



School site and the potential to walk to school: The impact of street connectivity and traffic exposure in school neighborhoods

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ABSTRACT

The impact of neighborhood walkability (based on street connectivity and traffic exposure) within 2 km of public primary schools on children regularly walking to school was examined. The most ($n=13$) and least walkable ($n=12$) schools were selected using a school-specific 'walkability' index and a cross sectional study undertaken of Year 5, 6 and 7 children ($n=1480$) and consenting parents ($n=1332$). After adjustment, regularly walking to school was higher in children attending schools in high walkable neighborhoods (i.e. high street connectivity and low traffic volume) (Odds ratio (OR) 3.63; 95% Confidence Interval (CI) 2.01–6.56), and less likely in neighborhoods with high connectivity but high traffic volume (OR 0.32; 95% CI 0.22–0.47). Connected street networks provide direct routes to school but when designed for heavy traffic, the potential for children to walk to school is reduced. This highlights the importance of carefully considering school siting and, particularly, street design in school neighborhoods.

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1. Introduction

Encouraging more daily active transport (AT) is one way to increase physical activity levels (Saelens et al., 2003; Andersen, 2007; Ogilvie et al., 2007) and has the potential to produce health, environmental (Mason, 2000; DETR, 2000) and social benefits (Leyden, 2003). AT includes travel by foot, bicycle and other non-motorized vehicles (National Public Health Partnership, 2001) and has dramatically declined in most developed countries in recent decades, particularly in children (Eakin et al., 1996; French et al., 2001; Bradshaw, 2001; Harten and Olds, 2004; McMillan, 2005; Panter et al., 2008; van der Ploeg et al., 2008).

1.1. What factors contribute to children's AT mode choice?

Amongst other things, time, distance, and real and perceived safety are key factors associated with AT in children (Ahlport et al., 2006; Ewing et al., 2004; Timperio et al., 2004; McMillan, 2007; Panter et al., 2008; Davison et al., 2008; Giles-Corti et al., 2009; Tester, 2009). All of these factors are influenced, at least in part, by urban and transportation planning policies that determine the design of neighborhoods surrounding schools. While perceived and real distance to destinations is important, only a fraction of US children who live within 1.6 km (i.e., 1 mile) of school now commute using active modes (Davison et al., 2008), suggesting other factors are at play. Concerns about traffic danger (Harten and Olds, 2004; Jago and Baranowski, 2004; Dellinger and Staunton, 2002; Lam, 2001a; Lam, 2001b; Macpherson et al., 1998; Carlin et al., 1997), lack of supportive infrastructure such as safe crossings (Timperio et al., 2004) and personal safety (Dellinger and Staunton, 2002; DiGiuseppi et al., 1998) are key drivers of parents' willingness to allow their children to use active modes to school without an adult present (Hillman et al., 1990). Parents who insist on driving their child(ren) – particularly those who live within a walkable distance – contribute to traffic congestion around schools,

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making roads less safe for children who want to use, or have no other choice but to use, active modes (Giles-Corti et al., 2009).

There is mixed evidence about the impact of neighborhood walkability on children walking to school. Kerr et al., 2006 found that in high income (but not low income) neighborhoods, more children actively commuted in high walkable compared with low walkable areas. Ewing et al. (2004), on the other hand, found no association between walking or biking to school and land use variables such as density and mix. Rather in this study short distances and the presence of sidewalks were more important. Land use variables are relevant for activities of daily living in adults, but less so for a child's daily commute to school (Schlossberg et al., 2006).

Thus, the evidence suggests that for children to be willing and able to walk to school, first they need to live close enough to school to make AT a viable option. Second, traffic exposure needs to be minimized and traffic control maximized to reduce the amount and speed of traffic (Black et al., 2001).

Since post-WWII, distances to school have increased as a result of policies to increase school sizes (Schlossberg et al., 2006). For example, in the US it has been suggested that the increase in distances to school accounts for one-half of the decline in AT observed (McDonald, 2007). A recent US study estimated that only one-half or fewer children from elementary to high school lived within a 'safe and reasonable' walking distance from their school (defined as within 1.6 km (1 mile)) of the school along the street network and on streets with traffic speeds ≤ 40 km/h (i.e., 25 mile/h) (Falb et al., 2007).

Relatively few studies have examined the potential for children to walk to school by studying the neighborhoods in which schools are sited. Information on the optimal fundamental street design of school neighborhoods would assist urban and transportation planners' decision-making when designing neighborhoods surrounding schools. Thus, the TRavel Environment and Kids study (TREK) developed a school-specific 'walkability' index using a Geographic Information System (GIS) that included measures of street connectivity and traffic exposure within 2 km of all government primary schools. It was hypothesized that children aged 10–12 years attending primary schools located in more walkable neighborhoods (i.e., high connectivity and low traffic exposure) would be significantly more likely to walk to and from school.

2. Methods

Ethics approval was received from The University of Western Australia's Human Ethics Committee. Informed written consent was obtained from all parents and children participating in the study. Data were collected from July to December, 2007.

2.1. Development of a school-specific walkability index

A school-specific walkability index was developed for all government primary schools in metropolitan Perth, Western Australia. Non-government schools were excluded from the study because their school catchment area is generally not limited to the local area, which may preclude children from using AT modes (DiGiuseppi et al., 1998). One government school was also excluded due to incomplete environmental data (final $n=238$).

Neighborhood walkability indices used in adult studies typically use the formal street network as a proxy for the pedestrian network in determining the walkable service area (Frank et al., 2005; Leslie et al., 2007). The informal pedestrian network consists of footpaths, pedestrian access ways at the end of cul-de-sacs and paths through parks, which provide more pleasant routes for pedestrians. Chin, 2004 found that ignoring informal routes may underestimate the walkability of some neighborhoods. Thus, a GIS dataset containing

both the formal street and informal pedestrian network was developed (Chin, 2004). The street network provided the foundation of the pedestrian network and high-resolution aerial photographs (i.e., one meter resolution) were used to digitize the informal networks (e.g., laneways, walkways and pedestrian access ways). A walkable service area (WSA) of 2 km around each school was defined and two walkability indices computed as follows.

2.1.1. Pedshed

The 'Pedshed' (i.e., a ratio of the pedestrian network area to the maximum possible area within a defined distance based on Euclidian (i.e., 'as the crow flies') distance) (Western Australian Planning Commission, 2000) was used to assess the connectivity of the walkable catchment area within 2 km of the school. The Pedshed was calculated using a three-step procedure within the GIS (Chin, 2004). First, a Euclidian distance buffer was created using a 2 km buffer around the school and the area within the buffer computed (referred to as 'the actual area or AA'). Second, a polygon was generated using the pedestrian network within a 2 km buffer around the school and the area computed (the WSA). Finally, the Pedshed for each school was calculated using the formula: WSA/AA. A Pedshed ratio closer to one indicates a more connected pedestrian network. The Pedshed was collapsed into deciles and the groups recoded from 1 to 10 (where 1=least walkable and 10=most walkable) (Leslie et al., 2007). A Pedshed ratio of ≥ 0.6 is said to be a good target for a 'walkable' catchment (Western Australian Planning Commission, 2000) and was, therefore, considered the optimum minimum Pedshed against which we compared the schools.

2.1.2. Vehicular traffic exposure

Previous indices of walkability (Frank et al., 2005; Leslie et al., 2007) typically do not include measures of traffic exposure. However, since traffic exposure influences children's AT behavior (Timperio et al., 2004; Carlin et al., 1997), a new measure was developed and trialed. Universal data for traffic volume were not available, hence 'road function' was used as a proxy for traffic volume based on the Main Roads Department of Western Australia's Functional Road Hierarchy (MRDWA). This hierarchy designated the function of all roads within Perth as follows: Primary Distributors (PD) are major regional and inter-regional roads that carry large volumes (i.e., can carry more than 15,000 vehicles daily) of generally fast moving traffic; District Distributors (DD) carry traffic between industrial, commercial and residential areas and generally connect to PDs and can carry more than 6000 vehicles daily; Local Distributors (LD) that carry traffic within a cell and link DD to Access Roads (AR) and carry no more than 6000 vehicles daily; and AR that carry no more than 3000 vehicles daily and are designed to be bicycle and pedestrian friendly through the prioritizing of amenity, safety and aesthetic features over motor vehicle movement. Using MRDWA GIS data, kilometers of each type of road was estimated within the WSA for each school and the ratio of kilometers of PD+DD+LD to kilometers of AR estimated. The higher the ratio, the higher the exposure to vehicular traffic. These scores were collapsed into deciles where 1=least exposure to traffic and 10=most exposure to traffic and then further collapsed into five categories; ratios greater than one, then four even categories of 0.25 increments below one.

2.1.3. Creation of index

The vehicular traffic decile exposure measure was reverse coded to match the Pedshed deciles (where 1=least walkable and 10=most walkable for both measures), and the two measures were summed together resulting in possible scores ranging from 2 to 20 (see Frank et al. (2005) and Leslie et al. (2007) for a similar approach in adults).

2.1.4. Selection of schools

Each of the metropolitan government primary schools was assigned a neighborhood walkability and SES (high, medium and low) score. The SES score was based on an unpublished index used by the Western Australian Department of Education and Training that provides a measure of the socio-economic (SES) context of the school. The four top and bottom walkable schools in each SES category were invited to participate. To maximize the difference in the urban design of neighborhoods surrounding schools from high and low walkable areas, schools located in semi-rural locations were excluded, as were 'high walkable' schools located on a busy road (defined as a PD road or higher). One additional high walkable low SES school was recruited as students in this category were underrepresented.

Overall, 69.4% of the schools approached agreed to participate ($n=25$). Schools that declined were replaced with the next ranked school. To reduce potential bias in AT patterns that may arise due to the weather, the order of the survey administration day for each school was randomized simultaneously on two factors: neighborhood walkability and SES. Allocation was stratified by Monday or Tuesday. Schools could choose the most suitable survey administration date from the four dates that were related to their school's walkability and SES level.

2.1.5. Study participant selection

One class from each Year 5–7 group in each participating school was randomly selected to participate until a total of 90 children/school and a minimum of 30 children/year group were recruited. Students completed a self-administered survey as a group during a 75 min classroom session. Height and weight were measured. Children were given a questionnaire to be completed by consenting parents. These were returned to the teacher for collection within eight days. Overall, 1480 children participated in the TREK study (a response rate of 56.6%) and 88.8% of their parents ($n=1314$) agreed to participate and completed and returned their questionnaires.

2.1.6. Pilot study

Four additional schools were recruited to participate in pilot studies, during which survey administration methods and the reliability of survey instruments were tested. All items included in the final survey had acceptable (i.e., good to excellent) reliability (kappa or an ICC ≥ 0.6) (Fleiss, 1981).

2.2. Other measures

Demographic and other individual characteristics included gender; year group (Years 5–7); maternal education completed (less than secondary, secondary/trade/diploma, or bachelor degree and higher); and measured height and weight converted into body mass index categories (i.e., acceptable, overweight or obese) using established cut-points (Cole et al., 2000).

2.2.1. Children's mode of transport

This was based on parent proxy ($n=1132$) of the number of trips/week their child(ren) traveled to and from school by various modes (driven, walked, cycled, public transport or other). Responses ranged from 0 to 10 trips/week for each mode, and regular walking to (and from) school defined as ≥ 6 trips/week.

2.2.2. Distance to school

The shortest distance (in meters) along the *pedestrian network* was calculated from each child's home address to the closest 'access point' of the school boundary (i.e. school polygon) using GIS network analyst.

2.3. Statistical analysis

SPSS for Windows version 15.0 and STATA were used for the analyses. For the multivariate analyses, logistic regression models were fitted to the data with Huber-White sandwich estimate of variance in order to adjust for clustering. This estimator is unbiased for cluster-correlated data (Williams, 2000). Single factor and adjusted models are presented. The interaction between the sub-components of the school-specific walkability index (i.e., traffic exposure and Pedshed) is presented in Tables 4 and 5. ArcGIS 9.2 was used for the GIS analyses.

3. Results

3.1. School-specific walkability index

The average Pedshed score for the 238 government primary schools was 0.64 ± 0.27 (range 0.03–1.00), however, approximately one-half (51%) of the schools had a Pedshed score below the 0.6 target for a 'walkable catchment' (Table 1). For 42.5% of metropolitan schools, the length of the low volume roads (i.e., 3000 vehicles/day or less) in surrounding neighborhoods was more than double the length of the high volume roads (i.e., carrying 6000 to $\geq 15,000$ vehicles/day), however, for 7% of schools the length of the higher volume roads exceeded the length of the low volume roads (Table 1). The average walkability for the 238 schools was 10.96 ± 4.39 (range 2–20).

Table 2 compares Pedsheds, the vehicular traffic exposure measure and the walkability index according to school SES. Lower SES schools had a significantly lower Pedshed than high SES schools ($p < 0.05$) and had an average Pedshed below the WA Planning Commission's target for a walkable catchment. Although there was no statistically significant difference in vehicular traffic exposure by SES level, traffic exposure in lower SES school neighborhoods

Table 1

School walkability index component scores for metropolitan government primary schools ($n=238$).

Walkability index component	Mean	SD	Ratio	% of Schools
Pedshed	0.64	0.27	≥ 0.6	49
			< 0.6	51
Vehicular traffic exposure	0.59	0.27	> 1	7.1
			0.76–1.00	13.9
			0.51–0.75	39.1
			0.26–0.50	34.9
			0.00–0.25	5.0

SD—Standard deviation.

Table 2

School walkability index results stratified by school socio-economic status.

SES	Schools (n)	Road volume exposure ^a	Pedshed ^b	Walkability ^c
		Mean $\pm$ SE ^d	Mean $\pm$ SE ^d	Mean $\pm$ SE ^d
High	114	0.58 ± 0.28	0.70 ± 0.26	11.78 ± 4.30
Med	73	0.60 ± 0.29	0.60 ± 0.28	10.58 ± 4.82
Low	51	0.62 ± 0.24	$0.56 \pm 0.27^*$	$9.53 \pm 3.60^*$
Total	238	0.59 ± 0.27	0.64 ± 0.18	10.93 ± 4.41
Test for trend		$p=0.664$	$p=0.003$	$p=0.007$

* Statistically significant ($p < 0.05$).

^a A ratio closer to 1 = more connected neighborhood.

^b A ratio closer to 1 = a greater exposure to traffic.

^c Pedshed and RVE scores collapsed into deciles (RVE reverse coded so that 10 = high walkability 1 = low walkability) and summed together.

^d Differences in SES level for Pedsheds, RVE & overall walkability scores assessed using One-Way-Anova.

was higher than in other school neighborhoods. Overall, neighborhoods surrounding lower SES schools were significantly less walkable than higher SES schools ($p < 0.05$), with this largely driven by the higher connectivity of the pedestrian network.

3.2. School neighborhood walkability and usual walking to and from school

Table 3 presents demographic characteristics and school walkability for the total sample of children and the sample for whom parent proxy data on usual school travel mode was available, and the univariate associations between demographic characteristics, walkability and usual walking to and from school (i.e., ≥ 6 trips/week). As shown, there were few differences between the total sample and the sample for which usual mode of travel data were available, thus, only the latter sample is described. Almost equal proportions of boys (47.4%) and girls (52.6%) participated. Due to a change in school entry age at Year 1 among this cohort, there was a smaller proportion of students across all Western Australian schools in Year 5 compared with Years 6 and 7. The participating schools were fairly evenly matched in terms of the proportion of children attending high (45.8%) and low (54.2%) walkable schools. However, there were slightly more students from high compared with low SES schools. Of the 80% of participants who agreed to participate in the anthropometric testing, nearly one in four were either overweight (20.0%) or obese (3.7%).

After full adjustment (Model 2), the odds of walking to school for ≥ 6 trips/week were 42% higher (OR 1.43; 95% CI 1.11–1.84) in girls than boys (Table 3). No other demographic or area-level characteristic was significant. Although the odds of regularly walking to school was 45% higher in children attending schools in high walkable areas in the single factor model, this result

attenuated after adjustment for clustering and distance to school (OR 0.94; 95% CI 0.65–1.35). For each kilometer a child had to travel school, the odds of regular walking decreased by 86% (0.08–0.24).

Table 4 presents the associations between walking to school ≥ 6 trips/week and the walkability index sub-components (i.e., street connectivity measured by Pedsheds and exposure to traffic). After adjustment for clustering, distance from home to school and all other covariates (Model 2), the odds of walking to school regularly were lower among children attending schools with high Pedsheds (OR 0.49; 95% CI 0.32–1.03). Model 3 extends Model 2 by examining the interaction between the Pedsheds and traffic volume, which was highly significant: compared with children attending schools

Table 4

Single factor and multivariate models examining the association between regular walking to school (≥ 6 trips/week) and individual characteristics, school SES and Pedshed and road traffic exposure.

Characteristic	Model 1 single factor model ^a	Model 2 adjusted model ^b	Model 3 adjusted plus interactions ^b	95% CI
Pedshed (dichotomized at medium)				
Low	1.00	1.00	1.00	
High	1.06	0.49	0.32	0.22–0.47
Road traffic volume (dichotomized at medium)				
High	1.00	1.00	1.00	
Low	1.45	1.64	0.68	0.44–1.06
Road traffic volume $\times$ Pedshed			3.63	2.01–6.56

^a Adjusted for clustering only.

^b Adjusted for clustering and individual-level demographic characteristics, SES of school, pedshed, road traffic volume, distance (km) and distance (km)².

Table 3

Characteristics of total sample and sample for which parent proxy of usual travel mode data provided and prevalence of walking to school by individual and environmental characteristics.

Characteristic	Total (n=1480) (%)	Sub-sample (n=1132) (%)	Walks < 6 trips/week (%)	Walks ≥ 6 trips/week (%)	p-value	Model 1 Single factor model ^b	Model 2 Adjusted model ^d	95% CI
Overall (%)	100	100	71.8	28.2				
Gender (%)								
Male	48.7	47.4	75.6	24.4	0.007	1.00	1.00	
Female	51.3	52.6	68.4	31.6		1.43	1.43	1.11–1.84
Year level (%)								
5	26.5	27.4	71.9	28.1	0.998	1.00	1.00	
6	35.9	35.4	71.8	28.2		1.01	1.07	0.72–1.58
7	37.6	37.2	71.7	28.3		1.01	1.04	0.67–1.61
Maternal education (%)								
Less than Secondary	24.2	28.6	75.9	24.1	0.167	1.00	1.00	
Secondary/trade/diploma	45.3	50.9	70.8	29.2		1.30	1.20	0.82–1.74
Bachelor degree or higher	14.1	14.9	66.9	33.1		1.56	1.61	0.99–2.62
No response	16.5	5.6	73.0	27.0		1.17	0.93	0.44–1.99
Weight status ^a (%)								
Acceptable weight	75.9	76.3	71.3	28.7	0.514	1.00	1.00	
Overweight or obese	24.1	23.7	73.6	26.4		0.89	0.89	0.60–1.33
Refused						0.99	1.01	0.62–1.64
SES of school (%)								
Low	27.3	25.7	68.4	31.6	0.094	1.00	1.00	
Medium	34.8	36.4	75.5	24.5		0.70	0.85	0.54–1.33
High	37.9	37.9	70.6	29.4		0.90	0.72	0.48–1.06
Walkability of school neighborhood (%)								
Low	53.6	54.2	75.2	24.8	0.005	1.00	1.00	
High	46.4	45.8	67.8	32.2		1.45	0.94	0.65–1.35
Distance (mean km [SD])	1.69 (0.07)	1.80 (0.08)	2.25 (0.96)	0.66 (0.75)	< 0.001	0.14 ^c	0.14	0.08–0.24

^a 299 students did not participate in the anthropometric measurements.

^b Adjusted for clustering only.

^c Adjusted for distance (km)² and clustering only.

^d Adjusted for clustering and individual-level demographic characteristics, SES of school, school walkability, distance (km) and distance (km)².

Table 5

Multivariate model^a showing adjusted interaction between Pedshed and road traffic exposure and association with regular walking to school (≥ 6 trips/week).

		Pedshed	
		Low	High
Road volume	High	1.0	0.32 (0.22–0.47)
	Low	0.68 (0.44–1.06)	3.63 (2.01–6.56)

^a Adjusted for clustering and individual-level demographic characteristics, SES of school, pedshed, road traffic volume, distance (km) and distance (km)².

located in areas with low connectivity (i.e., low Pedshed) and high traffic exposure, the odds of walking to school were three times higher (OR 3.63; 95% CI 2.01–6.56) in children attending schools located in high walkable areas (i.e., with high Pedshed and low traffic) (Table 4).

Table 5 unpacks the interaction term. After adjustment, the odds of regularly walking to school were almost 70% lower (OR 0.32; 95% CI 0.22–0.47) in children attending schools in areas with both a high Pedshed and high traffic exposure compared with a low Pedshed and high traffic exposure. Although not shown, for children attending schools located in low traffic volume areas, the odds of walking regularly to school were also more than twice as high (OR 2.48; 95% CI 1.56–3.93) if the school had a high rather than a low Pedshed.

4. Discussion

There is considerable evidence that proximity and traffic are important predictors of children's AT. Nevertheless, few studies have specifically studied the impact of the street design surrounding schools to provide specific guidance to urban and transportation planners responsible for siting schools. This study found a highly significant interaction between street network connectivity (measured by pedsheds) and traffic exposure that has not been identified previously. Importantly, children attending schools located in areas with roads with both high street connectivity and high traffic volumes were less likely to walk, while those attending schools in areas with high connectivity and low traffic were more likely to walk.

These results highlight the importance of planning decisions about the siting of primary schools and suggest that state and local government fundamental sub-division design principles require greater emphasis on child pedestrians, particularly around schools. There is ample evidence that parental concerns about traffic safety are key drivers in their decision about whether or not to allow their child(ren) to use active modes to travel to school (Timperio et al., 2004, 2006; Kerr et al., 2006; McMillan, 2005). Our results suggest that the impact of traffic on children's walking behavior is amplified positively or negatively, depending upon neighborhood street network design. Timperio et al. (2006) found that street connectivity was negatively associated with active commuting to school, but this may be because connected street networks have the potential for more traffic, higher speeds, and more street crossings (Sirard and Slater, 2008). Each of these factors increases the risk of pedestrian injury (Sirard and Slater, 2008).

While it is laudable (and desirable) to encourage children to walk to school, our results suggest that these efforts will be hampered unless urban and transport policies ensure that streets near school are highly connected to minimize distances between home and school, yet carry lower levels of traffic (Sirard and Slater, 2008), and that school catchment areas are proximate to schools (Ewing et al., 2004). This is important, given global trends towards increasing the size of primary schools, which increases the size of

school catchment areas and decreases the proximity of schools to students' homes (Ewing et al., 2004; Schlossberg et al., 2006; McDonald, 2007; Falb et al., 2007). For example, in the US the median distance between home and school for children aged up to 15 years is now said to be two miles (i.e., 3.2 km) (Dellinger and Staunton, 2002). Children who live within one mile of school (1.6 km) are three to five times more likely to walk or cycle to school than those living further away (Davison et al., 2008). Thus, the potential for children to walk is clearly diminished if schools are not within a real and perceived 'walkable' distance.

These findings support those found elsewhere (Ewing et al., 2004; Schlossberg et al., 2006; Sallis et al., 2004) and highlight the need for health and broader societal objectives to be aligned. For example, as pressures mount on government budgets, the number of schools has decreased and school catchment areas increased (Davison et al., 2008; Schlossberg et al., 2006; McDonald, 2007). Together with the growth in private school education, this increases the number of children attending schools outside of their neighborhoods (Davison et al., 2008). The unintended consequences of these trends has been to increase distances traveled to school and the amount of traffic on the road, thereby reducing the ability of children to walk or cycle to school.

Transportation planning that facilitates driving for the convenience of busy parents wishing to drop their child(ren) at school en route to work, increases traffic congestion on roads near schools reinforcing parental concerns about traffic safety and decreasing the safety of school routes. Thus, planning school neighborhoods focusing on the needs of child-pedestrians and cyclists (Ewing et al., 2004)—by designing accessible schools with low traffic exposure, sidewalks and drop-off zones some distance from the school—would increase the potential for walking and cycling to school, and decrease the need for children to be chauffeured. Moreover, it could decrease the risk of establishing a pattern of automobile dependence in children that carries over into adolescence and adulthood. These results suggest that pressures to site schools on busy roads should be resisted (Giles-Corti et al., 2009).

In this study, children attending schools in low SES areas were no more likely than others to regularly walk to school, findings inconsistent with previous research (Davison et al., 2008), some of which suggests that children in lower income areas also travel further to school than their higher SES counterparts (Macpherson et al., 1998). Nevertheless, children with lower SES backgrounds are more likely to be injured in child pedestrian accidents (Zhu and Lee, 2008), and in this study and others (Stevenson et al., 1996, 1995), these children appeared more likely to live in less supportive neighborhoods with increased exposure to traffic hazards. There is a priority to create safer neighborhoods for these vulnerable youth.

4.1. Limitations

This study has a number of limitations. Its cross-sectional design limits causal inferences being drawn. The school-specific walkability index included only two sub-components and may be strengthened by additional sub-components. For example, higher residential densities surrounding schools theoretically could increase the number of children who have the potential to walk to school. Density *per se* has not been found to be associated with school trips (Pont et al., 2009). However, there may be value in exploring interactions with other variables (e.g., exposure to traffic). In terms of traffic exposure, there also may be superior methods for creating traffic exposure measures, which warrant further investigation. Most children in this study lived within 2 km of the school. Removal of those living further away, did not substantially alter the final results, hence, these were included in the final analyses presented. Finally other social and individual

factors are likely to be associated with a child's active commute to school (e.g., parental perceptions and preferences). However, the focus of this paper was on creating the conditions that facilitate children walking to school, and school proximity and traffic safety are fundamental to parental decision-making.(McMillan, 2005).

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