On 350 calories — one apple tart or a “special” slice of Ray's Pizza — a cyclist can travel 10 miles, a pedestrian 3.5 miles, and an automobile 100 feet.

Transportation Alternatives, Bicycle Blueprint, 1998

“Carbonless Footprints” Paper in Preventive Medicine

TRANSPORTATION ENERGY INDEX
CHANGE study is currently recruiting participants!
How does your neighbourhood impact the way you get to work, shop, eat, exercise and socialize? We invite you to take part in a research study to help answer this important question. All participants will receive up to $50 plus a chance to win various prizes. CHANGE (Changes in Health, Activity, and Neighbourhood).
Note: Diet and nutrition, age, gender, income, genetics, and other factors also impact weight and chronic disease and to the extent possible are controlled in analyses. Vehicle age and climate impacts emissions and air quality, and respiratory function is also impacted by a variety of factors.

Dr. Lawrence Frank
Why Should we care?

- **Health Care Costs**
  - Changes in health care system service delivery
    - Affordable care act & Health District Planning

- **GHG Impacts and Co-Benefits**
  - Energy Security

- **Aging population need easy access to facilities**
  - Reduced response time
  - Increased efficiency of case management

- **Meeting the growing unmet demand for walkable environments**
“The Hidden Health Costs of Transportation” - Frank et al 2010
American Public Health Association
Proximity

Disconnected

Connected

Crow-Fly Buffer
Network Buffer
Sample Household

Single Family Residential
Multi Family Residential
Commercial
Office
Industrial
Institutional
Greenspace/Recreational
Parking
Unknown

Connectivity

2 KM

1 KM
Measures Calculated Using 1 km Network Buffers

1 km network buffer (2011)
1 km network buffer (2005)
1 km crow-fly buffer

Land use:
- Agriculture
- Civic
- Educational
- Mixed use
- Office
- Other
- Park
- Recreation
- Res_MF
- Res_SF
- Retail
- Retail (food)

 postal code centroid
## Comparing Two Communities

<table>
<thead>
<tr>
<th>Metric</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>
Built Environment Data Sources

GIS Data Layers
- Roads, trails, bicycle facilities, sidewalks

Ministry of Education
- Schools

Transit Agencies
- Transit stops and mode

Census
- Demographic covariates

Other
- Farmers’ markets, crime

Public Health
- Food locations

Assessors’ / Parcel data
- Residential density, land use mix, retail FAR
Utilitarian Walkability

Made up of: Residential density, retail Floor Area Ratio, intersection density, land use mix

Regional walkability distribution, by block group
Residents of the most walkable areas in Atlanta were 2.4 times more likely to get the recommended amounts of physical activity.

18 percent in the lowest versus 37 percent in the highest levels of walkability got recommended levels of physical activity.

## Predictors of Obesity

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>t-Ratio</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.012</td>
<td>6.00</td>
<td>0.000</td>
</tr>
<tr>
<td>Education</td>
<td>-0.080</td>
<td>-4.71</td>
<td>0.000</td>
</tr>
<tr>
<td>Income</td>
<td>-0.057</td>
<td>-4.75</td>
<td>0.000</td>
</tr>
<tr>
<td>Walk Distance</td>
<td>-0.049</td>
<td>-2.04</td>
<td>0.034</td>
</tr>
<tr>
<td>Car Time</td>
<td>0.001</td>
<td>2.875</td>
<td>0.003</td>
</tr>
<tr>
<td>Land Use Mix</td>
<td>-2.035</td>
<td>-5.65</td>
<td>0.000</td>
</tr>
<tr>
<td>Black Male</td>
<td>0.311</td>
<td>3.930</td>
<td>0.000</td>
</tr>
<tr>
<td>Black Female</td>
<td>0.372</td>
<td>5.09</td>
<td>0.000</td>
</tr>
<tr>
<td>White Female</td>
<td>-0.871</td>
<td>-11.3</td>
<td>0.000</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.497</td>
<td>-2.22</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Obesity Results – Driving and Walking

- Every additional hour per day in a car translates into a 6 percent increase in the likelihood of obesity.
- Time spent driving increases as walkability decreases.
- Every additional Kilometer (.6 miles) walked translates into 4.8 percent reduction in the likelihood of being obese.
- Distances walked increases with walkability.

Health and Built Environment Evidence to Date

1) built environments play a role in shaping health outcomes and disparities
   a) behaviors and b) exposures
2) Environments relate with health outcomes independent of preferences or self selection
   - relationship is at likely least partially causal
3) Built environment X Health relationships vary considerably across age, income, and gender
4) Meeting physical activity guidelines and reduced risk of obesity are associated with transit use and more bikable and walkable environments
   a) reduces odds of chronic disease onset for several morbidities
   b) logically reduces demands on health care system and associated costs
4) It is both possible and timely to monetize these costs
The Global Warming Gamble

Policy Levers to Reduce Transportation - Related CO2 emissions

- Fuel Mix
- Vehicle Efficiency
- Demand
CO2 & Neighbourhood Design

Source: LUTAQH final report, King County ORTP, 2005
Network Based WalkScore

Implemented and tested airline versus network distance measurement for Walk Score:

- Network method resulted in stronger bivariate association (as compared to airline method) with daily minutes of moderate or vigorous physical activity**, body mass index*, obesity, overweight**, and daily time spent in an automobile**

** = p < 0.01, * = p < 0.05
The Walkability Index has been linked to outcomes including:

- measures of walking and driving behaviour
- air pollutant generation (VOC, NO\textsubscript{x})
- Body Mass Index
- physical activity
- Diabetes, Respiratory, and CardioVascular Disease
- Social Capital, Mental Health, and Depression

Results of studies making these linkages have been widely published in peer-reviewed journals.
San Diego Health Impact Assessment Tool Development Project
Innovations

First large scale study to spatially match a prevalence (health outcome dataset - Calif. Health Interview Survey) with detailed parcel level built environment measures

- Piloted in San Diego County N= appx 18000

One of 3 efforts to date that have imported elasticities linking local (walkability) and regional accessibility (transit LOS) with chronic disease outcomes directly into a decision support tool

- Type II Diabetes, Cardiovascular disease, respiratory ailments along with obesity, physical activity levels

Results forthcoming in several publications

Tool operational, validated, and ready for use
Scenario planning overview

- 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.
Evidence based research on relationships
(regression models)

Urban Form Patterns
Residential Density
Land Use Mix
Street Network Connectivity
Retail Floor Area Ratio

Outcomes
Physical activity
Obesity / Body Mass Index
Transportation patterns
Greenhouse gas -- CO2

Integrate findings into existing software
Calculated Outcome Changes

Neighbourhood Design Feature

<table>
<thead>
<tr>
<th>Health Outcome</th>
<th>Base</th>
<th>Scenario A</th>
<th>Scenario B</th>
</tr>
</thead>
<tbody>
<tr>
<td>value X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>value Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>value Z</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Case study – Palomar Gateway

- Neighborhood-scale, using a parcel-level tool
- Located just east of I-5 in southern Chula Vista
- 100 acres of vacant, retail, and industrial land near Palomar St, with residential to the north and south
- Identified in the City’s 2005 General Plan as one of the top locations for infill and redevelopment
- Case study will test health impacts of potential Specific Plan alternatives
### Built environment changes

RESULTS ARE PRELIMINARY AND FOR ILLUSTRATIVE PURPOSES ONLY

<table>
<thead>
<tr>
<th>Name</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 Land 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>
West Don Lands (Toronto) Example

Pilot study site for software tool application:
- Substantial planning already done
- 80 acres
- Significant changes in built environment
  - Dense/mixed use development
  - 6000-6500 housing units
  - 1 million sq ft of office/retail
  - 2 new streetcar stops
  - New park space
- Redevelopment is part of revitalizing Toronto's waterfront
- Site of athlete’s village for Pan American Games (2015)
SCS Study Area Parcel-Based Polygons

Study area (grey polygons)

Impacted area (orange polygons)
## SCS Scenario Summary
(unweighted average)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Existing Conditions</th>
<th>Change Scenario 1: SCS Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study area postal codes (n=39)</td>
<td>Study area postal codes (n=39)</td>
<td>Study area postal codes (n=39)</td>
</tr>
<tr>
<td>Buffering</td>
<td>17.9</td>
<td>101.0</td>
</tr>
<tr>
<td>Net residential density (residential units per residential acres)</td>
<td>10.5</td>
<td>33.6</td>
</tr>
<tr>
<td>Land use mix (0-1)</td>
<td>0.11</td>
<td>0.57</td>
</tr>
<tr>
<td>Retail floor area ratio</td>
<td>0.20</td>
<td>0.56</td>
</tr>
<tr>
<td>Intersection density (count/sq km)</td>
<td>47.0</td>
<td>91.0</td>
</tr>
<tr>
<td>Transit density (count/sq km)</td>
<td>33.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Number of intersections</td>
<td>47</td>
<td>91</td>
</tr>
<tr>
<td>Number of transit stops</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Pedestrian-accessible roads (km)</td>
<td>14.2</td>
<td>20.0</td>
</tr>
<tr>
<td>Bicycle Facilities (km)</td>
<td>10.6</td>
<td>21.6</td>
</tr>
<tr>
<td>Trails (km)</td>
<td>6.7</td>
<td>7.2</td>
</tr>
<tr>
<td>Schools</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Food locations</td>
<td>53</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>93</td>
<td>113</td>
</tr>
<tr>
<td>Data source</td>
<td>Sample</td>
<td>Built environment inputs</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>-----------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>King County Neighborhood Quality of Life Study (NQLS)</td>
<td>1,228 adults</td>
<td>Walkability (composed of land use mix, street connectivity, net residential density, and floor-to-area ratio)</td>
</tr>
<tr>
<td>SMARTRAQ Atlanta Regional Commission Household Travel Survey</td>
<td>16,873 participants 5 years or older</td>
<td>Walkability (composed of land use mix, street connectivity, net residential density)</td>
</tr>
</tbody>
</table>
San Diego: Predicted MVPA
Stepping Towards Causation
Residential Density and Mix of Housing Type

If I were to move, I’d like to find a neighborhood...

A. that is a lively and active place, even if this means it has a mixture of single family houses, townhouses, and small apartment buildings that are close together on various sized lots.

or

B. with single family houses farther apart on lots 1/2 acre or more, even if this means that it is not an especially lively or active place.
Neighborhood Walkability (Objective) → Preference (Subjective)

Quadrant 1: Unmatched
Walkability -- Low
Preference -- Walk

Quadrant 2: Matched
Walkability -- High
Preference -- Walk

Quadrant 3: Matched
Walkability -- Low
Preference -- Auto

Quadrant 4: Unmatched
Walkability -- High
Preference -- Auto
## PREFERENCE VS NEIGHBORHOOD DESIGN

<table>
<thead>
<tr>
<th>Walkability &amp; Preference Groups</th>
<th>Percent Taking a Walk Trip (n)</th>
<th>Average Daily Vehicle Miles Traveled (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preference for Neighborhood Type</td>
<td>Walkability of Current Neighborhood</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>II</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>III</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>IV</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Evidence is quickly mounting on the health impacts of community design
- The ability to apply the evidence is also growing

There is a latent demand for walkable places
- More research is needed to understand the type of gaps between supply of and demand for residential environments

Designing communities that fully integrate health care is essential to meet health and environmental goals of the 21rst Century