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Article

Disparities in pedestrian streetscape environments by income and race/ethnicity

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ABSTRACT

Growing evidence suggests that microscale pedestrian environment features, such as sidewalk quality, crosswalks, and neighborhood esthetics, may affect residents' physical activity. This study examined whether disparities in microscale pedestrian features existed between neighborhoods of differing socioeconomic and racial/ethnic composition. Using the validated Microscale Audit of Pedestrian Streetscapes (MAPS), pedestrian environment features were assessed by trained observers along 1/4-mile routes ($N=2117$) in neighborhoods in three US metropolitan regions (San Diego, Seattle, and Baltimore) during 2009–2010. Neighborhoods, defined as Census block groups, were selected to maximize variability in median income and macroscale walkability factors (e.g., density). Mixed-model linear regression analyses explored main and interaction effects of income and race/ethnicity separately by region. Across all three regions, low-income neighborhoods and neighborhoods with a high proportion of racial/ethnic minorities had poorer esthetics and social elements (e.g., graffiti, broken windows, litter) than neighborhoods with higher median income or fewer racial/ethnic minorities ($p < .05$). However, there were also instances where neighborhoods with higher incomes and fewer racial/ethnic minorities had worse or absent pedestrian amenities such as sidewalks, crosswalks, and intersections ($p < .05$). Overall, disparities in microscale pedestrian features occurred more frequently in residential as compared to mixed-use routes with one or more commercial destination. However, considerable variation existed between regions as to which microscale pedestrian features were unfavorable and whether the unfavorable features were associated with neighborhood income or racial/ethnic composition. The variation in pedestrian streetscapes across cities suggests that findings from single-city studies are not generalizable. Local streetscape audits are recommended to identify disparities and efficiently allocate pedestrian infrastructure resources to ensure access and physical activity opportunities for all residents, regardless of race, ethnicity, or income level.

1. Introduction

Considerable evidence has shown that physical activity can reduce the risk of chronic diseases including CVD, diabetes, and some cancers (USDHHS, 2008). However, programmatic physical activity interventions often require resources that are not available in certain settings and may produce relatively modest, short-term effects, and

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only in individuals willing and able to enroll. Relatively little attention has been devoted to translating successful individual-level interventions to community use. Accordingly, international health organizations recommend a multi-level approach that includes population-level strategies, such as creating activity-friendly built environments, to increase physical activity and reduce risk of chronic disease in entire populations (World Health Organization, 2007). These policy recommendations are supported by substantial evidence documenting relationships between activity-friendly environments and greater physical activity (Bauman et al., 2012; Ding, Sallis, Kerr, Lee, & Rosenberg, 2011; Van Cauwenberg et al., 2011; Gebel, Bauman, & Petticrew, 2007).

Research on the built environment and physical activity typically has focused on macroscale features such as residential density, street connectivity, and land use mix (King & Clarke, 2014). More recently, however, interest has grown in how physical activity is affected by microscale factors, such as the quality of sidewalks, pleasant landscaping, and adequate street lighting (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009). It has been suggested that disparities in activity-supportive microscale features may help explain why individuals living in low-income urban neighborhoods, some of which have macroscale features that support walking, suffer from disproportionately high rates of chronic disease related to physical inactivity (Lovasi, Neckerman, Quinn, Weiss, & Rundle, 2009). Poor microscale pedestrian features like litter or unsafe crosswalks may offset the benefits of living in an urban environment with good macroscale walkability (Neckerman et al., 2009).

The relationship between physical activity, race/ethnicity, and income is complex, and differs depending on physical activity domain (e.g., leisure activity versus active transportation; Kruger, Ham, Berrigan, & Ballard-Barbash, 2008), age group (Cain et al., 2014), neighborhood type (urban versus suburban; Parks, Housemann, & Brownson, 2003), and racial/ethnic background (Li & Wen, 2013). For example, data from the 2005 National Health Interview Survey ($n=31{,}482$) showed that walking for transport was most prevalent among Asian women and non-Hispanic black men, but leisure walking was most prevalent among non-Hispanic White women and Asian men (Kruger et al., 2008). In a previously published study using the current data (Cain et al., 2014) we found that microscale pedestrian features explained differences in physical activity across four age groups. The present study expands upon the previous analysis by examining whether income or racial/ethnic disparities exist in microscale environments.

Only a few studies have examined whether microscale features differed based on neighborhood income (Gibbs, Slater, Nicholson, Barker, & Chaloupka, 2012; Sallis et al., 2011) or racial/ethnic composition (Neckerman et al., 2009; Yu, 2014; Zhu & Lee, 2008). Several studies suggest that low-income neighborhoods or neighborhoods with a high proportion of racial/ethnic minorities have worse microscale pedestrian environments (Gibbs et al., 2012; Lovasi, Hutson, Guerra, & Neckerman, 2009). A study of 2199 US adults found that residents in low-income neighborhoods perceived their microscale built and social environments to be worse than those living in high-income neighborhoods (Sallis et al., 2011). Gibbs et al. (2012) found that low income neighborhoods had fewer sidewalks, traffic calming devices, and marked crosswalks than high income neighborhoods. Other studies found that low income neighborhoods had more complete and wider sidewalks, but fewer esthetic features (Neckerman et al., 2009; Zhu & Lee, 2008). Focusing on active travel to school, Zhu and Lee (2008) concurrently examined income and race/ethnicity for routes ($N=73$) in Austin, Texas that were near public schools, had a posted speed limit of 30 mph, and had a sidewalk on at least one side of the street. They found that, around public schools in Austin, the relationship between microscale features and neighborhood income varied by neighborhood racial/ethnic composition. Additional evidence is needed to examine income and race/ethnicity interactions in a bigger and more varied sample of microscale environments. Most existing studies focused on a single city (Neckerman et al., 2009; Yu, 2014; Zhu & Lee, 2008) and therefore did not examine how microscale environments or disparities can vary across cities. Moreover, existing studies did not examine within-city variations in microscale environments based on neighborhood type (i.e., residential versus mixed-use neighborhoods).

Given that national and international authorities have identified the elimination of health disparities as a priority (World Health Organization, 2014; USDHHS, 2010; USDHHS, 2014), examining disparities in microscale pedestrian features is a first step toward addressing potential inequities in physical activity environments (LaVeist, 2005). As compared to changing macroscale urban features, such as the layout of roads, improving microscale features may provide a more feasible and affordable approach to creating activity-friendly environments (Cain et al., 2014). The objective of the present study was to conduct an in-depth examination of microscale pedestrian environments and the degree to which the quality of these environments is associated with the income and racial/ethnic composition of the neighborhood in which they exist. Data were collected from three US regions with markedly different SES levels, racial/ethnic composition, and walkability characteristics. This study adds to the literature by examining income and racial/ethnic disparities in three diverse regions, observing a large sample of routes, assessing residential and mixed-use neighborhoods, and using a validated direct observation tool (Cain et al., 2014).

2. Methods

2.1. Study design

The present analysis used microscale environmental data collected by trained raters in three observational studies: the Neighborhood Impact on Kids (NIK) Project (Frank et al., 2012), the Teen Environment and Neighborhood (TEAN) Study (Carlson et al., 2015), and the Senior Neighborhood Quality of Life Study (SNQLS, King et al., 2011). Each parent study explored the relationship between the built environment and physical activity. As shown in Table 1, the studies took place in urban and suburban neighborhoods in three US regions (San Diego County, CA; Seattle/King County, WA; and five counties in the Baltimore, MD-Washington, DC region) and sampled four age groups (children, teens, adults, and older adults). Previous articles detailed the methods for the three parent studies (Frank et al., 2012; Carlson et al., 2015; King et al., 2011). In brief, the studies employed a sampling strategy designed to maximize variability in income and macroscale walkability, except the NIK study that maximized variability in physical activity and nutrition environments (Frank et al., 2012). Census block groups were categorized as high or low walkability using a GIS-based walkability index that included four macroscale walkability components: intersection density, mixed land use, retail floor area ratio, and net residential density (Frank et al., 2010). Block groups were also classified as high or low-income based on 2000 US Census income data. Block groups were then categorized into one of four quadrants: high walkability/high income, high walkability/low income, low walkability/high income, and low walkability/low income (except for NIK). Participants were sampled from each quadrant. Thus, geographic locations were selected to represent a diversity of land use and demographic characteristics, and included both urban and suburban neighborhoods. In addition to collecting survey and accelerometer data from participants, researchers performed audits of the pedestrian environment along a 1/4-mile route starting at each participant's residence. The route served as the unit of analysis in

Table 1
Study characteristics: Neighborhood Impact on Kids (NIK) Study, Teen Environment and Neighborhood (TEAN) Study, and Senior Neighborhood Quality of Life Study (SNQLS).

Study	Participant ages	Design	Eligible destinations	Regions	Sample size: all routes	Years of MAPS data collection
NIK	6–11 and a parent	Activity environment[a] × Nutrition environment[b]	Cluster of ≥ 3 destinations (commercial locations, parks or schools)	San Diego County, CA	365	2009
				Seattle/King County, WA	393	2009–2010
TEAN	12–16 and a parent	Walkability[c] × Income[d]	Cluster of ≥ 3 commercial locations, a park, or a school	Seattle/King County,WA	427	2010
				Baltimore, MD-DC	470	2009–2010
SNQLS	66–97	Walkability[c] × Income[d]	Cluster of ≥ 3 destinations (commercial locations, parks, or school)	Seattle/King County, WA	367	2009

[a] Defined by GIS-derived block group walkability and park access.
[b] Defined by presence/absence of grocery stores and fast food restaurants.
[c] Walkability index consisted of GIS-derived intersection density, mixed land use, retail floor area ratio, and residential density.
[d] Based on 2000 Census data for block group median household income.

the present study. These studies received approval from Institutional Review Boards at participating institutions.

2.2. Measures

2.2.1. Microscale audit of pedestrian streetscapes

MAPS assessed microscale pedestrian features such as sidewalk quality, street design, crosswalk amenities, transit stops, and esthetics (Millstein et al., 2013). Trained observers collected MAPS data along a 1/4-mile route, starting at the participant's home and aimed toward the nearest "destination." Destinations included the nearest park, school, or cluster of shops along the street network, but the definition varied by the participant's age. For example, schools were not a defined destination for older adults. All MAPS routes were unique since they started from a participant's home. We did not use the same addresses for multiple studies. The MAPS tool includes 120 items and four sections: overall route (assessing characteristics of the entire 1/4-mile route), street crossings (evaluating each street crossing along the route), segment level (assessing segments of the route, which begin and end at each street crossing), and cul-de-sacs (evaluated in NIK and TEAN only). Auditors underwent a three-day training and certification process that required completion of four routes with 95% inter-rater agreement. Each route took an average of 28.5 min ($SD=13.2$) to complete. Inter-rater reliability was assessed on 13.7% of the routes, with the second rating completed by an independent rater within one week of the first. The majority of the items (75.6%) demonstrated moderate to excellent inter-rater reliability ($ICC \geq 0.4$; Millstein et al., 2013). Subscales were developed and classified as "negative" or "positive" based on their relationship with physical activity. A grand score was calculated by subtracting all the negative subscale scores from all the positive subscale scores (Millstein et al., 2013). This analysis evaluated microscale pedestrian environment features using 12 subscales from the Microscale Audit of Pedestrian Streetscapes (MAPS) tool. Subscales were selected to include most MAPS items without undue repetition. The 12 subscales were grouped into five categories: (1) esthetics and social features, (2) walkable destinations, (3) sidewalks, (4) street crossings, and (5) other walking barriers.

2.2.2. Median household income and race/ethnicity

For each route, 2000 Census-level block group data were collected for the two independent variables of primary interest: block group median household income and block group racial/ethnic composition. Routes were assigned to block groups based on the location of the participants' homes, which served as the starting points for the MAPS audits. Income was analyzed as a continuous variable. Race/ethnicity was analyzed as a continuous variable based on percentage non-White (including Hispanic) in the block group. To graph interactions, median household income and percentage non-White were divided into tertiles (high, medium, and low) in each region, with different cutoff points resulting from regional differences in income and racial/ethnic composition.

2.2.3. Residential-only and mixed-use

Routes were dichotomized into two groups: those that contained no retail destinations ("residential-only"), and those that contained at least one retail destination ("mixed-use"). Retail destinations included shops (e.g., grocery store, convenience store, pharmacy), restaurants and entertainment (fast-food, sit-down restaurants, cafes, etc.), institutional services (bank, health-related professional, or other service) and private recreation. Certain destinations were not categorized as retail, and could be present in a "residential-only" neighborhood (e.g., schools, places of worship, public recreation facilities [parks, community gardens, etc.], government services [libraries, museums, post office, senior center, social services], warehouses, abandoned buildings, and parking lots. Because routes began at individual residences, over two-thirds ($n=1368$ routes) were residential-only (69.6%, 65.9%, and 70.6% of routes in San Diego, Seattle, and Baltimore, respectively).

2.2.4. GIS walkability

In each parent study, GIS-based walkability was calculated for each block group by a weighted sum of region-specific z-scores of four macroscale built environment components: (1) net residential density, (2) intersection density, (3) retail floor to land area ratio (FAR), and (4) mixed use (Frank et al., 2010). Based on the four-part index, each block group was categorized as having high or low macroscale walkability.

2.2.5. Covariates

Census-level data for block groups were collected to assess the following potential covariates: block group median household age, proportion with college degree, proportion male, total block group population, and proportion of households with children under age 18. Macroscale walkability and study (NIK, TEAN, SNQLS) were also examined as potential covariates.

2.3. Analysis

Data were analyzed using SPSS Version 22 (Chicago, IL). Analyses using mixed model linear regressions were conducted to assess relationships between microscale pedestrian features and the independent variables: income and race/ethnicity. The analyses tested main effects of block group income and race/ethnicity on microscale pedestrian features and potential interactions between income and race/ethnicity. No data from individual participants were used in present analyses.

2.3.1. Preliminary analyses

Bivariate Spearman correlations were used to assess relationships between microscale pedestrian features and potential covariates and to evaluate which covariates warranted inclusion in the model. Macroscale walkability was significantly correlated with the majority of microscale pedestrian features, justifying inclusion in the analysis as a confounding variable. The other potential covariates were not consistently correlated with microscale pedestrian features and were excluded from the model. Multicollinearity was assessed by calculating Spearman correlations between the independent variables. The correlation between income and race/ethnicity (ρ=.376) did not reach the level of concern for multicollinearity and therefore both income and race/ethnicity were retained in the models.

2.3.2. Main analyses

Models were run separately for each of the three study regions (San Diego, Baltimore, and Seattle) due to differences in each region's demographic composition and walkability. Separate analyses were also conducted for residential-only and mixed-use (one or more retail destinations) neighborhoods because microscale pedestrian features were expected to differ between these neighborhood types. All analyses were adjusted for macroscale walkability and parent study as fixed effects and route clustering in census block groups as a random effect.

2.4. Disparities and equitable differences

Microscale pedestrian environments that were less favorable in lower-income or higher-minority neighborhoods were evidence of disparities. When less favorable microscale pedestrian features were found in higher-income or lower-minority neighborhoods, they were considered evidence of "equitable differences". This term was adopted because having better microscale environments in neighborhoods generally considered disadvantaged could be a strategy for reducing health disparities.

3. Results

The analyses indicate how microscale pedestrian environment features varied by block group median income and race/ethnicity (Table 2). In all three regions, the findings revealed that certain microscale pedestrian features were less favorable (i.e., lower quality or absent) in lower-income neighborhoods and other features were less favorable in higher-income neighborhoods. Similarly, some microscale pedestrian features were less favorable in neighborhoods with a higher proportion of racial/ethnic minorities and other features were less favorable in neighborhoods with fewer racial/ethnic minorities. In Table 2, meanings of positive and negative values vary depending on the nature of the microscale feature (i.e., positive or negative relationship with physical activity) and the independent variable of interest (income or race/ethnicity). To assist interpretation of Table 2, disparities are identified by bold and underlined font; equitable differences appear in bold font, without underlining.

Considerable variation existed between regions as to the type of microscale pedestrian features that had disparities, whether the disparities were found mostly in residential or mixed-use neighborhoods, the mix of disparities and "equitable differences", and whether the disparities were defined by neighborhood income level or racial/ethnic composition (Table 3). Across all three regions, 12 microscale pedestrian features were significantly worse in low-income neighborhoods, and 12 microscale pedestrian features were worse in high-income neighborhoods. Neighborhoods with a higher proportion of racial/ethnic minorities had 7 significantly worse microscale pedestrian features, as compared to 11 features that were worse in neighborhoods with fewer racial/ethnic minorities.

Disparities in microscale pedestrian features occurred more frequently in residential-only routes (11 significant findings) as compared to mixed-use routes (8 significant findings), but variation existed between regions. The Seattle region had more disparities in residential as compared to mixed-use routes, whereas the San Diego and Baltimore regions had an equal number of disparities in residential-only and mixed-use routes (Table 3). Results also included 11 significant interactions between income and racial/ethnic composition in relation to microscale pedestrian features (Table 2; Figs. 1–11).

3.1. Esthetic and social features

Of the 19 significant disparities identified in the analysis of main effects, over half (12 significant findings) related to unfavorable esthetic and social features. Across all three regions, low-income neighborhoods had more negative esthetics and social elements, like unmaintained buildings, graffiti, broken windows, litter, and social disorder, than neighborhoods with higher median income. In the Baltimore and Seattle regions, low-income neighborhoods tended to have fewer trees and less shade from trees or overhangs. In the San Diego and Seattle regions, neighborhoods with a large proportion of racial/ethnic minorities had fewer positive esthetics/social elements (such as art, landscaping, and neighborhood watch signs) as compared to neighborhoods with mostly White residents. Income by race interaction effects showed that in the San Diego and Seattle regions, low-income neighborhoods with a large proportion of racial/ethnic minorities had a larger number of negative esthetic and social features (Figs. 1 and 2).

3.2. Destinations

In all three regions, low-income residential neighborhoods had more positive destinations, such as libraries, schools, and places of worship, than high-income residential neighborhoods (Table 2). Prevalence of negative destinations like warehouses, abandoned buildings, and unmaintained lots, varied by region. In the Seattle region, low-income residential neighborhoods had more negative destinations as compared to high-income neighborhoods. In the Baltimore region, mixed-use neighborhoods with a large proportion of racial/ethnic minorities had more negative destinations than neighborhoods with fewer racial/ethnic minorities. In San Diego, income by race interactions showed that low-income residential neighborhoods with a large proportion of racial/ethnic minorities had more positive destinations and fewer negative destinations (Figs. 3 and 4).

3.3. Sidewalks

In the Baltimore region, low-income neighborhoods (both residential and mixed-use) had more sidewalks than higher-income neighborhoods, and sidewalk quality was better in neighborhoods with a high proportion of racial/ethnic minorities. In the Seattle region, low-income residential neighborhoods had fewer and poorer quality sidewalks than high-income residential neighborhoods (Table 2). An income by race interaction effect showed that Seattle's low-income residential neighborhoods with a high proportion of racial/ethnic minorities had better pedestrian

Table 2
Microscale pedestrian environment features by block group income and race/ethnicity in San Diego, Seattle and Baltimore's residential and mixed-use neighborhood types.

Pedestrian feature	San Diego				Seattle				Baltimore				Total disparities and equitable differences
	Residential-only (*n*=254)		Mixed-use (*n*=111)		Residential-only (*n*=782)		Mixed-use (*n*=405)		Residential-only (*n*=332)		Mixed-use (*n*=138)		
	B (Conf. Int.)	*P*	*B (Conf. Int.)*	*P*	*B (Conf. Int.)*	*P*	*B (Conf. Int.)*	*P*	*B (Conf. Int.)*	*P*	*B (Conf. Int.)*	*P*	
Esthetic and social features													
Positive esthetics/social: hardscape (fountains, sculpture, art), softscape (gardens, landscaping), landscape well maintained, neighborhood watch signs, signage for destinations													
Median block group income (10K)	.04 (−.03, .11)	.270	.09 (−.03, .20)	.159	.04 (−.004, .07)	.076	−.0007 (−.07, .07)	.998	−.10 (−.18, −.03)	**.008**	.03 (−.06, .13)	.486	1
% Non-white	−.81 (−1.39, −.24)	**.006**	−.83 (−1.61, −.05)	**.038**	−.11 (−.58, .35)	.632	−.64 (−1.20, −.11)	**.018**	.10 (−.37, .57)	.667	.34 (−.22, .90)	.232	3
Income*race	–	–	–	–	–	–	–	–	–	–	–	–	
Negative esthetics/social: unmaintained buildings, graffiti, abandoned cars, broken windows, drug paraphernalia, broken glass, litter, extent physical and social disorder													
Median block group income (10K)	–	–	−.28 (−.48, −.09)	**.005**	−.11 (−.17, −.06)	**<.001**	–	–	−.12 (−.21, −.03)	**.013**	−.17 (−.33, −.01)	**.033**	4
% Non-white	–	–	.92 (−.26, 2.10)	.123	.48 (−.18, 1.14)	.157	–	–	.81 (.23, 1.39)	**.007**	.50 (−.41, 1.41)	.277[a]	1
Income*race	−.75 (−1.05, −.45)	<.001	–	–	–	–	−.50 (−.94, −.07)	.024	–	–	–	–	
Trees and shade: Number of trees within 5 feet of sidewalk, general spacing of trees, percentage of sidewalk covered by trees or overhang													
Median block group income (10K)	.03 (−.05, .10)	.517	.08 (−.07, .23)	.320	.06 (.01, .11)	**.026**	.10 (.02, .18)	**.012**	.20 (.12, .29)	**<.001**	.21 (.10, .32)	**<.001**	4
% Non-white	−.26 (−.94, .43)	.458	−.60 (−1.50, .30)	.188	.11 (−.52, .73)	.740	.30 (−.32, .92)	.335	.32 (−.24, .87)	.263	.33 (−.30, .96)	.298	
Income*race	–	–	–	–	–	–	–	–	–	–	–	–	
Walkable destinations													
Positive destinations: retail destinations (e.g., grocery store, restaurants, entertainment, bank) and non-retail destinations (e.g., library, post office, school, place of worship, park, social services)													
Median block group income (10K)	–	–	−.58 (−1.14, .02)	**.042**	−.06 (−.10, −.01)	**.015**	−.13 (−.43, .18)	.414	−.12 (−.19, −.05)	**.001**	−.49 (−1.02, .04)	.067	3
% Non-white	–	–	−.35 (−3.92, 3.22)	.846	.91 (.36–1.46)	**.001**	−2.28 (−4.72, .15)	.066	.03 (−.43, .49)	.900	1.07(−2.04, 4.19)	.496	1
Income*race	−.31 (−.53, −.09)	.005	–	–	–	–	–	–	–	–	–	–	
Negative destinations: warehouse, industrial, abandoned building, unmaintained lot, casino, medium to large parking lot or parking garage													
Median block group income (10K)	–	–	−.041 (−.21, .13)	.628	−.05 (−.09, −.01)	**.01**	−.09 (−.18, .01)	.064	−.01 (−.07, .04)	.690	−.02 (−.14, .11)	.774	1
% Non-white	–	–	.027 (−1.01, 1.07)	.959	.35 (−.13, .82)	.155	−.03 (−.76, .70)	.931	.01 (−.34, .36)	.948	.77 (.03, 1.5)	**.04**	1
Income*race	−.18 (−.34, −.01)	.037	–	–	–	–	–	–	–	–	–	–	
Sidewalks													
Sidewalk presence and width: sidewalk greater than 5 feet=wide													
Median block group income (10K)	–	–	−.02 (−.09, .05)	.557	.06 (.02, .10)	**.004**	−.003 (−.05, .05)	.894	−.10 (−.14, −.03)	**.002**	−.08 (−.12, −.03)	**.001**	1, 2
% Non-white	–	–	.22 (−.20, .64)	.304	.70 (.23, 1.20)	**.004**	−.07 (−.50, .34)	.747	.12 (−.23, .44)	.529	−.03 (−.29, .22)	.798	1
Income*race	.18 (.01, .34)	.034	–	–	–	–	–	–	–	–	–	–	
Negative sidewalk features: sidewalk not continuous, poorly maintained, presence of trip hazard													
Median block group income (10K)	–	–	−.01 (−.17, .15)	.895	−.14 (−.23, −.05)	**.003**	.05 (−.05, .15)	.300	.12 (−.01, .25)	.063	.005 (−.11, .12)	.932	1
% Non-white	–	–	−.44 (−1.40, .52)	.367	−.94 (−2.01, .14)	.087	.33 (−.47, 1.14)	.413	−.83 (−1.65, −.02)	**.045**	−.38 (−1.03, .27)	.245	1
Income*race	−.50 (−.94, −.07)	.023	–	–	–	–	–	–	–	–	–	–	

Buffer for pedestrian safety: trees, landscaping or other barrier separating sidewalk from traffic													
Median block group income (10K)	−.07 (−.13, −.01)	**.032**	−.04 (−.16, .08)	.492	–	–	.001 (−.053, .06)	.965	.01 (−.05, .07)	.806	.03 (−.05, .11)	.477	1
% Non-white	.40 (−.10, .91)	.119	−.27 (−.97, .43)	.441	–	–	.38 (−.06, .82)	.087	.23 (−.16, .62)	.241	.06 (−.42, .53)	.814	
Income*race	–	–	–	–	−.41 (−.69, −.14)	.004	–	–	–	–	–	–	
Crossings													
Crosswalk amenities: crossing aids, marked crosswalk, high visibility striping, stop lines, raised crosswalk, different material than road, protected refuge islands, curb extensions													
Median block group income (10K)	.07 (.03, .12)	**.002**	.03 (−.07, .13)	.554	−.05 (−.09, −.01)	**.019**	−.05 (−.13, .02)	.178	.02 (−.03, .06)	.469	.05 (−.05, .16)	.310	1, 1
% Non-white	.84 (.46, 1.21)	< **.001**	.28 (−.29, .84)	.333	−.09 (−.54, −.36)	.700	−.60 (−1.17, −.02)	**.043**	.41 (.12, .70)	**.007**	.64 (.04, 1.23)	**.036**	1, 3
Income*race	–	–	–	–	–	–	–	–	–	–	–	–	
Curb presence and quality: ramp is present and lines up with crosswalk (pre-crossing and post-crossing)													
Median block group income (10K)	.02 (−.04, .09)	.479	−.01 (−.12, .10)	.890	–	–	−.02 (−.08, .04)	.481	.01 (−.05, .07)	.766	−.05 (−.12, .01)	.088	
% Non-white	1.14 (.60, 1.67)	< **.001**	.38 (−.298, 1.04)	.265	–	–	−.36 (−.84, .12)	.140	.23 (−.17, .64)	.254	.19 (−.18, .56)	.318	1
Income*race	–	–	–	–	.36 (.04, .69)	.029	–	–	–	–	–	–	
Intersection control and signage: stop signs, traffic signal, green arrows for turn lane, pedestrian walk signals, push buttons, countdown signal, audible walk signal													
Median block group income (10K)	–	–	.03 (−.17, .23)	.739	−.06 (−.08, −.03)	< **.001**	−.10 (−.17, −.02)	**.012**	−.0002 (−.03, .03)	.992	.02 (−.08, .13)	.636	2
% Non-white	–	–	.69 (−50, 1.88)	.252	−.35 (−.69, −.02)	**.038**	−.35 (−.93, .23)	.232	.36 (.14, .58)	**.002**	.67 (.07, 1.28)	**.030**	1, 2
Income*race	−.24 (−.44, −.04)	.021	–	–	–	–	–	–	–	–	–	–	
Other walking barriers: no public transit stops, speed limit greater than 25 mph, roll-over curbs, no street lights, six or more driveways													
Median block group income (10K)	–	–	.01 (−.10, .11)	.868	–	–	−.004 (−.06, .05)	.903	.08 (.03, .14)	**.004**	.12 (.03, .22)	**.014**	2
% Non-white	–	–	−.22 (−.87, .42)	.489	–	–	−.27 (−.73, .20)	.254	−.58 (−.94, −.23)	**.001**	−.20 (−.75, .35)	.478	1
Income*race	.17 (.02, .31)	.023	–	–	.40 (.14, .66)	.002	–	–	–	–	–	–	
Grand score: Sum of all positive measures (presence of sidewalks, trees, crossing features, etc.) less all negative measures (trip hazards, no public transit stops, no street lights)													
Median block group income (10K)	−.01 (−.12, .10)	.864	−.16 (−.40, .09)	.214	.07 (−.01,.16)	.094	.02 (−.13,.17)	.77	−.07 (−.19,.05)	.248	−.08 (−.28,.11)	.390	
% Non-white	.99 (.07, 1.92)	**.035**	−.69 (−2.19, .81)	.364	.71 (−.29, 1.71)	.162	−1.11 (−2.30, .07)	.065	.72 (−.05, 1.09)	.068	.55 (−.58, 1.7)	.344	1
Income*race	–	–	–	–	–	–	–	–	–	–	–	–	

Note: **Bold and underlined** findings indicate a disparity, i.e., the MAPS pedestrian feature is less favorable in neighborhoods with lower median block group income and/or high percent non-White. **Bold without underlining** indicates an "equitable difference", i.e., the MAPS pedestrian feature is less favorable in neighborhoods with high median block group income and/or high percent White. Median block group income and percent non-White is based on 2000 Census year data.

Table 3
Summary of significant main effects indicating disparities and "equitable differences", based on income or race/ethnicity, in microscale pedestrian environment features in San Diego, Seattle and Baltimore's residential and mixed-use neighborhoods.

	San Diego (n=365)		Seattle (n=1187)		Baltimore (n=470)		Totals (N=2022)		
	Disparities	Equitable differences	Disparities	Equitable differences	Disparities	Equitable differences	Disparities	Equitable differences	Grand Total
Residential-only									
Income	1	1	5	3	2	4	8	8	16
Racial/ Ethnic	1	3	1	2	1	4	3	9	12
Mixed use (1 or more retail destination)									
Income	1	1	1	1	2	2	4	4	8
Racial/ Ethnic	1	0	2	0	1	2	4	2	6
Total	4	5	9	6	6	12	19	23	42

Note: This table summarizes the significant findings of main effects presented in Table 2. A "disparity" refers to a finding that a MAPS outcome is less favorable in neighborhoods with lower median block group income and/or high percent non-White. An "equitable difference" occurs when the MAPS outcome is less favorable in neighborhoods with high median block group income and/or high percent White. Median block group income and percent non-White is based on 2000 Census year data.

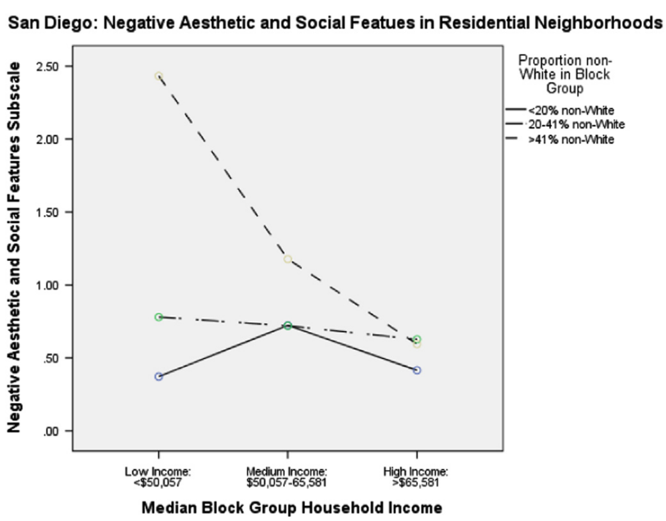

Fig. 1. In San Diego, low-income residential neighborhoods with a large proportion of racial/ethnic minorities had a larger number of negative esthetic and social features. In contrast, San Diego's low-income neighborhoods with mostly White residents had few negative esthetic/social features.

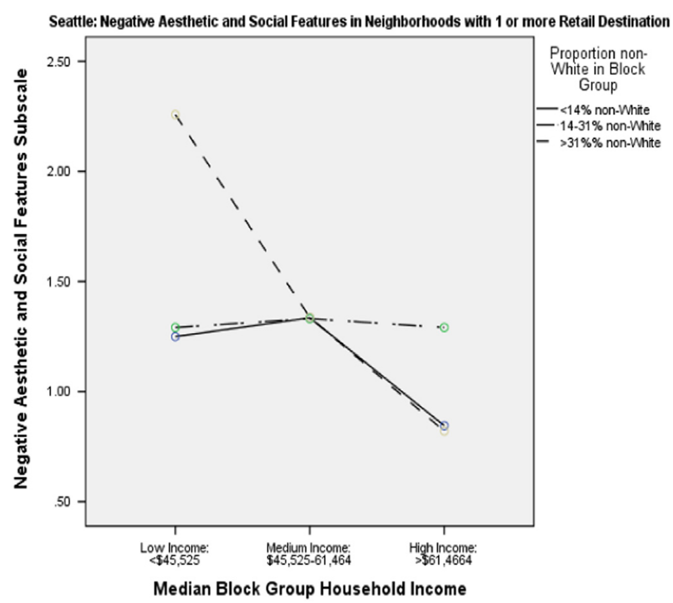

Fig. 2. In Seattle, low-income, high racial/ethnic minority mixed use neighborhoods had significantly more negative esthetic/social features.

buffers (i.e., landscaping or other barrier separating pedestrians from traffic) than high-income residential neighborhoods (Fig. 5). Interaction effects were also observed in the San Diego region, where high-income neighborhoods with a large proportion of White residents had fewer and poorer quality sidewalks (e.g., not continuous, poorly maintained, major trip hazards) than lower-income neighborhoods. San Diego's high-income neighborhoods with a large proportion of racial/ethnic minorities had the most sidewalks (Figs. 6 and 7).

3.4. Street crossings

Features relating to street crossings, including crosswalk amenities, curb quality, and intersection control, tended to be better in low-income and high racial/ethnic minority neighborhoods, demonstrating equitable differences. However, results varied between regions and neighborhood types (residential versus mixed use).

In the Baltimore region, neighborhoods with a large proportion of racial/ethnic minorities (both residential and mixed-use) had better crosswalk amenities (e.g., crossing aids and marked crosswalks) and intersection control features (e.g., stop signs, pedestrian walk signals, countdown signals) than neighborhoods with a large proportion of White residents (Table 2). Equitable differences were also observed in the San Diego region, where residential neighborhoods with a large proportion of racial/ethnic minorities had better crosswalk amenities and curb quality than neighborhoods with a large proportion of White residents. In contrast, in the Seattle region, neighborhoods with a large proportion of racial/ethnic minorities had worse crosswalk amenities (mixed use neighborhoods) and worse intersection control features (residential neighborhoods). Seattle's low income neighborhoods, however, had better crosswalk amenities (residential) and intersection control (residential and mixed use) than higher income neighborhoods (Table 2).

Interaction effects showed that San Diego' low-income residential neighborhoods with a large proportion of racial/ethnic minorities had the most favorable intersection control and signage (Fig. 8). In Seattle, curb quality was good in low-income, but not

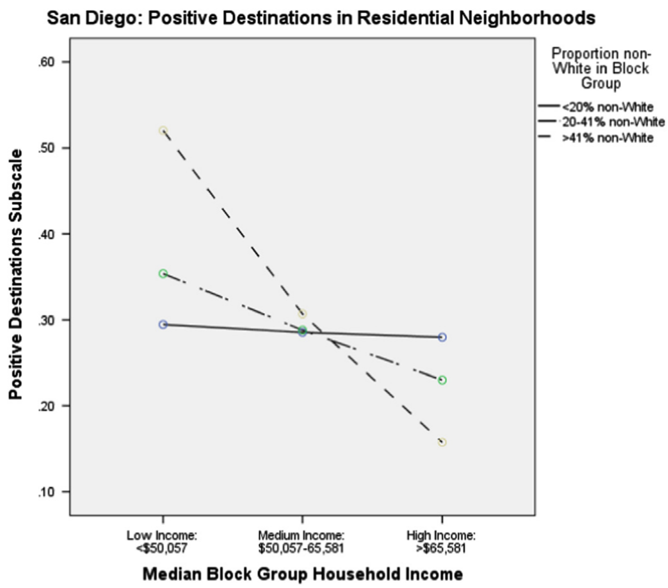

Fig. 3. In San Diego, low-income residential neighborhoods with a high proportion of racial/ethnic minorities had more positive destinations, such as libraries, schools, and places of worship, than high-income residential neighborhoods.

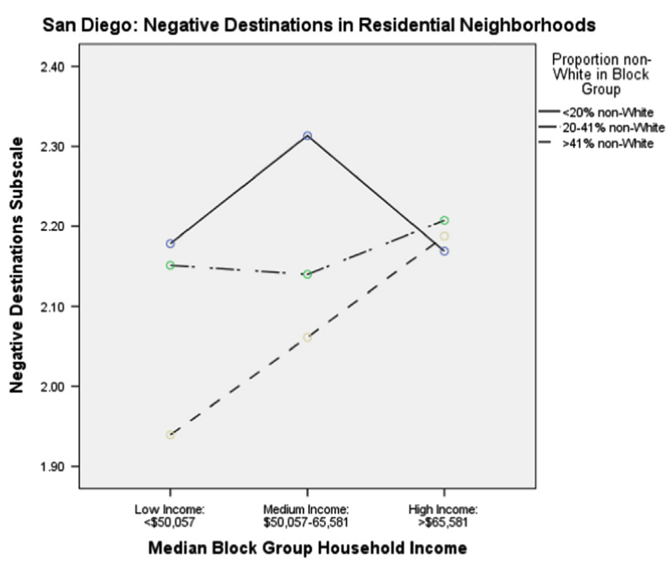

Fig. 4. In San Diego, low-income residential neighborhoods with a high proportion of racial/ethnic minorities had fewer negative destinations, like warehouses, abandoned buildings, and unmaintained lots.

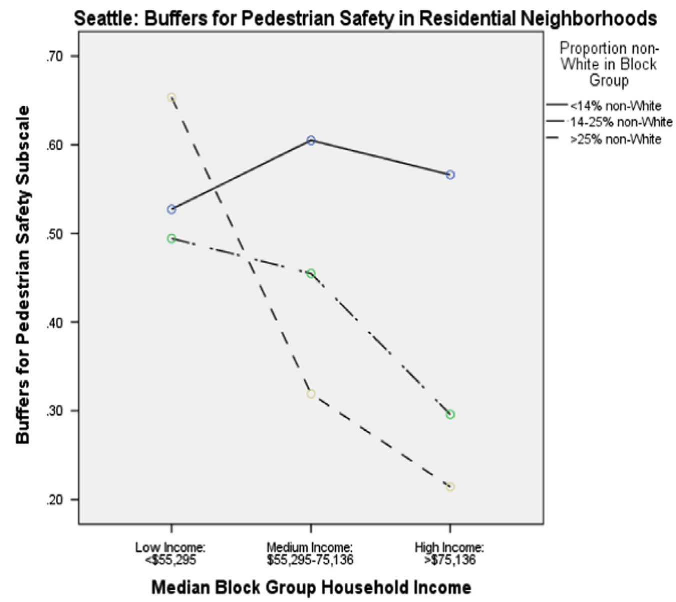

Fig. 5. Seattle's high-income residential neighborhoods with a high proportion of racial ethnic minorities had fewer pedestrian buffers (i.e., landscaping or other barrier separating the sidewalk from traffic) than low-income residential neighborhoods. For mostly White neighborhoods, buffers were good in both low and high-income neighborhoods.

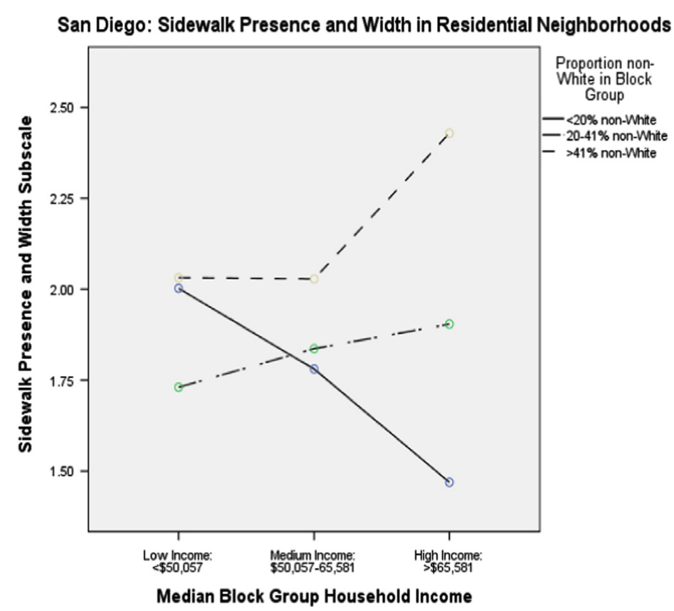

Fig. 6. In San Diego, high-income residential neighborhoods with a large proportion of White residents had the fewest sidewalks. In contrast, high-income neighborhoods with a large proportion of racial/ethnic minorities had the most sidewalks.

high-income, White residential neighborhoods. The highest scores for curb quality in the Seattle region were observed in high-income, high-minority residential neighborhoods (Fig. 9).

3.5. Other walking barriers

Walking barriers such as inadequate street lighting, roll over curbs, absence of public transit stops, or speed limits greater than 25 miles per hour tended to be less prevalent in low-income and high racial/ethnic minority neighborhoods. In the Baltimore region, main effects showed that low-income neighborhoods (residential and mixed use) and neighborhoods with a high proportion of racial ethnic minorities (residential) had fewer walking barriers (Table 2). Income by race interactions were found in residential neighborhoods in the San Diego and Seattle regions; in both regions low-income, high racial/ethnic minority neighborhoods had the fewest number of walking barriers (Figs. 10 and 11).

3.6. Grand score

In the San Diego region, the overall microscale environment was significantly better in residential neighborhoods with a higher proportion of racial/ethnic minorities as compared to neighborhoods with more White residents ($p < .035$). Though not statistically significant, a similar trend was observed in Baltimore's residential neighborhoods, where high racial/ethnic minority

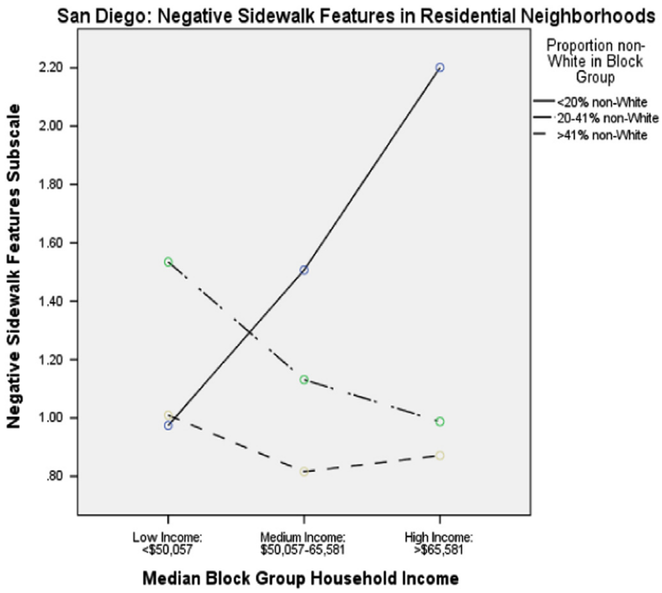

Fig. 7. In San Diego, high-income neighborhoods with a large proportion of White residents had the most negative sidewalk features (i.e., not continuous, poorly maintained, major trip hazards).

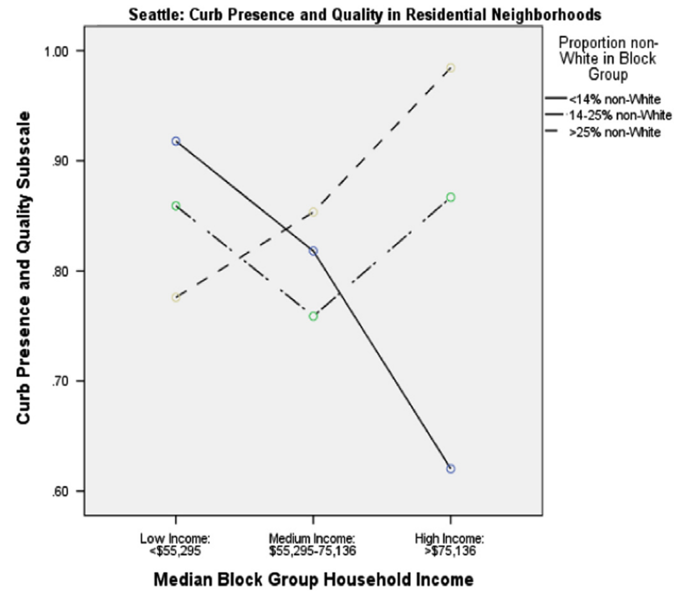

Fig. 9. In Seattle, curb quality was good in low-income, mostly White neighborhoods, but poor quality in high-income, mostly White neighborhoods (Fig. 9). High-income neighborhoods with a high proportion of racial/ethnic minorities had the best curb quality.

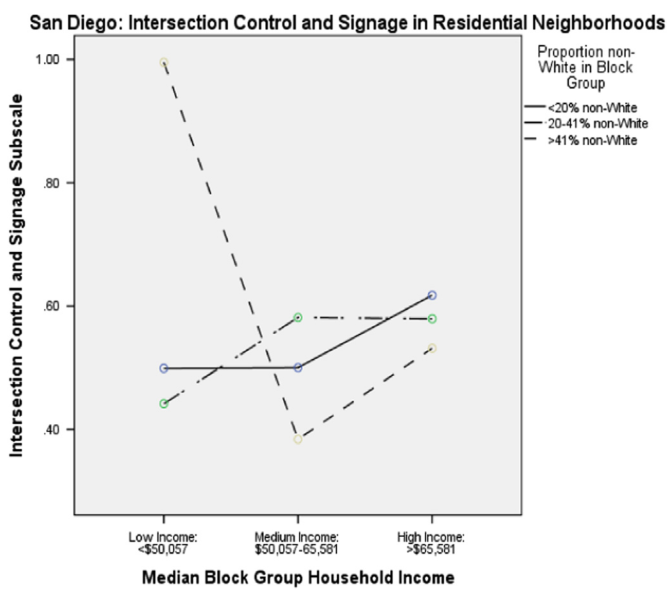

Fig. 8. Intersection control features in San Diego were best in low-income neighborhoods with a high proportion of racial/ethnic minorities.

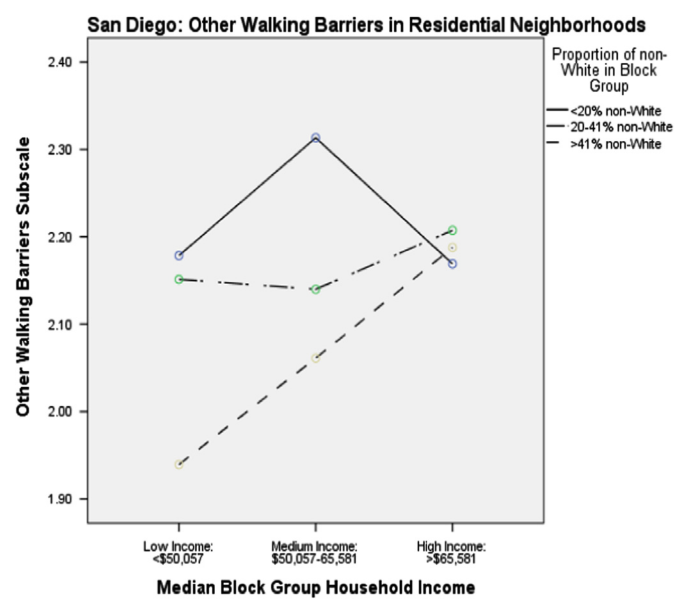

Fig. 10. In San Diego, low-income, high racial/ethnic minority residential neighborhoods had the fewest number of walking barriers. As neighborhood income increased in San Diego's racial/ethnic minority neighborhoods, so did walking barriers.

neighborhoods had better overall microscale environments ($p < .068$). An opposite trend occurred in mixed-use neighborhoods in Seattle, where microscale environments tended to be worse in neighborhoods with a large proportion of racial/ethnic minorities ($p < .065$). There were no significant neighborhood income effects in any region for the grand score of the microscale environment.

4. Discussion

This study provides evidence that unfavorable microscale pedestrian features occur in neighborhoods of all income levels and racial/ethnic compositions, but the type of adverse features and locations (residential versus mixed-use neighborhoods) varies greatly between cities. Previous studies of microscale environments have been limited to a single city (Neckerman et al., 2009; Yu, 2014; Zhu & Lee, 2008), or have combined data from multiple cities across the US (Gibbs et al., 2012). Our current approach, which included a comprehensive assessment of microscale pedestrian features, allowed us to examine the generalizability of findings regarding disparities in microscale features. Our results show that relationships between neighborhood income and race/ethnicity, and microscale features, vary widely across different regions in the US. Local streetscape audits are necessary for policy makers to determine how to best allocate resources to address

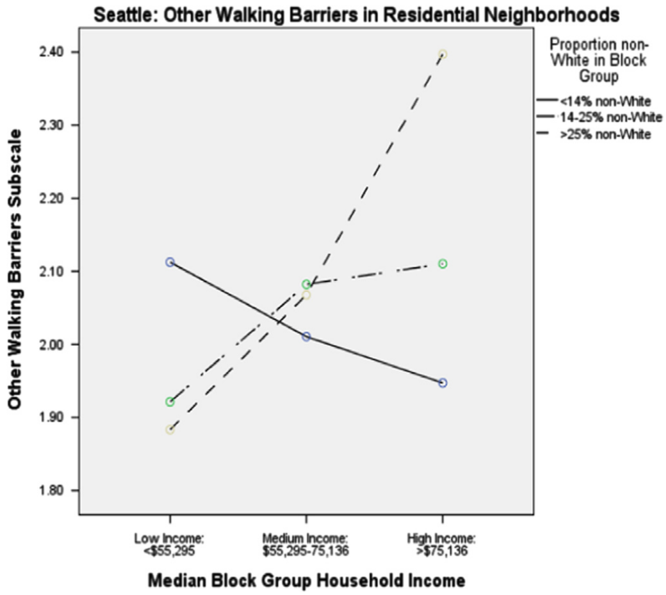

Fig. 11. In Seattle, low-income, high racial/ethnic minority residential neighborhoods had the fewest number of walking barriers.

disparities in local environments. Local audits can provide policy makers and urban designers with important information regarding how to build walkable environments and encourage higher levels of physical activity across all SES levels.

Despite the region-specific findings, a few generalizable results emerged. Across all three regions, esthetic/social features were consistently worse in low-income and high racial/ethnic minority neighborhoods as compared to high-income or mostly White neighborhoods. In San Diego and Seattle regions, neighborhoods with a high proportion of racial/ethnic minorities had fewer positive esthetic features such as art, fountains, sculptures, and landscaping. Low-income neighborhoods in all three regions had more negative esthetics and social elements (e.g., graffiti, broken windows, litter, drug paraphernalia, poorly maintained buildings) as compared to higher income neighborhoods. Seattle and Baltimore regions also had fewer trees in low-income neighborhoods. These findings are consistent with previous studies showing that disadvantaged neighborhoods have fewer trees (Landry & Chakraborty, 2009), landmarked buildings, and decorative architecture; and more noise, litter, and signs of disrepair (Neckerman et al., 2009). Indicators of social and physical disorder like graffiti have been linked to residents' evaluation of higher crime risk and fear of crime (LaGrange, Ferraro, & Supancic, 1992), and residents who feel unsafe may walk less in their neighborhoods (Mason, Kearns, & Livingston, 2013). Additional research is needed to examine relationships between microscale pedestrian environments, fear of crime, objective crime rates, and physical activity in neighborhoods with different income and racial/ethnic composition. We would expect interventions aimed at improving neighborhood esthetics and social elements to increase physical activity, and such interventions should be evaluated. Given concerns that neighborhood improvements would invite gentrification and displacement of current residents (Smith & Williams, 2013), we recommend a process that involves city planners, community groups, and health agencies in developing community revitalization efforts designed to benefit current residents.

Though some microscale pedestrian features, such as esthetics, were consistently better in high-income/White neighborhoods, a pattern emerged showing that certain microscale pedestrian features were better in low-income or high-minority residential neighborhoods. In residential neighborhoods across all three regions, microscale pedestrian features relating to crosswalks, intersections, and sidewalks were better in low-income and high racial/ethnic minority residential neighborhoods as compared to high-income and/or mostly White residential neighborhoods. Low-income or high-minority residential neighborhoods had fewer walking obstacles, such as inadequate street lighting, roll over curbs, or absence of public transit stops. Most of these "equitable differences" were found in residential-only neighborhoods and were not as evident along routes that included a mix of residential and non-residential uses. These results support previous findings that disadvantaged groups fared better with respect to microscale pedestrian features such as public transportation stops, unobstructed sidewalks (Neckerman et al., 2009), and sidewalk completeness (Zhu & Lee, 2008). These findings may indicate that local governments are taking steps to enhance the microscale pedestrian features that are important to the safety of pedestrians. An alternate explanation is that lower-income and higher-minority neighborhoods tend to be in older parts of cities that were built to be more pedestrian-oriented. Present analyses controlled for macroscale walkability factors (e.g., residential density and intersection density) to address concerns that lower-income neighborhoods simply had higher residential density and thus better provisions for pedestrians. It would be worthwhile to examine alternate explanations for the "equitable differences" so effective policy solutions that contributed to these enhancements could be adopted widely. Whatever the reasons, "equitable differences" in pedestrian environments may help reduce disparities in physical activity-related health problems such as chronic diseases.

Present findings based on direct observation of pedestrian environments by trained raters differed from environmental disparities reported based on resident self-report. In a study of adults in two of the same regions as the present study (Baltimore and Seattle regions), adult participants from lower income neighborhoods consistently reported having poorer microscale pedestrian features, including sidewalk presence and quality, crosswalk amenities, and esthetics, than higher income residents (Sallis et al., 2011). Only disparities in esthetics were replicated with both self-reported and observational measures of environments, showing discrepant results. Studies of the relation of perceived to objective environmental measures generally show moderate but somewhat inconsistent agreement (e.g., Adams et al., 2009). Though differences in indicators of esthetics may account for apparently discrepant findings in the present study, it would be useful to improve understanding of the relation between perceived and objective measures.

Study strengths included the examination of income and race/ethnicity-related disparities in microscale environments in three distinct regions of the US. Other strengths were the use of a validated direct observation measure of pedestrian microscale environment, testing of income by race/ethnicity interactions, and separating residential and mixed-use neighborhoods. A limitation of the current study was the inability to audit each participant's entire neighborhood or to systematically sample the routes audited to ensure representative coverage. Due to practical limitations, researchers only audited a 1/4-mile route starting at each participant's house, which likely did not capture all streetscape variations within each neighborhood. However, concern about sample representativeness was addressed by including a large sample of routes in each region and selecting neighborhoods with varying levels of income and macroscale walkability. The present study was conducted in three regions of the US, which is a small sample of metropolitan areas. Given the distinct patterns of findings in each region, it is important to examine streetscape disparities in many more regions that represent large cities to small towns. An important limitation was the exclusion of rural areas, which have very different built environment characteristics. Direct observation and self-report built environment measures have been developed for rural areas (Yousefian et al., 2010; Yousefian, Hansen, & Hartley, 2015), and these should be used to study environmental disparities among rural communities in multiple regions of the US. Future research might also examine how disparities in streetscape environments help explain demographic differences in physical activity across domains, especially leisure and transport.

In conclusion, the present study shows a greater level of complexity and variability in disparities in streetscape environments than previously documented. The variability between cities brings into question the ability to generalize findings of single-city studies. Disparities in microscale pedTheestrian features that disfavored low-income or high racial/ethnic minority neighborhoods were observed in each region, but the unfavorable features differed by region and by residential/retail character of neighborhoods. A large number of "equitable differences" were found that would be expected to improve the safety of walking. Because microscale environment disparities varied by region, it may be necessary for each community to conduct audits of microscale strengths and weaknesses. Using information from streetscape audits, local policy makers, urban planners, and community groups can identify disparities and make targeted changes to improve the pedestrian environment and increase physical activity opportunities for all residents, regardless of race, ethnicity, or income.

Acknowledgments

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