EFFECTS OF BUFFER SIZE AND SHAPE ON ASSOCIATIONS BETWEEN THE BUILT ENVIRONMENT AND ENERGY BALANCE

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ACTIVE LIVING RESEARCH 2013
Uncertain Geographic Context Problem

• Inconsistent findings in built environment and energy balance research

• **Uncertain Geographic Context Problem**
  – “The spatial uncertainty in the actual areas that exert the contextual influences under study and the temporal uncertainty in the timing and duration in which individuals experienced these contextual influences”*  

Inconsistent Findings in Built Environment Literature

• Previous research has relied mainly on pre-defined areas, or buffers, around a geocoded home address.

• Buffer definitions are based primarily on the transportation literature describing the upper limit of the distance that individuals will walk.

• However, there is no uniform buffer type used across studies.
Aims

• We examined how defining the built environment with different buffer sizes and buffer shapes could influence associations with physical activity and BMI.

• We hypothesized that
  – Measures of intersections (count and density) and businesses (count and density) would be positively associated with physical activity and negatively associated with BMI.
  – There would be an optimal buffer shape and size to isolate these associations.
Population

- Participants were selected from two large states in the nationwide the Nurses Health Study II, a large ongoing prospective cohort study
  - All female
  - Predominantly white
  - Pennsylvania (n=11,178)
  - Texas (n=6,255)
  - Had a geocoded home address at the street level in Pennsylvania or Texas and data on BMI in the year 2009
Exposure

- Geocoded questionnaire mailing addresses

- Street network data from TIGER 2010-based road network (Streetmap USA, ESRI)

- Business data from the commercially available InfoUSA 2009 database
Methods: Exposure

• Geographic information systems (GIS) created
  – Line-based network and radial buffers
  – 400m, 800m, 1200m, and 1600m

• Estimated business and intersection counts and densities within each buffer
Methods: Outcome

- Two self-reported energy balance-related variables:
  - Body mass index (BMI) (kg/m²)
  - Walking in metabolic equivalent hours per week (MET hrs/wk)

  - Questionnaires included recreational physical activity during the past year, with questions on the average time per week spent walking or hiking outdoors
  - Multiplied the reported time spent weekly at each activity by its typical energy expenditure requirements expressed in MET hours per week score
Methods: Statistical Analysis

• Cross-sectional linear regression
• Log-transformed built environment variables
• Adjusted for
  – Age (in years)
  – Census tract median income (in $) and household value (in $)
  – Smoking status (never, past, current <15/day, current ≥15/day)
  – Husband's education (<HS, HS, College, Grad School, Missing or Not Married)
# Results: N=17,433

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>28.2</td>
<td>6.7</td>
</tr>
<tr>
<td>Walking METs (hrs/wk)*</td>
<td>6.4</td>
<td>8.9</td>
</tr>
<tr>
<td>Census Tract Median Income</td>
<td>$ 63,571</td>
<td>$ 23,532</td>
</tr>
<tr>
<td>Census Tract Median Household Value</td>
<td>$ 129,349</td>
<td>$ 66,884</td>
</tr>
<tr>
<td>Census Tract Percent White</td>
<td>89.9</td>
<td>12.8</td>
</tr>
<tr>
<td>Census Tract Population Density</td>
<td>2378.2</td>
<td>3368.1</td>
</tr>
<tr>
<td>Census Tract Percent Urban</td>
<td>79.2</td>
<td>32.8</td>
</tr>
<tr>
<td>Census Tract Percent No High School Ed</td>
<td>13.3</td>
<td>8.6</td>
</tr>
</tbody>
</table>

*N=13,666 for walking analyses*
Results: N=17,433
Coefficients are presented as the effect on each outcome of a one unit increase in the lognormal value of each built environment measure.

All analyses adjusted for age, Census tract median income and household value, smoking status, and husband’s education.
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Conclusions

• Results indicate that the scale and type of built environment measures can have an impact on study results and may partly explain inconsistent findings from past studies of the built environment and energy balance.

• These findings underscore the issue of the Uncertain Geographic Context Problem, an emerging key concern for studies of associations between environment and behavior.
Acknowledgements

• Thanks to all my co-authors in the Transdisciplinary Research in Energetics and Cancer (TREC) Spatial and Contextual Measures and Modeling Working Group who contributed greatly to this analysis and presentation

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• Any questions or comments, please contact me

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## Built Environment Measures Positively Associated with Walking

All analyses adjusted for age, Census tract median income and household value, smoking status, and husband's education.

Coefficients are presented as the effect on each outcome of a one unit increase in the lognormal value of each built environment measure.

Bolded coefficients indicate $p < 0.05$.

<table>
<thead>
<tr>
<th>Buffer Size</th>
<th>Buffer Shape</th>
<th>Intersection Count</th>
<th>Density (count per km$^2$)</th>
<th>Business Count</th>
<th>Density (count per km$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400m</td>
<td>Line Based</td>
<td>0.10 (-0.06, 0.27)</td>
<td>0.03 (-0.12, 0.18)</td>
<td>0.10 (-0.02, 0.22)</td>
<td>0.02 (-0.07, 0.11)</td>
</tr>
<tr>
<td></td>
<td>Radial</td>
<td>0.09 (-0.06, 0.24)</td>
<td>0.08 (-0.05, 0.21)</td>
<td>0.10 (-0.01, 0.22)</td>
<td>0.08 (-0.02, 0.19)</td>
</tr>
<tr>
<td>800m</td>
<td>Line Based</td>
<td>0.14 (-0.01, 0.28)</td>
<td>0.16 (-0.04, 0.37)</td>
<td>0.12 (0.02, 0.21)</td>
<td>0.11 (0.01, 0.21)</td>
</tr>
<tr>
<td></td>
<td>Radial</td>
<td>0.12 (-0.02, 0.25)</td>
<td>0.12 (-0.03, 0.27)</td>
<td>0.08 (-0.02, 0.18)</td>
<td>0.08 (-0.02, 0.19)</td>
</tr>
<tr>
<td>1200m</td>
<td>Line Based</td>
<td>0.16 (0.02, 0.29)</td>
<td>0.25 (0.03, 0.48)</td>
<td>0.10 (0.01, 0.19)</td>
<td>0.12 (0.02, 0.23)</td>
</tr>
<tr>
<td></td>
<td>Radial</td>
<td>0.13 (0.02, 0.24)</td>
<td>0.15 (0.02, 0.28)</td>
<td>0.08 (-0.02, 0.17)</td>
<td>0.09 (-0.02, 0.20)</td>
</tr>
<tr>
<td>1600m</td>
<td>Line Based</td>
<td>0.12 (-0.01, 0.25)</td>
<td>0.17 (-0.06, 0.40)</td>
<td>0.10 (0.02, 0.19)</td>
<td>0.14 (0.03, 0.25)</td>
</tr>
<tr>
<td></td>
<td>Radial</td>
<td>0.09 (-0.05, 0.23)</td>
<td>0.09 (-0.07, 0.25)</td>
<td>0.07 (-0.02, 0.17)</td>
<td>0.09 (-0.02, 0.20)</td>
</tr>
</tbody>
</table>
## BMI Positively Associated with Built Environment Measures

<table>
<thead>
<tr>
<th>Buffer Size</th>
<th>Buffer Shape</th>
<th>Count</th>
<th>Density (count per km²)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>400m</td>
<td>Line Based</td>
<td>0.20 (0.09, 0.31)</td>
<td>0.16 (0.06, 0.26)</td>
<td>0.10 (0.02, 0.19)</td>
<td>0.08 (0.02, 0.14)</td>
</tr>
<tr>
<td></td>
<td>Radial</td>
<td>0.15 (0.05, 0.25)</td>
<td>0.13 (0.04, 0.22)</td>
<td>0.11 (0.03, 0.19)</td>
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<td>0.10 (0.02, 0.17)</td>
</tr>
<tr>
<td>1200m</td>
<td>Line Based</td>
<td>0.13 (0.04, 0.22)</td>
<td>0.17 (0.02, 0.32)</td>
<td>0.09 (0.03, 0.14)</td>
<td>0.09 (0.02, 0.16)</td>
</tr>
<tr>
<td></td>
<td>Radial</td>
<td>0.07 (0.00, 0.14)</td>
<td>0.09 (0.00, 0.18)</td>
<td>0.07 (0.01, 0.13)</td>
<td>0.08 (0.00, 0.15)</td>
</tr>
<tr>
<td>1600m</td>
<td>Line Based</td>
<td>0.11 (0.03, 0.20)</td>
<td>0.15 (-0.01, 0.30)</td>
<td>0.08 (0.02, 0.14)</td>
<td>0.09 (0.02, 0.17)</td>
</tr>
<tr>
<td></td>
<td>Radial</td>
<td>0.11 (0.02, 0.21)</td>
<td>0.13 (0.02, 0.23)</td>
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