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Influence of social and built environment features on children walking to school: An observational study

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ABSTRACT

Objectives. To estimate the proportion of children living within walking distance who walk to school in Toronto, Canada and identify built and social environmental correlates of walking.

Methods. Observational counts of school travel mode were done in 2011, at 118 elementary schools. Built environment data were obtained from municipal sources and school field audits and mapped onto school attendance boundaries. The influence of social and built environmental features on walking counts was analyzed using negative binomial regression.

Results. The mean proportion observed walking was 67% (standard deviation = 14.0). Child population (incidence rate ratio (IRR) 1.36), pedestrian crossover (IRR 1.32), traffic light (IRR 1.19), and intersection densities (IRR 1.03), school crossing guard (IRR 1.14) and primary language other than English (IRR 1.20) were positively correlated with walking. Crossing guard presence reduced the influence of other features on walking.

Conclusions. This is the first large observational study examining school travel mode and the environment. Walking proportions were higher than those previously reported in Toronto, with large variability. Associations between population density and several roadway design features and walking were confirmed. School crossing guards may override the influence of roadway features on walking. Results have important implications for policies regarding walking promotion.

Introduction

The effect of the built environment on physical activity is a topical issue in public health (Shay et al., 2003). Interventions directed at the “walkability” of the built environment have been promoted to encourage healthy active living. Walkability is a complex concept, and definitions are varied as are approaches to operationalizing the concept using modeling techniques. The concept of walkability will continue to be context-specific until there exists a validated and consistent list of environmental correlates of walking.

Many studies have examined the correlates of adult walking, with some consensus that adult walking is related to density, mixed land use, pedestrian infrastructure (e.g. sidewalks, crosswalks) high connectivity (grid network, short block lengths, many intersections, few cul-de-sacs/dead ends) and accessibility to multiple destinations (Saelens and Handy, 2008; Saelens et al., 2003; Shay et al., 2003). Walkability studies for elementary school children generally focus on walking to school, which has consistently been negatively associated with distance (Pont et al., 2009; Sirard and Slater, 2008; Wong et al., 2011), and positively associated with population density (Braza et al., 2004; Bringolf-Isler et al., 2008; Kerr et al., 2006; Kweon et al., 2006; McDonald, 2007; Mitra et al., 2010b; Wong et al., 2011). Associations with land use, pedestrian infrastructure and connectivity have been inconsistent and often contradictory to findings in adult studies (Pont et al., 2009; Wong et al., 2011). Environmental features correlated with adult walking may be different than those for children because of differing destinations and purposes for walking.

Varied methods of measurement for both built environment and walking outcomes may contribute to inconsistent results (Pont et al., 2009; Saelens and Handy, 2008; Sirard and Slater, 2008; Sirard et al., 2005; Wong et al., 2011). Walking outcome has generally been measured through parent/child report using different outcome definitions (e.g. usual trip, trip per/week), time frames, and targeted age ranges. To date, only one study incorporated direct observational counts of children walking to school; however, that study was limited by small sample size and little geographic diversity (Sirard et al., 2005).

Abbreviations: JK, junior kindergarten; TDSB, Toronto District School Board; DA, dissemination area; MPAC, Municipal Property Assessment Corporation; LOI, learning opportunities index; ATLICO, after tax, low income cut-offs; VIF, variance inflation factor; IRR, incident rate ratio; 95% CI, 95% confidence intervals.

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The purposes of this study were to 1) estimate the proportion of children living within walking distance to school who walk to school in a Canadian city and 2) correlate built and social environment features (with a focus on roadway design), with observational counts of children walking to school.

Methods

Study design, setting and population

A prospective observational study was conducted in the spring, 2011, involving junior kindergarten (JK) to grade 6 elementary schools in Toronto, Canada. Toronto consists of an older urban core characterized by pre-World War II traditional neighborhoods, and 5 inner suburb municipalities, representing newer, car-oriented post-World War II neighborhoods (City of Toronto, 2001).

Exclusion criteria were schools with 1) other grade combinations 2) special programs, which accept children from outside the school attendance boundaries (e.g. French immersion) and 3) involvement in other walking studies. Children arriving by school bus were excluded as they don't live within walking distance to the school. The Toronto District School Board (TDSB) transportation policy states that children grades JK-5 who live ≥1.6 km and those grades 5+ who live ≥3.2 km from their school are eligible for school bus transportation (TDSB, 2005). Ethics approval was obtained from the Hospital for Sick Children Research Ethics Board and the TDSB.

Outcome variable

Trained observers counted children arriving to school walking, by other active means (i.e. bicycle and scooter) or by private motorized vehicles. Observations were repeated at 10% of the schools, one week apart to determine test–retest reliability. The proportion of children walking to school was calculated from the total number of children observed and excluded those arriving by school bus.

Independent variables

Built environment features were identified from a literature review. All variables were mapped onto school attendance boundaries provided by the TDSB. Features were classified according to Cervero and Kockelman's 3D's: Density, Diversity and Design, originally developed to study adult walking behavior but which has since been applied to children's school transport (Cervero and Kockelman, 1997; Lin and Chang, 2010; Wong et al., 2011). The focus of the analysis was on roadway design features, as these are most feasible to change in existing neighborhoods compared with those related to density and diversity. Table 1 presents the variables considered for the multivariate modeling.

Table 1
Descriptive statistics of candidate variables for multivariate modeling.

Variable description	Mean (SD)/N (%)
Outcome	
Proportion walking to school[a,1]	67.3% (14.50)
Natural environment	
Poor weather (rain or cold) [c,5]	35 (29.66)
Built environment	
Density	
School boundary level	
Child population (#)/1000 m^2 [b,2]	0.54 (0.26)
Total population (#)/1000 m^2 [b,2]	6.09 (3.57)
Multi-dwelling (apartments, duplexes) (#)/1000 m^2[b,2]	1.43 (1.30)
Diversity	
School boundary level	
Recreational facilities (#)/km^2 [b,3]	1.78 (1.58)
Park land area/boundary[a,3]	7.60% (6.85)
Entropy (mixed land use) [b,4]	0.61 (0.13)
Commercial land use area/boundary [a,4]	6.49% (7.32)
Residential land use area/boundary [a,4]	44.2% (2.23)
Industrial land use area/boundary[a,4]	6.31% (8.96)
Institutional land use area/boundary[a,4]	8.65% (6.67)
Vacant land area/boundary[a,4]	8.75% (7.03)
Design	
School level	
School crossing guard observed[c,5]	45 (38.14%)
Cars appear to be driving fast near school[c,5]	56 (47.46%)
Traffic congestion seen around school during drop off [c,5]	76 (64.41%)
Dangerous midblock crossing near school [c,5]	70 (59.32%)
Dangerous intersection near school [c,5]	40 (33.9%)
Drop offs opposite side of road [c,5]	83 (70.30%)
Double parking[c,5]	54 (45.80%)
Cars blocking view[c,5]	73 (61.90%)
Mean speed >5 km over speed limit[c,5]	16 (13.56%)
School traffic/minute[b,5]	2.14 (1.00)
School boundary level	
Other schools within school boundary (#)[c,6,7]	39 (33.1)
Old houses (pre 1946) (#)/1000 m^2[b,2]	0.57 (0.82)
Collector roads km/km roads[b,3]	0.15 (0.09)
Crossing guard (#)/km roads[b,3]	0.12 (0.10)
Dead end (#)/km roads[b,3]	0.16 (0.20)
Flashing lights (#)/km roads [b,3]	0.07 (0.09)
Intersection (#)/km roads[b,3]	5.63 (1.75)
Route connectivity (intersections/dead ends)[b]	1.16 (0.20)
Local road km/km roads[b,3]	0.61 (0.15)
Major roads km/km roads[b,3]	0.16 (.10)
Minor roads km/km roads[b,3]	0.08 (.07)
One way streets km/km roads [b,3]	0.07 (.12)
Pedestrian crossover (#)/km roads[b,3]	0.10 (0.12)
Roads km/km^2[b,3]	12.53 (4.99)
Sidewalks (one) missing km/km roads[b,3]	0.08 (.09)
Sidewalks (both) missing km/km roads[b,3]	0.04 (.09)
Traffic calming segment km/km roads (e.g. speed bumps)[b,3]	0.05 (.07)
Traffic light #/km roads[b,3]	0.53 (.29)
Trails km/km road[b,3]	0.51 (0.67)
Urban area[c,3]	39 (33.05%)
Social environment	
School level	
Total school population[b,6]	309.67 (143.94)
Males at school (#)[a,6]	51.64 (31.61)
New immigrants (≤5 years)[a,6]	11.57 (8.73)
Primary language other than English[a,6]	47.99 (24.98)
Children grades 4 to 6[a,6]	32.75 (4.56)
School LOI[b,6]	0.50 (0.28)
At below LICO cut-off (school DA)[a,2]	13.76 (10.88)

Data type: [a]proportion, [b]continuous [c]dichotomous.
Data source: [1]Observational counts, [2]Canadian Census, [3]City of Toronto, [4]MPAC, [5]Site Survey, [6]Toronto District School Board, [7]Toronto Catholic District School Board.

Built environment

Density

Population density variables were obtained from the 2006 Canadian census by dissemination area (DA). DAs are the smallest standard geographic area for which all census data are disseminated with approximately 400–700 residents. DAs were mapped onto school boundaries and area-weighted proportionate analysis was used to estimate the census variables for each boundary (Braza et al., 2004; Falb et al., 2007).

Diversity

Diversity variables reflect different land uses. Recreational facilities and parks data were obtained from the City of Toronto and parcel level data by land use category was obtained from the Municipal Property Assessment Corporation (MPAC). Individual land uses were calculated as percentage of the school boundary. The mix of residential, commercial, industrial, institutional, and vacant land use (including parks and walkways) within school boundaries was measured using an entropy index:

$$\text{Land use mix} = \Sigma_u(p_u \times \ln\ p_u)/\ln\ n$$

where u = land use classification, p = proportion with specific land use, and n = total number classifications. Scores of 0 = single land use, 1 = equal distribution of all classifications (Frank et al., 2004; Larsen et al., 2009).

Design

Roadway design variables were obtained at the school level from school site audits conducted by two trained observers. The presence of adult school guards employed by Toronto Police Services was recorded. Vehicle speed and volume were measured using manual short-based methods by a third observer along a roadway within 150 m of the school (Donroe et al., 2008; Marler and Montgomery, 1993).

Design variables at the school boundary level were obtained from the City of Toronto and densities were calculated per school boundary area or linear km of roadway. The school was designated urban if over 50% of the attendance boundary fell within the inner urban area.