city, two of those lanes are for parking, reducing the number of vehicles traversing along the roadway for most of the day (parking can be prohibited during certain times depending on the roadway). Vehicles travelling along major arterial roadways in the inner suburbs typically move at much higher speeds. Land use differences are also prevalent within the two images. Figure 1.1 (a) displays a mixed-use environment with retail on the main floor and residential apartments on the upper levels, while 1.1 (b) shows only residential units. Figures 1.2 (a) and (b) also display a similar environment, with mixed uses in the central city and residential only in the inner suburbs.
These mixed land uses have an effect on the pedestrian activity within the neighbourhood. In the central city, it is common for people to be walking along the street for purposes not related to school travel. Residents may be walking to the local hardware store, café, library or another destination but are commonly present in the environment. In the sampled inner suburban neighbourhoods, there are few destinations within the school neighbourhood aside from the school itself. Thus, few people walk in the neighbourhood who are not going or escorting children to and from school, so there are fewer people or eyes on the street.

Differences also exist in the residential areas surrounding the schools. The density of housing is much higher in the central city, with houses closer together, fewer driveways and smaller front yards (Figure 1.3 (a) and (b); Figure 1.4 (a) and (b)) than in the inner suburbs. The presence of on-street parking is much more evident in the central city. Street parking may provide a dimension of safety for pedestrians, by giving them a buffer between the sidewalks and moving vehicles. The central city neighbourhoods also have a more complete sidewalk network, with most roadways having sidewalks on both sides of the street. As Figure 1.4 (b) illustrates, in
many inner suburban areas, sidewalks may only be present on one side of the street or missing entirely (Figure 1.3 (b)). One-way streets are common within the residential streets in the central city (Figure 1.3 (a), while very few (if any) existed in the sampled inner suburban neighbourhoods. Overall, as is visible within the photographs, environmental differences exist between the different neighbourhoods in features such as density, land use, street design, parking and sidewalks.

(a) Central city

(b) Inner suburbs

**Figure 1.3**

Local residential street in the (a) central city and (b) inner suburbs example 1
This classification system of the central city and inner suburbs is not to suggest that differences do not exist between areas within the central city or inner suburbs, but rather these examples loosely classifies regions of the city with ‘similar’ built environments. Environmental differences also exist within the broad neighbourhood classifications and by no means does this sample represent every neighbourhood type in Toronto. This sampling strategy allows researchers to examine a purposeful sample that captures specific environmental differences between older neighbourhoods and newer developments but does not account for every area within the city.

Figure 1.5 illustrates the street design in the sampled neighbourhoods. In general, schools in the central city illustrate a more gridded connected street network. There are a few exceptions when topographical (rivers, ravines, lakes etc.) or built features (highways, parks) interrupt the grid like pattern. Figure 1.5 illustrates the changing street patterns over time. Even in the more recent central city neighbourhoods, a relaxation of the straight gridded streets begins to appear.
Construction of schools in the inner suburbs took place after the Second World War. The street design for schools built in the late 1940s and 1950s consists of a fragmented or warped parallel street network, which is typical for that era of development. It is not as connected as earlier networks, but is more so than those constructed near the end of the 20th century, which display a more disconnected curvilinear street design with kidney shaped crescents and an abundance of cul-de-sac's. Most of these differences in street design are observable in the maps of the sample school neighbourhoods shown in Figure 1.5. Street patterns are continually changing over time and will continue to change as development matures. Figure 1.5 illustrates the types of street networks examined in this dissertation, and what type of road network children interact with when travelling to and from school. The following chapters examine school travel safety, mode choice and physical activity across the City of Toronto in a series of three studies that incrementally build on one another, beginning with – in the next chapter, a qualitative study of parent and child perspectives on school travel safety.
Figure 1.5
Sample of school neighbourhoods and street design
Chapter 2

Child and parent perspectives on how safety influences the journey to school

Introduction

School travel patterns have changed considerably over the past half century, with declining rates in active modes such as walking or bicycling and increases in the number of children driven to school (Pooley et al. 2005; McDonald 2007, Ham et al. 2008, Buliung et al. 2009; McDonald et al. 2011). Over the same time-period in which declines were evident in active travel, rates of childhood obesity have nearly tripled in Canada and the United States (Ogden et al. 2002; Tremblay et al. 2002; Belanger-Ducharme and Tremblay 2005; Shields 2006; Wang 2011). The rise in prevalence of child obesity relates to decreases in physical activity and increases in sedentary behaviour (Weinsier et al. 1998, Goran 2008). Other confounding factors such as unhealthy eating may also explain current trends. Within the described context, the journey to and from school presents an ideal opportunity to increase levels of physical activity through the use of active modes of transport (Tudor-Locke et al. 2002, Cooper et al. 2003, Cooper et al. 2005).

In order to increase participation in active school travel (AST), an understanding of what factors (barriers and enablers) actually influence parental decisions is required. Common correlates of active travel include distance, convenience (or what is perceived to be fastest and easiest) and safety concerns. Child safety is a commonly cited barrier to active travel. The safety construct includes both safety from traffic and personal security such as fear of strangers,
harassment and kidnapping (Joshi and MacLean 1995; DiGuiseppi et al. 1998; Collins and Kearns 2001; Ewing et al. 2004; Pooley et al. 2005; Schlossberg et al. 2006; McDonald and Aalborg 2009). There is a connection between safety and risk. As stated in the introduction, safety infers that one is ‘free from harm.’ Risk, on the other hand, relates to perceived or actual threats that may make a situation unsafe. Several studies have found a connection between risk and school travel mode (Joshi and MacLean 1995; Collins and Kearns 2001; Pooley et al. 2005). For the purpose of this dissertation, risk relates to how parents and children feel when they are faced with certain elements related to travel mode and environment (Slovic 2000; Cloutier et al. 2011). Although these questions may seem to be easy to answer, they are actually very complex. Respondents are expressing their concerns on how they feel about traffic and personal security concerns; but other outside features such as the media can also influence one’s thoughts regarding risk.

**Conceptual framework**

Comparisons of how parents and children perceive the environment aims to build a stronger understanding of the connection between safety and school travel. This work uses a multidimensional framework informed by the sociological and geographical understanding of childhood. Much of the previous literature uses adult-centred themes to examine children’s mobility. Furthermore, the gender of the child may also influence travel patterns, but is not always examined. The framework for this study acknowledges that the school travel experience may differ in relation to both gender and the fact that children and parents have different ideas and concerns.
Most of the qualitative work to date examines how parents or adults perceive safety for children (Joshi and MacLean 1995; Fesperman et al. 2007; Greves et al. 2007; Baslington 2008; Eyler et al. 2008; Lang et al. 2011; Price et al. 2011; Zuniga 2012). Exploring the fears of the parent likely relates to the fact that parents are commonly the decision makers when it comes to a child’s mode of travel (McMillan 2005). However, there is likely a disconnect between how parents and children perceive their environment and safety. It is impossible for parents to comprehend what children experience (Ward 1977). Children’s concerns regarding their school trips may relate to features that are not obvious to adults, as they interact and perceive the environment differently. Researchers argue that the needs and concerns of children differ from adults, (Brannen and O’Brien 1996; Prout and James 1990; James et al. 1998; Holloway and Valentine 2000), meaning children have their own concerns and ideas.

In the end, I aim to obtain a better understanding of exactly how safety concerns and the environment relates to school travel for both children and their parents. The fact that concerns of the child and the parent are examined separately is a methodological contribution to the current literature. Findings from this qualitative chapter will also guide the remaining quantitative pieces, as the ideas and concerns of parents and their children will be further explored.

For this chapter, the belief is that the school travel experiences vary across neighbourhoods and socio-spatial environments, thus sampling accounts for different neighbourhood types. This paper examines how parent and child safety concerns relate to school travel and how these concerns vary by gender, mode of travel, built and social environment. The primary research questions of this chapter are: 1) how do safety concerns differ between parents and their children; 2) how do safety concerns vary by primary travel mode to school; 3) how does the experience of school travel safety change across built/social environments and what is the
relationship between the environment and safety concerns; and 4) what is the relationship
between gender and perceptions of school travel safety? This work uses secondary data; other
research members conducted the interviews that were available to me in order to explore the
connection between safety and school travel. Previous work with this dataset has examined how
parental decision-making relates to mode choice, and how qualitative methods can be used to
explore AST (Faulkner et al. 2010, Fusco et al. 2012). Health researchers have completed
previous analysis on this dataset, while this chapter examines safety under the lens of the
disciplines of geography and planning. Following a brief review of the literature a section will
explain the methods used followed by the results and then a discussion of findings.

**Background**

Previous work has found distance, convenience and safety to be common correlates of AST.
Distance between home and school is one of the most common factors related to mode choice, as
distance increases, the likelihood of active travelling decreases (Ewing et al. 2004, McMillan
2007, Larsen et al. 2009, Mitra et al. 2010). Convenience may also influence mode choice as
parents often drive because it is easier to structure it into other daily household activities (Ewing
also typically perceive that driving saves time (Ewing, et al. 2004; Schlossberg et al. 2006;
McDonald and Aalborg 2009; Faulkner et al. 2010), but this may not always be the case. There
are other external and personal costs attached to this quest for time-savings (Tranter 2010).
Previous work has found that time spent working in order to afford the benefits of automobility,
often outweighs the potential time-savings for short trips (Tranter 2010).
Child safety is another factor related to mode of travel (DiGuiseppi et al. 1998, Collins and Kearns 2002, McMillan 2007, Ahlport et al. 2008, Wen et al. 2008). As previously stated, the child safety construct includes being free from risks associated with both personal security (e.g., kidnapping, harassment) and traffic. The literature review reported full details on the relationship between safety and school travel (P. 14). Most qualitative studies highlighted the importance of child safety (Joshi and MacLean 1995; Eyler et al. 2007; Greves et al. 2007; Mitchell et al. 2007; Ahlport et al. 2008; Fesperman et al. 2008; Kirby and Inchley 2011; Lang et al. 2011; Price et al. 2011; Zuniga 2012). Fear of strangers or abductions, fast moving traffic and inadequate sidewalks were factors associated with mode choice in one U.S. study (Eyler et al. 2007). In Seattle, the fear of traffic and personal safety was a barrier to active travel, but the study only examined low-income neighbourhoods (Greves et al. 2007). A comparative case study of two schools in North Carolina found parental fears of the child’s personal safety and the risk of kidnappings to impede active transport (Fesperman et al. 2008). Also in North Carolina, fear of child abduction was the number one barrier to active travel, while a supportive environment that included sidewalks and safe street crossings was important in its promotion (Ahlport et al. 2008). Personal security risk was one of the most perceived barriers related to AST in Scotland (Kirby and Inchley 2011), while research in New Zealand has highlighted the importance of road safety (Lang et al. 2011).

When examining the previous qualitative work on school transport, most studies only examine how adults perceive the environment (eight of the 10 reviewed). Only one study interviewed both parents and children, but did not examine how gender influenced safety and school travel, while the majority did not even address this issue. Furthermore, most studies also did not examine how neighbourhood income or the built environment relates to safety and school
travel. The sampling frame of this chapter targets neighbourhood differences, compares parents' and childrens’ perspectives and examines how gender associates with safety and school travel. These aspects of the sampling frame will shed light on how those features influence safety and mode choice, and will represent a contribution to the current qualitative literature on school travel and safety.

**Methods**

This dissertation was set in the City of Toronto, Canada’s largest city (Statistics Canada 2006). The sampling strata included one school from each of the following categories: high-income and central city (n=1); low-income and central city (n=1); high-income and inner suburbs (n=1); low-income and inner suburbs (n=1). High-income neighbourhoods were defined as those schools in census tracts with household income levels in the top quartile (above the 75th percentile -- >CDN$69 072.50), whereas low-income neighbourhoods are within the bottom quartile of households in the city (below the 25th percentile -- <CDN$40 003.50). The only method of class examined relates to socio-economic characteristics of the neighbourhood that were embedded into the sampling design. Several differences also exist when it comes to the built environment and sampled schools. The previous chapter presented full details on the types of built environments in Toronto (see page 24). The sampling frame of this dissertation does not include all neighbourhood types, but rather a sample of a few. Figure 2.1 illustrates the central city and inner suburban areas of the city. Stratifying the sample by geographical location allows for exploration of neighbourhood and individual differences. Household characteristics such as automobile ownership that may influence travel patterns also differ between residents of the central city (0.83 vehicles), and its inner suburbs (1.19 vehicles) (TTS, 2006).
Five motorized and five active travel child/parent dyads were recruited from each school. Dyads consisted of a child at a participating school and one of their parents. Motorized travel refers to any mode of travel to school by motor vehicle (e.g., passenger vehicle or transit), while active transportation consists of walking, cycling or skateboarding. Semi-structured interviews were conducted separately for grade 5 children (n=37) and their parents (n=37), allowing the researcher to independently examine how and what individual concerns exist regarding school travel. Ideally, the sample would have been of 40 parents/children (i.e., 10 dyads per school), but two parents were not able to complete the interview and one parent declined the interview process. Codes assigned to each transcript inform readers about the geographical and social stratum hosting each respondent, along with their typical school travel mode and gender. For example, the code CCHNON boy describes a: Child, Central city, High-income, Non active traveller who is a boy while PILAST describes a: Parent, Inner suburbs, Low-income, Active School Traveller. Codes ensure that both the school and participant can remain anonymous. See Faulkner et al. for more details on the data collection process (2010).

Figure 2.1
Example of broad neighbourhood classification types in the City of Toronto
Participants were asked about how the environment influences their journey, barriers to active travel and whether they feel safe (questions were not guiding the interviewees to answer specific safety concepts). The nature of the interview process allows for some structure to addresses certain concepts, but still lets the respondent talk about his or her own concerns related to school travel and the environment. Respondents were allowed to talk about their concerns and what was important to them, but the interviewee also asked certain questions to help guide the interview process. Examples of some of the types of questions asked for parents included: what factors influence decisions regarding how your child gets to school?; how else could your child get to school?; do you have any concerns when travelling to school? Children on the other hand had similar questions: what do you like about your trip to school?; are you concerned about anything while travelling to school?; what do you like to look at while travelling to school? The interview process lasted between 45 minutes and one hour for each participant (separate interviews for parents and children). This semi-structured interview process allows the researchers to obtain knowledge of the interviewee’s perspective about the trip to school. Nearly half of the sample was boys (49% versus 51% girls) (Table 2.1). The median age of the children interviewed was 10 years (ages ranged from 8 to 11 years), while the median age of parents was 41 years. The median distance to school for the full sample was 805.6 metres. Most respondents reported using the same route on a daily basis (78%). More than half of the interviewed participants (54%) used an active mode of travel to school. These rates were higher for boys (58 %) than girls (34 %). For motorized travel, only two students took transit and the remainder were driven.
Table 2.1
Descriptive statistics for participants

<table>
<thead>
<tr>
<th>Description</th>
<th>n</th>
<th>Percentage</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance between home and school (m)</td>
<td>37</td>
<td>---</td>
<td>1766.95</td>
<td>805.56</td>
<td>2.561.19</td>
</tr>
<tr>
<td>Same route daily? (Yes)</td>
<td>29</td>
<td>78</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Number of vehicles per licensed driver within the household</td>
<td>37</td>
<td>---</td>
<td>0.86</td>
<td>1.00</td>
<td>0.42</td>
</tr>
<tr>
<td>Average age of sampled children</td>
<td>37</td>
<td>---</td>
<td>9.72</td>
<td>10.00</td>
<td>0.77</td>
</tr>
<tr>
<td>Average age of sampled adults</td>
<td>37</td>
<td>---</td>
<td>41.80</td>
<td>41.00</td>
<td>6.25</td>
</tr>
<tr>
<td>Number of years at current home</td>
<td>34</td>
<td>---</td>
<td>7.00</td>
<td>6.00</td>
<td>5.16</td>
</tr>
<tr>
<td>Number of years at current school</td>
<td>35</td>
<td>---</td>
<td>5.89</td>
<td>6.00</td>
<td>1.55</td>
</tr>
<tr>
<td>Number of boys in child sample</td>
<td>18</td>
<td>48.6%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Number of girls in child sample</td>
<td>19</td>
<td>51.4%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Number of mothers in adult sample</td>
<td>30</td>
<td>81.1%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Number of fathers in adult sample</td>
<td>7</td>
<td>18.9%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Number of children walking to school</td>
<td>17</td>
<td>45.9%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Number of children driven to school</td>
<td>18</td>
<td>48.6%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Number of children taking transit to school</td>
<td>2</td>
<td>5.4%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Sometimes allowed to walk alone or with a friend</td>
<td>4</td>
<td>10.8%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Allowed to take transit alone</td>
<td>1</td>
<td>2.7%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Number of families where English is spoken at home</td>
<td>31</td>
<td>81.6%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Highest level of education obtained, college or higher</td>
<td>28</td>
<td>73.7%</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Adult accompaniment was common for most students. Only four students claimed they were allowed (or sometimes allowed) to walk with friends or alone to school, while one student took transit alone. Mothers typically were responsible for supervising school travel (70% of cases). Fathers were sometimes involved in the school travel with the mother, but in only two cases was the father reported as being the primary chaperone for the school trip. In most cases, the participating adult was also the child’s mother (81%). Residents had lived at their current address for an average of six years, and 82% spoke English at home. Three adult participants had a first language other than English. Interpreters assisted with these interviews to enable participation from these respondents. Adult respondents were typically well educated, with 74% holding a college diploma or university degree.
The process for thematic analysis of the interview data adopted previous methods used by Braun and Clarke, where themes represent something important or some type of patterned response related to the research question (2006). Although other researchers on the team conducted the interviews, I performed all of the analysis of the secondary data. Transcripts were read line by line and any sentence, phrase or clause related to safety was assigned a code. Although no specific themes or codes were compiled prior to reading the transcripts, previous knowledge obtained from reading the current literature indeed shaped some of the themes. This process used the transcripts to come up with the codes, but previous interaction with the school travel literature undoubtedly shaped some of my ideas pertaining to safety. For example, if a participant stated they were uncomfortable walking because they feared street crossings, this phrase would be coded for street crossings. This code came from the transcripts, but was also built around the previous knowledge pertaining to traffic safety and children. Coding also took place for factors related to easing safety concerns, such as crossing guards, crosswalks or safe arrival programs. Once completed, the codes were contrasted against each other and all related codes were grouped thematically. For example, all codes related to ‘traffic safety’ (street crossings, heavy traffic, vehicles around the school, etc.) were grouped together under their common theme. At this point, charts grouped all themes separately for each parent and child (Pope et al. 2000) to examine the two broad themes of personal security and traffic safety. The charting process consisted of reporting what themes for both traffic safety and personal security were relevant for each participant. One chart examines the parent’s data and another the child's to facilitate our understanding of the similarities and differences. See Appendix A for the completed charts. The themes were reviewed to ensure they were supported by the data. In total, the transcripts were read a minimum of five times to ensure accuracy with the coding and
themes. Once all checks were completed, the themes were organized into concept maps showing how safety was important to both parents and children (Figure 2.2).

Data were then stratified by neighbourhood type (built environment and income), and travel mode (active and motorized). Similarities and differences were added to the charts for the various strata for example, if personal security concerns were evident in low-income neighbourhoods but not in the high-income inner suburbs, this was noted in the data. Concept maps were then created for the four neighbourhood types to illustrate the similarities and differences related to the environment and safety (Figure 2.3).

![Flow chart describing themes related to safety for children and parents](#)
Results

This results section will explore concerns of personal security, first across all neighbourhoods, respondents and modes. Following this section analysis will examine how safety concerns vary by travel mode, between parents and children, and by neighbourhood type. Throughout this section, results highlight the connection between the child’s gender and safety. Finally, the discussion reports approaches to alleviating some of the identified concerns. For traffic safety concerns the data are examined using the same organizational structure.

There were several themes related to both personal and traffic safety evident in the transcripts. The concept map, (Figure 2.2) illustrates the connection between themes and their relation to safety. Inclusion of themes relates to both quantity (number of children/parents with a concern) and severity (e.g., only a few students/parents had concerns but they were extremely important). At first glance, safety appears to be entrenched in the school travel process, and differences exist between parents and their children. Children appear to have a different and broader set of potential safety concerns than their parents, including far of bullies and dogs. Parents are more likely to identify traffic concerns and the fear of strangers.
Figure 2.3
Flow chart illustrating neighbourhood differences in themes related to safety

**Personal security concerns**

As expected, the fear of strangers or ‘kidnappings’ was a consistent concern for the majority of parents (Figure 2.2). When asked, "What are your biggest hesitations or fears about your child walking to school alone?" One parent responded:
“Somebody approaching her. I think she would make smart decisions not to approach people, but she’s so tiny that I’d be afraid that, you know, a car driving up the hill, some wacko grabbing her and putting her in the back of the truck.” (PCHNON: Mother of girl)

Another parent in the central city was asked the same question and replied:

“Obviously everybody’s hesitation is, you know, she might meet a stranger on the way to school.” (PCHAST: Mother of girl)

Many children were also concerned about strangers and walking alone to school; however, their fears were not as evident as they were in parents’ transcripts. When a child was asked what makes it difficult to walk to school, he responded with:

“People and stuff, sometimes they can like kidnap me and stuff.” (CILNON: Boy)

Another child was asked about not wanting to walk alone and replied:

“Because that there could be someone strange or something.” (CCHAST: Boy)

Although it was not common, there were four parents with active travellers who seemed less concerned about the risk of abduction or were at least willing to allow their child to travel alone on occasion. One caregiver who let their child walk alone was asked whether they were concerned about strangers and responded:
“I don’t want to live in that fear, otherwise you’d never let them do anything.” (PCLAST: Mother of boy)

Although stranger concerns were evident, many children were actually more concerned about bullies or teenagers.

“All the putdowns and the pushing and they would be pretty mean.” (CCHNON: Girl)

“Bullies who used to go to our school, they were walking together and they were walking the same way I was.” (CCHAST: Girl)

When they were asked who they wanted to walk with, children often rejected “big kids” or teenagers because they are more likely to be bullies. While most children were concerned about bullies, it was not mentioned in the parents’ transcripts they seemed more concerned about abductions from adult strangers (Figure 2.2).

Children also seem to have safety concerns relating to the presence of dogs. One child was worried because:

“You don’t know if they are going to sniff you or if they are going to jump up and claw you.” (CCHAST: Boy)

Another child was asked what they didn’t like about walking to school and responded:
“Like stray dogs. I just saw a dog that I know, like a stray dog and it always barks at me. Then I have to run, because when dogs hate you, they could get really scary and they will attack you for no apparent reason.” (CILAST: Boy)

Or another was asked what makes you feel unsafe and the child stated:

“Dogs make me feel unsafe.” (CILAST: Girl)

Although they represent common fears for children, only one parent mentioned dogs as being a concern for her child and that particular child did not talk about their concern with dogs. Bullies were not mentioned at all in the parent transcripts.

When intra-household parent-child differences in safety perspectives were explored (with the child and parent), many children had different views on personal security concerns than their parent(s). Parents and their children both shared the fear of strangers, with children having additional concerns related to bullies, teenagers or dogs. This finding is important as it suggests different factors are at play concerning travel to and from school, as children perceive and experience threats differently from their parents. Children consistently had fears of bullies or dogs, while their parents were worried about strangers, regardless of neighbourhood type.

This intra-household analysis also explores how gender relates to school travel and risk. The examination of gender consisted of looking at the difference in perceived risk between boys and girls, and also how parents’ concerns varied according to the gender of their child. Boys and girls had similar personal security concerns, with dogs, bullies and strangers all being factors
regardless of gender. Previous work has stated that boys are more likely to report physical abuse and girls verbal abuse (Pagilia-Bloak et al. 2012). The children in this study did not discuss these specifics. Both boys and girls discussed concerns over strangers, but these fears were more evident for girls. One girl stated:

“I had nightmares and stuff that reminds me of it. [In these dreams] I have seen strangers and adults take me away. And then when I yell for help, people don’t know me and they don’t want to come rescue me.” (CCLNON: Girl)

Parental safety concerns appear to vary based on the gender of their child. Nearly twice as many parents of girls had concerns about strangers and the risk of abduction. One parent was asked why her daughter was not allowed to walk to school and responded:

“You know, there’s strange people around, I’m afraid of that.” (PILNON: Mother of a girl)

This type of response was common for parents with daughters. Their children commonly echoed these fears as well, and mothers and daughters commonly shared concerns about stranger danger. One parent stated their concern was:

“So obviously everybody’s hesitation is, you know, she might meet a stranger on the way to school. We’ve talked about the scenario and what you could do.” (PCHAST: Mother of girl)
While children may not exactly perceive the risk in the same manner as their parent, they do understand the concerns. One child stated:

“Like, my parents, I know, are always strict about not talking to strangers. Like, if I am not walking with my sister, and I am leaving before my mom leaves, she’s like, ‘Remember no talking to strangers.’ Well you told me that in grade four.” (CCHAST: Girl)

Easing concerns

Travelling in groups emerged as a possible method for alleviating children’s concerns about personal injury. Children liked the idea of group travel and commonly responded that they would feel safer because if someone tried to hurt them, other people could help or scare the attacker away. When one active traveller was asked whether she felt safe, she replied:

“I would feel safe if I was walking in a big group, but if I was walking alone I wouldn’t really.” (CCHAST: Girl)

These responses were common among both active and non-active travellers. A child who was driven to school stated travelling in groups is safer:
“Because if the kidnapper tried to get all of us, he couldn’t. And if he just took one of us, we would know right away to call the police and it’s safe with a lot of people.”

(CCHNON: Girl)

“If children walked together in a group and big bullies come, it won’t be easy for the big bullies to catch them because there will be so many.” (CCLNON: Boy)

While most parents did like the idea of travelling in groups, reservations remained. Many parents were not comfortable letting their child travel to school without adult accompaniment even when travelling in larger groups. They did state that eventually when their child was older they would be more open to the idea of allowing their child to travel with a group of friends, but not at their current age. When one parent was asked about this she responded:

“Yes, older, probably 12, 13, but with a group of friends, not by herself.” (PILNON: Mother of girl)

No general neighbourhood differences existed regarding questions about whether respondents felt safe in their community, but specific differences were evident from the transcripts. Parents living in high-income neighbourhoods (both central city and inner suburbs) were more likely to indicate they had a safe route between their home and school, and in fact, perceived their routes to be very safe. One respondent said:
“We’re really lucky that we have a nice route, it’s not that far, it’s very safe.” (PCHAST: Mother of girl)

In contrast, one parent whose child attended a lower income school said she did not like her child walking alone and, when she was asked why she was hesitant responded:

“This basically what’s going on around, you know. When they hear the name of the area everybody, ears rise up, you know. But there was an incident one time when my daughter’s friend was walking to school and there was one guy from high school approach them and ask them for money and these things and they were scared. So things like that, and other things other parents are talking about, I won’t allow them to walk by themselves.” (PILNON: Mother of girl)

While personal security was also a concern at schools located in wealthier neighbourhoods, it was more dominant in lower income neighbourhoods. Nearly the entire sample of low-income respondents discussed personal security, the majority of parents and children in high-income neighbourhoods did not mention these concerns.

The concept map in Figure 2.3 illustrates the organization themes identified for each neighbourhood type. Factors such as the presence of dogs were more important for children living in the low-income inner suburbs. Personal security in general was much more of a concern in low-income areas. In general, the concept map by neighbourhood type illustrates how
the construct of safety is important for everyone regardless of neighbourhood, but these concerns are not uniform and experiences differ based on where you live.

**Traffic safety**

As Figure 2.3 displays, traffic safety was more of a concern for parents and children living in higher income neighbourhoods. Surprisingly, parents living in the high-income inner suburbs only expressed traffic concerns during the interviews. The most common traffic concern for both children and their parents was crossing busy streets. One parent driver was asked why their child didn’t walk to school. They replied:

> “I think it’s safety. In my case, crossing one of the busiest streets, parents don’t want their kids doing that.” (PIHNON: Mother of a girl)

When another parent was asked to name the greatest factor that influences travel mode to and from school, the reply was:

> “I would say up until now, with our kids, has been the volume of traffic and getting across the busy street.” (PIHNON: Father of girl)

Although it is more of a concern for parents, children also have reservations when it comes to crossing streets. One non-active traveller was asked why they didn’t want to walk to school and she responded:
“Well, there’s a lot of traffic and it would be unsafe when you are crossing the road.”

(CCHNON: Girl)

It is unclear whether children are concerned about street crossings, or if they are merely reflecting the fears of their parents. Children perceive risk based on their life experiences, interaction and the adoption of their parents’ views (Murray 2009).

There were few household differences between the parents and their children with regard to traffic safety. Traffic safety concerns were generally uniform throughout household dyads, although parents had greater reservations and fears. When parents did not have concerns over traffic, their child typically felt the same way (see Appendix A for comparison of children and their parents). Furthermore, when parents worried about street crossings or busy streets, their child usually expressed similar concerns. Essentially, children mirrored the concerns of their parent.

When examining gender, boys and girls had similar concerns relating to traffic. Street crossings were concerns for both boys and girls. Findings from the parents were also consistent irrespective of their child’s gender. Unlike the increased concern parents had about their daughters and the risk of abduction, no gender differences were evident regarding traffic safety and their child. The following statements by mothers relate to traffic safety and their child:

“A child should not cross the street alone until they’re 10 because their judgment is just no, you know, their brain isn’t developed to the point where they can actually judge where the car is.” (PIHAST: Mother of boy)
“It’s maturity, age for sure, and the route home is, it’s a major intersection she would have to cross.” (PIHNON: Mother of girl)

In both of those statements, the parent talks about maturity and the age of their child in relation to their judgment regarding street crossings. Gender of the child does not appear to play a role in these concerns.

In addition to concerns about the crossing of major streets, parents were also concerned about the high volume of vehicles around the school.

“It’s also that on the street beside the school, there’s no real place for them to cross, so that’s been a bit of an issue about where they safely cross. I don’t like them to cross in front of the school here where the parking lot is because people park right beside the school yard, like right on the side of the road, not on the sidewalk, parked legally, but it’s just hard for them to see traffic and traffic is coming uphill so they’re not really, you know, looking for kids. So that’s an issue of crossing safely.” (PCHAST: Mother of girl)

Another parent was asked how traffic around the school is in the morning,

“It’s insane, it’s dangerous, there’s not enough parking for the amount of people that drop off their kids. Oh, it’s been an issue ever since I’ve brought my daughter to this school, for sure.” (PIHAST: Mother of a girl)

One parent was concerned about traffic around the school because:
“A few years ago a little child got hit right in front of the school. The guy stops, came around the car, the other guy didn’t see it and he just came right along and he hit her.”

(PILNON: Father of a boy)

Another parent said she drives her child to school because there are too many vehicles on the road and it is not safe to walk, but realizes she is contributing to the problem. She stated traffic concerns are her biggest fear:

“I think it’s just the busyness on the roads . . . which we’re not helping by driving, but ... [laughs].” (PIHNON: Mother of a boy)

While parents had concerns about the traffic around the school, none of the children commented on this issue. Parents were also concerned about the child’s maturity level for crossing streets and cite that as a reason for driving their children.

“He’s not at that stage yet. I don’t think he’s responsible enough to cross the street by himself. I don’t think it’s safe.” (PILNON: Mother of a boy)

Another parent had a similar view:
“It’s a maturity thing. Ten, you’re still not, you couldn’t leave them at home alone, so why would you let them walk home alone? And, she has to cross a major street to get home, that’s big.” (PIHNON: Mother of a girl)

It seems that the age of 12 or grade 6 is when parents start to believe the child is mature enough to travel without parental supervision. One parent who drove their child to school was asked what it is about grade 6 that makes her feel like her child can walk by himself.

“Well he’s more mature, much older. He’s moving on to a middle school, obviously he’ll have friends. Maybe by that time, from now until then we’ll decide on that. Because I have two other boys as well, much older, so they at grade 6 they basically started taking care of themselves, walking themselves to school and back and stuff like that. Until then I wouldn’t let my youngest son do it by himself.” (PILNON: Mother of a boy)

Parents also have reservations about crosswalks. When one parent was asked whether she liked crosswalks she laughed and responded:

“There’s been a couple of people hit at the crosswalk. So there is that thing about the crosswalks and it’s easier to explain to kids that a green light is safe to walk than a crosswalk, even if you use a crosswalk, you still have to be really careful that the cars see you and stop.” (PCHAST: Mother of a boy)

Another parent said:
“Crosswalks scare me, they scare me to death. Not all the drivers stop, you know [laughs]. I think that’s scary, so I always wait, press the button, wait until all the cars stop and then I go. And my son, he’s not an adult, he’s smaller, so from a driver’s perspective you can’t always see at that level if you’re not looking for it. People don’t always look for kids.” (PCLNON: Mother of a boy)

Although no neighbourhood differences were evident in the children’s transcripts, parents in high-income inner suburban neighbourhoods were more concerned about traffic safety than personal security (Figure 2.3). Traffic fears were also more evident among parents who drove their children to school (also see Collins and Kearns 2002). One parent who lives in the inner suburbs was asked why they drive to school and she responded:

“Well, because we’re the parents and we’re looking after them so we have to find the best ways to send them to school. And driving is best because if they were to walk there is a lot of traffic going on and a lot of people are in a rush and I don’t think it’s safe for the kids to be walking where there’s so many cars going through because we live really close to an avenue.” (PIHNON: Mother of a girl)

Another parent in the same neighbourhood drives her child to school because:

“In the morning it’s very heavy traffic. It is quite hectic and my street is very busy so I wouldn’t trust him to walk at all.” (PIHNON: Mother of a boy)
Similarly, the issue of sidewalks was only talked about by parents living in the high-income inner suburbs (Figure 2.2). When asked why they did not walk to school a parent said,

“Even if I wanted to in the summer we have no sidewalks.” (PIHNON: Mother of a boy)

Other parents noted that sidewalks are an important feature and missing on several streets. Only parents in the high-income inner suburbs discussed concerns about sidewalks, while children and parents living in other neighbourhoods did not talk about sidewalks in relation to safety. This likely relates to the presence of sidewalks in the other neighbourhoods, as only one school neighbourhood was missing sidewalks on some streets.

*Easing concerns*

Parents had various approaches for dealing with traffic concerns. Many adults would escort their child to and from school either in a vehicle or by walking with them, while others would spy on their kids or call the school secretary to ensure they arrived without harm. Parents comments in this regard included:

“We spy on our kids.” (PCHAST: Mother of a boy)

“I still call the secretary and say are the three of them there?” (PILAST: Mother of a boy)
“I prefer to accompany him because I don’t know what will happen safety wise and does not want to risk it.” (PCLAST: Mother of a boy)

One parent made sure his daughter crossed the street on top of the speed bump to increase the height and visibility of his young child.

“So now they actually cross on the speed bump on the top.” (PCHAST: Mother of a girl)

The employment of crossing guards was a commonly mentioned approach to easing traffic concerns, although most parents were not convinced that crossing guards improved safety. One parent who drives their child to school stated:

“The crossing guard can’t do anything. She’s not about to, or he’s not about to step in front of a moving car. And, you know, they’ve learned, you can talk to the crossing guards, they’ll tell ya, they put the sign out, they blow the whistle, but they don’t leave the sidewalk for the first five or six seconds either because chances are they aren’t going to stop.” (PIHNON: Father of a girl)

Another parent stated they [crossing guards] do nothing to calm fears:

“He’s not a policeman, cars don’t necessarily obey. If they’re aware I guess they’re not going to purposely nail a person, but they’re generally older people, retired, maybe hard of hearing.” (PIHNON: Mother of a girl)
Responses from parents whose children walk to school were more mixed. Many liked the idea of crossing guards, but were still concerned because they can only be at one intersection at a time. Crossing guards seem to reduce children’s concerns about street crossings for both active and motorized travellers. One child who walks to school was asked what they thought about crossing guards and said:

“I think it makes everything safe for the children. Because there may be no lights, so they would go out and tell them to stop or the lights not working. They go and tell them to stop so that the kids are not late for school. And they could also be your friend, like they could make friends seeing the crossing guard everyday.” (CCHAST: Boy)

Another child who is driven to school stated:

“I think they help children because they direct traffic so, like say there’s a child who crosses the street and doesn’t look both ways. They’re going to hold up the stop sign and the people in the cars are not going to drive over the crossing guard.” (CCHNON: Girl)

One child didn’t like crossing at crosswalks or traffic lights as he did not trust people would stop. He only felt safe crossing with a crossing guard:

“Because people don’t listen to the lights. When I press the button, they don’t listen.”

(CCLAST: Boy)
Another child said crossing guards make him feel safe:

“Cause the stop guard always stops. There are two stopping guards. One of the other one stands there and one is on the other side and they tell the car to stop and that’s really why I feel safe.” (CCLAST: Boy)

Discussion and conclusion

The purpose of this chapter was to explore how parents and children conceptualize safety, and how concerns vary between parents and children, across neighbourhoods and by school travel mode. This chapter also analyzed the connection between gender and school travel (both from the child's and parent's view). Parents and children did have differences when it comes to personal security concerns. Parents were mostly worried about strangers, while children tended to discuss the importance of bullies, teenagers and dogs. These findings have appeared in other qualitative studies examining children and school travel (Greves et al. 2007; Ahlport et al. 2008). These findings were highlighted within this chapter, which examined parents and children’s ideas about perceptions of safety separately.

Children of all ages are concerned about bullies. Recent research completed at the Provincial level in Ontario suggests that nearly 30% of grade 7 to 12 students’ claim they have been bullied (Pagilia-Boak et al. 2012). Other studies have exposed links between bullying and school travel (Greves et al. 2007, Ahlport et al. 2008). It appears that bullying is indeed a major issue for Canadian youth. Bullying in the school context is thought to be occurring at school, but this chapter suggests that school related bullying extends beyond the schoolyard and into the
streets. Bullying continues outside of the school-yard, as most children in this study were concerned about bullies during their school travels irrespective of the neighbourhood, gender or mode of travel. Children identified ‘the bully’ as their most imminent concern related to personal security, rather than their parents concerns over ‘the stranger’; and indeed a bully may or may not be stranger to a child. Children may be more concerned about bullies than abductions/strangers when it comes to personal security, as they see bullying as a more immediate and real threat.

This chapter presents another way in which bullying can be negatively influencing one’s health. Recent media attention has emphasized the importance of trying to curb bullying or even making it illegal (Anderssen 2011; Canadian Press 2011). Many celebrities are also supporting the anti-bullying initiative, which highlights its importance to today’s youth (Toronto Star 2011). With the recent media attention on the significance of bullying, it is possible that redoing the interviews today would produce different findings and bullying would become an important theme for parents. Bullying was not as common a topic in the local media during the interviews process as it is today. This recent attention has likely helped to inform parents of bullying concerns. The provincial government has recently taken steps to curb bullying in schools, by creating an act to ensure support is available for those who need it and giving tougher consequences for bullies (Government of Ontario 2012). This is an important preventative step towards resolving the issue, although more work needs to be done at all levels of government and within the schools themselves.

The fear of dogs was an interesting finding as it was not anticipated and not common in the school travel literature. This finding likely relates to a child’s knowledge and perception about real threats. A few children talked about how a dog attacked someone he or she knew.
While child abductions are much more serious events, they are exceedingly rare. Children appear to see dog attacks as a more pressing issue, something that seemed barely on the radar for parents. The enforcement (and informing students of the enforcement) of dog leash by-laws may be the easiest way to reduce these fears.

A connection exists between gender and school at multiple levels. Findings from previous work commonly indicate that girls are less likely to walk or bike to school than boys (McMillan et al. 2006; Mermon et al. 2006; Yarlagadda and Srinivasan, 2008; Mitra et al. 2010; McDonald 2011; Stewart et al. 2011; Larsen et al. 2012). When it comes to this chapter, gender emerged as an important factor, as boys were less likely to express fears about strangers than girls. Furthermore, parents with sons were also not as concerned about strangers.

It is important to understand the amount of responsibility mothers incur by supervising school travel of their child. For this sample, nearly three quarters of the adult respondents were mothers who were also escorting their children to and from school. These findings are comparable to other work from England, where 78% of mothers were responsible for supervising their child’s trip (Joshi and Maclean 1995). This highlights an important consideration regarding school travel data. First, mother's have completed most of the survey and interview responses to date, giving researchers a female dominated response regarding ‘parents’ ideas. Little discussion addresses how to engage fathers into the school travel process. Research should aim to explore this concept to get a better understanding of how fathers’ lives and perceptions relate to their child’s school travel.

Findings demonstrated a heightened fear of strangers for both the interviewed female child and parents with daughters. Previous work by Joshi and Maclean reported that boys and girls had similar concerns regarding strangers (1995). This chapter adds new light to discoveries
about gender and strangers for school travel. Over the years, many researchers have examined the connection between girls and mobility. Studies have suggested that girls have more restricted mobility, greater safety concerns (Steinberg 1987, Peters 1994, Valentine 1997) and different perceptions of risk than boys (Gustafson 1998). Findings from this chapter suggest that a connection also exists regarding school travel. School travel policies need to address the influence of gender and personal security concerns.

Although many studies examine how ethnicity/race along with gender relates to health behaviour (Kerr et al. 2007; Lim et al. 2007; Wang and Beydoun 2007; Morrison et al. 2012), the ethnicity/race of the parent and child were not examined in this dissertation. Data were collected on the ethnicity of the parent and where the child was born, but the breakdown of the sample made it difficult to categorize and analyze. There were 18 different ethnicities reported for adults, with many people indicating more than one ethnicity (Canadian/Greek or Canadian/Chinese). For children, only four were born outside of Canada, while the balance reported Toronto, Ontario or Canada as place of birth. The location of birth is also not always representative to what one may consider their race or ethnicity. The child’s parent may consider itself something other than Canadian, while their child was born in Canada. Does this make the child Canadian or is their ethnicity based on their parents’ background and cultural upbringing? In addition, what does it mean to be Canadian, and are there ethnic differences within different regions of Canada? In a diverse country with two official languages and people from all over the world, what does it mean to be Canadian? In order to understand how ethnicity relates to school travel there are some difficult conceptual issues to address. Future work should try to examine how ethnicity/race may relate to school travel patterns in Toronto, but this is beyond the scope of this dissertation.
Most qualitative studies find street crossings to be an important factor related to active school travel (Eyler et al. 2007; Greves et al. 2007; Fesperman et al. 2008), while quantitative studies on children’s travel and street crossings have mixed results (Schlossberg et al. 2006, Wen et al. 2008; Larsen et al. 2012). These mixed findings may relate to how these concerns are measured. In quantitative studies, the ‘number of street crossings’ is measured along the route or in the school neighbourhood. In qualitative studies, children or parents are talking about perceived street crossings. It appears that these perceptions of street crossings are an important predictor related to safety and travel mode, but they may not relate to actual objective measurements. These differences likely relate to the measurement or definition of street crossings (e.g., major versus local). Findings from this chapter demonstrate the importance of major street crossings for both parents and children irrespective of gender.

All parents have reservations about traffic safety, but parents in the high-income inner suburbs discussed this topic more frequently and in greater detail. This finding relates specifically to the environment of this inner suburban high-income school. There was a major road in front of the school, thus many children would have to overcome this barrier and cross the street. Furthermore, when this neighbourhood developed, sidewalks on residential streets were less common; consequently, respondents from this neighbourhood raised concerns over having a safe place to walk. Field analysis of the environment determined that this truly was the only school neighbourhood examined where some of the streets did not have sidewalks. Even if there were sidewalks on all of the streets in this neighbourhood, it is still unlikely that everyone would walk to school, but it would possibly ease safety concerns for some parents. Sidewalks are indeed important for parents in this neighbourhood and this does suggest that the built
environment plays a role in mode choice, but this needs to be verified with additional studies and larger sample sizes.

One important finding for traffic safety relates to the streets surrounding the school itself. Many parents were concerned about the number of vehicles and vehicle circulation patterns around the school. Driving parents and their children paradoxically had greater concerns about traffic than walkers. Walkers may feel more comfortable as they have built up knowledge on how to deal with the traffic (e.g., how to cross the street safely) or have discovered safer routes. Children and parents who drive to school are likely spending a lot of time on major roads and only seeing environments with lots of traffic, thus they may have a different perception of their environment. Walkers were more likely to say they had a safe route and were less concerned about street crossing and the vehicles around the school. This reiterates findings from previous work (Collins and Kearns 2002). This is an important determination, as every student must overcome these barriers, either as a pedestrian walking to school or a driver exiting their vehicle.

**Context in relation to previous work**

One parent said she drives her child to school because there are too many vehicles on the road and it is not safe to walk, but realizes she is contributing to the problem. The situation where parents are driving their children to protect them is very common, and many parents are aware that they are contributing to the issue. While parents who drive may reduce the risk of injury for their own child, they are also contributing to the problem and fear of too many vehicles in the school neighbourhood (Collins and Kearns 2002). This link between perceived risk and traffic volume can also work in the reverse direction. If more students walk to school, this will reduce traffic volumes and improve perceptions of safety for walkers. Furthermore, more people
walking in an area adds an additional dimension of traffic safety through increased numbers of people on the streets. A study by Jacobsen discovered that, regardless of neighbourhood design, the likelihood of a pedestrian being struck by a motor vehicle was inversely related to the number of pedestrians on the street (2003). Jacobsen also stated that motorists adjust their driving behaviour when there were more people walking (Jacobsen 2003). This suggests that more people walking and fewer driving to school will improve overall and perceptions of safety.

Parents who drive their children were more concerned about traffic, but also personal security. Driving parents also expressed greater concerns regarding strangers. Parents appear to be escorting their child by motor vehicle to reduce perceived risks. Parents may find it difficult to overcome their fears, but some recent work has suggested that supervised group travel (e.g., walking school bus), may be a possible solution (Kearns et al. 2003). This concept would also reduce the concerns of the child, as most children preferred the idea of walking in groups to prevent them from ‘bully’ attacks. For the idea of group travel (walking school buses) to be effective, however; parents will need to be convinced of its safety.

For parents living in lower income neighbourhoods, personal security concerns about their child is more evident. Neighbourhood differences were also particularly evident in children’s transcripts. Children living in low-income neighbourhoods, mainly discussed fear of harm from bullies, dogs and strangers, but not vehicles. Socio-spatial context may have a larger role in determining child rather than adult impressions of school travel. Connections between the theory about childhood were evident. Most participants expressed safety concerns, but these concerns were not uniform and varied across socio-spatial contexts, gender and travel modes. Children expressed concerns that were distinct from adults and identified threats to personal security that should likely be included in discourse regarding school transport.
Chapter 3

Safety and school travel: How does the environment along the route relate to safety and mode choice?

Introduction

Over the last four decades, decreasing rates of active travel to and from school have been accompanied by higher rates of obesity in children (Tremblay et al. 2002; Shields 2006; McDonald 2007; Ham et al. 2008; Buliung et al. 2009; McDonald et al. 2011; Wang 2011). Recent decline in physical activity may relate to the increasing prevalence of childhood obesity (Weinsier et al. 1998; Goran 2008). Active school transport (AST) presents an excellent opportunity to establish daily physical activity (Tudor-Locke et al. 2002; Cooper et al. 2003; Cooper et al. 2005; Murtagh and Murphy 2011; Owen et al. 2012). Walking alone is not likely to be enough activity for children to obtain significant levels of daily physical activity, or meet national guidelines, but it can be one part of a daily activity bundle necessary to produce an active, healthy lifestyle.

Recent research has found factors such as distance, convenience and safety (both personal security and traffic safety) are common reasons why parents are driving their children to school (Ewing et al. 2004, Schlossberg et al. 2006, McDonald and Aalborg 2009; Faulkner et al. 2010). The purpose of this chapter is to examine how environmental features along the route between home and school, as well as perceptions of safety, relate to the chosen mode of travel to
and from school. The framework for this chapter uses the ecological model to explore how place influences a child’s health. The introduction of this dissertation also discussed the background information examining the decline of AST, the built environment and travel patterns. This chapter will add to the findings from the previous chapter by modeling objective and perceived factors related to safety and mode of travel.

**Conceptual framework**

This chapter will build on the knowledge obtained from the qualitative study, but also uses the themes that emerged from the qualitative chapter to help shape the empirical models. The previous chapter examined how safety related to mode of travel for both parents and their children. Findings from that chapter suggest that both personal security and traffic safety impact travel decisions. There is a need for further examination of how traffic around the school, sidewalks and street crossings influence travel behaviour. This chapter will continue to test these associations. For parents, perceptions of ‘stranger danger,’ busy street crossings, maturity level and the traffic around the school were important themes associated with mode of travel. For children, their personal security worries related to strangers and the threat of bullies and dogs, while concerns around traffic safety mostly related to street crossings. Neighbourhood differences also existed, as personal security was more important in low-income neighbourhoods, and traffic safety concerns were more prevalent in inner suburban areas. This chapter will build on the previous findings and continue to explore how AST relates to safety and the environment.

Findings from the previous studies will be used to help frame this chapter, but the ecological model will also be adopted to assist with the model specification. An ecological
model can assist with the understanding of relationships between human behaviour and the environment. It implies that there is a connection between human health, well-being and the environment (Moos 1979; Stokols 1987; Stokols 1992; Hoehner et al. 2003). The use of an ecological model enables a way of thinking about or conceptualizing how people are interacting with their surroundings (e.g., built environment) and how this may influence mode of travel and physical activity.

The main concept of an ecological model relates to the nesting of multiple levels of influences from the individual to community features or the broader environment (Sallis et al. 2008; van Loon and Frank). Health organizations (such as the World Health Organization) stress the need to examine multiple levels of influence in order to understand and modify health behaviour (WHO 2004; IMNRC 2009; Goldstein et al. 2011). There are many different influences within the ecological model and several variations exist within the literature (Sallis et al. 2008; van Loon and Frank 2011), but all studies deal with the subject matter ranging from individual features to broader factors such as public policy. Sallis et al. (2008) outlined how an ecological model can relate to physical activity; this dissertation adopts a modified version of his model, as this model was specifically developed to examine health behaviour. An adaptation of a diagram used in a recent paper by Sallis et al. (2008) illustrates the connection between an ecological model and physical activity for school travel (Figure 3.1). I made slight modifications to the original diagram (Sallis et al. 2008) to help display the possible conceptual inter-linkages both the built and social environment in relation to active travel and physical activity. It includes four levels of influence: the individual, social/cultural environment, built environment and policy environment (Sallis et al. 2008). These levels interact with one another and, in turn, relate to health behaviour (physical activity levels, walking, eating behaviour, smoking etc). Table 3.1
below illustrates each of the levels of influence with examples of features that may relate to
health behaviour.

**Table 3.1**

**Ecological model and levels of influence**

<table>
<thead>
<tr>
<th>Influences:</th>
<th>Examples:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>Age</td>
</tr>
<tr>
<td></td>
<td>Demographics</td>
</tr>
<tr>
<td></td>
<td>Knowledge</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
</tr>
<tr>
<td>Social and cultural environment</td>
<td>Social norms</td>
</tr>
<tr>
<td></td>
<td>Cultural values</td>
</tr>
<tr>
<td></td>
<td>Media</td>
</tr>
<tr>
<td></td>
<td>Friends/family</td>
</tr>
<tr>
<td>Built environment</td>
<td>Land use</td>
</tr>
<tr>
<td></td>
<td>Density</td>
</tr>
<tr>
<td></td>
<td>Transportation infrastructure (roads, sidewalks, etc.)</td>
</tr>
<tr>
<td>Policy environment</td>
<td>School board policies</td>
</tr>
<tr>
<td></td>
<td>Road design standards</td>
</tr>
<tr>
<td></td>
<td>Zoning</td>
</tr>
<tr>
<td></td>
<td>Municipal bylaws</td>
</tr>
<tr>
<td></td>
<td>Laws</td>
</tr>
</tbody>
</table>

Within the school travel literature, there is no universally accepted model used to
examine AST. McMillan created a framework aimed at understanding how urban form related
to school travel decisions (2005), but ecological models have also been used to explore the
interaction between all levels of the environment (including built features, policy, social and
individual characteristics) and human behaviour (Spence and Lee 2003; Sallis et al. 2006; van
Loon and Frank 2011). Since the purpose of this chapter is to ultimately examine health
behaviour (walking and physical activity), the application of the ecological model provides adds
depth to help conceptualize how multiple levels of characteristics relate to the outcome (i.e.,
walking or physical activity), beyond what was identified in the qualitative chapter. The ecological model is used in partnership with the emerging themes from the qualitative chapter to enable identification and broad categorization of the features examined and is useful in model specification.

![Ecological Model](image)

**Figure 3.1**
An adaptation of an ecological model used to explain physical activity and walking
See Sallis et al 2006 for original image.

**Methods**

*Study area and data*

As part of the larger Built Environment and Active Transport (BEAT) project, grade 5 and 6 students (n=1035) completed travel behaviour surveys and mapping exercises at 17 elementary schools within the City of Toronto. Project BEAT is a large-scale, multidisciplinary study
examining how the built environment influences school travel patterns and levels of physical activity in the Greater Toronto Area. As previously stated, the study was set in the City of Toronto, which has a population of approximately 2.5 million people (Statistics Canada 2006) (see page 24 for full details on study area and examples of neighbourhood types and characteristics).

In January 2010, all elementary school principals (for schools with grades five and six) within the Toronto District School Board (TDSB) received an invitation to participate (n=469). From the pool of interested principals, selective sampling took place to create a mix of income and built environment types for the 17 school neighbourhoods. Neighbourhood income was the only measure of class applied for this dissertation, as it was embedded in the sampling design. This selection strategy applies the ecological model to discover how neighbourhood characteristics relate to safety and school travel. Certain environmental and social characteristics influence mode of travel in previous work (Scholossberg et al. 2006; Timperio et al. 2006; Larsen et al. 2012), thus under the applied ecological model, a connection should exist between one’s neighbourhood and travel patterns.

The sampled schools examine several neighbourhood types, but the sample does not capture every type of neighbourhood within Toronto. Recall Figure 2.1 (page 38), which illustrates the broad neighbourhood classification scheme by displaying examples of central city and inner suburban locations along with examples of the differences in street design. Nine of the sampled schools were within the central city, whereas eight were located in the inner suburbs. (Again, for full details on the study area and neighbourhood types see page 24). The University of Toronto research ethics board and the TDSB ethics review board granted ethics approval in advance. Individual schools, parents, and students gave consent to participate
prior to data collection. Student participation was voluntary, although participants did receive
small incentive. Each family received a $30 gift certificate if they successfully completed their
required tasks (Stores: Canadian Tire, Walmart, Chapters). Schools also received a small
donation for their participation in this study. Data collection took place in the spring/fall of 2010
and 2011. Grade 5 and 6 teachers recruited the children and parents. Eligible students obtained
a consent form asking for the child’s home address. Home addresses and school locations were
used to produce colour maps (aerial photographs) of participant neighbourhoods on ledger-sized
(279x432mm paper) (Figure 3.2). Both children and parents completed surveys allowing
researchers to examine how perceived characteristics of the neighbourhood and safety relate to
mode choice. Parents also completed travel behaviour surveys that they returned to the child’s
teacher to enable for collection of these datasets. Researchers manually entered survey data for
both the parent and child surveys into a database for analysis. Following in-classroom instruction
(that was completed by several members of the research team, including myself for several
schools), children brought home a parental survey, plus their map along with a red and blue
marker. For the maps, participants drew their ‘typical’ route to and from school, typical being
defined as what they tended to do on a regular basis. Both children and their parents completed
this exercise together. Figure 3.2 illustrates an example of a completed map. This is a
hypothetical example for a school and household that did not participate in the study.

This mapping exercise was labour intensive and completed entirely by myself for the
purpose of this dissertation and potentially, for further use in the larger project. There were
several steps necessary in order to successfully complete the mapping exercise with children and
their parents. First, each of the children’s household addresses needed to be geocoded in order to
obtain a geographical point file for each respondent’s home address. Once this was done,
individual maps were created for every participant, highlighting the home and school on a
ledger-sized map. Parents and children completed the mapping exercise and handed in the
finished maps to the school representative. Heads up digitizing was used to generate Geographic
Information Systems (GIS) based separate to and from routes with the assistance of 20cm
resolution aerial photography and field surveys when necessary. For the process, I manually
converted every route from the drawn paper map to a digitized GIS. Data loss resulted from
incomplete or illegible maps. There were 978 to school and 981 from school route maps
produced.

The digitized route maps allow for exploration of objective environmental characteristics
along each child’s reported route. Most studies examining school travel use aggregate data of
either the home or school neighbourhood (Kerr et al. 2006; Frank et al. 2007; McMillan 2007;
Larsen et al. 2009), while a few recent studies have examined characteristics along the shortest
path between home and school (Schollossberg et al. 2006; Timperio et al. 2006; Larsen et al.
2012). This approach is a methodological improvement over neighbourhood level analysis, but
it assumes the child travels along the shortest route, which may not always be the case. Within
this dataset, differences between the shortest path and the mapped route were evident and
statistically significant differences were found for the route structure and the built environment
(Buliung et al., 2013). Using a drawn route as the unit of analysis is a methodological
improvement over previous work; although the process is labour intensive, it produces a more
accurate representation of the environment. There may be slight discrepancies between the
mapped routes and actual routes travelled, but this is still a superior method (Buliung et al.
2013).
If parents and children accurately drew the correct route, and this is the route they traverse while travelling to and from school using a reported mapped route suggests that the features children actually interact with relates to their perceptions of the environment, safety and in turn mode of travel. This may not always be the case, as some parents may have made mistakes drawing the routes, or sometime children travel on different routes for different days. Furthermore, some parents and children may have a different idea of their neighbourhood and the environment surrounding them, which does not directly correlate to the route they actually travel to and from school. In these instances, the use of a broad neighbourhood buffer may also relate to the perceptions of safety and mode of travel. Nevertheless, since no clear understandings exists to date on how the environment and mode choice interact, it is believed in this context that what a child actually interacts with is a better method of analysis than vague neighbourhood based buffers. The characteristics along the route a child is physically exposed to while travelling to and from school are thought to be important, thus measuring the actual route is a contribution to the current literature.

The City of Toronto provided data on sidewalks, railways, street trees, traffic-calming device locations, and the street network. These data were used to construct route-based environmental variables. Parcel level land use data from the Municipal Property Assessment Corporation (MPAC) was also used to generate land use metrics. I verified all of the datasets along the routes in this study with the assistance of aerial photography and field visits when required.
Figure 3.2
Example of a hypothetical map drawn by a parent and their child

**Built environment**

This section explains approaches used to model built environment concepts. Several transport supply and route feature density measures were estimated (i.e., features per kilometre of route). Variables selected for analysis in this chapter needed to have a conceptual relationship with mode of travel and must clearly connect to the ecological model. Several studies have found conflicting evidence on how certain neighbourhood characteristics influence mode choice, but this work aims to provide clarity regarding the built environment, mode choice and safety.

Previous work has examined how street connectivity relates to mode choice. Studies typically measure street connectivity by calculating the density of intersections based on either
area or length of roadway. The findings for children are fairly mixed to date, as some studies have found a positive association (Braza et al. 2004; Schlossberg et al. 2006; Frank, et al. 2007; Kerr et al. 2007), another found no relationship (Larsen et al. 2009), and one study found perceived street crossings to be a negative factor for AST (Timperio et al. 2004). These mixed results may relate to several characteristics (age of child, study area, type of street, etc.) or the unit of measurement used to examine the environment may also cause inconsistent findings. When aggregated neighbourhood level or shortest path data examines the intersection density, it may not be capturing the characteristics along the child’s route; thus, findings may not correspond with actual mode choice. Furthermore, the negative relationship was significant when researchers examined perceived street crossings, rather than actual measured counts. There is likely a disconnect between what people perceive about street crossings or connectivity and measured intersection density. This chapter aims to add to the current literature by examining the number of both objective and perceived crossings along the child’s mapped route to/from school. Findings from this chapter should help to understand how this environmental feature actually relates to AST for children in Toronto. To date, it is unclear how street connectivity would influence mode of travel for children, but from a safety perspective, crossing more streets should negatively influence walking. When crossing a street the child is at risk of a motor vehicle collision. With the application of the ecological model, this is one way that the environment may be influencing mode of travel to and from school. Since this dissertation adapts a route-based methodology, the number of intersections crossed along each route (rather than density in a buffer) was compiled and weighted based on the distance travelled (i.e., number of intersections per kilometre).
The risk of crossing the street may also vary by street type. Street crossings may not be particularly dangerous if the street does not have a lot of traffic. The crossing of major streets on the other hand, may more directly relate to traffic safety. Again, results on this feature are inconsistent to date (Schlossberg et al. 2006; Wen et al. 2008; Larsen et al. 2012). Findings from the previous qualitative chapter, suggest that major street crossings influence perceptions of safety and mode of travel, thus objective measures of this feature needs further exploration. The classification of major streets also varies by study design, but most studies define major streets as arterials. For this chapter, both major arterial or minor arterial roadways as defined by the City of Toronto were classified as major streets. The major streets crossed variable was compiled in the same manner as that of intersection density, by taking the number of major streets crossed weighted by the distance travelled (giving each route a number of major street crossings per kilometre). This weighted measure adds controls for distance, and allows for examination of route features.

Sidewalks are a key element of pedestrian safety as they give pedestrians their own space away from moving vehicles. When thinking about sidewalks, safety and school travel, it is rational to assume that not having a designated space for walking would negatively influence actual rates of walking. Most neighbourhoods within the City of Toronto have sidewalks, but there are areas where these features are missing. Several of the sampled inner suburban neighbourhoods, did not have a complete sidewalk network. Some streets had sidewalks on one side of the street only, while others were completely missing this feature. For the purpose of this dissertation, missing sidewalks means sidewalks were not present on either side of the street. Since it is unknown, what side of the street children use while walking, when sidewalks were available on one side of the street only, they were still categorized as having access. This
variable calculated the proportion of each route without sidewalks. Values range from zero to one. A value of one means there are no sidewalks (on either side of the street) for the child’s trip to and from school, while a value of zero would represent a route with a complete sidewalk network (on at least one side of the street).

Although understudied in the child transport literature, the presence of street trees may influence the mode of travel to and from school. A few recent studies have found a connection between street trees and active travel to school (Larsen et al. 2009; Larsen et al. 2012); while other studies have found a positive association between green space and children’s physical activity levels or healthy body weights (Liu et al. 2007; Bell et al. 2008; Wolch et al. 2010). In Indianapolis, higher levels of tree cover or green space were significantly associated with the perception of a more pleasant walking environment for children (Liu et al. 2007). To date, it is unclear how street trees influence mode of travel, but it is important for researchers to try to understand the significance of this feature. The number of street trees along each route was weighted based on the distance travelled to create a street tree density variable.

Few studies to date examine how traffic-calming features relate to school travel. Traffic-calming devices can be chicanes, speed bumps, raised intersections, gateways, raised crosswalks or traffic circles. Research does suggest that incorporating traffic-calming devices into the environment leads to a reduction in the number of accidents (Morrison et al. 2004). How these features are associated with mode of travel and safety is unknown; however, they could relate to perceptions of safety and objective traffic speed. From a school travel standpoint, it is logical to assume that more people will be walking to school in areas with fewer fast moving vehicles. If the traffic calming devices are actually meeting their purpose, they may slow down traffic and lead to a more pleasant walking environment. The density of traffic-calming devices measured
the total number of features versus the distance travelled (number of traffic-calming devices per km of route).

Land use mix, which increases the number and proximity of potential destinations accessible by foot, commonly relates to higher rates of walking for adults (Powell et al., 2003; Saelens et al., 2003; Saelens et al., 2003b), but the relationship between children’s travel and mixed land uses is less clear. This lack of clarity is likely associated with the fact that the destination needed for children is the school itself. Thus, mixed land uses are not necessary to encourage potential destinations. At least two studies have found a positive association between land use mix and active travel to school (Kerr et al., 2006; McMillan, 2007), whereas other studies have found a negative association (Ewing et al., 2004; Larsen et al. 2012). To date, it has been found that mixed land uses may create a more dangerous environment for child pedestrians (Graham and Glaister 2003; Clifton et al. 2007; Loukaitou-Sideris et al. 2007), but more work needs to examine this relationship before definitive connections can be made. In areas with mixed use, the traffic conditions may produce a more dangerous environment for pedestrians than residential neighbourhoods. A few studies have found an association between land use and pedestrian safety, where mixed uses produced a more dangerous environment for pedestrians (Graham and Glaister 2003; Clifton et al. 2007; Loukaitou-Sideris et al. 2007), but more work needs to determine whether land use is a barrier or enabler for school travel and pedestrians.

Land use mix is often measured using an entropy index based on the area of land dedicated to particular uses (Frank et al. 2004; Leslie et al. 2007; Larsen et al. 2012). This dissertation examines the actual route travelled and not the area surrounding the home or school. Thus, a new route-based approach examines the mix of land uses along the property frontages for each child’s route. The use of a route-based frontage analysis is a contribution to the current
literature as it builds on previous methods, but adds a new dimension to route-based analysis. This method uses the same approach as previous work, but at a different spatial scale due to the route-based nature of this dissertation. All land parcel polygons within the City of Toronto were classified into five land use classes (parks, residential, institutional, industrial, and commercial). Land use parcels were then transformed into linear features at the front of each property. The total length of frontage for each land use was compiled for every route and an entropy approach was used to represent land use mix using the following formula:

\[
\text{LandUse Mix} = -\sum_{lu} (pu \ln pu)/ \ln n
\]

where \( lu \) is the land use, \( pu \) is the proportion of parcel frontage within a land use category, and \( n \) is the total number of land use classes. Values range from zero to one, with zero representing a route populated by a single land use and one indicating presence and equal distribution of all five land uses.

All of these environmental features have a conceptual connection to either safety and/or mode of travel. This section discusses the significance of environmental features which have been included in the preliminary analysis. These decisions were framed using findings from previous studies along with my current thinking on how those features may relate to this chapter. Under the ecological model, a connection should exist between these environmental features and a child’s travel mode to and from school.
Socio-economic variables

The ecological model also implies a connection exists between social characteristics and mode of travel. This section will explore the link between socio-economic characteristics, mode choice and safety. Income is an important characteristic for both school travel (McMillan et al. 2005; Vovsha and Petersen, 2005; Frank et al. 2007; Chillon et al. 2009; Dalton et al. 2011; Larsen et al. 2012) and pedestrian safety (Rivera and Barber 1985; Calhoun et al. 1998; DiMaggio and Li 2012). Income likely relates to both mode choice and perception of safety. Income is a proxy variable for the available resources (such as automobiles) within the household that are related to safety and mode of travel.

Many participants did not report their income when completing the survey, but did answer questions pertaining to educational attainment. Preliminary analysis included the individual educational attainment variable along with an aggregated income level dataset. Parents reported the educational attainment of the mother and father in the survey as a categorical response variable. Since no household level income variable was available, an aggregated neighbourhood income variable was created from census data. Neighbourhood level income for each respondent was assigned based on the location of their home and the corresponding median household income at the dissemination area (DA). If the home was located in a DA with a median household income of $48 000, this was the value assigned. This variable does not capture the income of the respondent, but rather the average income level immediately surrounding the child’s home. Dissemination areas are the smallest spatial unit where income level data is available in Canada and are typically only a few blocks in size in urban areas.
Characteristics of the traffic environment also relate to mode choice under the ecological model. Although the variable is understudied to date, this study aims to contribute to the literature by examining how traffic features and conditions influence mode of travel to and from school for children. Qualitative research examining traffic and school travel has reported a relationship between number of vehicles around the school and safety (Collins and Kearns 2001). These findings are also evident in the previous qualitative chapter. School travel interventions often focus on the school-end traffic environment. The use of actual recorded traffic counts is a major contribution of this dissertation. Manual traffic counts were taken at all access and egress points around each sampled school, producing a destination focused analysis of the role of traffic on mode choice. This approach to data collection ensures traffic data are available for at least one intersection for every child, unless they do not have to cross a street. Traffic counts were conducted in the morning and afternoon. Following methods used by Boarnet et al., (2005) data collection commenced one half hour before school started in the morning and continued for another 15 minutes after school begins. The same approach was applied for the journey home from school, with data collection commencing 15 minutes before the end of the school day. School principals confirmed the school start and end times to ensure accuracy. In agreement with common practice, data collection only took place on Tuesdays, Wednesdays and Thursdays; Mondays and Fridays have atypical traffic patterns (Box 1976). Traffic data were only collected in the spring and fall and not on days with poor weather. Counters were also instructed to record data on vehicle type. Training was given in advance to help counters distinguish among different vehicles.
This data collection process was once again labour intensive. I modified, created or conducted all of the instruments, data entry, methods, and training sessions. I also led the data collection process for each of the 17 schools with the assistance of trained undergraduate students. In order to successfully obtain traffic volume and fleet characteristics, several steps needed to take place prior to data collection. First, a manual traffic-recording instrument was modified from the traffic engineering handbook (Box 1976) to capture vehicle fleet and traffic volume in a manner appropriate for use in this chapter. Once I had the measurement tool, I led several training sessions in both the classroom and the field to ensure the assistants had the appropriate materials and knowledge to collect accurate data. Appendix B illustrates the tools used for data collection. A different recording sheet had to be used for three-way versus the standard four-way intersection. After completing data collection for each of the 17 sampled schools (over 120 intersections), I manually entered the data into a spreadsheet and assigned traffic volumes to each of the sampled intersections within GIS.

This chapter uses the observed traffic data in novel ways. Two measures of the traffic environment are used. The first measures the traffic volume (observed count) experienced at the school end, by looking at the maximum volume faced by a child across those locations where his/her route intersects with a data collection point. Maximum volume refers to the intersection with the highest volume of traffic or most vehicles per route. This approach takes into consideration findings from the pedestrian safety literature where greater volume correlates with greater perceived safety risk (Lee and Abdel-Aty 2005, Sze and Wong 2007; Harwood et al. 2008; Zegeer and Bushell 2012). I assumed that differences in volume at the high end are most likely to systematically associate with safety and mode choice. School end traffic density was
also tested to examine effect of average traffic volume on mode choice. Traffic density looks at the average or mean number of vehicles per intersection crossed.

To date no known study has examined how fleet characteristics relate to either mode choice or safety. It is unknown exactly how this particular aspect of the traffic environment will interact with safety perceptions or mode choice. Perhaps, for example, a disproportionate presence of larger vehicles could produce differences in perceived safety and mode choice. Since no known measure exists to examine fleet characteristics, I created an index based on previous knowledge and other applicable formulas. Passenger car equivalents are a common measure used in the transportation demand and forecasting literature as a way to model the impact of larger vehicles on road systems. For this, essentially larger vehicles are assigned a multiplier where one truck = four cars or one bus equals three cars (TRB, 1985). While this is an acceptable method for traffic demand or forecasting, no known vehicle index or multiplier exists for linking vehicle fleet characteristics with pedestrian safety. This chapter experimented with a weight-based vehicle multiplier to create a car equivalent for the pedestrian safety application. The creation of this index is a contribution to the current literature as it provides a new method to examine the traffic environment, pedestrian safety and mode choice. When it comes to pedestrian safety, the difference between smaller and larger motor vehicles relates to vehicle mass and speed. Fleet size influences vehicle on vehicle collisions, as there is a direct relationship between the mass of a vehicle and risk of fatality (Tay 2003). Table 3.2 displays the multipliers applied based on the average weight of each vehicle type (NHTSA 2003; EPA 2010)*. The mass of a bus, school bus and truck can differ substantially based on the number of occupants or load. For these types of vehicles, the multiplier is based on the average weight between a full and empty vehicle, implying that a bus/truck is at half of the capacity.
Table 3.2  
Pedestrian safety multiplier for car equivalency  

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>1.0</td>
</tr>
<tr>
<td>SUV / Mini van</td>
<td>1.3</td>
</tr>
<tr>
<td>Bus</td>
<td>11.2</td>
</tr>
<tr>
<td>School bus</td>
<td>6.1</td>
</tr>
<tr>
<td>Truck</td>
<td>13.2</td>
</tr>
</tbody>
</table>

The application of a weighted vehicle fleet index examines fleet characteristics around each school. Observed fleet data were aggregated to four vehicle categories: Passenger vehicle, Transit, School bus and Truck. Passenger vehicles included cars, mini vans and SUV’s. A reverse entropy index is used to model the vehicle mix around each school. Once again, this methodology is novel and not previously used, but the use of an entropy index is common within the school travel and land use literature (Frank et al. 2004; Leslie et al. 2007; Larsen et al. 2012), but not for vehicle mix as no known study has examined this feature. For the sake of consistency with previous indices examining the mix of neighbourhood characteristics (e.g. land use), a reverse entropy index was applied using the following formula:

\[
\text{Fleet mix} = \left( \sum v(pv \ln pv)/ \ln n \right) + 1, 
\]

where \(v\) is vehicle type, \(pv\) is the proportion of vehicle types at each intersection dedicated to a particular category (i.e., passenger, transit, school busy or truck); and \(n\) is the total number of categories. Fleet mix scores range between zero and one; a score of zero is a mix dominated by trucks, transit and school buses, while a score of one represents an intersection with only passenger vehicles. Rather than using a standard entropy index, which categorizes mix as the highest value (i.e., closest to one), a reverse entropy index assigns the highest value to a
single use or type (e.g. passenger vehicles only) and is more applicable for this type of analysis as having only passenger vehicles is hypothesized to be a safer traffic environment.

To further test for fleet effects, an unweighted vehicle mix index was tested in a preliminary analysis that applied the same approach but without vehicle type multipliers. Figures 3.3 and 3.4 illustrate the location where traffic counts took place and how vehicle mix and traffic volume may vary by intersection. These are hypothetical examples and do not actually represent a participating school; all street names are incorrect. Larger circles at intersections would represent higher traffic volumes or more passenger vehicles (Figures 3.3 and 3.4).

Few studies to date examine whether parking or drop-off facilities at the school relate to mode of travel. It is unknown how this feature associates with mode of travel but it is possible that these facilities encourage driving by making it easier. I once again conducted research at each of the schools in order to survey parking facilities and drop-off locations. Schools were classified as having parking facilities if a pickup/drop-off zone with signage was observable, or if a school had a drive through area in front of the school for drop-offs and pick-ups.
Figure 3.3
Example of traffic count locations and vehicle counts, 8:00-8:45 a.m.

Figure 3.4
Example of traffic count locations and vehicle mix, higher values represent more passenger vehicles, 8:00-8:45 a.m.
**Individual characteristics**

Gender and distance are common factors associated with mode choice for school travel (Evenson et al. 2003; Fulton et al. 2005; Merom et al. 2006; Yarlagadda and Srinivasan, 2008; Mitra et al. 2010; McDonald 2011; Larsen et al. 2012). Boys are more likely to walk than girls, and longer distances decrease the likelihood of walking. These individual characteristics along with others such as age, parents’ gender and vehicle ownership will also be explored. Recent studies have found that as the age of the child increases, so does the likelihood of walking (McDonald 2008b; Mitra et al. 2010), but no conclusive evidence exists to date. Age and the child’s maturity level were also relevant themes in the previous qualitative chapter, suggesting that as children grow older, they are more likely to participate in active school travel. Safety concerns might differ based on the gender of the parent, as mothers and fathers may perceive these factors differently. The previous chapter also discovered that mothers take on more than their proportional share of responsibilities regarding school travel. Most of the previous work to date has not explored how the gender of the parent responsible for the school travel process may actually relate to these decisions, but it would be beneficial to understand how gender of the parent translates into perceived safety concerns and mode of travel. It is rational to presume that fathers (or other male caregivers) have different concerns and ideas about the school travel experience for their child. This chapter will examine this feature in an effort to build on the connection between school travel and gender. Once again, this chapter does not examine how ethnicity or race relates to mode of travel, as the data were not collected. The previous chapter discussed some of the difficulties of examining ethnicity, and although it is important it was not addressed in this dissertation (see discussion on page 61 for more details related to ethnicity).
The availability of automobiles is an important individual level characteristic. If a household does not own or have access to a working vehicle, it may not be possible to drive the child to school. Again, with regard to school travel, no conclusive findings exist to date, but it is logical to assume that vehicle ownership is negatively associated with walking. Vehicle ownership was found to be related to travel mode in one study (Vovsha and Petersen 2005), but Schlossberg et al. (2006) found no relationship. The number of vehicles per licensed driver variable used a ratio based on the responses from the parental survey.

To account for self-selection, or whether parents chose to live in a particular neighbourhood so their children could walk or cycle to school, preliminary testing examined parental responses to a question about neighbourhood location. Recent studies of travel behaviour and physical activity have started to examine how and/or whether observed travel patterns or activity levels associate with the built environment; or whether personal preferences on neighbourhood selection play more of a role in determining travel behaviour or activity levels (Boone-Heinonen et al. 2011; Cao et al. 2009; Handy et al. 2006). A review of 38 empirical studies determined that while self-selection was important for travel behaviour, so too were aspects of the built environment (Cao et al. 2009). Self-selection for school travel, relates primarily to the preferences of the parent as they have most of the say regarding home location and what school the child will attend. To help to control for self-selection, a question from the parental survey was added to the preliminary analysis to determine whether it was statistically significant. The question asked parents if, “They have chosen to live in this neighbourhood because it is easy for our child(ren) to walk or cycle to school.”
Empirical Analysis and Modeling

Table 3.3 displays a list of relevant variables obtained from the survey and the objective environmental characteristics entered into preliminary analysis along with the predicted relationship and how they fit into the ecological model. The previous section reported the rationale for including these variables, but each of these variables conceptually relate to mode of travel. Categorical response variables were coded using dummy variables for statistical exploration and analysis. Univariate logistic regression was used first to determine which variables independently associate with walking (Table 3.4). Factors such as distance, gender of child and parent and automobile availability were analyzed to control for these individual child and adult characteristics. Responses from the child and parent surveys were tested independently. Variables continued into subsequent analyses using a p value cut-off of \( p < 0.05 \). For categorical responses, three of the four categories must have met the criterion \( p < 0.05 \), while the other category must have been approaching significance \( p < 0.1 \). Ideally a multinomial analysis would be completed, but the number of cases of bicycling, transit and school bus does not allow such modelling \((n=58)\). Only children who were driven in a vehicle or walked to and from school were included in the analysis \((n=905)\). Although only 22 students rode the school bus, all TDSB students living more than 1.6 km from school have bus eligibility. The TDSB measures distance along the shortest public thoroughfare from the child’s residence to the closest school access point.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Predicted direction</th>
<th>Relationship with ecological model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age <em>(Age of child)</em></td>
<td>Positive</td>
<td>Individual</td>
</tr>
<tr>
<td>Gender *(Boys: 1, <em>Girls: 0)</em></td>
<td>Positive</td>
<td>Individual</td>
</tr>
<tr>
<td>Gender of parent *(Father: 1, <em>Mother: 0)</em></td>
<td>Positive</td>
<td>Individual</td>
</tr>
<tr>
<td><strong>Income (home DA)</strong></td>
<td>Negative</td>
<td>Individual/Social environment</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>Vehicles per licensed driver (parent model only)</strong></td>
<td>Negative</td>
<td>Individual</td>
</tr>
<tr>
<td><strong>Educational attainment of parents (Secondary, College, University, Graduate)</strong></td>
<td>Negative</td>
<td>Individual</td>
</tr>
</tbody>
</table>

**Objective environmental characteristics**

| **Distance (Distance between home and school in km)** | Negative | Built/Policy environment |
| **Number of intersections crossed along route (per km of total distance)** | Negative | Built/Policy environment |
| **Number of major intersections crossed along route (per km of total distance)** | Negative | Built/Policy environment |
| **Number of railway crossings along route (per km of total distance)** | Negative | Built/Policy environment |
| **Proportion of route missing sidewalks** | Negative | Built/Policy environment |
| **Street tree density** | Positive | Built/Policy environment |
| **Presence of parking facilities at school** | Negative | Built/Policy environment |
| **School neighbourhood - Built environment (Central city: 0, Inner suburbs: 1)** | Negative | Built environment |
| **School neighbourhood - Income (High-income: 0, Low-income 1)** | Positive | Social environment |
| **Maximum traffic along the route** | Negative | Built/Policy environment |
| **Land use mix** | Negative | Built/Policy environment |
| **Traffic-calming density** | Positive | Built/Policy environment |
| **Traffic density around school** | Negative | Built/Policy/Social environment |
| **Vehicle fleet index (1: all passenger vehicles, 0: trucks, transit, school bus)** | Positive | Built/Policy/Social environment |
| **Unweighted vehicle mix (1: all passenger vehicles, 0: trucks, transit, school bus)** | Negative | Built/Policy/Social environment |

**Perceived environmental characteristics (Child model only)**

| **Safe area to walk (No, Don’t know, Yes)** | Positive | All |
| **Safe crossing roads (No, Don’t know, Yes)** | Positive | Built/Policy environment |
| **Lots of traffic (No, Don’t know, Yes)** | Negative | Built/Policy/Social environment |
| **Fast cars (No, Don’t know, Yes)** | Negative | All |
| **Fear of strangers (No, Don’t know, Yes)** | Negative | Individual/Social environment |
| **Fear of older kids (No, Don’t know, Yes)** | Negative | Individual/Social environment |

**Perceived environmental characteristics (Parent model only)**

| **Enough Sidewalks (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Positive | Built/Policy environment |
| **Enough crosswalks/traffic lights (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Positive | Built/Policy environment |
| **Fear of strangers (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Negative | Individual/Social environment |
| **Heavy traffic around school (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Negative | Built/Policy/Social environment |
| **Route crosses busy streets (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Negative | Built/Policy environment |
| **Drivers are too fast (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Negative | All |
| **Enough crossing guards (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Positive | Built/Policy environment |
| **Live in a safe area (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Positive | All |

**Parental self-selection (Parent model only)**

| **Chosen to live in this neighbourhood because it is easy for our child to walk or cycle to school (Strongly Agree, Agree, Neither, Disagree, *Strongly Disagree)** | Positive | All |

*Referent
Table 3.4
Univariate logistic regression testing for preliminary analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>To School</th>
<th></th>
<th>From School</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Child</td>
<td>p value</td>
<td>Parent</td>
<td>p value</td>
</tr>
<tr>
<td>Age</td>
<td>0.055</td>
<td>-</td>
<td>0.199</td>
<td>-</td>
</tr>
<tr>
<td>Gender (girls as referant)</td>
<td>&lt;0.001</td>
<td>+</td>
<td>&lt;0.001</td>
<td>+</td>
</tr>
<tr>
<td>Gender of parent (Mother as referent)</td>
<td>----</td>
<td>----</td>
<td>0.151</td>
<td>+</td>
</tr>
<tr>
<td>Distance</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Intersections</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Major crossings</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Proportion missing sidewalks</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Maximum traffic</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Land use mix</td>
<td>&lt;0.004</td>
<td>+</td>
<td>&lt;0.004</td>
<td>+</td>
</tr>
<tr>
<td>Traffic calming density</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Traffic density</td>
<td>0.091</td>
<td>-</td>
<td>0.016</td>
<td>-</td>
</tr>
<tr>
<td>Vehicle fleet index</td>
<td>0.001</td>
<td>+</td>
<td>0.004</td>
<td>+</td>
</tr>
<tr>
<td>Unweighted vehicle mix</td>
<td>0.095</td>
<td>+</td>
<td>0.295</td>
<td>+</td>
</tr>
<tr>
<td>Home DA income</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Street tree density</td>
<td>0.056</td>
<td>+</td>
<td>0.003</td>
<td>+</td>
</tr>
<tr>
<td>Parking facilities</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Vehicles per licensed driver</td>
<td>----</td>
<td>----</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Neighbourhood - Inner suburbs</td>
<td>&lt;0.001</td>
<td>-</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Educational father - Secondary</td>
<td>----</td>
<td>----</td>
<td>0.408</td>
<td>+</td>
</tr>
<tr>
<td>- College</td>
<td>----</td>
<td>----</td>
<td>0.837</td>
<td>-</td>
</tr>
<tr>
<td>- University</td>
<td>----</td>
<td>----</td>
<td>0.660</td>
<td>+</td>
</tr>
<tr>
<td>- Graduate</td>
<td>----</td>
<td>----</td>
<td>0.970</td>
<td>-</td>
</tr>
<tr>
<td>Educational mother - Secondary</td>
<td>----</td>
<td>----</td>
<td>0.026</td>
<td>+</td>
</tr>
<tr>
<td>- College</td>
<td>----</td>
<td>----</td>
<td>0.123</td>
<td>-</td>
</tr>
<tr>
<td>- University</td>
<td>----</td>
<td>----</td>
<td>0.037</td>
<td>+</td>
</tr>
<tr>
<td>- Graduate</td>
<td>----</td>
<td>----</td>
<td>0.034</td>
<td>+</td>
</tr>
<tr>
<td>Not enough sidewalks - Strongly agree</td>
<td>----</td>
<td>----</td>
<td>0.001</td>
<td>-</td>
</tr>
<tr>
<td>- Agree</td>
<td>----</td>
<td>----</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>- Neither</td>
<td>----</td>
<td>----</td>
<td>0.009</td>
<td>-</td>
</tr>
<tr>
<td>- Disagree</td>
<td>----</td>
<td>----</td>
<td>0.172</td>
<td>-</td>
</tr>
<tr>
<td>Enough crosswalks</td>
<td>----</td>
<td>----</td>
<td>0.063</td>
<td>-</td>
</tr>
<tr>
<td>- Strongly agree</td>
<td>----</td>
<td>----</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>- Agree</td>
<td>----</td>
<td>----</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>- Neither</td>
<td>----</td>
<td>----</td>
<td>0.343</td>
<td>-</td>
</tr>
<tr>
<td>- Disagree</td>
<td>----</td>
<td>----</td>
<td>0.002</td>
<td>-</td>
</tr>
<tr>
<td>Fear of strangers</td>
<td>----</td>
<td>----</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>- Strongly agree</td>
<td>----</td>
<td>----</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>- Agree</td>
<td>----</td>
<td>----</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Neither</td>
<td>Disagree</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
<td>-------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>Traffic around school</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Crosses busy streets</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Drivers are too fast</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Crossing guards</td>
<td>0.005</td>
<td>0.171</td>
<td>0.184</td>
<td>0.037</td>
</tr>
<tr>
<td>Live in a safe area</td>
<td>0.926</td>
<td>0.138</td>
<td>0.344</td>
<td>0.184</td>
</tr>
<tr>
<td>Parent self-selection</td>
<td>&lt;0.001</td>
<td>0.174</td>
<td>0.854</td>
<td>0.05</td>
</tr>
<tr>
<td>Safe area to walk</td>
<td>0.05</td>
<td>0.136</td>
<td>0.397</td>
<td>0.019</td>
</tr>
</tbody>
</table>

Significant variables in bold
Multicollinearity analysis of the filtered set of variables followed the unadjusted modelling exercise, using Pearson correlations and variance inflation factor (VIF) approaches. Multicollinearity was detected for the traffic maximum and density variables along with the weighted and unweighted vehicle fleet mix. Since preliminary testing revealed greater significance for the maximum traffic and weighted vehicle fleet index variables, these variables remained in the adjusted models. The following characteristics that may relate to safety and mode choice were entered into the binomial logistic regression model: number of intersections along the route, number of major intersections along the route, proportion of route missing sidewalks, street tree density, maximum traffic, weighted vehicle fleet mix, parking facilities, income, land use mix, traffic-calming density, living in a safe area to walk alone (child response), a fear of strangers (parent response), heavy traffic around the school (parent response) and having busy streets to cross (parent response). Furthermore, gender, distance, neighbourhood type and vehicles per licensed driver were also included to control for commonly relevant characteristics related to mode choice (McMillan et al. 2006; Frank et al. 2007; Mitra et al. 2010).

**Model specification and structure**

A binomial logistic regression model explores how objective and perceived characteristics of safety influence mode of travel with walking (versus driving) as the dependent variable. These models are not predictive, but rather descriptive and designed to explore how certain features are or are not influencing mode of travel. Recent studies have shown different patterns in the trip to school versus the trip from school (Mitra et al. 2010; Larsen et al. 2012); thus, two separate models examine the two trips. Logistic regression models estimate the probability that one of the two binomial events occurs based on the independent variables. This model describes which
features relate to walking and how they influence the modal decision. The purpose of these models is to help explain how perceived and objective measures of safety influence mode choice; they are not meant to be predictive models.

To examine the strength and fit of the models, Hosmer and Lemeshow and Nagelkerke R² tests were completed. The Hosmer and Lemeshow test is common in studies using logistic regression to model a binary outcome variable. It examines the fit of the predicted probabilities, where a larger \( p \) value is required (Lemeshow and Hosmer, 1982). In these models, values were well above the required significance level, suggesting a good fit (to school model: 0.458; from school model: 0.512). Furthermore, the Nagelkerke R² test reports the proportion of variance explained by the model, with higher numbers relating to stronger models. Both the to and from school models had values that would explain half or 49% to 53% of the variance (to school model: 0.522; from school model: 0.494). These tests suggest that the models explain a large percentage of the cases, with the to school model explaining slightly more variance.

**Results**

Descriptive statistics for included cases (n=905) are reported in Table 3.5. Nearly 68% (n=654) walked to school, while 26% were driven (n=251). Although not included in the analysis, only 22 children (2%) rode the school bus, 19 cycled (2%), and 17 took transit (2%) to school. For the trip home, rates varied slightly with 76% of children walking (n=733) and 18% driven (n=173). Alternative modes remained stable with 2% of the sample biking, taking transit or riding on a school bus home from school. The average age of the sampled children was 10.5 years. Fifty-four percent of respondents were girls (n=482) and 46% boys (n=516).
Table 3.3
Descriptive statistics for participants routes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>To school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicles per licensed driver</td>
<td>0.85</td>
<td>1.00</td>
<td>0.28</td>
<td>905</td>
</tr>
<tr>
<td>Distance to school (m)</td>
<td>900.21</td>
<td>634.10</td>
<td>1329.37</td>
<td>905</td>
</tr>
<tr>
<td>Intersections crossed on route</td>
<td>5.85</td>
<td>5.98</td>
<td>3.16</td>
<td>905</td>
</tr>
<tr>
<td>Major street crossings on route</td>
<td>1.69</td>
<td>0.00</td>
<td>2.58</td>
<td>905</td>
</tr>
<tr>
<td>Maximum traffic on route</td>
<td>470.89</td>
<td>281.00</td>
<td>510.40</td>
<td>905</td>
</tr>
<tr>
<td>Vehicle fleet index</td>
<td>0.44</td>
<td>0.42</td>
<td>0.19</td>
<td>905</td>
</tr>
<tr>
<td>Missing sidewalks</td>
<td>0.03</td>
<td>0.00</td>
<td>0.11</td>
<td>905</td>
</tr>
<tr>
<td>Street tree density</td>
<td>74.48</td>
<td>70.30</td>
<td>64.82</td>
<td>905</td>
</tr>
<tr>
<td>Income (SCDN)</td>
<td>72495.98</td>
<td>70290.00</td>
<td>40564.06</td>
<td>905</td>
</tr>
<tr>
<td>Traffic-calming density</td>
<td>0.55</td>
<td>0.00</td>
<td>1.34</td>
<td>905</td>
</tr>
<tr>
<td>Land use mix</td>
<td>0.24</td>
<td>0.18</td>
<td>0.24</td>
<td>905</td>
</tr>
<tr>
<td>From school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicles per licensed driver</td>
<td>0.85</td>
<td>1.00</td>
<td>0.28</td>
<td>905</td>
</tr>
<tr>
<td>Distance to school (m)</td>
<td>895.35</td>
<td>634.28</td>
<td>1276.30</td>
<td>905</td>
</tr>
<tr>
<td>Intersections crossed on route</td>
<td>5.73</td>
<td>5.83</td>
<td>3.16</td>
<td>905</td>
</tr>
<tr>
<td>Major street crossings on route</td>
<td>1.57</td>
<td>0.00</td>
<td>2.41</td>
<td>905</td>
</tr>
<tr>
<td>Maximum traffic on route</td>
<td>407.60</td>
<td>229.00</td>
<td>468.02</td>
<td>905</td>
</tr>
<tr>
<td>Vehicle fleet index</td>
<td>0.35</td>
<td>0.34</td>
<td>0.25</td>
<td>905</td>
</tr>
<tr>
<td>Missing sidewalks</td>
<td>0.03</td>
<td>0.00</td>
<td>0.10</td>
<td>905</td>
</tr>
<tr>
<td>Street tree density</td>
<td>82.60</td>
<td>78.07</td>
<td>60.04</td>
<td>905</td>
</tr>
<tr>
<td>Income (SCDN)</td>
<td>72495.98</td>
<td>70290.00</td>
<td>40564.06</td>
<td>905</td>
</tr>
<tr>
<td>Traffic-calming density</td>
<td>0.63</td>
<td>0.00</td>
<td>1.53</td>
<td>905</td>
</tr>
<tr>
<td>Land use mix</td>
<td>0.23</td>
<td>0.18</td>
<td>0.24</td>
<td>905</td>
</tr>
</tbody>
</table>

There was an even mix when it came to environments, with 456 respondents living in the central city (50%), and 448 in the inner suburbs (50%). The sample also evenly captured neighbourhood income with 436 students from high-income neighbourhoods (49%) and 468 from lower income areas (51%). Nearly 60% of the sample had access to parking facilities at the school (n=533). More than 50% of fathers and 46% of mothers had a university degree. Median distance for the trip to and from school was 634 m, while the mean distance varied slightly (895-900 m). Any to and from difference in trip length relates to different routes taken for these trips. Most respondents had to cross five streets, but very few of these streets were classified as major roads. Traffic-calming features were present for some of the routes, but many did not include these devices (n=638). The values for land use mix were quite low, meaning single land uses
dominated the landscape for most routes. The traffic environment was different during the to and from school trips. There were more vehicles around schools in the morning period, and most of these vehicles were passenger vehicles. This likely relates to the higher rates of driving during the trip to school, as most children are driven in passenger vehicles.

Regression models

As expected, distance emerged as one of the stronger correlates of mode of travel to and from school. As distance increased, the odds of walking decreased. The odds ratio for distance reveals that although similar, distance is actually more important on the trip home from school (Table 3.6). Child gender was also a significant factor for both trips, with boys more likely to walk than girls. School neighbourhood also played a role in both trips. Living in inner suburban areas decreased the likelihood of walking, while children in the central city were more likely to walk. This was even more important for the trip to school, which suggests there are more people driving for the morning trip in the suburbs.

With respect to social class, median household income of the home DA was only significant in the trip home from school model. Households living in DAs with a higher income corresponded with less walking on the trip home. The vehicles per licensed driver ratio was only significant for the to school trip, as households with a higher ratio (more drivers and licenses) were less likely to walk. The number of intersections along the route significantly relates to mode of travel for both trips, but the need to cross major streets produced no effect. Children faced with routes with many intersections, irrespective of road type, were less likely to walk.
Table 3.4
Logistic regression estimation results with walk as the dependent variable

<table>
<thead>
<tr>
<th></th>
<th>To school</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>Wald</th>
<th>p value</th>
<th>Odds Ratio</th>
<th>95% C.I. Lower</th>
<th>95% C.I. Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gendera</td>
<td></td>
<td>0.554</td>
<td>0.209</td>
<td>7.012</td>
<td>0.008</td>
<td>1.741</td>
<td>1.155</td>
<td>2.624</td>
</tr>
<tr>
<td>Vehicles per licensed driver</td>
<td></td>
<td>-1.303</td>
<td>0.409</td>
<td>10.139</td>
<td>0.001</td>
<td>0.272</td>
<td>0.122</td>
<td>0.606</td>
</tr>
<tr>
<td>Neighbourhood type: inner suburbsb</td>
<td></td>
<td>-1.604</td>
<td>0.363</td>
<td>19.517</td>
<td>&lt;0.001</td>
<td>0.201</td>
<td>0.099</td>
<td>0.410</td>
</tr>
<tr>
<td>Neighbourhood income: lowc</td>
<td></td>
<td>0.707</td>
<td>0.276</td>
<td>6.552</td>
<td>0.010</td>
<td>2.027</td>
<td>1.180</td>
<td>3.482</td>
</tr>
<tr>
<td>Distance to school (km)</td>
<td></td>
<td>-1.462</td>
<td>0.245</td>
<td>35.684</td>
<td>&lt;0.001</td>
<td>0.232</td>
<td>0.143</td>
<td>0.374</td>
</tr>
<tr>
<td>Intersections crossed on route</td>
<td></td>
<td>-0.170</td>
<td>0.041</td>
<td>17.110</td>
<td>&lt;0.001</td>
<td>0.843</td>
<td>0.778</td>
<td>0.914</td>
</tr>
<tr>
<td>Major street crossings on route</td>
<td></td>
<td>-0.052</td>
<td>0.064</td>
<td>0.661</td>
<td>0.416</td>
<td>0.949</td>
<td>0.838</td>
<td>1.076</td>
</tr>
<tr>
<td>Maximum traffic on routed</td>
<td></td>
<td>-0.053</td>
<td>0.026</td>
<td>4.148</td>
<td>0.042</td>
<td>0.948</td>
<td>0.901</td>
<td>0.998</td>
</tr>
<tr>
<td>Vehicle fleet index</td>
<td></td>
<td>0.436</td>
<td>0.759</td>
<td>0.330</td>
<td>0.566</td>
<td>1.546</td>
<td>0.349</td>
<td>6.848</td>
</tr>
<tr>
<td>Missing sidewalksc</td>
<td></td>
<td>-2.348</td>
<td>0.946</td>
<td>6.160</td>
<td>0.013</td>
<td>0.096</td>
<td>0.015</td>
<td>0.610</td>
</tr>
<tr>
<td>Street tree density</td>
<td></td>
<td>0.002</td>
<td>0.002</td>
<td>0.427</td>
<td>0.513</td>
<td>1.002</td>
<td>0.997</td>
<td>1.006</td>
</tr>
<tr>
<td>Incomef</td>
<td></td>
<td>-0.001</td>
<td>0.003</td>
<td>0.055</td>
<td>0.815</td>
<td>0.999</td>
<td>0.994</td>
<td>1.005</td>
</tr>
<tr>
<td>Land use mix</td>
<td></td>
<td>0.446</td>
<td>0.575</td>
<td>0.603</td>
<td>0.438</td>
<td>1.562</td>
<td>0.506</td>
<td>4.819</td>
</tr>
<tr>
<td>Parking facilities at the schoolg</td>
<td></td>
<td>-0.827</td>
<td>0.287</td>
<td>8.312</td>
<td>0.004</td>
<td>0.437</td>
<td>0.249</td>
<td>0.767</td>
</tr>
<tr>
<td>Traffic-calming density</td>
<td></td>
<td>0.022</td>
<td>0.093</td>
<td>0.055</td>
<td>0.814</td>
<td>1.022</td>
<td>0.852</td>
<td>1.226</td>
</tr>
<tr>
<td>Safe area to walk aloneh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td></td>
<td>0.415</td>
<td>0.397</td>
<td>1.092</td>
<td>0.296</td>
<td>1.514</td>
<td>0.696</td>
<td>3.293</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>0.862</td>
<td>0.374</td>
<td>5.305</td>
<td>0.021</td>
<td>2.369</td>
<td>1.137</td>
<td>4.935</td>
</tr>
<tr>
<td>Fear of strangersi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td></td>
<td>-0.896</td>
<td>0.440</td>
<td>4.154</td>
<td>0.042</td>
<td>0.408</td>
<td>0.172</td>
<td>0.966</td>
</tr>
<tr>
<td>Somewhat agree</td>
<td></td>
<td>-0.883</td>
<td>0.431</td>
<td>4.189</td>
<td>0.041</td>
<td>0.414</td>
<td>0.178</td>
<td>0.963</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td></td>
<td>-0.805</td>
<td>0.477</td>
<td>2.852</td>
<td>0.091</td>
<td>0.447</td>
<td>0.176</td>
<td>1.138</td>
</tr>
<tr>
<td>Somewhat disagree</td>
<td></td>
<td>-0.827</td>
<td>0.482</td>
<td>2.948</td>
<td>0.086</td>
<td>0.437</td>
<td>0.170</td>
<td>1.124</td>
</tr>
<tr>
<td>Heavy traffic around the schooli</td>
<td></td>
<td>-0.424</td>
<td>0.395</td>
<td>1.154</td>
<td>0.283</td>
<td>0.654</td>
<td>0.302</td>
<td>1.419</td>
</tr>
<tr>
<td>Strongly agree</td>
<td></td>
<td>-0.708</td>
<td>0.381</td>
<td>3.456</td>
<td>0.063</td>
<td>0.493</td>
<td>0.234</td>
<td>1.039</td>
</tr>
<tr>
<td>Somewhat agree</td>
<td></td>
<td>-0.489</td>
<td>0.465</td>
<td>1.103</td>
<td>0.294</td>
<td>0.613</td>
<td>0.246</td>
<td>1.527</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td></td>
<td>-0.626</td>
<td>0.425</td>
<td>2.173</td>
<td>0.140</td>
<td>0.535</td>
<td>0.233</td>
<td>1.229</td>
</tr>
<tr>
<td>Somewhat disagree</td>
<td></td>
<td>-1.306</td>
<td>0.433</td>
<td>9.109</td>
<td>0.003</td>
<td>0.271</td>
<td>0.116</td>
<td>0.633</td>
</tr>
<tr>
<td>Busy streets to crossi</td>
<td></td>
<td>-0.058</td>
<td>0.359</td>
<td>0.026</td>
<td>0.872</td>
<td>0.944</td>
<td>0.467</td>
<td>1.906</td>
</tr>
<tr>
<td>Strongly agree</td>
<td></td>
<td>-0.316</td>
<td>0.356</td>
<td>0.788</td>
<td>0.375</td>
<td>0.729</td>
<td>0.362</td>
<td>1.466</td>
</tr>
<tr>
<td>Somewhat disagree</td>
<td></td>
<td>0.082</td>
<td>0.278</td>
<td>0.087</td>
<td>0.767</td>
<td>1.086</td>
<td>0.630</td>
<td>1.871</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td>6.174</td>
<td>1.008</td>
<td>37.529</td>
<td>&lt;0.001</td>
<td>480.076</td>
<td></td>
<td></td>
</tr>
<tr>
<td>From school</td>
<td>Coefficient</td>
<td>S.E.</td>
<td>Wald</td>
<td>p value</td>
<td>Odds Ratio</td>
<td>95% C.I. Lower</td>
<td>95% C.I. Upper</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td>-------</td>
<td>-------</td>
<td>---------</td>
<td>------------</td>
<td>----------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Gendera</td>
<td>0.728</td>
<td>0.240</td>
<td>9.172</td>
<td>0.002</td>
<td>2.071</td>
<td>1.293</td>
<td>3.317</td>
<td></td>
</tr>
<tr>
<td>Vehicles per licensed driver</td>
<td>-0.462</td>
<td>0.438</td>
<td>1.113</td>
<td>0.291</td>
<td>0.630</td>
<td>0.267</td>
<td>1.486</td>
<td></td>
</tr>
<tr>
<td>Neighbourhood type: inner suburbsb</td>
<td>-0.987</td>
<td>0.350</td>
<td>7.967</td>
<td>0.005</td>
<td>0.373</td>
<td>0.188</td>
<td>0.740</td>
<td></td>
</tr>
<tr>
<td>Neighbourhood income: lowc</td>
<td>0.361</td>
<td>0.277</td>
<td>1.699</td>
<td>0.192</td>
<td>1.435</td>
<td>0.834</td>
<td>2.470</td>
<td></td>
</tr>
<tr>
<td>Distance to school (km)</td>
<td>-1.264</td>
<td>0.220</td>
<td>32.938</td>
<td>&lt;0.001</td>
<td>0.282</td>
<td>0.183</td>
<td>0.435</td>
<td></td>
</tr>
<tr>
<td>Intersections crossed on route</td>
<td>-0.172</td>
<td>0.046</td>
<td>14.143</td>
<td>&lt;0.001</td>
<td>0.842</td>
<td>0.770</td>
<td>0.921</td>
<td></td>
</tr>
<tr>
<td>Major street crossings on route</td>
<td>0.044</td>
<td>0.071</td>
<td>0.388</td>
<td>0.533</td>
<td>1.045</td>
<td>0.909</td>
<td>1.201</td>
<td></td>
</tr>
<tr>
<td>Maximum traffic on routed</td>
<td>-0.005</td>
<td>0.025</td>
<td>0.034</td>
<td>0.854</td>
<td>0.995</td>
<td>0.948</td>
<td>1.045</td>
<td></td>
</tr>
<tr>
<td>Incomef</td>
<td>-0.006</td>
<td>0.003</td>
<td>4.067</td>
<td>0.044</td>
<td>0.994</td>
<td>0.988</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Land use mix</td>
<td>-0.911</td>
<td>0.637</td>
<td>2.041</td>
<td>0.153</td>
<td>0.402</td>
<td>0.115</td>
<td>1.403</td>
<td></td>
</tr>
<tr>
<td>Parking facilities at the schoolg</td>
<td>-0.133</td>
<td>0.320</td>
<td>0.174</td>
<td>0.676</td>
<td>0.857</td>
<td>0.468</td>
<td>1.637</td>
<td></td>
</tr>
<tr>
<td>Safe area to walk aloneb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td>0.400</td>
<td>0.377</td>
<td>1.128</td>
<td>0.288</td>
<td>1.492</td>
<td>0.713</td>
<td>3.123</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1.208</td>
<td>0.366</td>
<td>10.913</td>
<td>0.001</td>
<td>3.347</td>
<td>1.634</td>
<td>6.853</td>
<td></td>
</tr>
<tr>
<td>Fear of strangersi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>-1.252</td>
<td>0.547</td>
<td>5.236</td>
<td>0.022</td>
<td>0.286</td>
<td>0.098</td>
<td>0.836</td>
<td></td>
</tr>
<tr>
<td>Somewhat agree</td>
<td>-0.852</td>
<td>0.538</td>
<td>2.509</td>
<td>0.113</td>
<td>0.427</td>
<td>0.149</td>
<td>1.224</td>
<td></td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>-0.387</td>
<td>0.604</td>
<td>0.410</td>
<td>0.522</td>
<td>0.679</td>
<td>0.208</td>
<td>2.221</td>
<td></td>
</tr>
<tr>
<td>Somewhat disagree</td>
<td>-0.775</td>
<td>0.606</td>
<td>1.634</td>
<td>0.201</td>
<td>0.461</td>
<td>0.140</td>
<td>1.512</td>
<td></td>
</tr>
<tr>
<td>Heavy traffic around the schooli</td>
<td>-0.044</td>
<td>0.478</td>
<td>0.008</td>
<td>0.927</td>
<td>0.957</td>
<td>0.375</td>
<td>2.442</td>
<td></td>
</tr>
<tr>
<td>Somewhat agree</td>
<td>-0.251</td>
<td>0.446</td>
<td>0.317</td>
<td>0.574</td>
<td>0.778</td>
<td>0.325</td>
<td>1.865</td>
<td></td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>-0.570</td>
<td>0.475</td>
<td>1.440</td>
<td>0.230</td>
<td>0.566</td>
<td>0.223</td>
<td>1.434</td>
<td></td>
</tr>
<tr>
<td>Somewhat disagree</td>
<td>-0.107</td>
<td>0.490</td>
<td>0.048</td>
<td>0.827</td>
<td>0.898</td>
<td>0.344</td>
<td>2.347</td>
<td></td>
</tr>
<tr>
<td>Busy streets to crossi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>-1.305</td>
<td>0.443</td>
<td>8.668</td>
<td>0.003</td>
<td>0.271</td>
<td>0.114</td>
<td>0.646</td>
<td></td>
</tr>
<tr>
<td>Somewhat agree</td>
<td>-0.597</td>
<td>0.383</td>
<td>2.429</td>
<td>0.119</td>
<td>0.551</td>
<td>0.260</td>
<td>1.166</td>
<td></td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>-0.671</td>
<td>0.397</td>
<td>2.857</td>
<td>0.091</td>
<td>0.511</td>
<td>0.235</td>
<td>1.113</td>
<td></td>
</tr>
<tr>
<td>Somewhat disagree</td>
<td>-0.269</td>
<td>0.330</td>
<td>0.664</td>
<td>0.415</td>
<td>0.764</td>
<td>0.400</td>
<td>1.459</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>5.684</td>
<td>0.959</td>
<td>35.137</td>
<td>&lt;0.001</td>
<td>294.009</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|aFemale is as referent |
|bCentral city as referent |
|cHigh-income as referent |
|dMaximum traffic in 100 vehicle increments |
|eProportion of route with sidewalk missing on both sides of street |
|fHome dissemination area level income |
|gNo as referent |
|hNo as referent, based on child survey |
|iStrongly disagree as referent, based on parent survey |

Note: Significant variables with a p value < 0.05 in bold
This finding was consistent for both trips, but was even more important on the journey to school. The absence of sidewalks also decreased the odds of walking. Route-based measurement of street trees, traffic calming, and land use mix were not statistically associated with the mode outcome. Although methodological improvements aimed at accurately capturing the environment, it is possible that other approaches or measurements of these features in relation to mode choice, or route choice for that matter, could produce a different result.

With respect to traffic environment, for the trip to school, increased traffic volume, at the school end appears to decrease the odds of walking. While this may appear as an expected result, it was only significant for the morning trip. Informed by the preliminary univariate analysis, vehicle fleet index was only entered into the to school model and was not significant. The finding suggests that, in terms of school-end characteristics, mode choice may not relate to vehicle fleet mix, the greater concern may be traffic volume overall. Parking facilities were also only important for the to school trip, indicating that the presence of facilities may enable driving in some way. Overall, the larger number of significant variables in the to school model may suggest that the traffic environment around the school has a larger and potentially more diverse set of impacts on mode choice in the morning than for the trips at day’s end.

Turning attention toward environmental perceptions, the odds of walking to and from school appeared higher for children who perceived that they lived in a safe area to walk alone. Parents' heightened risk perception regarding strangers appeared to inversely correlate with the odds of walking for both to and from trips. In contrast with findings regarding objective measurement of the traffic environment, perception of heavy traffic around the school was not significant for either trip. Also in contrast with a corresponding objective measure, strong parental agreement on child interaction with too many busy street crossings was inversely related
to the odds of walking. An interesting finding, then, of incongruence between what is widely considered to be objective environmental measurement and respondent perception of the same environment.

**Discussion**

Several key findings have come up in this chapter. The examination of objective and perceived safety variables is a contribution to the current literature, as few studies compare the relationship between objective and perceived environments. Findings from this chapter differ from what Kerr et al. (2006) discovered regarding the objective and perceived environments. In this chapter, several characteristics of the objective environment were significant, while Kerr et al. found the perceived variables were more important. Individual, traffic and environmental characteristics of the route and perceived environments all influence mode of travel. This relates to the ecological model as individual, social and cultural environment, built environment and policy environment all influenced mode of travel. Furthermore, the findings highlight the differences and importance of studying the trip to school versus from school separately. This chapter demonstrates the importance of safety when it comes to mode choice for the journey to school. The findings can improve safety and encourage walking for school travel.

**Traffic volume and vehicle fleet**

One of the major contributions of this work relates to the inclusion of actual traffic counts around the sampled schools at the times when children are travelling to and from school. Traffic, (or the maximum volume along the child’s route), was a significant factor related to mode choice. This finding is important, as few studies have examined this variable within a school travel context.
Some studies have used aggregated daily counts, but no known study has used traffic counts around the school during the morning and afternoon periods. Findings from this variable are not surprising as a higher traffic volume at an intersection relates to decreases in walking. A higher number of vehicles could produce an unpleasant walking environment. From a safety standpoint, higher traffic volume can also be associated with increased risk of pedestrian injury and death. This finding confirms that there is a link between school end traffic volume and AST.

While maximum traffic around the school was significant for the trip to school, it was not for the journey home. This finding likely relates to differences in the trips themselves. There are fewer vehicles around the school in the afternoon. There are two possible reasons for this. One is that the start of the school day overlaps with the morning rush hour, with people driving to work adding vehicles to the roadway in the morning. As well, it is likely easy for parents who begin work in the morning to drop their child off on their way. There was nearly a 10% increase in the rate of people driving to school versus from school. Both the mean and median number of vehicles around the school were significantly lower for the trip home from school (Table 3.5). The difference between the two trips does not suggest that traffic is not important on the trip home, but rather that it is more significant in the morning when traffic volumes are higher.

It appears from this finding that traffic and other environmental features are less important on the trip home from school when more people are walking. This likely relates to parents' work schedules, and the fact that working parents are not being able to pick up their child after school. Many parents will drop off their child in the morning on the way to work, but because of the structure of the workday (i.e., 9am-5pm) and the school day (i.e., 8am-3pm) are not available to pick up their children after school. Although unintended, the lack of synchronicity at day’s end between school and adult paid work may limit the transport options
available to households. This could produce an overall reduction in school-end traffic volumes, and a more temporally fragmented arrival at the school of those parents who pick their children up at the end of the school day.

The inclusion and calculation of the fleet mix variable is indeed a contribution over previous work. No known study to date has examined this feature, but fleet mix around the school does not appear to associate with mode choice. This does not mean that fleet mix should be universally ignored with regard to the school travel issue. It could relate to route choice, and fleet mix around the home might affect mode choice. Moreover, and from an injury perspective, vehicle type/size/mass and speed are of concern. To ensure methods captured this variable effectively, preliminary analysis tested two measures of vehicle fleet mixture. Since there has been very little work on this completed to date, it was not known what would be the most appropriate conceptualization of vehicle mix. The weight based index was entered into the regression analysis because it possesses strong conceptual links with the injury problem. It was also a stronger correlate in preliminary analysis. The odds ratio from the vehicle fleet index suggests that, in neighbourhoods where passenger vehicles dominate the traffic environment, children are more likely to walk, but the finding was not significant. Reasons for the insignificance of the finding could relate to the dominance of passenger vehicles in the school traffic environment. In general, it seems like reducing the number of vehicles may be more important than the vehicle fleet, but more research needs to explore this dimension in another setting.
The objective environment

It appears that environmental characteristics may relate to travel behaviour. In general, living in the inner suburbs decreased the likelihood of walking both to and from school. This variable is a proxy for neighbourhood type, which likely is associated with particular characteristics of the built environment. Further analysis of the built variables determined that several features such as intersections crossed, traffic volume, parking facilities and sidewalks influence mode choice.

Availability of a designated place to drop-off in the morning increased the odds of driving. This is an important finding, as few studies have examined the presence of parking facilities to date and in an effort to decrease the number of parents driving their children this needs further investigation. This chapter only examined designated parking facilities, as nearly every school would have informal drop-off areas. Staff parking lots or nearby streets may act as unofficial drop-off/pick-up zones. The fact that parking matters demonstrates that formal parking facilities need further examination. An official drop-off zone may influence parental perceptions of convenience, which is commonly an important factor related to AST (Ewing et al. 2004; Schlossberg et al. 2006; McDonald and Aalborg 2009; Faulkner et al. 2010). This chapter did find a connection between designated parking facilities and mode of travel, even though all schools would have access to informal pickup and drop-off zones. From a policy standpoint, it is unlikely that merely removing these designated areas would significantly encourage walking in the short term, since many parents would merely park in nearby areas, but more research on this topic is needed and changes may occur over a longer time-period.

Missing sidewalks were negatively associated with walking to school. Many studies examine how sidewalks influence AST, with mixed results to date (Boarnet et al., 2005; Fulton et al., 2005; Kerr et al., 2006; Larsen et al. 2012). These mixed results likely relate to complete
sidewalk networks around elementary schools. While most neighbourhoods in Toronto have a complete network, a few areas are missing this important characteristic. Findings here suggest that when this feature is missing the odds of walking decreased. This finding directly translates into policy applications related to sidewalk development (i.e., no new development should take place without the construction of a complete sidewalk network). School travel alone probably provides an insufficient business case for sidewalk development and so the broader benefits of the infrastructure require communication to influential stakeholders. Little doubt exists that they relate to safety and the perception of one’s environment.

Crossing streets was a negative factor for both the journey to and from school. Routes where children have to cross more streets lowers the likelihood of walking. Much of the research examining street crossings for children has found mixed results. Some studies have found a positive association (Braza et al. 2004; Schlossberg et al. 2006; Frank, et al. 2007; Kerr et al. 2007; Larsen et al. 2012), while others have found the opposite (Timperio et al. 2004; Ulfarsson and Shankar 2008). This chapter adds to the mixed findings, but from a child’s standpoint, this finding makes logical sense. Crossing streets is an important traffic safety concern for many parents, which reiterates findings from the qualitative chapter and previous work (Wen et al. 2008). The fact that crossing more streets was a negative factor for children walking makes sense, from a safety standpoint. Although this finding is rational, the mixed results discovered in the previous work highlight a combination of factors at play when it comes to street crossings. There is the physical act of crossing the street and traffic safety, but also the added connectedness that likely shortens routes for some people. This finding does not mean street crossings are negative for all situations, but rather adds to the current mixture of findings on this topic.
The relationship between street crossings (or intersection density) and mode of travel within the adult literature is more consistent. Intersection density has commonly been a positive predictor for adults (Frumkin et al. 2004; Owen et al. 2004). A higher number of intersections are associated with more route options and potentially a shorter, more direct route between two points. Much of the research on children has drawn variables from the adult literature, although it has become increasingly evident that differences exist between adults and children regarding the built environment. A similar trend exists regarding land use mix. For adults, mixed land uses increase the number of possible destinations (e.g. drinking/dining establishments, shopping, recreation facilities, employment, etc.) whereas for school travel an increase in possible destinations does not likely associate with mode choice. Findings from this chapter suggest that mixed uses do not correspond to mode of travel for children. Since the only destinations of interest to children were school and home, having additional destinations or mixed land uses did not have an impact. Results from this chapter add evidence that children’s travel has different relationships with the environment than adult travel.

Several features such as major street crossings, traffic calming and land use mix did not influence mode of travel, but may be associated with the actual route children traverse. People likely avoid features of the environment that are less pleasing and plan their routes along quiet more enjoyable roadways. Crossing major streets, a higher density of traffic calming devices and mixed land uses were not related to mode of travel. This should not suggest that these features are not important to the environment, nor should it advocate they are unrelated to school travel. There are several reasons that these environmental features did not associate with mode choice. The purpose of this paper was to explore mode choice, not route choice. The insignificance of major street crossings likely relates to the fact that many people did not have to
cross busy intersections. As indicated in Table 3.5, the median number of major streets crossed was zero, suggesting that many routes avoid major intersections.

Children likely intentionally travel along routes that do not require crossing many busy streets to make for a more enjoyable trip. A similar story likely exists for traffic-calming devices. Traffic-calming features are supposed to slow down vehicles, improve perceptions of safety, and reduce the frequency of pedestrian collisions (Lockwood 1997), although the effectiveness for reducing pedestrian injuries is inconclusive (Bunn et al. 2003). Construction of these devices is more common on busier streets, where an attempt to modify driver behaviour through design interventions can produce a more benign traffic environment. Little work on school travel examines this variable, but the insignificant finding may relate to the fact that many children are selecting a route along quieter streets, where speed bumps or other traffic-calming devices are not necessary, or where earlier installation of these devices has produced a desirable walking environment. Similar to the way that major street crossings were irrelevant, these features may actually relate to the routes travelled but not the mode. To obtain a better understanding of how environmental features influence these decisions, future work should examine how children and parents select their route to and from school.

The density of street trees along the route was not a significant predictor. While a few recent papers examined this feature (Larsen et al. 2009; Larsen et al. 2012), it remains relatively understudied. This finding is not surprising in Toronto as the majority of neighbourhoods have an abundance of street trees. Most of the routes in this dissertation had between 70 to 80 street trees along their route to and from school. These high numbers suggest that adequate tree coverage exists in most neighbourhoods. Although street trees may not relate to safety and mode of travel in this chapter, they do contribute to a more pleasant environment. This finding does
not mean street trees are not important in other cities. Tree-planting efforts should continue to improve the environment and encourage AST.

Characteristics of the social environment are also important. Children living in lower income households were more likely to walk home from school than those in the high-income households. This finding relates to previous work as many studies have found higher income children to have lower rates of ATS (McMillan et al. 2006; Vovsha and Petersen 2005; Frank, et al. 2007; Chillon et al. 2009; Mitra et al. 2010; Larsen et al. 2012). Since this characteristic was only significant for the trip home from school, there is likely a connection between income and parent’s work schedules. Higher income families may have only one parent working, a parent(s) with a flexible work schedule or a household labour scenario that enables more driving. As well, higher income households generally have higher rates of automobile ownership and usage (Schimek 1996).

**The perceived environment**

Child and parent perceptions also influenced mode of travel. Initial analysis revealed that most of the answers from the child and parent survey pertaining to safety were not statistically associated with school travel (Table 3.4). Social fears about strangers and older kids, along with perceived traffic, were not statistically significant for children. It was evident from the qualitative study that strangers and bullies were indeed relevant. This may relate to how children answered or understood the survey or the questions themselves may also not have got at exactly what the children were concerned about. It could also be the case that, because adult risk perceptions ultimately determine mode choice, the risk perceptions of children did not directly correlate with a mode choice process largely controlled by parents. The only perceived factor
from the child respondents that was statistically significant was living in a safe area to walk alone, which may relate to perceptions of safety and the decision making process for school travel. Based on findings from the objective variables, sidewalks, traffic and intersections may play a role in enhancing children’s risk perception but more work needs to examine the extent to which this is the case. Irrespective of design features, feeling safe was important for children.

Heightened parental perception of child pedestrian risk of injury, strangers or busy street crossings appeared to limit the odds of walking. It would appear, however, from the presence of contrasting findings regarding objective and subjective assessment of environmental risk factors, that parents ideas about the planned and engineered environment that they experience somehow differ from professional expectations regarding precisely how the built environment lines up with and affects school travel mode choice. This kind of asymmetry between the language and concepts of planning, engineering and everyday life represents an important opportunity for education and outreach that probably requires some additional attention in the context of school travel planning and policy.

It would appear from these findings that what parents perceive as a busy street might not correlate with the City of Toronto’s definition of arterial roadways. The objective count of major street crossings was not significant in the model, yet the perception about crossing the road was significant. This disconnect is likely caused by how parents perceive busy streets. Local streets may indeed be perceived as busy if there is an abundance of traffic around school start and end times. This corresponds with the objective findings, where crossing more streets (regardless of type) was a negative factor associated with walking to and from school.

The fear of strangers was also significant for parents. This again relates to the findings in the qualitative chapter. Most parents have concerns about strangers whether it related to
interaction or fear of abduction; they do not like the idea of strangers in their neighbourhood.
This variable is even more important on the trip home from school. The reason for this may
relate to adult accompaniment. Adult accompaniment may have a significant relationship with
perceptions of safety and mode choice. Previous work has discovered that children accompanied
by adults had a significant reduction in the risk of pedestrian injury (Roberts et al., 1995).
Findings from the qualitative chapter suggested that many parents are escorting their children to
and from school to reduce their safety concerns from both strangers and traffic. Differences in
the rates of accompaniment may translate into the increased importance of stranger concerns for
the trip home from school. On the trip to school, only 33% of children were not accompanied by
their parent, while the rates increased to over 41% on the trip home from school. Since fewer
parents are able to travel home from school with their child, stronger fears over strangers exist.

**Individual characteristics**

The child’s gender, vehicles per licensed driver and distance were all significant characteristics.
Distance is a function of both the individual and the built environment. The street design of a
neighbourhood can make routes more or less direct, thus altering the distance to a destination.
Parents also choose to live in a particular house in a certain neighbourhood and may select the
school their child will attend, all of which relate to individual characteristics. The distance
between home and school is an important variable for both school related trips; as the distance
increased the odds of walking decreased. The results were similar for both trips, with a higher
odds ratio for the trip home from school. These results are not surprising and nearly every study
to date has determined that distance matters (Ewing et al. 2004, Merom et al. 2006; McMillan
Distance is an important factor for people who live far from the school, but the median distance for children in the sample was 634 m. Over 90% of the sample live under 1.6 kilometres (1 mile) from school, and this is a common maximum walking distance for children (Timperio et al. 2004; Schlossberg et al. 2006; McDonald 2007; McMillan 2007). A distance of 1.6 kilometres is also the distance the TDSB uses to determine school bus eligibility, and only students living beyond that distance will qualify. Only 83 students (from the sample of 905 – 9%) lived beyond 1.6 kilometres and 20 of them still walked to school. Just 63 students who live beyond 1.6 kilometres were driven to school, but distance was still a significant variable.

Many students are being driving to school even when they live within one mile of the school, suggesting that not everyone perceives walkable distances in the same manner. Distance should not be relevant for the really short or long trips (i.e., those less than 500 m or more than 1.6 kilometres). This suggests that the mid-range distances are influencing mode choice and this is perhaps where the environment matters the most. Findings from this chapter likely relate to mode choice for people living at these mid-range distances where walking is a viable option, but many students are still being driven. For children living between 1 kilometre and 1.6 kilometres from school, over 59% were driven to school, meaning it is not just children who live really far who travel to school by private motor vehicle. These are the students to target for a mode shift to walking, as distance should not be a factor. All those who are physically able to should have the opportunity to walk. More research needs to explore these mid-range distances to determine what exactly is causing parents to drive their children when walking should be a viable option.

Boys are more likely to walk both to and from school than girls. This is consistent with previous work (Evenson et al. 2003; Fulton et al. 2005; McMillan et al. 2006; Merom et al. 2006; Yarlagadda and Srinivasan 2008; Mitra et al. 2010; McDonald 2011b; Larsen et al. 2012). For
the a.m. trip the odds ratio for boys was 1.73, whereas for the trip home it was 1.98, meaning gender of the child is even more important on the trip home from school. A boy is nearly two times as likely to walk home than a female classmate. In order to improve overall rates of AST, research and policies should target increasing rates of walking for girls, while ensuring the environment is safe. Findings revealed that perceptions and one’s environment might influence mode choice differently for boys and girls. Previous work has found that parents have different social beliefs and stronger personal security concerns for girls (Evenson et al. 2003; Fulton et al. 2005; Merom et al. 2006; Yarlagadda and Srinivasan 2008). Furthermore, the way in which people interact with their surroundings may relate to the gender of the child (Clampet-Lundquist et al. 2011). These findings confirm evidence from the qualitative chapter, which highlights the importance of gender in understanding the different safety concerns associated with school travel.

This chapter examined the idea of self-selection, or whether parents chose to live in a particular neighbourhood so their child could walk to school. Findings from the preliminary analysis suggested that children were significantly more likely to walk if parents strongly agreed or agreed with the question pertaining to living in an area so their child could walk. This question was not included in the final model as it was not significant at other levels of the Likert scale and preliminary analysis reported positive associations regardless of how parents responded to the question (i.e. even for those who disagreed, the children were still positively associated with walking). The responses for the self-selection question may relate to why this variable was not significant at several levels of the Likert scale. Nearly 42% or respondents strongly agreed that they have chosen to live in this neighbourhood because it is easy for their child to walk or cycle to school, while over 72% either strongly or somewhat agreed to this
statement. These results are consistent for people living in the central city (72%) and inner suburbs (70%). The fact that only 11% of respondents disagreed with this comment suggest that it is an important factor, but there is not enough variability within the data to model these associations. Findings from previous work on travel and self-selection commonly discover that self-selection is important, but characteristics of the built environment are also statistically significant even after self-selection has been accounted for (Cao et al. 2009). When examining physical activity, recent research has argued that more work need to account for self-selection using longitudinal studies (Boone-Heinonen et al. 2011). For school travel in Toronto, self-selection likely plays a role in mode of travel, but other factors are also at play.

Differences in trips to and from school

Several features such as vehicles per licensed driver, low-income neighbourhoods, maximum traffic, missing sidewalks and parking facilities were only significant on the trip to school. This reiterates the importance of studying these trips separately. Many of these findings likely relate to the fact that more students walk home from school, suggesting that more transportation options are available to students for the trip to school. The environment and other individual factors likely play more of a role on the trip to school. Certain individual characteristics may influence the importance of one’s surroundings differently. For example, if more mode options are available on the trip to school, the environment may be perceived in a different manner.

Over the past half century, rates of AST have decreased, but the structure of many households in Canada and the U.S. has transformed over the same time-period. The increase of women in the workforce has been arguably the most dramatic shift in the household structure
over the past century (Bianchi 2000). The increasing prevalence of working mothers has undoubtedly resulted in changes to school travel patterns. For school travel, mothers still take a disproportionate share of the responsibilities associated with escorting their children to and from school (Yarlagadda and Srinivasan 2008). In this chapter, 77% of respondents from the parental survey were mothers, 22% were fathers and only 1% responded as others. While it is unknown whether the respondent was responsible for their child’s school travel, by completing the survey, they were taking on some of the responsibility. Increasingly, more mothers are entering the workforce, but are still responsible for their child’s school travel. The changes in workforce involvement by mothers likely corresponds with the differences in rates of AST for the to and from school trips. These findings are not unique to this chapter and previous research has found more people driving to school and a larger number of relevant factors in the to school models (Larsen et al. 2009; Mitra et al. 2010; Larsen et al. 2012). These differences can also help to explain why the adult accompaniment rate is much lower for the trip home from school (67% to school and 59% from school). Many parents (most notably mothers) are simply unavailable to escort their child after school due to employment responsibilities. Previous work reports similar findings, where Yarlagadda and Srinivasan (2008) found that mothers were unable to escort their children home from school (either by car or by walking) because of work constraints.

The fact that fewer adults are available to drive their children home after school helps to explain why the vehicle per licensed driver variable was important for the trip to school, but not for the journey home. Even if a vehicle is available, if the parent is unable to schedule a ride home for their child this will be irrelevant.

Gender becomes more important on the trip home from school. For children driven to school, 64% were girls whereas on the trip home 69% of students driven were girls. Although
the mode share for those driven in a passenger vehicle is lower on the trip home, the proportion of girls being driven has increased, suggesting that parents are more likely to allow boys to walk home than girls. This highlights the importance of understanding exactly what it is about gender that is leading to the variance in mode of travel.

**Conclusion**

The application of the ecological model assisted with the categorization and organization of the variables to explore neighbourhood differences. Beyond previously discussed contributions, this chapter was uniquely focused on reported (mapped) routes travelled rather than modelled network shortest path or aggregated buffers. This enabled a more fine-grained exploration of the characteristics children and/or parents might actually experience or perceive as enabling or threatening environmental qualities on the trip to and from school. Furthermore, another methodological contribution relates to the use of actual recorded traffic counts at each intersection around the sampled schools rather than average daily counts on select streets and the creation of the vehicle fleet mix. All of these methodological contributions were labour intensive, but necessary to improve the methods within the literature and more accurately explore the connection between the environment and travel behaviour.

Previous work has determined that safety concerns are common reasons why children are driven, but few studies have examined actual characteristics and perceptions of safety. This dissertation collected traffic data around the school to improve the evidence base concerning the relationship between different qualities of the traffic environment at the school end, and mode of travel to and from school. Traffic volume related to mode choice for the journey to school, and insignificant findings regarding traffic mix suggest that, overall, volume is potentially more
problematic than vehicle type in regards to mode choice. That is not to say that vehicle type is not important in the context of pedestrian injury and/or death. Evidence from this chapter supports reducing vehicles around schools. School based policies should aim to reduce the number of vehicles around the school to encourage ATS.

*Notes: No data exists from any Federal agency in Canada or from the Province of Ontario. They have suggested using U.S. data as the vehicle fleets in these two countries are nearly identical. Both Transport Canada and Natural Resources Canada use the U.S. data.
Chapter 4

Physical activity and school travel: Assessing how traffic safety and the built environment relate to physical activity levels before and after school

Introduction

Only 7% of Canadian children aged 5 to 11 and 4% of 12 to 17 year olds are active enough to meet the national physical activity guidelines (Active Healthy Kids Canada 2013). Active transportation, which includes walking, cycling, in-line skating and skateboarding is an important source of physical activity for children (Lee et al. 2008; Morency and Demers 2010; Larouche et al. 2012). There are many problems associated with not being physically active. Low levels of physical activity can lead to an increased risk of obesity and other chronic diseases (Trost et al. 2001; Janssen and LeBlanc 2010). For children, a major concern regarding low levels of physical activity is that this may predispose them to a lifetime of physical inactivity. Being active at a young age is important for the overall health of the individual. Physically active children are more likely to remain active as adults, so encouraging physical activity at a young age is particularly important to help build healthy habits (Rowland and Freedson 1994, Vanreusel et al. 1997, Telama et al. 2005; Conroy et al. 2005).
Research consistently demonstrates that children who walk or bike to school are more physically active than those who are driven, although the evidence is less consistent regarding the relationship between active school travel and healthier body weights (Sirard and Slater 2008; Faulkner et al. 2009). Certain neighbourhood characteristics have been connected to the prevalence of obesity or levels of physical activity in some studies (Ross 2006; Nelson and Woods 2009; Frank et al. 2012), but little is known within the realm of safety, physical activity and school travel. Much of the obesogenic environment research to date has focused on access to parks or other walkability measures (Frank et al. 2012; Saelens et al. 2012), while little is known about safety and children’s travel patterns. The chapter aims to further the understanding of how the built environment relates to school travel and children’s health in a Canadian city.

This chapter uses two methodological approaches to exploring the connection between characteristics of the built environment and physical activity levels. This two-phased methodological approach will contribute to the current literature by first assessing whether broad environmental features matter for children’s health, and then by identifying whether specific features along the route to and from school associate with children’s health, where in the context of this chapter children’s health is modelled as minutes of physical activity before and after school. The first method is a spatial exploratory data analysis of the school neighbourhoods and examines environmental differences through visual representation of the street network around each school neighbourhood. These images highlight the broad neighbourhood level differences between the built environment and health. This type of exploratory spatial data analysis is not common within studies examining the built environment and physical activity, and is a contribution to the current literature.
This first phase of analysis helps to understand the data and to generate hypotheses related to the environment and physical activity which will later be tested with the modelled analysis. The second form of analysis looks at specific details along the route to and from school by using multiple linear regression to explore associations between safety, environmental attributes, physical activity levels and body weight. The use of these two approaches allows for a more thorough examination of the connection between physical activity, safety and the built environment, first at the broad neighbourhood level, then to identify specific environmental features at the micro level.

Previous sections examined the literature pertaining to physical activity, school travel, safety and the built environment (see literature review starting on page 5), but a brief review will follow. This chapter will add to the findings by examining how safety and the environment relate to physical activity. This will be completed at two levels, the neighbourhood (broad) and individual routes (detailed).

**Background**

For children, the mode of travel to school has changed considerably over the past 50 years. Rates of active travel to and from school have decreased, while sedentary travel in a motor vehicle has become increasingly common (McDonald 2007; Ham et al. 2008; Buliung et al. 2009; McDonald et al. 2011). According to Pate et al., “Sedentary behaviour refers to activities that do not increase energy expenditure substantially above the resting level and includes activities such as sleeping, sitting, lying down, and watching television and other forms of screen-based entertainment” (174, 2008). Screen time (or time spent watching TV, playing on computers or video games) is the most prevalent form of sedentary behaviour for children, but
being transported by motorized modes of transport is the next most common (Biddle et al. 2009, Biddle et al. 2009b). Switching from a sedentary activity such as being driven to school to an active one such as walking may influence overall activity levels. Increasing physical activity levels is important, as daily activity may be one of the best measures to tackle obesity in children (Kwon et al. 2013).

A connection exists between mode of travel to and from school and levels of physical activity, but this link appears to rarely translate into healthier body weights (Sirard and Slater 2008; Faulkner et al. 2009). A link also exists between the built environment and mode of travel for children, as certain neighbourhood characteristics can be AST barriers or enablers (Schlossberg et al. 2006; Larsen et al. 2009; Panter et al. 2010a). Characteristics of the built environment can promote or hinder rates of physical activity (Humpel et al. 2002; Lee and Moudon 2004). Previous work examining the school neighbourhood determined that environmental features relate to levels of physical activity for children (Sallis et al. 2001). This chapter will examine how broad neighbourhood level differences and specific environmental features along the route relate to physical activity levels during the times when children travel to and from school. Previous work reported that neighbourhood features and adult supervision increased activity levels for school aged boys and girls (Sallis et al. 2001). Although this connection may exist between the built environment, mode of travel and physical activity, little work has examined how the built environment relates to physical activity during the travel times to and from school.

More recently, research has started to examine how other features of the school trips, aside from mode, affect rates of physical activity (van Sluijs et al. 2009; Panter et al. 2011). Panter et al. (2011) examined how distance between home and school related to physical activity
levels of the child. Findings from this study determined that, for children in the United Kingdom (U.K.), walkers obtained more physical activity during school travel times (8 to 9 a.m., and 3 to 4 p.m.), with a stronger connection as distance increased (Panter at al. 2011). These findings highlight the importance of walking to school at all distances, and suggest that longer distances, as they mean more time walking or more time to play while travelling all of which can relate to higher levels of physical activity. This chapter will add to the current findings by examining how additional features (i.e., safety and the built environment) relate to levels of activity.

Aside from distance, environmental features may also influence levels of physical activity during school travel times. While few studies have examined the link between physical activity and route characteristics, findings from previous work have found a connection between the environment and mode of travel (Kerr et al. 2007; Larsen et al., 2009; Mitra et al. 2010; Panter et al. 2010b). Much of the previous literature examining school travel and the environment uses aggregated buffers of the home and/or school neighbourhood (Braza et al. 2004; Kerr et al. 2006; Frank et al. 2007; McMillan 2007; Larsen et al. 2009). Studies that are more recent have examined the shortest path between a child’s home and school (Schlossberg et al. 2006; Timperio et al. 2006; Panter et al. 2010; Panter et al. 2011; Larsen et al. 2012). The shortest path is an improvement over previous methods, but assumes the child travels along the shortest route, which is not always the case (Buliung et al. 2013). The use of the mapped route is a contribution of this work; for more details on the methodological improvements of using the mapped route analysis, see methods section in Chapter 3 (commencing on page 72).

Findings from these shortest path route-based studies suggest that the environment relates to both walking and rates of physical activity. Timperio et al. (2006) discovered that factors such as distance, busy street crossings or more direct routes negatively influenced rates of walking to
school in Australia. In Oregon, features associated with the street network relate to walking; where lower street connectivity and a higher concentration of cul-de sac’s both negatively influenced walking rates to and from school (Schlossberg et al. 2006). In the U.K., a higher road density increased the odds of walking, while a more direct route was a negative factor for walking and a higher concentration of street lights discouraged cycling (Panter et al. 2010). Finally, findings from a Canadian study found that factors such as land use mix, residential density and traffic volume negatively related to walking/cycling, while street trees encouraged AST to school (Larsen et al. 2012). For the trip home from school, traffic and major street crossings decreased the odds of walking/cycling, whereas street connectivity encouraged AST (Larsen et al. 2012). These studies assess how the environment influences mode of travel, which may impact physical activity levels; however, this chapter aims to move beyond travel mode analysis and explore how health behaviour (i.e., physical activity) relates to the environment.

The specific research questions of this chapter are: 1) Do neighbourhoods relate to a child’s body weight and/or physical activity levels?; 2) What specific features along the route influence physical activity levels?; and 3) How do these features differ for the trip to and from school? This will add to the work by Panter et al. (2011) that examined only how distance and mode influenced levels of physical activity, by examining environmental features. The exploratory spatial analysis of school neighbourhoods explores question 1, by examining rates of walking, BMI and physical activity levels at the school neighbourhood level. This involves comparisons of rates based on the school location (income and central city versus inner suburbs) and preliminary results for broad neighbourhood level differences are reported. To address questions 2 and 3 more detailed exploration is required. The second analysis examines the environment at
route-based level, which allows for micro-level assessment of environmental features children interact with during school travel.

**Conceptual framework**

Findings from the previous two chapters confirmed that safety and perceptions of safety were important factors relating to school travel mode and a relationship existed between certain environmental characteristics along the route and walking rates. The purpose of this chapter is to examine how traffic safety and characteristics of the built environment may relate to physical activity levels before and after school. This chapter will build on the knowledge from the two previous chapters by exploring how children’s health (in terms of physical activity and body weight) actually relates to travel mode and safety concerns. While it follows that factors influencing mode choice also influence activity levels, few studies have tested whether environmental features are associated with activity levels for children during school travel times. Findings from the previous two chapters helped to guide the conceptual thinking of what features may relate to activity levels.

Aside from the inclusion of important variables from the previous chapters, this research also adopts the ecological model to assist with the categorization and understanding of contextual features. Within the ecological model, features of the environment are theorized or assumed important in determining health behaviour (Sallis et al. 1997). This implies that there is a connection between human health, well-being and the environment (Moos 1979; Stokols 1987; Stokols 1992; Hoehner et al. 2003). In the two quantitative chapters, the ecological model is used in combination with the emerging themes from the qualitative chapter to help with model
specification. For full details on the application of the ecological model in this dissertation, see the conceptual framework in the previous chapter (page 33).

Methods

As with the previous chapters, data collection for this dissertation was completed in the City of Toronto as part of the Built Environment and Active Transportation (BEAT) project. After piloting, travel behaviour surveys were completed by grade 5 and 6 students (n=1035) at 17 elementary schools (n=1035 children) within the City of Toronto. Since physical activity data for the pilot study was not available for one school (n=1 school, n=34 children), this chapter only examined 16 of the 17 schools. Eight schools were located in the central city and another eight schools were located in the inner suburbs. The sampled schools had an even mix for neighbourhood income, with eight in high-income and eight low-income neighbourhoods. Once again, neighbourhood income was the only measure of class examined, as the socio-economic characteristics of the neighbourhood were embedded in the sampling design. The previous chapter reported full details on data collection process (page 72).

Students and parents completed consent forms prior to data collection. Researchers supervised the completion of surveys and gave instructions to participants on how to wear their accelerometers. Child and parental surveys obtained the mode of travel to and from school along with socio-demographic information. Once the survey and instructions were completed, researchers obtained individual height and weight measurements for each student. The measured height and weight data allowed researchers to estimate BMI for each of the students. BMI is an indicator of body fatness and is a reliable measure in determining healthy body weights for children (CDC 2011). Overweight, underweight and obesity classification for children varies by
age of the child in months and by gender. Being overweight for children is having a BMI greater than the 85th percentile, while obesity is greater than the 95th percentile and underweight is less than the 5th percentile (CDC 2011).

Accelerometers measured physical activity for each of the students for seven days (ActiGraph GT1M). In order to obtain rapid transitions in activity patterns, which are common for children, a five-second epoch was used (Stone et al. 2009). Children were asked to wear their accelerometer at all times for seven days, unless they were swimming or bathing (i.e., whenever they were in water as that can potentially cause damage to the accelerometers). Children were instructed to wear the device while they were sleeping, to ensure they did not forget to put them back on in the morning. Data collection commenced at midnight on the day children received the accelerometers and continued for seven full days. Any partial days of data (collected on the first day or last day) were excluded. Time spent participating in various levels of activity (sedentary, light, moderate, vigorous and hard) was calculated for each participant using published thresholds from previous work (Stone et al. 2009b). Accelerometers measure activity using a ‘counts’ output which is a measure of the force of acceleration of an object. These counts need to be converted into meaningful measurement units based on differing intensity threshold identified through validation research. For example, counts can be transformed into the number of minutes a child is active (light, moderate or vigorous) during the school travel timeframe. For this chapter, thresholds of light, (300-3581) moderate (3581-6130), and vigorous (>6130) counts per minute were used (Stone et al. 2009b).

This chapter examines light, moderate and vigorous activity levels for the hour before and hour after school. Light activities were included rather than only moderate to vigorous activities for several reasons. Recent studies have found even light activities may improve one’s
health (Healy et al. 2008; Powell et al. 2011). Furthermore, this chapter adopted conservative cut-off points for light, moderate and vigorous activity, meaning that what some previous studies have classified as moderate activity may be defined as light in this dissertation (Stone et al. 2013). The timeframe of interest for this chapter was during the trip to and from school, thus the data used here are only for one-hour segments before and after school. One hour before school commences was the definition used for the ‘before school’ travel period, while one hour after school was the ‘after school’ period. School principals confirmed the school start and end times to ensure accuracy. This classification method includes both the trip to and from school but also inevitably captures other activities before or after the trip itself, such as playing in the school-yard or more structured after school sports (e.g. soccer, hockey, baseball).

**Exploratory spatial data analysis of the street network around schools**

Previous research has found a connection between street design and levels of physical activity (Jago et al. 2005), suggesting that neighbourhood characteristics may directly relate to activity levels and health behaviour. Previous studies have examined the progression of street design over the past century (Baladassare 1986, Southworth and Owens 1993, Southworth 2005), but little is known as to how streets influence physical activity levels before or after school. In order to assess the broad neighbourhood differences between street design and physical activity levels for children, the use of images helped me examine how the street design around each of the sampled schools may relate to health behaviour (e.g. rates of walking, physical activity and BMI). The exploratory visual analysis is used to generate hypotheses on relationships between the environment and children’s health behaviour. Following the work of Southworth and Owens
(1993), which examined the changes in street networks over time, each of the school neighbourhoods was mapped to display the street pattern along with characteristics of the streets themselves.

The main entrance of each school was used as the centre point to generate images of the school neighbourhood. The City of Toronto provided a complete dataset with the current street network. The street centreline file was converted into a polygon to illustrate the visual outline of the street network. The widths of the lines correspond with actual street widths. This process first involved automation of street widths, and visual examination was used later to manually adjust or fix any errors. The road network was also used to calculate the length of streets, number of intersections and cul-de-sacs within each school neighbourhood (one square kilometre) used in Figure 4.1. Figures 4.1, 4.2, 4.3 and 4.4 display a one square kilometre area around each of the 16 sampled schools (one school was excluded due to its missing accelerometry data). For Figures 4.2 through 4.4, data was divided into quartiles to display and explore neighbourhood differences in school travel mode, BMI and physical activity levels before school. Four different shades of grey illustrate the quartiles for each measure, displaying the current rates related to health behaviour.

**Detailed assessment of the routes to and from school**

Data on sidewalks, street trees, traffic calming devices and the street network were obtained from the City of Toronto and used to measure various characteristics along the routes between home and school. When necessary, I verified all of the datasets through field survey and the use of aerial photography. Children and parents completed a mapping exercise to report the child’s route to and from school. Full details on this process were explained in the previous chapter
Once again, the exercise to obtain the mapped routes was labour intensive, but it is a contribution of this work and a step towards obtaining more representative route-based results. I manually digitized each of the maps with the assistance of aerial photography (20 cm resolution) and field surveys when necessary. The reported routes allowed researchers to obtain measured data on the distance between home and school, and to examine the environmental characteristics children actually may have an opportunity to interact with during their trips to and from school, i.e., a GIS modelled shortest path route and straight-line distances likely place children away from their actual travel environments (see Buliung and Larsen 2013). A few maps were missing data, inaccurate or incomplete, producing 956 of the 1001 routes to school and 959 from school routes with adequate information for analysis.

Several environmental characteristics, selected due to their presence in the literature, along the routes were examined for both the to and from school trip. The density of intersections crossed was calculated based on the distance each child travels (to give a number of street crossings per kilometre of route), and repeated to indicate major intersections as well. Classification of major intersections consists of arterial streets (major or minor arterial) as defined by the City of Toronto. Both of these variables may be related to traffic safety and one’s ability to manoeuvre through the environment. The literature review discussed details pertaining to their interaction (see page 15). A more connected street network (or higher number of intersections) can increase possible route options and decrease distances to destinations; however, crossing a higher number of streets (or major streets) may increase traffic exposure. No clear connection exists to date regarding street (and major street) crossings and mode of travel/activity levels for children (Braza et al. 2004; Schlossberg et al. 2006; Frank, et al. 2007; Kerr et al. 2007; Larsen et al. 2012), but from a safety perspective crossing streets may be linked
to lower rates of walking. A reduction in walking also likely translates into decreases in physical activity during school travel times.

A few recent studies have found a link between street trees and active travel to school (Larsen et al. 2009; Larsen et al. 2012), but more work is needed to determine how markedly street trees influence mode choice. For physical activity, studies have found a positive association between green space and children’s activity levels and healthy body weights (Liu et al. 2007; Bell et al. 2008; Wolch et al. 2010). It is unclear whether street trees influence activity levels for children in Toronto, but this chapter aims to test this hypothesis.

The proportion of missing sidewalks was compiled by identifying the length of sidewalks missing on both sides of the street in relation to the length of the trip (i.e., finding the proportion of route with missing sidewalks). Sidewalks may be an important characteristic of pedestrian safety as they give people space away from moving vehicles. The density of traffic calming devices (chicanes, speed bumps, raised intersections, gateways, raised crosswalks and traffic circles) was also examined in relation to the distance travelled. These features may slow traffic and reduce traffic safety concerns by reducing the perceived and or actual risk of severe injury or death. More complete sidewalk networks and a higher density of traffic calming devices are hypothesized to create an environment that is more pleasant for not only walking to school but also other activities before and after school as well. If these characteristics do actually encourage walking, this should translate into higher levels of physical activity before and after school.

Income associates with both school travel and pedestrian safety. Lower income neighbourhoods commonly have a higher incidence of child pedestrian injury (Rivera and Barber 1985; Calhoun et al. 1998; DiMaggio and Li 2012, but also have higher rates of walking to and from school (McMillan et al. 2005; Vovsha and Petersen, 2005; Frank et al. 2007; Chillon et
al. 2009; Dalton et al. 2011; Larsen et al. 2012), physical activity levels (O’Loughlin et al. 1999; Cerin and Leslie 2008; Gk et al. 2009). The median household income (2006) for each dissemination area (DA) was the measure of income used (Statistics Canada). Since no individual level income variable was available, DA level income tests the association between neighbourhood level income and physical activity. Similar to methods in the previous chapter, routes were assigned an income value based on the location of a student’s home within a DA. (For example, if the home was located in a DA with a median household income of $56 000, this would be the value assigned.) Higher income households commonly have higher rates of driving to and from school, but it is unknown exactly how income influences activity for the entire hour before and after school, although in general activity levels correlate with income (O’Loughlin et al. 1999; Cerin and Leslie 2008; Gk et al. 2009).

Gender and distance are commonly associated with mode choice for school travel (Evenson et al. 2003; Fulton et al. 2005; Merom et al. 2006; Yarlagadda and Srinivasan, 2008; Mitra et al. 2010; McDonald 2011; Larsen et al. 2012), where boys are more likely to walk than girls, and longer distances decrease the likelihood of walking. Previous work has also discovered a connection between distance, gender and minutes of activity (Panter et al. 2011). Distance and physical activity levels have a direct dose response relationship for walkers: people who walk longer distance obtain more activity (Panter et al. 2011; Stone et al. 2013). The influence of gender on physical activity during school travel is less clear. Some studies have reported more activity for boys only (Cooper et al. 2003; Rosenberg et al. 2006), while more recent studies report no gender differences (vanSluijs et al., 2009; Panter et al. 2011). This work will further explore the association between gender and activity levels. Once again, the ethnicity of the child is not examined, even though ethnicity commonly relates to both mode of travel and
physical activity levels (Kerr et al. 2007; Wang and Beydoun 2007; Morrison et al. 2011; Ogden et al. 2011; Wang 2011; Ogden et al. 2012). Aside from the conceptual issues previously discussed, data on ethnicity were not available within this dataset. Future work should examine how ethnicity relates to physical activity levels before school for children in Toronto.

Traffic counts

No conclusive evidence exists regarding the relationship between school travel, physical activity and traffic conditions. Findings from the previous chapter did suggest that a higher concentration of vehicles along one’s route influenced mode of travel to school. Under this assumption, lower traffic volumes may encourage physical activity within an environment perceived by adults and their children to be safer, at least in terms of exposure to traffic. Manual traffic counts were conducted at all of the intersections surrounding each school. See the previous chapter for full details on this process and its contribution to the literature and this dissertation (page 84). The process involved collecting data on the number and type (cars, truck, bus, etc.) of vehicles at all access and egress points around the schools. This approach provides traffic data for the entire block surrounding the school, and helps to obtain an idea of traffic conditions around the school. Previous work discovered that higher traffic volume is the largest concern for pedestrians (Lee and Abdel-Aty 2005, Sze and Wong 2007; Harwood et al. 2008; Zegeer and Bushell 2012). For the sake of consistency with the methods used in Chapter 3 and findings from the pedestrian safety literature, the intersection, accessed by each student, having the highest number of vehicles along each route (or maximum traffic) was the measure of traffic volume applied to each student record in the database.
To understand how different types of vehicles relate to safety and physical activity, a vehicle fleet index was created, using the same approach as outlined in the previous chapter. For this, a multiplier (based on average vehicle weights) was applied to obtain car equivalents for each vehicle type (NHTSA 2003; EPA 2010)*. More details on these methods are on page 84. Once again, no known study has examined this feature so it is unknown exactly how it will relate to activity, but the inclusion of actual recorded traffic volumes and mix contributes to the current literature. The measure of passenger vehicles consisted of the weighted SUV/mini van totals and the number of cars. Four vehicle classification types (passenger, transit, school bus, truck) were used to create the fleet index. A reverse entropy index was calculated to represent the mix of vehicles around each of the sampled schools using the following formula:

\[
\text{Fleet mix} = \left( \frac{v \cdot (p \cdot \ln p)}{\ln n} \right) + 1,
\]

where \(v\) is the type of vehicle; \(p\) is the proportion of the vehicle type dedicated to that classification; and \(n\) is the total number of classifications (\(n=4\): passenger vehicles, transit, school bus and trucks). Fleet mix scores will range from zero to one. Zero represents a mix dominated by trucks, transit and school busses, while a score of one represents an intersection with only passenger vehicles.

**Data analysis**

Preliminary data analysis involved visually exploring connections between the school neighbourhoods in relation to the street network, mode of travel, BMI and physical activity. The main purpose of this exploratory spatial data analysis is to get a better understanding of possible
relationships between neighbourhoods and health behaviour. Findings from this exploratory analysis will be used to generate hypotheses which will be tested in the second phase of analysis. The beginning of the results section displays these figures and findings. Descriptive statistics of the sample more thoroughly explored trends indicated by the maps (Figures 4.1, 4.2, 4.4 and 4.6).

Since the exploratory analysis suggested that neighbourhood differences related to health behaviour, more detailed route-based analysis followed. After the initial examination of the route-based dataset, exploration within the data took place to ensure there was a linear relationship between the variables of interest and to look for outliers. Table 4.1 displays the independent variables examined in the detailed analysis along with the predicted relationship based on concepts discussed in the literature review. Table 4.1 also reports how each of the features relates to the ecological model, and what level of influence each variable falls within. Following the initial examination, it became obvious that when the route distance was longer than 1.6 kilometres or 1 mile there were several outliers; thus only people living within 1.6 kilometres of school were included in this analysis.

Pearson correlation tests were used to examine collinearity among continuous variables and to determine associations between characteristics along the route and physical activity levels for the hour before and after school. Table 4.2 illustrates all of the features and their correlation to light, moderate and vigorous activity. Variables were entered into the modelled analysis if the $p$ value was less than 0.1. This process was repeated for the from school routes and activity for the hour after school ends (when children are travelling home from school) (Table 4.2).
Table 4.1  
Variables examined in the models and the predicted relationship to physical activity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Anticipated direction</th>
<th>Relationship with ecological model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (Boys: 1, *Girls: 0)</td>
<td>Positive</td>
<td>Individual</td>
</tr>
<tr>
<td>Income (home DA)</td>
<td>Negative</td>
<td>Individual/Social environment</td>
</tr>
<tr>
<td><strong>Objective environmental characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance (Distance between home and school in km)</td>
<td>Positive</td>
<td>Built/Policy environment</td>
</tr>
<tr>
<td>Number of intersections crossed along route (per km of total distance)</td>
<td>Negative</td>
<td>Built/Policy environment</td>
</tr>
<tr>
<td>Number of major intersections crossed along route (per km of total distance)</td>
<td>Negative</td>
<td>Built/Policy environment</td>
</tr>
<tr>
<td>Proportion of route missing sidewalks</td>
<td>Negative</td>
<td>Built/Policy environment</td>
</tr>
<tr>
<td>Street tree density</td>
<td>Positive</td>
<td>Built/Policy environment</td>
</tr>
<tr>
<td>Density of traffic calming devices</td>
<td>Positive</td>
<td>Built/Policy environment</td>
</tr>
<tr>
<td>Maximum traffic along the route</td>
<td>Negative</td>
<td>Built/Policy environment</td>
</tr>
<tr>
<td>Vehicle fleet index (1: all passenger vehicles, 0: trucks, transit, school bus)</td>
<td>Positive</td>
<td>Built/Policy/Social environment</td>
</tr>
</tbody>
</table>

Following initial analysis, all of the variables were tested for multicollinearity issues. A correlation matrix tested all the variables to ensure no correlation existed between them. After this process, the variance inflation factor (VIF) of each characteristic was also examined. Variables that had multicollinearity issues identified in the previous chapter were not entered into the preliminary analysis for this chapter. Maximum traffic, traffic calming density, major street crossings and dummy control variables for mode of travel and gender were all entered into the before school model. For the after school model, income, traffic calming density and street crossings were used along with gender and mode of travel.
Table 4.2
Pearson correlation with light, moderate and vigorous physical activity

<table>
<thead>
<tr>
<th></th>
<th>To School</th>
<th>From School</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Income</strong></td>
<td>Correlation -0.056</td>
<td>-0.102</td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td>0.136</td>
</tr>
<tr>
<td><strong>Tree density</strong></td>
<td>Correlation 0.049</td>
<td>-0.044</td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td>0.189</td>
</tr>
<tr>
<td><strong>Vehicle fleet index</strong></td>
<td>Correlation 0.007</td>
<td>-0.028</td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td>0.844</td>
</tr>
<tr>
<td><strong>Maximum traffic</strong></td>
<td>Correlation <strong>0.063</strong></td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td><strong>0.092</strong></td>
</tr>
<tr>
<td><strong>Traffic calming density</strong></td>
<td>Correlation <strong>0.183</strong></td>
<td>0.080</td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Missing sidewalks</strong></td>
<td>Correlation -0.025</td>
<td>-0.047</td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td>0.513</td>
</tr>
<tr>
<td><strong>Intersections crossed</strong></td>
<td>Correlation 0.019</td>
<td><strong>-0.099</strong></td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td>0.608</td>
</tr>
<tr>
<td><strong>Major street crossings</strong></td>
<td>Correlation <strong>0.145</strong></td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Distance (KM)</strong></td>
<td>Correlation <strong>-0.147</strong></td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td><em>p</em></td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Bold represents variables that were entered into linear models.

**Model specification**

Multiple linear regression models identify the connection between environmental characteristics with light, moderate and vigorous physical activity during the hour before and after school as the dependent variable. Including light activities not only makes sense for walking and improving one’s health (Healy et al. 2008; Powell et al. 2011), but including light activity in the models also increased the variability within the data, increasing the significance and model fit. Models were created independently for the before school trip and then the after school timeframe. Linear models examine how a linear combination of independent variables relates to the dependent variable (or minutes of activity). The purpose of these models is to explore how mode choice and environmental attributes relate to safety, and to explore whether they are associated with physical activity for the hour before or after school. Once again, these models are not predictive, but rather describe and explore the data available in relation to the built environment, safety and
physical activity. The methodological improvements using mapped routes and actual recorded traffic data is a major strength of this work.

Aside from the tests of multicollinearity, several checks examined model fit. Part and partial correlation coefficient tests were also performed to ensure all of the independent variables were providing unique information to the model (i.e., adding to the model by providing data not available through any of the other variables). The next step tested the coefficient of variation, which ensures the model does not have too much unexplained variability. The before school model produced a result of under 10% which is ideal, while there were more problems in the after school model. The coefficient of variation for the trip home from school was nearly 15%, meaning there is slightly too much unexplained variability with this model (Yan and Su 2009). This may relate to the differences in the trips themselves. The trip home from school and activities after school are very different from those during the morning period. See the discussion section for further details on the difference between the trips to and from school. The intervals for the after school model are quite wide and should not be used for predictive purposes. Finally, all data were tested to ensure homoscedasticity, and no problems were found.

The R² values which help to report the proportion of variance explained by the model, were also examined for each of the models. For the before school model, nearly 7% of variance could be explained (0.067) while the after school model was much lower at only 3% (0.032). These tests also suggest that the before school model is a much better fit than after school model. The following section provides more discussion on why these models have different R² values, but the results likely go beyond the techniques applied to construct these models and relate to the differences in the trips themselves along with what other activities takes place before and after school.
Results

Presentation of the results is in two stages. First, results of the exploratory spatial data analysis, which explored neighbourhood differences pertaining to school travel mode, BMI and physical activity levels. The following section presents findings from the analysis of specific features along the route in relation to levels of physical activity for the hour before and after school.

Examination of school neighbourhoods

Figure 4.1 illustrates the street design around each of the sampled school neighbourhoods, along with the year each school opened. These figures illustrate an area of one square kilometre centred on the school’s main entrance. As displayed on Figure 4.1, most of the central city neighbourhoods have straighter (and more connected) blocks, a higher number of intersections and linear metres of roadways. The more recent inner suburban neighbourhoods have a less connected street network (fewer intersections), curvy streets and less land dedicated to roadways (linear metres). Differences also exist within the central city and inner suburban neighbourhoods themselves. As the era of development progresses, so too does the street design. It is obvious that differences exist between the sampled neighbourhoods, within and amongst central city and inner suburban areas.
Figure 4.1
Street design around each of the sampled school and characteristics of the environment
It appears from this sample that where you live influences school travel patterns, as mode of travel varies by neighbourhood type. Figure 4.2 displays the percentage of students walking to school for each of the neighbourhood types. Data on mode of travel was divided into quartiles to help illustrate the differences. All of the schools where less than 50% of the sample was walking were located in the inner suburbs, while three of the four schools where walking rates were greater than 80% were in the central city. Furthermore, three of the four schools where rates of walking ranged between 75% and 80% were also in the central city. At first glance, it appears that more respondents who attend a central city school walking to school. In general, it appears as though a more connected or “gridded” street network with more intersections may be encouraging rates of walking to school, as this type of design was more common in the central city.

Table 4.3 reiterates those trends as it shows that over 82% of students living in the central city walk to school, versus 62% for children in the inner suburbs. It also appears that boys have higher rates of walking to school, while girls are more commonly driven. Further investigation reveals that connections also exist between gender and neighbourhood type. Ninety four percent of boys living in the central city walked to school, while only 69% of boys walked in the inner suburbs. This compares to 82% of girls walking in the central city and 62% of girls in the inner suburbs. These findings suggest that environments and gender may both relate to children’s travel behaviour.
Figure 4.2
Percentage of students walking to school for each of the neighbourhood types
Table 4.3
Mode of travel to school by gender and neighbourhood type

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
<th>Central city</th>
<th>Inner suburbs</th>
<th>High income</th>
<th>Low income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk</td>
<td>78.4%</td>
<td>66.8%</td>
<td>72.2%</td>
<td>82.7%</td>
<td>61.6%</td>
<td>65.8%</td>
<td>78.2%</td>
</tr>
<tr>
<td>Driven</td>
<td>21.6%</td>
<td>33.2%</td>
<td>27.8%</td>
<td>17.3%</td>
<td>38.3%</td>
<td>34.2%</td>
<td>21.8%</td>
</tr>
<tr>
<td>Girls Walk</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>82.4%</td>
<td>62.6%</td>
<td>69.5%</td>
<td>75.9%</td>
</tr>
<tr>
<td>Boys Walk</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>94.3%</td>
<td>69.0%</td>
<td>74.4%</td>
<td>87.6%</td>
</tr>
<tr>
<td>Girls Driven</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>17.6%</td>
<td>37.4%</td>
<td>30.5%</td>
<td>24.1%</td>
</tr>
<tr>
<td>Boys Driven</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>5.7%</td>
<td>31.0%</td>
<td>25.6%</td>
<td>12.4%</td>
</tr>
</tbody>
</table>

It also appears that neighbourhood income may relate to mode of travel, as a higher percentage of students were walkers in low-income neighbourhoods (Table 4.3). While no real trends appear evident within the central city schools and income levels, all of the schools in the lowest quartile for walking rates are located in high-income neighbourhoods within Toronto’s inner suburbs (Figure 4.2).

Table 4.4 below displays a breakdown of body weight classification for each of the neighbourhoods along with differences by gender. The values, defined by using growth charts provided by the Centers for Disease Control and Prevention (CDC) indicate that BMI is calculated differently based on the child’s age (in months) and gender. Differences exist regarding the percentage of students who are overweight and obese for both neighbourhood type and income. Children in this sample living in the central city are less likely to be overweight, underweight or obese with 73.1% of the population having a normal body weight. Those living in the inner suburbs appear to have higher rates of overweight and obesity. These trends are even more evident when examined by income. Three quarters of children living in high-income neighbourhoods have normal body weights, whereas rates are only 64.8% in the lower income areas. The obese category presents the most drastic differences, where rates are nearly 10% higher for students attending schools located in neighbourhoods of lower income.
Table 4.4

Body weight breakdown by gender and neighbourhood type

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
<th>Central city</th>
<th>Inner suburbs</th>
<th>High income</th>
<th>Low income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>5.3%</td>
<td>4.3%</td>
<td>4.8%</td>
<td>4.1%</td>
<td>5.3%</td>
<td>3.9%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Normal</td>
<td>63.0%</td>
<td>74.2%</td>
<td>69.0%</td>
<td>73.1%</td>
<td>66.2%</td>
<td>75.5%</td>
<td>63.8%</td>
</tr>
<tr>
<td>Overweight</td>
<td>15.2%</td>
<td>15.4%</td>
<td>15.3%</td>
<td>13.6%</td>
<td>15.4%</td>
<td>14.3%</td>
<td>14.7%</td>
</tr>
<tr>
<td>Obese</td>
<td>16.6%</td>
<td>6.1%</td>
<td>10.9%</td>
<td>9.2%</td>
<td>13.1%</td>
<td>6.3%</td>
<td>16.0%</td>
</tr>
<tr>
<td>Overweight or obese</td>
<td>31.7%</td>
<td>21.5%</td>
<td>26.2%</td>
<td>22.8%</td>
<td>28.5%</td>
<td>20.7%</td>
<td>30.7%</td>
</tr>
<tr>
<td>Girls Underweight</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>4.8%</td>
<td>4.4%</td>
<td>5.4%</td>
<td>3.8%</td>
</tr>
<tr>
<td>Boys Underweight</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>4.3%</td>
<td>6.1%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Girls Normal</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>77.6%</td>
<td>66.0%</td>
<td>77.3%</td>
<td>66.7%</td>
</tr>
<tr>
<td>Boys Normal</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>67.6%</td>
<td>57.9%</td>
<td>68.3%</td>
<td>57.4%</td>
</tr>
<tr>
<td>Girls Overweight</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>13.3%</td>
<td>18.4%</td>
<td>13.8%</td>
<td>17.8%</td>
</tr>
<tr>
<td>Boys Overweight</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>14.6%</td>
<td>18.3%</td>
<td>15.6%</td>
<td>17.3%</td>
</tr>
<tr>
<td>Girls Obese</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>4.3%</td>
<td>11.2%</td>
<td>3.4%</td>
<td>11.7%</td>
</tr>
<tr>
<td>Boys Obese</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>13.5%</td>
<td>17.8%</td>
<td>12.8%</td>
<td>18.3%</td>
</tr>
<tr>
<td>Girls Overweight or Obese</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>17.8%</td>
<td>29.6%</td>
<td>17.2%</td>
<td>29.6%</td>
</tr>
<tr>
<td>Boys Overweight or Obese</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>28.1%</td>
<td>36.0%</td>
<td>28.3%</td>
<td>35.6%</td>
</tr>
</tbody>
</table>

It appears from these findings that neighbourhoods not only influence rates of overweight and obesity, but also the incidence of underweight children. In general, boys are more likely to be underweight, while living in a low-income neighbourhood exaggerates this trend. Only 3.3% of boys living in high-income areas were underweight, whereas for low-income neighbourhoods rates were more than double at nearly 7%. The opposite effect is present in the data for the girls, but not to the same degree. More girls are underweight in high-income areas in comparison. In general, children living in the inner suburbs are also more likely to be underweight, although this trend differs slightly for girls. Rates for girls are nearly the same, with slightly more underweight girls in the central city. The largest overall difference for gender, relates to the percentage of girls who have a normal body weight in comparison to boys. Over 74% of girls had healthy body weight compared with 63% of boys. Descriptively, these findings highlight differences in body weight by place and gender (i.e., underweight but also overweight and obesity).
Figure 4.3 illustrates the percentage of students who are overweight or obese in each school neighbourhood. Three of the four schools in the lowest quartile are located in the central city. The images also illustrate a relationship between income and bodyweight, as three quarters of the lowest quartile schools were in high-income neighbourhoods. The maps clearly display the trends observed in Table 4.4, which suggest that both neighbourhood and income differences relate to healthy body weights.

For gender, even though more boys were walking to school, they are also more commonly overweight or obese. Only 63% of males had normal weight versus over 74% of females. Rates for the percentage of overweight children were nearly identical by gender, but the rate of obese and underweight children was higher for boys. These trends continue regardless of built environment or income level. Obesity rates are much higher for boys regardless of neighbourhood type. Although more boys are walking to school, classification for normal body weight is more common for girls.

On average, children were only active for 16.5 minutes of the hour before school starts (or the time when children are travelling to school) (Table 4.5). These numbers were consistent (within a few minutes) regardless of income, gender or neighbourhood. Living in the central city slightly increased the number of active minutes before school regardless of mode, but larger differences existed for those driven to school. Children driven in the central city obtained 2.4 more minutes of activity than their inner suburban counterparts. Children living in the lower income school neighbourhoods were also more active, and only a one-minute loss of activity was recorded for those being driven to school. Overall, children who are walking to school are receiving more activity than those who are driven (average three minutes) irrespective of gender or neighbourhood differences.
Figure 4.3
Percentage of overweight and obese students by neighbourhood type
Table 4.5
Average minutes of light, moderate and vigorous physical activity during the journey to school by gender and neighbourhood type

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
<th>Central city</th>
<th>Inner suburbs</th>
<th>High income</th>
<th>Low income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk</td>
<td>17.6</td>
<td>17.2</td>
<td>17.4</td>
<td>17.7</td>
<td>16.9</td>
<td>17.3</td>
<td>17.6</td>
</tr>
<tr>
<td>Driven</td>
<td>15.3</td>
<td>13.8</td>
<td>14.4</td>
<td>16.0</td>
<td>13.6</td>
<td>13.9</td>
<td>14.9</td>
</tr>
<tr>
<td>Total</td>
<td>17.1</td>
<td>16.1</td>
<td>16.5</td>
<td>17.4</td>
<td>15.7</td>
<td>16.1</td>
<td>17.0</td>
</tr>
<tr>
<td>Girls Walk</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>17.6</td>
<td>17.0</td>
<td>17.3</td>
<td>17.4</td>
</tr>
<tr>
<td>Boys Walk</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>17.8</td>
<td>16.8</td>
<td>17.3</td>
<td>17.5</td>
</tr>
<tr>
<td>Girls Driven</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>15.5</td>
<td>12.1</td>
<td>13.2</td>
<td>13.2</td>
</tr>
<tr>
<td>Boys Driven</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>16.5</td>
<td>14.5</td>
<td>13.7</td>
<td>15.4</td>
</tr>
</tbody>
</table>

Figure 4.4 illustrates the average of light, moderate and vigorous physical activity for the hour before school. Once again, the data were broken up into quartiles for each of the sampled schools. All of the four schools in the highest quartile were located in the central city, suggesting these students were more active. Furthermore, all of the schools in the second lowest quartile were located in the inner suburbs. In general, children living in the central city spend more time active during the hour before school than their inner suburban counterparts. This suggests that a connection exists between neighbourhood characteristics and activity levels before school. The image highlights the street design, which may be encouraging walking through a more connected central city street network, but other features not visible on the images such as access to parks or other environmental features may also be at play. Findings from this analysis produced a hypothesis that certain features of the environment may be related to health behaviour. The hypotheses that neighbourhood design associates with physical activity during the time periods in question and mode choice is studied and tested in the next section. The following section explores (using micro-level analysis) how specific characteristics of the route to and from school relate to levels of physical activity.
Figure 4.4
Average minutes light, moderate and vigorous physical activity before school
**Detailed examination of the child’s route to and from school**

For the hour before school, children were active (in light, moderate or vigorous activity) for an average of 16 minutes, while activity levels were slightly higher during the home from school time frame (20 minutes) (Table 4.6). The sample only included 687 children for this analysis, as missing data or living beyond a distance of 1.6 kilometres excluded several cases. The sample included 52% girls (n=359) and 48% boys (n=328). Just over half of the sample lived in the inner suburbs (n=352), while 49% resided in the central city (n=339). There were 362 children from lower income neighbourhoods (52%) and 329 from high-income areas (48%). Nearly 55% of respondents’ fathers and 49% of mothers reported completing a university or graduate degree. The median household income of the respondents home DA was $72,932 (mean $71,564.13).

Distance was controlled for by only examining children living within 1.6 kilometres. Within this sample, the median distance was 587 metres for both the trip to and from school. Each route crosses an average of about five streets, although very few of these streets crossed would be classified as major roads (1.44 mean, 0 median). Each route involved more vehicles in the morning trip, but there were more trucks and buses in the vehicle fleet around schools during the trip home. Most of the routes had a complete sidewalk network with an abundance of street trees. Traffic calming devices were not evident on every route, but over half of the routes did have some form of traffic calming device.
Table 4.6
Descriptive statistics for participant routes

<table>
<thead>
<tr>
<th>To school</th>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minutes of activity hour before school*</td>
<td>16.5</td>
<td>15.9</td>
<td>6.37</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Distance to school (m)</td>
<td>656.51</td>
<td>587.23</td>
<td>369.49</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Intersections crossed on route</td>
<td>5.69</td>
<td>5.79</td>
<td>3.24</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Major street crossings on route</td>
<td>1.44</td>
<td>0.00</td>
<td>2.43</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Maximum traffic on route</td>
<td>443.09</td>
<td>253.00</td>
<td>518.15</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Vehicle fleet index</td>
<td>0.45</td>
<td>0.42</td>
<td>0.19</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Missing sidewalks</td>
<td>0.03</td>
<td>0.00</td>
<td>0.10</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Street tree density</td>
<td>76.48</td>
<td>72.13</td>
<td>65.13</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Income $CDN</td>
<td>71 564.13</td>
<td>72 932.00</td>
<td>38 827.92</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Traffic calming density</td>
<td>0.56</td>
<td>0.00</td>
<td>1.40</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>From School</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minutes of activity hour after school*</td>
<td>20.19</td>
<td>19.45</td>
<td>6.06</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Distance to school (m)</td>
<td>655.94</td>
<td>587.07</td>
<td>368.90</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Intersections crossed on route</td>
<td>5.52</td>
<td>5.59</td>
<td>3.26</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Major street crossings on route</td>
<td>1.29</td>
<td>0.00</td>
<td>2.25</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Maximum traffic on route</td>
<td>378.09</td>
<td>215.00</td>
<td>474.39</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Vehicle fleet index</td>
<td>0.35</td>
<td>0.34</td>
<td>0.26</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Missing sidewalks</td>
<td>0.03</td>
<td>0.00</td>
<td>0.10</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Street tree density</td>
<td>82.20</td>
<td>77.75</td>
<td>61.30</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Income $CDN</td>
<td>71 564.13</td>
<td>72 932.00</td>
<td>38 827.92</td>
<td>687</td>
</tr>
<tr>
<td></td>
<td>Traffic calming density</td>
<td>0.63</td>
<td>0.00</td>
<td>1.59</td>
<td>687</td>
</tr>
</tbody>
</table>

*Light, moderate and vigorous physical activity

Multiple linear regression models

Preliminary analysis revealed that many of the objective built environment characteristics thought to relate to traffic safety were not associated with levels of physical activity (Table 4.2). For the before school trip, only traffic volume, crossing major intersections, distance and traffic calming devices were associated with activity levels. Dummy variables for gender was also included to control for this important variable. In the linear modeled analysis, even fewer characteristics influenced physical activity. Only the density of traffic calming devices and distance were significant factors associated with activity for the hour before school (Table 4.7).

The distance between one’s home and school also influences activity levels. As the distance increases, so do activity levels for the hour before school. Finally, the only
characteristic significantly related to traffic safety was the density of traffic calming devices. If a route has more of these environmental features, students are spending more time physically active. More speed bumps and other traffic calming features relate to increased activity. Both maximum traffic and major street crossings were not significantly associated with physical activity levels.

Preliminary analysis revealed differences between the independent variables and light, moderate and vigorous activity for the hour after school. Findings suggest that income, intersections crossed and traffic calming were important characteristics after school. Neighbourhoods of higher income were negatively associated with activity levels after school, with children in higher income neighbourhoods appearing to be less active after school. Street crossings also related to activity levels after school. Children who have to cross more intersections along their route were less active. Finally, similar to the before school model, the density of traffic calming devices was again related to activity levels. The existence of more traffic calming devices relates to the number of minutes physically active for the hour after school as well. This was the only consistent finding between the two models.
Table 4.7  
Multiple linear regression analysis with light, moderate and vigorous physical activity as the dependent variable during the school travel time-period

<table>
<thead>
<tr>
<th>Hour before school</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>Constant</td>
<td>14.054</td>
<td>0.555</td>
<td>25.326</td>
</tr>
<tr>
<td>Maximum traffic</td>
<td>-0.020</td>
<td>0.056</td>
<td>-0.017</td>
</tr>
<tr>
<td>Traffic calming density</td>
<td>0.732</td>
<td>0.169</td>
<td>0.162</td>
</tr>
<tr>
<td>Major intersections crossed</td>
<td>0.280</td>
<td>0.119</td>
<td>0.107</td>
</tr>
<tr>
<td>Distance (km)</td>
<td>2.023</td>
<td>0.672</td>
<td>0.118</td>
</tr>
<tr>
<td>Gender(^a)</td>
<td>0.807</td>
<td>0.471</td>
<td>0.064</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hour after school</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>Constant</td>
<td>21.601</td>
<td>0.920</td>
<td>23.473</td>
</tr>
<tr>
<td>Income</td>
<td>-0.013</td>
<td>0.006</td>
<td>-0.089</td>
</tr>
<tr>
<td>Traffic calming density</td>
<td>0.314</td>
<td>0.145</td>
<td>0.083</td>
</tr>
<tr>
<td>Intersections crossed</td>
<td>-0.194</td>
<td>0.074</td>
<td>-0.106</td>
</tr>
<tr>
<td>Major intersections crossed</td>
<td>0.135</td>
<td>0.110</td>
<td>0.050</td>
</tr>
<tr>
<td>Gender(^a)</td>
<td>0.143</td>
<td>0.459</td>
<td>0.012</td>
</tr>
</tbody>
</table>

\(^a\)Female as referent  
School travel time-period defined as 60 minutes before school starts or 60 minutes after school ends

Discussion

With two unique methodological approaches, this chapter reported several important findings for the connection between physical activity, mode of travel, safety and the built environment. In the broad neighbourhood level analysis, differences in rates of walking to school, BMI and minutes of physical activity were evident within different school neighbourhoods. Where you live appears to be associated with mode choice, physical activity and body weight, but further examination of specific features along the route to and from school was less convincing.

Analysis of the routes between home and school determined very few variables associated with physical activity for the hour before and after school. This section will first discuss the findings related to the exploratory spatial data analysis followed by the examination of the routes in
Neighbourhood differences

Visual analysis of the school neighbourhoods illustrated obvious differences regarding mode of travel to school for both built environment and income. Children living in the central city or lower income neighbourhoods have higher rates of walking. This confirms the findings from the logistic mode choice models in the previous chapter; living in the inner suburbs or higher income areas reduced the likelihood of walking. This finding also restates what has commonly been discovered, as people living in higher income neighbourhoods have lower rates of AST (McMillan et al. 2006; Vovsha and Petersen 2005; Frank et al. 2007; Chillon et al. 2009; Larsen et al. 2012). Environmental and social factors appear to be influencing mode of travel within the sampled schools.

For children’s health, the exploratory data analysis involved an examination of both BMI and physical activity at the neighbourhood level. Little evidence exists to date as to whether school travel actually relates to healthy body weights (Faulkner et al. 2009), but it appears within this sample of children that BMI is associated with neighbourhood characteristics. Students living in the central city were more likely to have a normal body weight as defined by the CDC, while children living in lower income neighbourhoods had much higher rates of obesity. The link between income and obesity has been found in previous work, as households of lower income commonly have higher rates of childhood obesity (Gable and Lutz 2000; Lin et al. 2004; Singh et al. 2010; Wang and Beydoun 2007). Low-income neighbourhoods also had a higher rate of underweight children, but not to the same degree. Although only evident at the broad
neighbourhood level, it appears for healthy body weights, neighbourhood income can influence both ends of the spectrum to some degree. These findings suggest that a relationship may exist between neighbourhood income and diet. More work should examine why low-income residents have higher rates of overweight and obesity but also underweight children. Dietary behaviour or nutritional content in the foods children are eating may play a role in their body weights.

Respondents from low-income neighbourhoods had a very high rate of walking to school and a higher number of active minutes, yet they were also the most likely to be obese, suggesting that other factors are involved. This reiterates the importance of needing additional daily physical activity beyond school travel. Many children in low-income areas are walking to school, yet students who are not walking to school, but live in higher income neighbourhoods have healthier body weights. These children in high-income areas may have more access to organized sports or other after school activities to ensure they meet their required activity levels in order to obtain a healthy body weight. According to the 2013 report card on active children in Canada, active transportation is only one of five behaviours that relates to levels of physical activity (Active Healthy Kids Canada 2013). Active Healthy Kids Canada is a charitable organization aimed at providing better programs and policies to improve physical activity levels for Canadian children. The most recent report focused on active transportation as one method for children to obtain additional physical activity. Aside from active travel, other factors such as physical education, active play, organized sports and sedentary behaviour also play a role in the overall activity levels of children (Active Healthy Kids Canada 2013). Again the walk to and from school is just a small piece of the activity picture, and several other factors need to be explored.
Aside from the factors associated with energy output, energy intake factors such as diet may have a direct relationship with the socio-economic trends observed between obesity and neighbourhood income. Eating behaviours and food choices have a significant impact on obesity levels and the overall health of an individual (Lake and Townshend 2006). The majority of obesity-related health problems have a direct relationship with a diet that is low in fruit and vegetable consumption and high in fat and sugar (WHO 2003). Previous work suggests a link exists between parental income and their child’s diet, as income increases so too does the consumption of fruits and vegetables (Sausenthaler et al. 2006). More recently in Canada, research has found a connection between income levels, diet and obesity (Mark et al. 2012). There appears to be an association between income and healthy body weights, thus to properly understand the relationship between obesity and income, further exploration of both energy intake and expenditure beyond the school travel construct is necessary.

Overall, people who walk to school experience three more minutes of activity during the hour before school. Although slight differences did exist, these values are fairly consistent (~2 to 4 minutes) regardless of neighbourhood type, income or gender; however, walkers in the central city were the most physically active. These findings are similar to previous work by Panter et al. (2011), where they discovered children who walked obtained between two and four additional minutes of physical activity (2011). Even though discrepancies between mode of travel and activity are only a few minutes, this is not an insignificant finding. These modest increases in activity are significant, as they can help children obtain the recommended daily activity levels (Active Healthy Kids Canada 2013). Adding minutes of activity over the long term is acceptable for energy expenditure as you are physically burning the energy while exercising, but this sporadic activity does not provide the same cardiovascular benefits. When
these minutes are added up for two trips per day, five days a week for nearly 10 months of the year (or the minimum of 194 school days per year) (Ministry of Education 2012), a difference of two minutes per trip equals nearly 800 additional minutes (13.5 hours) of physical activity over the school year. If the difference were three minutes per trip, it would be nearly 1200 minutes (20 hours) during a school year. If children were to walk for both of these trips, the numbers would double creating even more minutes of daily activity. If children were to walk both trips, this could add an additional 4-8 minutes of activity per day or 7%-13% of their recommended daily needs (i.e. 60 minutes per day). These additional minutes of daily physical activity add up to significant increases over the long term. If children walked for all trips that were less than 1 km (not just for school travel), they would obtain 15-20 additional minutes of activity per day (Active Healthy Kids Canada 2013). These behavioural changes in mode choice have the potential to significantly increase activity levels in children, and allow them to get one-step closer to receiving the 60 minutes of recommended daily physical activity. What may also be even more important than the additional minutes of activity children obtain while walking to school is the habits that begin to form regarding mode choice later in life. Previous research reports that children who are active at a young age, are more likely to continue these practices as they grow older (Rowland and Freedson 1994, Vanreusel et al. 1997, Telama et al. 2005; Conroy et al. 2005), thus walking to school may help to encourage walking to other destinations as children become adults.

**Routes and physical activity**

Distance related to activity levels for the before school trip. These findings relate to previous work completed in the U.K. (Panter et al. 2011), but this chapter also examined additional
elements of the environment. The issue of distance between home and school is twofold. If the distance is too far, a child is less likely to walk and will spend more time sedentary in an automobile. Whereas if the distance is too short, even if the student is walking, they are unlikely to obtain a significant amount of activity. Distance is the most common factor associated with mode of travel; as the distance increases, rates for walking decrease (Ewing et al. 2004, Merom et al. 2006; McMillan 2007, Larsen et al. 2009, Mitra et al. 2010; Mitra and Buliung 2012). This chapter controlled for distance by only including routes within a maximum distance of 1.6 kilometres, thus removing cases beyond 1.6 kilometres. Several studies have found that living within 1.6 kilometres significantly increases the likelihood of walking and is a common cut off in the literature (Timperio et al. 2004; Scholossberg et al. 2006; McDonald 2007; McMillan 2007; Larsen et al. 2009). Findings from this model determined that as distance increases, minutes of physical activity also increase. As expected, there is a direct relationship between distance and physical activity. Panter et al. (2011) also found that distance was positively associated with activity levels for children living within 2 km. Children who walk longer distances obtain more activity through walking, but also other activities they may participate in while travelling between home and school. Longer distances may lead to greater opportunity for play, along the way. The accelerometers record energy expenditure for walking and everything else. In the end, the additional time spent walking may be one of many ways in which children obtain higher rates of physical activity.

The relationship between distance, walking and physical activity is mixed. We want shorter distances so more people will walk to school (or at least encourage walking), but to have any real health benefit distances need to be longer. Previous work has reiterated the importance of distance on activity levels, as routes have to be longer in order to provide significant health
benefits (Sleap and Warburton 1993; van Sluijs et al. 2009). Distances between 1 km and 1.6 km may provide optimal physical activity benefits for school travel, as they are long enough to obtain physical activity but short enough to walk; yet it is unrealistic (if not impossible) to have everyone living between 1 km and 1.6 km’s from school. Since conflicting evidence exists regarding distance, walking and physical activity, it may be best to decide what is most important. It may be better to encourage walking by trying to limit the distances children have to travel between home and school. Although, this will not provide a lot of activity for some people, it will help to form healthier habits and may relate to mode choice decisions when travelling to other destinations and allow for additional minutes of walking and physical activity.

This corresponds with recent recommendations from the Active Healthy Kids Canada report card (2013), which states parents should encourage and support active travel to school and other destinations. To overcome the issue of distances not being long enough to obtain significant health benefits, it is also important to promote walking to other places, such as friends’ houses or even the grocery store. Having children walk to more destinations, aside from school, is one way of meeting both needs (increased rates of AST and potential health benefits). The Active Healthy Kids Canada report also has another idea towards increasing rates of AST for part of the trip. They suggested that parents park their car a walkable distance from school (or other destinations) and walk part way with their child when distances make walking the entire way not possible. While this may seem counterintuitive to the findings from this chapter, suggesting that longer distances increase activity levels. It addresses the issue of distance and how some people simply live too far from school (or other destinations) to walk. Since modifying current travel distances to and from school is difficult, this may be one approach to allow certain children to partake in AST for at least part of the trip. This could start to
commence healthier travel habits for these children, while reducing the number of vehicles around the school itself.

Distance between home and school can relate to a variety of factors including the location of the school. The Active Healthy Kids Canada report also recommends that school boards consider children’s travel needs when deciding where to build a school. School siting can relate to the distances children must travel, which associates with both rates of walking and physical activity. Again, siting schools in areas that will minimize distances may encourage walking and this recommendation should be taken into account.

Density of traffic calming devices also influenced activity levels for both the before and after school models. When routes had a higher density (or higher number along the route), the number of active minutes increased. This relationship was the only finding directly related to safety along the route and was associated with activity levels for the before school model. While the previous chapter discovered several environmental factors were related to mode of travel (i.e., traffic volume, sidewalks and parking), none of these variables significantly influenced physical activity levels along the route. Traffic calming devices have been defined as, “a combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behaviour and improve conditions for non-motorized street users.” (Lockwood 1997, 22). There are many types of traffic calming devices (e.g. chicanes, speed bumps, raised intersections, gateways, raised crosswalks, traffic circles), but the purpose of these devices remains the same: to slow down motor vehicles, reduce the frequency of collisions and improve safety (and perception of) for non-motorized street users (Lockwood 1997).

It appears from these findings that traffic-calming devices are not independently associated with mode choice as Chapter 3 discussed, but do affect one’s level of activity before
and after school. This finding likely relates to the methods used in this chapter. Since activity levels examined the hour before and after school and not only the trips to and from school, these environmental characteristics are likely influencing other forms of physical activity before or after school. Speed bumps or other traffic calming features may not be associated with mode of travel to school, but they could relate to additional forms of physical activity outside of the actual school trip. Traffic calming features may influence perceived traffic safety when subjects are walking to other destinations before or after school, and thus increases overall rates of physical activity. The exact relationship is not known, but it is clear from the findings that traffic calming appears to impact rates of activity before and after school.

The only specific built environment feature related to safety and activity was traffic calming. For the density of traffic calming features, there are nearly 10 times as many devices in the central city compared to the inner suburbs (1.48/km² in the inner suburbs versus 14.04/km² in the central city). While there are many different types of calming devices within Toronto, speed bumps are the most common, as over 82% of all traffic calming features within the city are speed bumps. It is unknown whether constructing more speed bumps (or other devices) in the inner suburbs would directly translate to increasing levels of activity, but these findings suggest there may be a relationship between activity levels and traffic calming. From a policy standpoint, it is not overly difficult to encourage the construction of traffic calming devices, but the effectiveness is still inconclusive. Traffic-calming features are supposed to slow down vehicles and improve safety for pedestrians, although their efficacy in reducing pedestrian injuries is inconclusive. Some have reported that traffic calming features are an effective way to slow down traffic (Herrstedt 1992), while others have found the opposite (Bunn et al. 2003). Before these features are constructed, more work needs to explore the impact on traffic speeds and safety in Toronto.
The Active Healthy Kids Canada report also offers suggestions for policy makers that appear to intersect well with findings from this chapter. The report states, planning mechanisms should ensure the built environment supports walking for children (Active Healthy Kids Canada 2013). This policy recommendation also coincides with the objectives of the ‘Big Move’, which is a regional transportation plan for the Greater Toronto and Hamilton Area (GTHA) created by Metrolinx (the provincial agency in charge of transportation in the GTHA). The ‘Big Move’ also aims to improve safety by designing environments that encourage walking. Many environmental features related to walking from the mode choice chapter, but with regard to physical activity, only street crossings and traffic calming features were significant. This directly relates to the next policy recommendation by Active Healthy Kids Canada, to enforce and increase traffic calming features around schools. Increasing the number of traffic calming features may increase levels of physical activity, reduce vehicle speeds or parental traffic concerns, but as previously stated, more work on the topic is necessary. Although I am not convinced that traffic calming features will increase physical activity levels, this should not go against the recommendation to encourage traffic calming devices. If traffic calming features do actually slow down traffic, then they may have a long-term influence on walking rates and overall physical activity within the community.

On the trip home from school, the number of intersections crossed was associated with physical activity levels. If children had to cross more streets (or intersections), they had fewer minutes of activity after school. This corresponds with the findings from the previous chapter, as more street crossings reduced the likelihood of walking, suggesting that street crossings along the route are negatively related to both walking and physical activity levels. The previous chapter discussed why this is relevant and from a safety standpoint, and this makes logical sense,
as crossing more streets will put a child at an increased risk of being struck by a motor vehicle. Furthermore, parents may perceive these environments as more dangerous and may not allow their child to walk, leading to fewer minutes of activity. This feature was only significant for the trip home from school. It is unknown why this feature was not significant for the to school trip, but it could relate to the structure of the trips themselves or the other activities children are participating in after school. After school, children would be more likely to travel to other destinations (e.g. parks, friend’s house, etc.) and that could relate to the differences observed in several of the environmental findings.

Finally the income levels of the home DA were also relevant on the after school trip. People living in higher income DAs were spending less time active after school. This may relate to the higher rates of motorized travel for children of higher income. More time spent sitting in an automobile will directly translate to fewer minutes of activity, although travelling home is only one activity children participate in the hour after school. Again, this was not significant for the trip to school, corresponding with the findings from the mode choice chapter (Chapter 3). Income appears to be more important for the trip home from school, as students in higher income neighbourhoods walk less and obtain lower activity counts after school. This may simply be because higher income households have higher rates of automobile ownership and usage (Schimek 1996).

Several other route-based factors that were relevant in the previous chapter were not significant with regard to physical activity levels. Most notably traffic volume, which was associated with mode of travel in the previous chapter, did not associate with activity levels before or after school. Although only the maximum traffic volume was included in the analysis, preliminary testing also examined the average traffic volume as per the tests from the previous
mode choice chapter (for details on the methodology used please see traffic environment section on page 84). The average traffic volume around the school was also insignificant when tested against physical activity levels before or after school. The inclusion of this traffic variable is a major contribution to this chapter, so the findings are of particular interest. The hour before school captures the journey to school but also other activities outside of school (i.e., discretionary time), or activities beyond the street – in parks, etc. Traffic volumes likely do not influence these other activities; thus traffic was not significantly associated with physical activity for the hour before school. Although a connection exists between traffic and mode choice, it does not appear to directly influence overall physical activity before or after school. Aside from the journey to school, much of the activity children receive in the hour before school would take place at the home or in the schoolyard, where traffic volume should not be a factor. This association is likely similar for other environmental variables that were important in the mode choice chapter, but not connected to physical activity.

_Differences in the route-based analysis before and after school_

The models before and after school were very different, suggesting temporal variability exists within the associations. The only common factor was the density of traffic calming features. For both trips, this was an important characteristic positively related to activity. Both the effect size and significance of traffic calming was higher for the hour before school. In general, the models did a better job of explaining physical activity levels for the hour before school. One of the big differences in the models does not relate to the characteristics themselves, but rather the model structure. Before school, the model had an $R^2$ value of nearly 7%, while the after school model
had a value of only 3%. Furthermore the coefficient of variation for the after school model was also much higher.

These findings likely relate to the different structure of the trips themselves (which Chapter 3 discussed in detail starting on page 115), along with the activities children participate in for the hour before and after school. It was obvious from the models that safety and the environment along the route do not have a major relationship with activity levels during the trip home from school. One rationale for this relates to the differences between the two trips themselves. When travelling to school, many children likely have more mode options available to them. Since school start times commonly coincide with the start of the workday for parents, this mode option may exist in the morning, but not in the afternoon as parents are still at work. This assumption can translate into higher rates of driving to school. Another recommendation in the Active Healthy Kids Canada report is to encourage employers to offer more flexible working hours, allowing parents to support AST for their children. If parents had more flexible schedules, they may be able to escort their children on foot in the morning rather than by automobile. Regardless of the parental work schedules, previous work has also commonly found more environmental factors to matter for the to school trip (Larsen et al. 2009; Mitra et al. 2010; Larsen et al. 2012). After school, safety and the environment may not play the same role as they do for the before school trip. This coincides with the findings from the previous mode choice chapter.

Since these models examined the hour before and hour after school there are also differences in the activities children would participate in during these times. After school, many children may have structured activities such as soccer, hockey, baseball, ballet among others. They may be driven home from school but obtain their activity through participation in
organized sports after the hour immediately following the school day. Children may also be active after school by playing with friends, going to the park or numerous other unstructured (by adults), all of which the accelerometer captures as activity. Thus, when modelling the hour after school, there is likely too much other activity aside from the trip itself to produce an appropriate model associated with activity occurring while travelling home from school. Regardless of what the children are doing after school, it is likely very different from what they do in the hour before school. These differences in both the trips themselves and other activities are possible reasons why the models produced varying results and temporal differences. Rather than only looking at the one-hour window, it would be useful to obtain data on physical activity levels when children are travelling home from school only, but this type of data is difficult to collect. Since children were wearing the accelerometers for a seven-day period, it is hard to only capture the school travel timeframe, but tools such as activity diaries may assist with this data collection.

**Gender**

The previous chapter(s) examined how gender relates to safety and mode of travel. It is clear from the neighbourhood analysis that more boys are walking to school than girls (78.4% boys versus 66.8% girls – see Table 4.3). Findings from the mode choice chapter (Chapter 3) determined that boys were significantly more likely to walk than girls, which corresponds with previous work (McMillan et al. 2006; Larsen et al. 2012).

For levels of physical activity, gender of the child does not appear to be a major factor in either the route-based or neighbourhood analysis. Both the before school and after school model determined that gender was not a significant characteristic. When examined at the neighbourhood level, boys are receiving 17.1 minutes of activity in the morning, while girls are
slightly lower at 16.1. Even though more boys are walking, there is very little difference when it comes to activity. This finding differs from previous studies of gender and activity, as girls are commonly less active than boys (Page and Tucker 1994; Myers et al. 1996; Vincent et al. 2003; Duncan et al. 2006; Loucaides and Jago 2008; Colley et al. 2011). Similar trends have been observed during school travel, where boys were found to take more steps (and have higher rates of activity) during school travel (both before and after school) (Vincent et al. 2003; Loucaides and Jago 2008). Although the previous literature does not support this finding of equality, this discovery highlights the significance of walking to school for girls, as it may be an important source of daily activity. Findings also suggest that regardless of mode, boys and girls are obtaining similar amounts of physical activity before and after school. Reasons for these findings may relate to the fact that this chapter examined light, moderate and vigorous activities. Previous work has found that girls more commonly participate in light to moderate activity, while boys tend accumulate more minutes of vigorous activity (Myers et al. 1996). Further analysis examined the average number of minutes of MVPA boys and girls obtain before school and the finding were again similar (boys: 2.9; girls: 2.6), but when you look at the overall rates, boys are more active than girls (Stone et al. 2013). This suggests that these findings relate to the type of analysis. Since this chapter only examined the hour before and after school, it is likely that boys and girls obtain similar amounts of activity during this period, while boys are more active overall as previous research suggests.

The neighbourhood based analysis found fewer girls were walking to school, and their rates for activity levels were slightly lower, but they were also more likely to have a healthy body weight. Over 74% of girls were not underweight, overweight or obese (i.e., they were between the 5th and 85th percentile), compared to only 63% of boys. The largest difference
occurred in the obesity category, where rates for boys were over 10% higher. Reasons for the
trend may relate to girls having a healthier diet, eating less, eating unhealthily less often or
participating in more physical activity during school or on evenings and weekends.

Determinants of obesity include genetic deposition, dietary intake and energy expenditure (Hill
and Peters 1998; Andersen 2000). The rapid increase in obesity is believed to be associated with
the imbalance between energy intake and expenditure, and not genetics (Andersen 2000;
Tremblay 2003). The fact that activity levels and rates of walking were lower for girls even
though they were more likely to have a healthy body weight highlights the fact that there is more
to obesity than just physical activity. Other lifestyle factors such as diet are just as important
(Ebbeling et al. 2002).

**Conclusion**

This chapter shed some light on how traffic safety, mode of travel and the environment relate to
physical activity in a Canadian city. The two phases of analysis helped to understand whether
neighbourhoods influenced a child’s health, while specific models explored the connection
between objective environmental features and physical activity. The examination of actual
routes to and from school in comparison to measured levels of activity and traffic conditions is a
methodological contribution as it allows for analysis that more accurately measures one’s
environment. It builds on previous findings from Panter et al. where distance and mode of travel
were determined to be important, but the environment itself was not examined (2011).

This chapter helps to tie together previous findings from the first two studies. The first
results chapter reported that safety was indeed a factor related to mode of travel; the next chapter
determined that several environmental features and traffic conditions relate to mode of travel,
while this chapter examines how mode choice and safety relate to children’s health, in the context of school transport. This chapter aimed to help with the understanding of how physical activity levels relate to the environment children interact with during the trip to and from school.

The built environment does influence children’s health, but more research needs to examine how neighbourhood features affect energy intake and expenditure. Observational neighbourhood and modelled analysis of the routes examined the connection between safety, the built environment and children’s health. It was obvious from Figures 4.2, 4.3 and 4.4 that neighbourhoods are associated with mode of travel, BMI and to some degree minutes of activity. This confirms that a connection exists between neighbourhoods and health. For specific features along the route to and from school, the results were less convincing. There was a modest association between specific neighbourhood features and the light, moderate and vigorous physical activity levels during school travel, but results were not as compelling as the exploratory spatial data analysis of the school neighbourhoods. These findings demonstrate, of course, that the trip to school is only one source of physical activity for children and healthy body weights may relate to other features of the built environment.

The importance of traffic calming devices for the route-based analysis was indeed an important finding. Few studies have examined how characteristics of a child’s route may influence activity levels during school travel. Although most of the variables examined were not relevant, simple environmental features such as speed bumps relate to higher activity levels. This is an inexpensive and easily modifiable method to potentially slow down vehicles and improve parents’ perception of safety within the environment.

Even though children who walk to school only received a few more minutes of activity, this is still important. Active travel to and from school should not be the only activity children
receive, and childhood obesity research needs to look beyond AST for an actual solution. If children are walking to and from school, they are receiving a few minutes of daily physical activity, which accumulates to more significant figures over the school year. More importantly, encouraging walking at a young age is important to setting healthy habits later in life.

*Notes:
No data exists from any Federal agency in Canada or from the Province of Ontario They have suggested using U.S. data as the vehicle fleets in these two countries are nearly identical. Both Transport Canada and Natural Resources Canada use the U.S. data.
Chapter 5

Conclusion

This dissertation examined how correlates of safety and the traffic environment may relate to mode of travel and physical activity levels for the trips to and from school. The overall aim of this dissertation was to help provide a better understanding as to why children in Toronto are or are not walking to or from school and what steps may encourage active transportation for children who are physically able to walk. This dissertation helps to further develop the school travel literature through methodological improvements to the data and analysis. One of the major contributions of this work is the use of measured traffic characteristics around each of the sampled schools. Although traffic relates to overall safety and/or perceptions, safety itself was not actually measured.

Each empirical chapter answered one of the research sub-questions. The first examined 1) the differences and similarities between parent and child perceptions of safety. Results highlighted several differences regarding personal safety for children and their parents. The threat of bullies, dogs and strangers emerged as concerns for children, while parents’ only real fear related to strangers. The comparison for traffic safety was much more uniform, while parents had additional concerns. The next sub-question explored 2) how environmental features along the route between home and school, as well as perceptions of safety, relate to school travel mode. Findings did present evidence that neighbourhood features related to mode of travel.
Missing sidewalks, traffic around the school and street design (e.g. street crossings) were all significant factors identified in the mode choice chapter, while vehicle fleet mix was not significant. Perceptions of busy street crossings and strangers were also significant in the modelled analysis. The final question assessed 3) how the traffic environment influenced a child’s physical activity levels. Findings did present some evidence that a relationship may exist between certain environmental correlates and mode of travel, BMI and physical activity levels. Table 5.1 displays the research questions and major findings, but the following section discusses the contributions of each study.

Findings from this work contribute to the current literature in several ways. Aside from the empirical contributions made by each chapter, this work determined that safety in some dimension related to decisions regarding school travel and that personal safety concerns are not uniform. Further analysis confirmed that traffic safety around the school and other objective and perceived characteristics significantly correlated with mode of travel and levels of physical activity. One of the largest strengths of this work was the methodological improvement regarding the examination of parents and children, traffic data collection and route-based data analysis. The examination of actual mapped routes and manually collected traffic data around the school are significant improvements over previous work. Both of these processes were extremely labour intensive, but produced a more accurate representation of the traffic environment along the route(s) children travel to and from school. Finally, the fact that this dissertation is set in Toronto also provides a useful addition to a body of research that mainly focuses on the U.K., U.S.A., Australia and New Zealand. The following section provides a brief overview of each of the three studies, the ways they answer the specific research questions and the contributions they make to the school travel literature.
Table 5.1
Summary of results and research questions

<table>
<thead>
<tr>
<th>Research Sub-question</th>
<th>Findings</th>
<th>Implications</th>
</tr>
</thead>
</table>
| What are the differences and similarities between parent and child perceptions of safety? | - Traffic concerns fairly uniform (street crossings and busy traffic around school)  
- Personal safety: Children concerned about dogs, bullies and strangers: Parents only strangers | - Anti-bullying campaign  
- Reduce vehicles around the school  
- Walking School Bus or other form of supervised travel |
| How environmental features along the route between home and school, as well as perceptions of safety, relate to school travel mode? | - Street crossings  
- Missing sidewalks  
- Parking facilities  
- Traffic around the school  
- Fleet mix was not significant | - Reduce vehicles around the school  
- Ensure sidewalk networks are complete |
| How does the traffic environment influence a child’s physical activity levels?          | - Broad neighbourhood level factors appear to be influencing the child’s health (walking, BMI, activity levels)  
- Few of the specific features along the route to/from school were significantly related to activity levels before and after school | - AST is only one factor related to a child’s health  
- Diet and other forms of physical activity are also important |

Review of studies and contributions

Findings from the first qualitative chapter guided the following two empirical chapters and were used to model interactions between the objective and perceived environments with mode of travel and levels of physical activity before and after school. The first empirical chapter involved a thematic analysis of how parents and children conceptualize safety, along with how these concerns vary between parents and children, by gender, across neighbourhoods and by
school travel mode. Findings from this chapter suggest that safety in general is a concern, but these concerns are not uniform.

Examining child and parent concerns separately adds further understanding on how parents and children perceive safety concerns differently, as most of the previous work has only examined the views of the parent. It is crucial to look beyond the views of the parent to gain a better understanding of how safety relates to school travel for those who are directly affected. This is a major contribution of this chapter, as we now know how children perceive their trip and that bullies and dogs are real threats while travelling to school. The concern about bullies is actually very timely here in Ontario. Recent media attention over the past year has highlighted problems with bullies and emphasized the importance of trying to curb bullying or even making it illegal (Anderssen 2011; Canadian Press 2011). This chapter also added to the understanding of the connection between safety concerns and gender during the trip to and from school. These findings confirm what other studies have found regarding overall mobility (not just school travel) and girls. Studies suggest that girls generally have more restricted mobility and greater safety concerns (Steinberg 1987, Peters 1994, Valentine 1997), which was paired by findings in this chapter.

The use of route-based analysis in the second and third empirical chapters is a methodological contribution to the current AST and environment literature. Most of the previous work examining the environment and school travel used aggregated neighbourhood buffers of the home or school neighbourhood (Kerr et al. 2006; Frank et al. 2007; McMillan 2007; Larsen et al. 2009) or shortest path analysis (Schlossberg et al. 2006; Timperio et al. 2006; Larsen et al. 2012). Neither of these methods accurately capture the environment as previously discussed in the introduction (see section starting on page 20. Global Positioning Systems (GPS) can also
examine the route to and from school (Duncan and Mummery 2007), but its use for research may be premature. There are still many issues (e.g. batteries, tall buildings, tree cover, clouds, etc.) that need to be resolved before it can be an effective tool (Department for Transport 2012; Rainham et al. 2012). The application of the mapped route to and from school is a methodological improvement, producing what should be, a more accurate representation of the environment walkers are exposed to while travelling to or from school. The route analysis not only advances the methods used within the literature, but should also more accurately characterize the environment children interact with while travelling to and from school. In turn, the findings should be a better representation of how neighbourhood features actually relate to mode of travel.

Other methodological contributions relate to the use of observed traffic counts and fleet characteristics around sampled schools. Traffic around the school was an important theme for parents in the qualitative study, and no known study has collected data on the traffic environment in the past; thus the data collection and construction of these traffic variables is a major contribution of this dissertation. Most of the previous literature examining traffic uses daily average cordon counts for select streets where traffic data is available (Larsen et al. 2012). Many of the streets around the school will not have recorded daily traffic volume counts available. The collection of traffic data at each intersection not only gives each street a count, but also provides a count that was obtained when children were actually travelling to and from school rather than a daily average.

The purpose of the second empirical chapter was to test the relationship between route-based environmental variables and perceptions of safety with mode of travel to and from school. The mode choice chapter provided significant empirical contributions. The examination of
several unique features such as traffic volume around the school, vehicle fleet mix and the presence of parking facilities all add to the current understanding of school travel and the environment. To date, no known studies examine actual traffic counts, fleet characteristics or parking facilities, all of which add to the literature. The inclusion of these variables is in the models is important, but so is the construction of the vehicle fleet index. I applied my knowledge from pedestrian safety and AST to build a weighted reverse entropy index in order to examine how vehicle mix may relate to school travel and physical activity. This in itself is a contribution and helps to shed some light on the fleet mix around schools.

The purpose of the final empirical chapter was to determine whether the findings from the first two empirical chapters were actually related to children’s health. To this point, we know that certain environmental features may relate to the perceptions of safety and mode of travel, but we do not know whether this translates into a healthier (or less healthy) child. The final empirical chapter used a unique two-method approach that began by examining the broad neighbourhood environment and then continued with the examination of specific features along the route. The application of both methods is a contribution; first the exploratory visual analysis examines the data and helps to understand current relationships between health behaviour and the environment. Phase two of the analysis tests the specifics of these relationships with route-based micro-level examination of environmental features. Rates of walking, BMI and minutes of physical activity did differ by neighbourhood type, but many of the specific features along the route were not significant. Findings from this chapter suggest that environmental features that influence mode of travel may not relate to other episodes of physical activity before and after school aside from the trip itself.
The third empirical chapter contributes novel analysis of the association between physical activity, school transport, and the built environment. Results from the mode choice chapter suggest that environmental characteristics can encourage walking and findings from this chapter determined that walking increases levels of physical activity before school. Findings here suggest children are obtaining other episodes of physical activity outside of the trip to and from school. Future work needs to explore the broad interactions between neighbourhood environments and activity levels for children, not only during the school travel time frame, but also during the entire after school period. The use of travel diaries or other activity monitoring tools could be useful to further comprehend how and where children are obtaining physical activity. Furthermore, future work also needs to examine the energy intake side of the obesity epidemic. Healthy (or unhealthy) eating is also a contributing factor associated with the current prevalence of childhood obesity. New studies should not only explore the physical activity behaviour of children outside of the school travel time frame, but also look into other confounding factors such as diet. Regardless of the current findings, children who walked to school were more active than those who were driven. Even though this may only translate into a few minutes per day, these numbers add up to much more over the school year.

**Avenues for future research**

Aside from providing a better understanding of what features are important for parents and children, this dissertation also used unique methods to test the association between the traffic environment, mode of travel and levels of physical activity. Features related to traffic safety such as vehicles around the school, sidewalks, street crossings and parking facilities all influence
mode of travel. Personal safety concerns such as the fear of strangers are also affecting mode choice. While this work helped to provide further knowledge on how safety relates to AST, in order to further advance the children’s health literature, more work needs to explore the relationship between physical activity levels and the built environment outside of the school travel paradigm, which was beyond the focus of this dissertation. School travel is only a small factor in the childhood obesity epidemic and only one behaviour that contributes to children’s activity levels. Other episodes of physical activity, aside from school travel, can also influence the health and well-being of the child. Active travel to and from school has the potential to both increase daily physical activity levels (Tudor-Locke et al. 2002; Cooper et al. 2003; Cooper et al. 2005; Murtagh and Murphy 2011; Owen et al. 2012), and assist with the formation of healthier habits as the child transforms into adulthood (Rowland and Freedson 1994; Vanreusel et al. 1997; Telama et al. 2005; Conroy et al. 2005). Although beneficial, active travel alone will not solve the childhood obesity problem. The majority of work to date, including this dissertation has focused on school travel.

Although not directly related to safety, more work needs to examine the aspects related to energy intake and how dietary behaviour influences rates of childhood obesity. Food choice and eating behaviours can significantly affect the overall health of an individual (Lake and Townshend 2006). Most dietary concerns relate to a high fat and sugar diet, and not consuming enough fruits and vegetables (WHO 2003). More exploration of the interaction between food access and diet within and around home and school is necessary to further develop the childhood obesity literature. Finally, due to data and time constraints the ethnicity of the child and their parents’ were not included in this dissertation. This is a limitation of the data and this dissertation. Ethnicity likely relates to decisions regarding school travel, perceptions of safety
and the overall built environment. Future work needs to examine how race/ethnicity may relate to school travel in a multicultural city like Toronto.

**Intersections with Policy**

Interest in children’s transport appears at multiple levels of government, regional, provincial and federal levels; within non-governmental, charitable and professional organizations (Green Communities Canada, OPPI, Active Healthy Kids Canada); and at the more local scale – within school boards, individual classrooms, across neighbourhoods, and within households. At the provincial level, the Ontario Professional Planners Institute (OPPI), a professional organization, which is a voice of planning in Ontario that provides vision and leadership on planning issues, including children and their transportation needs (OPPI 2009). At the national level, several non-government organizations such as the Active & Safe Routes to School program, encourages AST through focusing on key initiatives such as school travel planning, promoting walking school buses, walk to school day/month among other programs. Active Healthy Kids Canada, which is a charitable organization at the federal level, also aims to provide better programs and policies to improve physical activity levels for Canadian children. At the local level, Metrolinx, which is a provincial agency in charge of transportation in the Greater Toronto and Hamilton Area (GTHA), has identified goals and recommendations towards improving mobility of children through their regional transportation plan, along with supporting the 'Stepping It Up' pilot project which promoted AST in the region through school travel planning. This last section of the dissertation examines some of the specific intersections between the work of this dissertation and the broad policy environment described above.
In 2009, OPPI emphasized the importance of planning for children and their transportation needs (OPPI 2009). OPPI identified three aims to improve transportation needs for children, two of which relate to the findings of this dissertation. First, to ensure policies favour walking to and from school and second to help arrange walking school buses (OPPI 2009). The Active and Healthy Kids Canada report also recommends walking school buses and the sharing of adult supervision. Encouraging walking school buses will also reduce safety concerns for children, as adult supervision may alleviate several of the parental concerns highlighted in the qualitative assessment such as stranger danger and traffic safety. Ensuring policies favour walking relates to many of the findings from this dissertation and highlight the importance of reducing the number of vehicles around the school and ensuring children, who are physically able to have safe places to walk (i.e., sidewalks and street crossings). Policies that discourage vehicles around the school may encourage walking for children.

In Canada, Active & Safe Routes to School promotes and celebrates active school travel, with a goal towards increasing rates of AST and improving safety (Active & Safe Routes to School 2013). Findings from this dissertation should help to further address the safety concerns children must overcome. These results should be especially applicable in Canada as they provide research from a Canadian city, where most AST research has been completed in the U.S., U.K., Australia and New Zealand. Current programs include, Walk or Wheel Wednesdays, Winter Walk Day, International Walk to School Day/Month, Idle Free Zones, among others. Additional programs that address bullying or concerns with dogs such as anti-bullying day or dog awareness day may help children address their concerns and encourage walking. This dissertation provides additional evidence through the findings related to parking facilities and
actual recorded traffic volume, which could promote safe route to school campaigns and help to increase rates of AST.

The previous chapter discussed in detail how some of the recent recommendations by Active Healthy Kids Canada relate to physical activity, but many of these also relate to other aspects of this dissertation. The first suggestion was to ensure planning mechanisms create a supportive built environment to encourage active travel (Active Healthy Kids Canada 2013). Environmental features that may create a more supportive built environment relate to the findings from the mode choice chapter, such as sidewalks, street crossings, reduced traffic volume and parking, while traffic calming features associated with physical activity levels. Many of these features also directly relate to the second policy recommendation in the report to enforce and increase traffic calming and safety measures such as designated crossings, speed bumps and sidewalk infrastructure.

School transport alone may not have enough sway to affect complete sidewalk infrastructure, but sidewalks are an important environmental element. Improving the sidewalk network will not only improve the pedestrian environment for children, but also for adults and seniors. Working towards a more complete sidewalk network around school is a policy recommendation that agrees with the current recommendations, not only by Active and Healthy Kids Canada but also other agencies discussed here as well. Similarly, as previously discussed, traffic calming features can also be constructed around schools. Although I am not convinced that traffic calming features will increase physical activity levels, they may improve perceptions of safety over the long term.

The 'Big Move' which is a regional transportation plan for the GTHA, developed by the regional transportation planning authority, Metrolinx, also has some recommendations and
policy objectives for children’s transportation. Some of these goals are to improve transportation options for children and to create safe and secure mobility so parents feel comfortable letting their children walk to destinations (Metrolinx 2008). To meet these goals they have highlighted several objectives and aim to increase rates of walking and cycling for school travel to 60% for the entire region by 2033. With regard to children's safety, the 'Big Move' aims to progress towards zero casualties/injuries on all modes of transportation along with improving real and perceived safety (with a concentration on children and seniors). Some of their policy recommendations relate to what has already been discussed from the Active Healthy Kids Canada report and previous sections of this dissertation, but include designing environments that encourage walking and ensuring sidewalks are constructed on all new roads. It is clear from the plans of the 'Big Move' that children and AST in general are part of this 25 year plan.

The 'Stepping It Up' pilot project aimed to promote AST in the GTHA through school travel planning. There were six main steps this project implemented to encourage AST. Many of these relate to the findings of this dissertation. The first created walking to school announcements and newsletters. This type of educational initiative could be used to inform parents of the benefits of walking, provide information on children’s concerns such as bullies and parental fears regarding the number of vehicles around schools. This newsletter can be a tool to educate parents on the determinants of AST (such as a high number of vehicles around schools) in an effort to modify travel behaviour. Another initiative that relates to the findings from this dissertation is the walking school bus, which has already been discussed but may help to alleviate some parental concerns.

The final two actions from the “Stepping It Up” project that relate to this dissertation were crossing guards and police enforcement along with improving pedestrian safety through
Findings from the qualitative chapter suggest that parents were not convinced of the effectiveness of crossing guards and improving pedestrian safety, but police enforcement may be effective. Police enforcement of speeding vehicles and dangerous drivers may improve perceptions of the traffic environment around schools. Finally, improving signage and education may also reduce traffic concerns. Much of this has already been discussed in the previous sections, but educating students is an important step towards both improving perceptions of safety and reducing the risk of an incidence while travelling to or from school. The Active Healthy Kids Canada report also suggested implementing school travel plans, which include road safety education. Road safety education may help to alleviate concerns regarding street crossings, which were a correlate of physical activity levels after school and mode of travel between home and school. The models in this dissertation did not test for relationships between signage around the schools and mode choice, but there is some evidence from the 'Stepping It Up' program that these actions improved the traffic environment and encouraged AST.

Principals, teachers and parents all reported that the traffic environment around the school became safer in the morning and people driving around the school were more aware of children walking (Stepping It Up 2012). These results highlight some of the findings and concerns from this dissertation suggesting that the actions taken in the 'Stepping It Up' program, have the potential to encourage AST in Toronto.

Findings from this dissertation suggest that characteristics of the traffic environment and perceived safety support many of the recent policy recommendations. Encouraging educational awareness campaigns along with improvements to the sidewalk and traffic calming infrastructure all have the potential to improve pedestrian safety, personal safety and reduce the number of
vehicles around the school, which may encourage AST. Although walking to and from school will not solve the obesity epidemic, it is a step towards a healthier lifestyle for children that may continue into their adult life.
References:


(CLast assessed March 10, 2012)


Department for Transport: London.


Garder, P.E. 2004. The impact of speed and other variables on pedestrian safety in Maine.

*Accident Analysis and Prevention*, 36: 533-542.


Appendix: A
Charting of data from qualitative assessment
<table>
<thead>
<tr>
<th>Code</th>
<th>Child Personal</th>
<th>Parent Personal</th>
<th>Child Traffic</th>
<th>Parent Traffic</th>
<th>Similarities</th>
<th>Differences</th>
<th>Gender</th>
<th>Parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>none</td>
<td>strangers</td>
<td>general traffic safety -- likes the signs that warn drivers of children crossing</td>
<td>crossing the street - crosses at speed bump</td>
<td>both have general concerns over traffic safety and street crossings</td>
<td>child not concerned about strangers while parents are</td>
<td>Female</td>
<td>Mother</td>
</tr>
<tr>
<td>B2</td>
<td>strangers</td>
<td>strangers</td>
<td>traffic is busy and there are too many cars but does not feel unsafe crossing the street -- likes walking in groups to feel more safe</td>
<td>crossing the street - does not like crosswalks</td>
<td>both are concerned about traffic and strangers</td>
<td></td>
<td>Male</td>
<td>Mother</td>
</tr>
<tr>
<td>B3</td>
<td>bullies - but not really that concerned feels safe</td>
<td>murders and kidnapping</td>
<td>none feels safe</td>
<td>none -- takes the route she does to avoid busy and loud streets</td>
<td>both have no traffic concerns</td>
<td>parents concerned about murders/kidnapping while child feels safe but knows bullies exist</td>
<td>Female</td>
<td>Mother</td>
</tr>
<tr>
<td>B4</td>
<td>weird looking people (maybe homeless)</td>
<td>knowing whether she arrived safely, some freak person/strangers</td>
<td>none only has one street to cross so feels safe</td>
<td>no traffic concerns she doesn't have to cross any major streets...there are a lot of vehicles around the school though, but not a concern...they have a very safe route</td>
<td>both have no traffic concerns and both are concerned about strangers/weird looking people</td>
<td></td>
<td>Female</td>
<td>Mother</td>
</tr>
<tr>
<td>B5</td>
<td>gangsters, homeless people asking for money, bullies</td>
<td>none</td>
<td>drunk drivers, likes the idea of crossing guards</td>
<td>Maturity level feels they are old enough now no real fears</td>
<td>no real traffic concerns although child has minor concerned about drunk drivers</td>
<td>child worried about bullies/homeless and gangsters, parents have no personal safety concerns</td>
<td>Male</td>
<td>Father</td>
</tr>
<tr>
<td>B6</td>
<td>kidnapping/strangers</td>
<td>somebody approaching her, some wacko put her in a trunk</td>
<td>none</td>
<td>number of vehicles around the school its madness</td>
<td>strangers</td>
<td>parents are concerned about the number of vehicles around the school</td>
<td>Female</td>
<td>Mother</td>
</tr>
<tr>
<td>B7</td>
<td>not nice people/strangers or people who smoke</td>
<td>maturity and strangers</td>
<td>traffic is busy so crossing the streets are a concern</td>
<td>construction everywhere makes things more dangerous</td>
<td>both worried about strangers and traffic</td>
<td>Female Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------------------</td>
<td>------------------------</td>
<td>-------------------------------------------------------</td>
<td>---------------------------------------------------</td>
<td>----------------------------------------</td>
<td>---------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B8</td>
<td>bullies - likes the idea of walking in a group -- strangers</td>
<td>strangers/ wild animals (fox)</td>
<td>traffic and crossing busy streets -- speed of vehicles and the size of buses especially when they do corners</td>
<td>morning traffic can be a little careless</td>
<td>both concerned about traffic</td>
<td>parents are worried about strangers/wild animals while child is worried about bullies</td>
<td>Female Mother</td>
<td></td>
</tr>
<tr>
<td>B9</td>
<td>uncomfortable by himself but would feel better by walking in a group (strangers/something happening)</td>
<td>strangers/ just paranoia</td>
<td>no real traffic concerns as the school is in a safe area with not a lot of traffic, crossing guards would help other students feel safe though as they would assist with crossing and direct traffic</td>
<td>traffic around the school, people coming in every direction</td>
<td>strangers</td>
<td>parents are concerned about the number of vehicles around the school</td>
<td>Female Mother</td>
<td></td>
</tr>
<tr>
<td>B10</td>
<td>strangers - walking in groups alleviates fears - knows mom is concerned about drunks and random people near bars</td>
<td>none just basic survival skills and maturity</td>
<td>states his mom is worried about busy streets and traffic, but he/she is not really concerned -- likes the idea of crossing guards to help with traffic flow and safety</td>
<td>maturity levels and traffic</td>
<td>he knows his mom is worried about traffic but he isn't</td>
<td>traffic and maturity level, he is more concerned about random people/drunks</td>
<td>Female Mother</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>strangers but feels safer with his dad</td>
<td>none</td>
<td>none but likes the crossing guard</td>
<td>none believes child is mature enough</td>
<td>no real traffic safety concerns</td>
<td>child concerned about strangers</td>
<td>Male</td>
<td>Mother</td>
</tr>
<tr>
<td>D2</td>
<td>teenagers</td>
<td>strangers</td>
<td>none feels safe unless there is a crazy driver</td>
<td>clued out crossing the street, not mature enough to walk alone</td>
<td>child concerned about teenagers or bullies while parents worried about strangers, child has no traffic concerns while parent does not think he is mature enough and concerned about street crossings</td>
<td>Male</td>
<td>Father</td>
<td></td>
</tr>
<tr>
<td>D4</td>
<td>strangers/kidnapping pings</td>
<td>accompanies the child because doesn't know what might happen</td>
<td>car crashes</td>
<td>traffic really worried about heavy traffic</td>
<td>both worried about strangers and traffic</td>
<td>Male</td>
<td>Mother</td>
<td></td>
</tr>
<tr>
<td>D5</td>
<td>strangers/kidnapping pings</td>
<td>says children are scared of dogs but children do not mention it</td>
<td>crossing guards make it safe</td>
<td>traffic is fast, very fast cars lots of traffic crossing the street</td>
<td>both have traffic fears</td>
<td>Male</td>
<td>Father</td>
<td></td>
</tr>
<tr>
<td>D6</td>
<td>bullies, homeless people</td>
<td>crazy people out there</td>
<td>none but likes the crossing guard</td>
<td>none</td>
<td>no traffic concerns</td>
<td>child scared of bullies and homeless people, while parent is concerned about crazy people out there</td>
<td>Female</td>
<td>Mother</td>
</tr>
<tr>
<td>D7</td>
<td>drunk people doing random things, bad things happen on busy streets</td>
<td>none</td>
<td>none</td>
<td>traffic and crossing streets, crosswalks scare her to death,</td>
<td>parents have no personal concerns but are worried about traffic, child is worried about drunk people doing bad things but has no traffic concerns</td>
<td>Male</td>
<td>Mother</td>
<td></td>
</tr>
<tr>
<td>D8</td>
<td>strangers</td>
<td>it is ok around school but after 5pm it is dangerous/ kidnapings</td>
<td>crossing the street -- crossing guard would help</td>
<td>street crossings</td>
<td>strangers/kidnapping s and street crossings</td>
<td>Female</td>
<td>Mother</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Scenario</td>
<td>Child's Concerns</td>
<td>Parents' Concerns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D9</td>
<td>D bullies getting picked on, teenagers, strangers crossing big intersections, likes crossing guards</td>
<td>traffic and street crossings</td>
<td>street crossings and traffic</td>
<td>child is concerned about bullies and parents strangers</td>
<td>Male</td>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D10</td>
<td>bullies likes people or eyes on her child makes her feel safer from strangers not concerned if there is a crossing guard</td>
<td>actually likes her child on the busy streets because less likely for something to happen</td>
<td>no real traffic concerns</td>
<td>parents are concerned about strangers child worried about bullies</td>
<td>Male</td>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>none safe area</td>
<td>feels safe - likes crossing with guard but feels safe anyway….doesn't really like crossing lawrence but is ok</td>
<td>none</td>
<td>no personal safety concerns or traffic concerns</td>
<td>Male</td>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>none he and he thinks his parents say it's safe</td>
<td>car crashes but not that concerned -- he isn't allowed to cross busy streets or in big trouble</td>
<td>none because there are no major roads to cross and there is a safe arrival program otherwise would be concerned if streets were busier</td>
<td>child knows he isn't allowed to cross big streets or is in big trouble by parent</td>
<td>Male</td>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>kidnapping/strangers</td>
<td>crossing the streets….not enough time to cross -- crossing guards would help</td>
<td>not mature enough to walk alone on busy streets, too much traffic around the school, it would be nice to have sidewalks, too much traffic and going to fast on streets</td>
<td>street crossings and traffic</td>
<td>child is concerned about kidnappings while parents are not….parents are concerned about the child's maturity level when crossing the street</td>
<td>Female</td>
<td>Mother</td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>teenagers strangers/kidnappings</td>
<td>crossing the streets too many cars and they zoom by -- crossing guards would help, busy around the school in the morning</td>
<td>maturity to cross streets/cognitive abilities</td>
<td>street crossings</td>
<td>parents are concerned about strangers child worried about teenagers</td>
<td>Male</td>
<td>Mother</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Gender</td>
<td>Role</td>
<td>Concerns</td>
<td>Details</td>
<td>Parent Concerns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>--------</td>
<td>-----------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R5</td>
<td>Female</td>
<td>Father</td>
<td>none none not crossing any busy streets to cross a busy street</td>
<td>there are a few spots of concern along the route, glad she doesn't have to walk along a busy street, sidewalks would help</td>
<td>parent identifies a few sections of the route where traffic may be a minor concern, sidewalks could help</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R6</td>
<td>Male</td>
<td>Mother</td>
<td>bullies/strangers only mentioned strangers when asked about them, traffic is more of a concern</td>
<td>child is worried about bullies/strangers while the parent is concerned about street crossings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R7</td>
<td>Female</td>
<td>Mother</td>
<td>bad guys kidnappings, doesn't feel that it is a safe area</td>
<td>both concerned about traffic and strangers or bad guys</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R8</td>
<td>Female</td>
<td>Mother</td>
<td>strangers/someone shooting you crazy people out there/kidnapping</td>
<td>both concerned about crossing streets and strangers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age Group</td>
<td>Concerns</td>
<td>Traffic Concerns</td>
<td>Safety Concerns</td>
<td>Relationships</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>----------</td>
<td>-----------------</td>
<td>----------------</td>
<td>---------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R9</td>
<td>teenagers</td>
<td>none not that worried but knows stranger danger exists</td>
<td>traffic too busy and not sidewalks crossing those streets is madness, crossing guard can't do anything its too busy, traffic around the school is also dangerous</td>
<td>child not concerned about traffic while parents think it is madness around the school, it is too busy and there are not enough sidewalks— child concerned about teenagers, while parents are concerned about strangers</td>
<td>Female</td>
<td>Father</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R10</td>
<td>none</td>
<td>none</td>
<td>traffic is busy, a crossing guard would help</td>
<td>Parents also are concerned about traffic around the school and the lack of sidewalks</td>
<td>Male</td>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>strangers/kidnapping and Dogs</td>
<td>overall safety very vague</td>
<td>scared of cars but doesn't have to cross any major streets….if she did she would like a crossing guard</td>
<td>overall traffic safety</td>
<td>Female</td>
<td>Father</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>violence, loose dogs</td>
<td>none they are trained to not stop and talk with people</td>
<td>none but likes the crossing guard/ B - doesn't like crossing streets as people blow red lights</td>
<td>crossing the street</td>
<td>Male</td>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T5</td>
<td>dogs, people fighting</td>
<td>strangers and bad people</td>
<td>doesn't cross any streets</td>
<td>none</td>
<td>no traffic concerns</td>
<td>parents are concerned about strangers while child is worried about dogs and people fighting</td>
<td>Male</td>
<td>Mother</td>
</tr>
<tr>
<td>T6</td>
<td>strangers, animals</td>
<td>strangers and maturity</td>
<td>crossing streets doesn't trust the fast cars, likes crossing guards</td>
<td>maturity</td>
<td>both are worried about strangers</td>
<td>child is also worried about dogs/animals and doesn't like fast cars, while parents are worried about maturity</td>
<td>Female</td>
<td>Mother</td>
</tr>
<tr>
<td>T7</td>
<td>kidnappings</td>
<td>strangers/kidnappings</td>
<td>no real fears but crossing guards would help</td>
<td>street crossings</td>
<td>strangers</td>
<td>parents are concerned about street crossings while child has no traffic fears</td>
<td>Female</td>
<td>Mother</td>
</tr>
<tr>
<td>T8</td>
<td>strangers/ bad people</td>
<td>arriving safely/ strangers</td>
<td>feels safe but like the crossing guard</td>
<td>busy streets, crossing the street</td>
<td>strangers</td>
<td>parents also concerned about safe arrival and busy streets while child has no traffic fears</td>
<td>Male</td>
<td>Mother</td>
</tr>
<tr>
<td>T9</td>
<td>bullies beating up on little kids, strangers/kidnappings, teenagers</td>
<td>none</td>
<td>none</td>
<td>traffic around the school</td>
<td>traffic around the school  -- parents to personal concerns, children no traffic</td>
<td>child is concerned about bullies and strangers while parents are concerned about traffic around the school</td>
<td>Female</td>
<td>Father</td>
</tr>
<tr>
<td>T10</td>
<td>kidnapping, dogs</td>
<td>none</td>
<td>crossing the streets</td>
<td>maturity and crossing streets</td>
<td>street crossings</td>
<td>parents also worried about maturity and child is concerned with dogs and kidnappings</td>
<td>Male</td>
<td>Mother</td>
</tr>
</tbody>
</table>
Appendix: B

Traffic counting instruments

<table>
<thead>
<tr>
<th>School:</th>
<th>Intersection:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time:</td>
<td>Observer:</td>
</tr>
</tbody>
</table>

Sheet held with arrow pointing (CIRCLE ONE) **NORTH** or **SOUTH**

<table>
<thead>
<tr>
<th>Direction (CIRCLE ONE) <strong>NORTH</strong> or <strong>SOUTH</strong> On:</th>
<th>Direction (CIRCLE ONE) <strong>EAST</strong> or <strong>WEST</strong> On:</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Location - PLEASE CIRCLE ONE: SE corner or NW corner

- SB – School bus
- B – Bus (TTC, Greyhound)
- T – Truck
- X – Minivan/SUV/Pickup-Truck
- S – Streetcar
- M – Motorcycle
- – Car/Taxi
Intersection – 3 Way or T: Manual traffic counts

<table>
<thead>
<tr>
<th>School:</th>
<th>Intersection:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time:</td>
<td>to</td>
</tr>
<tr>
<td>Observer:</td>
<td>Date:</td>
</tr>
</tbody>
</table>

*Hold sheet with top pointing towards the T intersection*

**Street name:**

![Diagram of traffic flow]

**Street name:**

- SB – School bus
- B – Bus (TTC, Greyhound)
- T – Truck
- X – Minivan/SUV/Pickup-Truck
- S – Streetcar
- M – Motorcycle
- C – Car/Taxi