Transport Reviews, 2013
Vol. 33, No. 1, 21–43, http://dx.doi.org/10.1080/01441647.2012.743490

Routledge
Taylor & Francis Group

Independent Mobility and Mode Choice for School Transportation: A Review and Framework for Future Research

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(*Received 18 March 2012; revised 19 October 2012; accepted 22 October 2012*)

ABSTRACT *Interest in active school transportation has emerged in response to concern over the reduced levels of physical activity (PA) among children. PA derived from active school travel may have important implications for the healthy development of children and youth. This article reviews transportation, urban planning, health and environmental psychology literatures to explore current understanding of school travel behaviour. The major theoretical approaches used to study and explain walking/cycling behaviour were examined; and existing evidence of the influences on school travel outcomes was summarized. Based on this review, the paper outlines a conceptual framework for exploring school travel behaviour of children and youth. The model hypothesizes multiple levels of influence on independent mobility and mode choice for school transportation; independent mobility is conceptualized within the household activity-travel paradigm. Future empirical research based on this framework will inform policy interventions that are focused on children's active mobility and PA.*

Keywords: physical activity; children; youth; built environment; escort; behavioural model of school transportation

Introduction

Researchers and practitioners have identified active school transportation (AST: walking and cycling to or from school) as a potential source of physical activity (PA) and daily energy expenditure for children and youth. Underlying this observation is concern over the increase in the prevalence of childhood overweight and obesity in North America and other Western countries during the past decades (Ogden et al., 2006; Shields, 2004; Wang & Lobstein, 2006). Research on adults indicates that regular participation in endurance-type PA, such as walking and cycling, can offer longer term health benefits by reducing the risk of obesity, several types of chronic diseases including cardio-vascular diseases and type II diabetes, and by improving quality of life (DHHS, 1996; Saris et al., 2003; Transportation Research Board, 2005). Empirical evidence on children is

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limited, but those who actively travel to and/or from school, and subsequently adapt to an active lifestyle, may also enjoy similar health benefits (Faulkner, Buliung, Flora, & Fusco, 2009; Tudor-Locke, Ainsworth, & Popkin, 2001). In addition, researchers have hypothesized that increased participation in AST may associate with a decrease in localized congestion (Black, Collins, & Snell, 2001). Within this context, then, it is concerning that AST rates have declined across Western countries, at least during the last three decades (Buliung, Mitra, & Faulkner, 2009; Grize, Bringolf-Isler, Martin, & Braun-Fahrländer, 2010; McDonald, 2007; van der Ploeg, Merom, Corpuz, & Bauman, 2008).

To reverse this trend, policy-makers, practitioners and community-based organizations have emphasized the need for interventions that enable AST uptake among children and youth (DHHS, 2009; Green Communities Canada, 2011; MHPO, 2005; NC-SRTS, 2007; OPPI, 2009). For example, in the USA, the Federally funded Safe Routes to School (SRTS) programs broadly focus on interventions such as education on road safety, encouragement about walking and cycling, enforcement of traffic laws around school, and engineering of the neighbourhood/street along the school routes (e.g. sidewalks), to create an enabling environment for walking/cycling (NC-SRTS, 2007). The 2005 SAFETEA-LU Federal transportation bill allocated $612 billion to the SRTS programs, which is distributed to the local agencies through the State Department of Transportations (NC-SRTS, 2007; Stewart, 2011). However, the SAFETEA-LU legislation requires 70–90% of this Federal funding to be spent on transportation-related infrastructure development (Stewart, 2011). In contrast, education and promotion have remained the focus of the community-based School Travel Planning (STP) program in Canada, which is funded by the Public Health Agency of Canada (Buliung, Faulkner, Beesley, & Kennedy, 2011; Green Communities Canada, 2011; Metrolinx, 2011).

The effectiveness of these interventions remains understudied; limited existing research has reported only small improvements in AST rates after interventions were implemented. For example, in California, USA, SRTS projects that emphasized on improved sidewalks, crosswalks, bicycle lanes proved to be less effective in increasing AST rates (Boarnet, Anderson, Day, & McMillan, 2005). In Canada, AST rates increased only by 2.1% after STP interventions were implemented at 12 elementary schools (Buliung et al., 2011). However, a survey of parents/caregivers of these children revealed that road safety education was more effective in influencing their behaviour, compared with the capital improvement projects. Weather and convenience (related to the value of time and trip chaining) were identified as primary reasons for an escorted automobile trip to/from school (Buliung et al., 2011). These findings are not entirely surprising, because initiatives such as SRTS and STP were not informed by adequate evidence-based research on school transportation behaviour. An improved understanding of the social and environmental influences on school travel mode choice behaviour is critical, then, in order to facilitate the development of more appropriate policy and programs/initiatives in future, or improve the current ones for that matter.

Empirical knowledge on the enablers and barriers to AST continues to develop. The existing research has largely adopted an ecological approach to study school travel, and explores the potential influence of generalized travel cost (e.g. distance) and the environment (perceived or objective) on the choice between travel modes. Some researchers have explored school travel within the household activity-travel framework (Black et al., 2001; McDonald, 2008a; McMillan, 2005;

Yarlagadda & Srinivasan, 2008). Despite an emerging interest in caregiver–child travel interactions that may lead to an escorted versus an independent school trip, the behavioural processes related to independent school travel remains unclear and an understudied theme in the current literature.

This paper reviews current conceptual and empirical understanding of school transportation behaviour, with a view to developing a conceptual framework for exploring the school travel behaviour of children and youth. The paper has three objectives: (1) to evaluate the major theoretical approaches used by researchers to study and explain walking/cycling behaviour in general, and AST in particular; (2) to review evidence of the potential influences on school travel outcomes and (3) to outline a conceptual framework of the relationship between the environment, household travel constraints and school travel outcomes, in order to guide future research on school transportation behaviour, particularly in North America. Empirical research based on this framework will advance current understandings of school travel mode choice processes, and will help transportation/urban planners and public health professionals in designing informed interventions to encourage AST.

Active School Transportation as a Research Problem

Transportation, urban planning and public health professionals have explored active travel behaviour, particularly that of an adult, within different contexts. A rather extensive literature in urban planning has examined the relationship between the built environment and walking/cycling. This literature is primarily motivated by the desire to better understand how various transport outcomes may or may not emerge from the implementation of contemporary urban planning principles such as New Urbanism, Transit-Oriented Development and Smart Growth. Notably, these principles collectively advocate for walking/cycling and using transit as means to improve environmental sustainability and urban livability (Cao, Mokhtarian, & Handy, 2009; Greenwald & Boarnet, 2001; Saelens, Sallis, & Frank, 2003). Transportation mode choice (e.g. decision to walk) is explored in relation to regional distribution of land use and transportation infrastructure, the neighbourhood built environment, and the attitudes and preferences of an individual or household towards lifestyle and travel (Boarnet & Crane, 2001; Cao et al., 2009; Cervero & Kockelman, 1997; Handy, Cao, & Mokhtarian, 2006).

Some researchers have recognized the difference in travel behaviour between an adult and a child/youth (Copperman & Bhat, 2010; Gilbert & O'Brien, 2005; McMillan, 2007; Mitra, Buliung, & Roorda, 2010). First, the definition of a walking-friendly built environment can be different for these two populations. The type of built environment that potentially encourages an adult to walk for non-work travel purposes (e.g. street connectivity, land use mix) may not provide an appropriate or attractive environmental setting for a child to walk to/from school. Instead, proximity to school and safety, or perhaps even the availability of places for play and meet others along the way, could be more important motivations for walking (McMillan, 2007; Mitra et al., 2010; Timperio et al., 2006). Second, a child's travel mode is likely to be related to the decision processes that determine whether the child travels independently, or is accompanied by an adult caregiver (i.e. is escorted to/from school). For example, the likelihood of an escorted school trip may depend on the availability of caregivers during the morning or afternoon periods (Copperman & Bhat, 2010; McDonald, 2008a;

Mitra, Buliung, & Faulkner, 2010), which may trigger the use of an automobile as the travel mode.

The number of studies that have explored walking/cycling from a public health perspective has also increased over the past two decades. Active travel, in this literature, is viewed as a potential opportunity to accumulate the recommended daily levels of PA. Much of this research in North America followed the US Surgeon General's Report on Physical Activity and Health (DHHS, 1996), which had highlighted the importance of lifelong practice of moderate PA, such as walking or cycling, in improving the health and quality of life for Americans. Several policies since then have also focused on the recommended levels of PA for both adults and children, and active travel as a means to achieve those targets (DHHS, 2009; MHPO, 2005). However, some researchers have emphasized the importance of distinguishing between transportation-related and recreational PA, because the factors that influence the participation in one or more of these activities can be very different (Lee & Moudon, 2004; Transportation Research Board, 2005).

For children and youth, the potential sources of PA can take four possible forms: (1) outdoor leisure or recreational type PA including organized sport or play, (2) organized PA during school hours, (3) PA at home and (4) active transportation to and from places and activities such as school. Since a child has to travel to/from school on a daily basis, AST can be a regular source of PA during the school year. Empirical research also suggests that children who regularly walk to school are more physically active overall (Cooper, Page, Foster, & Qahwaji, 2003; Faulkner et al., 2009). Similar to adults, these different types of PA are undertaken within different contexts. Recent research on children's PA participation has indicated that the correlates for each type of PA are also potentially different (Page, Cooper, Griew, & Jago, 2010). Drawing a conceptual distinction between school transportation from other types of PA is important for future empirical research, because interventions designed to promote active travel to/from school may not directly increase participation in other types of PA (Giles-Corti, Timperio, Bull, & Pikora, 2005; Page et al., 2010).

The Intersection of Theory and Active Travel

The purpose of this paper is to outline a conceptual model for future empirical work on children's mobility for school transportation. Existing empirical research has used several theoretical approaches to explore active travel among adults and children, with noticeable overlap across disciplines owing to the interdisciplinary nature of the research problem. These approaches are reviewed in this section. An effort has been made to classify them by the primary fields of their applications, which include transportation/urban planning, PA/public health, and environmental psychology.

Transportation and Urban Planning

In the fields of transportation and urban planning, quantitative travel behaviour research has drawn largely on consumer choice theory and its further developments by Ben-Akiva and Lerman (1985), McFadden (1974) and other researchers. A transportation model usually treats mode choice as an economic choice process, where each individual maximizes his/her net benefit or *utility* in terms of the

generalized costs associated with a trip. For example, an individual will walk to a destination if it is cheaper (a function of the generalized cost of travel), safer and easier than driving.

Early transportation engineering models of travel mode choice largely explored the attributes of a trip itself (e.g. generalized cost) and that of the traveller; characteristics of the origins and destinations (i.e. the trip-ends) remained largely overlooked (Cervero, 2002; Ewing, Schroeer, & Greene, 2004). Research in urban planning has extended this theoretical framework to examine the relationship between the built environment and mode choice; the built-environment characteristics are hypothesized to contribute to the utility (i.e. explain, at least partly, the generalized travel cost) of taking a particular mode for travelling between destinations (Boarnet & Crane, 2001; Cervero, 2002; Cervero & Kockelman, 1997).

Working within a consumer choice theory-based framework, Cervero and Kockelman (1997) popularized the concept of considering density, diversity or land use mix and design, (i.e. the 3Ds) to examine the built environment for transportation research. Later research has repeatedly used this approach to study adult travel behaviour (Cervero, 2002; Krizek, 2003). The Transportation Research Board (2005) has defined the built environment to include land use patterns, transportation infrastructure and urban design features (i.e. aesthetic, physical and functional qualities of buildings and streets). Together, these elements are expected to facilitate active travel and PA. Also, Moudon and Lee (2003) proposed a behavioural model of environment, which identifies the generic environmental aspects that may influence participation in outdoor physical activities, particularly walking/cycling for adults. Using this normative framework, Lee and Moudon (2006) later suggested that the characteristics at the destination, distance, density and travel route (i.e. the 3D + R) likely influence the choice of an active mode for travelling between destinations. Despite a recognition that the environment-related enablers and barriers to walking/cycling can be different for adults and children, efforts to conceptualize the relationship between the built environment and a child's travel remains limited (McMillan, 2005; Panter, Jones, & van Sluijs, 2008). Instead, the current AST research has largely drawn its environmental variables based on theoretical or empirical works that explore adult travel behaviour (Ewing et al., 2004; Lin & Chang, 2010; Panter, Jones, van Sluijs, & Griffin, 2010a).

Transportation/urban planners have also taken notice of the relationship between attitudes/preferences, cognitive processes and travel demand, particularly, the choice of active modes such as walking and cycling (Boarnet & Crane, 2001; Cao et al., 2009; Ewing & Cervero, 2010; Kitamura, Mokhtarian, & Laidet, 1997). With regard to school transportation, a child's travel mode can often be influenced by a household's residential location choice, where a household, perhaps with sufficient income, self-selects themselves into a neighbourhood of preference. Also, a child's travel may be influenced by the perceived convenience of travel modes (McMillan, 2007; Panter, Jones, van Sluijs, & Griffin, 2010b). Typical consumer choice theory-based models of travel behaviour are theoretically weak in explaining such relationships (Walker, 2001). These models link observed variables to the potential behavioural outcomes, assuming that the alternative with the maximum utility is chosen; the actual behavioural process remains largely unexplored. While econometric modeling methods can be enhanced to allow a closer examination of the behavioural processes (e.g. attitudes can be studied as latent variables) (Walker, 2001), existing quantitative

research on travel behaviour, for most part, has largely explored attitudes/preferences as *control* or confounding variables (Black et al., 2001; Cao et al., 2009; Ewing & Cervero, 2010). To explain the association between environmental and travel-related attitudes and mode choice outcomes of both adults and children, researchers have frequently drawn on the theory of planned behaviour (TPB) (Bagley & Mokhtarian, 2002; Black et al., 2001; Cao et al., 2009; Handy et al., 2006).

The TPB hypothesizes that intentions, together with perceptions of behavioural control (i.e. difficulty in performing a behaviour), explain variations in the actual behaviour, when resources and opportunities are available (Ajzen, 1991). The intention to perform a certain behaviour (e.g. walking to school) can be reasonably predicted from three psychological constructs—attitudes, subjective norms and perceived behavioural control. However, the TPB conceptualizes behaviour only as a product of these psychological constructs, and assumes that all other attributes (including household socio-demographics and the built environment) operate through the constructs of the theory (Ajzen, 1991; Bamberg, Ajzen, & Schmidt, 2003). This conceptualization is a potential limitation of this theory in terms of its application in travel behaviour research. For example, the theory is weak in examining the direct effects of the built environment on travel, unless it is assumed that a household's perception of the environment can be objectively represented by measured built-environment characteristics.

Some researchers in the field of transportation/urban planning have adopted the human activity theory to explore the effect of household preferences and constraints on travel outcomes. This approach to travel behaviour research is based on the theorization of household activity participation pattern in space and time, and is commonly known as the activity-travel approach (Chapin, 1974; Hägerstrand, 1970; Jones, 1979). The activity-travel framework provides a number of advantages with respect to understanding household travel, which can also be translated to school transportation behaviour. First, by acknowledging spatial, temporal and inter-personal constraints on activity participation, the activity-travel concept provides a theoretical basis to study the effects of scheduling and trip-chaining on travel patterns of a child and his/her caregiver(s), and the subsequent mode choice outcomes. Second, this approach not only recognizes the possibility of a child's travel being influenced by caregivers' travel needs, it also remains open to accommodate the possibility that caregivers may adjust their travel in response to the child's activity participation at school, elsewhere within a neighbourhood, or beyond (Copperman & Bhat, 2010). Finally, the activity-travel framework acknowledges the importance of environment-related preferences (i.e. attitudes) and constraints on travel decision processes (Jones, 1979; McMillan, 2005), and hence, can be applied to design theoretically grounded research focused on the relationship between the environment, attitudes and travel outcomes.

However, the application of the activity-travel framework in understanding mode choice behaviour remains limited; perhaps because of the unavailability of data at the appropriate levels of detail, and the potential methodological complexity involved in research design (Buliung & Kanaroglou, 2007; McNally, 2000). While several studies have contextualized school travel within the household activity-travel framework (Black et al., 2001; McDonald, 2008a; McMillan, 2005; Yarlagadda & Srinivasan, 2008), only a few have explored the influence of caregiver activity-travel constraints on AST (McDonald, 2008a; Mitra & Buliung, 2012b; Yarlagadda & Srinivasan, 2008).

PA/Public Health

Contrary to transportation and urban planning research, the PA/public health literature largely conceptualizes the choice between active and non-active modes as behavioural, and not economic, in nature. Empirical studies in this field have mostly applied dominant behavioural theories to understand the processes involved in the undertaking of active travel and PA. Many of them have drawn on social cognitive theory (SCT) and social ecological models (Glanz, Rimer, & Viswanath, 2008).

The SCT builds on the works by Miller and Dolland (1941) and Rotter (1954), who explained human behaviour based on established principles of learning within a social context. The theory explains human behaviour as a product of an individual's psychosocial and physical capabilities, perception of the environment and cognitive learning through observation (Bandura, 1986, 1999; McAlister, Perry, & Parcel, 2008). The SCT also emphasizes a reciprocal relationship between a person and the environment, where the person learns from and adapts to the environment (McAlister et al., 2008).

Social ecological models also emphasize the influence of the environment and policy on behaviour, while recognizing the social and psychological influences (Lee & Moudon, 2004; Sallis, Owen, & Fisher, 2008; Stokols, 1977, 1992). The ecological models have evolved around the core concept that behaviour has multiple levels of influence, and that an exploration of the reciprocal interaction between these levels is the most effective approach to understand behaviour, or a change in behaviour. For example, the likelihood of a child's walking to school can be influenced by intra-personal (e.g. age, sex), inter-personal (e.g. household composition, attitudes, social-norm, activity-scheduling), organizational (e.g. education at school), neighbourhood (e.g. sidewalks) and policy (e.g. school bussing policy) level influences and the interplay between these aspects across different levels. A change in behaviour is expected to be maximized within a supportive "behavior settings" (i.e. the physical environment and policy), given the presence of individual motivations and social support towards AST (Baker, 1968; Bandura, 1986; Sallis et al., 2008).

The social ecological models are robust, and are adaptable to many aspects/categories of human behaviour (Sallis et al., 2008). Researchers have explored specific health outcomes and behaviours, such as diabetes (Fisher et al., 2005), nutrition environments or eating behaviour (Glanz, Sallis, Saelens, & Frank, 2005) and PA (Transportation Research Board, 2005), using the social ecological models approach. The approach can also be useful in exploring children's school travel behaviour, allowing researchers to conceptualize multi-level influences such as social and the built environment of a neighbourhood, caregiver–child travel interactions and household attitudes on school transportation outcome. Not surprisingly, then, several recent studies have explored AST within a social ecological framework (Emond & Handy, 2012; Panter et al., 2010a; Robertson-Wilson, Leatherdale, & Wong, 2008).

Some researchers have also explored PA and active travel using a behavioural economics approach (Epstein, 1998; Faulkner, Richichi, Buliung, Fusco, & Moola 2010). Unlike the consumer choice model (which assumes rational choice), the behavioural economics conceptualizes that time allocation between daily activities (e.g. sedentary versus physically active episodes) is influenced by the circumstances of a given situation, for example, the availability of alternatives, the behavioural cost

needed to access an activity, the reward of engaging in a behaviour, and the delay between an action and receiving the reward (i.e. immediate benefit versus benefits in the distant future). The application of this theoretical approach in travel behaviour research, however, remains limited (Faulkner et al., 2010).

Environmental Psychology

In the field of environmental psychology, Johansson (2006) used Kűller's model of human-environment interaction (HEI) (Kűller, 1991) to explore the behavioural processes that may influence a child's independent mobility for leisure activity participation. Kűller argued that activity participation is the result of a four-step emotional (i.e. neuropsychological) process (Kűller, 1991). When applied to children's travel, the emotional process for choosing a transportation mode, according to the HEI-model, starts when a child needs to get to an activity (e.g. school) for the first time. The need for an activity triggers an "activation" phase (similar to a psychological arousal), that motivates a child/caregiver to travel. The next stage in the process is the "orientation" phase, when different travel modes such as walking, cycling, private automobile and transit, are considered carefully for the trip, either in the company of an adult, or independently. Next, the available or accessible mobility options go through an "evaluation", where the prevailing states of the physical and social environment that may facilitate or discourage the use of certain travel modes are considered. This environmental evaluation may be mediated by individual/household characteristics. Finally, and once a decision has been made about the preferred travel mode, "control" is obtained, leading to a trip (Johansson 2006). Kűller (1991) also argued that once control over a particular transport mode is established, the choice may become habitual, unless the environmental and/or individual circumstances are altered.

Findings from Existing Research

The literature on children's school travel behaviour is emerging (Sirard & Slater, 2008; Stewart, 2011). In order to explore the existing evidence on school transportation behaviour, a scoping review was performed (Arksey & O'Malley, 2005; Brien, Lorenzetti, Lewis, Kennedy, & Ghali 2010). Forty-two empirical studies were reviewed, which were published in peer reviewed English language journals.

Of these 42 studies, 21 have explicitly reported the use of a theoretical approach in understanding school travel. Five of these studies have adopted an activity-travel approach to understand the links between parental travel characteristics and school travel behaviour (Black et al., 2001; Lin & Chang, 2010; McDonald, 2008a; Vovsha & Petersen, 2005; Yarlagadda & Srinivasan, 2008). Only three studies emphasized a re-conceptualization of the built environment–travel relationship in order to explore children's travel, and have explored AST behaviour within the context of a conceptual framework developed specifically for children's school travel (McMillan, 2007; McMillan, Day, Boarnet, Alfonzo, & Anderson, 2006; Mitra et al., 2010).

The existing research varies widely with respect to the age-groups that were explored. While most of these studies focus on children ($\leq$13 years old, elementary and middle school students), six of them have specifically explored youths' (14–17 years old, high school students) travel behaviour, and nine others have

examined the travel behaviour of all children and youth aged <18 years. Most of this reviewed research used logistic regression or the discrete choice models (i.e. logit models) to explore school travel mode choice behaviour. Two studies used a qualitative approach to explore enablers and barriers to AST (Faulkner et al., 2010; Lang, Collins, & Kearns, 2011). In the field of transportation/urban planning, researchers have largely explored walking/cycling in relation to all potentially available travel modes for school travel (i.e. transit, school bus, private automobile). In contrast, the PA/public health research has focused primarily on the difference between active (e.g. walking and/or cycling) and non-active (e.g. transit, school bus, private automobile) travel choices; the difference in choice processes between individual travel modes within these two broad categories is not emphasized in this literature.

Empirical findings from the current literature can be summarized as follows. First, household attitudes and self-efficacy beliefs are likely associated with mode choice for school transportation. Multiple studies have reported that a child was more likely to be driven to/from school when caregivers viewed cars to be a convenient and socially acceptable mode of transportation (Faulkner et al., 2010; Lang et al., 2011; McMillan, 2007; McMillan et al., 2006; Panter et al., 2010b; Trapp et al., 2011). In contrast, a household's environmental consciousness was associated with walking (Black et al., 2001). Confidence about a child's capability of being physically active, and road safety skills, also increased the probability of walking (Emond & Handy, 2012; Lang et al., 2011; Martin, Lee, & Lowry, 2007; Trapp et al., 2011; Wen et al., 2008). Parents who were supportive to active transportation and/or acknowledged the importance of a child's social interaction (i.e. meeting other children) were more likely to allow their child(ren) to walk or cycle to school (Emond & Handy, 2012; McMillan, 2007; Timperio et al., 2006).

Second, a household's socio-economic characteristics may moderate school travel outcome. For example, a household's access to private automobiles likely enables driven school trips (Black et al., 2001; Ewing et al., 2004; Grize et al., 2010; Mitra et al., 2010; Sidharthan, Bhat, Pendyala, & Goulias, 2011). Findings related to some other socio-economic correlates remain mixed. For example, some studies have observed correlations between a child's sex (Emond & Handy, 2012; Evenson, Huston, McMillen, Bors, & Ward, 2003; Larsen et al., 2009; McDonald, 2008a), ethnicity (Bere, van der Horst, Oenema, Prins, & Brug, 2008; Evenson et al., 2003; Martin et al., 2007; McDonald, 2008b, 2008c; Wilson, Marshall, Wilson, & Krizek, 2010; Yarlagadda & Srinivasan, 2008) and school travel modes; others have reported on the contrary (Black et al., 2001; McDonald, 2008b; Mitra et al., 2010). In some studies, an association was observed between low household income (Ewing et al., 2004; McMillan, 2007; Sidharthan et al., 2011; Wilson et al., 2010) or low neighbourhood income (Larsen et al., 2009; McDonald, 2008c) and travel mode choice; in some others, these socio-economic measures were not correlated with travel outcome (McDonald, 2008a; Timperio et al., 2006).

Limited empirical evidence indicates that parental work-travel characteristics are correlated with escorted (e.g. accompanied by an adult caregiver) school trip (Faulkner et al., 2010; Vovsha & Petersen, 2005; Yarlagadda & Srinivasan, 2008), and that independent travel (i.e. trips without the supervision of an adult caregiver) is associated with the likelihood of walking/cycling (Page et al., 2010; Trapp et al., 2011; Zwerts, Allaert, Jenssens, Wets, & Witlox, 2010). Children/

youths were less likely to walk to school when parents travelled to work in the morning period (McDonald, 2008a) or were available for escorting (Emond & Handy, 2012). The age of a child also is constantly reported to have a strong association with the likelihood of walking/cycling (Babey, Hastert, Huang, & Brown, 2009; Bere et al., 2008; Johansson, Hesselberg, & Lafflame, 2011; McDonald, 2008a, 2008b; Robertson-Wilson et al., 2008). This "age-effect" may relate to a child's physical/cognitive development as an independent traveller. In other words, the travel behaviours of a child (an elementary school student) and a youth (a high school student) can be different. A closer examination into the potential moderating effect of age on the relationship between travel outcome and its social and environmental correlates can improve our understanding of school transportation behaviour. More broadly, the decision processes related to escorted versus independent school trips, and their relationship with mode choice outcomes, remain understudied in the current school transportation literature. Household level travel interactions, and how those interactions may influence mode choice for school transportation, should also be adequately theorized and examined to guide future policy focused on children's active travel and PA.

Third, the neighbourhood environment appears to influence mode choice for school transportation. Distance between school and the residence, or travel time, is most consistently reported to have an association with active mode choice. As distance/travel cost increased, children and youth were less likely to walk or cycle to/from school (Babey et al., 2009; Emond & Handy, 2012; Ewing et al., 2004; McDonald, 2008b; Mitra & Buliung, 2012a; Panter et al., 2010a). Distance between home and a parent's workplace was also associated with the likelihood of a child being escorted, particularly for school-to-home trips in the afternoon (Vovsha & Petersen, 2005). Active travelling was also more common in urban areas, compared with non-urban or rural locations (Babey et al., 2009; Grize et al., 2010; Martin et al., 2007; Robertson-Wilson et al., 2008).

With regard to built-environment characteristics, most studies have reported a negative association between concern over personal and traffic/pedestrian safety and the likelihood of walking/cycling among children (Bringolf-Isler et al., 2008; Lang et al., 2011; McDonald & Aalborg, 2009; McMillan, 2007; Panter et al., 2010b; Timperio et al., 2006). Busy traffic in the neighbourhood streets (Giles-Corti et al., 2011; Lin & Chang, 2010; Trapp et al., 2011; Zwerts et al., 2010) and major street crossings (Bringolf-Isler et al., 2008; Emond & Handy, 2012; Larsen, Gilliland, & Hess, 2012; Trapp et al., 2011) were also barriers to AST. Some studies suggest positive correlations between pedestrian connectivity (e.g. presence of sidewalks; pedestrian crossings) and walking school trips (Boarnet et al., 2005; Dalton et al., 2011; de Vries, Hopman-Rock, Bakker, Hirasing, & van Mechelen, 2010; Ewing et al., 2004; Kerr et al., 2006; Panter et al., 2010a); others have found a negative association between higher intersection density (Larsen et al., 2012; Mitra et al., 2010; Schlossberg, Greene, Phillips, Johnson, & Parker, 2006), street connectivity (Panter et al., 2010a) or street width (Larsen et al., 2012; Lin & Chang, 2010) and the likelihood of walking, perhaps due to their potential contribution to traffic safety concerns (Giles-Corti et al., 2011). Findings related to land use design and mode choice outcome, however, remains inconclusive. For example, some studies found dense (Dalton et al., 2011; Kerr et al., 2006; Lin & Chang, 2010; McDonald, 2008a, 2008b; Nelson, Foley, O'Gorman, Moyna, & Woods, 2008) and mixed-use neighbourhoods (Larsen et al., 2009; McMillan, 2007) to associate with walking; others have indicated to the contrary (Ewing et al., 2004; Mitra

et al., 2010; Yarlagadda & Srinivasan, 2008). High density of residential blocks tends to associate with more walking (Lin & Chang, 2010; Mitra et al., 2010). The neighbourhood environment (e.g. sidewalks, smaller residential blocks, low density of street intersections) may also influence independent versus escorted school travel (Lin & Chang, 2010). Social environment of a neighbourhood is important. Current research suggests that the odds of AST was also higher in the neighbourhoods that are perceived as "walkable", have a sense of community, or where other children and adults also walked (Dalton et al., 2011; Mitra et al., 2010; Panter et al., 2010b; Timperio et al., 2006).

Finally, some researchers have explored the natural environment and policy-related influences on school travel outcome. For example, Babey et al. (2009) reported that children attending public schools were more likely to walk to school. Students attending neighbourhood schools were also more likely to walk, compared to those attending larger "magnet schools" (Wilson et al., 2010). Others, however, found no association between school-specific policies (e.g. walk to school initiative, separate entrance for pedestrians) and AST (Panter et al., 2010a). Seasonal climate and weekly weather were found to be uncorrelated with mode choice (Mitra & Faulkner, 2012; Robertson-Wilson et al., 2008); but weather conditions at the time of travel likely influenced mode choice (Zwerts et al., 2010). The topography of the neighbourhood (e.g. steep slope) also influenced mode choice (Lin & Chang, 2010; Panter et al., 2008; Timperio et al., 2006). Further systematic research is warranted to examine the potential influence of these natural and policy-related enablers and barriers to travel mode choice.

A Behavioural Model of School Transportation

Adult travel behaviour has been widely theorized within the current discourse of transportation, urban planning and PA literatures. Several conceptual models also exist for studying particularly the walking/cycling behaviour of adults (Moudon & Lee, 2003; Saelens et al., 2003; Transportation Research Board, 2005). In comparison, systematic conceptualization of a child's or youth's school travel behaviour has received less attention. McMillan (2005) proposed a framework that relates the neighbourhood built environment with mode choice behaviour for a child's school travel. The framework made an important contribution by re-conceptualizing the effects of the built environment on children's travel, instead of merely transferring knowledge from the research on adult travel behaviour to the context of children's school transportation. McMillan argued that a household's attitudes, norms, socio-demographic characteristics and mobility options (i.e. access to private automobile) influence school travel behaviour. The built environment influences mode choice indirectly, by contributing to personal and traffic safety within a neighbourhood, and by limiting a household's transportation options (e.g. increased distance). McMillan conceptualized school travel behaviour largely as a product of parental decision processes. The conceptualization recognizes but does not emphasize a child's role in school travel decision processes. While the framework applies to the majority of younger children for whom the caregivers likely play the key role in travel decision making, it may not adequately explain the travel behaviour of youth who are more independent.

In a different framework, Panter et al. (2008) focused on the active travel behaviour of youth, and hypothesized that both parents and youth may participate in the travel decision processes. The authors took an ecological approach to under-

stand travel behaviour, and based on current empirical evidence, identified four domains of influence on the choice of active travel modes—individual/household factors (e.g. attitudes, perceptions, socio-demographics), the built environment (neighbourhood, destination and travel route), external domains of influence (e.g. weather, travel cost, government) and main moderators (e.g. age, sex, distance to destination). The framework presents a comprehensive summary of the correlates of active travel. However, it remains less clear in explaining the behavioural processes that may link these factors to the choice of active modes.

For some time, travel behaviour research has moved towards being theoretically grounded in the activity-travel framework (Buliung & Kanaroglou, 2007; Kang & Scott, 2011). This approach can also be important for AST research, particularly in the context of evidence suggesting that children are often accompanied by caregiver(s) during school travel (Copperman & Bhat, 2010; McDonald, 2008a; Vovsha & Petersen, 2005; Yarlagadda & Srinivasan, 2008). Copperman and Bhat (2010) and McDonald (2008a) theorized that parents take decisions about an escorted versus independent (i.e. when children are not accompanied by adults) school trip in relation to their work participation needs, and that a child is more likely to be driven to/from school if escorted by a parent. However, the potential influences of other factors, such as the built environment, on independent mobility or escorted travel, were not explicitly conceptualized.

Informed by an extensive literature review, this paper outlines a conceptual framework of school transportation behaviour. Current empirical evidence indicates that school travel outcome may be affected by multiple levels of influence (e.g. the urban environment, household, characteristics of a child/youth and other external factors). The behavioural model of school transportation (BMST) that is outlined here adopts a social-ecological framework to conceptualize this multi-level relationship. However, the intra-household dynamics of school travel behaviour, particularly those related to independent (versus escorted) school travel, can be better understood when contextualized within the household activity-travel framework (Copperman & Bhat, 2007; Vovsha & Petersen, 2005). Some researchers have hypothesized that a joint-travel outcome, such as an escorted trip, is determined by caregiver mobility options (e.g. access to private automobiles) and activity constraints (e.g. employment) (Copperman & Bhat, 2010; McDonald, 2008a; Vovsha & Petersen, 2005; Yarlagadda & Srinivasan, 2008). Others, however, emphasize multi-level influences on escorting decision (Faulkner et al., 2010). The framework outlined here adopts this latter approach, and hypothesizes that household members negotiate the possibility of an independent or escorted school trip based on: (1) perceived importance of an escorted trip, which is influenced by household attitudes, a child's physical and cognitive development, and an evaluation of the neighbourhood environment, (2) mobility options, such as access to private automobiles and (3) activity constraints, such as a commitment to work and travel scheduling.

The BMST improves on current theoretical understanding of school travel behaviour in several ways. First, the framework explicitly conceptualizes escorted versus independent mobility and mode choice as two components of the school travel outcome. Second, with regard to the influence of the neighbourhood environment, the framework adopts McMillan (2005)'s approach in identifying the conceptual domains of relationship between the neighbourhood and school travel outcome. McMillan (2005, 2007) discussed the potential influence of proximity, traffic/pedestrian safety and aesthetics on AST. This research extends

McMillan's conceptualization, and informed by the findings from current research that was discussed in the previous section, identifies five domains of causal links between the neighbourhood environment and school travel outcome.

Finally, the model draws on ecological theories of human behaviour (Bandura, 1989; Bronfenbrenner, 1989) and hypothesizes that as children become more mature, they assume greater control over mobility decisions such as mode choice. In other words, this research argues that the travel behaviours of a child and a youth are indeed different. Current evidence indicating an association between a child's age and mode choice (Babey et al., 2009; Bere et al., 2008; Johansson et al., 2011; McDonald, 2008a, 2008b; Robertson-Wilson et al., 2008) supports this suggestion. The hypothesized relationships among different attributes within and between the proposed dimensions are discussed below. Figure 1 describes the key dimensions of the model. However, the figure is not an exhaustive description of every variable that might be relevant in any specific dimension.

The Urban Environment

The urban environment may influence travel in several ways. First, urban spatial structure, which is defined by the regional distribution of residences, employment

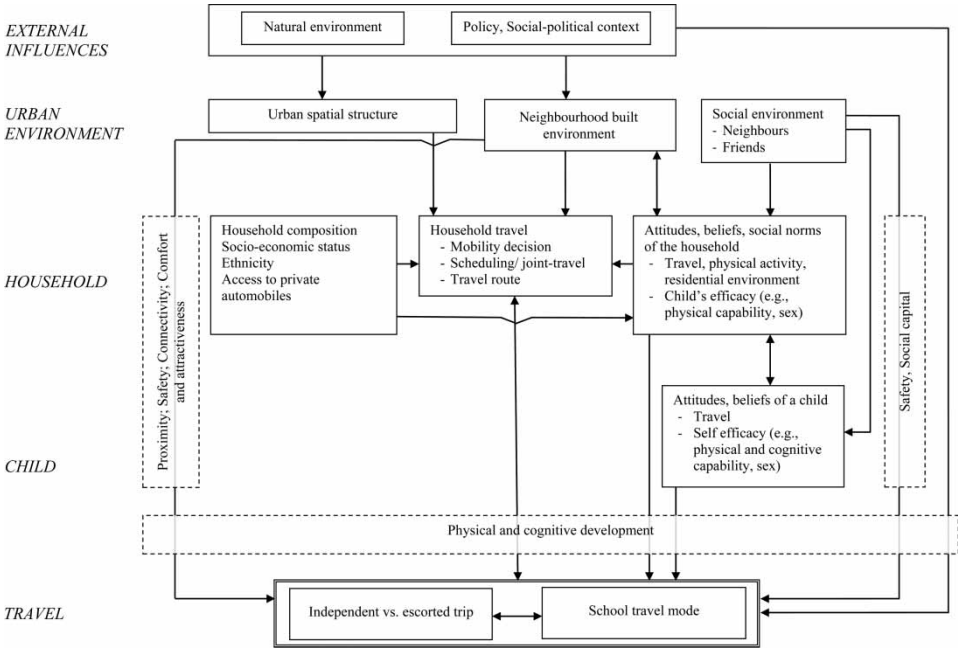

Figure 1. A behavioural model of school transportation.
Notes: Independent trip: a child/youth travels alone or with peers (i.e. siblings or friends), and is not accompanied by adults. Escorted trip: an adult caregiver facilitates the trip. The built and social environments of a neighbourhood influence independent mobility and active travel through five conceptual domains of relationship (i.e. mediators)—(1) proximity or the generalized travel cost, (2) traffic and personal safety, (3) connectivity, (4) comfort and attractiveness and (5) opportunity to produce and maintain social capital. A mediator is an intervening causal factor between an explanatory variable and travel outcome (McMillan, 2005). A child's physical and cognitive development moderates the relationship between various levels of influences and school travel outcome.

and other urban facilities (Giuliano & Small, 1993; Shen, 2000), influences a household's travel pattern across space and over time. Second, the built environment, which is characterized by the extent and quality of land use mix, transportation network and urban design features (i.e. aesthetic, physical and functional qualities of buildings and streetscapes) (Transportation Research Board, 2005), influences transportation mode choice. Previous research has indicated that the neighbourhood built environment at the residence, at destinations (e.g. around the school) and en route potentially influence travel outcome (Larsen et al., 2012; Lee & Moudon, 2004; McMillan, 2005; Mitra et al., 2010; Panter et al., 2008). In case of school transportation, neighbourhood environment may also influence a child's/youth's independent mobility. Finally, friends, neighbours and other members of the community (i.e. the social environment) may have important influences on travel choices.

The BMST conceptualizes five domains of relationship between the neighbourhood environment (both built and social) and school travel outcomes. These domains are the mediators (i.e. the intervening causal factors) between neighbourhood characteristics and school travel outcome (McMillan, 2005). First, proximity to school reduces the generalized cost of travel, and makes walking/cycling a feasible option for school transportation (Ewing et al., 2004; McDonald, 2008b). Parents are also more likely to let their children travel alone for short distances.

Second, traffic and personal safety concerns are most commonly reported as major barriers to AST, along with concerns over travel distance (McDonald & Aalborg, 2009; McMillan, 2007; Panter et al., 2010b). Neighbourhood street design, such as the presence of sidewalks, enhances the perception of traffic safety (Boarnet et al., 2005; Ewing et al., 2004; Panter et al., 2010a). Other characteristics such as four-way streets with high volume of traffic and busy intersections, may produce safety concerns, and thus, may discourage independent travel and AST (Giles-Corti et al., 2011; Larsen et al., 2012; Lin & Chang, 2010; Mitra et al., 2010; Schlossberg et al., 2006). The quality of land use mix/design is also important. Smaller residential blocks and the presence of street-level retail in the neighbourhood places eyes on street, and may increase pedestrian safety (McMillan, 2007; Mitra et al., 2010). Larger retail centers or employment districts, on the contrary, may discourage AST, particularly when a child is not accompanied by an adult, due to both traffic and personal safety concerns. In addition, the social environment of a neighbourhood may produce important safety concerns leading to more escorted trips and less walking/cycling for school transportation. Previous research has identified that children walked less in neighbourhoods where there were concerns around stranger danger (Panter et al., 2010b; Timperio et al., 2006) and a child being bullied (Zwerts et al., 2010).

Third, improved street connectivity encourages active travel among adults (Ewing & Cervero, 2010). However, studies on children have largely reported a negative association between street connectivity and children's AST (Larsen et al., 2012; Panter et al., 2010a; Timperio et al., 2006). In a recent research, Giles-Corti et al. (2011) found that children were more likely to walk to school in neighbourhoods characterized by high street connectivity and low traffic volume, and were less likely to walk in neighbourhoods with high street connectivity and high volume of traffic. An interconnected street network may produce high volume of motorized traffic, and may discourage independent mobility and AST due to traffic safety concerns. Improved pedestrian/bicycling connectivity

(i.e. sidewalks, bike paths) between residence and school locations, on the other hand, would enable AST.

Fourth, pedestrian comfort and attractiveness of the travel route may encourage active travel (escorted or otherwise) over automobile use (Larsen et al., 2012; McMillan, 2007). The presence of open space/parks, tree-lined streets, smaller neighbourhood blocks and pedestrian-oriented buildings/houses, for example, may enhance the enjoyment of walking/cycling, or make it comfortable to navigate the built environment between the home and school locations.

Finally, the opportunity to produce and maintain social capital is a potentially important yet poorly understood mediator for walking amongst adults and children. The social environment, particularly a walkable environment with a strong sense of community and social cohesion, may provide an opportunity to meet and greet others and facilitate the maintenance and production of social capital, and encourage independent mobility and active travel to/from school (Fyhri, Hijorthol, Mackett, Forel, & Kyttä, 2011; Mitra et al., 2010; Waygood & Kitamura, 2009; Zwerts et al., 2010).

The Household

School travel decisions involve two components: the choice between independent and escorted school trips, and between available travel modes. The caregiver(s) and child(ren) evaluate available or accessible mobility options such as walking, cycling, taking transit, and driving, either in the company of an adult or independently.

The perceived importance of an escorted trip and AST can be different across households. The major household-level influences on school travel outcome relate to socio-demographic and economic characteristics, household travel behaviour and attitudes. First, social norms, ethnic/cultural values or peer support may influence school travel behaviour (McAlister et al., 2008; Mitra et al., 2010; Valentine, 1997). Household mobility options (e.g. access to private automobile), which may relate to socio-economic status, also facilitate or impose constraints on the use of certain travel modes (McMillan, 2005; Panter et al., 2008; Sidharthan et al., 2011).

Second, a household's activity participation across space and over time may enable or restrict a child's independent travel and/or mode choice for school transportation, given that school travel is fixed in time (i.e. fixed start and end times for a school). For example, if the primary caregiver of a child has to travel to work in the morning, this caregiver may escort the child for convenience (Faulkner et al., 2010; McDonald, 2008a). In a household with multiple children, this process may lead to an escorted travel with multiple stops, or the caregiver may not escort all children in the household, and rather let them accompany each other to/from school (Mitra & Buliung, 2012b). However, if the primary caregiver is unavailable at the time of school travel (i.e. remains engaged in other fixed activities such as work), the child is more likely to travel independently (Mitra & Buliung, 2012b). A household's activity-pattern will likely be influenced by its socio-demographic characteristics and mobility options. A child's travel needs may also influence adult travel pattern. The primary caregiver may adjust travel schedule to facilitate an escorted school trip, if and when an escorted school trip is perceived to be highly important. The travel mode of an escorted school trip will likely depend on the caregiver's travel mode to work and other

activities (Lin & Chang, 2010; Vovsha & Petersen, 2005; Yarlagadda & Srinivasan, 2008). In contrast, an independent school trip will eventually lead to a walking/cycling, transit or school bus trip, alone or with siblings/friends (Mitra & Buliung, 2012b; Zwerts et al., 2010).

Finally, confidence about a child's physical and cognitive capabilities for independent travel, or an awareness of the benefits of PA, influences school travel outcome (Faulkner et al., 2010; Lang et al., 2011; Martin et al., 2007; Wen et al., 2008). A household's residential location decision within an urban area is also likely influenced by their attitudes and preferences towards residential environment (e.g. urban versus suburban, automobile-oriented versus walking friendly) (Boarnet & Crane, 2001; Cao et al., 2009; Kitamura et al., 1997). This pre-travel decision (also known as "self-selection" in urban planning literature) will then be reflected in the travel behaviour of a household (Cao et al., 2009; Kitamura et al., 1997; McMillan, 2007; Panter et al., 2010b). However, in the longer term, the household may adapt to their residential environment and the norms of the community through repeated exposure and learning.

The Child

A child's/youth's self-efficacy belief and attitudes may influence their school travel outcome. Some youths are more confident about their own capabilities of travelling independently to/from school than others (Robertson-Wilson et al., 2008). A child may also develop their own attitudes towards school travel and PA, as they learn from their parents, friends and neighbours.

Ecological theories of human behaviour emphasize that a child develops and matures through an active interplay with the environment (or the psychological construction of it) (Bandura, 1989; Bronfenbrenner, 1989). In the context of school travel, children may develop physical and cognitive capabilities of navigating the neighbourhood environment and handling potential dangers in urban streets through repeated exposure to the built and social environments. These developments influence school travel behaviour; research has demonstrated that children who are considered more "mature" are more likely to be allowed to walk or cycle on their own (Johansson, 2006; Prezza et al., 2001; Wen et al., 2008). These physical and cognitive developments would likely correlate with a child's age. Caregiver attitudes or evaluations towards independent school travel, and perhaps, taking an active mode to/from school, also change with a child's perceived maturity (Johansson, 2006; Marzoughi, 2011; Timperio, Crawford, Telford, & Salmon, 2004). In addition, a youth's personal attitudes may have a significant influence on school travel outcome. As a result, children become more independent (i.e. tied less to the travel constraints of adults) as they grow up, and have more control over the choice of transportation options as youths.

External Influences

Finally, school travel outcome can be influenced by factors that are external to a household and the physical/social environment of the neighbourhood and the region (Panter et al., 2008). These external influences can be (1) natural and (2) policy related. First, the natural environment within which school travel takes place (e.g. steep slope) can influence mode choice (Timperio et al., 2006).

Extreme weather conditions on the day of travel may restrict the choice of active modes (Zwerts et al., 2010). However, the usual school travel mode may not change due to seasonal climate (e.g. general climatic conditions during fall versus winter) (Mitra & Faulkner, 2012; Robertson-Wilson et al., 2008).

Second, national, regional, local and organizational policy contexts may influence mobility decisions around school transportation. Some regions/municipalities have policies that enable active- and transit-oriented travel practices. School boards have policies regarding the location of schools, the delineation of catchment areas and the provision of transportation to students (e.g. larger "magnet schools" versus smaller neighbourhoods schools, school bus distance thresholds, strategic partnering with local transit authorities for transit pass provision). In addition, school policy around student transportation differs across age groups (e.g. for school bus service, different cut-off distance between elementary, secondary and high school levels; transit pass provision for youth) (Mitra & Buliung, 2012b), which may lead to different travel choice processes between children and youth. Schools may also encourage or discourage the use of certain school travel modes (e.g. walking school bus, no cycle rack on the school premise) (Babey et al., 2009; Trapp et al., 2011; Wilson et al., 2010).

Conclusions

In the context of an emerging literature that examines children's school travel, the purpose of this study was to review the prevalent theories of travel behaviour, explore current literature on school transportation, and use findings from these reviews to inform the development of a conceptual framework for future empirical research on this topic, particularly in the North American context. With this in view, the key theories that may explain walking/cycling behaviour were reviewed. A total of 42 empirical studies, which exclusively explore children's school travel, were also examined. Based on this theoretical and empirical review, this paper outlines a BMST.

Theorization of school travel behaviour is important in the context of an increasing policy interest towards the promotion of walking/cycling among children and youth. An improved understanding of school travel behaviour is critical for the development of appropriate planning and public health interventions. To inform the planning of effective interventions, this article outlined three major research issues at the outset. First, this paper identified that there is a need to theorize the causal relationship between built environment and the choice of an active mode for children's school travel, instead of translating the findings from adult travel literature to understand AST. Second, the caregiver–child travel interaction was recognized as a potentially important influence on school travel outcome. Third, the difference between school transportation and other types of PA was emphasized. The conceptual framework (BMST) addresses these three issues. It emphasizes a multi-level relationship between the urban environment, household, intra-personal characteristics of a child/youth, natural and policy contexts, and school travel outcome. In addition, the framework contextualizes independent travel within the broader household activity-travel paradigm, and argues that household members negotiate the possibility of an independent or escorted school trip based on perceived importance of an escorted trip, mobility options and activity constraints. Five environmental domains of influence on school travel outcome are also identified.

However, the validity of the nature and direction of the hypothesized relationships can only be tested by designing empirical research based on this model. Future research can make use of this model to further the current understanding of school transportation behaviour. This understanding, in due course, will help the development of interventions focused on children's active mobility and PA, and will contribute towards the development of healthy communities in the years to come.

Acknowledgements

This research was supported by the Social Sciences and Humanities Research Council, Canada, doctoral fellowship. The author thanks Dr Ron Buliung, Dr Guy Faulkner and Dr Paul M. Hess, at the University of Toronto, for providing their comments on the draft manuscript.

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