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ORIGINAL ARTICLE

Beyond Distance: Children's School Travel Mode Choice

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Abstract

Background Long distance is a leading environmental barrier to walking to school and requires long-term, multilevel interventions. Meanwhile, childhood obesity remains highly prevalent, calling for more immediate solutions.

Purpose The purpose of this study was to examine attitudinal and environmental correlates of walking to the elementary school, controlling for distance.

Methods Using parental survey data, 601 child pairs with matched home locations and different school travel modes (walking vs. private automobile) were examined, using conditional logistic regressions.

Results Despite the same/similar objectively measured distance and home location, perceptions of distance, sidewalk and traffic conditions, park presence, and convenience of walking differed between walkers and automobile users. Parental attitudes and children's preferences were associated with the odds of walking. Safety concerns (traffic danger, stranger danger, and getting lost) were higher among drivers, but only significant in bivariate analyses.

Conclusions To promote walking to school, route/street improvements appear promising, but parallel educational and promotional efforts may be needed to address perceptual and attitudinal barriers.

Keywords Active living · Built environment · School transportation · Walking to school

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Introduction

Walking to school is promoted as a healthy alternative to being driven to school. However, private automobiles remain the predominant school travel mode (45.3 % mode share) followed by school buses (39.4 %), while walking or bicycling together account for only 12.7 % of the total school transportation mode share in the USA as of 2009 [1]. In addition to personal and social factors such as parents' education, income and attitudes, children's age, race, gender and attitudes, and peer influence [2, 3], studies have found many built environmental factors associated with school travel behaviors [4–6]. Environmental approaches to promote walking to/from school have become increasingly popular with the recognition that a safe environment is a prerequisite to any promotional efforts. Further, environmental improvements are relatively permanent and can lead to population-level changes over time if successful.

Among the environmental correlates, home-to-school distance has shown to be the most consistent and often the strongest predictor of school travel mode choice, followed by safety and weather [7–9]. However, shortening the distance to school is not simple. It requires long-term, multilevel policy and environmental changes, such as school siting, zoning, and land development policies/practice.

Meanwhile, more immediate and readily implementable environmental solutions are needed to promote active transportation to school, which can help address the high and socio-demographically unequal prevalence of physical inactivity and childhood obesity. Also importantly, even for students living within a walkable distance, many still do not walk to school due to other personal and environmental barriers. For example, according to this study's survey data, 24.2 % of the parents/guardians who perceived the home-to-school distance to be close enough for their child to walk reported still driving their child to school [10]. Targeted promotion for students living within a walkable distance but not walking will have greater potential for success than interventions targeting those living too far to walk to school. Further, inner-city, lower-income, and minority students tend to live closer to school and outside the school bus service area (defined as beyond 2 miles from the school or within 2 miles but with hazardous conditions such as freeway barriers in Texas) and/or do not have a car in their household. These students may be forced to walk as they lack other transportation options, but the health benefits of walking may be compromised by significantly higher crime and crash risks en route to school [11]. Therefore, addressing environmental barriers other than distance can bring more benefits to those children who are more vulnerable to both environmental and personal risk factors related to safety threats and poor health outcomes.

A growing number of studies have reported that modifiable microscale environmental features such as sidewalks, crosswalks, signals, and lighting are important in encouraging or discouraging walking to school [12, 13]. However, compared to the macroscale factors such as distance, highway presence, and neighborhood safety, the roles of microscale elements are not well understood due to limited data availability. While many macroscale variables are often available from the existing sources such as Geographic Information Systems (GIS), data for microscale variables are rarely found from secondary sources, requiring new surveys or field audits/observations which are costly and time consuming. Another important group of variables that require further attention are those related to attitudes, awareness, and behavioral preferences which have been shown to be important in predicting school travel mode choice [12, 14, 15].

Utilizing 601 child pairs living in the same/similar home location (not from the same household) but using different school travel modes (walking vs. private automobile), this study offers insights into more readily modifiable environmental features than the physical distance that can promote walking to/from school. This study used data from a new survey instrument designed to gather all study variables for this specific study, including socio-demographics, attitudes, and preferences, as well as macroscale and microscale environmental factors, relevant to walking to school. By controlling the most influential factor (distance), this paired comparison method increases the statistical power to detect other significant and more easily modifiable correlates. The main hypotheses of this study are that despite the same built environment, parents who walk their child to school will have significantly (1) more positive perceptions of walkability, (2) less safety concerns about walking to/from school, and (3) more positive attitudes and greater preferences toward walking and physical activity.

Methods

Study Population and Setting

This research studied students attending 22 public elementary schools in the Austin Independent School District (AISD). The district has a total of 81 elementary schools as of 2011 and serves most of the city of Austin, Texas, USA. The study population and schools were purposively sampled to ensure a wide range of socioeconomic and environmental characteristics and to over-sample inner-city and lower-income students who are at higher risk of obesity but will not be well represented under a random sample scenario. As a result, the study schools had more Hispanic students (57.1 and 58.9 % based on 2006–2007 and 2009–2010 academic year data) and more lower-income students eligible for free or reduced-price lunch (61.0 and 63.5 %) than the district-wide average (46.3 and 48.6 % of Hispanic students and 55.5 and 59.0 % of free or reduced-price-lunch-eligible students for the two academic years, respectively) [16]. Geographically, Hispanic students were more concentrated in the eastern areas of the district, which also had higher percentages of lower-income households (Fig. 1). The study area included diverse neighborhoods with a wide range of built environmental characteristics (e.g., street pattern, sidewalk availability, land use, density, etc.) and safety conditions (e.g., crime and crash rates) as reported previously [11].

Study Design

In order to control for the actual home-to-school distance, this study identified student pairs who lived in the same/similar home location (and therefore had the same/similar home-to-school distance and objective environmental conditions in neighborhoods and along home-to-school routes) but used different school travel modes (walking vs. private automobile). This paired structure is somewhat similar to that of twin studies assessing environmental influences on health-related outcomes, controlling for genes [17]. Twin studies explore the discordance of a target outcome variable

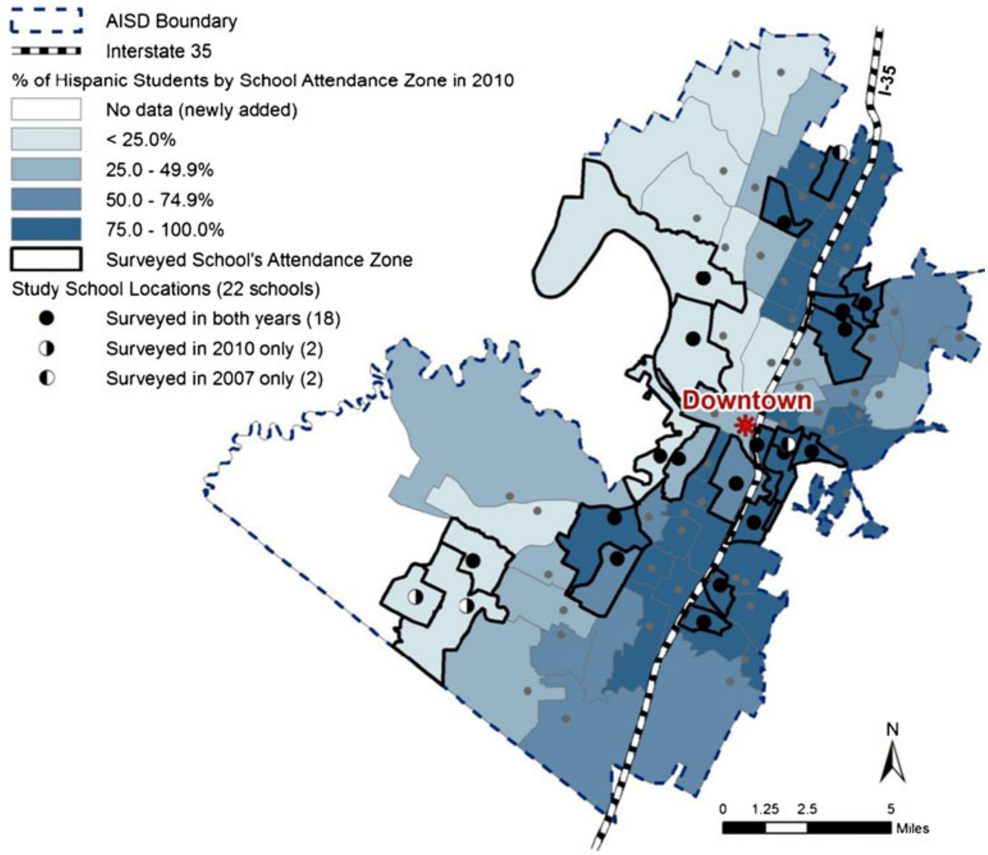

Fig. 1 Study schools and settings: elementary schools in Austin Independent School District and locations of 22 study schools surveyed in 2007 and 2010

between twin pairs with enhanced ability to control for many other potential causal factors [18]. In this study, examining the discordance between the walkers and drivers controlling for home locations allows us to control for the impact of the most influential environmental predictors of school mode choice: objectively measured home-to-school distance and objectively measured neighborhood, home-to-school route, and school environments. For the purpose of this study, children walking to/from school are considered as case subjects, and those driven to school as control subjects. Walkers in this paper refer to students walking to or from school, and drivers refer to students being driven to and from school.

Data Collection Method

This study used two rounds of parental surveys carried out in 2007 and 2010 (response rates=22.7 and 34.2 %, respectively). Hard copy surveys along with a cover letter were sent home from school via students' weekly portfolios, and completed surveys were returned to the students' teachers also via weekly portfolios. The survey administration process was assisted by the city of Austin. Small incentives were provided to the participating parents/guardians and students, and the participating schools' teachers and staff. The study protocols and instruments were approved by AISD and the Texas A&M University Institutional Review Board.

A four-page bilingual (English and Spanish) survey instrument was developed based on the literature, the National Center for Safe Route to School survey, and three previously validated instruments [19–21]. The surveys included items related to: (a) children's socio-demographic and health/disease status information, (b) school travel mode and physical activity behaviors, (c) parental attitudes toward school transportation, (d) parental and children's preferences for walking and parental perceptions about walking, (e) overall neighborhood environments, (f) home-to-school route qualities, and (g) environmental and safety barriers to walking to school. The test–retest reliability of the survey instrument was examined with the data collected from 17 respondents who completed the same survey twice with an interval of 2 or 3 weeks. The overall mean intraclass correlation coefficient (ICC) was 0.998 averaging ICCs from all subscales (range, 0.981–1.000), and the overall kappa mean was 0.718 (range, 0.409–0.966), across 148 individual items and 21 subscales [22]. The English version survey instrument was developed first and translated into Spanish by two bilingual persons independently and translated back to English by another two bilingual persons. All inconsistencies between the original and the back-translated versions were thoroughly discussed among the research team and the translators, and several minor modifications were made to the Spanish versions. The final Spanish version was reviewed again by a small convenience sample of respondents (N=14) and confirmed for clarity and consistency in wording and the overall organization.

Identification of Walker–Driver Pairs

The paired data were used to control the undue influence of distance and therefore to facilitate the identification of other important and more easily modifiable correlates of walking to school. The matched pairs of children were identified based on: (a) one child from each pair walked to or from school (the walker) and the other driven to and from school (the driver), (b) both students attending the same school, and (c) both students' home locations were the same (e.g., the same apartment complex or duplex) or nearby (≤200 ft). The matched pairing process started by geocoding all respondents' home addresses from the surveys (Fig. 2). Out of 7,223 completed surveys returned from both data collection rounds, 6,540 (90.5 %) addresses were successfully geocoded using GIS software ArcGIS 10.0. A subset of 4,849 respondents were selected according to the criteria of either driving or walking to school and living within 2 miles from school (walking is usually difficult beyond this distance, and school bus service is provided beyond this distance in Texas) [23]. Next, the closest walker–driver pairs were identified in GIS, and only those within 200 ft from each other were kept, resulting in 699 matched pairs. All but the within-pair home distances (200 ft airline distance) were based on the street network distance.

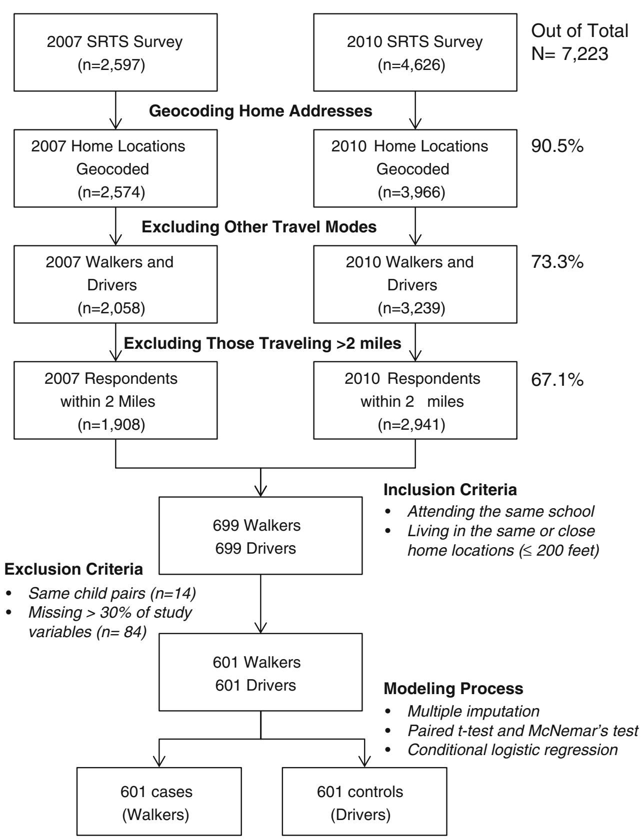

Fig. 2 Matched pairing and analyses process

In order to ensure the validity of the data, two exclusion criteria were applied: missing values (84 pairs excluded for missing >30 % of study variables) and same-child pairs (14 pairs excluded). We used surveys from two different years, and therefore, there was a possibility of the same parent answering for the same child twice and still qualified as a pair. The 14 excluded same-child pairs were identified by having the matching age, gender, name, address, and the number of siblings. Finally, an additional test was carried out to help assess if the actual built environment changed between the two survey years. The GIS data collected from 2007 and 2010 and the geocoded home and school locations were used to generate two test variables that were available: presence of parks and presence of highways along the shortest route from home to school. The results showed no significant differences (p=1.000 for both variables). This test supported that macro-level variables are not likely to change over a short period. However, it is still possible that other variables such as land uses or micro-level variables such as sidewalks or crosswalks could have changed, but repeated measures of those other variables were not available. This entire selection and exclusion process yielded the final sample size of 601 matched child pairs to be used in this study (Fig. 2).

Outcome Variable

Respondents were asked about the typical travel mode that their child used to get to and from school. Seven modes were included as response options: walk alone, walk with friends, walk with a parent/adult, bicycle, school bus, public bus or light rail, and private car (including carpool). For this study, a dichotomous outcome variable was used: walkers vs. drivers. The walker category combined "walk alone," "walk with friends," and "walk with a parent/adult," and the driver category included those who used a "private car" (Table 1).

Control Variables

The distance between home and school was the control variable in this study. About half of the matched pairs (51.1 %) lived in the same location (e.g., same apartment or duplex), and the rest lived within 200 ft (61.0 m) of each other. The mean distance to school was exactly the same between walkers and drivers (0.491 miles or 791.2 m).

Table 1 Respondent characteristics: descriptive statistics and bivariate tests

Variable	Walker	Driver	Bivariate test[a]
Distance (ft) between matched pairs (mean±SD)	47.9±61.87		–
0 ft (*N* (%))	307 (51.1 %)		–
1–100 ft (*N* (%))	154 (25.6 %)		
101–200 ft (*N* (%))	140 (23.3 %)		
Walking type (*N* (%))			
Alone	51 (8.5 %)	–	–
With friends	122 (20.3 %)	–	–
With parent/adult	428 (71.2 %)	–	–
Female (*N* (%))	325 (54.4 %)	319 (53.3 %)	χ^2=0.225 (p=0.636)
Grade (mean±SD)[b]	1.90±1.826	1.61±1.768	t=2.798 (p=0.005)
Hispanic (*N* (%))	441 (76.2 %)	418 (73.2 %)	t=−1.264 (p=0.207)
BMI percentile (mean±SD)	67.63±36.451	70.71±34.729	t=−1.232 (p=0.220)
Special lunch (*N* (%))[c]	228 (81.7 %)	251 (79.4 %)	–
Parental education (*N* (%))			
≥College/associate degree	166 (28.3 %)	232 (39.5 %)	t=−7.535 (p<0.001)
Number of siblings (mean±SD)	2.68±1.261	2.57±1.198	t=1.488 (p=0.137)
Years living in current residence (mean±SD)	4.34±4.647	4.56±4.402	t=−1.586 (p=0.113)
Reason to choose the neighborhood: *N* (%)			
Housing/rent price	204 (34.4 %)	235 (39.4 %)	χ^2=4.472 (p=0.034)
Close to school	322 (54.3 %)	276 (46.3 %)	χ^2=7.652 (p=0.006)
Easy to walk around	142 (23.9 %)	68 (11.4 %)	χ^2=32.102 (p<0.001)
Cars in the household (mean±SD)	1.40±1.056	1.66±0.895	t=−5.892 (p<0.001)
Driver's licenses in the household (mean±SD)	1.33±0.823	1.57±0.710	t=−6.346 (p<0.001)

[a]Paired *t* test and McNemar's test were used for the matched child pair data

[b]Students' grades were coded as "−1" for prekindergarten and "0" for kindergarten

[c]Not surveyed in 2007 and excluded from bivariate tests

Independent Variables

The main independent variables are environmental perceptions about (a) walkability, (b) safety concerns, and (c) parental attitudes and preferences (Table 2). Initial candidate variables were identified based on the study hypotheses: perceived accessibilities (12 variables), perceived environmental barriers (4), perceived sidewalk conditions (4), perceived overall walking environments (7), safety concerns (7), personal barriers to walking (4), and personal motivators of walking (9) (Table 2). These variables were measured as presence vs. absence or on a 5-point Likert scale (1="strongly disagree" to 5="strongly agree"). An exception was the sidewalk condition variable, which had one more category (0) to indicate a condition where no sidewalk existed, making it a 6-point scale variable.

Confounding Variables

Theoretically and statistically important personal and social factors were considered as confounding factors in this study based on the extant literature (Table 1) and later used to build the base model in the multivariate analyses. They included children's age, race, gender, grade, body mass index (BMI) percentile, and special lunch qualification, and parents' education levels, number of siblings, number of cars and drivers' licenses, years lived in the current residence, and reasons for choosing the current neighborhood.

Statistical Analysis

All candidate variables listed in Table 2 were tested for the item reliability and their bivariate association with the outcome variable. To compare between walkers and drivers, paired samples *t* test and McNemar's test [24] were used. Those variables significant at the 0.05 level were considered for the multivariate analysis [25, 26]. Due to the matched-pair nature of the data, study variables had a significant number of missing values ranging from 2.0 to 11.8 %. Multiple imputation models were used to impute variables missing greater than 5 %, and random or median imputation methods were applied to those missing less than 5 % [27]. With five iterations of imputations, multiple imputation models specified with socio-demographic variables predicted the missing values [28, 29]. All imputations were performed for walkers and drivers separately.

Table 2 Environmental, attitudinal, and preference factors between walkers and drivers: descriptive statistics, bivariate tests, and reliability tests

Variable	Walker	Driver	Bivariate test	Cronbach's α if item deleted[e]
Environments: walkability				
Home-to-school airline distance (mean±SD)[a]	0.491±0.285	0.491±0.285	t=−0.011 (p=0.991)	
≤0.5 miles	377 (62.7 %)	376 (62.6 %)		
0.51–1.0 miles	189 (31.4 %)	190 (31.6 %)		
1.01–2.0 miles	35 (5.8 %)	35 (5.8 %)		
Perceived being close enough for walking (N (%))	440 (73.2 %)	378 (62.9 %)	χ^2=19.380 (p<0.001)	
Accessibility on home-to-school route (Cronbach's α=0.701) (N (%))[b]				
Presence of playground	120 (20.0 %)	118 (19.6 %)	χ^2=0.006 (p=0.939)	0.690
Presence of park	127 (21.1 %)	96 (16.0 %)	χ^2=6.207 (p=0.013)	0.693
Presence of walking path	156 (26.0 %)	149 (24.8 %)	χ^2=0.183 (p=0.669)	0.713
Presence of convenience store	86 (14.3 %)	127 (21.1 %)	χ^2=12.800 (p<0.001)	0.663
Presence of bakery/cafe/restaurant	53 (8.8 %)	62 (10.3 %)	χ^2=0.877 (p=0.349)	0.655
Presence of small retail	62 (10.3 %)	66 (11.0 %)	χ^2=0.090 (p=0.764)	0.656
Presence of bus stop	257 (42.8 %)	272 (45.3 %)	χ^2=0.912 (p=0.340)	0.679
Presence of community center	32 (5.3 %)	29 (4.8 %)	χ^2=0.075 (p=0.784)	0.695
Large parking lot/garage	101 (16.8 %)	103 (17.1 %)	χ^2=0.006 (p=0.937)	0.672
Presence of large office building	41 (6.8 %)	61 (10.1 %)	χ^2=4.198 (p=0.040)	0.674
Presence of industrial site	23 (3.8 %)	23 (3.8 %)	χ^2=0.000 (p=1.000)	0.699
Presence of vacant lot	83 (13.8 %)	98 (16.3 %)	χ^2=1.390 (p=0.238)	0.694
Environmental barrier on home-to-school route (Cronbach's α=0.324) (N (%))[b]				
Presence of highway or freeway	60 (10.0 %)	46 (7.7 %)	χ^2=1.878 (p=0.171)	0.304
Presence of road with busy traffic	261 (43.4 %)	309 (51.4 %)	χ^2=8.697 (p=0.003)	0.314
Presence of intersection without street signals or stop signs	133 (22.1 %)	121 (20.1 %)	χ^2=0.651 (p=0.420)	0.256
Presence of intersection without a painted crosswalk	107 (17.8 %)	111 (18.5 %)	χ^2=0.059 (p=0.808)	0.178
Sidewalk condition on home-to-school route (Cronbach's α=1.000) (mean±SD)[c]				
Sidewalk maintenance condition	3.41±1.509	3.56±1.466	t=−1.844 (p=0.065)	0.999
Wide enough	3.73±1.443	3.68±1.493	t=0.561 (p=0.575)	0.999
Separated from traffic	3.05±0.070	2.93±0.065	t=1.321 (p=0.187)	1.000
Free of obstructions	3.01±0.071	3.17±0.064	t=−1.659 (p=0.099)	0.999
Overall walkability (Cronbach's α=0.834) (mean±SD)[d]				
Convenience of walking to school	3.90±1.204	3.54±1.379	t=5.392 (p<0.001)	0.813
Well maintained and clean	3.69±1.241	3.65±1.235	t=0.698 (p=0.485)	0.799
Well shaded by trees	3.22±1.331	3.22±1.301	t=0.000 (p=1.000)	0.810
Quiet neighborhood	3.37±1.407	3.11±1.354	t=3.586 (p<0.001)	0.810
Nice things to see	3.12±1.323	2.98±1.281	t=1.969 (p=0.049)	0.813
Well-lit street	3.16±1.342	3.15±1.309	t=0.135 (p=0.893)	0.808
Well-enforced school zones	3.36±1.427	3.38±1.415	t=−0.308 (p=0.758)	0.826
Environments: safety concerns (Cronbach's α=0.880)[d]				
Getting lost	2.70±1.505	2.88±1.474	t=−2.135 (p=0.033)	0.870
Being taken or hurt by a stranger	3.54±1.386	3.82±1.291	t=−3.696 (p<0.001)	0.854
Getting bullied, teased, or harassed	3.28±1.377	3.41±1.325	t=−1.605 (p=0.109)	0.853
Being attacked by stray dogs	3.32±1.431	3.45±1.374	t=−1.795 (p=0.073)	0.859

Table 2 (continued)

Variable	Walker	Driver	Bivariate test	Cronbach's α if item deleted[e]
Being hit by a car	3.63±1.381	3.91±1.284	t=−3.658 (p<0.001)	0.860
Harmed from exhaust fumes	2.94±1.331	2.86±1.247	t=1.082 (p=0.280)	0.872
No one to see and help my child in case of danger	3.12±1.346	3.20±1.345	t=−1.062 (p=0.289)	0.870
Attitudes and preferences (Cronbach's α=0.681)[d]				
Attitudes toward walking:				
Walking to school is "cool"	3.77±1.274	3.59±1.235	t=2.677 (p=0.007)	0.653
Enjoying walking with child	4.22±1.137	3.75±1.202	t=7.375 (p<0.001)	0.642
Liking the idea of walking	3.77±1.270	3.37±1.237	t=5.958 (p<0.001)	0.637
Good way to exercise	4.70±0.784	4.71±0.734	t=−0.298 (p=0.766)	0.659
Good way to interact with other people	4.12±1.143	4.01±1.168	t=1.742 (p=0.082)	0.647
Walking requiring too much planning ahead	2.53±1.436	2.86±1.303	t=−4.210 (p<0.001)	0.696
Easier/faster to drive child	3.58±1.408	4.31±1.068	t=−10.336 (p<0.001)	0.701
Too much to carry	2.47±1.274	2.65±1.273	t=−2.399 (p=0.016)	0.689
Getting too hot and sweaty	3.28±1.387	3.15±1.333	t=1.629 (p=0.104)	0.685
Walking preference:				
Walking in daily routine (child)	3.88±1.186	3.12±1.364	t=10.497 (p<0.001)	0.654
Walking in daily routine (parent)	4.02±1.160	3.52±1.244	t=7.355 (p<0.001)	0.646
Other kids walking to school	4.25±1.091	4.06±1.158	t=3.048 (p=0.002)	0.664
Other kids and parents walk	3.98±1.104	3.88±1.097	t=1.714 (p=0.086)	0.644

[a] Home-to-school distance measured by airline distance in GIS

[b] Measured with binary scale: "0" absence and "1" presence

[c] Measured with 6-point scale: "0" no sidewalk and "1" strongly disagree to "5" strongly agree

[d] Measured with 5-point scale: "1" strongly disagree to "5" strongly agree

[e] Cronbach's alpha values based on the full sample (N=4,626) and descriptive and bivariate tests based on N=1,202 (601 pairs) used in this paper

For multivariate analyses, we referred to several statistical methods used in twin pair studies which offered helpful methodological insights relevant to this study [17, 30]. The conditional logistic model was determined appropriate for this study, because it allows the independent variables to predict the discordant outcome between cases and controls within one-to-one matched pairs. Within the geographically matched pairs, walkers in this study were considered cases and drivers as controls to predict the odds of walking. The modeling process involved three steps: (a) base model estimation, (b) one-by-one tests, and (c) final model estimation. The base model included only the confounding variables (socio-demographics). One-by-one tests were conducted by adding one independent variable at a time to the base model. The final model was estimated with all significant variables from the one-by-one tests. A p value of less than 0.05 was used to determine the statistical significance, but several additional variables with marginal significance ($0.05 \leq p < 0.2$) were kept in the model if there was significant theoretical importance (e.g., safety concern variables) or improvement in the overall model fit. Chi-square tests were used to compare the −2 log likelihood ratios among the alternative models to determine the best-fitting model [31, 32]. All statistical analyses were carried out with the statistical package SPSS 19.0.

Results

Respondent Characteristics

The 601 walker–driver child pairs (before imputation) had a mean grade of 1.76 (kindergarten is coded as 0 and prekindergarten as −1), with 1.90 for walkers and 1.61 for drivers (Table 1). Gender composition was similar between the walker and the driver groups. For children's ethnicity, 74.7 % were of Hispanic origin (76.2 vs. 73.2 % among walkers vs. drivers). The mean BMI percentile values were 67.63 among walkers and 70.71 among drivers. Over 80 % of children qualified for free or reduced-price lunch (81.7 vs. 79.4 % among walkers vs. drivers). Over 70 % of walkers went to school with their parents or other adults.

Differences Between Matched Child Walkers and Drivers: Bivariate Analyses

Socio-demographics

From the result of paired-sample tests, seven socio-demographic variables and three neighborhood selection variables were significantly different between walkers and drivers at the 0.05 level (Table 1). Walking children were older, had parents with lower education levels, and had fewer cars and driver licenses in the household than those driven to school. No significant differences were found between walkers and drivers in terms of gender, race, BMI percentile, number of siblings, and years lived in the current residence. Reasons that parents considered when choosing the current neighborhood were asked to help assess the potential self-selection biases that are commonly found in environment behavior studies [33]. Drivers were more likely to consider housing/rent price, while walkers were more likely to consider proximity to school and neighborhood walkability. This finding suggests the presence of potential biases related to residential "self-selection"—those who like walking choose to live in more walkable neighborhoods, and therefore, the roles of environments are negated [34]. When longitudinal studies are not possible, statistical controls are considered acceptable by including variables such as reasons for residential choice, attitudes, and preferences in the multivariate model. All of these variables are included in this study's multivariate model [33, 35].

Walkability

The respondents were asked whether or not they thought the distance to school was close enough for their children to walk. Even though they lived in the same/nearby locations, significantly ($p<0.001$) more walkers reported the distance to be close enough (73.2 vs. 62.9 % among drivers) (Table 2). This shows that the maximum distance considered walkable varies by individuals' perceptions. Regarding land uses present along the route to school, parks (223 out of 601 pairs) and convenience stores (213) were most commonly found. Walkers were significantly more likely to report having parks en route to school than drivers (21.1 vs. 16.0 %, $p=0.013$), whereas drivers were more likely to observe convenience stores (21.1 vs. 14.3 %, $p<0.001$) and large office buildings (10.1 vs. 6.8 %, $p=0.040$). It should be noted that most convenience stores in our study area were located within a gas station. More drivers (51.4 vs. 43.4 %, $p=0.003$) perceived having roads with busy traffic along the route to school.

In terms of perceived sidewalk conditions en route to school, only one item showed marginally significant difference between walkers and drivers. Drivers were more likely to agree with the sidewalks being well maintained and clean, compared to walkers (mean, 3.56 vs. 3.41; $p=0.065$). This finding can be attributed to the fact that walkers use sidewalks more often and therefore naturally notice more problems with them. The perceptions of overall walking environments were consistently higher among walkers: (a) being convenient to walk to school, (b) being quiet without much noise from cars, airplanes, factories, etc., and (c) having nice things to see, all significant at the 0.05 level (Table 2). Possible reasons for these differences are that different mode users notice different characteristics along the same route due to differences in the exact street locations used (vehicular roadways for drivers vs. sidewalks or shoulders for walkers) and in the speed at which they experience the environment. They may also take slightly different routes to school despite the same home and school locations for reasons like faster travel times for drivers and fewer crossings of busy streets for walkers [36].

Safety Concerns

Of the seven questions on safety concerns about walking to school, three had significantly higher ratings among drivers: getting lost, being taken or hurt by a stranger, and being hit by a car (Table 2). This finding supports the general hypothesis that a major reason for driving the child to school is the safety concern.

Attitudes and Preferences

Many attitude and preference variables showed significant variations between the two mode users. Walkers' parents were more likely to agree that (a) their child thinks walking to school is "cool," (b) their child walks quite often in the daily routine, (c) they (parents) walk quite often in the daily routine, (d) they enjoy walking with their child to school, (e) their family and friends like the idea of walking to school, and (f) other kids in the neighborhood walk to school (Table 2). Attitudinal barriers also helped explain why drivers did not allow their children to walk to school. Drivers were more likely to agree that: (a) walking requires too much planning ahead, (b) driving is easier/faster, and (c) their child has too much to carry.

Variables Associated with the Odds of Walking vs. Driving to School: Multivariate Analyses

Results from multivariate analyses (one-by-one tests and final model) are shown in Table 3. After controlling the six socio-demographic and household-related variables for the base model (socio-demographics in Table 3), five walkability variables, two safety concern variables, and seven attitudinal and preference variables were significant at the 0.05 level in the one-by-one tests. The final model included six walkability and four attitudinal/preference variables among which five and three, respectively, were significant at the 0.05 level.

Table 3 Factors predicting the odds of walking vs. driving to/from school: multivariate analyses

Variable	One-by-one test[a]			Final model		
	Odds ratio	95 % CI	*p* value	Odds ratio	95 % CI	*p* value
Socio-demographics [base model]						
Grade	1.125	1.044–1.212	0.002	1.100	1.004–1.205	0.041
Hispanic	1.188	0.787–1.794	0.411	1.584	0.943–2.659	0.082
BMI percentile	0.994	0.990–0.999	0.020	0.992	0.986–0.997	0.005
Education level [6 ordinal categories]	0.647	0.557–0.752	<0.001	0.712	0.591–0.857	<0.001
Reason to choose the neighborhood: easy to walk around	2.190	1.509–3.179	<0.001	1.793	1.135–2.832	0.012
Number of cars in the household	0.621	0.511–0.754	<0.001	0.640	0.509–0.805	<0.001
Environment—walkability						
Home-to-school distance: perceived being close enough for walking[b]	1.909	1.363–2.672	<0.001	1.507	1.002–2.267	0.049
Home-to-school route						
Presence of park[b]	1.397	0.965–2.021	0.076	1.847	1.138–2.999	0.013
Presence of convenience store[b]	0.598	0.389–0.919	0.019	0.648	0.384–1.092	0.103
Presence of road with busy traffic[b]	0.688	0.518–0.915	0.010	0.700	0.494–0.992	0.045
Sidewalk maintenance condition[c]	0.942	0.856–1.036	0.215	0.865	0.756–0.990	0.036
Overall walkability						
Convenience of walking to school[d]	1.286	1.145–1.443	<0.001	1.289	1.099–1.512	0.002
Quiet neighborhood[d]	1.115	1.006–1.237	0.039	Excluded		
Environment—safety concerns[d]						
Getting lost	0.946	0.865–1.036	0.234	1.101	0.966–1.255	0.150
Being taken or hurt by a stranger	0.861	0.779–0.951	0.003	0.886	0.749–1.049	0.160
Being attacked by stray dogs	0.940	0.851–1.038	0.222	1.128	0.959–1.328	0.146
Being hit by a car	0.868	0.785–0.959	0.005	0.860	0.731–1.011	0.068
Attitudes and preferences[d]						
Attitudes toward walking						
Enjoying walking with child	1.388	1.227–1.571	<0.001	1.217	1.037–1.428	0.016
Easier/faster to drive child	0.616	0.543–0.697	<0.001	0.615	0.530–0.713	<0.001
Liking the idea of walking	1.266	1.128–1.421	<0.001	Excluded		
Walking requiring too much planning ahead	0.820	0.743–0.904	<0.001	Excluded		
Too much to carry	0.865	0.781–0.958	0.005	Excluded		
Walking preference						
Walking in daily routine (child)	1.595	1.422–1.788	<0.001	1.538	1.329–1.780	<0.001
Walking in daily routine (parent)	1.395	1.245–1.563	<0.001	1.146	0.978–1.344	0.092

[a] Each independent variable was added to Base Model one at a time

[b] Measured with a binary scale: "0" absence and "1" presence

[c] Measured with a 6-point scale: "0" no sidewalk and "1" strongly disagree to "5" strongly agree

[d] Measured with a 5-point scale: "1" strongly disagree to "5" strongly agree

Walkability

In the final model, parents reporting the home-to-school distance to be close enough (OR 1.507, $p=0.049$), the presence of parks (OR 1.847, $p=0.013$), and the overall convenience in walking to school (OR 1.289, $p=0.002$) were more likely to allow their child to walk to school (Table 3). On the other hand, parents reporting the presence of roads with busy traffic (OR 0.700, $p=0.045$) and less well-maintained sidewalks (OR 0.865, $p=0.036$) en route to school were more likely to drive their child to school. Additionally, in the one-by-one test, parents of walking children were more likely to report their neighborhood to be quiet, while parents who drove their child were more likely to report the presence of convenience stores en route to school.

Safety Concerns

All safety concern variables became insignificant at the 0.05 level in the final model, but two variables were significant in the one-by-one tests. Parents who were concerned about their child being hit by a car (OR 0.868, p=0.005) and being taken or hurt by a stranger (OR 0.861, p=0.003) were more likely to drive their child to school. Importance of safety has been reported repeatedly in previous studies, but this study provides additional evidence on the subjectivity in parents' assessments of dangers (few previous studies actually compared differences in perceived safety of the exactly same environment), suggesting the need to target both the actual and the perceived barriers for interventions.

Attitudes and Preferences

In the final model, parents perceiving driving their child to school to be easier or faster than walking were more likely to drive their child to school (OR 0.615, p<0.001). Parents whose child walked in his/her daily routine (OR 1.538, p< 0.001) and parents who enjoyed walking with their child (OR 1.217, p=0.016) were more likely to choose walking for school transportation. Additionally, in the one-by-one tests, parents perceiving walking as involving too much planning ahead and their child having too much to carry were more likely to drive their child to school. Parents and children who walked in their daily routine and parents who liked the idea of walking were more likely to choose walking for school transportation (Table 3 and Fig. 3).

Discussion

Findings from this study supported the hypotheses that parents who walk vs. drive their child to school have significantly different perceptions of walkability and safety, despite the same objective environment, and differences in their attitudes and preferences toward walking. Parents who walked their child to school had significantly more positive perceptions of walkability with the exception of sidewalk conditions. Drivers reported greater safety concerns, especially related to traffic dangers. Parents and children who walked to school reported walking more in general in their daily routine, and parents also

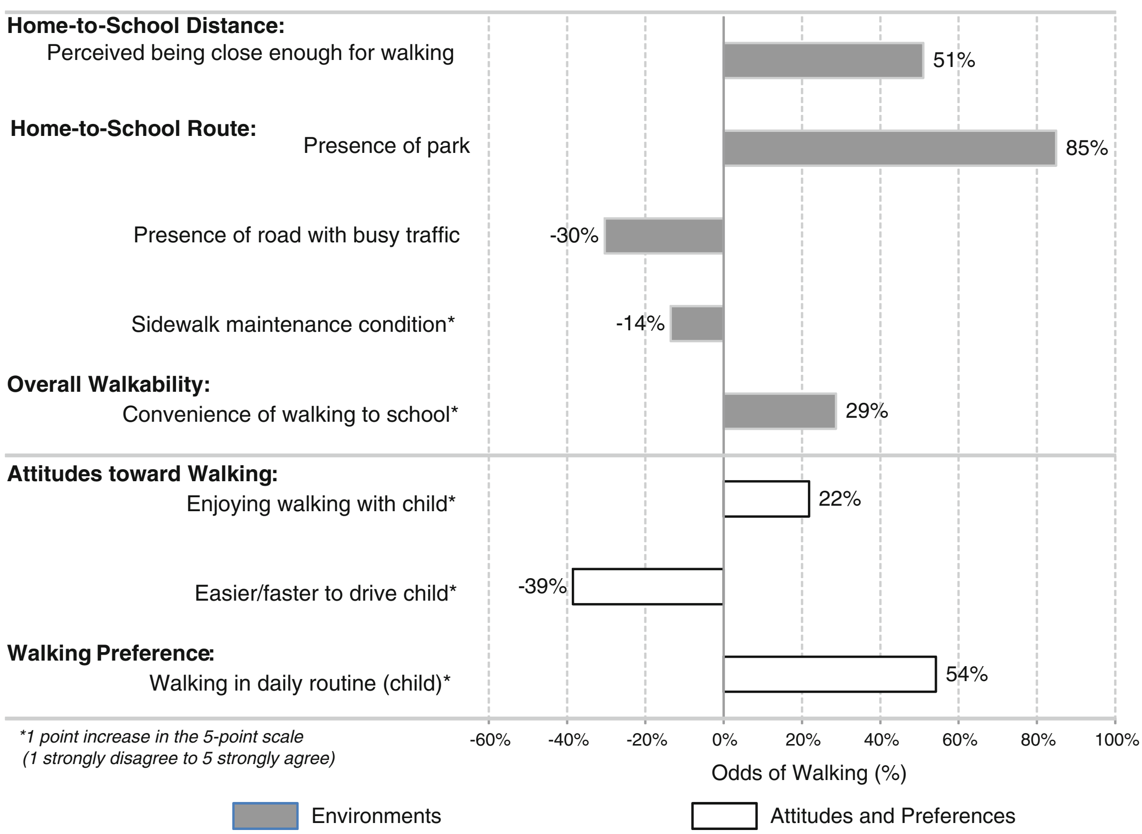

Fig. 3 Summary of environmental, attitudinal, and preference factors predicting the odds of walking vs. driving to school: results from multivariate conditional logistic regression models

reported higher levels of enjoyment of walking with their children, than their counterparts. These findings suggest the importance of education and promotional programs and pedestrian safety trainings. Improvements in the objective environment alone may not be sufficient in triggering the mode shift from driving to walking to school, especially among those with negative attitudes and low preference toward walking.

Perceived Distance and Factors Beyond Distance

Among the parents living within 2 miles from schools, this study found that only 37.1 % of the drivers and 26.8 % of the walkers considered their home-to-school distance to be too far for their child to walk. The 26.8 % of walkers who considered the distance being too far still chose walking, likely because of reasons such as: (a) limited availability of cars in the household (1.40 vs. 1.66 cars among walkers vs. drivers), (b) more positive attitudes toward walking (8 out of 13 attitude variables asked in the original survey were significantly different at the 0.05 level between those who reported the home-to-school distance to be close enough vs. not), or (c) more positive perceptions of their environments in terms of safety (6 out of 7 variables) and walkability (9 out of 11 variables). Also importantly, 62.9 % of the drivers perceived the home-to-school distance to be close enough, but they still drove their children to school. Unlike the longer-distance walkers, shorter-distance drivers in our study had more positive attitudes and preference for walking (11 out of 13 variables significant at the 0.05 level), better walking environments (9 out of 11), and lower levels of safety concerns (2 out of 7), compared to longer-distance drivers who perceived the distance to be not close enough for walking. The "perception" of distance being close enough for walking, as one of the strongest predictors of mode choice, was significantly different between walkers and drivers. This result shows that other factors, such as socioeconomics, attitudes, and environmental perceptions, also influence the parental determination of a "walkable" distance for their children's school travel [37]. This study suggested that the definition of a walkable distance among the current walkers was more strongly influenced by environmental factors, while other personal factors appeared more important among the current drivers. Further study is needed to investigate factors influencing parental perception of a walkable distance to school, which is an important prerequisite for parents to even consider walking as a viable alternative to driving.

Variations in Perceptions of the Same Environmental Settings

For perceived land uses and transportation facilities along their child's route to school, walkers and drivers showed clearly different perceptions for the same/similar actual conditions. Walkers were more likely to report the presence of walking-friendly facilities (i.e., park); drivers were more likely to perceive the presence of barriers to walking (i.e., road with busy traffic). The impacts of the residential self-selection (although statistically controlled in this study) may partially explain these differences. When choosing where to live, drivers were significantly more likely to consider housing/rent price, while walkers were more likely to consider distance to school and neighborhood walkability. This finding supports that personal experiences, awareness, and/or preferences may lead to different views toward the same physical environment [15]. It is also possible that walkers and drivers may sometimes choose different routes even if they live in the same/similar home locations. Educational programs and promotional campaigns to help foster positive attitudes, social supports, and increased awareness of walking benefits and safer walking routes may be important interventions to help address these factors. The fact that drivers perceived different environmental and personal barriers suggests that more tailored interventions targeting the specific group, such as short-distance drivers, are more likely to be effective than a one-size-fits-all approach. Further, the significance of the self-selection variables suggests the potential for real estate development and marketing strategies, such as using neighborhood walkability as a marketing point and supplying enough housing options in walkable neighborhoods to meet the existing demand by the home buyers who prefer such neighborhoods.

Socio-demographics, Attitudes and Preferences

Many personal factors such as safety concerns and personal attitudes and preferences helped explain the difference in school travel mode choice. In bivariate analyses, drivers raised significantly more safety concerns and personal barriers (negative attitudes). Results from this study's socio-demographic correlates of walking were mostly consistent with previous studies except BMI [38]. The BMI percentile which was not significant in this study has been reported significant in previous studies [39, 40]. Students with lower socioeconomic status or Hispanic ethnicity were more likely to walk to/from school, while those with higher parental education and car ownership were less likely to walk [15]. Better understanding of the relationships between attitudes/preferences and the built environment appear to be an important next step of research in this area.

Limitations

This study is a cross-sectional research with no ability to assess causal relationships between study variables. While its settings and populations are diverse, it was carried out in a single-city and a single-school district, limiting its external validity. This study utilized two rounds of surveys with an approximately 3-year interval, which may lead to some inconsistencies in the responses. While the response rates from both surveys were considered acceptable and our respondents were fairly representative of the sample frame, it is still possible that those parents who are more interested in school transportation or issues in the neighborhood were more likely to respond to the survey. Due to the retrospective matching process to identify the pairs based on the same home location, respondents included in this study had over-representation of multifamily and lower-income residents (44.7 vs. 56.1 % of multifamily residents and 64.7 vs. 80.5 % qualifying for free/reduced-price lunch, in the full survey data vs. 601 pairs used in this study). Further, the pairs were not matched in other important personal variables such as age and gender. Attempts were made to use additional personal matching variables, but not feasible due to the low probability of finding two children meeting additional matching criteria from the existing survey participant pool that this study used.

The built environmental variables used in this study included only the perceived measures from the survey. This study's focus was on the perceived measures, and because of the pairs matched in home and school locations, objective measures would have been the same and could not be analyzed. The specific home-to-school route each student took can vary between walkers and drivers, but such route-specific data (often gathered from wearable global positioning system (GPS) units) are very difficult to gather on a large sample study while ensuring sufficient accuracy and reliability [41]. Further, our previous analyses comparing the GPS-generated actual routes with the GIS-generated shortest routes, based on a subset of 142 samples from these survey participants, showed an approximate matching rate of 0.89. The remaining 11 % varied, in most cases only partially, between the GPS and GIS routes. Finally, further analyses on the interactions that attitudinal/preference factors may have with the built environmental variables and with the perception of a "walkable" distance appear valuable.

Conclusions

After controlling the objective home-to-school distance, the strongest known predictor, this study found that parental attitudinal and preference factors were strong predictors of school mode choice for their children, along with environmental perception variables. Walkers' attitudes toward walking and perceptions of their neighborhood walkability were more positive than drivers'. Most significant environmental correlates of walking to/from school were route related: presence of parks (+), busy traffic (−), and sidewalk maintenance (−). Many safety barriers, social support, and general walkability variables were significantly different between walkers and drivers in the bivariate analyses, but most of them did not maintain statistical significance in the final multivariate model, except one general walkability variable: overall convenience of walking (+).

The major parental determinants of driving their children to/from school were the convenience of driving and traffic safety concerns. Policies and environmental improvements to enhance the safety of child pedestrians appear to be the key to facilitate mode shift from driving to walking. Continued efforts to improve sidewalk conditions and social supports seem important to keep current walkers walking. While findings from this study suggest that route/street improvements are promising environmental strategies, more effective outcomes can be expected if combined with educational and promotional efforts to address parental attitudinal barriers.

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Conflict of Interest The authors have no conflict of interest to disclose.

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