WALKABILITY AND CRIME

Does walkable environment affect outdoor violent crime?

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INTRODUCTION

Walkable Environment and Walkability

- **Walkable Environment**
  - A walkable environment is widely used as an indicator of a desirable place to live, work, and play as a key element of smart growth (*Dannenberg et al. 2003*).

- **Walkability**
  - Walkability is a measurement of how much certain areas provide opportunities to walk (*Leyden 2003*).
INTRODUCTION

Benefits of Walkable Environment

• **Health Benefit**
  - Walking is the most feasible means to meet the CDC’s *physical activity* (*PA*) recommendation.
  - PA can reduce many health problems such as *obesity*, cardiovascular disease, osteoporosis, type II diabetes, certain cancers, depression, etc. (Berke et al. 2007, Lee et al. 2013); and can also prevent *falls* and *injuries* (Nelson et al. 2007).

• **Social Benefit**
  - A walkable environment helps people maintain *independence* and *interactions* with the broader community (Frank et al. 2010).

• **Economic Benefit**
  - Non-motorized modes can reduce traffic problems, parking needs, energy consumption, and emissions (Litman 2004).
Walk Score

- Walk Score measures walkability of any addresses.
- Walk Score algorithm calculates a score of walkability based on **distance to amenities** (e.g., grocery stores, coffee shops, restaurants, bars, schools, parks, etc.)
- Each category is weighted equally and points are summed and normalized to yield a score **0-100** based on network distance.
- Walk Score is **a valid measure of estimating certain aspects of neighborhood walkability**, particularly at the 1600-meter buffer (Duncan et al. 2011, Carr et al. 2010).
- Walk Score does not capture the infrastructure conditions, like sidewalk availability or tree canopy.
Measurements of Walkable Environment

**INTRODUCTION**

- **Walkability Index**
  - Walkability index based on conceptual (Frank & Engelke 2001) and empirical literature (Cervero & Kockelman 1997; Saelens, Sallis & Frank 2003) that identify net residential density, mixed land use, retail floor area ratio, and street connectivity as key components of walkability.

  - Walkability index was widely used for measuring neighborhood walkability and comparing other health outcomes, such as actual walking behavior, body mass index (BMI), and Quality of life (Sallis et al. 2009).

  - The walkability index was a weighted sum of z-scores of the four normalized urban form measures as stated in following equation:

    \[
    \text{Walkability} = [(2 \times z - \text{intersection density}) + (z - \text{net residential density})
    + (z - \text{retail floor area ratio}) + (z - \text{land use mix})]
    \]
A walkable environment can increase street activities.
However, A walkable environment could also attract strangers and potential criminals.
**Jacob’s Observation**

Jane Jacobs (1961) emphasized the importance of the built environment on crime rates and suggested “eyes on the street” concept that could promote surveillance on the street with increased mixed-land use, numbers of windows, sidewalks, and adjacent buildings.

**Crime Pattern Theory**

Brantingham and Brantingham (1981) indicated that locations of daily routine activities, such as pathways and streets from home to work, school, and church, can attract potential offenders.
INTRODUCTION

Research Questions & Aim

• Do walkable environments actually increase crime incidents?
• How and when do walkable environments reduce crime incidents?

The aim of this study is to test the relationship between walkability and violent crime, motivated by two conflicting background theories.
• **Setting**
  Austin, Texas (population: 790,390)
  (US Census Bureau 2010 Population Estimate)

• **Unit of Analysis**
  To analyze neighborhood-level outdoor crime incidents, we used census block groups as the unit of analysis. **452 census block groups** within the city limits were used in the study, excluding one airport area, one downtown area (outlier), and two with missing data.

• **Crime Data**
  This study examined the **locations of violent crime incidents** occurred over five years (2008-12) as reported to the Austin Police Department.
STUDY DESIGN
Crime Type (Violent)

What are the types of crimes potentially related to walking activities?

rape/robbery
assault
kidnapping

The violent crime includes AGG ASSAULT, AGG KIDNAPPING, AGG KIDNAPPING with FAMILY VIOLENCE, AGG RAPE, AGG ROBBERY BY ASSAULT, ASSAULT BY THREAT, INTOXICATION ASSAULT, KIDNAPPING
Where do the violent crimes occur?

TOTAL VIOLENT CRIME: 13,992 incidents
OUTDOOR VIOLENT CRIME: 4,181 incidents (29%)
  STREETS: 2,558 incidents
  PARKING LOTS: 1,623 incidents

NOTE: The location types include BANKS, BAR/NIGHT CLUB, RELIGIOUS FACILITY, COMMERCIAL/OFFICE, CONSTRUCTION SITE, CONVENIENCE STORE, DEPARTMENT, DRUG STORE, HOTEL, LIQUOR STORE, and etc.
Outdoor Violent Crime vs. Total Violent Crime

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor Violent Crime</td>
<td>6.874</td>
<td>9.641</td>
<td>0</td>
<td>70</td>
</tr>
<tr>
<td>Total Violent Crime</td>
<td>24.987</td>
<td>27.254</td>
<td>0</td>
<td>174</td>
</tr>
</tbody>
</table>

STUDY DESIGN

Dependent Variable (OVC vs. TVC)
1. Create 800ft grid

2. Find the centroid of each grid

3. Select the centroid points located within the study area

4. Calculate Walk Score based on each centroid point

5. Calculate the mean Walk Score for each census block group

**STUDY DESIGN**

*Independent Variable (Walk Score)*
Walk Score Thresholds:

- **90–100 Walker’s Paradise**: Daily errands do not require a car
- **70–89 Very Walkable**: Most errands can be accomplished on foot
- **50–69 Somewhat Walkable**: Some errands can be accomplished on foot
- **25–49 Car-Dependent**: Most errands require a car
- **0–24 Car-Dependent**: Almost all errands require a car

City level mean Walk Score = 35
# Study Design

## Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor violent crime</td>
<td>Number of outdoor violent crimes</td>
<td>6.87</td>
<td>9.64</td>
<td>0.00</td>
<td>70.00</td>
</tr>
<tr>
<td>Total violent crime</td>
<td>Number of total violent crimes</td>
<td>24.99</td>
<td>27.25</td>
<td>0.00</td>
<td>174.00</td>
</tr>
<tr>
<td><strong>Confounding variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demographic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total areas</td>
<td>Total areas (acres/1,000)</td>
<td>0.25</td>
<td>0.25</td>
<td>0.02</td>
<td>1.84</td>
</tr>
<tr>
<td>Total population</td>
<td>Number of total population (N/1,000)</td>
<td>1.48</td>
<td>0.78</td>
<td>0.25</td>
<td>8.36</td>
</tr>
<tr>
<td>Older adult population</td>
<td>Number of over 65 years population (N/1,000)</td>
<td>0.11</td>
<td>0.10</td>
<td>0.00</td>
<td>0.89</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Racial diversity index</td>
<td>Index created based upon four race</td>
<td>0.59</td>
<td>0.19</td>
<td>0.07</td>
<td>0.98</td>
</tr>
<tr>
<td>Income</td>
<td>Total median income (dollars /1,000)</td>
<td>54.34</td>
<td>31.84</td>
<td>0.00</td>
<td>215.67</td>
</tr>
<tr>
<td>Physical environmental status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacant housing rate</td>
<td>Vacant housing units / total housing units</td>
<td>0.08</td>
<td>0.07</td>
<td>0.00</td>
<td>0.46</td>
</tr>
<tr>
<td>Disorder</td>
<td>Number of disorders (graffiti/abandoned vehicle/littering)</td>
<td>22.60</td>
<td>18.10</td>
<td>0.00</td>
<td>128.00</td>
</tr>
</tbody>
</table>

Note: There are 452 samples based on census block group as an analysis unit.

Racial diversity = \( A/(\ln(N)) \) when \( A = (b1/a)\ln(b1/a) + (b2/a)\ln(b2/a) + (b3/a)\ln(b3/a) + (b4/a) \)

\( a = \text{total population} \) \( b1 = \text{White population} \) \( b2 = \text{Black population} \) \( b3 = \text{Asian population} \) \( b4 = \text{Hispanic population} \)

Source: Local police department for Crime and Disorder data, ACS 2006-2010 for demographic, socioeconomic status
<table>
<thead>
<tr>
<th>variable label</th>
<th>Definition</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>independent variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Land use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk Score</td>
<td>Walk Score</td>
<td>43.81</td>
<td>20.46</td>
<td>0.74</td>
<td>93.25</td>
</tr>
<tr>
<td>Walk Score square</td>
<td>Square of walk score</td>
<td>2337.28</td>
<td>1942.88</td>
<td>0.55</td>
<td>8695.56</td>
</tr>
<tr>
<td>Land Use Mix Index(^b)</td>
<td>Evenness of distribution based on Square footage of R, C, and O (see note)</td>
<td>0.44</td>
<td>0.30</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Multi-family &amp; commercial areas</td>
<td>Total areas of multi-family and commercial areas (acres/1,000)</td>
<td>0.04</td>
<td>0.04</td>
<td>0.00</td>
<td>0.36</td>
</tr>
<tr>
<td>Affordable housing</td>
<td>If 1=present, 0=absent</td>
<td>0.23</td>
<td>0.42</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Transportation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street intersections</td>
<td>Number of street interactions (3+ way)</td>
<td>28.49</td>
<td>16.24</td>
<td>0.00</td>
<td>112.00</td>
</tr>
<tr>
<td>Bus stop</td>
<td>Number of bus stops</td>
<td>5.50</td>
<td>5.46</td>
<td>0.00</td>
<td>34.00</td>
</tr>
</tbody>
</table>

Note: \(^b\) The land-use mix measure was adopted from the Strategies for Metropolitan Atlanta’s Regional Transportation and Air Quality study (Frank et al., 2005).

\((-1) \times [(\text{area of R/total area of R, C, and O}) \times \ln (\text{area of R/total area of R, C, and O}) + (\text{area of C/total area of R, C, and O}) \times \ln (\text{area of C/total area of R, C, and O}) + (\text{area of O/total area of R, C, and O}) \times \ln (\text{area of O/total area of R, C, and O})]/\ln (\text{number of land uses present})\)

C = commercial land use; O = office land use; R = residential land use

Source: Walk Score website for Walk Score, ACS 2006-2010 for land use, The Austin Tenants Council for affordable housing, and transportation for GIS
### Outcomes

- **Outdoor Violent Crime (OVC)**
- **Total Violent Crime (TVC)**

### Predictors

- **Unadjusted NBR (Demographic)**

### RESULTS

<table>
<thead>
<tr>
<th>Controls</th>
<th>OVC: $\beta = -0.091$, $p = 0.689$</th>
<th>TVC: $\beta = 0.121$, $p = 0.514$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>OVC: $\beta = 0.381$, $p = 0.000$</td>
<td>TVC: $\beta = 0.425$, $p = 0.000$</td>
</tr>
</tbody>
</table>
RESULTS

Outcomes

Predictors

Unadjusted NBR (SES & Physical Status)

Outdoor Violent Crime (OVC)

OVC: $\beta = 0.788, p = 0.015$

TVC: $\beta = 1.147, p = 0.000$

Racial diversity index

OVC: $\beta = -0.033, p = 0.000$

TVC: $\beta = -0.028, p = 0.000$

Median income

OVC: $\beta = 5.547, p = 0.000$

TVC: $\beta = 4.697, p = 0.000$

Vacant housing rate

OVC: $\beta = 0.037, p = 0.000$

TVC: $\beta = 0.033, p = 0.000$

Disorder
Outcomes

Predictors

RESULTS

Unadjusted NBR (Land Use)

Outdoor Violent Crime (OVC)

Walk Score

Total Violent Crime (TVC)

Land use mix

Multi-family and commercial area

Affordable housing

OVC: $\beta = 0.016, p = 0.000$

OVC: $\beta = 1.328, p = 0.000$

TVC: $\beta = 0.009, p = 0.001$

TVC: $\beta = 1.122, p = 0.000$

OVC: $\beta = 5.718, p = 0.003$

OVC: $\beta = 0.948, p = 0.000$

TVC: $\beta = 6.240, p = 0.000$

TVC: $\beta = 0.879, p = 0.000$
Outcomes

Outdoor Violent Crime (OVC)
Total Violent Crime (TVC)

Predictors

RESULTS

Unadjusted NBR (Transportation)

OVC: $\beta = -0.027, p = 0.374$
TVC: $\beta = -0.002, p = 0.457$

OVC: $\beta = 0.103, p = 0.000$
TVC: $\beta = 0.089, p = 0.000$
### RESULTS

**Adjusted NBR (Coef.)**

- **Interpretation of Coefficient**

  Counts of street intersections capture street connectivity as well as street length. Street interactions were negatively associated with both OVC and TVC incidents.

```
N of Street intersection
A < B
Length of street
A > B
```

- **Note**

  The dependent variable is violent crime between 2008 and 2012. N = 452

  * p-value<0.5 ** p-value<0.01 *** p-value<0.001

  Standard errors are in parentheses.

  Red: positive association (+)
  Blue: negative association (-)
The results showed that both outdoor and total violent crimes started to drop when Walk Score reached certain threshold levels in the city of Austin.
**DISCUSSION**

*Limitations and Further research*

- **Measurement of Walkability**
  Commonly used macro-level measurements of walkability, including Walk Score, land use mix, and street connectivity cannot fully account for how much certain areas provide opportunities to walk; **micro-level** walkability variables (not considered in this study) such as aesthetic, sidewalk conditions, and surveillance are likely to be significantly associated with crime incidents.

- **Small units of geography**
  Census block groups do not allow for explaining the variation of different crimes within the block group. Further studies with **smaller spatial unit** such as buffers around individual addresses or street segments are needed to better understand more specific locational characteristics of crimes.

- **Actual walking behavior vs. walkability**
  To better understand the role of walkability on crime, including actual walking behaviors can be helpful.
DISCUSSION

Findings and Significance

• In addition to the previously documented health, social, and economic benefits, walkability could also help reduce crimes in neighborhoods.

• The findings suggest that there exists meaningful walkability (measured by Walk Score) **thresholds** below which walkability may actually increase crimes, possibly by inviting strangers to the neighborhood, but beyond this threshold (with sufficient street activities and density of amenities), increased walkability can help reduce violent crimes possibly by increasing informal social control and surveillance.
THANK YOU
Interpretation of IRR (Incident Rate Ratio)

Over 65 aged population was significantly associated with decreased outdoor violent crime, with each additional 1/1000 population being associated with \((1 - 0.886) \times 100 = 11.4\%\) decreases in the incident rate of OVC, but not significantly associated with the incident ratio of TVC while holding all other variables in the model constant.

<table>
<thead>
<tr>
<th>Variables</th>
<th>OVC IRR</th>
<th>TVC IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>total area (acre/ 1,000)</td>
<td>1.345</td>
<td>1.048</td>
</tr>
<tr>
<td>Population (number/1,000)</td>
<td>1.311***</td>
<td>1.249***</td>
</tr>
<tr>
<td>over 65 aged population (number / 1,000)</td>
<td>0.886*</td>
<td>0.950</td>
</tr>
<tr>
<td>racial diversity index</td>
<td>0.973</td>
<td>1.560**</td>
</tr>
<tr>
<td>Median income ($/1,000)</td>
<td>0.983***</td>
<td>0.984***</td>
</tr>
<tr>
<td>vacant housing rates</td>
<td>17.172***</td>
<td>11.737***</td>
</tr>
<tr>
<td>Disorders</td>
<td>1.025***</td>
<td>1.024***</td>
</tr>
<tr>
<td>walk score</td>
<td>1.031**</td>
<td>1.018*</td>
</tr>
<tr>
<td>Walk score squared</td>
<td>1.000**</td>
<td>1.000***</td>
</tr>
<tr>
<td>land use mix index</td>
<td>0.904</td>
<td>0.973</td>
</tr>
<tr>
<td>Multi-family and commercial area (acre/ 1,000)</td>
<td>0.869</td>
<td>0.916</td>
</tr>
<tr>
<td>Affordable housing (if 1=presence of affordable housing 0=no)</td>
<td>1.426***</td>
<td>1.416***</td>
</tr>
<tr>
<td>Three or more leg intersections</td>
<td>0.989**</td>
<td>0.993*</td>
</tr>
<tr>
<td>Bus stop</td>
<td>1.036***</td>
<td>1.021**</td>
</tr>
<tr>
<td>constant</td>
<td>2.220*</td>
<td>10.312***</td>
</tr>
<tr>
<td>Lnalpha constant</td>
<td>-0.732***</td>
<td>-1.148***</td>
</tr>
<tr>
<td>alpha constant</td>
<td>0.481***</td>
<td>0.317***</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.149</td>
<td>0.137</td>
</tr>
<tr>
<td>LR chi2(14)</td>
<td>397.16***</td>
<td>524.57***</td>
</tr>
</tbody>
</table>

APPENDIX

Adjusted NBR (IRR)

- **Interpretation of IRR (Incident Rate Ratio)**

Vacant housing rates tell the degree of declining neighborhoods. Vacant housing rates and numbers of disorders such as graffiti, abandoned vehicle, and littering were positively and significantly associated with both OVC and TVC while holding all other variables in the model constant.

Areas with affordable housing compared to without affordable housing are expected to have 42.6% higher incident ratio of outdoor violent crime and 41.6% higher incident ratio of total violent crime, given the other variables were held constant in the model.

- **Note**

The dependent variable is violent crime between 2008 and 2012. \(N = 452\)

*\( p\)-value<0.5 \* \( p\)-value<0.01 \*** \( p\)-value<0.001

Standard errors are in parentheses.

Red: positive association \((x>1)\)

Blue: negative association \((x<1)\)