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Gender-based differences in school travel mode choice behaviour: Examining the relationship between the neighbourhood environment and perceived traffic safety

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ABSTRACT

A consistent decline in active school transportation among North American children has drawn attention of those concerned with children's health and wellbeing. Consequently, an emerging literature has explored the enablers and barriers to walking and cycling, including the role of the neighbourhood environment. This study makes a novel contribution by examining the relationship between the objectively measured neighbourhood characteristics and parental perceptions of traffic safety, and gender based differences in this relationship, as it relates to school travel mode choice behaviour (walking versus being driven) in Toronto, Canada. Structural equation models were estimated to explore home-to-school trip data on 720 students attending 5th/ 6th grade in 16 public schools. Results indicated that boys were more likely to walk to school than girls. Distance, sidewalk unavailability and intersection density were inversely correlated with parental perceptions of neighbourhood automobile safety and walking infrastructure for both genders. However, parental perception of automobile safety was negatively correlated with heavy traffic near school only for boys, and with major road crossings en route to school only for girls. Interestingly, both perceptions were only associated with a boy's school travel outcome; a girl's school travel mode choice was not affected by these two parental perceptions. Policies and programmes to increase walking to/from to school should also acknowledge the gendered nature of school travel behaviour.

1. Introduction

Active Transportation is the engagement in physical activity for making trips using one or several human-powered modes of transportation such as walking or cycling (Public Health Agency of Canada, 2013; Sallis et al., 2004). Guidelines in Canada recommend 60 minutes of moderate-to vigorous-intensity physical activity (MVPA) a day everyday for a child's and youth's healthy development (Canadian Society for Exercise Physiology, 2011), which can be achieved through combinations of playful and recreational activities and active transportation. Many studies have highlighted that regular participation in physical activity and/or active transportation may also enhance a child's social well-being and cognitive abilities (Bürgi et al., 2011; Fusco et al., 2012; Tomporowski et al., 2008). Furthermore, children who acquire patterns of physical activity at a younger age are expected to carry forward this healthy lifestyle and its benefits over their life span (Bürgi et al., 2011).

Transportation to and from school is the most common type of travel for children and youth during weekdays of a school year (Copperman and Bhat, 2007). Many children live within a reasonable walking/cycling distance from school, and for these children, active school transport (AST: walking and cycling to/from school) can be a great opportunity to accumulate physical activity on a regular basis. Recent research supports in this hypothesis, with an emerging body of evidence indicating a statistical association between AST uptake

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and higher daily physical activity levels among children and youth; a review of this literature can be found elsewhere (Larouche et al., 2014). However, AST uptake in Western countries has consistently declined over the past decades. For example in the Greater Toronto Area, Canada, walking to school by 11–13 year old children has declined from 53% to 42% between 1986 and 2006 (Buliung et al., 2009). This decline in AST levels may have major consequences for children's health; thus improving AST participation in children and youth is important for the future health of younger population.

Researchers, practitioners and community-based organizations alike have recognized that the neighbourhood environment plays an important role in facilitating AST. Existing literature has reported a strong negative correlation between school travel distance and AST (e.g., McDonald, 2008; Mitra and Buliung, 2014; Waygood and Susilo, 2015). Some researchers have found positive association between higher street network connectivity and AST (Panter et al., 2010a), while others have reported higher street network connectivity resulting in reduced AST rates (Larsen et al., 2012; Giles-Corti et al., 2011). The presence of active transportation infrastructure (e.g., sidewalks, pedestrian crossings, cycle routes, controlled traffic crossings) was found to be associated with AST (Mitra and Buliung, 2014; Schlossberg et al., 2006; Timperio et al., 2006). On the other hand, streets with high traffic and busy intersections may discourage AST uptake (Giles-Corti et al., 2011; Larsen et al., 2013). Results related to the land use also remain mixed. Some researchers found mixed-use neighbourhoods to associate with walking (McMillan, 2007; Mitra and Buliung, 2014), while others have indicated to the contrary (Larsen et al., 2012; Yang et al., 2012).

Recent research has also reported an association between neighbourhood environmental perceptions and a child's school travel mode outcomes (e.g., Lee et al., 2013; McMillan, 2007; Panter et al., 2010b). For example, parental perception on a child's general safety within a neighbourhood (e.g., "a safe neighbourhood to walk") was found to correlate with AST (Larsen et al., 2013; McMillan, 2007). With regard to more specific environmental perceptions, concerns about busy street crossings (Larsen et al., 2013; Timperio et al., 2006) and sidewalk maintenance (Lee et al., 2013) may discourage walking to school. Some studies have indicated a negative statistical correlation between parental perceptions of heavy traffic on neighbourhood streets and AST (Hsu and Saphores, 2014; Lee et al., 2013; Panter et al., 2010b); others found no such association (Larsen et al., 2013; Timperio et al., 2006). Similarly, some researchers reported parental perceptions of stranger danger to negatively correlate with walking (Larsen et al., 2013; Lee et al., 2013), while others found no such association (Timperio et al., 2006).

The relationship between these objective (i.e., measurable) and subjective (i.e., perceived) qualities of the neighbourhood environment, however, has yet to be systematically examined in school transportation literature. Recent theoretical works, such as the ones proposed by McMillan (2005) and Mitra (2013), have conceptualized that the neighbourhood environment (i.e., objectively measurable neighbourhood characteristics) informs qualitative perceptions of the neighbourhood, which influence household decisions related to a child's school travel outcome. Within this context, empirical research exploring this relationship is critical in advancing our understanding of the behavioural processes relating to school travel mode choice, and in informing policy and practice that is centred on creating an enabling built environment to improve AST rates.

Socio-demographic characteristics of a household and a child, including household income (Larsen et al., 2012; Yang et al., 2012), access to private automobiles (Mitra and Buliung, 2014; Waygood and Susilo, 2015), parental work commitments (McDonald, 2008; Yarlagadda and Srinivasan, 2008), and a child's age (Lee et al., 2013; McDonald, 2008), may also influence school travel mode choice. One characteristic that is particularly relevant to this study is a child's gender, which can be an important determinant of AST. Some North American studies have reported that male students were more likely to walk to school than female students (Larsen et al., 2013; McDonald, 2008; Mitra and Buliung, 2014). Some others did not find any statistical association between a child's gender and school travel mode choice (Lee et al., 2013; McDonald, 2012). However, there exists only a limited literature that has systematically examined gender-based differences in the school travel mode choice behaviour. For example, McMillan et al. (2006) explored gender-differences in school travel among students attending grades 3–5 in California, US. Girls were 40% less likely to walk or cycle to school compared to boys, but the authors did not observe any association between gender-specific parental perceptions of neighbourhood safety and AST. In another study conducted in Baltimore, Maryland, US, Clifton et al. (2011) explored gender-related differences in school travel behaviour among grades 9–12 students. Girls living in mixed-use neighbourhoods were more likely to drive to school; those living in neighbourhoods with well connected streets were more likely to use transit. No such associations were found among boys. Leslie et al.'s (2010) exploration of 10–14 year-old children across three states in Australia revealed that girls walked more, but cycled less, than boys. Access to recreational facilities and a student's perceived safety for walking/ jogging alone correlated with AST among both genders. Conceivably, caregiver perceptions of the neighbourhood environment may vary based on a child's gender, and parents of young girls (compared to boys) may be more protective of their children's independent and/or active mobility. The topic, however, remains understudied in current literature.

This study addresses these two important gaps in the current literature by examining (1) the relationship between the measurable environmental qualities and parental perceptions of traffic safety, and (2) the variations of this relationship based on a child's gender, as they relate to their school travel mode choice behaviour (more specifically, walking versus being driven) in the City of Toronto, Canada. The findings of this study will inform Canadian and North American policy in developing more behaviourally grounded interventions, and particularly in addressing the gender gap in school travel behaviour.

2. Method

2.1. Conceptual design

This study builds on previous theoretical works on children's school travel behaviour (McMillan, 2005; Mitra, 2013), which hypothesize that school travel mode choice is impacted by multiple levels of influence, including household and child/youth characteristics, the urban environment, and external influences (e.g., natural environment and policy context). In particular, Mitra (2013) hypothesized that the neighbourhood environment influences a child's travel mode outcome through five latent mediators (i.e., subjective perceptions): (1) proximity; (2) traffic and personal safety concerns; (3) street connectivity; (4) pedestrian facilities and aesthetics; and (5) social connectedness.

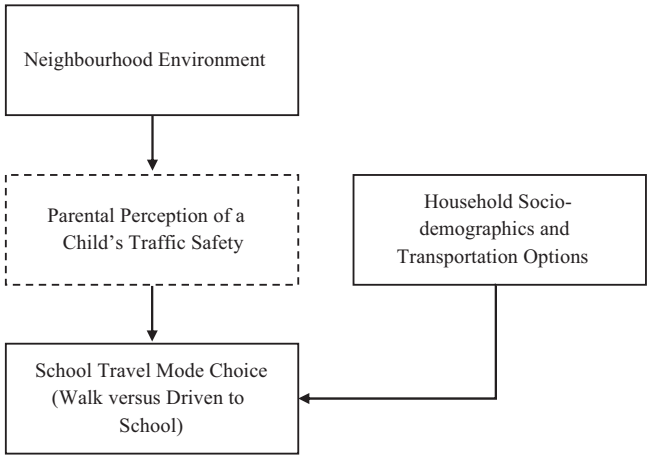

Fig. 1. Conceptual framework of the relationship between a parental perception of child's traffic safety and school travel mode choice. NOTE: Dashed boundary indicates parental perceptions related to child's safety and was conceptualized to be latent (i.e., cannot be observed directly). Adopted from Mitra (2013).

Recent school transportation research has identified distance/proximity and safety as the two major barriers to AST (McDonald and Aalborg, 2009; Mitra, 2013). This study specifically focuses on the decision between walking, versus driven in a privately owned vehicle, for trips to school, and the potential influence of traffic safety perceptions. While the importance of personal safety concerns on children's mobility (e.g., safety from strangers, as discussed by Lee et al. (2013) and Larsen et al. (2013) among others) is acknowledged, this paper does not address that aspect of neighbourhood safety. Similar to McMillan (2007) and Mitra (2013), we assume that for young children, parents take a central role in deciding their child's school travel mode choice, and consequently, parental perceptions of the neighbourhood safety were examined. Fig. 1 shows the conceptual framework adapted in this study, in which, latent parental perception of a child's traffic safety is conceptualized as a mediator that explains the relationship between the objectively measured built environment and travel mode outcome (i.e., walk versus driven). In the empirical analysis that follows, direct association between objectively measured neighbourhood environmental characteristics and mode choice was also examined, which, theoretically, would indicate the presence of other latent mediators outlined in Mitra (2013) that remain unexplored in this study. Hypothetically, parental/ caregiver perception of traffic safety may vary based on a child's gender, which in turn, may produce different school travel mode outcomes for a young girl versus a boy.

2.2. Data

To test the hypotheses of the conceptual framework (Fig. 1), this study utilized data collected through the Project BEAT (Built Environment and Active Transportation; www.beat.utoronto.ca), which is a multidisciplinary and mixed method research project focused on children's mobility and health in Toronto, Canada. School travel data were collected between April 2010 and June 2011 at eight inner-urban schools (i.e., located within pre-World War 2 neighbourhoods surrounding Toronto's downtown core) and eight inner-suburban schools (i.e., located within relatively newer neighbourhoods further away from downtown). Grades 5 and 6 students (likely 10 and 11-year olds) and their adult caregivers (mostly mothers) participated in the study. The collected data included details on a child's typical school travel route, a child's and parent's neighbourhood perceptions, attitudes and activity patterns, as well as socio-demographic characteristics of the household. A total of 1027 students and their parents/adult caregivers took part in the BEAT study. For the purpose of this research, data from the caregiver surveys were used to capture parental perceptions. Only home-to-school trip data were analysed in this work.

Our goal was to understand what stopped a child from walking (or being allowed to walk) to school and being driven instead, a topic that is typically at the centre of the debate around children's school transportation and physical activity in North American communities. Observations with travel distance greater than 3.2 km (2 mile; 3.6% of all respondents travelled >3.2 km) were removed from analysis with an assumption that beyond this distance, walking would not be a feasible travel option for a child. Our preliminary analysis of the BEAT data showed that 74% of all students who travelled less than 1.6 km (1 mile), and 14% of those who travelled between 1.6 and 3.2 km (1 and 2 mile) walked to school. None of the survey respondents walked beyond 3.2 km. Moreover, mode shares for bicycle, school bus and public transit, for travelling <3.2 km, were 2.1%, 1.7% and 1% respectively, further justifying the exclusion of these travel modes from our empirical analysis. We recognize that in children's active transportation literature, walking and cycling are often explored together as "active" modes of travel. However, the neighbourhood environment-related enablers/barriers to cycling and walking are potentially different; parental perceptions of safety may also vary across these two modes. In the context of this study, then, combining these travel modes as "AST" would not be conceptually appropriate. After these adjustments, and after eliminating missing data and outliers, the final data included 720 observations.

2.3. Objectively measured neighbourhood environment

We hypothesized that (Fig. 1) the neighbourhood environment influences school travel mode choice indirectly by informing parental perceptions. Travel distance from home to school was measured using school travel route data provided by the children, in ArcGIS 10. Five other school route-based neighbourhood environment variables were measured objectively, by intersecting a child's travel route with data from the City of Toronto (i.e., major roads, missing sidewalk, traffic calming devices and intersections) and other private providers (i.e., retail density) (Table 1).

Table 1
Summary statistics ($n=720$).

Variables	Mean (S.D.)	Percent
Travel mode for trip to school		
Driven		27.4
Walk		72.6
Socio-demographics and transportation options		
Gender		
Girl		52.5
Boy		47.5
Age (Years)	10.58 (0.70)	
Vehicles per licensed driver	0.87 (0.25)	
Median household income [a]		
Above low income cut-off		82.2
Below low income cut-off		17.8
Mother's employment status		
Part or full time employed	70.00	
Not employed	30.00	
Parental perceptions of traffic safety		
There is heavy traffic near my home		
Strongly agree/agree		43.5
Neither agree nor disagree/disagree/strongly disagree		56.5
There is heavy traffic around my child's school in the morning		
Strongly agree/agree		57.1
Neither agree nor disagree/disagree/strongly disagree		42.9
Our child has to cross too many busy streets walking to/from school		
Strongly agree/agree		19.3
Neither agree or disagree		80.7
Most drivers go too fast while driving in my neighbourhood		
Strongly agree/agree		47.6
Neither agree nor disagree/disagree/strongly disagree		52.4
There are not enough sidewalks		
Strongly agree/agree		9.7
Neither agree nor disagree/disagree/strongly disagree		90.3
There are major barriers/obstacles to walking in my local neighbourhood that make it hard to get from place to place		
Strongly agree/agree		7.9
Neither agree nor disagree/disagree/strongly disagree		92.1
Objectively measured neighbourhood environment along school travel route		
Travel distance in km from house to school	0.78(0.52)	
Traffic calming devices [b,c]		
Yes		22.1
No		77.9
Retail density (retail outlets/km)[d]	6.05 (14.97)	
Missing sidewalks (proportion of school route without a sidewalk)[b]	0.04 (0.12)	
Major road crossing[b]		
Yes		41.3
No		58.7
Intersection density (number of intersections/km)[b]	6.11 (3.42)	
Traffic count around school (number of vehicles)	580.44 (523.56)	

[a] A child's area of residence was classified as a low-income when the DA-level median household income was less than median income for the City of Toronto (i.e. CAD 43,291) (Statistics Canada, 2013).
[b] Street network related neighbourhood characteristics were computed using data from the City of Toronto's Open Data Toronto Initiative. http://goo.gl/SBwHj6.
[c] The presence of any of the following traffic calming devices, along a child's school travel route, was considered: chicanes, speed bumps, raised intersections, gateways, raised crosswalks and traffic circles.
[d] Business data was obtained from Canadian Business Data (2010.04) provided by Pitney Bowes Software Inc.

In addition to school travel distance and the characteristics of neighbourhood design, traffic volume in the neighbourhood streets may also influences parents' perception of traffic safety on the route to school (Giles-Corti et al., 2011; Larsen et al., 2013). To understand this relationship, traffic count data was analysed. Manual traffic counts were conducted at all intersections surrounding each school, from one-

half hour before to 15 min after the school start time. The process involved counting the number of vehicles at all access and egress points around a school. Previous research on traffic safety has reported a correlation between higher traffic volume and a greater safety risk (Giles-Corti et al., 2011; Larsen et al., 2013). Accordingly, for each student's school travel route, the highest intersection count (among all intersections along the route) was explored as a measure of traffic volume.

2.4. Parents' perceptions of traffic safety

Parents' responses to seven statements, related to the neighbourhoods in which they live in, were investigated. The surveys asked parents whether they agreed or disagreed to these statements; the responses were recorded on a 5-point scale where 1 represented "Strongly Agree" and 5 represented "Strongly Disagree". A bi-variate logistic regression of walking (versus driven in car) was performed against each statement. One of the statements – "There are enough crosswalks or traffic lights to help walkers cross busy streets" was not associated with walking at $\alpha=0.10$; thus was dropped from further analysis.

To identify conceptually meaningful environmental perceptions out of remaining six responses, a principal component analysis (PCA) with varimax rotation (which assumes the factors are uncorrelated) was performed. Two clear factors emerged, namely (a) perception of automobile safety and (b) perception of neighbourhood walking infrastructure. Table 2 shows factor loadings for each statement. For Multivariate analysis, two new variables 'Automobile Safety' and 'Walking Infrastructure' were created using factor loadings described in Table 2.

Table 2
Principal component analysis of parental environmental perceptions: factor loadings.

Caregiver perception statements	Factor 1 (Automobile Safety)	Factor 2 (Walking Infrastructure)
There is heavy traffic near my home	0.845	
There is heavy traffic around my child's school in the morning	0.817	
Most drivers go too fast while driving in my neighbourhood	0.779	
Our child has to cross too many busy streets walking to/from school	0.616	
There are not enough sidewalks		0.878
There are major barriers/obstacles to walking in my local neighbourhood that make it hard to get from place to place		0.679

NOTE: Factors were generated using varimax rotation method. Kaiser–Meyer–Olkin Measure: Bartlett's test significance −0.775 ($p<0.000$)

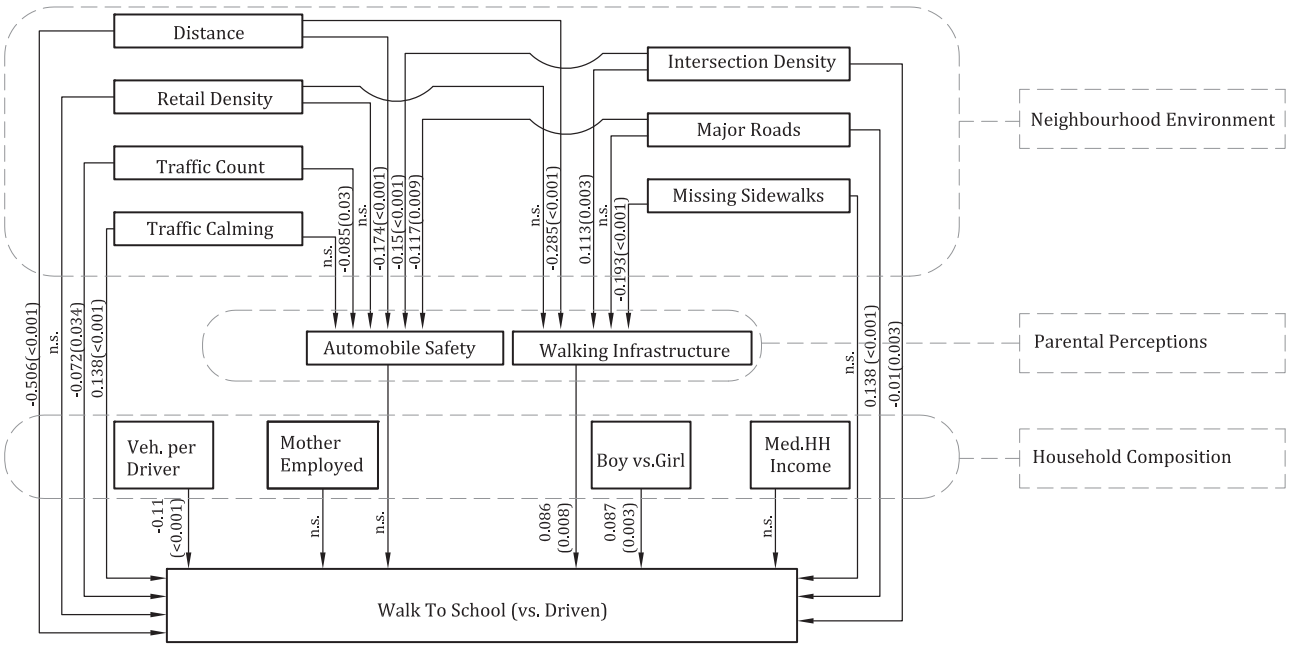

Fig. 2. Standardized direct effects on a child's school travel mode outcome. NOTE: The numbers outside of parentheses are standardized direct effects (regression weights). The numbers in parentheses are p-values. Associations that are shown were significant at $\alpha=0.05$. Correlations that were not significant at $\alpha=0.05$ are marked as "n.s.". Model Fit: ratio of the chi-square ($\chi 2$) statistic and degree of freedom (df) $=2.78$, goodness-of-fit index (GFI)$=0.98$, root mean square error approximation (RMSEA)$=0.05$.

2.5. Socio-demographic characteristics

Socio-demographic information collected through the BEAT caregiver survey and Statistics Canada were explored. Informed by the existing literature, five key socio-demographic variables were included in the analysis: child's gender, number of vehicles available per licensed driver, mother's employment status, and median household income. Many respondents in the BEAT survey did not provide individual level household income data. To rectify the problem, year 2010 median household income data at the dissemination area (DA) level (The smallest geographical unit in which Statistics Canada releases income data) collected by the Statistics Canada was used (Table 1). A child's area of residence was classified as a low-income neighbourhood when the DA-level median household income was less than median income for the City of Toronto (i.e. CAD 43,291) (Statistics Canada, 2013).

2.6. Multivariate statistical analysis

A Structural Equation Modelling (SEM) approach was applied to explore the multi-level relationships between the variables relating to (1) objectively measured neighbourhood environment, (2) parents' perceptions of traffic safety (identified using a PCA approach described in Sections 2.4), (3) socio-demographic characteristics, and (4) school travel mode. Travel mode outcome was measured in the form of a binary variable indicating a walking versus driven trip to school.

The analytical framework of the SEM is presented in Fig. 2. Hypothesized directions of influence were strategically added between exogenous variables (i.e., objectively measured neighbourhood built environment characteristics, and household socio-demographics) and endogenous variables (i.e., environmental perceptions and mode choice), following the conceptual framework outlined in Section 2.1. For example, Traffic calming devices and Traffic counts around school were hypothesized to interact only with perceptions related to "automobile safety". Similarly, Missing sidewalks would only influencing the perception of "walking Infrastructure". Major roads crossing, intersections density, retail density and distance were allowed to interact with both of the perceptions. Finally, socio-demographic, parental perceptions, the neighbourhood environment variables were hypothesized to directly correlate with the mode choice variable.

Since all of the endogenous and exogenous variables were either observed or computed using PCA of observed variables, an observed endogenous variable approach, as explained by Mueller (1996), was adopted for this analysis:

$$Y = \mathrm{B}Y + \Gamma X + \zeta,$$

where $Y=(N_Y \times 1)$ column vector of endogenous variables (N_Y=number of endogenous variables), $X=(N_X \times 1)$ column vector of exogenous variables (N_X=number of exogenous variables), $\mathrm{B}=(N_Y \times N_Y)$ matrix of coefficients representing the direct effects of endogenous variables on other endogenous variables, $\Gamma=(N_Y \times N_X)$ matrix of coefficients representing the direct effects of exogenous variables on endogenous variables, and, $\zeta=(N_Y \times 1)$ column vector of errors.

Separate models were also estimated for boys ($n=342$) and girls ($n=378$) to assess gender disparities in the AST behaviour. The maximum likelihood estimation (MLE) approach was applied to estimate the models. All multivariate analyses were performed using SPSS Amos® software. The estimated standardized direct effects are summarized in Figs. 2–4.

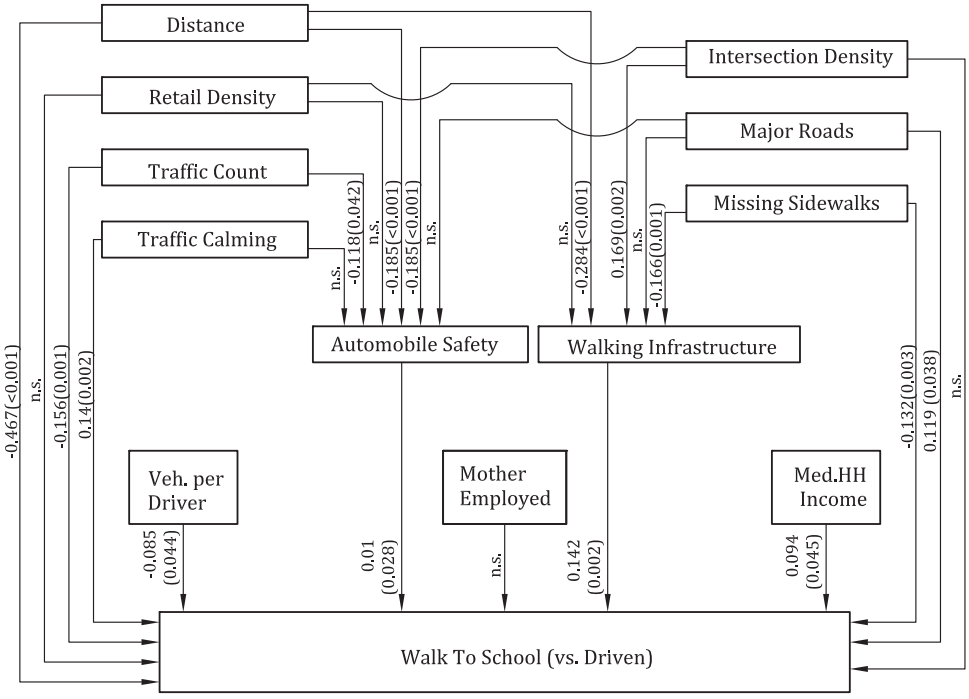

Fig. 3. Standardized direct effects on a boy's school travel mode outcome. NOTE: the numbers outside of parentheses are standardized direct effects (regression weights). The numbers in parentheses are p-values. Associations that are shown were significant at $\alpha=0.05$. Correlations that were not significant at $\alpha=0.05$ are marked as "n.s.". Model Fit: ratio of the chi-square ($\chi 2$) statistic and degree of freedom (df) =1.46, goodness-of-fit index (GFI)=0.98, root mean square error approximation (RMSEA)=0.04.

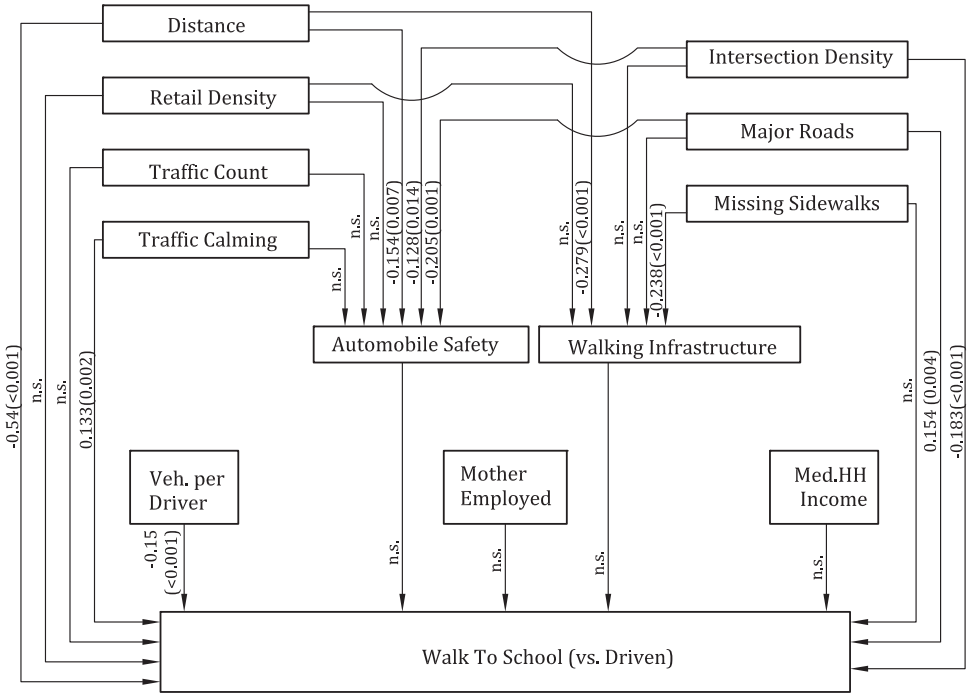

Fig. 4. Standardized direct effects of a girl's school travel mode outcome. NOTE: the numbers outside of parentheses are standardized direct effects (regression weights). The numbers in parentheses are *p*-values. Associations that are shown were significant at $\alpha=0.05$. Correlations that were not significant at $\alpha=0.05$ are marked as "n.s.". Model Fit: ratio of the chi-square ($\chi 2$) statistic and degree of freedom (df) =2.37, goodness-of-fit index (GFI)=0.97, root mean square error approximation (RMSEA)=0.05.

3. Results and discussion

School travel behaviour of $n=720$ grade 5 and 6 children in Toronto, Canada, was analysed using an SEM approach. Among these children, 52.5% were girls and 47.5% of them were boys; the average age of surveyed children was 10.58 years (Table 1). The mean school travel distance was 0.76 km. Of all children in the sample, 73% walked to school as opposed to 26% who were driven. Among those students who lived <3.2 km from school, 67.5% of the girls walked to school as opposed to 78.4% boys (i.e., 32.5% girls versus 21.6% boys were driven to school).

Fig. 2 summarizes results from a SEM of walking (versus driven) using pooled sample that included both boys and girls; Figs. 3 and 4 summarize results from models on boys and girls respectively. For each of these models, the ratio of the chi-square ($\chi 2$) statistic and degree of freedom (df) was <3, goodness-of-fit index (GFI) was closer to 1, and the root mean square error approximation (RMSEA) was ≤ 0.05, indicating a good fit for the estimated models.

3.1. Socio-demographic characteristics and walking

Fig. 2 shows that boys were more likely to walk to school than girls. However, some similarities as well as differences were observed between boys and girls when explored separately (Figs. 3 and 4). For example, availability of private automobiles (i.e., vehicles per licensed driver in a household) was negatively associated with walking among both boys and girls. On the other hand, no significant association was found between mother's employment status and mode choice for either a boy or a girl. With regard to differences across gender, a significant positive association was noted between neighbourhood level household income and the likelihood of walking in the case of boys only.

3.2. Perceptions of traffic safety and walking

Two latent parental perceptions related to a child's traffic safety, namely: automobile safety and walking infrastructure, were explored. Distance, Intersection density, presence of major road crossings en-route to school and heavy traffic near school were negatively associated with parental perception of automobile safety, but this perception did not have a direct effect on a child's likelihood of walking to school at $\alpha=0.05$ (Fig. 2). On the other hand, parental perception of walking infrastructure played a significant role in influencing a child's likelihood of walking to school. This perception was negatively correlated with school travel distance and missing sidewalks (i.e., proportion of school route without a sidewalk).

When travel behaviour of boys and girls were examined separately (Figs. 3 and 4), noticeable differences were found between these gender-specific models and the combined model, echoing with our hypothesis that AST decision process is likely gendered. Our findings related to these differences (and similarities) are discussed below:

3.2.1. Parental perception of automobile safety

School travel distance and intersection density were negatively associated with parents' perception of automobile safety for both boys (Fig. 3) and girls (Fig. 4). Heavy traffic around school negatively affected parental perception of automobile safety for a boy's school travel,

but not for a girl's. In contrast, the presence major road crossings was negatively associated with parental automobile safety perception for a girl's school travel, but not for a boy's.

Traffic calming devices en-route to school did not associate with this parental perception for either gender, as one might expect (Figs. 3 and 4). Although traffic calming devices are commonly believed by planners and engineers to improve pedestrian safety (Lockwood, 1997), our results suggest that at least for the 5th/6th grade students in Toronto, such engineered environment may not always influence parents' subjective perceptions of a child's safety from traffic. This observed dissonance between subjective views of the neighbourhood environment and the objective measures of safety improves our understanding of the AST behaviour.

With regard to the association between subjective perceptions and school travel behaviour, the models indicated that parents' perception of automobile safety had a direct positive effect on walking among boys (Fig. 3), but not among girls (Fig. 4). This gender-based difference resonates with existing literature, which points out that parents encourage boys over girls to take risks or to engage in more physical activity within the context of a safer and/or enabling environment (Kimm et al., 2005; Morrongiello and Dawber, 1999; van Mechelen, 2000). Our results indicate the absence of such encouragement towards a grade 5/6 girl, or at least a large variation in the degree of parental support that produced a statistically insignificant effect.

3.2.2. *Parental perception of walking infrastructure*

School travel distance and the proportion of school route with missing sidewalk were negatively associated with parental perception of walking infrastructure in a neighbourhood, for both boys (Fig. 3) and girls (Fig. 4). Intersection density was positively associated with parental perceptions for boys only.

Similar to our findings in Section 3.2.2, a positive association was found between parents' perception of neighbourhood walking infrastructure and walking to school among boys attending grades 5 and 6 (Fig. 3), but not among girls of the same age (Fig. 4). As explained in Section 3.2.2, this finding may reflect a caregiver tendency to be more protective of girls and to place greater restrictions on girls' active and perhaps independent mobility.

3.3. *Direct effect of the neighbourhood environment*

This study hypothesized that the neighbourhood environment (i.e., measurable characteristics of a neighbourhood) influences a child's school travel outcome by informing parental perceptions (Fig. 1). While existing theoretical works have identified multiple domains of perceptual mediators (McMillan, 2005; Mitra, 2013), this paper only focused on one of them, namely, perception of traffic safety. The presence of a direct association between the neighbourhood environmental variables and mode choice (i.e., walk versus driven) in the estimated models, then, would conceivably indicate the presence of other mediators that remained unaddressed here.

School travel distance was negatively associated with walking among both genders (Figs. 3 and 4), similar to what has been found elsewhere (Mitra, 2013). In contrast, the presence of traffic calming measures en route to school was positively associated with walking for both boys and girls. This finding is particularly interesting in the context of a lack of statistical association between traffic calming measures and the parental perception of automobile safety as discussed in Section 3.2.1, and indicates that although they are primarily designed to improve travel safety (Lockwood, 1997), traffic calming devices perhaps influence other types of parental perceptions that were not examined in this research. Nevertheless, these devices may improve the likelihood of walking among elementary schoolchildren.

Major road crossings appeared to improve the likelihood of walking both for boys and girls, which is contrary to findings from some other studies that have reported a negative association between them (Bringolf-Isler et al., 2008; Mitra and Buliung, 2014). One explanation of this contradictory finding could be that after accounting for parental safety concerns, the presence of major roads may be representative of a well-connected street network, which in turn, may enable walking (Mitra, 2013). However, this hypothesis could not be confirmed with our data.

With regard to differences across gender, heavy traffic near school (i.e., traffic count) and missing sidewalks (i.e., proportion of school travel route without sidewalks) were directly associated only with a boy's travel outcome (Figs. 3 and 4). In addition, a negative direct association was observed between intersection density and walking only among girls.

3.4. *Limitations*

The results from this study, however, may not be generalizable beyond what is permitted by the data. First, the study population was purposefully kept limited to grades 5 and 6 children to avoid variations in behaviour due to different levels of cognitive ability and independence. Second, only parental perceptions related to a child's traffic safety were explored, with an acknowledgement that there may be other perceptual domains through which the built environment influences school travel mode choice decisions. Third, we recognize that a child's environmental perceptions and attitudes may have some influence on a household's decisions around school travel (Mitra, 2013), but the topic remains a subject of our future research.

Within the scope of this research, however, the findings provide novel insights into the relationship between the neighbourhood environment, parental perceptions of neighbourhood safety, and children's school travel outcomes. The study also begins to identify gender-based differences in household decisions around school travel, a topic that remains understudied in current literature but may have important policy implications.

4. Implications and conclusion

From an exploration of school travel behaviour in Toronto, Canada, it appears that positive parental perceptions related to a child's traffic safety improves the likelihood of walking to school, particularly among male students attending grades 5 or 6. Our results also indicated that in Toronto, the household decision processes related to the choice between walking and being driven may vary across gender. These findings improve our understanding of the school travel mode choice behaviour, particularly in relation to the effects of the neighbourhood-level environment. The findings also draws attention to gender-specific enablers and barriers to a child's walking.

Current interventions in North America aimed at increasing AST rates have remained somewhat tied to organizational mandates and to a large extent, to the availability of funding. For example in the US, Federally funded and the State Departments of Transportation administrated Safe Routes to School (SRTS) programmes empower schools to increase walking/cycling uptake and safety of school travel. Between 70% and 90% of all SRTS funding are earmarked for engineered infrastructure (e.g., sidewalks) improvement (McDonald et al., 2013). A review of the current interventions in Canada reveals noticeable contrast to the US approach. Community-based Green Communities Canada, with financial support from various government agencies, introduced and has implemented School Travel Planning (STP) initiative in >106 elementary and middle schools across Canada (Mammen et al., 2014). Metrolinx, which is the provincial transportation planning authority for the Toronto Region, partnered with Green Communities Canada from 2009 to 2011 in implementing STP programmes in the region (Metrolinx et al., 2014). Since 2011, Metrolinx has remained engaged in the promotion of AST through community mobilization; however, a longer term revenue stream has yet to be identified. Due to limited finding, the STP interventions have focused largely on education and promotion, with some engineering components. The Toronto District School Board (TDSB) and several other school boards across Canada have recently adapted charters for safe and sustainable transportation among students (Toronto District School Board, 2013). At this point, these documents merely outline a commitment to invest in resources related to STP programmes and road safety education within schools.

Several recent studies have evaluated the impact of SRTS programmes in the US using large samples of schools and SRTS projects, and have reported a significant increase in the AST rate among students attending schools that participated in the SRTS programmes (McDonald et al., 2014; Stewart et al., 2014). In another recent investigation that included 53 STP case studies across Canada, 17% parents reported that they were driving less than before (Mammen et al., 2014). Results from our study confirm from a behavioural perspective, the importance of capital improvement projects in improving AST, particularly walking. Our results suggest that infrastructure-centred interventions, such as constructing sidewalks and implementing traffic calming measures, may increase the likelihood of walking regardless of parental perceptions of traffic safety that may attach to these environmental features.

Another important finding from this study, which requires adequate attention in policy and practice, is the difference in school travel behaviour between male and female students. Policy and programmes that focus on improving AST rates should place particular emphasis on AST undertaking among girls. Our models indicated that the correlates of a girl's school travel mode can be different than those of a boy. We also observed a weaker association between parental perceptions and school travel outcome in girls compared to the boys attending grades 5 and 6. More specifically, while parental perceptions of automobile safety and neighbourhood pedestrian infrastructure likely influenced a boy's school travel mode outcome, these perceptions did not explain the choice between walking versus being driven for a girl's morning school trip. Although these findings do not fully explain the behavioural mechanisms causing differences in travel mode outcomes between boys and girls, the results perhaps indicate that parental limits and control on mobility may be stronger for girls than boys. Unfortunately, however, gender-specific school travel interventions are rare in a North American context. While more research is needed to fully understand this and other gender-based differences in children's mobility and health behaviour, it is important that policy and programmes begin to recognize the existence of gender gaps and address them when designing school level interventions with a goal of improving AST and physical activity among children.

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