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Predictors of driving among families living within 2 km from school: Exploring the role of the built environment

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ABSTRACT

Rates of active school travel have declined over time in line with decreasing levels of physical activity among children. Understanding why some children are driven to school when walking is an option is important for future intervention. The purpose of this study was to evaluate demographic characteristics, parent/family level factors, attitudinal and psychosocial factors, route features, access to vehicles, and environmental factors which appear to influence the decision to drive children who live within a walkable distance from school in the Greater Toronto and Hamilton Area (GTHA), Canada. Computer-aided telephone interviews were conducted in 2009 with 1001 parents of children attending elementary school in the GTHA, Canada's largest urbanized region. Hierarchical logistic regression analyses were conducted to examine the household demographics, parent/family factors, attitudinal and psychosocial factors, route features, access to vehicles, and environmental factors (qualities of urban design) that predict driving among households less than 2 km away from school ($n=529$). In the GTHA, attitudes and psychosocial factors have a stronger role to play than the built environment in influencing driving behavior within close proximity to school. The introduction of built environment characteristics in the final regression model only explained an additional 4% of the variance in driving to school. To promote AST among drivers living within a walkable distance from school, non-infrastructure programs that provide adult supervision, such as Walking School Bus Schemes, may be a more powerful strategy to alleviate safety concerns while potentially reducing the parental time costs of escorting the child, than capital projects targeting changes to the built environment.

1. Background

The trip to/from school can be an important source of physical activity for children. Research consistently demonstrates an association between walking and biking to school and higher levels of physical activity (Faulkner et al., 2009), with active commuters accumulating a greater volume of activity and more minutes of moderate-to-vigorous physical activity in comparison to children who are driven to school. The trip to and from school is therefore a means by which children can accumulate daily physical activity necessary to the attainment of current physical activity recommendations for health. Like the United States (U.S. Department of Health and Human Services, 2008) and United Kingdom (Department of Health UK, 2011), Canadian children are advised to accumulate 60 min of moderate-to-vigorous physical activity per day to maintain a healthy physiological and psychological state of health; yet very few children in Canada, the US or the UK are able to achieve this goal (Colley et al., 2011; Troiano et al., 2008; Craig et al., 2009).

One source of physical activity, walking to/from school, has been steadily declining over time; in the Greater Toronto Area, for example, active school travel (AST) has dropped from 53% to 42% in the am period, and from 56.7% to 49.5% in the pm period (1986–2006) (Buliung et al., 2009). Trends in the United Kingdom are similar, as rates of AST have decreased from 75% in 1975 to 55% in 2001 for children aged 5 to 10, and from 60% to 45% for children aged 11–16 over the same time span (Pooley et al., 2005). In the

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United States, the decreasing trend is even more apparent, with AST mode share for 5 to 18 year olds having decreased by almost 30% between 1969 and 2001 (McDonald, 2007; Ham et al., 2008). Alongside the decline in active travel, the proportion of Canadian and US children classified as being obese has increased (Tremblay et al., 2010). The recent trends in childhood obesity are theorized to be associated with decreasing levels of physical activity and increasing engagement in sedentary behaviors such as automobile usage (Spanier et al., 2006). Hence, there is a clear need to better understand why valuable opportunities for daily physical activity are not being utilized. Furthermore, a shift to more sustainable modes of transportation like walking could reduce gas emissions and air pollution, and alleviate congestion and safety hazards around schools (Metrolinx, 2014).

1.1. Why do some parents drive?

Parents are assumed to be the ultimate decision makers when it comes to whether their child can walk to school or not (McMillan, 2005). Yet the decision that parents ultimately make about the school trip mode can be complex. Developed from a qualitative study of parent/child interviews focused on AST, Faulkner et al. (2010) described a two-stage AST decision-making process, with one decision being whether or not the child needs escorting to/from school, and the second decision being about mode choice, which is largely influenced by issues of convenience. An extensive list of correlates of AST (i.e., distance, time, safety) consequently factor into this decision-making process.

Parents often cite traffic danger as a major barrier to walking and cycling to school (e.g. Cole et al., 2007; Kerr et al., 2006), suggesting the potential of infrastructure improvements/modifications to the built environment as a means of facilitating AST. Distance between home and school is one of the most important determinants related to a child's mode of travel; as distance increases, the likelihood of AST decreases (Wong et al., 2011). Work by Mitra et al. (2010) in the Greater Toronto Area found that distance from home to school had the strongest correlation with mode choice; a 1 km decrease in distance increased the odds of walking by 0.71 to 0.72 times. Consequently, a logical target for AST initiatives are households where children are driven but live within a walkable distance to/from school (i.e., ≤ 2 km; Nelson et al., 2008).

Accordingly, McDonald and Aalborg (2009) investigated the reasons why children (between the ages of 10 and 14, living in the San Francisco Bay Area), who live within two miles from school, were driven. Reasons for driving fell into two main categories: convenience and safety, with 75% of parents citing convenience as a barrier, and 30% listing safety. Concerns about children's independent mobility to/from school were tied in with convenience issues; the threat of “stranger danger” actually surpassed traffic fears and played a defining role for 75% of parents who did not allow their children to walk to school without adult supervision. These results speak to the importance of addressing time/convenience concerns alongside perceptions of safety in building models to predict driving behavior. The results also suggest that such “psychosocial variables” are in fact impacting decision-making independent of environmental determinants. The authors did not investigate characteristics of the home/school neighborhood or route as predictors of driving within close proximity to school, and therefore, we do not know what individual contributions these components of the travel environment might make to understanding why different AST decisions are taken. To our knowledge, this is a gap in the literature, an inquiry that stands to make an important contribution to AST intervention efforts like the Safe Routes to School initiative in the US (National Center for Safe Routes to School, 2013) and School Travel Planning (STP) initiatives in Canada (Green Communities Canada, 2013). School travel planning is a multi-disciplinary, multi-sectoral, school-specific intervention that engages key stakeholders (e.g., STP facilitator, public health, police officials, municipal planners and traffic engineers, school boards, parents, children, school administrators and teachers) in the survey and evaluation of school travel issues (Green Communities Canada, 2013; see also Mammen et al., 2013).

1.2. The built environment

While three environmental components (the neighborhood around the home, the route between home and school, and the environment of the school) are typically considered (Lee and Moudon, 2004; Panter et al., 2010), Mitra et al. (2010) recently identified the built environment around the child's residence to have a stronger correlation with mode choice than the school environment, the effect being strongest for home-to-school trips. Consequently, it is appropriate to investigate the impact of the built environment around the child's home on mode choice to school.

Variables such as residential density, land use mix and era of development are all proxy type characteristics of the built environment that are supposed to capture elements related to travel behavior. While evidence may be more established in the adult literature, no clear association currently exists for children's travel patterns. Higher density neighborhoods are believed to be more conducive to walking as they can decrease distances to possible destinations. Ewing et al. (2004) found no connection between residential density and rates for walking to school, but other studies have determined that higher densities are positively associated with AST (Braza et al., 2004; Kerr et al., 2007).

Land use mix, which again increases the number of potential destinations accessible by foot, is commonly studied in the children's literature, but findings are mixed to date. A few studies have found a positive association between land use mix and AST (Kerr et al., 2006; McMillan, 2007; Larsen et al., 2009), while Ewing et al. (2004) found land use mix to be insignificant. More research is needed to fully understand if and how land use mix relates to children's school travel.

The configuration of the street network may be an important determinant in children's travel patterns, but more research is needed to thoroughly understand the relationship. Intersection density is a common measure of street connectivity or layout, but does not account for the types of streets intersected. Intersection density increases route options and directness, yet also raises the number of intersections one must cross. A higher density of intersections was found to be positively associated with AST among a few studies (e.g., Braza et al., 2004; Schlossberg et al., 2006; Kerr et al., 2007), while others have reported an inverse relationship (Timperio et al., 2004; Ulfarsson and Shankar, 2008). In an effort to more thoroughly understand how street network design influences mode of travel among children, the current study also examined the number of major intersections and proportion of local roadways. These characteristics are rarely assessed in the school travel literature, but should assist with the understanding of how different types of streets (i.e. major arterial or local road) influence mode choice for children.

2. Purpose

The objective of this paper was to build on the work of McDonald and Aalborg (2009) and then extend it by an introduction of characteristics of the home/school neighborhood or route into the predictive model. This research exercise is also about engaging in knowledge translation and exchange (KTE) with an agency of the Government of Ontario (Metrolinx), which was created to improve the coordination and integration of all modes of transportation in the Greater Toronto and Hamilton Area (GTHA). A KTE network has already been established with Metrolinx, and the intent is that Metrolinx will communicate these results to planning and health practitioners who are testing school travel planning approaches in the GTHA through a project called Stepping it Up (Metrolinx, 2011). To meet these objectives, this study identifies demographic characteristics, parent/family level factors, attitudinal and psychosocial factors, route features, access to vehicles, and environmental factors which appear to influence the decision to drive children who live within a walkable distance from school. The creation of a two-step prediction model, the first being a "psychosocial" model, and the second being the inclusion of built environment predictors into the model, identifies the unique contribution of built environment characteristics on the decision to drive children who live in close proximity to school.

3. Methods

3.1. Geographic context

The GTHA is composed of the metropolitan areas of the cities of Toronto and Hamilton, Ontario along with the regional municipalities of Durham, Halton, Peel and York. With a population of over 6 million people, the GTHA is Canada's largest and most culturally diverse metropolitan region (Statistics Canada, 2011). The region has varying built environments spread across traditional downtown, inner and outer suburban areas. Marked differences in qualities of urban design, and transport infrastructure and services, housing style, population density, era of development and overall built environment can be found across the GTHA. These differences are commonly associated with varying rates of AST and automobile use (Handy et al., 2002; Frumkin et al., 2004). Central city neighborhoods are found near the downtown core of Toronto and Hamilton. Within the central city street networks are more commonly connected (gridded), have a higher density of intersections, shorter straight blocks, include higher building densities and mixed use (Sewell, 1993). By contrast, in both the inner and outer suburbs, the streets may be curvilinear, there is more open space, land uses are segregated and lower density housing exists (Sewell, 1993). Inner suburbs can be defined as neighborhoods within the City of Toronto but outside of or farther from the downtown core, whereas outer suburbs are newer areas in the regional municipalities of Durham, Halton, Peel and York (Canada Mortgage and Housing Corporation, 2009).

3.2. Study design

A School Travel Household Attitudinal Survey was conducted over a 3-week period to provide the first in-depth GTHA-wide picture of elementary school (children age 4–13 years, junior kindergarten to grade eight) travel behavior, perceptions and parental awareness of school travel programs. Computer-aided telephone interviews were conducted with 1001 parents or guardians of children attending elementary school within the GTHA. The sample was drawn from Harris/Decima's ASDE Survey Sampler database based on Census Division (CD) from the 2006 Census. Cases were weighted by the child's gender, grade and CD. The survey response rate for the survey was 33.9%. Respondents living within 2 km from school (n=529) were selected for analyses and dichotomized into: (a) drivers (n=191) and, (b) walkers (n=338). Given our interest in predicting driving, the 'walking' group also included a small number of cyclists (n=10). We acknowledge that the determinants of cycling versus walking are likely to be different but given the very low mode share for cycling this decision is unlikely to have an effect on the results.

3.3. Measures

3.3.1. Household demographics

Demographic information was collected on both the parent and eldest child. Parental demographics included age (18–34, 35–44, 45–54, > 55 years), gender, employment status (employed [full- or part-time], not employed, stay-at-home/student/parental leave), primary language spoken at home (English vs. other), and weekly minutes of walking. Child demographics included eldest child's age and gender, and number of children attending elementary school.

3.3.2. Parent/family level factors

Parents were also asked to report on how they themselves travelled to school as a child (drive or carpool, walk or bike, other mode), and also at what age they would allow their child to travel to/from school without adult accompaniment.

3.3.3. Attitudinal factors

Parents were asked questions to gauge perceptions regarding alternative modes for their child's school travel. Attitudes towards the following constructs were examined: neighborhood safety; walking and biking safety; interest in trying alternative travel modes; importance of exercise during the school trip; and importance of travelling to school in an environmental-friendly way. Parents were asked to cite the main reason for the mode choice for their child's school travel from five options including (a) it is the only option, (b) it is the most convenient way, (c) after-school activities, (d) concerns about other methods, (e) my child prefers to go that way and (f) a health issue/mobility impairment.

3.3.4. Route features

Time taken to travel to school was assessed using the response options of (a) 0–5 min, (b) 6–10 min, and (c) > 10 min. Distance in kilometers between the household and the child's school was assessed using the response options of (a) < 1 km, (b) 1–2 km, and (c) > 2 km.

3.3.5. Access to vehicles

Parents were asked to report the number of vehicles in their household, and the number of household members with valid driving licenses. A vehicle-to-licensed drivers ratio was computed and used for analyses.

3.3.6. Built environmental factors

Survey data were geocoded to the geographic center of the identified home address postal code. Within the sample of 529 respondents, 503 (95%) had valid postal codes. Postal codes are commonly used in Canadian research as they allow for anonymity of participants, but are also reasonable proxies for the home address in urban environments (Bow et al., 2004). Unlike US Zip Codes, Canadian postal codes represent relatively small spatial units in urban areas (they are larger in rural districts) which identify the address to the block face in urban areas. Neighborhood straight line buffers were created around each of the respondents' postal codes to analyze characteristics of the built environment. In an effort to capture attributes immediately around the home, a radius of 500 m commencing at the geographic center of the home postal code was applied. A straight-line buffer and distance of 500 m are commonly used in research examining the built environment around the home (Larsen et al., 2009; Berke et al., 2007).

Data on street networks and land use were obtained from DMTI Route Logistics dataset, while population counts and era of development were gathered from Statistics Canada (DMTI, 2009; Statistics Canada, 2011). *Population density* was determined by taking the total number of people at census block level, divided by the total area of residential land (square kilometers) within each buffer. *Era of development* was computed at the dissemination area level (as only population and dwelling counts exist at the block level in Canada in order to protect the anonymity of respondents). Era of development is used as a proxy for neighborhood type. It was calculated by finding the proportion of buildings built in dissemination areas within the buffer prior to 1946. The year 1946 was selected to represent a proxy for pre and post war (World War 2) neighborhoods. Development patterns changed in the post war era, land uses started to become segregated, residential densities were lower, and the street design moved away from the gridded street network to a curvilinear design with a planned street hierarchy (Sewell, 1993). Since this study takes place at the regional scale and includes contrasting neighborhood environments (i.e. central city, inner and outer suburbs) it is important to control and assess these differences.

Street design variables included intersection density, number of intersections, and proportion of local roads. *Intersection density* which increases route options was calculated by finding the number of 3- or 4-way intersections per square kilometer. In an effort to more thoroughly understand how street crossings relate to AST, the number of major intersections was also examined. Since major street crossings are a common determinant of AST (Larsen et al., in press, Wen et al., 2008), the *number of major intersections* where arterial or collector streets intersected local streets was calculated. Only major intersections (arterial or collector) were examined as it is may be that crossing local streets is less of a concern for parents. This was computed using the street classification given in DMTI's Route Logistics (DMTI, 2009), and gives a raw number of major and local street intersections for each buffer. In order to account for the supply of smaller capacity road facilities, likely to be more supportive environments for walking, the *proportion of local roads* variable was created. This was calculated by taking the total distance of local roads divided by the total length of all roadways within each buffer. The values range from 0 meaning no local roads to 1 (all local roads). Finally, land use parcels were again obtained through the DMTI Route Logistics dataset (DMTI, 2009). *Land use mix* was compiled using an entropy index in a similar manner to previous work on the built environment (Frank et al., 2004; Leslie et al., 2007; Larsen et al., 2009). An entropy index calculates how evenly each land use is distributed throughout each of the six classes. Land use parcels were classified into 6 broad categories: residential, resource and industrial, government and institutional, commercial, open area, along with parks and recreational. The total area for each classification was calculated for every buffer and the distribution was calculated using the following entropy formula:

$$[\mathrm{LUM} = -\Sigma_{lu}\,(p_{lu}\ \ln\ p_{lu})/\ln\ n]$$

lu is the land use classification (i.e. residential); *p* is the proportion of land area dedicated to a specific land use; and *n* is the total number of land use classifications (i.e. six). Scores range from zero to one, with zero representing all land in a buffer being single land use (e.g., all residential), and one representing an even distribution of all six land use classifications.

3.4. Statistical analyses

Descriptive statistics were used to examine household demographics and attitudinal variables. Independent samples *t*-tests and chi-square analyses were used to test for group differences (drivers [$n=191$] and walkers [$n=338$]) on the continuous and categorical factors, respectively, related to household demographics, parent/family level factors, attitudes, route features, and access to vehicles. Only those variables which were significantly ($p < .05$) different between the two groups were entered into the logistic regression model to predict driving. The one exception to this rule was for the variables assessing child's age and gender. Given that age and gender have been shown to be significant correlates of school travel behavior (Sirard and Slater, 2008), these variables were included in the regression model in Block 1 regardless of the results from the univariate analyses. For the logistic regression analysis, a hierarchical approach was used where household demographics variables were entered first (Block 1), followed by parent/family level factors (Block 2), attitudinal factors (Block 3), route features (Block 4), and vehicle to licensed drivers ratio (Block 5).

To examine the additional variance explained by the environmental factors, a second logistic regression was conducted with all measures of the built environment entered in three additional blocks: era of development (Block 6), land use and density (Block 7), and street connectivity (Block 8). Since several of the environmental variables are inter-related, cross-correlation was tested among all of these factors. While it is possible for certain features such as intersection density, sum of major and minor intersections and proportion of local roads to be correlated, no such multicollinearity issues were found. The Omnibus chi-square test ($p < .05$) and Hosmer and Lemeshow test ($p > .05$) were used to determine model fit, while the Nagelkerke's R^2 was used as an index of variance explained. All analyses were conducted using SPSS 18 (IBM, PASW Statistics). Only those respondents with complete data were included in the regression analyses ($n=359$). An alpha level of.05 was used for all statistical tests.

4. Results

4.1. Sample characteristics

Table 1 provides the demographic characteristics for the overall sample, as well as for drivers and walkers separately. The mean age of the overall parent sample was 40.54 ± 7.46 years, with the majority of the sample between 35 and 44 years of age (52%), female (59%), and employed (70%). English (77%) was the primary language spoken in the household. The majority of parents reported only one child attending elementary school (60%), while an additional 33% had two, and 8% had three or more children attending elementary school.

4.2. Group differences on measured psychosocial factors

4.2.1. Household demographics

Chi-square analyses revealed no significant differences between parents who walk their children to school versus those who drive their children on any of the measured parental demographic variables listed in Table 1. In terms of child demographic variables, significant group differences were found for gender, $\chi^2(1)=6.93$, $p < 0.01$, with significantly more females being driven to school (58.3%) than walking (45.9%). Children being driven to school were also significantly less likely to travel to and from school with other school-aged children, $\chi^2(1)=50.0$, $p < 0.001$, in comparison to walkers (30% versus 62%, respectively). No significant between-group differences were found on child age ($p=0.60$), or the number of children attending elementary school ($p=0.86$).

4.2.2. Parent/family level factors

Drivers were significantly less comfortable with letting their child walk to school without adult accompaniment in comparison

Table 1
Characteristics of walkers ($n=338$) and drivers ($n=191$).

	Overall	*Walkers*	*Drivers*
	($n=529$)	($n=338$)	($n=191$)
Parental characteristics			
Age (in years), % (n)			
18 to 34	16.3% (86)	15.0% (51)	18.3% (35)
35 to 44	54.3% (287)	55.9% (189)	51.4% (98)
45 to 54	22.3% (118)	22.4% (76)	22.0% (42)
> 55	3.9% (21)	4.1% (14)	3.5% (7)
Refused/don't know	3.3% (18)	2.6% (9)	4.6% (9)
Gender, % (n)			
Male	41.4% (219)	40.8% (138)	42.4% (81)
Female	58.6% (310)	59.2% (200)	57.6% (110)
Employment status, % (n)			
Employed	71.7% (380)	70.3% (238)	74.1% (142)
Unemployed	10.5% (56)	11.1% (38)	9.5% (18)
Other	17.8% (94)	18.6% (63)	16.4% (31)
Child characteristics			
Age (years), $M \pm SD$*	8.36 ± 2.90	8.41 ± 2.97	8.27 ± 2.77
Gender, % (n)			
Male	48.4% (256)	52.4% (177)	41.3% (79)
Female	50.4% (267)	45.9% (155)	58.3% (112)
Refused/don't know	1.2% (7)	1.7% (6)	0.4% (1)
Household characteristics			
# of children attending elementary school, % (n)			
1	59.9% (317)	60.4% (204)	58.9% (113)
2	32.7% (173)	32.6% (110)	32.9% (63)
≥ 3	7.5% (40)	7.0% (23)	8.3% (15)
Language spoken in the home, % (n)			
English	78.2% (414)	79.7% (269)	75.5% (144)
Other	21.8% (116)	20.3% (69)	24.5% (47)

Note: Data were weighted by the child's gender and grade, and by the Census Divisions (CD) to ensure cross-regional analysis was not biased.

* Missing data from 11 participants ($n=518$).

Table 2
Logistic regression predicting driving to school from socio-demographics, parental/family, attitudes, school travel and access to vehicles, $n=359$.

	OR	p	95%CI
Socio-demographics			
Gender			
Female	1.00	–	–
Male	0.56	0.05	0.31 to 1.00
Age, years	1.06	0.33	0.94 to 1.19
School travel with other children			
No	1.00	–	–
Yes	3.93	< 0.001	2.13 to 7.27
Parental/family level			
Age without adult accompaniment, years	1.18	0.01	1.04 to 1.35
Attitudes			
Discussion of bullies and strangers	1.06	0.63	0.85 to 1.32
Discussion of walking and biking safety	0.75	0.02	0.60 to 0.95
Interest in trying alternative travel modes	1.28	0.01	1.05 to 1.55
Importance of exercise during the school trip	0.52	< 0.001	0.39 to 0.69
Importance of travelling to school in an environmentally-friendly way	0.87	0.44	0.61 to 1.24
Main reason for school travel choice			
Other (e.g., safety)	1.00	–	–
Convenience	0.60	0.08	0.33 to 1.07
Distance to school			
< 1 km	1.00	–	–
1–2 km	2.80	< 0.001	1.53 to 5.15
Access to vehicles			
Cars to drivers ratio	1.39	0.51	0.52 to 3.69

Note: OR=Odds ratio, CI=Confidence interval. Total variance explained (R^2)=44%.

to walkers, $\chi^2(1)=29.34$, $p < 0.001$. Approximately 85% of drivers did not feel comfortable letting their child walk to school without adult accompaniment in comparison to 63% of walkers. Walkers were also significantly more likely to let their child travel to/from school without adult accompaniment at a younger age than drivers, $F(1, 450)=22.3$, $p < 0.001$. No significant differences were found between drivers and walkers in the way that they travelled to school when they were a child ($p=0.84$).

Table 3
Logistic regression predicting driving to school from socio-demographics, parental/family, attitudes, school travel, access to vehicles and GIS factors, $n=359$.

	OR	p	95%CI
Socio-demographics			
Gender			
Female	1.00	–	–
Male	0.55	0.06	0.30 to 1.01
Age, years	1.05	0.42	0.93 to 1.19
School travel with other children			
No	1.00	–	–
Yes	4.03	0.001	2.10 to 7.73
Parental/family level			
Age without adult accompaniment, years	1.15	0.04	1.01 to 1.32
Attitudes			
Discussion of bullies and strangers	1.12	0.34	0.89 to 1.42
Discussion of walking and biking safety	0.75	0.02	0.59 to 0.96
Interest in trying alternative travel modes	1.35	0.004	1.10 to 1.65
Importance of exercise during the school trip	0.48	<0.001	0.36 to 0.65
Importance of travelling to school in an environmentally-friendly way	0.96	0.82	0.66 to 1.40
Main reason for school travel choice			
Other (e.g., safety)	1.00	–	–
Convenience	0.54	0.06	0.29 to 1.01
Distance to school			
<1 km	1.00	–	–
1–2 km	2.65	0.003	1.41 to 5.00
Access to vehicles			
Cars to drivers ratio	1.23	0.70	0.43 to 3.51
Era of development (in years)			
Prior to 1946	0.32	0.14	0.07 to 1.47
Land use and density			
Land use mix	4.41	0.09	0.80 to 24.24
Population density	1.00	0.93	0.99 to 1.02
Street connectivity			
Intersection density	1.02	0.09	1.00 to 1.04
Proportion of local roads	1.04	0.02	1.01 to 1.07
Sum of major/minor intersections	1.11	0.009	1.03 to 1.19

Note: OR=Odds ratio, CI=Confidence interval. Total variance explained (R^2)=48%.

4.2.3. Attitudinal factors

Parents who drove their children to school tended to be more worried about strangers and bullies approaching their child if they travelled alone in comparison to those parents whose children walked to school, $\chi^2(4)=16.46$, $p=0.002$. Significantly fewer drivers had discussed how to walk or cycle to school safely with their children (74%) versus walkers (90%), $\chi^2(4)=43.62$, $p<0.001$. Drivers were more interested in considering alternatives to the way that their child currently travels than walkers, $\chi^2(4)=19.66$, $p=0.001$. Drivers were significantly less likely to perceive the trip to/from school as having an important contribution to daily exercise, $\chi^2(4)=114.57$, $p<0.000$. While 76% of walkers strongly agreed that it was important that their child gets exercise while travelling to and from school, only 31% of drivers believed this to be the case. A significantly greater proportion of walkers (78%) in comparison to drivers (64%) believed that it was important that their child gets to and from school in an environment-friendly way, $\chi^2(4)=18.29$, $p=0.001$. More walkers (55%) than drivers (34%) indicated ‘convenience’ to be the main reason for school travel mode choice, more so than other factors (e.g., safety, work/school scheduling conflicts), $\chi^2(4)=18.29$, $p=0.001$.

4.2.4. Route features

The time taken to travel to school was significantly lower for drivers than walkers, $\chi^2(2)=45.81$, $p=0.000$, with 75% of drivers taking less than 5 min to travel in comparison to 45% of walkers.

4.2.5. Access to vehicles

Drivers were more likely to have access to a car, $\chi^2(3)=25.45$, $p<0.001$, and reported more licensed drivers within their households than walkers, $\chi^2(3)=20.95$, $p<0.001$. For example, 44% of walkers either did not have a car (7%) or only had access to one car (36%), while the vast majority of drivers had access to two or more cars (75%) and at least two drivers per household (93%).

4.3. Psychosocial logistic regression model of driving to school

Overall, the 12 variables entered into the regression model explained 44% of the variance in driving to school (Table 2). The model was found to have a good fit (Omnibus test: $\chi^2(12)=131.85$, $p<.001$; Hosmer and Lemeshow test: $\chi^2(8)=14.40$, $p=.07$). Of the 12 variables included in the model, seven were found to be significant predictors of driving to school (see Table 2 for odds ratios and CIs). Having a female child (OR=0.56), travelling to school with other children (OR=3.93), older reported age for child to walk to school without adult accompaniment (OR=1.18), less discussion of how to walk or cycle to school safely (OR=0.75), greater parental interest in alternative school travel modes (OR=1.28), lesser perception of the trip to/from school as being an important contribution to daily exercise (OR=0.52), and greater distance to travel to school (OR=2.80) were significant correlates of driving to school. In addition, when parents indicated other reasons besides convenience as the main reason for their child's travel mode, there was a greater likelihood that they would drive their child to school (OR=0.60).

4.3.1. The built environment and explaining driving to school

Overall, the six environmental variables entered into the regression model explained an additional 4% of the variance in driving to school, resulting in a total explained variance of 48%. The final model was found to have a good fit (Omnibus test: $\chi^2(18)=147.10$, $p<.001$; Hosmer and Lemeshow test: $\chi^2(8)=14.65$, $p=.07$). Of the 18 variables included in the full regression model, eight were found to be significant predictors of driving to school (see Table 3 for odds ratios and CIs). In terms of the psychosocial variables, older reported age for child to walk to school without adult accompaniment (OR=1.15), travelling to school with other children (OR=4.03), less discussion of how to walk or cycle to school safely (OR=0.75), greater parental interest in alternative school travel modes (OR=1.35), lesser parental perception of the trip to/from school as being an important contribution to daily exercise (OR=0.48), and greater distance to travel to school (OR=2.65 for 1–2 km versus >1 km) were all significant correlates of driving to school. Meanwhile, for the built environment variables, greater proportion of local roads (OR=1.04) and number of major and minor intersections (OR=1.11) were significant correlates of driving to school.

5. Discussion

While at the elementary school level parents are the ultimate decision-makers on how their child travels to school, policy makers and school administrators must understand the basis on which parental decisions are made, including perceptions of the built environment and social factors, such as convenience, safety, and the degree of perceived social capital in the community. Program interventions should be designed to improve perceptions of AST by identifying and addressing both real and perceived barriers and introducing local solutions.

This is one of the first studies to investigate the decision to drive to school when living in close proximity (≤2 km), using a 2-step prediction model: the first step examining the influence of psychosocial variables (demographics, parent/family level factors, attitudinal factors, route features, access to vehicles) and the second step examining the influence of built environment factors (population density, era of development, intersection density, number of intersections, proportion of local roads, land use mix). We found evidence that attitudinal variables, route features and built environment factors were significant predictors of driving children who live less than 2 km away from school. Notably, the introduction of built environment characteristics in the final model only explained an additional 4% of the variance in driving to school, resulting in a total explained variance of 48%. This suggests that in the GTHA, the social environment has a stronger role to play than the built environment (only as measured by the variables included in our model) in influencing driving behavior within close proximity to school. In fact, common attributes of the built environment such as: population density, mixed land uses and the density of intersections were not significant predictors in the model.

Many of these environmental variables are common within the adult literature and conceptually relate to mode of travel. As previously stated, for children the relationship between population density, land use mix, intersection density and school travel is less clear. These results may also relate to the method of measurement. Land use mix was calculated using an entropy index, which is a common approach in both the child and adult literature (Frank et al. 2004; Leslie et al. 2007; Larsen et al. 2009; Larsen et al. 2012); however, does having a perfectly mixed environment actually relate to school travel? While a perfect land use mix may relate to adult travel patterns, having industrial lands around the home, likely does not encourage walking to school. In an entropy index, a value of 1 represents an even mix of all land use categories. For school travel, a lower value which includes only residential, parks and open spaces is probably more beneficial for walking than busier commercial and industrial areas. In the end, land use mix was not a significant characteristic in this study, and perhaps future work should apply different measures of land use mix for children to more accurately capture what may be important for children's mobility.

Era of development, which is a proxy variable for neighborhood design was also not significant. The proportion of local roads and the number of major and minor street intersections were the only built environment characteristics that were significant predictors in the final model. The number of major and minor street intersections was positively associated with driving to school. This is an interesting finding as it relates to traffic safety and street crossings. Having to cross a street is thought to be a key element of pedestrian safety (Larsen et al., 2012). Crossing streets puts the child at a risk for being hit by a motor vehicle; the number of, and type of street crossing, may play a role in mode choice. Major street crossings may be perceived as more dangerous than crossing local neighborhood streets. While evidence is somewhat mixed as to how street crossings influence travel mode for children, our finding is similar to those of other studies, where crossing major streets were significant determinants of AST (Larsen et al., 2012; Wen et al., 2008).

The proportion of local roads was positively associated with driving to school. Why more local roads was a determinant of driving is unclear; it was hypothesized that more local roads would encourage active travel, as local roads are typically perceived as more pedestrian friendly and safer. This variable may be acting as a proxy for other built environment characteristics or relate to neighborhood type. A higher proportion of local roads, typically relates to a more suburban neighborhood where major arterials with high traffic volume and fast moving vehicles are present. Even though proportionally, the neighborhood is made up of mostly local streets, the arterials in the suburban neighborhood are extremely busy and may be perceived as dangerous for children to cross. In the central city, the street network is more likely to be mixed with a combination of local, collectors and arterials. Consistent with McDonald and Aalborg (2009), we found that concerns over safety and independent mobility were important predictors of driving. Objective indicators of intersection density and proportion of local roads suggest traffic safety concerns are real for these parents. This is perhaps reflected in reduced independent mobility of these children given that parents who drive their child think the child should be older to travel unescorted to school. McDonald et al., 2010 present an interesting case study by Coleman (1988) to highlight how parental beliefs about the neighborhood social environment can affect children's travel behavior. In his analysis of this case study, Coleman, a major theorist on social capital, came to the conclusion that parental decision-making is heavily influenced by perceived differences in the levels of social capital between neighborhoods. In their paper, McDonald et al. incorporate a dimension of the social environment borrowed from Sampson et al. (1999), child-centered social control, the expectation that neighborhood residents can and will intervene on the behalf of children. The authors discovered an association between parental perceptions of child-centered social control and walking and biking to school, with associations stronger for girls and minority groups (McDonald et al., 2010). Our dataset also reinforced the notion that school travel continues to be a gendered practice, with more girls being driven to school than boys. Parents who made the decision to drive their children were less likely to have discussed with their child how to walk or cycle to school safely and these children were less likely to have other children to travel to school with. Policies, at all levels, must support school/family and community partnerships: promoting greater social capital in communities may contribute to the sustainability of AST interventions. Interventions should be designed to create positive social capital by informing local merchants, residents and community groups about AST initiatives and welcoming their involvement.

Our findings also highlight that AST can be a convenient option. McDonald and Aalborg (2009) found that convenience was the most common reason for driving. In contrast, parents in our study whose children walked to school were more likely to give convenience as the reason for this travel mode. Distance may contribute to this finding. Even within two kilometers from school, distance was a significant predictor of driving behavior (i.e., drivers were more likely to have a greater distance to travel to school than walkers (OR=2.65 for 1–2 km versus >1 km). For short trips, walking may indeed be more convenient than driving. Alternatively, other barriers are more important than convenience; for example, 19.8% of drivers reported that driving was the 'only option' in comparison to 7.9% of walking parents. Regardless of the reasons for this finding, it emphasizes the need to examine how AST modes can be made more convenient for driving households.

Like the U.S. (National Center for Safe Routes to School, 2013) and the U.K. (Sustrans, 2011), Canada has been supporting AST for some time now. A national, community-based comprehensive approach called School Travel Planning (STP) has emerged (Green Communities Canada, 2013), and provincial organizations like Metrolinx (2011) are engaging in KTE with associated partners to disseminate "best practice" approaches for fostering AST using the STP model through projects like Stepping It Up. The STP intervention involves mobilization of key community stakeholders (governments, parents, children, teachers, school administrators) for the purpose of addressing school-specific barriers and facilitators to AST. Walking School Bus (WSB) schemes are among a handful of "action plan" items within a school STP which may also include safety training, and infrastructure improvements (Buliung et al., 2011).

WSB schemes hold some promise in encouraging AST among households within a walkable distance from school and might offer a means of tackling some of the "predictors" of driving behavior within our model. For one, WSB programs provide the option for children who would otherwise be driven to travel with a group of children and adult volunteers. These schemes also provide a means of adult supervision, a way to alleviate independent mobility barriers, such as intersections, faced by children that are driven to school. The introduction and maintenance of WSB schemes also has great potential to influence and improve perceived neighborhood social capital. The schemes offer a way for members of a community to interact (Kingham and Ussher, 2007; Mackett et al., 2003), and there is evidence that community interaction is connected to AST (Hume et al., 2009). Perhaps embedded in this is the need to inform drivers of the value of the trip to school as a consistent opportunity for physical activity (and means of attaining daily physical activity recommendations for health), given the finding that such parents were more likely to have lesser perceptions about the trip to school as making an important contribution towards daily activity.

6. Conclusions

Overall, offering non-infrastructure programs that provide adult supervision, such as WSB Schemes, may be a more powerful strategy to alleviate safety concerns while potentially reducing the parental time costs of escorting the child, than capital projects targeting changes to the built environment. However, more research and practice attention should be focused on how to implement WSB schemes in a way that is sustainable. It is necessary to establish support systems to overcome the challenges faced in practicing AST: Parents and school personnel alike must sometimes overcome a large array of internal and external challenges to transform their regular perceptions and behaviors. Training for practitioners can promote parental and staff roles in behavior change. Having practitioners, such as school administrators and school health nurses, learn by doing; being responsible for collaborating with parents, families, and community and business members; and reflecting on effective strategies in group and professional development settings as a regular part of their ongoing work can be a powerful strategy to build capacity and overcome challenges. Understanding how to empower these stakeholders as key players in activities such as school travel planning, and how to mobilize their community to support children and parents in using AST modes, remains a research and practice priority.

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References

Berke, E.M., Koepsell, T.D., Moudon, A.V., Hoskins, R.E., Larson, E.B., 2007. Association of the built environment with physical activity and obesity in older persons. Am. J. Public Health 97 (3), 486–492.
Bow, C.J.D., Waters, N.M., Faris, P.D., Seidel, J.E., Galbraith, P.D., Knudtson, M.L., Ghali, W.A., 2004. APPROACH Investigators, 2004. Accuracy of city postal code coordinates as a proxy for location of residence. Int. J. Health Geogr. 3 (1), 5.
Braza, M., Shoemaker, W., Seeley, A., 2004. Neighborhood design and rates of walking and biking to elementary school in 34 California communities. Am. J. Health Promotion 19 (2), 128–136.
Buliung, R.N., Mitra, R., Faulkner, G., 2009. Active school transportation in the Greater Toronto Area, Canada: an exploration of trends in space and time (1986–2006). Prevent. Med., 48; , pp. 507–512.
Buliung, R., Faulkner, G., Beesley, T., Kennedy, J., 2011. School travel planning: mobilizing school and community resources to encourage active school transportation. J. School Health 81 (11), 704–712.
Canada Mortgage and Housing Corporation (2009) Comparing Neighbourhood Types—Toronto. Retrieved 26 January, 2014, from ⟨http://www.cmhc-schl.gc.ca/en/co/buho/sune/sune_006.cfm⟩.
Cole, R., Leslie, E., Donald, M., Cerin, E., Owen, N., 2007. Residential proximity to school and the active travel choices of parents. Health Promotion J. Aust. 18 (2), 127–134.
Coleman, J., 1988. Social capital in the creation of human capital. Am. J. Sociol. 94, S95–S120 (Supplement).
Colley, R., Garriguet, D., Janssen, I., Craig, C., Clarke, J., Tremblay, M.S. (2011) Physical Activity of Canadian Children and Youth: Accelerometer Results from the 2007 to 2009 Canadian Health Measures Survey, Health Reports/Statistics Canada, Canadian Centre for Health Information, 22(1), pp. 15–23.
Craig, R., Mindell, J., Hirani, V. (Eds.), 2009. Health Survey for England 2008. The Information Centre, London (Retrieved 26 January 2014, from). ⟨http://www.cmhcschl.gc.ca/en/co/buho/sune/sune_006.cfm⟩.
Department of Health UK (2011) Start Active, Stay Active: A Report on Physical Activity for Health from the Four Home Countries. Retrieved 26 January 2014 from ⟨https://www.gov.uk/government/publications/start-active-stay-active-a-report-on-physical-activity-from-the-four-home-countries-chief-medical-officers⟩.
DMTI, 2009. CanMap RouteLogistics, v2009. DMTI Spatial Inc., Markham, Ontario
Ewing, R., Schroeer, W., Greene, W., 2004. 'School location and student travel: analysis of factors affecting mode choice'. Transp. Res. Rec. 1895, 55–63.
Faulkner, G.E.J., Buliung, R.N., Flora, P.K., Fusco, C., 2009. Active school transport, physical activity levels and body weight of children and youth: a systematic review. Prevent. Med. 48 (1), 3–8.
Faulkner, G.E.J., Richichi, V., Buliung, R.N., Fusco, C., Moola, F., 2010. What's "quickest and easiest?" Parental decision making about school trip mode. Int. J. Behav. Nutr. Phys. Act. 7, 62.

Frank, L.D., Andresen, M.A., Schmid, T.L., 2004. Obesity relationships with community design, physical activity, and time spent in cars. Am. J. Prevent. Med. 27 (2), 87–96.
Frumkin, H., Frank, L., Jackson, R., 2004. Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities. Island Press, Washington.
Green Communities Canada (2013) School Travel Planning. Retrieved 25 March, 2013, from 〈http://www.saferoutestoschool.ca/〉.
Ham, S.A., Martin, S., Kohl, H.W., 2008. Changes in the percentage of students who walk or bike to school-United States, 1969 and 2001. J. Phys. Act. Health 5 (2), 205–215.
Handy, S.L., Boarnet, M.G., Ewing, R., Killingsworth, R.E., 2002. How the built environment affects physical activity: views from urban planning. Am. J. Prevent. Med. *23* (2 Suppl), 64–73.
Hume, C., Timperio, A., Salmon, J., Carver, A., Giles-Corti, B., Crawford, D., 2009. Walking and cycling to school: predictors of increases among children and adolescents. Am. J. Prevent. Med. 36 (3), 195–200.
Kerr, J., Rosenberg, D., Sallis, J., Saelens, B., Frank, L., Conway, T., 2006. Active commuting to school: associations with environmental and parental concerns. Med. Sci. Sports Exercise 38 (4), 787–794.
Kerr, J., Frank, L., Sallis, J.F., Chapman, J., 2007. Urban form correlates of pedestrian travel in youth: difference by gender, race-ethnicity and household attributes. Transp. Res. Part D 12 (3), 177–182.
Kingham, S., Ussher, S., 2007. An assessment of the benefits of the walking school bus in Christchurch, New Zealand. Transp. Res. Part A: Policy Pract. 41 (6), 502–510.
Larsen, K., Gilliland, J., Hess, P., Tucker, P., Irwin, J., He, M., 2009. The influence of the physical environment and sociodemographic characteristics on children's mode of travel to and from school. Am. J. Public Health 99 (3), 520–526.
Larsen, K., Gilliland, J., Hess, P.M., 2012. Route based analysis to capture the environmental influences on a child's mode of travel between home and school. Ann. Assoc. Am. Geogr. 102 (6), 1348–1365.
Lee, C., Moudon, A.V., 2004. Physical activity and environment research in the health field: implications for urban and transportation planning practice and research. J. Plann. Lit. 19 (2), 147–181.
Leslie, E., Coffee, N., Frank, L., Owen, N., Bauman, A., Hugo, G., 2007. Walkability of local communities: using geographic information systems to objectively assess relevant environmental attributes. Health Place 13 (1), 111–122.
Mackett, R.L., Lucas, L., Paskins, J., Turbin, J., 2003. A methodology for evaluating walking buses as an instrument of urban transport policy. Transp. Policy 10 (3), 179–186.
Mammen, G., Stone, M.R., Faulkner, G., Ramanathan, S., Buliung, R., O'Brien, C., Kennedy, J., 2013. Active school travel: an evaluation of the Canadian school travel planning intervention. Prevent. Med. , http://dx.doi.org/10.1016/j.ypmed.2013.12.008 (Epub ahead of print).
McDonald, N.C., 2007. Active transportation to school: trends among U.S. schoolchildren, 1969–2001. Am. J. Prevent. Med. 32 (6), 509–516.
McDonald, N.C., Aalborg, A.E., 2009. Why parents drive children to school: implications for safe routes to school programs. J. Am. Plann. Assoc. 75 (3), 331–342.
McDonald, N.C., Deakin, E., Aalborg, A.E., 2010. Influence of the social environment on children's school travel. Prevent. Med. 50 (Suppl. 1), S65–S68.
McMillan, T.E., 2005. Urban form and a child's trip to school: the current literature and a framework for future research. J. Plann. Lit. 19 (4), 440–456.
McMillan, T.E., 2007. The relative influence of urban form on a child's trip to school. Transp. Res. Part A: Policy Pract. 41 (1), 69–79.
Metrolinx (2011) Stepping it Up. Retrieved 26 January, 2014, from 〈www.metrolinx.com/schooltravel〉.
Metrolinx, Green Communities Canada and University of Toronto. (2014). The Costs and Benefits of School Travel Planning Projects in Ontario, Canada. Metrolinx, Toronto.
Mitra, R., Buliung, R.N., Roorda, M.J., 2010. Built environment influences on school travel mode choice in Toronto, Canada. Transp. Res. Rec.: J. Transp. Res. Board 2156, 150–159.
National Center for Safe Routes to School (2013) Safe Routes. Retrieved 26 January, 201, from 〈http://www.saferoutesinfo.org/〉.
Nelson, N.M., Foley, E., O'Gorman, D.J., Moyna, N.M., Woods, C.B., 2008. Active commuting to school: how far is too far? Int. J. Behav. Nutr. Phys. Act. 5, 1.
Panter, J.R., Jones, A.P., van Sluijs, E.M.F., Griffin, S.J., 2010. Attitudes, social support and environmental perceptions as predictors of active commuting behaviour in school children. J. Epidemiol. Commun. Health 64 (1), 41–48.
Pooley, C.A., Turnbull, J., Adams, M., 2005. The journey to school in Britain since the 1940s: continuity and change. Area 37 (1), 43–53.
Sampson, R., Morenoff, J., Earls, F., 1999. Beyond social capital: spatial dynamics of collective efficacy for children. Am. Sociol. Rev. 64, 633–660.
Schlossberg, M., Greene, J., Phillips, P.P., Johnson, B., Parker, B., 2006. School trips: effects of urban form and distance on travel mode. J. Am. Plann. Assoc. 72 (3), 337–346.
Sewell, J., 1993. The Shape of the City: Toronto Struggles with Modern Planning. University of Toronto Press, Toronto.
Sirard, J., Slater, M., 2008. Walking and bicycling to school: a review. Am. J. Lifestyle Med. 2 (5), 296–372.
Spanier, P., Marshall, S., Faulkner, G., 2006. Tackling the obesity pandemic: a call for sedentary behaviour research. Can. J. Public Health 97, 255–257.
Statistics Canada (2011) Census of Canada, 2011, Statistics Canada, Ottawa.
Sustrans (2011) Safe Routes to School Program. Retrieved on 26 January, 2014, from 〈http://www.sustrans.org.uk/what-we-do/safe-routes-to-schools〉.
Timperio, A., Crawford, D., Telford, A., Salmon, J., 2004. Perceptions about local neighborhood and walking and cycling among children. Prevent. Med. 38 (1), 39–47.
Tremblay, M.S., Shields, M., Laviolette, M., Craig, C., Janssen, I., Gorber, S.C. (2010) Fitness of Canadian Children and Youth: Results from the 2007–2009 Canadian Health Measures Survey, Health Reports (Statistics Canada, 82-003XPE), 21(1), pp. 1–15.
Troiano, R.P., Berrigan, D., Dodd, K.W., Masse, L.C., Tilert, T., McDowell, M., 2008. Physical activity in the United States measured by accelerometer. Med. Sci. Sports Exercise 40 (1), 181–188.
Ulfarsson, G.F., Shankar, V.N., 2008. Children's travel to school: discrete choice modeling of correlated motorized and nonmotorized transportation modes using covariance heterogeneity. Environ. Plann. B: Plann. Des. 35 (2), 195–206.
U.S. Department of Health and Human Services (2008) 2008 Physical Activity Guidelines for Americans, U.S. Department of Health and Human Services, Washington.
Wen, L.M., Fry, D., Rissel, C., Dirkis, H., Balafas, A., Merom, D., 2008. Factors associated with children being driven to school: implications for walk to school programs. Health Edu. Res. 23 (2), 325–334.
Wong, B.Y., Faulkner, G.E., Buliung, R.N., 2011. GIS measured environmental correlates of active school transport: a systematic review of 14 studies. Int. J. Behav. Nutr. Phys. Act. 8, 39.