Thresholds and Impacts of Walkable Distance for Active School Transportation in Different Contexts

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CONTENTS

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**BACKGROUND**

- **Distance:** One of the strongest correlates of walking to school (WTS)
- **Questions about “walkable distance” remain**
  - What is the threshold?
  - Does its impact vary by context?
- **Significance:** Inform school planning & future interventions

![Healthy, Green, Cost-Effective](https://www.norsesys.com/)

![SCHOOL BUS](https://www.thinksmartplan.com/)

How do we plan for walkable schools/neighborhoods?

What is walkable?

Schematic of a neighborhood unit for modest dwellings (Perry, 1929)
Found 43 studies that examined impacts of distance

36 reported negative impacts

21 used continuous variables of distance
   (15 based on parental/child estimate, 6 based on objective measures)

15 used categorical variables of distance with thresholds of 0.25, 0.5, or 1 mile
   (mostly based on parental estimate)
A few examined **thresholds** of walkable distance

- One asked parents about perceived thresholds
- A few used cumulative %s of WTS per covered distance
  - 1 km, 0.8 km & 0.5 km ranges used (too coarse)
  - 85% & 50% WTS used to decide the criterion distance

- A few studied **age/gender-specific** thresholds
- No studies on **context-specific** thresholds
STUDY DESIGN

- Cross-sectional study
- Data collection
  - Parental survey in Austin (2007 & 2010, n=6233)
    (Collected: school travel modes; personal, social & physical environmental factors)
  - Geocoding & shortest route analysis
- Data analysis
  - Descriptive statistics: Cumulative %s of WTS ⇒ Threshold of walkable distance
  - Structural Equation Modeling predicting “perceived close-enough distance” & “WTS”
STUDY SETTING

Legend

- Suburban high-income
- Urban mid-income
- Urban low-income
- Inner-city low-income
- ES Location 2010

Elementary Schools in AISD

% of free or reduced-price lunch

- 0.00 - 16.70
- 16.71 - 61.40
- 61.41 - 76.20
- 76.21 - 93.70
- 93.71 - 97.80

* Downtown
## STUDY SETTING

### Mean (Standard Deviation) of Physical Environmental Characteristics

<table>
<thead>
<tr>
<th>School type</th>
<th>Inner city, low-income (4 schools)</th>
<th>Urban, low-income (8 schools)</th>
<th>Urban, mid-income (4 schools)</th>
<th>Suburban; high-income (6 schools)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population density (/acre)</td>
<td>9.3 (4.7)</td>
<td>11.2 (3.2)</td>
<td>6.6 (1.5)</td>
<td>2.5 (1.6)</td>
</tr>
<tr>
<td>Living within ½ mile (%)</td>
<td>39 (23)</td>
<td>28 (15)</td>
<td>23 (5)</td>
<td>14 (6)</td>
</tr>
<tr>
<td>Sidewalk completeness</td>
<td>36 (9)</td>
<td>38 (19)</td>
<td>28 (12)</td>
<td>8 (1)</td>
</tr>
<tr>
<td>Street intersection density</td>
<td>0.32 (0.16)</td>
<td>0.18 (0.05)</td>
<td>0.20 (0.06)</td>
<td>0.12 (0.07)</td>
</tr>
<tr>
<td>Land use mix</td>
<td>0.57 (0.12)</td>
<td>0.54 (0.15)</td>
<td>0.48 (0.21)</td>
<td>0.18 (0.17)</td>
</tr>
<tr>
<td>Crash rate</td>
<td>9.0 (2.5)</td>
<td>6.9 (3.5)</td>
<td>5.1 (3.4)</td>
<td>1.9 (1.3)</td>
</tr>
<tr>
<td>Crime rate</td>
<td>100 (35)</td>
<td>102 (52)</td>
<td>40 (15)</td>
<td>10 (8)</td>
</tr>
</tbody>
</table>

Sample map
## Study Population

<table>
<thead>
<tr>
<th>School type</th>
<th>Inner city, low-income (4 schools)</th>
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<th>Urban, mid-income (4 schools)</th>
<th>Suburban; high-income (6 schools)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic (%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>90 (6)</td>
<td>82 (4)</td>
<td>58 (15)</td>
<td>15 (6)</td>
</tr>
<tr>
<td>Free or reduced-price lunch (%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>92 (1)</td>
<td>94 (3)</td>
<td>65 (12)</td>
<td>7 (6)</td>
</tr>
<tr>
<td>Medium household income&lt;sup&gt;c&lt;/sup&gt;</td>
<td>24,303 (1,878)</td>
<td>36,257 (3,737)</td>
<td>45,531 (8,506)</td>
<td>87,123 (21,030)</td>
</tr>
</tbody>
</table>

<sup>a</sup> For total student enrolment at school; <sup>b</sup> For the survey sample; <sup>c</sup> Based on the Census data.
RESULTS

GIS ANALYSIS: Shortest Home-to-School Route
# Descriptive Statistics

## Mean (Standard Deviation) or Frequency of Physical Environmental Characteristics

<table>
<thead>
<tr>
<th>School type</th>
<th>Inner city, low-income (4 schools)</th>
<th>Urban, low-income (8 schools)</th>
<th>Urban, mid-income (4 schools)</th>
<th>Suburban; high-income (6 schools)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sample size by school</td>
<td>202 (91)</td>
<td>383 (133)</td>
<td>208 (24)</td>
<td>271 (101)</td>
</tr>
<tr>
<td>Hispanic students among respondents</td>
<td>90% yes</td>
<td>85% yes</td>
<td>54% yes</td>
<td>13% yes</td>
</tr>
<tr>
<td>Highest parental education</td>
<td>2.8 (1.1)</td>
<td>2.7 (1.1)</td>
<td>4.0 (1.4)</td>
<td>5.4 (0.8)</td>
</tr>
<tr>
<td>(range: 1 lowest-6 highest)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students walking to/from school</td>
<td>29% Yes</td>
<td>44% Yes</td>
<td>28% Yes</td>
<td>22% Yes</td>
</tr>
<tr>
<td>Parents perceiving close-enough distance</td>
<td>40% Yes</td>
<td>55% Yes</td>
<td>47% Yes</td>
<td>56% Yes</td>
</tr>
<tr>
<td>Students with school bus service</td>
<td>56% Yes</td>
<td>29% Yes</td>
<td>25% Yes</td>
<td>28% Yes</td>
</tr>
<tr>
<td>Home-to-school distance (Mile)</td>
<td>1.45 (1.60)</td>
<td>0.92 (1.35)</td>
<td>1.67 (2.35)</td>
<td>1.87 (2.15)</td>
</tr>
<tr>
<td>Child crossing freeway en route to school</td>
<td>19% Yes</td>
<td>15% Yes</td>
<td>15% Yes</td>
<td>18% Yes</td>
</tr>
</tbody>
</table>
Walkable Distance

• What is the threshold?

• Does distance & WTS have a linear relationship?

• Does it vary by contexts?
## Home-to-school Distance for Different Groups

### Descriptive statistics for home-to-school distance

<table>
<thead>
<tr>
<th>Walking to/from school</th>
<th>Perception of Distance close enough</th>
<th>Mean</th>
<th>S.D.</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Mean=0.550</td>
<td>S.D.=0.738</td>
<td>1693 (27.16%)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Mean=1.303</td>
<td>S.D.=2.061</td>
<td>390 (6.26%)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Mean=0.691</td>
<td>S.D.=1.143</td>
<td>2083 (33.42%)</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>Mean=0.864</td>
<td>S.D.=0.989</td>
<td>1509 (24.21%)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Mean=2.15</td>
<td>S.D.=2.310</td>
<td>2641 (42.37%)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Mean=1.680</td>
<td>S.D.=2.023</td>
<td>4150 (66.58%)</td>
</tr>
<tr>
<td>Total</td>
<td>Yes</td>
<td>Mean=0.698</td>
<td>S.D.=0.880</td>
<td>3202 (51.37%)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Mean=2.044</td>
<td>S.D.=2.293</td>
<td>3031 (48.63%)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Mean=1.349</td>
<td>S.D.=1.838</td>
<td>6233 (100%)</td>
</tr>
</tbody>
</table>
WTS within Different Distance Ranges (Total Sample)

- Walking to/from school (%)
- Perception of distance close enough (%)

Home-to-school distance (Miles)

- 0.52 miles
- 0.85 miles
Cumulative % of WTS & Perceived Close-Enough Distance, by Home-to-School Distance

- Walking to/from school
- Distance Close Enough

Home-To-School distance (GIS)

- 0.4 miles
- 0.93 miles
Cumulative % of Walking to/from School by Distance in Different Contexts

- Inner-city low-income
- Urban low-income
- Urban mid-income
- Suburban high-income

**Home-to-school Distance (Miles)**

- 0.14
- 0.35
- 0.38
- 0.48
Cumulative % of Perceiving Close-enough Distance in Different Contexts

- Inner-city low-income
- Urban low-income
- Urban mid-income
- Suburban high-income

Distance Points:
- 0.75 miles
- 1.05 miles
- 1.25 miles
- 1.52 miles
Predict Perceived Walkable Distance

• Completed analysis: used the 2007 survey sample

• Final analysis: will combine 2007 & 2010 samples & run separate models for 4 types of contexts
Model Comparison

A:
- AIC: 2383.706; BIC: 2424.741; Adjusted BIC: 2402.500
- R-square: .799

B:
- AIC: 2482.903; BIC: 2512.214; Adjusted BIC: 2496.327
- R-square: .834

C:
- AIC: 2487.433; BIC: 2510.881; Adjusted BIC: 2498.172
- R-square: .834

(Note: Standardized results)
SEM Predicting **Perceived Close Distance**: Model C

AIC: 2383.706; BIC: 2424.741; Adjusted BIC: 2402.500
R-square: .799

- **Obj. HTS Distance**: OR = 0.027
- **Perceived Safety**: OR = 0.531
- **Distance X Safety**: OR = 1.334**
- **Sidewalk Compl.**: OR = 1.499
- **Car Ownership**: OR = 1.345
- **Bus Availability**: OR = 0.401

**Per. Close Distance**

- **Per. Close Distance**: OR = 1.499
- **Perceived Close Distance**: OR = 0.891**
- **Distance X Safety**: OR = 0.038*
- **Sidewalk Compl.**: OR = 0.067**
- **Car Ownership**: OR = 0.107**
Predict Walking to/from School

1. Test the mediator role of “perceived walkable distance” in influencing WTS

2. Predict WTS using personal, social & physical environmental variables
AIC: 8503.845; BIC: 8544.888; Adjusted BIC: 8522.647

**mediator role of “perceived walkable distance”:**

**Model Comparison**

**A:**
- Bus Availability
  - OR=.324
- Car Ownership
  - OR=.735
- Obj. HTS Distance
  - OR=.220
  - Walk to School

**B:**
- Bus Availability
  - OR=.318
- Car Ownership
  - OR=.655
- Obj. HTS Distance
  - OR=.068
  - Per. Close Dist.
  - OR=6.408
  - Walk to School

**C:**
- Bus Availability
  - OR=.370
- Car Ownership
  - OR=.671
- Obj. HTS Distance
  - OR=.068
  - Per. Close Dist.
  - OR=3.436
  - Walk to School

AIC: 8395.326; BIC: 8442.222; Adjusted BIC: 8416.804

AIC: 9559.448; BIC: 9594.621; Adjusted BIC: 9575.557

AIC: 8503.845; BIC: 8544.888; Adjusted BIC: 8522.647

AIC: 8503.845; BIC: 8544.888; Adjusted BIC: 8522.647

AIC: 8395.326; BIC: 8442.222; Adjusted BIC: 8416.804

AIC: 8503.845; BIC: 8544.888; Adjusted BIC: 8522.647

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AIC: 8503.845; BIC: 8544.888; Adjusted BIC: 8522.647

AIC: 8503.845; BIC: 8544.888; Adjusted BIC: 8522.647
SEM Predicting WTS: Model C

AIC: 8395.326; BIC: 8442.222; Adjusted BIC: 8416.804

- Bus Availability
  - OR = 0.370
- Car Ownership
  - OR = 0.671
- Obj. HTS Distance
  - OR = 0.068
- Per. Close Dist.
  - OR = 0.398
- Walk to School
  - OR = 3.436
  - 1.234***
  - -2.695**
  - -0.921***
  - -0.399***
  - -0.995***

(Unstandardized results.)
SEM Predicting WTS:

- **Personal factors**
  - Measurement models tested first
  - Model fit tested
  - N=2,569

- **Social factors**

- **Objective physical environment**

- **Walking Barriers**
  - Too much planning: R²=.434***
  - Easier to drive: R²=.506***
  - Too much to carry: R²=.580***
  - No time to Walk: R²=.580***
  - Kid think WTS cool: R²=.521***
  - Kid walks often: R²=.607***
  - Walk good: R²=.574***
  - Peo in neigh walks: R²=.544***
  - Enjoy WTS w/ Kid: R²=.604***
  - Family likes WTS: R²=.740***
  - Other Kids WTS: R²=.871***
  - Oth K walk in daily: R²=.810***
  - Oth parents walk

- **Positive Attitudes**
  - OR=.389***
  - OR=2.184

- **Peer Influences**
  - OR=.959
  - OR=.999

- **Walk to School**
  - OR=1.351
  - OR=.843
  - OR=1.158
  - OR=.720
  - OR=.651
Discussions

- **0.5-mile threshold** for walkable distance  
  (Consistent with some previous studies.)

- **Perception of walkable distance** is influenced by non-distance related factors & acts as a **significant mediator** in influencing WTS.  
  (Implications for interventions.)

- Distance vs. walking to school is **not necessarily a linear relationship**, as shown in sub-group analysis, & the relationship **varies by context**.

- Distance & freeway are 2 **significant physical environmental factors**.  
  (Future school/neighborhood planning should respond to this.)