Tools for Pedestrian and Bicycle Safety and Exposure Analysis

David Ragland, Founding Director, UC Berkeley SafeTREC

John Bigham, GIS Program Manager, SafeTREC

Robert Schneider, Researcher, SafeTREC

June 5, 1 pm
Today’s Presentation

⇒ Introduction and housekeeping

⇒ Audio issues? Dial into the phone line instead of using “mic & speakers”

⇒ PBIC Trainings and Webinars
   http://www.walkinginfo.org

⇒ Registration and Archives at
   http://walkinginfo.org/webinars

⇒ Questions at the end
Webinar

Tools for Pedestrian and Bicycle Safety and Exposure Analysis
Tuesday, June 5, from 10-11:30am (PDT)

- Introduction
  - David Ragland, UC Berkeley SafeTREC
    - www.tsc.berkeley.edu
Topics

- SafeTREC (Overview)
- Pedestrian and Bicyclist Safety (Examples)
- Data Reports and Data Tools (Examples)
- Data steps for pedestrian and bicyclist safety
SafeTREC

- Founded in 2000 with a grant from OTS to reduce traffic fatalities and injuries through multi-disciplinary collaboration in education, technical assistance, and outreach.

- UC Partners include Public Health, Transportation Engineering, City and Regional Planning

- Funders have included NHTSA, OTS, Caltrans, local cities, agencies, foundations
Topics

- SafeTREC (Overview)
- Pedestrian and Bicyclist Safety (Examples)
- Data Reports and Data Tools (Examples)
- Data steps for pedestrian and bicyclist safety
Safe Routes to School Safety and Mobility Analysis: Report to the California Legislature
UC Campus Periphery Project

Fatal  Severe Injury  Minor Injury

Land Use Zones
- Adjacent Blocks North
- Adjacent Blocks South
- Adjacent Blocks West
- Campus Park
- Hill Campus
- Lawrence Berkeley National Laboratory
- Southside/Clark Kerr Campus
Barriers to Transit among Seniors
Topics

- SafeTREC (Overview)
- Pedestrian and Bicyclist Safety (Examples)
- Data Reports and Data Tools (Examples)
- Data steps for pedestrian and bicyclist safety
Strategic Highway Safety Plan (Data Support Contract)

Roles

- Data Support
  - Provide standard and customized data analyses to each Challenge Area
- 5% Report
  - Local Roads
- Challenge area participation
SHSP Version 2
5% Report
Continuous Risk Profile (CRP) Demonstration Webinar for Caltrans District Leaders

**Background:** Many existing methods for detecting collision concentration locations (such as the conventional sliding moving window approach) require segmentation of roadways and assume traffic collision data are spatially uncorrelated, resulting in false positives and false negatives.

**CRP Capabilities:**
- does not require segmentation of roadways
- spatial correlation in the collision data does not affect results
- lower false positive rates
- proactive identification of locations
- plots are highly reproducible over the years
- can capture “spillover benefit” of countermeasures
- simple to use.
Topics

- SafeTREC (Overview)
- Pedestrian and Bicyclist Safety (Examples)
- Data Reports and Data Tools (Examples)
- Data steps for pedestrian and bicyclist safety
# Data steps for pedestrian and bicyclist safety

<table>
<thead>
<tr>
<th>Areas</th>
<th>Examples from SafeTREC</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Crash/injury data</td>
<td>TIMS (geocoding)</td>
<td>John</td>
</tr>
<tr>
<td>2. Data access</td>
<td>Public Access to TIMS</td>
<td>John</td>
</tr>
<tr>
<td>3. Pedestrian/bicycle volume</td>
<td>Location-based analyses</td>
<td>Bob</td>
</tr>
<tr>
<td>4. Hazard assessment</td>
<td>Bayesian analysis, Continuous Risk Profile</td>
<td></td>
</tr>
<tr>
<td>5. Causal analysis / countermeasure assessment</td>
<td>Collision modification factors</td>
<td></td>
</tr>
<tr>
<td>6. Benefit/cost</td>
<td>Safety Index</td>
<td>John</td>
</tr>
<tr>
<td>7. Integration with larger roadway data systems</td>
<td>Integrate active transportation data with Caltrans data system</td>
<td></td>
</tr>
</tbody>
</table>
PBIC Webinar—Tools for Pedestrian and Bicycle Safety and Exposure Analysis

John Bigham
jbigham@berkeley.edu

Safe Transportation Research and Education Center
University of California, Berkeley
www.safetrec.berkeley.edu
Topics

• Overview of TIMS
• Accessing and visualizing pedestrian and bicycle collision data in TIMS
  – SWITRS Query & Map
  – SWITRS GIS Map
• Benefit-cost calculator for safety countermeasures
Transportation Injury Mapping System (TIMS)

• Provides data and mapping analysis tools and information for traffic safety related research, policy and planning.
• Free account application, open to everyone
• http://tims.berkeley.edu
SWITRS

- California Statewide Integrated Traffic Records System
- Maintained by California Highway Patrol
- Approximately 200,000 injury collisions each year
SWITRS Query & Map Tool

• Data query focused application
  – Quick results, quick refresh
• One page summary statistics
• Download collision, party, victim files
• Google Maps collision display
  – 5,000 collisions limit
  – Collision points clustered until zoomed in
SWITRS GIS Map

- Map-centric collision viewing with other data layers (census tracts, TAZ, schools, etc.)
- Same collision query UI as Query & Map tool
- 1,000 collisions display limit
- Focused collision spatial selection tools
  - Drawing
  - Buffer (intersection or corridor)
  - Region (TAZ, census tract, zip code)
TIMS Mapping Applications

• DEMO
Message: Buffer Process Prepared. Select drawing option and draw on map.
Benefit-Cost Calculator

- Evaluate benefit-cost of potential safety countermeasures
  - Benefit = reduction in comprehensive collision costs
  - Cost = construction costs

- Required for agencies to use that are applying for Highway Safety Improvement Program (HSIP) funds in California

- Includes pedestrian and bicycle specific countermeasures
Benefit-Cost Calculator

- DEMO
Local Roadway Safety Manual

• Partnership of Caltrans, FHWA and SafeTREC

• Great resource for conceptual guidance
  – Identifying safety issues
  – Safety data analysis
  – Countermeasures selection and b/c analysis

• [http://www.dot.ca.gov/hq/LocalPrograms/HSIP/apply_now.htm](http://www.dot.ca.gov/hq/LocalPrograms/HSIP/apply_now.htm)
Import into Benefit-Cost Calculator
### Select Countermeasure

#### Roadway

<table>
<thead>
<tr>
<th>CM Number</th>
<th>Project Type</th>
<th>Countermeasure</th>
<th>Crash Type</th>
<th>CRF</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>R29</td>
<td>Operation / Warning</td>
<td>Install curve advance warning signs (flashing beacon)</td>
<td>All</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>R30</td>
<td>Operation / Warning</td>
<td>Install dynamic / variable speed warning signs</td>
<td>All</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>R31</td>
<td>Operation / Warning</td>
<td>Install delineators, reflectors and/or object markers</td>
<td>All</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>R32</td>
<td>Operation / Warning</td>
<td>Install edge-lines and centerlines</td>
<td>All</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>R33</td>
<td>Operation / Warning</td>
<td>Install no-passing line</td>
<td>All</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td>R34</td>
<td>Operation / Warning</td>
<td>Install centerline rumble stripes / stripes</td>
<td>All</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>R35</td>
<td>Operation / Warning</td>
<td>Install edgeline rumble strips / stripes</td>
<td>All</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>R36</td>
<td>Ped and Bike</td>
<td>Install bike lanes</td>
<td>Ped &amp; Bike</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td>R37</td>
<td>Ped and Bike</td>
<td>Install sidewalk / pathway (to avoid walking along roadway)</td>
<td>Ped &amp; Bike</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>R38</td>
<td>Ped and Bike</td>
<td>Install pedestrian crossing (with enhanced safety features)</td>
<td>Ped &amp; Bike</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>R39</td>
<td>Ped and Bike</td>
<td>Install raised pedestrian crossing</td>
<td>Ped &amp; Bike</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td>R40</td>
<td>Animal</td>
<td>Install animal fencing</td>
<td>Animal</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>R41</td>
<td>Truck</td>
<td>Install truck escape ramp</td>
<td>All</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

### Selected Countermeasure

<table>
<thead>
<tr>
<th>CM Number</th>
<th>Project Type</th>
<th>Countermeasure</th>
<th>Crash Type</th>
<th>CRF</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>R37</td>
<td>Ped and Bike</td>
<td>Install sidewalk / pathway (to avoid walking along roadway)</td>
<td>Ped &amp; Bike</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

[Yes] [Cancel]
This map will not be saved within the project. Please print the map after displaying the crash locations.

7 of 7 (100%) crash(es) mapped. (Crash Type: Ped & Bike)

### Project Information
- Application ID: 07-Pomona
- Crash Data: 9 years
  - From 01/01/2001
  - To 12/31/2009

### Countermeasure 3
- CM Number: S19
- Mod: Ped and Bike
- Name: Install pedestrian countdown signal heads
- Crash Type: Ped & Bike
- CRF: 25
- Life: 20

#### Crash Summary

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Fatality (Death)</th>
<th>Severe Injury</th>
<th>Injury - Other Visible</th>
<th>Injury - Complain of Pain</th>
<th>Property Damage Only</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Night</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Ped &amp; Bike</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Emerg Vehicle</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Animal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- Green: Crash Type of Selected Countermeasure

[Google Map Interface]

---

[Print Map] [Ok] [Cancel]
1. Project Information

Application ID: 07-Pomona  Version: 2

2. Countermeasures and Crash Data

- Install pedestrian countdown signal heads

<table>
<thead>
<tr>
<th>CM Number</th>
<th>Project Type</th>
<th>Crash Type</th>
<th>CRF</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>S19</td>
<td>Ped and Bike</td>
<td>Ped &amp; Bike</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Fatality (Death)</th>
<th>Severe Injury</th>
<th>Injury - Other Visible</th>
<th>Injury - Complaint of Pain</th>
<th>Property Damage Only</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ped &amp; Bike</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

Annual Benefit: $14,714
Life Benefit: $294,278
Cost: $1,000,000
B/C Ratio: 0.29

3. Benefit Cost Result

| Total Benefit | $294,278 |
| Total Cost    | $1,000,000 |
| B/C Ratio     | 0.29     |
Funding Support

- Funding for TIMS was provided by a grant from the California Office of Traffic Safety, through the National Highway Traffic Safety Administration.
- Funding for the B/C Calculator provided by the Caltrans Division of Local Assistance.
Questions?

• Thank you!
Pedestrian & Bicycle Volume Modeling for Crash Risk Analysis

Robert Schneider, Ph.D.
UC Berkeley Safe Transportation Research & Education Center
PBIC Webinar—June 2012
How Many People are Walking & Bicycling?
What Types of Locations have the Greatest Risk of Pedestrian or Bicycle Crashes?
## Pedestrian Crash Analysis

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mission Boulevard</td>
<td>Torrano Avenue</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Davis Street</td>
<td>Pierce Avenue</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Foothill Boulevard</td>
<td>D Street</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Mission Boulevard</td>
<td>Jefferson Street</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>University Avenue</td>
<td>Bonar Street</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>International Boulevard</td>
<td>107th Avenue</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>San Pablo Avenue</td>
<td>Harrison Street</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>East 14th Street</td>
<td>Hasperian Boulevard</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>International Boulevard</td>
<td>46th Avenue</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Solano Avenue</td>
<td>Masonic Avenue</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Broadway</td>
<td>12th Street</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>
## Pedestrian RISK Analysis

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Boulevard</td>
<td>Torrano Avenue</td>
<td>1,169</td>
<td>60,796</td>
<td>607,964</td>
<td>5</td>
<td>82.24</td>
</tr>
<tr>
<td>Davis Street</td>
<td>Pierce Avenue</td>
<td>1,570</td>
<td>81,619</td>
<td>816,187</td>
<td>4</td>
<td>49.01</td>
</tr>
<tr>
<td>Foothill Boulevard</td>
<td>D Street</td>
<td>632</td>
<td>32,862</td>
<td>328,624</td>
<td>1</td>
<td>30.43</td>
</tr>
<tr>
<td>Mission Boulevard</td>
<td>Jefferson Street</td>
<td>5,236</td>
<td>272,246</td>
<td>2,722,464</td>
<td>5</td>
<td>18.37</td>
</tr>
<tr>
<td>University Avenue</td>
<td>Bonar Street</td>
<td>11,175</td>
<td>581,113</td>
<td>5,811,127</td>
<td>7</td>
<td>12.05</td>
</tr>
<tr>
<td>International Boulevard</td>
<td>107th Avenue</td>
<td>3,985</td>
<td>207,243</td>
<td>2,072,429</td>
<td>2</td>
<td>9.65</td>
</tr>
<tr>
<td>San Pablo Avenue</td>
<td>Harrison Street</td>
<td>4,930</td>
<td>256,357</td>
<td>2,563,572</td>
<td>2</td>
<td>7.80</td>
</tr>
<tr>
<td>East 14th Street</td>
<td>Hasperian Boulevard</td>
<td>3,777</td>
<td>196,410</td>
<td>1,964,102</td>
<td>1</td>
<td>5.09</td>
</tr>
<tr>
<td>International Boulevard</td>
<td>46th Avenue</td>
<td>12,303</td>
<td>639,752</td>
<td>6,397,522</td>
<td>3</td>
<td>4.69</td>
</tr>
<tr>
<td>Solano Avenue</td>
<td>Masonic Avenue</td>
<td>22,203</td>
<td>1,154,559</td>
<td>11,545,589</td>
<td>2</td>
<td>1.73</td>
</tr>
<tr>
<td>Broadway</td>
<td>12th Street</td>
<td>112,896</td>
<td>5,870,590</td>
<td>58,705,898</td>
<td>5</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Which Intersection Features are Associated with Pedestrian Risk?

(*Exploratory Research*)

**Pedestrian Crossings (+)**
While intersections with more pedestrian crossings have more pedestrian crashes, there may be a “safety in numbers” effect (i.e., lower crash risk per crossing).

(Expected Effect*: 100% more pedestrian crossings, 49% more crashes)

**Motor Vehicle Volume (+)**
There may be a “danger in numbers” effect with mainline motor vehicle volume, but need to explore the influence of congestion and speed.

(Expected Effect*: 100% more mainline AADT, >100% more crashes)

For more information on this study, see:
Which Intersection Features are Associated with Pedestrian Risk?

**Number of Right-Turn-Only Lanes (+)**
Intersections with more right-turn-only lanes may have longer crossing distances and more complex interactions between drivers and pedestrians.

*(Expected Effect*: 1 more right-turn-only lane, 53% more crashes)*

**Number of Driveway Crossings (+)**
Intersections with more non-residential driveway crossings within 50 ft. may have more conflict points; drivers may focus on entering or exiting motor vehicle lanes.

*(Expected Effect*: 1 more driveway crossing, 33% more crashes)*

**Medians (-)**
Mainline and cross-street legs with medians have a refuge that allows pedestrians to cross one direction of traffic at a time, which may make crossing safer.

*(Expected Effect*: Medians on mainline roadway crossings, 75% fewer crashes)*
Which Intersection Features are Associated with Pedestrian Risk?

**Number of Commercial Properties (+)**
Intersections with more commercial properties within 0.1 miles may have more drivers looking at signs and for parking; more pedestrians may cross between cars.

*(Expected Effect*: 10 more commercial properties: 45% more crashes)*

**Percentage of Residents Under 18 (+)**
A greater percentage of young pedestrians within 0.25 miles may indicate that more of the people crossing are less experienced and have higher risk crossing busy streets.

*(Expected Effect*: 1% more residents under 18: 7% more crashes)*

*Italics show the change in the expected number of pedestrian crashes at intersections with different features, in order to provide a frame of reference. These numbers are based on the model, which reflects the 81 Alameda County study intersections as a whole. The effect of any particular treatment is highly context specific.*
Many Demand Analysis Methods

- Traditional 4-step models
- Direct counts & surveys
- Sketch plan with expert-defined weights
- Network-based models
- Location-based models
The Traditional Four Step Model

Berkeley, CA Traffic Analysis Zones
The Traditional Four Step Model

- Ignores trips that occur within zones (many short pedestrian & bicycle trips)
- Misses “secondary” trip modes (e.g., walk from parking or walk to transit)
Census/ACS Data

Source: City of Seattle Bicycle Master Plan, 2007
Sketch Plan Methods

Source: Lancaster County Pedestrian and Bicycle Transportation Plan, Phase II, 2004
Sketch Plan Methods

Sketch Plan Methods
Network-Based Model: Space Syntax

- Street and path networks (potential movement patterns)
- Viewsheds
- Fathom Visibility Graph Analysis Software

Downtown Boston
Network-Based Model: Clifton Maryland Ped Model

Location-Based Model

Approach: Develop a model to estimate pedestrian intersection crossing volumes at different locations
Location-Based Models

- Schneider, *et al.* San Francisco pedestrian (2012)
- Griswold, Medury, & Schneider, Alameda County bicycle (2011)
- Fehr & Peers, Santa Monica pedestrian & bicycle (2010)
- Schneider, Arnold & Ragland, Alameda County pedestrian (2009)
- Liu & Griswold, San Francisco pedestrian (2009)
- Pulugurtha & Repaka, Charlotte pedestrian (2008)
# Intersection-Based Pedestrian Models

## TABLE 1 Examples of Previous Pedestrian Intersection Volume Models

<table>
<thead>
<tr>
<th>Model Location</th>
<th>Developed by</th>
<th>Intersections Used for Model</th>
<th>Pedestrian Count Description</th>
<th>Type of Count Sites</th>
<th>Count Period(s) Used for Model</th>
<th>Weather During Counts</th>
<th>Statistically-significant predictive variables</th>
<th>Model Output</th>
<th>Model Type</th>
<th>Validation Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlotte, NC</td>
<td>UNC Charlotte (Pulugurtha &amp; Repaka 2008)</td>
<td>176</td>
<td>Pedestrians counted each time they arrived at the intersection from any direction</td>
<td>Signalized intersections</td>
<td>7am-7 pm</td>
<td>Clear weather conditions</td>
<td>Pop. within 0.25 mi.</td>
<td>Number of bus stops within 0.25 mi.</td>
<td>Total pedestrians approaching intersections from 7 am to 7 pm (shorter periods also modeled)</td>
<td>Linear</td>
</tr>
<tr>
<td>Alameda County, CA</td>
<td>UC Berkeley SafeTREC (Schneider, Arnold, &amp; Ragland 2009)</td>
<td>50</td>
<td>Pedestrians counted every time they crossed a leg of an intersection (pedestrians within 50 feet of the crosswalk were counted)</td>
<td>Signalized and unsignalized intersections</td>
<td>Tu, W, or Th: 12-2 pm or 3-5 pm; Sa: 9-11 am, 12-2 pm, or 3-5 pm</td>
<td>All weather conditions; weather adjustment factors were calculated from automated counters</td>
<td>Pop. within 0.5 mi.</td>
<td>Employment within 0.25 mi.</td>
<td>Total pedestrian crossings at intersections during a typical week</td>
<td>Linear</td>
</tr>
<tr>
<td>San Francisco, CA</td>
<td>San Francisco State (Li &amp; Grissom 2009)</td>
<td>63</td>
<td>Pedestrians counted each time they crossed a leg of an intersection (no distance to crosswalk specified)</td>
<td>Signalized and unsignalized intersections</td>
<td>Weekdays 2:30-6:30 pm</td>
<td>Not reported</td>
<td>Population density (mi) within 0.5 mi.</td>
<td>MUNI (light rail transit) stop density within 0.38 mi.</td>
<td>Total pedestrian crossings at intersections from 2:30-6:30 pm on typical weekday</td>
<td>Linear</td>
</tr>
<tr>
<td>Santa Monica, CA</td>
<td>Fehr &amp; Peers (Mannes et al. 2010)</td>
<td>92</td>
<td>Pedestrians counted each time they crossed a leg of an intersection (no distance to crosswalk specified)</td>
<td>Signalized and unsignalized intersections</td>
<td>Weekdays 9-6 pm</td>
<td>Not reported</td>
<td>Employment density within 0.25 mi.</td>
<td>Presence of bike lane at intersection</td>
<td>Total pedestrian crossings at intersections from 5-6 pm on typical weekday</td>
<td>Linear</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>Alta Planning + Design (Jones et al. 2010)</td>
<td>80</td>
<td>Pedestrians counted each time they arrived at the intersection from any direction</td>
<td>Signalized and unsignalized intersections (includes some trail/roadway intersections)</td>
<td>Weekdays 7-9 am</td>
<td>Nice weather</td>
<td>Population density within 0.25 mi.</td>
<td>Greater than 6,000 transit ridership at bus stops within 0.25 mi.</td>
<td>Total pedestrians approaching intersections from 7 am to 9 am</td>
<td>Loglinear</td>
</tr>
<tr>
<td>Montreal, Quebec</td>
<td>McGill University (Miranda-Moreno &amp; Fernandes 2011)</td>
<td>1018</td>
<td>Pedestrians counted each time they crossed a leg of an intersection (no distance to crosswalk specified)</td>
<td>Signalized intersections</td>
<td>Weekdays 6-9 am, 11 am-1 pm, and 3:30-6:30 pm</td>
<td>Most counts during nice weather; weather variables were analyzed</td>
<td>Population within 400 m</td>
<td>Commercial space within 50 m</td>
<td>Total pedestrian crossings at intersections over 8 count hours (shorter periods also modeled)</td>
<td>Loglinear (also used Negative binomial)</td>
</tr>
</tbody>
</table>

# Intersection-Based Pedestrian Models

## TABLE 1 Examples of Previous Pedestrian Intersection Volume Models

<table>
<thead>
<tr>
<th>Model Location</th>
<th>Developed by</th>
<th>Intersections Used for Model</th>
<th>Pedestrian Count Description</th>
<th>Type of Count Sites</th>
<th>Count Period(s) Used for Model</th>
<th>Weather During Counts</th>
<th>Statistically-significant predictive variables</th>
<th>Model Information</th>
<th>Validation Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlotte, NC</td>
<td>UNC Charlotte (Pulugurtha &amp; Repaka 2008)</td>
<td>176 Pedestrians counted each time they crossed a leg of the intersection (pedestrians within 50 feet of the crosswalk were counted)</td>
<td>Signalized intersections</td>
<td>7am-7 pm</td>
<td>Clear weather conditions</td>
<td>Pop. within 0.25 mi.</td>
<td>Number of bus stops within 0.25 mi.</td>
<td>Total pedestrians approaching intersections from 7 am to 7 pm (shorter periods also modeled)</td>
<td>Linear</td>
</tr>
<tr>
<td>Alameda County, CA</td>
<td>UC Berkeley SafeTREC (Schneider, Arnold, &amp; Ragland 2009)</td>
<td>50 Pedestrians counted every time they crossed a leg of the intersection (pedestrians within 50 feet of the crosswalk were counted)</td>
<td>Signalized and unsignalized intersections</td>
<td>Tu, W, or Th: 12-2 pm or 3-5 pm, Sa: 9-11 am, 12-2 pm, or 3-5 pm</td>
<td>All weather conditions; weather adjustment factors were calculated from automated counters</td>
<td>Population within 0.5 mi.</td>
<td>Total pedestrian crossings at intersections during a typical week</td>
<td>Linear</td>
<td>46 historic counts used for validation (30 additional intersections were counted for validation in 2009)</td>
</tr>
<tr>
<td>San Francisco, CA</td>
<td>State (Liu &amp; Grisswoold 2009)</td>
<td>63 Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Signalized and unsignalized intersections</td>
<td>Weekdays 2:30-6:30 pm</td>
<td>Not reported</td>
<td>Employment density (net) within 0.25 mi.</td>
<td>Mean slope within 0.063 mi.</td>
<td>Total pedestrian crossings at intersections from 2:30-6:30 pm on typical weekday</td>
<td>Linear</td>
</tr>
<tr>
<td>Santa Monica, CA</td>
<td>Fehr &amp; Peers (Haynes et al. 2010)</td>
<td>92 Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Signalized and unsignalized intersections</td>
<td>Weekdays 8-6 pm</td>
<td>Not reported</td>
<td>Employment density within 0.25 mi.</td>
<td>Total pedestrian crossings at intersections from 5-6 pm on typical weekday</td>
<td>Linear</td>
<td>Approximately 107 additional intersections were counted for validation</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>Alta Planning + Design (Jones et al. 2010)</td>
<td>80 Pedestrians counted each time they arrived at the intersection from any direction</td>
<td>Signalized and unsignalized intersections (includes some trail/roadway intersections)</td>
<td>Weekdays 7-9 am</td>
<td>Nice weather</td>
<td>Employment density within 0.25 mi.</td>
<td>Total pedestrians approaching intersections from 7 am to 9 am</td>
<td>Loglinear</td>
<td>None reported</td>
</tr>
<tr>
<td>Montreal, Quebec</td>
<td>McGill University (Miranda-Moreno &amp; Fernandes 2011)</td>
<td>1018 Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Signalized intersections</td>
<td>Weekdays 6-9 am, 11 am-1 pm, and 3:30-6:30 pm</td>
<td>Most counts during nice weather; weather variables were analyzed</td>
<td>Population within 400 m</td>
<td>Total pedestrian crossings at intersections over 8 count hours (shorter periods also modeled)</td>
<td>Loglinear (also used Negative Binomial)</td>
<td>Counts at 20% of the intersections were compared to a model based on 80% of the intersections for validation</td>
</tr>
</tbody>
</table>

# Intersection-Based Pedestrian Models

## Table 1: Examples of Previous Pedestrian Intersection Volume Models

<table>
<thead>
<tr>
<th>Location</th>
<th>Developed by</th>
<th>Intersections Used for Model</th>
<th>Pedestrian Count Information</th>
<th>Count Period(s) Used for Model</th>
<th>Weather During Counts</th>
<th>Statistically-significant Predictive Variables</th>
<th>Model Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlotte, NC</td>
<td>UNC Charlotte (Pallagotta &amp; Repaka 2008)</td>
<td>176</td>
<td>Pedestrians counted each time they crossed a leg of the intersection (pedestrians within 50 feet of the crosswalk were counted)</td>
<td>7am-7 pm</td>
<td>Clear weather conditions</td>
<td>Pop. within 0.25 mi; <em>Jobs within 0.25 mi.</em></td>
<td></td>
</tr>
<tr>
<td>Assema County, CA</td>
<td>UC Berkeley SafeTREC (Schneider, Arnold, &amp; Ragland 2009)</td>
<td>50</td>
<td>Pedestrians counted every time they crossed a leg of the intersection (pedestrians within 50 feet of the crosswalk were counted)</td>
<td>Tu, W, or Th: 8-9 am; Sa: 9-11 am, 12-2 pm, or 3-5 pm</td>
<td>All weather conditions; weather adjustment factors were calculated from automated counters</td>
<td>Pop. within 0.5 mi; Employment within 0.25 mi; BART (regional transit) station within 0.1 mi; Commercial property within 0.25 mi.</td>
<td></td>
</tr>
<tr>
<td>San Francisco, CA</td>
<td>San Francisco State University (Liu &amp; Griswold 2009)</td>
<td>63</td>
<td>Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Weekdays 2:30-6:30 pm</td>
<td>Not reported</td>
<td>MUNI (light rail transit) stop density within 0.38 mi; Presence of bike lane at intersection</td>
<td></td>
</tr>
<tr>
<td>Santa Monica, CA</td>
<td>Fehr &amp; Peers (Haines et al. 2010)</td>
<td>92</td>
<td>Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Weekdays 7-9 am</td>
<td>Not reported</td>
<td>Employment density within 0.33 mi; Within a commercially zoned area; Afternoon bus frequency</td>
<td>Linear model for pedestrian volume at intersections from 2:30-6:30 pm on typical weekday</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>Alta Planning + Design (Jones et al. 2010)</td>
<td>80</td>
<td>Pedestrians counted each time they arrived at the intersection from any direction</td>
<td>Weekdays 7/9 am</td>
<td>Nice weather</td>
<td>Population density within 0.25 mi; Employment density within 0.5 mi; Presence of retail within 0.5 mi.</td>
<td></td>
</tr>
<tr>
<td>Montreal, Quebec</td>
<td>McGill University (Miranda-Moreno &amp; Fernandez 2011)</td>
<td>1018</td>
<td>Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Weekdays 6-9 am, 11 am-1 pm, and 3:30-6:30 pm</td>
<td>Most counts during nice weather; weather variables were analyzed</td>
<td>Population within 400 m; Commercial space within 4000 m; Subway within 150 m; Bus station within 150 m; Major arterial within 400 m; Open space within 150 m; Streets segments within 400 m; 4-way intersection</td>
<td>Distance to downtown; Daily high temperature &gt;32°C; Total pedestrian crossing at intersections over 8 count hours (shorter periods also modeled); Loglinear (also used Negative Binomial)</td>
</tr>
</tbody>
</table>

# Intersection-Based Pedestrian Models

## TABLE 1 Examples of Previous Pedestrian Intersection Volume Models

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<tr>
<th>Model Location</th>
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<tbody>
<tr>
<td>Charlotte, NC</td>
<td>UNC-Charlotte (Puliguturtha &amp; Repaka 2008)</td>
<td>176</td>
<td>Pedestrians counted each time they arrived at the intersection from any direction</td>
<td>Signalized intersections</td>
<td>7am-7 pm</td>
<td>Clear weather conditions</td>
<td>Population within 0.25 mi. • Jobs within 0.25 mi. • Mixed lane use within 0.25 mi. • Urban residential area within 0.25 mi.</td>
<td>Linear</td>
</tr>
<tr>
<td>Alameda County, CA</td>
<td>UC Berkeley SafeTREC (Schneider, Arnold, &amp; Ragland 2009)</td>
<td>50</td>
<td>Pedestrians counted every time they crossed a leg of the intersection (pedestrians within 50 feet of the crosswalk were counted)</td>
<td>Signalized and unsignalized intersections</td>
<td>Tu, W, or Th: 3-5 pm; Sa: 9-11 am, 12-2 pm or 3-5 pm</td>
<td>All weather conditions; weather adjustment factors were calculated from automated counters</td>
<td>Population within 0.5 mi. • Employment within 0.25 mi. • Commercial properties within 0.25 mi.</td>
<td>Linear</td>
</tr>
<tr>
<td>San Francisco, CA</td>
<td>San Francisco State (Liu &amp; Grissold 2009)</td>
<td>63</td>
<td>Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Signalized and unsignalized intersections</td>
<td>Weekdays 2:30-6:30 pm</td>
<td>Not reported</td>
<td>Population density (net) within 0.5 mi. • Employment density (net) within 0.25 mi. • Patch richness density within 0.061 mi. • Residential land use within 0.061 mi.</td>
<td>Linear</td>
</tr>
<tr>
<td>Santa Monica, CA</td>
<td>Fehr &amp; Peers (Payne et al. 2010)</td>
<td>92</td>
<td>Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Signalized and unsignalized intersections</td>
<td>Weekdays 9-5 pm</td>
<td>Not reported</td>
<td>Employment density within 0.33 mi. • Within a commercially-zoned area</td>
<td>Linear</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>Alta Planning + Design (Jones et al. 2010)</td>
<td>80</td>
<td>Pedestrians counted each time they arrived at the intersection from any direction</td>
<td>Signalized and unsignalized intersections (includes some trail/roadway intersections)</td>
<td>Weekdays 7-9 am</td>
<td>Nice weather</td>
<td>Population density within 0.25 mi. • Employment density within 0.5 mi. • Presence of retail within 0.5 mi.</td>
<td>Linear</td>
</tr>
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<td>Montreal, Quebec</td>
<td>McGill University (Miranda-Moreno &amp; Fernandes 2011)</td>
<td>1018</td>
<td>Pedestrians counted each time they crossed a leg of the intersection (no distance to crosswalk specified)</td>
<td>Signalized intersections</td>
<td>Weekdays 6-9 am, 11 am-1 pm, and 3:30-6:30 pm</td>
<td>Most counts during nice weather; weather variables were analyzed</td>
<td>Population within 400 m • Commercial space within 0.5 m • Open space within 150 m • Schools within 400 m</td>
<td>Loglinear</td>
</tr>
</tbody>
</table>

Example: Development of the Alameda County Pedestrian Volume Model

Pedestrian Model Development

- Sample of intersections along arterial and collector roadways
- Pilot Model: April to June 2008 (N=50)
- Validation: April to June 2009 (N=30)
2008 Location Selection Process

• All Possible Intersections = 7,466
• Choose 50 Intersections
  – Ensure a wide variety of characteristics are represented
  – Ensure a wide geographic distribution

• Restrictions
  – No intersections with low pop. density, no grade separated crossings, no intersections within ¼-mile of county line
  – Include at least 2 trail/roadway crossings & 3 CBD intersections
Alameda County Intersection Map

50 Intersections Counted in 2008
Pilot Model Pedestrian Volume Data

- Pedestrian crossings within 50 feet of each study intersection
- 2-hour manual counts (Weekday & Saturday)
- April to June 2008
- Counts extrapolated and adjusted for land use & weather
Example automated counter location: Broadway & 12th Street (Oakland)
"Typical" Alameda County Pedestrian Activity Pattern
“Typical” Alameda County Pedestrian Activity Pattern

Percent of Weekly Pedestrian Volume per Hour

2-hour count period
One study intersection: Martin Luther King Jr. Wy. & 17th St., Oakland

Approximately 5,600 pedestrian crossings per week (Spring 2008)
Alameda County Pilot Model

Estimated Weekly Pedestrian Crossings =

0.928 * Total population within 0.5-miles of the intersection
+ 2.19  * Total employment within 0.25-miles of the intersection
+ 98.4  * Number of commercial properties within 0.25-miles of the intersection
+54,600 * Number of regional transit stations within 0.10-miles of the intersection
- 4910 (Constant)

Adjusted $R^2 = 0.897$
Root Mean Squared Error = 5760
Explanatory variables significant at 95% confidence interval
Pilot Pedestrian Volume Model Application

Alameda County
Estimated Weekly Pedestrian Volumes
Crossing Main Roadway Intersections

Estimated Weekly Volume
- 100,000 to 150,000
- 50,000 to 99,999
- 30,000 to 49,999
- 20,000 to 29,999
- 15,000 to 19,999
- 10,000 to 14,999
- 5,000 to 9,999
- 0 to 4,999
- Below model range
- Not calculated

Other Features
- Rapid Transit Station
- Roadway
- Major roadway
- Multi-Use Trail
- County Boundary
- Water

Information about base transportation network and other count locations is available in comments. For full report, visit odo.ca.gov. "Alamed County Pilot Pedestrian Intersection Crossing Volume" Website: http://www.oaklandtrafficcenter.com/ for information on Transportation Research Institute/University of California, 2007. All plans subject to change due to future development and data.
**Alameda County Pedestrian Volume Forecasting Spreadsheet**

### Pedestrian Intersection Crossing Volume Model

**Pilot Model--January 2009**

Developed by Robert Schneider, Lindsay Arnold, and David Ragland

University of California Berkeley Safe Transportation Research & Education Center

<table>
<thead>
<tr>
<th>Intersection Identification</th>
<th>Model Inputs</th>
<th>Model Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Estimated Pedestrian Crossings in a Typical Week</td>
</tr>
<tr>
<td><strong>Mainline Roadway</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telegraph Avenue</td>
<td>59th Street</td>
<td>Oakland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total population within 1/2-mile radius</td>
</tr>
</tbody>
</table>

**Notes:**

1. This is a revised version of the pilot model of weekly pedestrian volumes at 50 intersections in Alameda County, CA. The model has a good fit for the Alameda County study data (adjusted-\(R^2\)=0.900). Since the analysis was conducted on 50 intersections in Alameda County, CA, more research is needed to refine the model equation and determine the applicability of the results for other communities. The model equation is: Estimated pedestrian intersection crossings per week = 0.987 * Total population within 0.5-miles of the intersection + 2.19 * Total employment within 0.25-miles of the intersection + 71.1 * Number of commercial retail properties within 0.25-miles of the intersection + 49,300 * Number of regional transit stations within 0.10-miles of the intersection - 4850. Details of the study are provided in two papers: 1) Schneider, R.J., L.S. Arnold, and D.R. Ragland. "Extrapolating Weekly Pedestrian Intersection Crossing Volumes from 2-Hour Manual Counts," UC-Berkeley Traffic Safety Center, Transportation Research Record, 2010, and 2) Schneider R.J., L.S. Arnold, and D.R. Ragland. "A Pilot Model for Estimating Pedestrian Intersection Crossing Volumes," UC-Berkeley Traffic Safety Center, Transportation Research Record, 2010.

2. The pedestrian volume estimates produced by the model are intended for planning, prioritization, and safety analysis at the community, neighborhood, and corridor levels. Since the model provides rough estimates of pedestrian activity, actual pedestrian counts should be used for site-level safety, design, and engineering analyses.

3. The intersections selected for the study did not include intersections in areas with very low population densities (<50 people per square mile). Therefore, the model is not appropriate for intersections below this density threshold (i.e., the model does not apply if there are fewer than 64 people within a 1/2-mile radius).

4. The study of Alameda County, CA found that land use characteristics are the most important factors for predicting pedestrian activity. Roadway design factors, such as the presence of sidewalks, median crossing islands, curb radii, or pedestrian crossing signals may have minor effects on pedestrian volumes, but they are not as significant for predicting pedestrian activity. However, roadway design factors are critical for pedestrian safety and comfort. Roadways must be designed to accommodate pedestrians of all abilities, regardless of volume.

5. The model output is an estimate of the number of pedestrian crossings during a typical 168-hour week (with an average seasonal volume). Pedestrian crossings are counted each time a pedestrian crosses any leg of the intersection (e.g., one person is counted twice if they cross the east leg and then the south leg of an intersection). Pedestrians do not need to cross completely inside the crosswalk; they are counted if if they cross within 50 feet of the intersection.

6. The model may not perform well in locations close to special attractors, such as amusement parks, waterfronts, sports arenas, regional recreation areas, and major multi-use areas.
### Alameda County Pedestrian Volume Forecasting Spreadsheet

#### Pedestrian Intersection Crossing Volume Model

**Pilot Model--January 2009**

Developed by Robert Schneider, Lindsay Arnold, and David Ragland

University of California Berkeley Safe Transportation Research & Education Center

<table>
<thead>
<tr>
<th>Intersection Identification</th>
<th>Model Inputs</th>
<th>Model Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Estimated Pedestrian Crossings in a Typical Week</td>
</tr>
<tr>
<td><strong>Mainline Roadway</strong></td>
<td><strong>Intersecting Roadway</strong></td>
<td><strong>City</strong></td>
</tr>
<tr>
<td>Telegraph Avenue</td>
<td>59th Street</td>
<td>Oakland</td>
</tr>
<tr>
<td>Telegraph Avenue</td>
<td>59th Street</td>
<td>Oakland</td>
</tr>
</tbody>
</table>

**Notes:**

1. This is a revised version of the pilot model of weekly pedestrian volumes at 50 intersections in Alameda County, CA. The model has a good fit for the Alameda County study data (adjusted-\( R^2 = 0.900 \)). Since the analysis was conducted on 50 intersections in Alameda County, CA, more research is needed to refine the model equation and determine the applicability of the results for other communities. The model equation is: Estimated pedestrian intersection crossings per week = 0.987 * Total population within 0.5-miles of the intersection + 2.19 * Total employment within 0.25-miles of the intersection + 71.1 * Number of commercial retail properties within 0.25-miles of the intersection + 49,300 * Number of regional transit stations within 0.10-miles of the intersection - 4850. Details of the study are provided in two papers: 1) Schneider, R.J., L.S. Arnold, and D.R. Ragland. "Extrapolating Weekly Pedestrian Intersection Crossing Volumes from 2-Hour Manual Counts," UC-Berkeley Traffic Safety Center, Transportation Research Record, 2010, and 2) Schneider R.J., L.S. Arnold, and D.R. Ragland. "A Pilot Model for Estimating Pedestrian Intersection Crossing Volumes," UC-Berkeley Traffic Safety Center, Transportation Research Record, 2010.

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3. The intersections selected for the study did not include intersections in areas with very low population densities (<50 people per square mile). Therefore, the model is not appropriate for intersections below this density threshold (i.e., the model does not apply if there are fewer than 64 people within a 1/2-mile radius).

4. The study of Alameda County, CA found that land use characteristics are the most important factors for predicting pedestrian activity. Roadway design factors, such as the presence of sidewalks, median crossing islands, curb radii, or pedestrian crossing signals may have minor effects on pedestrian volumes, but they are not as significant for predicting pedestrian activity. However, roadway design factors are critical for pedestrian safety and comfort. Roadways must be designed to accommodate pedestrians of all abilities, regardless of volume.

5. The model output is an estimate of the number of pedestrian crossings during a typical 168-hour week (with an average seasonal volume). Pedestrian crossings are counted each time a pedestrian crosses any leg of the intersection (e.g., one person is counted twice if they cross the east leg and then the south leg of an intersection). Pedestrians do not need to cross completely inside the crosswalk; they are counted if they cross within 50 feet of the intersection.

6. The model may not perform well in locations close to special attractors, such as amusement parks, waterfronts, sports arenas, regional recreation areas, and major multi-use.
### Alameda County Pedestrian Volume Forecasting Spreadsheet

**Pedestrian Intersection Crossing Volume Model**

Pilot Model--January 2009¹,²

Developed by Robert Schneider, Lindsay Arnold, and David Ragland

University of California Berkeley Safe Transportation Research & Education Center

<table>
<thead>
<tr>
<th>Mainline Roadway</th>
<th>Intersecting Roadway</th>
<th>City</th>
<th>Total population within 1/2-mile radius¹</th>
<th>Total employment within 1/4-mile radius¹</th>
<th>Total number of commercial properties within 1/4-mile radius¹</th>
<th>Presence of regional transit station within 1/10 mile (Yes = 1, No = 0)</th>
<th>Estimated Pedestrian Crossings in a Typical Week²,⁶,⁷</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telegraph Avenue</td>
<td>59th Street</td>
<td>Oakland</td>
<td>10270</td>
<td>610</td>
<td>27</td>
<td>0</td>
<td>8542</td>
</tr>
<tr>
<td>Telegraph Avenue</td>
<td>59th Street</td>
<td>Oakland</td>
<td>20540</td>
<td>1220</td>
<td>27</td>
<td>0</td>
<td>20014</td>
</tr>
<tr>
<td>Telegraph Avenue</td>
<td>59th Street</td>
<td>Oakland</td>
<td>20540</td>
<td>1220</td>
<td>100</td>
<td>0</td>
<td>25205</td>
</tr>
</tbody>
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6. The model may not perform well in locations close to special attractors, such as amusement parks, waterfronts, sports arenas, regional recreation areas, and major multi-use areas.
36 Intersections Counted in 2009 (Red)
Validation Analysis

• Compared pilot model estimated volume with “actual” volume at 30 intersections in 2009
  – Where did the Pilot model work well?
  – Where did the Pilot model overestimate volumes?
  – Where did the Pilot model underestimate volumes?
• Model tended to underestimate
• Issue with some negative predictions at low-volume intersections
2009 Observed Volumes vs. Pilot Model Predictions

Line Representing Perfect Prediction (Observ. = Pred.)

Trendline for Observed vs. Predicted Data
Variation in Pedestrian Volumes
Variation in Pedestrian Volumes

- 5 Control Intersections

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>315</td>
<td>310</td>
<td>-5</td>
<td>1.6%</td>
</tr>
<tr>
<td>2650</td>
<td>15691</td>
<td>16113</td>
<td>422</td>
<td>2.7%</td>
</tr>
<tr>
<td>9179</td>
<td>8342</td>
<td>7429</td>
<td>-913</td>
<td>12.3%</td>
</tr>
<tr>
<td>9436</td>
<td>105297</td>
<td>88118</td>
<td>-17179</td>
<td>19.5%</td>
</tr>
<tr>
<td>499</td>
<td>5186</td>
<td>3448</td>
<td>-1738</td>
<td>50.4%</td>
</tr>
</tbody>
</table>

1) Percent difference is calculated using the smaller number as the base value. If the model value is greater than the actual value, the percent difference is calculated as \((2009 - 2008)/2008\). If the actual value is greater than the model value, the percent difference is calculated as \((2008 - 2009)/2009\).
Variation in “Typical” Alameda County Pedestrian Activity Pattern

95% of mid-day counts are between 20% above and 20% below the hourly mean.
Variation in Pedestrian Volumes

• Time of day, weather, etc. (accounted for)
• Measurement error
• “Unexplainable” variation
  – Individual sickness, people walking for scenery, store sales, etc.
  – Not feasible to predict in a planning-level model
  – Require additional data and cost for small benefit
**Alameda County Revised Model**

**Estimated Weekly Pedestrian Crossings =**

\[
0.987 \times \text{Total population within 0.5-miles of the intersection} \\
+ 2.19 \times \text{Total employment within 0.25-miles of the intersection} \\
+ 71.1 \times \text{Number of commercial properties within 0.25-miles of the intersection} \\
+ 49,300 \times \text{Number of regional transit stations within 0.10-miles of the intersection} \\
- 4850 \text{ (Constant)}
\]

Adjusted $R^2 = 0.900$
Root Mean Squared Error = 5310
Explanatory variables significant at 93% confidence interval
Key Consideration for Applying Existing Pedestrian & Bicycle Volume Models

• Designed for estimating volumes at neighborhood, corridor, and community levels. Actual pedestrian counts should be used for site-level safety, design, and engineering analyses.
Application for Pedestrian Safety Analysis: San Francisco Pedestrian Volume Model

Reported Pedestrian Crashes by Intersection (11/2004 to 10/2009)

San Francisco Pedestrian Volume Model

<table>
<thead>
<tr>
<th>Model Variables</th>
<th>Coefficient</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total households within 1/4 mile (10,000s)</td>
<td>1.81</td>
<td>2.12</td>
<td>0.040</td>
</tr>
<tr>
<td>Total employment within 1/4 mile (100,000s)</td>
<td>2.43</td>
<td>2.22</td>
<td>0.032</td>
</tr>
<tr>
<td>Intersection is in a high-activity zone</td>
<td>1.27</td>
<td>3.79</td>
<td>0.000</td>
</tr>
<tr>
<td>Maximum slope on any intersection approach leg (100s)</td>
<td>-9.40</td>
<td>-3.07</td>
<td>0.004</td>
</tr>
<tr>
<td>Intersection is within 1/4 mile of a university campus</td>
<td>0.635</td>
<td>1.45</td>
<td>0.154</td>
</tr>
<tr>
<td>Intersection is controlled by a traffic signal</td>
<td>1.16</td>
<td>4.03</td>
<td>0.000</td>
</tr>
<tr>
<td>Constant</td>
<td>12.9</td>
<td>33.29</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Overall Model**

| Sample Size (N)                                      | 50          |
| Adjusted $R^2$-Value                                 | 0.804       |
| F-Value (Test value)                                 | 34.4 ($p < 0.001$) |

1) The dependent variable is the natural logarithm of the annual pedestrian intersection crossing volume at each of the 50 study intersections. This represents the sum of all crossings on each approach leg within 50 feet of intersection. The annual volume estimate is extrapolated from a two-hour manual count taken in September 2009 or July-August 2010. The extrapolation method accounts for variations in pedestrian activity by time of day, day of week, weather, and land use.

2) All distances used to calculate the model variables are straight-line distances rather than roadway network distances.

Reported pedestrian crashes

Model-estimated pedestrian crossings

Map prepared by Fehr & Peers Transportation Consultants
Highest Estimated Pedestrian Crash Risk

General Characteristics of Intersections with Highest Pedestrian Risk in SF

- Most were unsignalized intersections.
- Many were along multilane arterial roadways.
- Several were located near schools.
- Several were in areas with steep slopes.
Bicycle Intersection Volume Models
San Diego County Bicycle Volume Model

PM Peak Hour Intersection Volume =

\[ \text{BAM} = -4.279 + 0.718 \times C + 0.438 \times \text{ED} \]

Where:
\begin{align*}
\text{BAM} & = \text{Morning peak bicycle count} \\
C & = \text{Footage of Class I bicycle path within a quarter-mile} \\
\text{ED} & = \text{Employment density within a quarter-mile}
\end{align*}

\[ R^2 = 0.474 \]
Explanatory variables significant at 95% confidence interval

San Diego County Bicycle Volume Model

Santa Monica Bicycle Volume Model

PM Peak Hour Bicycle Intersection Volume =

+ 10.97 * Land Use Mix
+ 0.342 * PM Bus Frequency
− 5.809 x 10^{-3} * Population Density Under Age 18
+ 5.581 * Bike Network Score
+ 14.89 (Constant)

R^2 = 0.471
Explanatory variables significant at 95% confidence interval

Table 4. Alternative Bicycle Model Specifications

<table>
<thead>
<tr>
<th>Model Variable</th>
<th>Model A: All Counts</th>
<th>Model B: Weekday</th>
<th>Model C: Weekend</th>
<th>Model D: Weekday Alt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable = 2-hr Intersection Bicycle Count</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>3.776</td>
<td>0.185***</td>
<td>3.899</td>
<td>0.262***</td>
</tr>
<tr>
<td>NComPropT</td>
<td>0.024</td>
<td>0.007***</td>
<td>0.030</td>
<td>0.010***</td>
</tr>
<tr>
<td>BikeSym</td>
<td>0.477</td>
<td>0.163***</td>
<td>0.437</td>
<td>0.230*</td>
</tr>
<tr>
<td>lnUCBDist</td>
<td>-0.458</td>
<td>0.059***</td>
<td>-0.546</td>
<td>0.083***</td>
</tr>
<tr>
<td>SlopeH</td>
<td>-0.517</td>
<td>0.073***</td>
<td>-0.659</td>
<td>0.103***</td>
</tr>
<tr>
<td>CNRH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.811</td>
<td>0.127***</td>
<td>1.002</td>
<td>0.180***</td>
</tr>
<tr>
<td>Overall Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size (N)</td>
<td>162</td>
<td>81</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.505</td>
<td>0.600</td>
<td>0.386</td>
<td>0.450</td>
</tr>
<tr>
<td>F-test</td>
<td>33.87***</td>
<td>24***</td>
<td>11.08***</td>
<td>17.38***</td>
</tr>
</tbody>
</table>

NOTE: Coeff. = coefficient and Std. Err. = standard error. *** = significant at 99% (p < .01); ** = significant at 95% (p < .05); * = significant at 90% (p < .10). Model variables are defined in Table 3.

### Alameda County Bicycle Volume Models

#### Table 4. Alternative Bicycle Model Specifications

<table>
<thead>
<tr>
<th>Model Variable</th>
<th>Model A: All Counts</th>
<th>Model B: Weekday</th>
<th>Model C: Weekend</th>
<th>Model D: Weekday Alt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.776</td>
<td>0.185***</td>
<td>3.899</td>
<td>0.262***</td>
</tr>
<tr>
<td>NComPropT</td>
<td>0.024</td>
<td>0.007***</td>
<td>0.030</td>
<td>0.010***</td>
</tr>
<tr>
<td>BikeSym</td>
<td>0.477</td>
<td>0.163***</td>
<td>0.437</td>
<td>0.230*</td>
</tr>
<tr>
<td>lnUCBDist</td>
<td>-0.458</td>
<td>0.059***</td>
<td>-0.546</td>
<td>0.083***</td>
</tr>
<tr>
<td>SlopeH</td>
<td>-0.517</td>
<td>0.073***</td>
<td>-0.659</td>
<td>0.103***</td>
</tr>
<tr>
<td>CNRH</td>
<td>4.634</td>
<td>0.989***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count09</td>
<td>0.811</td>
<td>0.127***</td>
<td>1.002</td>
<td>0.180***</td>
</tr>
</tbody>
</table>

**Overall Model**

- Sample size (N) = 162
- Adjusted R² = 0.505
- F-test = 33.87***

**Notes:** Coeff. = coefficient and Std. Err. = standard error. * = significant at 90% (p < .10). Model variables are categorical. **p**-value of the F-test is less than 0.0005.

- Commercial properties within 0.1 miles
- Bicycle facility on intersection approach
- **Distance to UC Berkeley**
- Slope
- Roadway network connectivity

Common Bicycle Volume Model Variables

- Presence of bicycle facilities (e.g., multi-use trails, bicycle lanes)
- Employment or population density
- Proximity to commercial areas
Future Research
Conclusions

- Volume model uses: Planning, general risk analysis
- Location-based models have been developed recently
  - Simple regression equations with spreadsheet applications
  - Other methods are being explored (Portland, NCHRP, others)
- Community-specific models (No universal model yet)
- Planning-level accuracy
- Pedestrian models more common than bicycle
Questions & Discussion

UC Berkeley Safe Transportation Research & Education Center (SafeTREC)
www.safetrec.berkeley.edu
Thank You!

⇒ Archive at http://www.walkinginfo.org/webinars
  - Downloadable and streaming recording, transcript, presentation slides

⇒ Questions?
  - E-mail David Ragland at davidr@berkeley.edu
  - E-mail John Bigham at jbigham@berkeley.edu
  - E-mail Robert Schneider at rjschneider@berkeley.edu