Walkability and the Built Environment: A Neighborhood- and Street-Scale Assessment of Diverse San Francisco Neighborhoods

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Abstract Physical activity can be strongly influenced by the built environment. In the early 1990s, almost three quarters of adults did not get enough physical activity to meet health recommendations (Stokols 1992). Today, physical inactivity has increasingly severe health implications. Although San Francisco was named the most 'walkable' city in the U.S., diverse neighborhoods within the city experience varying levels of walkability and capacity to safely, conveniently be active (Walkscore 2009). Four study sites within San Francisco, two of high socioeconomic status (SES) and two of low SES, were selected. Correlations between neighborhood- and street-scale walkability and SES were analyzed. It was expected that lower income areas would be less walkable and that correlations between SES and walkability would exist at the fine detailed street-level, but not the neighborhood-level. Whether or not neighborhood- and street-scale assessments present similar walkability measures was analyzed with the hypothesis that there would be some similarities. Neighborhood-scale attributes were subdivided into 5 categories: residential density, public transit, street connectivity, crime, and land use mix. Using GIS mapping techniques these were analyzed. Using the PEDS audit street-scale measures were subdivided into finer-detailed attributes (i.e. condition of sidewalk, perceived attractiveness, etc). The PEDS revealed a significant correlation between walkability and SES, while GIS did not. It was also found that the unique assessments did not produce similar walkability scores or "walkscores." This highlights the need for more reliable measures of neighborhood- and street-scale walkability to approach physical inactivity.

Introduction

In the early 1990s McGinnis found that physical inactivity was responsible for an estimated 200,000 to 300,000 premature deaths each year in the United States (McGinnis 1992). With obesity considered one of the most pressing epidemics of the 21st century, health risks associated with a lack of adequate exercise are becoming very serious topics to address for urban planners, policymakers, and public health figures in U.S. cities. Walking is often the most effective, convenient way to achieve these recommended physical activity levels. Urban planning can either promote walking and the use of alternate modes of transportation or promote inactivity and the use of cars (Dannenburg 2003). As residential and commercial sectors of large U.S. cities continue to grow rapidly, suburbs outside of the city develop. These suburbs are often car-dependent and associated with sedentary lifestyles and health problems such as obesity, adding as much as $76 billion annually to U.S. medical expenses (Cervero and Duncan 2003). Residents of such neighborhoods tend to both commute via car more often and fail to attain recommended physical activity levels easily achieved by walking for transport or leisure. Recently, city planning research has focused primarily on barriers to walkable neighborhoods outside of urban environments, in the newly developed suburbs. However, strategic urban planning that can accommodate high population densities and provide highly walkable, healthy communities is as important now as ever within U.S. inner cities. Residents of cities such as San Francisco continue to experience health problems associated with neighborhood environmental characteristics. These urban communities must be studied further to better understand the built environment's influence on walkability on all scales.

The health benefits of daily walking are well established. Walking ten or more blocks per day is associated with a 33% decrease in the risk of cardiovascular disease (Frumkin 2001). In order for someone to reap the benefits of physical activity, that person's local environment should have a high walkability. Although gyms and recreational facilities can provide similar exercise potential, favorable neighborhood walking environments often provide the most effective options for convenient activity. The "walkability" of a community may be thought of as the extent to which characteristics of the built environment and land use may or may not be conducive to neighborhood residents walking for either leisure, exercise, to access services, or to get to work (Leslie et al 2005). Walkability is affected by the design of the built environment and its many features. Relevant community characteristics typically reflect distance between places (proximity) and ease of travel between places (connectivity) (Norman 2006).

San Francisco possesses attributes indicative of traditional, urban neighborhoods of the 1930s, which emphasize this proximity and connectivity. It was around this time that much of the city's development took place and the current built environment features were established. People living in such traditional communities – characterized by higher residential density, a mixture of land uses (residential and commercial), and grid-like street patterns with short block lengths – engage in more walking than do people in sprawling areas (Saelens 2003). These characteristics emphasize the importance of density, diversity, and connectivity of neighborhood environments when measuring walkability. Residential density, street connectivity, public transit, crime, and land use mix are significant environmental attributes most often used to measure neighborhood walkability (Cervero and Kockelman 1997). Each community characteristic affects walking behavior uniquely (Table 1). Substantial research has measured these neighborhood-scale environmental factors influencing pedestrian walking activity. However, these large-scale assessments using Geographic Information Systems (GIS) and secondary sources of census data often cannot assess small-scale pedestrian infrastructure.

Recent research has revealed that it is likely that micro-features in an environment largely shape how accommodating an area is for pedestrian travel (Clifton 2006). Such features are sidewalk infrastructure and condition, presence of trees for shading, safety features, street lighting, aesthetics, and public transportation facilities. These detailed, multiple dimensions of the physical walking environment are often measured using systematic observational audit tools such as the Pedestrian Environment Data Scan (PEDS) (Pikora *et al.* 2002). It can be argued that these fine-grained elements of the street-scale environment influence walkability significantly, however, detailed and comprehensive measures at both the neighborhood- and street-scale must be implemented to reveal more accurate, representative neighborhood walkability assessments.

Table 1. Elements of neighborhood-scale environmental characteristics and relationships to walkability (Leslie *et al* 2005).

Environmental attributes	Implied relationship with walkability
Residential density	• High-density neighborhoods encourages mixed-use development (improves accessibility to variety of interests and increases utility) • Associated with increase in retail/services variety (results in shorter, more walkable distances between interests)
Street connectivity	• High intersection densities provide more potential routes for walking and greater accessibility • Greater neighborhood connectivity, shorter distances to destinations
Public transit density	• High public transit density provides shorter, more walkable distances to alternate modes of transportation (buses, etc) • Use of more accessible bus stops encourages walking between leisure, work, and home
Crime density	• High-density crime discourages walking in neighborhood • Sense of lack of pedestrian safety encourages more protected automobile use and alternate transportation methods
Land use mix	• Multiple and diverse retail/services opportunities encourage more specialized, frequent, and shorter shopping trips by foot • More land use mix means more varied and interesting built environment, creating neighborhoods conducive to walking

In 2008 San Francisco was named the "#1 Most Walkable City in the US" with a walkability score of 86 on a scale of 100 (WalkScore 2009). However, this acknowledged walkability is not pronounced equally among all the city's neighborhoods. The nine districts of the San Francisco metropolis all demonstrate variable degrees of walkability (WalkScore 2009). These degrees of walkability appear to have some correlation with socioeconomic status (SES). Previous studies have found that disadvantaged urban neighborhoods are generally characterized by such features as poor access to services, aesthetics, safety, and pedestrian infrastructure (Lovasi 2008). However, land use mix, residential density, transit use and transit access have been found to be higher in some low-income neighborhoods (Papas 2007). It appears there is no definitive correlation between walkability and SES. More adequate, detailed documentation and approaches for assessing these two elements with respect to the built environment in the context of a diverse metropolis is deserved and needed.

Each San Francisco neighborhood possesses a unique urban design capable of providing various opportunities and obstacles for its residents on many scales. The objective of this study was to measure various attributes of the built environment affecting walkability in unique low- and high-income urban areas. This study intended to compare findings between street-scale pedestrian infrastructure assessment and neighborhood-scale walkability indicators: residential density, land use mix, street connectivity, public transit density, and crime density. Another objective was to determine if there is a significant correlation between a neighborhood's SES and its walkability.

To approach this, four San Francisco study sites of different SES and "walkscores" were compared (Table 2). SES was represented solely by per capita and household median income. Social indicators such as ethnic/racial relationships were excluded due to resource and time constraints of the project. These previously calculated walkscores were derived solely based on proximity and accessibility to neighborhood amenities (shops, recreational facilities, etc.) (Walkscore 2009). Therefore, I used two unique tools and approaches to measure the other relevant neighborhood- and street-scale features: GIS spatial analysis and the Pedestrian Environment Data Scan (PEDS) audit. I collected data in two neighborhoods of high SES (North Beach and Marina) and two of low SES (Bayview and Chinatown). With multiple sites of similar SES I was able to more accurately determine if there is a significant correlation between the SES of a neighborhood and its walkability.

Table 2. Neighborhood SES and walkscores

Neighborhood	Per capita and household median income	Walkscore (out of 100)
Bayview	$18,090	74
Chinatown	$13,807	99
North Beach	$45,907	98
Marina	$106,604	93

Note: Per capita and household median income data gathered from Human Development Measurement Tool (HDMT 2009). Walkscores compiled from "Walkscore" site (Walkscore 2009).

My first hypothesis was that PEDS street-scale measurements would not present findings similar to GIS neighborhood-scale analyses. My second hypothesis was that a weak correlation would be found between walkability and the SES of a neighborhood using the GIS approach, but a strong correlation would be found with the PEDS. The study sites characterized by lower SES – Bayview and Chinatown – were expected to present a slightly less favorable walking environment. The study sites characterized by higher SES – North Beach and the Marina – were expected to present a slightly more favorable environment. It should be demonstrated by comparison of these four San Francisco study sites that physical and social factors of street-scale pedestrian walking environments, as well as SES, have little effect on neighborhood walkability.

Methods

My study was primarily observational and consisted of two components – a systematic observation audit of street-scale pedestrian infrastructure and GIS spatial analysis maps of neighborhood-scale environmental characteristics affecting walking.

GIS and neighborhood-scale approach I overlaid 2000 U.S. Census data with GIS to create site maps displaying existing neighborhood-scale characteristics. This allowed for spatial analysis and helped indicate most walkable sites and contributing factors. A ¼ mile radial buffer around each study neighborhood's commercial core was created so that relevant, nearby variables were measured. Five neighborhood-scale indicators affecting walkability were created using existing data: residential density, street connectivity, public transit, land use mix, and crime density (Table 3). These maps were individually scored by calculating the total count of each feature within the ¼ mile area and creating density values. The scores were then classified into quartiles: 1st quartile – lowest walkability, 4th quartile – highest walkability. These indexes were then mapped to visually identify areas at the extremes of walkability with respect to each neighborhood-scale feature. The GIS neighborhood-scale indicators were compared to the results of the street-scale PEDS analysis to assess any similarities in results achieved by measuring walkability between the two unique approaches.

Table 3. GIS walkability index for neighborhood-scale variables

Measure	Definition	Data source
Land use mix	Sum of eating places, groceries, business services, and misc. retail stores per square mile	San Francisco commercial use dataset
Residential density	Housing units per square mile	2000 Census and San Francisco County block group housing dataset
Street connectivity	Number of 3- to 4-way intersections per square mile	San Francisco County street centerline dataset
Public transit density	Bus stops per square mile	San Francisco County public transit dataset
Crime density	Number of crimes per square mile	San Francisco Gov. SFDP CrimeMaps dataset

Note: "crimes" include forcible rape, arson, vehicle theft, robbery, burglary, vandalism, aggravated assault, larceny/theft, drug offenses. Number of crimes was total count over 90-day period ending March 14, 2009.

PEDS and street-scale approach With this audit tool I directly observed and measured the fine-grained details of pedestrian infrastructure that influence walkability. These measurements were then compared to the GIS maps indicating neighborhood-scale attributes. The PEDS uses primary sources and detailed observations, rather than readily available secondary sources such as U.S. Census data (population density, land use mix, etc.) most commonly used in urban planning. It measures 78 streetscape characteristics that other research has shown to influence walkability (Schlossberg 2007). These include sidewalk conditions, pedestrian facilities, street lighting, public transportation access, aesthetics, safety, and many other street scale pedestrian environment features. It is primarily structured in a Likert scale format (poor, fair, good, etc.). The PEDS was developed by Dr. Kelly Clifton and Andrea Livi at the University of Maryland and Dr. Daniel Rodriguez at the University of North Carolina, three notable researchers in the field of urban planning.

Walking segment sites Audits were conducted in four locations within each neighborhood. One of the locations was assigned to the "commercial core" of the community where pedestrian activity and density is most prevalent. The other three sites of the neighborhood were selected (within the same ¼ mile area about the commercial core used for the GIS analysis) by methods of random stratified sampling to ensure measurements were more representative of each community. I used GIS and 2000 U.S. Census data for San Francisco County from "SFGov" to select my random points for auditing. Once the three points were selected, addresses were assigned to the locations. Each selected point for sampling was created into a "walking segment" which consisted of one block spanning unilateral opposite directions of the designated address.

Using the PEDS Beginning at the start location of the 1-block segment I walked the entire length first without writing anything on the audit tool, looking in all directions for significant pedestrian features (i.e. traffic control devices, sidewalks obstructions, articulation in building design, etc.). I went to the end of the segment on one side and returned on the opposite side of the street to ensure thorough observation. Then I walked the entire segment and completed the survey as I went. All audits were conducted between 10AM and 4PM for matters of safety, convenience, and visual quality. The auditing process took approximately 20-30 minutes per segment.

Size of sample The total sample size was 16; 4 segments within each of the four sites. Since my study was primarily observational and involved a more qualitative approach, a small representative sample size was sufficient for each site. Also, the homogeneity of the street environments within individual neighborhoods allowed for a small sample size to be representative.

PEDS scoring and ANOVA I scored the PEDS based on the point system provided (Table 4). Scores were added up for each subsection of the PEDS and the cumulative score of each segment was derived. The mean score for each neighborhood was then calculated by averaging the segment scores within that location. An ANOVA was conducted for each scored subsection of the PEDS (environment, road attributes, walking environment, etc.) to analyze variance in measured walkability between the four neighborhoods. This indicated whether each subsection of the PEDS found statistically significant data used in evaluating each neighborhood's walkability score. I calculated P-values, F-ratios, standard errors, and degrees of freedom to assess the validity of my findings. Linear regression analysis was used to illustrate a correlation between SES and walkability by plotting my PEDS walkscores against per capita and household median income.

Table 4. Sample PEDS scoring rubric

Street-scale walkability feature	Score
Path condition/maintenance (poor/fair/good)	0-2
Segment intersections (deadends-4way)	0-4
Slope (flat/slight/steep)	0-2
Crossing Aids (yes or no)	0-1
Articulation in building designs (little/some/highly)	0-2
Bus stops (no/signage/bench/shelter)	0-3

Note. The PEDS audit protocol manual was studied and used to ensure greater accuracy and reliability.

Results

GIS neighborhood-scale approach

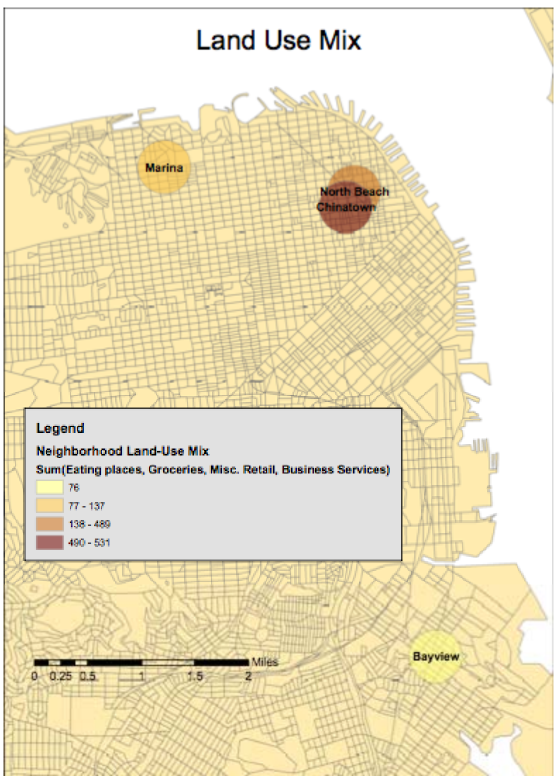

Figure 1. Total count of eating places, groceries, miscellaneous retail stores, and business services within each neighborhood.

Land use mix There is no correlation between SES and land use mix (proximity/access to eating places, groceries, business services, and misc. retail stores). Chinatown, the lowest-income area, was found to have the greatest number of eating places, groceries, misc. retail stores, and business services at 531 (4th quartile) within its ¼ mile neighborhood radius (Fig. 1). Bayview was found to have the lowest count with 76 and lowest density of land use mix within walking distance of the 4 study sites. Marina, the highest-income neighborhood, presented the second lowest land use mix density (Table 5).

Table 5. Land use mix count and density

Neighborhood	Eating places	Groceries	Misc. retail stores	Business services	Total density
Bayview	12	9	29	26	388
North Beach	93	38	166	192	2,495
Chinatown	88	43	200	200	2,709
Marina	37	2	38	60	699

Note: Land use mix density calculated accordingly; Sum (EP + G + MRS + BS) / mi^2.

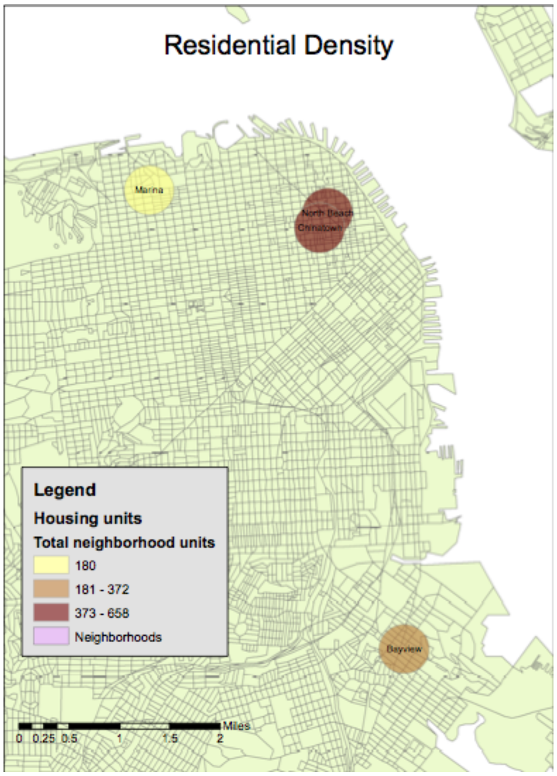

Figure 2. Total count of housing units within each neighborhood ¼ mile radial buffer.

Residential density There is no significant correlation between SES and residential density affecting walkability. Marina, the highest-income neighborhood, presented the lowest residential density of all four neighborhoods with a count of 180 units (1st quartile) within the ¼ mile neighborhood area (Fig. 2). North Beach and Chinatown, neighborhoods of unique SES, presented the greatest housing unit counts of 658 and 579 respectively.

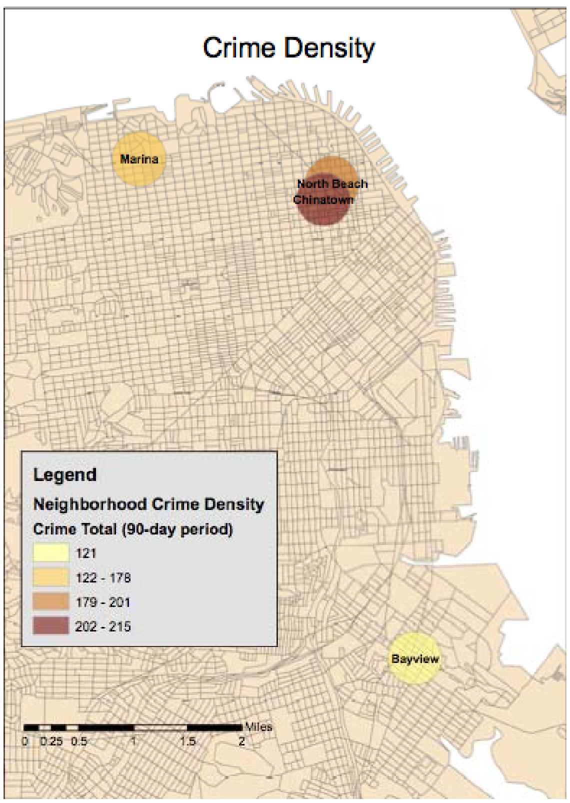

Figure 3. Total count of reported crimes over 90-day period ending March 14, 2009.

Crime density There is no correlation between number of reported crimes and the SES of the neighborhood. It was not expected that the highest income neighborhoods North Beach and Chinatown would experience the most crime (Fig. 3). Surprisingly, Bayview experienced the least number of crimes within the 90-day period up to March 14th, 2009 at 121. Chinatown experienced the greatest crime density with 215 reports; North Beach followed closely behind with 201 reports.

Street Connectivity There is no correlation between SES and street connectivity influencing greater neighborhood walkability. North Beach and Chinatown exhibit the greatest density of 3 or more way intersections with counts of 81 and 85 respectively, while Bayview and Marina exhibit much lower densities and street connectivity with intersection counts of 38 and 48. See Fig. 4.

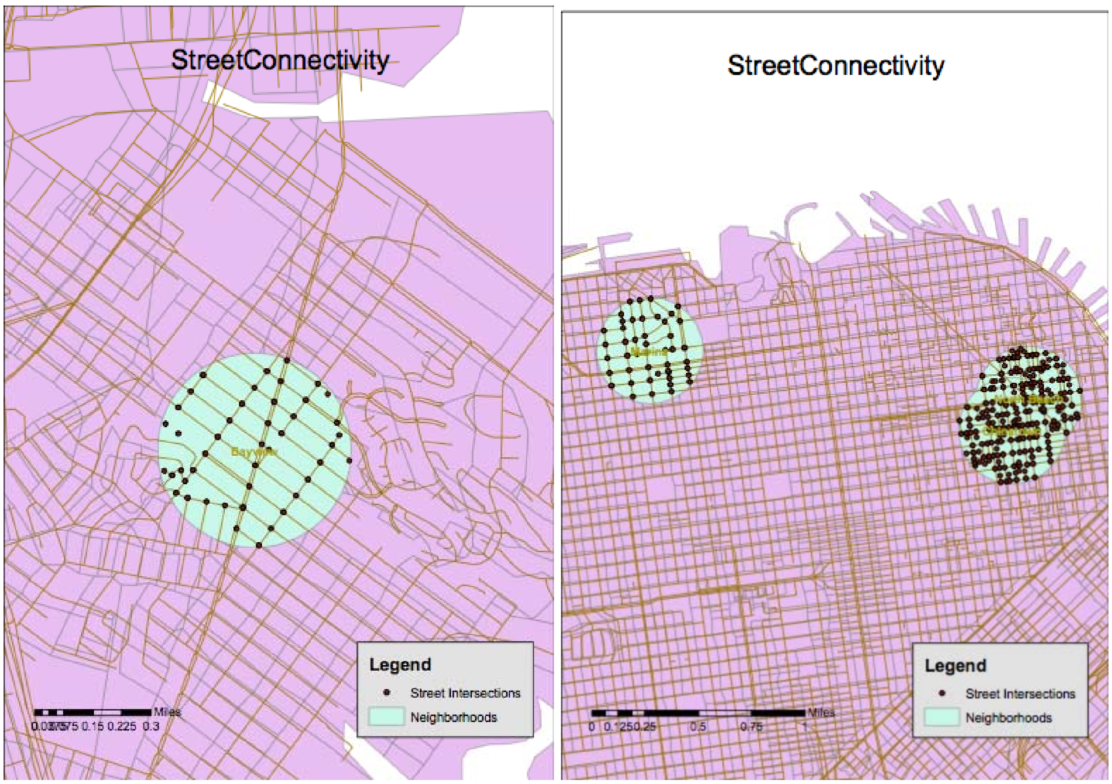

Figure 4.Total counts of street intersections with at least 3 unique directions.

Public transit There is no correlation between SES and public transit. North Beach and Chinatown have the greatest bus stop counts at 40 and 57 respectively. Bayview and Marina, on the other hand, have only 30 and 26 bus stops. The most affluent community in this case demonstrates the least accessibility and proximity to public transportation. See Fig. 5.

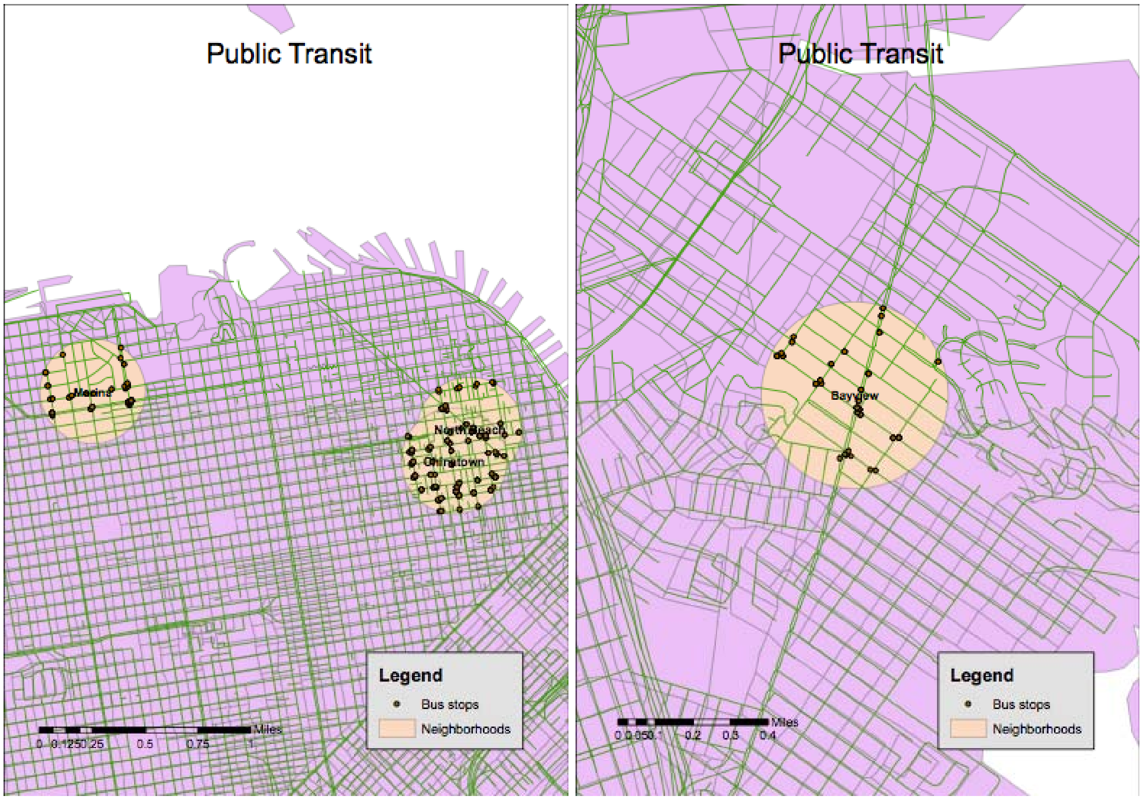

Figure 5. Total bus stop count within neighborhood buffer

Total walkability score It can be determined that there is no significant correlation between SES and combined walkability of these four San Francisco neighborhoods from the GIS analyses. Although North Beach, one of the two high-income neighborhoods, scored the greatest walkability, Marina, the most affluent of all four, scored the lowest walkability (Table 6).

Table 6. Neighborhood-scale walkability indicator densities

Neighborhood	Housing density	Intersection density	Bus stop density	Crime density	Total walkability score
Bayview	1,898	194	153	617	403
North Beach	3,357	413	204	1,026	1,089
Chinatown	2,956	434	291	1,097	1,059
Marina	918	245	133	908	217

Note: Crime counts over 90-day period up to March 14, 2009.

It can be observed in Figure 6 that North Beach and Chinatown have significantly greater densities for each indicator and thus are considered more walkable than Marina and Bayview through the GIS approach. It is important to note that although North

Beach and Chinatown had the greatest crime densities, the values of the other more influential walkability indicators outweighed the negative influence of the crimes on walkability when scored.

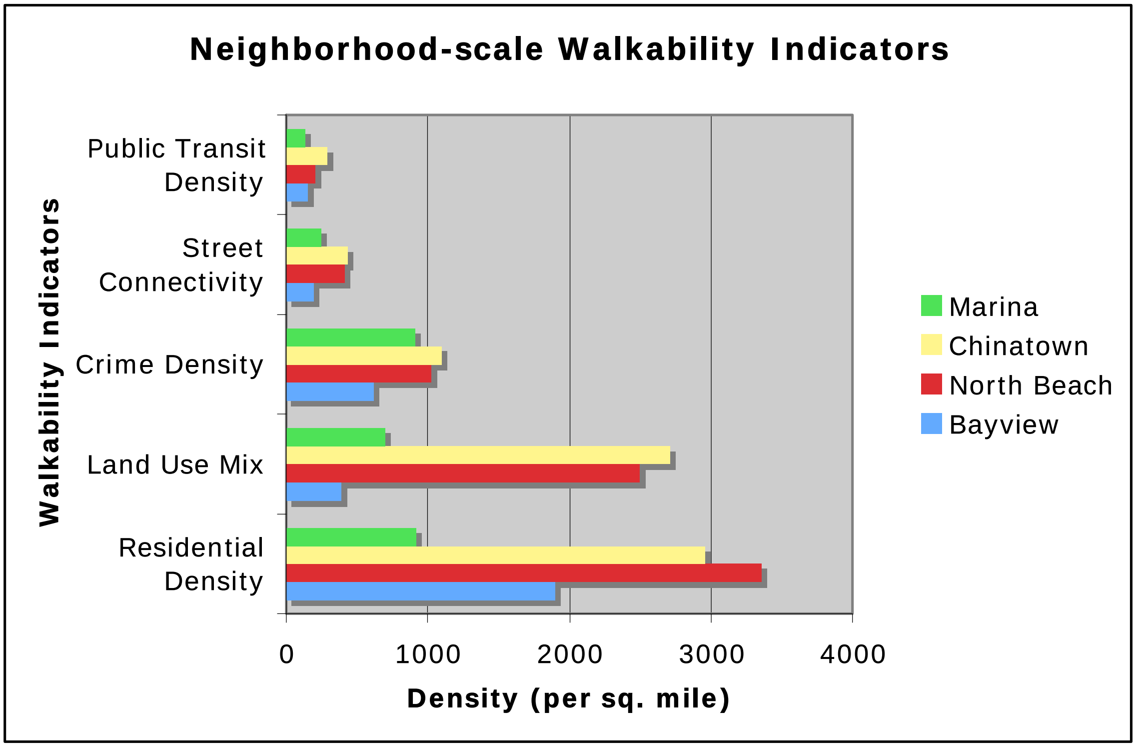

Figure 6. GIS-derived walkability factors and their respective densities within each neighborhood's ¼ mile radial buffer.

Plotting the total walkscores of the walkability indicators against per capita and household median income data for each study neighborhood indicated that there is a negative and insignificant correlation between walkability and SES using the GIS approach (Fig. 7).

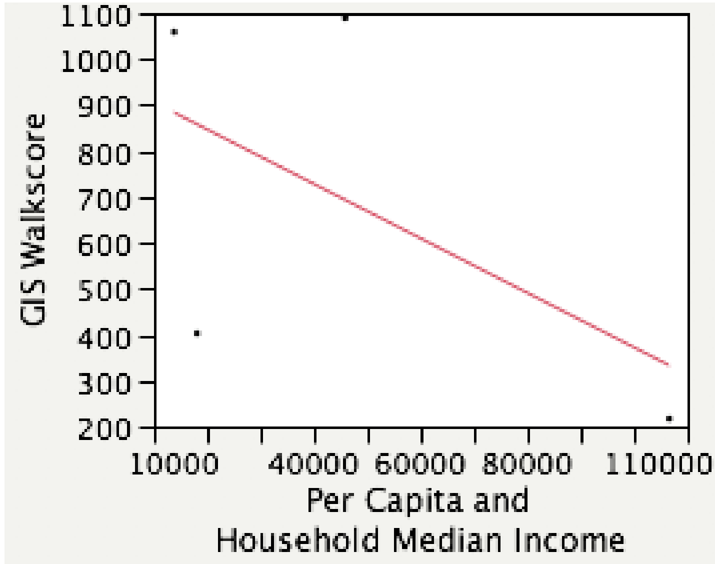

Figure 7. GIS walkscores and per capita and household median income data presented within a linear regression model (p-value = 0.4331, F-ratio = 0.9474).

PEDS street-scale approach

Observational Street-scale Walkability Comparison
Commercial Core Segments

North Beach: Columbus Ave, Jackson to Green St.


Note: Photo #1. Attractive, articulated walking environment. Photo #2. Many crossing aids and pedestrian amenities; large trees providing sidewalk shade. Photo #3. Bus stops with bench/shelter; trash bin for curbing littering and loose garbage.

Chinatown: Stockton St., Broadway to Clay St.



Note: Photo #1. Lots of garbage; unattractive sidewalk conditions. Photo #2. Dense commercial area; high-density pedestrian environment with street-crossing aids. Photo #3. School playground within high-density commercial/residential area (land use mix).

Marina: Chestnut St., Fillmore to Scott St.

Note: Photo #1. Dense trees for attractive/comfortable sidewalk shading. Photo #2. Great cleanliness/condition of walking segment; safe, inviting café/restaurant aura; highly articulated design. Photo #3. Traffic control devices and pedestrian safety caution signs.

Bayview: Third St., Kirkwood to Oakdale Ave.

Note: Photo #1. Despite trash bins, garbage all over sidewalk; no comfort features such as benches, or trees. Photo #2. Many street lanes to cross; unattractive, little articulation in design/environment; amenities/businesses gated and locked up. Photo #3. Automobile emphasis; many traffic control devices yet less convenient crossing lengths.

PEDS walkscore There is a positive, significant correlation between SES and walkability using the street-scale PEDS measurement method (Fig. 8). The results show Marina and North Beach, the two highest-income neighborhoods, as the most walkable, both with a total score of 137 between the four walking segments. The communities with the lowest per capita and household median income, Bayview and Chinatown, demonstrated the least walkability with scores of 74 and 112 respectively.

An analysis of variance was conducted to assess variance, error, and significance within the PEDS subsections and between the four neighborhoods. Street-scale PEDS measures found to be statistically significant were pedestrian facility, walking environment, and subjective assessment (Table 7). The environment and road attributes sections were found insignificant.

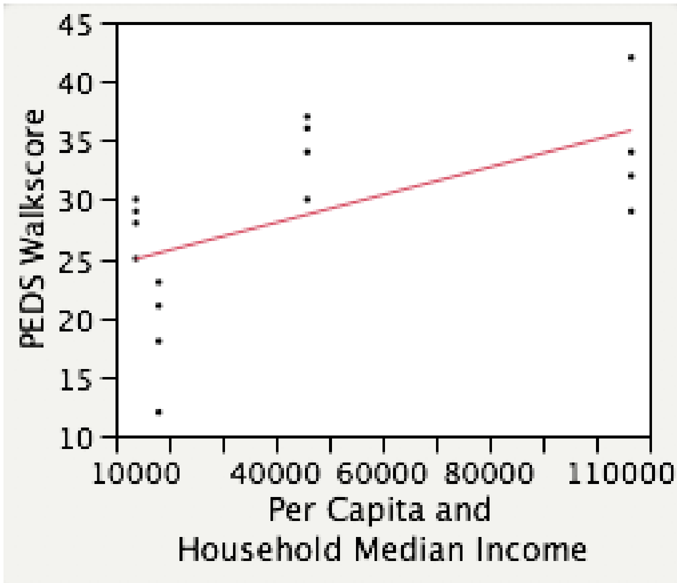

Figure 8. Linear regression model plotting PEDS walkscores for each neighborhood (n=4) against per capita and household median income data (p-value = .0164, F-ratio = 7.4329)

Table 7. Variance and significance within PEDS subsections and between neighborhoods

PEDS subsection	P-value	F-ratio	Standard error	Degrees of freedom
Environment	0.8194	0.3077	0.8229	3
Pedestrian facility	0.0365	3.9231	0.5204	3
Road attributes	0.0867	2.7808	0.6166	3
Walking environment	0.0014	9.9759	0.9298	3
Subjective assessment	0.0001	107.9474	0.3146	3
Total PEDS score	0.004	12.998	2.0640	3

Discussion

This study attempted to measure the walkability of diverse San Francisco communities at the neighborhood and street scales. The results of the neighborhood-level analysis indicate that there is no significant correlation between the walkability and SES of a neighborhood. Chinatown's objectively measured high walkability poses the greatest argument, considering the neighborhood has a per capita and household median income of $13,807. On the other hand, subjective street-level measurements using the PEDS indicate that SES does have a significant affect on neighborhood walkability.

Objectively measured GIS data indicated North Beach and Chinatown are the two most walkable neighborhoods. However, subjective PEDS-measured analysis of perceived aesthetics, safety, and pedestrian infrastructure conditions indicated the two high-income communities, the Marina and North Beach, are the most walkable as both received walkscores of 137. This demonstrates that street-scale built environment variables have little to no correlation with neighborhood-scale measures of connectivity, density, and diversity in terms of assessing walkability.

In the neighborhood-scale analyses North Beach and Chinatown are consistently found to be significantly more walkable with respect to residential density, street connectivity, public transit, and land use mix GIS-measured indicators, which previous literature has maintained are most influential for walking behavior. Areas of greater density of people and places, a larger number of intersections offering alternative routes to destinations, and a large variety of land uses are given higher walkability scores (Leslie et al 2005). While safety from crime is an accepted dimension affecting walking, it is important to note that Chinatown and North Beach both experienced the highest crime counts per square mile over a 90-day period with 1,097 and 1,026 respectively. Considering the physical disorder of Bayview and the neighborhood's low SES, a much larger crime rate was expected. However, the majority of Bayview's crimes were of greater severity such as drug offenses and aggravated assault, while the other neighborhoods' high crime densities were primarily attributable to larceny/theft and vandalism. It can be assumed that Marina and North Beach experienced high larceny/theft counts due to the high density of tourists within the neighborhood. This discrepancy in crime density further emphasizes the argument that high density, diversity, and connectivity are often considered most influential among the community elements, as demonstrated by Chinatown and North Beach's high calculated walkscores.

The street-scale analysis consistently rated the high-income Marina and North Beach neighborhoods as the most favorable neighborhoods. It is apparent that with use of the PEDS scale and scoring system there is indeed a correlation between the street-level built environment measures and SES. Chinatown and Bayview, on the other hand, scored street-level walkability scores of 112 and 74 respectively. The influence of community streets on physical activity is even larger on low-income communities than high-income.

In a recent study on urban neighborhood walkability, 66% of low-income participants indicated that neighborhood streets were their primary outlets for physical activity (Giles-Corti 2002). Future emphasis should be placed on making low-income neighborhood street segments more attractive, safe, and functional.

There are a number of confounds and problems with this study. Measurement with the PEDS audit tool presents a good amount of subjective data that is merely perceived such as attractiveness of the walking segment or how safe the block feels (Zhu Barch 2008). This method could be more rigorous and more reliable with greater sample sizes and multiple individuals recording observations. This detailed street-scale method of data collection is also limited by the amount of time required for block to block observations, the myriad features within a segment that potentially affect a pedestrian's perception of walkability, and issues with logically weighing the relative important of each feature. These factors weaken the validity and significance of my findings.

A number of problems are presented with the neighborhood-level analysis as well. Weighing relative importance of land use mix, crime density, street connectivity, public transit density, and residential density is a significant obstacle to GIS walkability assessment. Each person's preference for walking as a mode of transportation and the most important factors influencing that preference will be unique in any urban environment (Vernez-Moudon and Lee 2003). While neighborhood-level variables such as high intersection density and land use mix present greater connectivity and access to destinations, not all large-scale measures can capture the many fine-grained dimensions of the physical environment, particularly those met during walking (Clifton 2006). The residential density measure presented unexpected housing unit counts for Marina and Bayview. 2000 U.S. Census data shows that of all four neighborhoods the Marina has the greatest number of housing units, yet my analysis indicates that Marina has the lowest residential (housing unit) density. This, however, is dependent upon the location of my study site, neighborhood size, and distribution of features. It also further demonstrates the importance of density measures in evaluating more localized neighborhood attribute influences. It is important to note that my calculated residential density does not take into account the number of residents per housing unit, merely the number of housing units due to resource limitations.

Previous research shows design features that create favorable urban walking environments are the presence of sidewalks, streetlights, interconnectivity of streets, public transportation, access to services, safety from traffic and crime, and street aesthetics (Lopez and Hynes 2006). Yet, there still exists some ambiguity when identifying definitive characterizations of such elements and how they are individually affecting an area's walkability. One of the greatest difficulties in this field of research is implementing the most effective strategy for assessing the myriad built environment dimensions and then identifying and quantifying the partial effects of each characteristic (Cervero and Kockelman 1997).

The health implications of not meeting recommended amounts of physical activity due to a neighborhood that is not considered walkable are serious. Street-scale observations of high- and low-income areas have indicated correlations between SES and perceived walkability. However, a reliable and effective approach is necessary to include both relevant neighborhood- and street-scale variables with proven influence and create more accurate and representative walkability measurements in diverse socioeconomic urban communities. Urban planners, researchers, and policy makers need to collaborate and make significant efforts to strategically assess the correlation between walkability and SES. Once more reliable, accurate assessment measures are created, possible environmental injustices can be approached most efficiently so all residents are provided equal opportunity for physical activity in their neighborhoods.

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Appendix

Name: ____________ Date: ____________ Study Area: ____________ PEDS

Segment Number: ____________ Time: ____________ Weather: ____________

0. Segment type
- Low volume road 1
- High volume road 2
- Bike or Ped path - skip section C 3

A. Environment

1. Uses in Segment *(all that apply)*
- Housing - Single Family Detached 1
- Housing - Multi-Family 2
- Housing - Mobile Homes 3
- Office/Institutional 4
- Restaurant/Café/Commercial 5
- Industrial 6
- Vacant/Undeveloped 7
- Recreation 8

2. Slope
- Flat 1
- Slight hill 2
- Steep hill 3

3. Segment Intersections
- Segment has 3 way intersection 1
- Segment has 4 way intersection 2
- Segment has other intersection 3
- Segment deadends but path continues 4
- Segment deadends 5
- Segment has no intersections 6

B. Pedestrian Facility *(skip if none present)*

4. Type(s) of pedestrian facility *(all that apply)*
- Footpath (worn dirt path) 1
- Paved Trail 2
- Sidewalk 3
- Pedestrian Street (closed to cars) 4

The rest of the questions in section B refer to the best pedestrian facility selected above.

5. Path material *(all that apply)*
- Asphalt 1
- Concrete 2
- Paving Bricks or Flat Stone 3
- Gravel 4
- Dirt or Sand 5

6. Path condition/maintenance
- Poor (many bumps/cracks/holes) 1
- Fair (some bumps/cracks/holes) 2
- Good (very few bumps/cracks/holes) 3
- Under Repair 4

7. Path obstructions *(all that apply)*
- Poles or Signs 1
- Parked Cars 2
- Greenery 3
- Garbage Cans 4
- Other 5
- None 6

8. Buffers between road and path *(all that apply)*
- Fence 1
- Trees 2
- Hedges 3
- Landscape 4
- Grass 5
- None 6

9. Path Distance from Curb
- At edge 1
- < 5 feet 2
- > 5 feet 3

10. Sidewalk Width
- < 4 feet 1
- Between 4 and 8 feet 2
- > 8 feet 3

If no sidewalk, skip now to section C.

11. Curb cuts
- None 1
- 1 to 4 2
- > 4 3

12. Sidewalk completeness/continuity
- Sidewalk is complete 1
- Sidewalk is incomplete 2

13. Sidewalk connectivity to other sidewalks/crosswalks
- number of connections ____ 1

C. Road Attributes *(skip if path only)*

14. Condition of road
- Poor (many bumps/cracks/holes) 1
- Fair (some bumps/cracks/holes) 2
- Good (very few bumps/cracks/holes) 3
- Under Repair 4

15. Number of lanes
- Minimum # of lanes to cross ____ 1
- Maximum # of lanes to cross ____ 1

16. Posted speed limit
- None posted 1
- (mph): ____ 1

17. On-Street parking *(if pavement is unmarked, check only if cars parked)*
- Parallel or Diagonal 1
- None 2

18. Off-street parking lot spaces

0-5	6-25	26+
1	2	3

19. Must you walk through a parking lot to get to most buildings?
- Yes 1
- No 2

20. Presence of med-hi volume driveways
- < 2 1
- 2 to 4 2
- > 4 3

21. Traffic control devices *(all that apply)*
- Traffic light 1
- Stop sign 2
- Traffic circle 3
- Speed bumps 4
- Chicanes or chokers 5
- None 6

22. Crosswalks
- None 1
- 1 to 2 2
- 3 to 4 3
- > 4 4

23. Crossing Aids *(all that apply)*
- Yield to Ped Paddles 1
- Pedestrian Signal 2
- Median/Traffic Island 3
- Curb Extension 4
- Overpass/Underpass 5
- Pedestrian Crossing Warning Sign 6
- Flashing Warning Light 7
- Share the Road Warnign Sign 8
- None 9

24. Bicycle facilities *(all that apply)*
- Bicycle route signs 1
- Striped bicycle lane designation 2
- Visible bicycle parking facilities 3
- Bicycle crossing warning 4
- No bicycle facilities 5

D. Walking/Cycling Environment

25. Roadway/path lighting
- Road-oriented lighting 1
- Pedestrian-scale lighting 2
- Other lighting 3
- No lighting 4

26. Amenities *(all that apply)*
- Public garbage cans 1
- Benches 2
- Water fountain 3
- Street vendors/vending machines 4
- No amenities 5

27. Are there wayfinding aids?
- No 1
- Yes 2

28. Number of trees shading walking area
- None or Very Few 1
- Some 2
- Many/Dense 3

29. Degree of enclosure
- Little or no enclosure 1
- Some enclosure 2
- Highly enclosed 3

30. Powerlines along segment?
- Low Voltage/Distribution Line 1
- High Voltage/Transmission Line 2
- None 3

31. Overall cleanliness and building maintenance
- Poor (much litter/graffiti/broken facilities) 1
- Fair (some litter/graffiti/broken facilities) 2
- Good (no litter/graffiti/broken facilities) 3

32. Articulation in building designs
- Little or no articulation 1
- Some articulation 2
- Highly articulated 3

33. Building setbacks from sidewalk
- At edge of sidewalk 1
- Within 20 feet of sidewalk 2
- More than 20 feet from sidewalk 3

34. Building height
- Short 1
- Medium 2
- Tall 3

35. Bus stops
- Bus stop with shelter 1
- Bus stop with bench 2
- Bus stop with signage only 3
- No bus stop 4

Subjective Assessment: Segment...

Enter 1,2,3, or 4 for 1=Strongly Agree 2= Agree, 3=Disagree, 4=Strongly Disagree
- .....is attractive for walking. ____ 1
- .....is attractive for cycling. ____ 1
- .....feels safe for walking. ____ 1
- .....feels safe for cycling. ____ 1

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