Straight to Recording for All:
Methods to Measure Walkability: From Qualitative to Quantitative
Methods to Measure Walkability: From Qualitative to Quantitative

Organized by ANF10 – Standing Committee on Pedestrians
Measuring Walkability
Today’s Webinar

Defining and Applying Walkability to Decision Making: Predicting Equity, Health & Economic Benefits of Land Use & Transportation Investments

Lawrence Frank, Urban Design 4 Health

Using Embodied Videos of Walking Interviews in Walkability Assessment

Geoffrey Battista and Kevin Manaugh, McGill University

The Pedestrian Index of the Environment (PIE)

Patrick Singleton, Portland State University
DEFINING AND APPLYING WALKABILITY TO DECISION MAKING: PREDICTING EQUITY, HEALTH & ECONOMIC BENEFITS OF LAND USE & TRANSPORTATION INVESTMENTS

Presentation for TRB | Washington D.C. | July 27, 2017

Dr. Lawrence Frank, AICP, PhD
President, UD4H

Eric Fox, MScP
GIS Manager, UD4H
• Unique background and depth of experience in the modeling of health and built environment relationships
• UD4H and collaborators have led over $25 million in research linking transportation and land use development actions with health outcomes
• Among most published scholars on health and built environment globally
• Key Focus Areas:
  o Tool & Evidence Development
  o Objective Measuring & Surveying
  o Education, Outreach & Policy Development
CORE EXPERTISE

• Measuring spatial phenomena including walkability, transit level of service, regional accessibility and pedestrian environments

• Developing predictive models of travel patterns for non-motorized, transit, private vehicle based demand

• Providing guidance for project-level programming and prioritization of active transport investments
“The Hidden Health Costs of Transportation”
Frank et al 2010
American Public Health Association
Built Environment Data Sources

- Transport
  - Roads, trails, bicycle facilities, sidewalks

- Ministry of Education
  - Schools

- Transit Agencies
  - Transit stops
  - Travel Time

- Census
  - Demographic covariates

- Assessor’s / Parcel data
  - Residential density, land use mix, retail FAR

- Food Environment
  - Food Stores
  - Restaurants

- Green Space
  - Tree canopy
  - Parks
**Local Walkability – “How”**

<table>
<thead>
<tr>
<th></th>
<th>Uptown Moody Park</th>
<th>Queensborough</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Residential Density (dwelling units/acre)</td>
<td>40.29</td>
<td>7.73</td>
</tr>
<tr>
<td>Mixed Use Index (range 0 – 1)</td>
<td>0.58</td>
<td>0.09</td>
</tr>
<tr>
<td>Intersection Density (per square km)</td>
<td>70.12</td>
<td>27.91</td>
</tr>
<tr>
<td>Retail Floor Area Ratio</td>
<td>0.64</td>
<td>0.30</td>
</tr>
<tr>
<td>Overall Walkability</td>
<td>4.26</td>
<td>-3.74</td>
</tr>
</tbody>
</table>
Scenario planning is a method for analyzing and comparing the impacts of various land use and transportation alternatives. Typical impacts considered include financial costs, transportation accessibility & housing availability. More recently health impacts are being added. Results are used to inform decision-making about infrastructure investments, master planning, development proposals, etc.
GENESIS OF TOOL DEVELOPMENT

- **2005**: INDEX: Livable Community Initiative: Atlanta (SMARTRAQ)
- **2007**: I-PLACE3S: King County, added health module
- **2011**: UrbanFootprint: Vision California
- **2012**: CommunityViz: San Diego, & Toronto, Ontario & Surrey, BC—added health module
- **2015**: California Public Health Assessment Module (CPHAM) for Urban Footprint 2.0
- **2016**: National Public Health Assessment Model (NPHAM) supported by National Environment Database (NED)
• San Diego Healthy Works
• Application—Palomar Gateway Development
• Data Sources:
  – Health Outcomes: California Health Interview Survey (CHIS) data from 2001-2009 for San Diego County (n = 18,044 adults, 1,368 teens, 2,715 children)
  – Travel Behavior: SANDAG Household Travel Survey (n = 5,974 adults, 1,589 children & teens)
Physical Activity Inhibitors: Composite Map Methodology

Made up of the following Base Maps:
- Traffic Volume Density
- Arterial Density
- Vacant Parcels
- Physical Disorder
- Violent Crime

- To calculate the composite score:
- Each Base Map measure was given a standardized value (z-score) for each block group.
- The final composite score per block group is the average of the Base Map z-scores.
- Block groups were separated into quintiles (5 groups with equal numbers of block groups in each) based on their composite score.
- Although only the western third of the region is shown in the map, the analysis is based on all 1,762 block groups in the San Diego region.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Base Scenario</th>
<th>Change Scenario</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Family DU</td>
<td>192</td>
<td>80</td>
<td>housing units</td>
</tr>
<tr>
<td>Multi-Family DU</td>
<td>155</td>
<td>1626</td>
<td>housing units</td>
</tr>
<tr>
<td>Total Population</td>
<td>884</td>
<td>3841</td>
<td>people</td>
</tr>
<tr>
<td>Residential Area</td>
<td>44.3</td>
<td>68.5</td>
<td>acres</td>
</tr>
<tr>
<td>Net Residential Density</td>
<td>7.8</td>
<td>24.9</td>
<td>units/acre</td>
</tr>
<tr>
<td>Retail Floorspace</td>
<td>370073</td>
<td>395221</td>
<td>square feet</td>
</tr>
<tr>
<td>Retail Area</td>
<td>15.7</td>
<td>7.3</td>
<td>acres</td>
</tr>
<tr>
<td>Retail FAR</td>
<td>0.5</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Office Floorspace</td>
<td>0</td>
<td>41238</td>
<td>square feet</td>
</tr>
<tr>
<td>Office Area</td>
<td>0</td>
<td>1.2</td>
<td>acres</td>
</tr>
<tr>
<td>Office FAR</td>
<td>0</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Civic and Education Floorspace</td>
<td>0</td>
<td>20035</td>
<td>square feet</td>
</tr>
<tr>
<td>Recreation and Entertainment Floorspace</td>
<td>0</td>
<td>68393</td>
<td>square feet</td>
</tr>
<tr>
<td>Park Area</td>
<td>1.2</td>
<td>1.2</td>
<td>acres</td>
</tr>
<tr>
<td>Number of Schools</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Number of Transit Stops</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Number of Grocery Stores</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total Road Centerline Miles</td>
<td>4.2</td>
<td>4.2</td>
<td>miles</td>
</tr>
<tr>
<td>Total Sidewalk Miles</td>
<td>4.5</td>
<td>5.5</td>
<td>miles</td>
</tr>
<tr>
<td>Sidewalk Coverage</td>
<td>53%</td>
<td>66%</td>
<td></td>
</tr>
<tr>
<td>Total Bike Miles</td>
<td>0.5</td>
<td>1.2</td>
<td>miles</td>
</tr>
</tbody>
</table>
• All adult health metrics improved in the change scenario, including
  – 68% increase minutes of daily transportation walking
  – 15.4% reduction in prevalence of high blood pressure
  – 9.6% reduction in prevalence of type II diabetes
• Child/teen results were mixed
  – Physical activity predicted to increase for children/teens
  – Obesity prevalence for teens predicted to increase
  – Asthma prevalence for children/teens predicted to increase
• Collision risk factor increased
**Funder:** California Strategic Growth Council

**Key Elements:**

- Quantitative statistical models of **built environment & health**
  - Outcomes include BMI, likelihood of being obese, likelihood of having high blood pressure/heart disease/type 2 diabetes
- Integrated into Calthorpe’s UrbanFootprint
30 counties across five California regions:

- San Francisco Bay Area
- Sacramento
- San Diego County
- San Joaquin Valley
- Southern California (including Los Angeles)
Key Elements continued:

- **Data** from parcel level and address-level large, representative surveys
  - Parcel level built environment data (density, connectivity, etc) from UrbanFootprint
  - California Household Travel Survey (CHTS)
  - California Health Interview Survey (CHIS)
  - 5 MPO regions
- **Fine spatial scale** analysis and predictions
  - 1-km buffers around 150x150 grid cells
Key Elements continued:

- Outcomes:
  - Recreation Physical Activity - Minutes Daily
  - Walking - Minutes Daily
  - Biking - Minutes Daily
  - Auto - Minutes Daily
  - Obese Population (%)
  - High Blood Pressure (%)
  - Heart Disease (%)
  - Diabetes - Type 2 (%)

Weight-Related Disease Rates

and demographic characteristics of scenarios.
**Strength of Approach**

- **Large sample sizes**
  - 53,733 California Household Travel Survey participants
  - 40,617 California Health Interview Survey participants

- **Cohort-specific model development**
  - 4 age groups (seniors, adults, teens, children)
  - For adults, three HH income groups (<$50k, $50-100k, >$100k)

- **California-specific evidence base**
  - CHIS and CHTS data were collected from a representative cross-section of Californians

- **Variability in built environment characteristics**
  - 30-county study area covers a broad range of built environments and travel behaviors across California
Applying Evidence to the Los Angeles Long Range Plan

<table>
<thead>
<tr>
<th>Adults: Ages 18-65</th>
<th>Base Year 2012</th>
<th>Net Change: (2012 - 2040)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreation Physical Activity - Minutes Daily</td>
<td>13 min</td>
<td>+ 9%</td>
</tr>
<tr>
<td>Walking - Minutes Daily</td>
<td>23 min</td>
<td>+ 10%</td>
</tr>
<tr>
<td>Biking - Minutes Daily</td>
<td>3 min</td>
<td>+ 12%</td>
</tr>
<tr>
<td>Auto - Minutes Daily</td>
<td>55 min</td>
<td>- 6%</td>
</tr>
<tr>
<td>Obese Population (%)</td>
<td>21.5%</td>
<td>- 3%</td>
</tr>
<tr>
<td>Poor Health Population (%)</td>
<td>24.1%</td>
<td>- 13%</td>
</tr>
<tr>
<td>High Blood Pressure (%)</td>
<td>19.6%</td>
<td>- 1%</td>
</tr>
<tr>
<td>Heart Disease (%)</td>
<td>4.3%</td>
<td>0%</td>
</tr>
<tr>
<td>Diabetes - Type 2 (%)</td>
<td>5.6%</td>
<td>- 11%</td>
</tr>
</tbody>
</table>

*Source:* California Public Health & Activity Model – Scenario Planning for Southern California Association of Governments
## C-PHAM in SCAG Predictions

<table>
<thead>
<tr>
<th>Adults: Ages 18-65</th>
<th>2040 Trend</th>
<th>Adopted Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreation Physical Activity - Minutes Daily</td>
<td>14.6 min</td>
<td>+ 0.4%</td>
</tr>
<tr>
<td>Walking - Minutes Daily</td>
<td>12.1 min</td>
<td>+ 33%</td>
</tr>
<tr>
<td>Biking - Minutes Daily</td>
<td>1.6 min</td>
<td>+ 26%</td>
</tr>
<tr>
<td>Auto - Minutes Daily</td>
<td>64.8 min</td>
<td>- 4.4%</td>
</tr>
<tr>
<td>Obese Population (%)</td>
<td>26.3%</td>
<td>- 1.3%</td>
</tr>
<tr>
<td>High Blood Pressure (%)</td>
<td>21.5%</td>
<td>- 1.2%</td>
</tr>
<tr>
<td>Heart Disease (%)</td>
<td>4.4%</td>
<td>- 1.0%</td>
</tr>
<tr>
<td>Diabetes - Type 2 (%)</td>
<td>6.1%</td>
<td>- 1.0%</td>
</tr>
</tbody>
</table>

*Source: California Public Health & Activity Model – Scenario Planning for Southern California Association of Governments*
National Environmental Database (NED) & National Public Health Assessment Model (N-PHAM)
Goal: Develop a nationally consistent database of built, natural, and social environmental indicators

Funder: Robert Wood Johnson Foundation

Key Elements:
- Built, natural, and social environment
- Developed at block group geography
- National coverage
NED Database

- From 30+ national & region-specific databases
  - Government Agencies
  - Universities
  - Private Sector

- Contains over 200 variables

- Leveraging existing variables, developing new variables
• Types of Variables
  – Existing nationwide variables (e.g. SLD, EnviroAtlas)
  – Composite measures
  – Variable weighting
  – Region-specific new variables at smaller spatial scale

• Frequent updates of variables at regular intervals where available
**Goal:** Develop a nationally applicable health impact tool that empower communities and developers to **quantify localized health impacts of alternative land use and transportation investment scenarios**

**Funder:** U.S. Environmental Protection Agency

**Key Elements:**

- **Statistical regression models of **built, natural, and social environment effects on health**
  - Direct connection with modeled land use, walkability and health outcomes

- **Block group level analysis and model predictions**
  - Models developed from California statewide travel and health surveys
National Database (NED)

National Tool (N-PHAM)

Planners and public health officials can measure and optimize health impacts of transport and land use investment
N-PHAM CONNECTS WITH EXISTING TOOLS

• Connects to scenario planning software via end user API and software-specific plug-in
• Fully integrated with:
  – Envision Tomorrow (Fregonese Associates)
  – Urban Footprint (Calthorpe Analytics)
  – CommunityViz (City Explained, Inc., formerly Placeways)
NPHAM Phase 1 - Outcomes

- Physical Activity:
  - Transport walking, transport biking, recreational PA
- Sedentary time:
  - Auto travel
- General health:
  - Prevalence of poor self-reported general health

- Obesity-related:
  - Average BMI, obesity prevalence, overweight prevalence
- Mental health:
  - Moderate to serious psychological distress prevalence

Diabetes and cardiovascular disease planned in Phase II
Dr. Larry D. Frank:  ldfrank@ud4h.com

Mr. Eric Fox:  efox@ud4h.com

Visit our website:  www.ud4h.com
Using Embodied Videos of Walking Interviews in Walkability Assessment

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Walkability: Measuring Physical Space

What is walkability?

Generalizable instruments
• Geospatial measures
• Audit-based measures

Shortcomings to date
• Locals’ perceptions
  (Hajna et al., 2013)
• Socioeconomic factors
  (Manaughe and El-Geneidy, 2011)
Context Matters

The “Uncertain Geographic Context” Problem (Kwan 2012)

• How do complex areal attributes (e.g., land use mix) impact individual outcomes?

• How can we balance
  • generalizable processes and their particularities,
  • across space and among individuals,

  to better understand the relationship between context and outcomes?

We propose that assessment treats the pedestrian as integral to the geographic context of walkability.

http://esoiesmarina.blogspot.ca/
Toward Socializing Walkability

Rethinking walkable space
(Lefebvre, 1974/1991; Massey, 2005)
- Physical and social distances
- Complex and everchanging

Ways of understanding
- Embodiment and reflection
  (Middleton, 2010; Spinney, 2006; 2011)
- Walking interviews
  (Anderson, 2004; Evans and Jones, 2011)
Our Approach

**Sedentary interview (1hr)**
1. Start with personal history and neighborhood selection
2. Discuss routines and preferred amenities, e.g., shopping
3. Use amenities to discuss nearby streets, e.g., traffic, crime, and aesthetics
4. Flexibly pursue emerging themes

**Walking interview (1hr)**
1. Mount GoPro camera and begin participant-led tour
2. Prompt participant re: physical features, events, their feelings
3. Stop at key locations to discuss in greater depth, relating to previous statements
4. Debrief and solicit ideas for improving walking
Generating new insights

**Sample**: 5 pilot-testing cases, followed by 30 residents of one neighbourhood

Our approach illuminates:

- Features in conventional tools
- Amenities and paths unique to locals
- Informal behavior by participants and others (and its impact on walking)
- Local knowledge of crime and traffic

Top: “I don’t know why they don’t redraw the lines. Does that mean they don’t want it to be a crossing path anymore?” (Elena)

Bottom: Dodging a cyclist on the sidewalk
Cars turning very quickly from highway
Friend mugged outside temple
Pedestrian countdown very short, causing participant to run
Mafia firebombing
Aggressive panhandler hangs out
"Ogilvy is a sketchy street"
4 daycares, no crosswalks
Halfway house
Poor intersection design promotes jaywalking

KEY
Unsafe from traffic
Unsafe from crime
Taking a closer look...

Cars turning very quickly from highway
amenity – food – ephemeral
amenity – cafe/bar - old man
Alleyway: Shortcut or amenity?
Implications for Practice

**Complement existing walkability measures**
- Compare local and technical knowledge
- Examine difference among different groups, e.g., people with disabilities, low-income
- Use multimedia as compelling evidence

**As a stand-alone approach**
- Gauge local needs at low cost, e.g., for cash-strapped advocacy groups
- Engage the community; people love to talk about themselves
- Tailor walkability audits and performance measures to local context
Methodological Insights

A versatile, collaborative approach

• Reflect on physical and social spaces shaping walking behavior
• Inform design of pedestrian interventions beyond built solutions, e.g., law enforcement, social inclusion policies
• Relatively low-cost (camera, interviewing manual, compensation)

Acknowledging limitations

• Researcher should be familiar with walkability audits and interviewing
• Difficult to compare trajectories and assessments*

Thank you!

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The Pedestrian Index of the Environment (PIE)

Patrick A. Singleton
Portland State University
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  – Joseph Totten
  – Christopher Muhs
Outline

• Walkability
• Pedestrian Index of the Environment (PIE)
• Transferable PIE
• Comparing between & within regions
• Conclusions & future work

Adapted from: http://www.flickr.com/photos/takomabibelot/3223617185
Why walkability?

- Pedestrian planning, infrastructure
- Physical activity, health & safety
- Mode shifts, emissions
- Property values, neighborhood vitality
Walkability measures

- Pedestrian Environment Factor (PEF)$^1$
- Walkability Index$^2$
- Walk Opportunities Index$^3$
- Walk Score$^4$

- Pedestrian Index of the Environment (PIE)$^5$

Original objectives

• Metro: Portland’s metropolitan planning organization (MPO)

• Improving representation of the pedestrian environment in travel demand models
  – Four-step travel demand forecasting process
  – Finer spatial resolution
  – Research-based measures of the built environment
  – Behavioral sensitivity

1. Generation
2. Distribution
3. Mode choice
4. Assignment
What is PIE?

The Pedestrian Index of the Environment (PIE) = \( \sum \) (6 dimensions) weighted by association with walking

**People & job density**

**Transit access**

**Urban living infrastructure**

**Block size**

**Sidewalk extent**

**Comfortable facilities**

ULI = Urban Living Infrastructure: pedestrian-friendly shopping and service destinations used in daily life.
PIE’s unique contributions

• Calibrated to walking behavior

• Grid cells: pedestrian analysis zones (PAZs)

• Fine-grained built environment data

Adapted from: https://www.flickr.com/photos/65478477@N06/6063689338/
New objectives

- Transferability and forecasting of the PIE for modeling and planning applications
  - Retain unique aspects: small scale, behavioral
  - Use nationally-available built environment data
  - Evaluate transfer to different regions and urban contexts
  - Examine issues & needs when forecasting PIE
PIE 2.0

- EPA’s Smart Location Database (SLD)
  - Census block groups
  - Population density
  - Transit frequency density
  - Employment density (retail + entertainment)
  - Intersection density (pedestrian-oriented)
Variations between regions

Walk trip mode share vs Population density (people/acre)

- Seattle
- Portland
- San Francisco
- Los Angeles
- San Diego
Variations within regions

- Low density: $R^2 = 0.61$
- High density: $R^2 = 0.13$

Walk trip mode share vs. Population density (people/acre)
Challenges

• Data availability
  – Behaviorally-relevant measures of the built environment
  – Small spatial scale of walk trips

• Variations in behavioral relationships
  – Between or among regions
  – Within regions: non-linear?
Conclusions

• Increasing behavioral and environmental data
• Calibrated walkability measures for...
  – Behaviors
    • Utilitarian/recreational walking, public activity
  – Applications
    • Travel demand, residential location, health, safety
• Networks, connectivity, accessibility
• Future work:
  – Spatial scale
  – Forecasting
Thank you!

• Learn more
  http://trec.pdx.edu/research/project/510
  http://trec.pdx.edu/research/project/677
  http://trec.pdx.edu/research/project/1028

• Pedestrian Modeling Workshop
  Transportation & Communities Summit
  September 12, 2017 – Portland, OR

• Questions?

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