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Exploring differences in school travel mode choice behaviour between children and youth

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ABSTRACT

A child's school travel behaviour may change with the transition toward adolescence. However, the topic remains understudied in current literature. This paper examines school travel mode choice behaviour of 11-year-old children and 14–15 year old youth in Toronto, Canada. Morning period school trip data was analysed using multinomial logit models. Distance to school was the most important barrier to walking for both age groups; neighbourhood built environment characteristics (i.e., major street intersections, retail density and block density) had a stronger association with a child's odds of walking; and access to transit was correlated with only a youth's travel mode outcome. In addition, a male youth was more likely to walk than a female youth; gender of a child was not associated with school travel mode. As school travel related programmes are beginning to be adapted to the high-school context, our results indicate that a current North American model that is largely designed around capital improvement of transport infrastructure may not be very successful. Rather, programmes and initiatives should emphasize education, and perhaps attempt to understand and reshape the culture of youth mobility, in order to encourage healthy and sustainable travel practices.

1. Introduction

Researchers, policy makers and community-based organizations have for some time now recognized the potential importance of active school transportation (AST: travel to/from school by human powered modes such as walking and cycling) to the healthy physical and mental development of children. For example, those who regularly walk to and from school are more active overall than those who are driven (Active Healthy Kids Canada, 2014; Faulkner et al., 2009; Mackett, 2013), have greater and/or different knowledge about their neighbourhood environment, and potentially a stronger sense of community (Active Healthy Kids Canada, 2014; Fusco et al., 2012). In addition, recent research in the US estimated that 10–14% of all private automobiles on the road during morning peak hours are related to school trips (McDonald et al., 2011). Notably, most of these school trips are relatively short, and can potentially be substituted by other more sustainable options such as walking, cycling and transit; modes that if used could reduce vehicular emissions, free up road space during peak hours, and reduce the risk of pedestrian–motor vehicle collisions (Badland and Schofield, 2005; McDonald et al., 2013).

Despite potential benefits, current school transportation research has reported a steady decline in AST and transit use across the Western nations over the last five decades (Buliung et al., 2009; Fyhri et al., 2011; McDonald, 2007; van der Ploeg et al., 2008). Most of these walking, cycling and transit trips were replaced by trips in private automobiles. Not surprisingly, then, an emerging literature has explored school travel behaviour, in order to understand and potentially reverse the current trend. With regard to AST correlates, the literature has largely focused on four major aspects: (a) distance (e.g., McDonald, 2008a; Schlossberg et al., 2006; Yang et al., 2012), (b) neighbourhood built and the social environment related to traffic and personal safety (e.g., Larsen et al., 2013; Lee et al., 2013; Mitra and Buliung, 2014; Panter et al., 2010a), (c) neighbourhood walkability (e.g., Lee et al., 2013; Yang et al., 2012) and (d) the activity and travel patterns of parents or adult caregivers (e.g., McDonald, 2008b; Mitra and Buliung, 2014; Yarlagadda and Srinivasan, 2008). A detailed discussion of this literature can be found elsewhere (Mitra, 2013; Stewart, 2011).

However, the results from this literature are sometimes at odds with each other, particularly with regard to the influence of the neighbourhood environment. For example, while higher residential density (McDonald, 2008a) and mixed land use (McMillan, 2007; Mitra and Buliung, 2014) were identified by some as potential enablers of walking, others have reported negative or no

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association (Larsen et al. 2012; Yang et al., 2012; Yarlagadda and Srinivasan, 2008). Similarly, higher street density associated with the likelihood of walking in some case studies (Panter et al., 2010b; Yang et al., 2012); in others, a negative association was documented (Schlossberg et al., 2006). Several external effects such as differences in school policy (Yang et al., 2012) and the cultural and policy-related contexts around mobility in general (Mitra, 2013) may explain the inconclusive and often mixed results, in addition to, of course, historically rooted differences in neighbourhood design. Part of the problem may also relate to how children's mobility is conceptualized. One such conceptual aspect that remains relatively less examined in current literature is the potentially moderating effect of a child's age on school transportation mode choice behaviour.

Recent theoretical works on children's mobility, such as the ones by Panter et al. (2008) and Mitra (2013), emphasize that various influences on a child's/youth's school travel outcome can be moderated by a child's age. The ecological theories of human behaviour (Bandura, 1989; Bronfenbrenner, 1989) posit that a child develops and matures through an active interplay with the environment (or the psychological construction of the environment). Previous research also indicates that parental perception of a child's "maturity" was associated with unsupervised walking and cycling (Johansson, 2006; Prezza et al., 2001). Drawing on this literature, Mitra (2013) conceptualized that through repeated exposure to the neighbourhood environment, a child develops physical and cognitive capabilities of navigating the neighbourhood environment and urban streets. One proxy measure of this development can be his/her age. Conceivably, a household's attitudes or evaluations toward a child's capability of travelling to/from school unsupervised on foot, cycle or by transit may change with a child's perceived maturity with age. Children may also become more independent decision makers as they transition into teenage years (i.e., >12 years), and their mode choice process may differentiate from that of their parents.

Many studies have recognized this potential "age effect" on school travel decision processes, and in response, have explored travel behaviour of specific age groups (e.g., Larsen et al., 2013; Mitra and Buliung, 2014; Panter et al., 2010a; Schlossberg et al., 2006). However, a very limited literature has examined and compared the potential influences on school travel outcomes across multiple age groups, providing deeper insights into how school travel behaviour might change with a child's age and perhaps with improved maturity. For example, Timperio et al. (2006) explored the correlates of walking between children aged 5–6 years and 11–12 years in Melbourne, Australia. Their results indicate that for both age groups, parental perception of the absence of other children in the neighbourhood, the absence of street lights or crossings, and the presence of major barriers on the way to school may reduce the likelihood of walking. However, some differences across the two age groups were also reported. Younger children (5–6 years) were less likely to walk or cycle if their travel routes to school had steep slopes. In comparison, older children (10–12 years) with direct travel routes to school (representing well-connected streets, and perhaps with busy traffic, in comparison to poorly connected streets) were less likely to travel actively.

In a study of US school children/youth aged 5–14 years and 15–18 years, McDonald (2008b) also reported some important age-related differences in school travel behaviour. For the <15 years age cohort, a child's age was positively associated with the likelihood of walking to school, while for the 15–18 years group, age was not associated with the travel mode outcome. Similarly, <15 year old children were less likely to walk when their mothers travelled to work in the morning; an older youth's travel outcome was not associated with his/her parents' travel patterns. Urban residential density was associated with walking across both age groups.

This paper takes a similar approach to McDonald (2008b) and Timperio et al. (2006) in exploring the differences (or similarities) in school travel mode choice behaviour between elementary school students aged 11 years (5th/6th grade) and high school students aged 14–15 years (9th/10th grade) in Toronto, Canada. The paper advances our current understanding of school travel behaviour by contributing to a very limited literature that has investigated potential changes in the correlates of AST as children age. An emphasis on the differences in neighbourhood environment-related correlates across the two age groups is particularly novel in the North American context.

In addition, the findings from this study has direct implications for transportation policy that is centred on children's mobility and well being, particularly in the context of recent community and professional interests in Canada around promoting and facilitating AST among older youth. The School Travel Planning (STP) programmes in Canada, similar to the Federally legislated Safe Routes to School (SRTS) programmes in the US, are designed for elementary and middles schools (Green Communities Canada, 2014; National Center for Safe Routes to School, 2011). At the time when school boards across Canada are showing increased commitment to active, safe and sustainable transportation of their students (e.g., Toronto District School Board, 2014; Waterloo Region District School Board, 2011), the STP model is beginning to be adapted to the high school context (Stuckless, 2012). Findings from this study can inform such adaptations and implementations, and the development of new programmes and interventions in Canada, the US and elsewhere focused broadly on the health of children and the youth.

2. Study design

2.1. Study area

The City of Toronto is the largest city as well as the business/financial capital of Canada with a population of 2.6 million (Statistics Canada, 2012). Steady population growth over the last century, and political amalgamation of Toronto's older neighbourhoods with the inner ring suburbs in the late 1990s, have produced a city with neighbourhoods that are diverse with regard to built form, politics, and preferences for housing and transport. The downtown and inner-city neighbourhoods have high walkability, while automobile oriented "planned suburban" design dominates the inner-suburban neighbourhoods that became part of the City during a political amalgamation in 1998.

Most children in Toronto attend publicly funded schools; a recent study reported that 88% of all 5th/6th grade students were travelling to public schools (Mitra and Buliung, 2014). The two publicly funded school boards (Toronto District School Board: TDSB, and faith based Toronto Catholic District School Board: TCDSB) maintain small travel distance thresholds (through school districting/catchments), and children/youth are generally expected to attend the school that is closest to their residential location.

2.2. Data

School travel data from the 2006 Transportation Tomorrow Survey (TTS) was analysed. TTS is a large cross-sectional survey of travel behaviour that is conducted every five years since 1986 (Data Management Group, 2009). The 2006 version includes a 5.2% random sample of all households in Southern Ontario, including the City of Toronto (approximately 150,000 households in total; 51,500 households in Toronto). The survey includes retrospective travel data for all household trips by ≥ 11 year olds (e.g., origin/

destination, trip start time, purpose, primary travel mode) for a randomly selected weekday in fall or winter (Data Management Group, 2009). An adult household member proxy-reported household trips for the day prior to interview.

Within the context of this study, we defined a "youth" as a student who is >13 years old, i.e., who likely attends high school (Stuckless, 2012). Home-to-school trips with start times between 6 am and 9 am, by 11 year-old children (i.e., typically 5th/6th Grade) and 14–15 year old youth (i.e., typically 9th/10th grade) were analysed. School travel behaviour of <11 year old children could not be examined because of data unavailability; youth aged >15 years were excluded with an expectation that school travel behaviour may change significantly once a youth reaches legal driving age (i.e., 16 years in Toronto). Only children and youth travelling to public and Catholic schools were studied. Those attending private/special schools were excluded; these schools tend to serve households who self-select their children's school, and as a result, a child/youth may often have to travel longer or have specialized school transport needs (e.g., more busing and/or driving).

This paper explored four school travel modes (walk, transit, school bus and car). Other excluded modes including cycle constituted less than one percent of all school trips. Also, high schools are larger and are located farther apart than the elementary schools. As a result, older youth typically travel longer distances for school travel. In order to keep the results comparable between the two subpopulations of this study, only children and youth living within 3.2 km (2 mile) network distance from their schools were included in the analysis. We assumed that beyond this distance, the feasibility of walking for a child/youth reduces significantly.

Multiple levels of influence on school travel mode choice were hypothesized based on previous theoretical works on this topic (McMillan, 2005; Mitra, 2013; Panter et al., 2008). Information on household socio-demographics was obtained from the TTS. Following Mitra (2013), we also hypothesized that a youth's travel modes will be more independent from travel characteristics of other household members, compared to a child. For example, we hypothesize that a youth's school travel outcome will be less dependent on the presence of other children in the household or the availability of adult caregivers at the time of school travel. The TTS survey allowed the construction of some variables related to these intra-household social and travel interactions (Table 1). However, the 2006 TTS does not provide data on the kinship relations among household members (e.g., mother, father, sister, brother). As a result, parental availability (i.e., a mother's availability, father's availability, or the travel supervisory roles within same sex households) could not be explored separately.

Data on actual travel routes were not available. As a result, travel distances between home and school locations were estimated. For walk mode, network distance between home and school locations was used; for car mode, network distance with driving restrictions was used; for school bus and transit modes, straight line distance was used. In particular, two distance categories were explored: ≤ 400 m (i.e., approximately 5 min walking distance for a child or youth) and >1.6 km (i.e., approximately 20 min walking distance; 1.6 km or 1 mi also represents typical catchment areas for TDSB elementary schools). Data on the neighbourhood built environment came from several sources, which are described in Table 1. Consistent with some previous studies on school travel behaviour (Mitra and Buliung, 2014; Schlossberg et al., 2006; Yarlagadda and Srinivasan, 2008), built environment characteristics were measured within a 400 m straight line buffer distance of each student's home locations, which is roughly equivalent to a 5-min walking distance for a child/youth.

2.3. Statistical analysis

The correlates of school travel modes were explored using multinomial (conditional) logit models, which is a widely used

Table 1
Description of independent variables explored in multivariate analysis.

Socio-demographic characteristics
MALE: 1 if the student was a male; 0 if female.
CHILDREN: Number of children aged ≤ 10 years in the household.
SINGLE ADULT HH: 1 if there was only one adult household member (>17 yrs); 0 otherwise.
VEHICLES PER LICENCE: Number of vehicles in the household per licensed driver.
Travel distance[a]
$\leq$ 400 M: 1 if travel distance was equal to or less than 400 m; 0 otherwise. $>$ 1.6 KM: 1 if travel distance was between 1.6 and 3.2 km (i.e., 1 and 2 mi); 0 otherwise.
Household travel interactions
SAME SCHOOL: 1 if multiple children (age ≥ 11 years) from same household went to the same school; 0 otherwise.
DIFF SCHOOL: 1 if children (age ≥ 11 years) from a household went to different schools; 0 otherwise.
ADULTS UNAVAILABLE: 1 if all adult household members (>17 years) started their work/school/facilitating trips (i.e., trips to out-of-home activities with fixed schedule) before the school-trip start time; 0 otherwise.
AVG WORKTRIP DIST: Average straight work trip length for household adults.
DRIVING PROPENSITY: Automobile mode share for daily household trips by all members, other than the school trips.
Neighbourhood Built Environment
NO STREET CROSSING[a]: 1 if a student did not have to cross any major street (primary highway, secondary highway, and major/arterial roads) on the way to school; 0 otherwise.
INDIRECT TRAVEL ROUTE[a]: The ratio between network distance and straight line distance between home and school locations. Values start from 1; higher value means lower street connectivity.
RETAIL DENSITY[b]: Total number of retail, ambulatory health care, personal & laundry services related destinations within a 400 m buffer around a student's home location. 1st Quartile: 1 if belongs to the lowest quartile; 0 otherwise.4th Quartile: 1 if belongs to the top quartile; 0 otherwise.
BLOCK DENSITY[c]: Number of street-blocks within a 400 m buffer around a student's home location.
DEADEND DENSITY[a]: The ratio of dead-ends plus cul-de-sacs to total number of street intersections within a 400 m buffer around a student's home location.
TRAFFIC LIGHT DENSITY[a,d]: The ratio of intersections with traffic signal lights to total number of street intersections within a 400 m buffer around a student's home location.
LOWINCOME NH[e]: 1 if the median household income for all DAs within a 400 m buffer was less than the low income cut off (i.e., economically disadvantaged neighbourhood). Average household size for the sample was 4.3 ($sd=1.28$). In a large metropolitan area such as Toronto (i.e., population $>500{,}000$), the low income cut-off in 2006 was CAD 39,399 for a four-member household.
Other
TRANSIT ACCESS[f]: Total number of transit routes available within a 400 m buffer around a student's home location.
CATHOLIC: 1 if the student went to a Catholic school; 0 if the student went to public school.
WINTER: 1 if travel data was collected on a winter week-day (i.e., between the weeks ending on 24th December, 2006, and 19th February, 2007); 0 if data was collected on a fall weekday (i.e., between the weeks ending on September 10th, 2006, and December 17th, 2006).

[a] Street network characteristics were computed using the DMTI CanMap© RouteLogistics file (version 2007.3).
[b] Obtained from Canadian Business Data (2010.04) provided by Pitney Bowes Software Inc.
[c] Block density was calculated based on the 2006 census boundary files provided by Statistics Canada.
[d] Data on street-lights were collected from City of Toronto's Transportation Department.
[e] Data available from Statistics Canada.
[f] Data on transit routes came from the Toronto Transit Commission (TTC). Data on transit stops was not available.

approach in the school transportation literature (McDonald, 2008a; Mitra and Buliung, 2014; Yarlagadda and Srinivasan, 2008). Separate models were estimated to explore school travel behaviour of each of the two age groups. The neighbourhood built environment was assumed to primarily influence the decision between walking and other modes. Prior to multivariate logit estimation, the degree of multi-collinearity among built environment variables was also examined. None of the built environment characteristics were correlated with each other at $r \geq 0.50$. Adjusting for missing data and outliers, the final dataset included 945 home-to-school trips by 11 year olds and 1269 trips by 14–15 year olds.

The relative importance of various potential influences in explaining school travel outcome (i.e., the effect on model fit) was graphed. Variables related to each aspect shown in this figure (i.e., one or more variables that represent each aspect, Table 1) were added to the multivariate model sequentially, and each aspect's contribution on the improvement of the log likelihood was identified. Standardized values (i.e., % contribution to log likelihood improvement) were plotted to facilitate comparison between children and the youth.

3. Results

Differences and similarities in school travel mode choice behaviour between 11 year old children and 14–15 year old youth, for home-to-school trips in the morning, were explored using multivariate logit models. Table 2 describes the data that were analysed in this paper. Most of the travel data were collected during the Fall season (September to mid-December), when the typical weather conditions in Toronto are more suitable for walking compared to the Winter season (Mitra and Faulkner, 2012). For example in 2006, the mean temperature in October was 9.7 °C, compared to −2.4 °C in February (Environment Canada, 2011).

The two samples were comparable with respect to their socio-demographic characteristics. However, the youth travelled longer to get to their schools; 41% of them lived between 1.6 and 3.2 km from their schools, compared to only 13% children who lived that far (Table 2). Approximately 61% of all 11-year old children walked to school; walk mode share for the older youth was also similar at 58%. The biggest differences were in the use of transit and school bus. More children travelled to schools in school buses, while youth used public transit more often.

Fig. 1 shows the difference in walking rates by distance between the two age groups. While the overall walking rates for the two age groups were similar, this figure suggests that within the 3.2 km cut-off distance, high school students (i.e., 14–15 year olds) typically walked longer than elementary school students (i.e., 11 year olds). For example, almost half (47%) of all high school students walked to school at a distance of 2 km, while only 24% of all elementary school students walked at that distance.

Results from multivariate analyses are summarized in Table 3. Distance to school was strongly associated with travel mode choice, for both age groups. In addition to distance, both children and youth were more likely to walk when the potential school routes were more indirect. Other than route indirectness, the neighbourhood built environment was largely uncorrelated with a youth's likelihood of walking. By contrast, several built environment characteristics, namely the absence of major street crossing en-route to school, high density of retail land use and smaller street blocks, were associated with a child's walking trip to school.

With regard to intra-household travel interactions, parental (or adult caregiver living in the same household) unavailability at the time of school travel was positively correlated with walk, transit and school bus use among both children and youth, while a household's driving propensity (i.e., private-automobile mode share for daily household trips, excluding the school trips) was positively correlated with a driven school trip. The presence of other school age children in the household (attending the same or different schools) increased the probability of walking and using transit for 11-year old children. No such association was observed for older youth.

A household's automobile ownership was associated with drive trips to school, but the relationship was stronger among children compared to youth (Table 3). The gender of a 11-year old child did not correlate with walking (versus being driven), however a male youth aged 14–15 years was 1.57 times (Odds Ratio, $OR = e^{0.45}$) more likely to walk to school than a female of that same age.

A youth living in a low-income neighbourhood with greater access to public transit was more likely to use transit as the school

Table 2
Summary statistics, for children and youth living within 3.2 km of their schools.

	11 year-olds ($n=945$)		14–15 year-olds ($n=1{,}269$)		χ^2
	Freq.	%	Freq.	%	
Sex					0.01 ($p=0.92$)
Female	444	46.98	599	47.20	
Male	501	53.02	670	52.80	
Household composition					0.02 ($p=0.86$)
Single-adult household	119	12.59	163	12.84	
Multiple adults in household	826	87.41	1106	87.16	
Access to personal vehicles					0.53 ($p=0.77$)
No vehicle	140	14.81	191	15.05	
One vehicle	508	53.76	663	53.25	
Two or more vehicles	297	31.43	415	32.70	
Household location					2.17 ($p=0.34$)
Downtown	31	3.28	50	3.94	
Inner-city	181	19.15	268	21.12	
Inner-suburban	733	77.57	951	74.94	
School type					43.44 ($p<0.01$)
Catholic	237	25.08	178	14.03	
Public	708	74.92	1091	85.97	
Period of data collection					1.47 ($p=0.23$)
Fall	753	79.68	984	77.54	
Winter	192	20.32	285	22.46	
School travel distance					225.14 ($p<0.01$)
≤ 400 m	178	18.83	90	7.09	
401 m to 1.6 km	642	67.94	663	52.25	
1.6–3.2 km	125	13.23	516	40.66	
Travel mode (trip to school)					203.56 ($p<0.01$)
Walk	581	61.48	731	57.60	
Transit	44	4.66	283	22.30	
School bus	101	10.69	20	1.58	
Car	219	23.17	235	18.52	

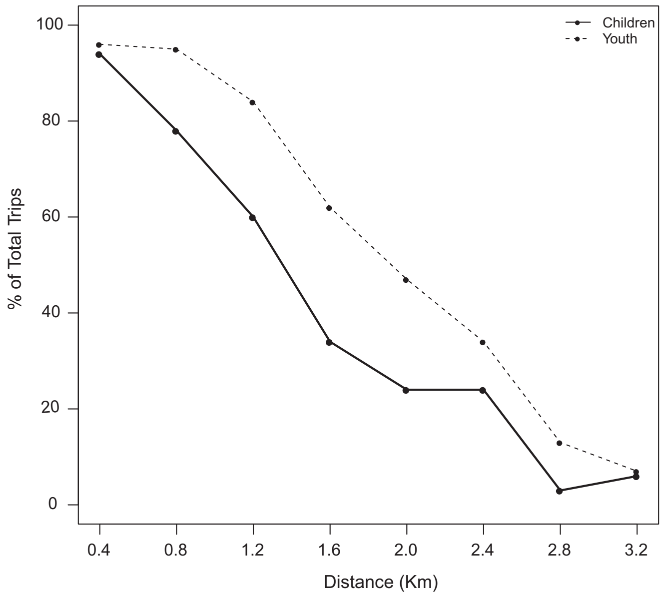

Fig. 1. Walking rates for journey to school by distance.

travel mode. Youth were also less likely to walk to school in Winter months. These factors were not associated with a child's school travel mode outcome. School type was correlated with travel mode choice. Children attending Catholic schools were 13.2 times more likely to take a school bus to school. A similar association was observed among youth though the effect size was relatively smaller (OR=3.71).

Fig. 2 summarizes the abovementioned similarities and differences between children and youth with regard to the correlates of school travel mode outcomes. The figure shows relative effects of different types of influences on mode choice behaviour. More specifically, it compares the contribution of each aspect (i.e., one or a group of variables, in Table 3) to the % improvement in the log likelihood of the estimated logit models. Distance to school was clearly the most important correlate for both age groups, followed by household-level travel interactions (e.g., parental unavailability). School system (i.e., Catholic versus public schools) was a potentially larger predictor of a child's travel outcome. The neighbourhood built environment, as a whole, also had a relatively stronger effect on a child's mode choice compared to that of a youth.

Table 3
Correlates of mode choice for trips-to-school.

	11 year olds (n=945)				14–15 year olds (n=1269)			
	Walk Coef. (S.E.)	Transit Coef. (S.E.)	School bus Coef. (S.E.)	Car Coef. (S.E.)	Walk Coef. (S. E.)	Transit Coef. (S.E.)	School Bus Coef. (S. E.)	Car Coef. (S.E.)
Socio-demographics								
MALE[a]	0.22 (0.19)	−0.06 (0.36)	**0.67 (0.29)**		**0.45 (0.18)**	0.14 (0.20)	**1.76 (0.59)**	
CHILDREN	***0.20 (0.12)***	−0.16 (0.27)	0.16 (0.19)		**0.33 (0.15)**	**0.39 (0.17)**	0.27 (0.42)	
SINGLE ADULT HH[a]	−0.21 (0.38)	0.60 (0.51)	-0.28 (0.50)		−0.40 (0.31)	−0.20 (0.33)	−0.13 (1.09)	
VEHICLE PER LICENCE				**0.82 (0.27)**				**0.56 (0.22)**
Household activity-travel interactions and behaviour								
SAME SCHOOL[a]	**1.03 (0.33)**	**1.24 (0.53)**	0.65 (0.43)		−1.10 (0.31)	−0.44 (0.39)	−0.84 (1.08)	
DIFF SCHOOL[a]	**0.70 (0.26)**	**1.57 (0.43)**	***0.71 (0.40)***		0.35 (0.23)	**0.70 (0.26)**	−0.52 (0.79)	
ADULTS UNAVAILABLE[a]	**1.54 (0.44)**	**1.26 (0.63)**	**1.81 (0.53)**		**2.32 (0.43)**	**1.86 (0.44)**	**2.59 (0.72)**	
AVG WORKTRIP DIST				***−0.02 (0.01)***				−0.01 (0.01)
DRIVING PROPENSITY				**2.98 (0.39)**				**2.60 (0.33)**
Travel distance								
$\leq$ 400 m[a]	**1.89 (0.35)**	**−2.02 (1.03)**	**−1.48 (0.55)**		**1.30 (0.56)**	***−1.79 (1.04)***	−27.7 (.16e[7])	
> 1.6 km[a]	**-2.00 (0.26)**	**1.04 (0.41)**	**0.04 (0.39)**		**−1.90 (0.16)**	**1.48 (0.18)**	**0.97 (0.48)**	
Neighbourhood built environment								
NO STREET CROSSING[a]	**0.41 (0.18)**				0.31 (0.25)			
INDIRECT TRAVEL ROUTE	**0.67 (0.22)**				**0.59 (0.27)**			
RETAIL DENSITY (1st quartile)[a]	0.05 (0.21)				0.03 (0.18)			
RETAIL DENSITY (4th quartile)[a]	**0.52 (0.23)**				0.17 (0.21)			
BLOCK DENSITY	**0.04 (0.02)**				0.02 (0.01)			
DEADEND DENSITY	0.06 (0.98)				−1.24 (0.85)			
TRAFFIC LIGHT DENSITY	1.10 (1.20)				−0.15 (1.04)			
Other								
LOWINCOME NH[a]	0.39 (0.33)	0.57 (0.49)	0.44 (0.42)		0.44 (0.31)	**0.80 (0.32)**	0.25 (0.81)	
TRANSIT ACCESS		−0.01 (0.05)				**0.05 (0.02)**		
CATHOLIC[a]			**2.58 (0.27)**				**1.31 (0.48)**	
WINTER[a]	−0.28 (0.21)	−0.16 (0.45)			**−0.54 (0.20)**	−0.20 (0.23)		
Constant	**1.38 (0.61)**	0.42 (0.59)	0.06 (0.49)		**2.91 (0.59)**	**1.06 (0.38)**	**−2.10 (0.74)**	
$-2\ [L(c)-L(\beta)]$	306.96				388.6668			
McFadden's ρ^2 (adj.)	0.32 (0.31)				0.30 (0.29)			

Coefs in **bold** are significant at α=0.05; coefs in ***bold italics*** are significant at α=0.10.

[a] Dummy variables.

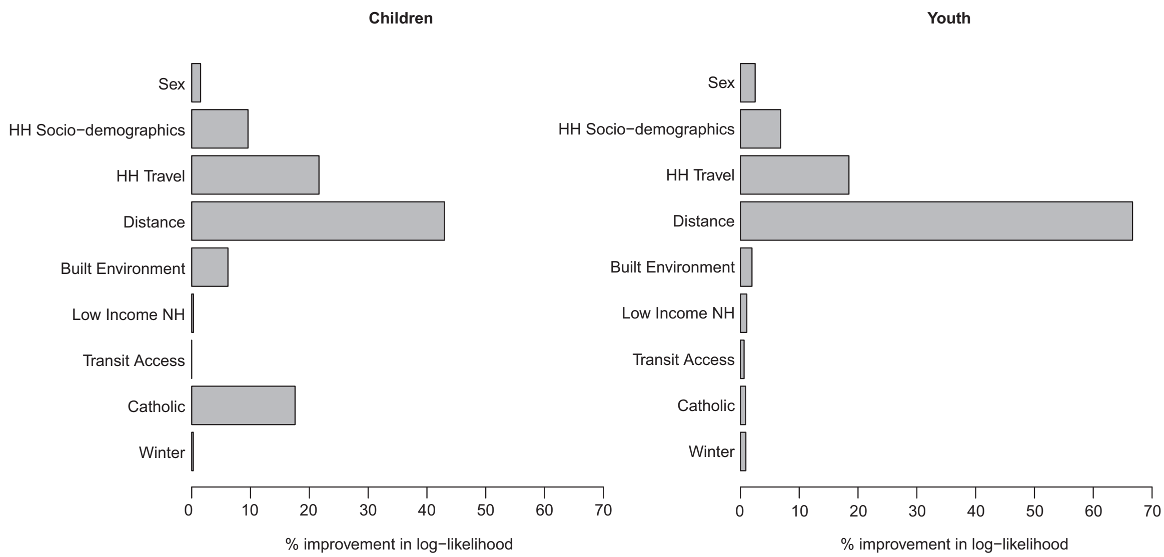

Fig. 2. Relative influences on school travel mode choice.

4. Discussion and conclusions

This study examined differences in the correlates of school travel mode outcomes between children and youth. We conceptualized that a child's actual or perceived maturity with age (Bronfenbrenner, 1989; Mitra, 2013) might produce some differences between children and youth in how parents or a child/youth choose travel mode to school. In exploring these differences, multiple levels of influence were hypothesized. Particular importance was placed on the neighbourhood built environment and travel dependence on other household members. Findings from this study contribute to a very limited literature that examines difference in the correlates of travel modes between children and youth (McDonald, 2008b; Timperio et al., 2006).

This study is particularly relevant in the context of significant policy interest and investment over the last decade that are aimed at improving walking and cycling among school-going children/youth. For example in the US, more than $879 million was appropriated to State DOTs between 2005 and 2012, for the implementation of SRTS programmes near elementary and middle schools (McDonald et al., 2013). The related Federal legislation (SAFETEA-LU) earmarked 70–90% of the allocated funds toward infrastructure improvement, and as a result, improvements in the built environment (particularly those related to traffic safety such as sidewalks and traffic calming measures) have remained the major focus of the SRTS programmes (McDonald et al., 2013; National Center for Safe Routes to School, 2011).

In contrast, STP programmes in Canada remain largely community-driven, without any dedicated government funding, with only occasional partnering with and funding from government agencies (Green Communities Canada, 2014). As a result, the STP interventions have focused more on education and less on physical infrastructure. However, recent research has reported at best a moderate impact of SRTS and STP interventions on AST rates (Boarnet et al., 2005; Mammen et al., 2014), indicating the need for systematic research that would improve our current understanding of school travel mode choice behaviour to inform development of future interventions, and to reshape interventions to improve their alignment with the particular populations they are intended to influence.

In addition, the current focus of SRTS and STP programmes on elementary/middle schools can benefit only a proportion of all students who can potentially take up walking and cycling as travel modes to/from school. In other words, a large number of students who attend high schools remain excluded from these interventions. Not surprisingly, the feasibility of adapting the STP framework to the high school context has received some recent attention. Between 2010 and 2012, Green Communities Canada has implemented modified-STP programmes in seven high schools in Ottawa (Stuckless, 2012). Two major challenges/opportunities were identified based on outcomes from these pilot interventions. First, youth are more independent decision makers and travellers, compared to younger children who are more dependent on adult caregivers. Second, youth may report a negative perception toward walking, unlike younger children who typically like to walk to/from school and consider AST as "cool" (Stuckless, 2012). Clearly there are different cultures of mobility within the child and youth populations – these differences need to be adequately exposed and understood with a view to developing targeted, successful interventions within these disparate populations. The research that is presented in this paper begins to provide insights into these differences by means of empirical evidence of the variations in the correlates of school travel outcomes. The remainder of this section discusses these results and outlines their potential implications.

Previous research has consistently reported lower AST rates among older youth, compared to younger children who attend elementary schools (Buliung et al., 2009; McDonald, 2007; van der Ploeg et al., 2008). The primary reason for this difference may be geographical. Longer travel distances to high schools may make walking/cycling a less attractive option for some high-school students. Results from this study also support this hypothesis, indicating that in general 14–15 year old students live farther away from their schools compared to younger students (Table 2). However, we also found that high school students (i.e., 14–15 years) typically walked longer than elementary school students (i.e., 11 year olds), indicating that when adapted in the context of a high school, programmes similar to STP or SRTS may not necessarily have to target only those students who live within close proximity of their schools.

In addition to distance, concern for traffic and personal safety has previously been identified as a major barrier to AST (Fyhri et al., 2011; Larsen et al., 2013; Lee et al., 2013; Panter et al., 2010a). Our results were similar, suggesting statistical association between walking and the neighbourhood environmental characteristics that may relate to safety along school travel routes. For example, the absence of major road crossings and perhaps major roads (an aspect that is indirectly captured here by the variable INDIRECT) likely improves safety from traffic (Schlossberg et al., 2006; Mitra and Buliung, 2014; Timperio et al., 2006). Mixed land use (e.g., high retail density) and smaller blocks are also characteristics that are typically representative of "walkable" neighbourhoods. All of these characteristics were positively associated with a child's odds of walking to school. For youth, however, the built environment was largely uncorrelated with travel mode (Table 3 and Fig. 2). This difference is interesting but not surprising. Recent research indicates that while parents (i.e., adult caregivers) are typically concerned about a child's traffic and personal safety related to the neighbourhood environment, children may not necessarily perceive the neighbourhood environment as a major barrier to walking (Fusco et al., 2012). Perhaps as a result, when children grow up and become more independent decision makers (with regard to school travel) as youth, the characteristics of the built environment become a less important consideration in choosing transportation mode to school. This finding is significant from a policy perspective because it suggests that typical SRTS-type interventions that emphasize improved traffic safety (e.g., sidewalk development, traffic calming) may have limited effect in modifying youth travel behaviour.

Transit ridership was higher (22%) among 14–15 year old youth than for children (5%), which is another indication of their perceived capability of independently navigating the neighbourhood environment and urban streets. Better access to transit increased the odds of youth transit use. Transit is more environmentally sustainable compared to private automobiles (Newman and Kenworthy, 1999), and because most transit trips involve some walking, they contribute to overall physical activity accumulation (Besser and Dannenberg, 2005; Lachapelle and Frank, 2009). A positive correlation between transit access and use is then encouraging, and indicates that improved transit infrastructure, a goal that most North American cities including Toronto are striving to achieve, may also encourage sustainable and healthy travel behaviour among youth, at least when it comes to travelling to and from school.

For children who attended Catholic schools, the average travel distance was only 0.12 km higher than those who attended public schools. For youth, average travel distance between two school systems was not statistically significant at $\alpha=0.05$. However, the models revealed a strong correlation between school system and school bus use. Children and youth attending Catholic schools were more likely to travel to school by school bus, compared to those attending public schools. Previous research based in Toronto has also reported a similar association (Mitra and Buliung, 2014), which can partly be explained by a flexible school transportation policy (i.e., eligibility for a school bus) of the Catholic School Board (TCDSB). The Catholic schools often provide transportation to students who live much closer to 1.5 km, arguably to attract students to schools with declining enrollment (Mitra and Buliung, 2014). This finding offers evidence of the power the boards have in shaping patterns of school travel.

With regard to household level influences, we found that both child and youth school travel modes were associated with parental availability at the time of school travel. In other words, parental availability was related to a higher likelihood of automobile trips. A youth's school travel was also gendered; our results indicate that male students aged 14–15 years were more likely to walk compared to female students (Table 3). These findings are contradictory to our initial conceptualization of older youth as independent travellers, but are not entirely surprising. Previous research has reported a systematic decline in children's independent mobility over the last decades, and has argued that constant adult supervision has become an essential component of modern childhood (Timperio et al., 2006; Hillman et al., 1990; Mitra et al., 2014). While this existing literature primarily focuses on young children, our results suggest that the same hypothesis may also hold true for older youth, although the overall effect of intra-household travel interactions on their school travel may be smaller for this age group (Fig. 2). In other words, while the youth may enjoy some degree of independence with regard to travel decision making, their actual mobility, at least to some extent, remains subject to parental supervision. Although unobservable here, there is strong qualitative evidence regarding the gendered and generational quality of the good parenting model, and the impact of the risk and mobility experiences of mothers on household travel decisions and the greater supervision of the mobility of girls (Murray, 2009).

The scope of this investigation was somewhat limited because of the data used. TTS is a trip-based survey and consequently, variables related to intra-household travel interactions are approximate and were derived based on some assumptions. In other words, the actual extent of travel dependence (i.e., whether a child/youth travelled to school alone, with siblings/friends, or with parents) could not be completely ascertained. It is also conceivable that a youth's and his/her parents' perceptions toward the neighbourhood environment and attitude toward school travel (or travel in general, in particular, preference toward travel mode or independence) may influence school travel behaviour. In fact, a recent Canadian pilot study reported that walking and cycling are perceived by high school students as "hard, inconvenient and uncool", and this negative perception was a major barrier in promoting AST among youth (Stuckless, 2012). However, the TTS does not collect information on neighbourhood perceptions or travel attitudes, and as a result, these potential influences were left unexplored. Lastly, travel behaviour of two groups of students was studied here and the correlates of travel modes were compared. While the samples were large enough to produce statistically reliable results, the data was not longitudinal. In other words, we did not directly explore changes in travel behaviour as children grow up.

Despite some limitations, findings from this study have important implications for policy and practice. The current model of school travel related interventions that are primarily designed around transportation infrastructure (e.g., SRTS in the US) may not be very successful if and when implemented in the context of high schools. Instead, programmes and initiatives focused on high school students should emphasize education and promotion of AST, and perhaps attempt to understand and reshape the culture of youth mobility. Based on the findings of this study, it appears that educational programmes that encourage youth, particularly female youth as well as their parents, to become more independent travellers may increase AST rates among this sub-population, and in the long term, potentially improve their physical and psychological health and well being.

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