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Environmental Audits of Friendliness toward Physical Activity in Three Income Levels

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ABSTRACT *An important research area is the relationship among income status, health, and the environment. This study examined the relationships among income levels, features of the environment and friendliness toward physical activity. We investigated whether low-, middle-, and high-income neighborhoods differ in terms of four environmental characteristics that affect the degree to which an area is conducive to physical activity: population density, land use diversity, street design, and physical disorder in the environment. In a large, urban southwestern county, 30 block groups were randomly selected to represent low-, middle-, and high-income neighborhoods. Using the St. Louis Environmental Checklist Audit, walking audits were conducted and analyzed. The low-income neighborhoods had significantly greater density and land use diversity than the high-income neighborhoods. High- and middle-income neighborhoods had significantly fewer manifestations of physical disorder and incivility than low-income neighborhoods. Features of physical activity-promoting environments were found in each income level neighborhood.*

KEYWORDS *Physical activity, Environmental characteristics, Income levels, Deprivation amplification, Underserved populations*

INTRODUCTION

An extensive body of literature indicates that people of lower income are less likely to engage in leisure time or regular physical activity than people of higher income.[1–5] One reason for this finding may be that people of lower income live in neighborhoods that are not conducive to initiating and maintaining a physically active lifestyle.[6,7] This hypothesis, which has been referred to as "deprivation amplification," states that in places where people have fewer personal resources, the

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local facilities that enable people to lead healthy lives are poorer than they are in nonimpoverished and nonsocially deprived areas.[8] That is, neighborhoods of low socioeconomic status provide fewer resources for physical activity such as parks, sports facilities, and walking/biking trails than do neighborhoods of medium and high socioeconomic status.[9–12] Although a study found no differences in the distribution of parks among income areas, low-income areas were 4.5 times more likely to have no physical activity facilities than high-income areas.[13]

Primarily, the available literature is based on analyses of databases that include the locations of parks, trails, and recreation facilities rather than community field audits that assess street-scale characteristics (also referred to as "fine grain" features) of the environment. These features include the quality of sidewalks; traffic volume and speed; the extent of litter, garbage, and graffiti; and the frequency of traffic-calming devices (e.g., stop signs, speed bumps, and terminating vistas).[14] Two studies[15,16] that involved community field audits reported dissimilar results related to poverty and environmental characteristics associated with physical activity. The findings reported in the current literature are inconsistent and limited to a small set of variables (e.g., parks and physical activity facilities), and few of them are the product of community field audits. Thus, the empirical knowledge is limited.

In our review of the literature, we found no published studies that involved walking, street-scale environmental audits in which low-, middle-, and high-income neighborhoods were randomly selected to assess environmental characteristics related to physical activity. To fill this obvious gap in the literature, we conducted walking, street-scale environmental audits of selected neighborhoods to assess differences by income level (low, middle, and high) among four environmental, neighborhood factors most associated with physical activity:[17–28] population density (defined as the number of people per square mile, apportioned to the size of the block), land use diversity (defined as the mix of commercial destinations and residential land uses in an area), street design (defined as the extent to which neighborhoods are pedestrian- and bicycle-friendly, e.g., by having sidewalks, bicycle lanes, traffic calming features, etc.), and physical disorder/incivilities (defined as the extent to which litter, graffiti, stray dogs, and other unpleasant attributes are present in the environment). The best environment for promoting physical activity has population density, land use diversity and street design conducive to activity and low levels of physical disorder/incivilities.[17–28] From the relevant literature cited above, we formulated four hypotheses:

1) Population density and income are negatively related.
2) Land use diversity and income are negatively related.
3) Street design and income are positively related.
4) Physical disorder/incivilities and income are negatively related.

Environmental friendliness toward physical activity is determined by the extent to which the physical environment provides cues and opportunities for physical activity and by the presence or absence of environmental attributes associated with rates of physical activity.[14] For several reasons, it is important to know whether there are consistent differences among income levels, features of the environment and physical activity friendliness. First, people of lower incomes have lower levels of physical activity,[1–5] which may be explained by the environments in which people live (i.e., deprivation amplification). Second, effective interventions to increase physical activity should account for environmental factors and influences. Third, conceptu-

ally, these data can provide insights about the relative advantages and disadvantages of income levels, environments, and physical activity. We intentionally selected walking environmental audits to capture street-scale characteristics and features visible by personal observations instead of street view and other GIS approaches which pose challenges related to time stamp. Street-scale characteristics are litter, graffiti on buildings, cracked sidewalks, broken glass in the street, drug-related paraphernalia in gutters, stray dogs, incomplete playground equipment, diesel fumes, noise pollution, aggressive drivers, and people acting hostile. Furthermore, we chose the most consistently identified environmental features related to physical activity.[17–28]

MATERIALS AND METHODS

Description of County

Harris County is the third largest county in the US and includes the city of Houston, the fourth largest city in the US. In 2000, Harris County included 1,205,516 households and had a land area of 1,728mi^2. The home ownership rate was 55.3%, and the median value of owner-occupied housing units was $87,000. Of the Harris County residents who were 25 years of age or older, 74.6% were high school graduates, and 26.9% had at least a 4-year college degree.[29] In 2004, the median household income in Harris County was $41,922, and 16.8% of the population was below the poverty level. These data make Harris County similar to Texas as a whole in an economic sense; in 2004, the median household income for Texas was $41,645, and 16.2% of the population was below the poverty level.[29] The population of Harris County reflects gender, racial/ethnic and income diversity. In 2006, Harris County's population of 3,886,207 people was 49.9% male and 50.1% female. The racial/ethnic composition of the county was 38.2% Hispanics or Latinos, 36.9% non-Hispanic Whites, 19.0% Blacks and 5.4% Asians.[29]

Sampling Procedure for Block Groups

We selected the census block group as our unit for auditing. A block group is a subunit of a census tract, and it usually contains between 600 and 3,000 people. Its boundary is usually delineated and submitted by a local government agency to the U.S. Census Bureau (http://www.census.gov/geo/www/cob/bg_metadata.html). In a fashion similar to the methods used by Moore et al.,[13] all block groups in the county were stratified into low, middle, and high income levels according to tertiles of median household income. We chose 30 block groups because that sample size would be large enough to apply the large sample theory for statistical analysis but small enough to accommodate staff size for field audits. Thirty block groups were selected from a total of 1,813 block groups in Harris County. A half mile distance would, on average, cover a block group area. A person's active space is most intense within a half mile of his or her residence.[30] The population of individual block groups ranged from 500 to 4,987 and averaged 1,775. Ten nonadjacent (i.e., separated by $\geq$0.5 mi or $\geq$800 m) and nonboundary (not situated on the Harris County boundary) block groups from each income stratum were randomly selected, so that the study included a total of 30 block groups. A half-mile radius was drawn from the centroid of each block. The principal investigator (WCT) randomly assigned the 30 block groups (10 in each income category) to the auditors, who were blind to the income classifications of the block groups.

Maps had a designated area indicated by a circle. Because all auditors were from the local area, such a reference map was sufficient for them to conduct field auditing. Auditors identified a central intersection by walking the neighborhood, guided by the centroid of the circle. Then, the auditors identified two 2/5-mi (640-m) areas (north to south and east to west) within the boundaries of the designated section shown on the map. Two such areas were audited for each block group. Even though a designated area sometimes extended to the next block group, it usually represented a continuation of the same block group characteristics. Table 1 presents the mean population and income levels of the 30 selected block groups and of the total sample. To assess population density, we used data from the 2000 United Status census.

Description of Environmental Audit

The St. Louis Environmental Checklist Audit was selected for use in this study because it is comprehensive, reliable, and valid and because it has a training module.[31] Three of the domains of the audit were used in this study. *Land-use diversity* was assessed by having auditors answer two questions from the St. Louis Checklist Audit: "Are residential and non-residential land uses visible in this segment?" which auditors answered yes or no, and "What types of commercial destinations are visible in this segment?" which auditors answered by selecting visible or not visible for each of 21 specific types of destinations. Two questions from the St. Louis Checklist Audit were used to assess *street design* features: "Are the following features present in this segment? (yes or no)," which was followed by a list of five features (e.g., sidewalks, bicycle lanes, street shoulders, bus stops, and paths or trails), and "Please indicate your agreement (yes or no) with the following statements about street characteristics for this segment," which was followed by seven statements related to street characteristics (e.g., street type connectivity, design characteristics, traffic calming devices, aggressive drivers, crossing aids, and street lighting). Finally, *physical disorder/incivilities* were assessed with the question, "Is physical disorder visible in this segment?" This question was followed by a list of eight types of physical disorder (e.g., abandoned cars, graffiti, broken windows, cans, cigarette butts, and liquor bottles), and auditors answered yes or no for each.

Training and Background of Auditors

All auditors were trained according to a comprehensive protocol that included operational definitions and practice sessions.[14] To be certified for the research project, each auditor had to conduct a solo audit with reliable and accurate results. Each auditor completed two or more practice audits with the master trainer (WCT) until 97% to 100% agreement was achieved with the master trainer (WCT). The

TABLE 1 Selected block groups and total block groups in Harris County: mean population and income

Category	30 selected block groups	1,813 total block groups	Low-income block groups	Middle-income block groups	High-income block groups
Mean population per block group	1,830	1,775	1,909	2,069	1,935
Median household income per block group	$43,643	$42,598	$23,064	$36,966	$62,550

auditors were professors, postdoctoral fellows, and graduate students. The data collection was completed by pairs of auditors for safety reasons.

Environmental Audit Protocol

The audits were conducted from March 2005 to October 2006. Each auditor received maps with the block groups highlighted. Auditors were blinded with respect to the income classification of the neighborhoods they audited. Each auditor drove to the designated area, located the center point and identified two 2/5-mi (640-m) walking street areas (i.e., one area north to south and one area east to west) within the designated study area. A separate audit was conducted for each area. Two areas were audited, and the total distance was 4/5 mi. The auditors walked the selected street areas during daylight hours (from 8:00 AM to 5:00 PM) at various times of the day and on various days of the week. Fifty percent of the audits were conducted in the morning, and 50% were conducted in the afternoon. The social environment questions in the audit (e.g., questions about the presence of people and their activities) are the most sensitive to time of day;[14] therefore, we did not analyze the responses to these questions.

Analysis Plan

For each block group, the audit data from one auditor (randomly selected) were used for the analysis to avoid the issue of resolving any potential discrepancies between two auditors. Mean proportions were computed in each income group and compared across groups by using analysis of variance. Post hoc Bonferroni corrections were used for pairwise multiple comparisons among means. For example, Bonferroni corrections were used when low-income neighborhoods were compared with middle-income neighborhoods and with high-income neighborhoods. For the Bonferroni correction, the alpha level was set at 0.01 to account for the multiple comparisons.

RESULTS

Environmental Characteristics

As seen in Table 1, the mean population and median income were comparable between the selected sample and the population sample. Differences in the environmental characteristics across the three income groups are reported in Table 2. The findings by population density, land-use diversity, street design, and physical disorder/incivilities are reported in the following subsections. Across the three income classifications, there were no systematic differences in time of day and weekend versus weekday for the observations.

Reliability Strict reliability testing was conducted during the audit training. For 19 areas that were audited by two auditors for reliability, the Kappa value for the land use diversity items (the most questions in the audit) was 0.68, indicating substantial agreement.[32] Reliability testing was not conducted after the audit training.

Hypothesis One—Population Density There were significant differences among the three income levels in the population densities of their neighborhoods ($p=0.02$). Specifically, the low-income neighborhoods had the highest density (8,076±5,954), whereas the high-income neighborhoods had the lowest density (4,462±1,973)

TABLE 2 Differences in environmental characteristics of low-income, middle-income, and high-income neighborhoods

	Low income	Middle income	High income	*P*-value
Mean density[b] (persons/km^2)	8,076	5,677	4,462	0.02
Diversity (%)				
Land use[a,b]	89	45	30	<0.01
Gas stations[a,b]	32	10	5	0.05
Fast food restaurants	25	5	5	0.08
Other restaurants[a,b]	35	0	5	<0.01
Convenience stores[a,b]	45	5	0	<0.01
Supermarkets	5	0	5	0.61
Banks	0	0	10	0.13
Drug stores	0	5	5	0.61
Coffee shops	0	0	5	0.37
Laundromats	15	0	10	0.23
Movie halls/theaters	10	5	0	0.36
Hotels	0	5	0	0.37
Strip malls[a,b]	30	0	5	0.01
Industrial buildings[a,b]	20	0	0	0.01
Office buildings	20	10	10	0.57
Bars or liquor stores	10	5	5	0.77
Auto shops[a,b]	45	0	5	<0.01
Other retail stores[a,b]	35	5	5	0.01
Other services[a,b]	45	15	5	<0.01
Design (%)				
Sidewalks	55	80	65	0.25
Bike lanes	10	0	0	0.14
Street shoulders[b,c]	0	0	20	0.01
Bus stops[b]	30	10	0	0.01
Paths or trails[b,c]	0	0	15	0.04
Street type	90	85	75	0.45
Connectivity	95	95	95	1.00
Street design	15	40	15	0.10
Traffic calming devices	40	60	55	0.43
Aggressive drivers	20	0	15	0.13
Crossing aids	35	45	55	0.46
Street lighting	95	90	95	0.77
Disorder (%)				
Physical disorder[b,c]	90	85	50	0.01
Bottles or cans[b]	80	40	10	<0.01
Cigarettes	50	35	25	0.27
Garbage[b]	90	85	55	0.02
Abandoned cars[a,b]	53	10	0	<0.01
Graffiti	25	20	0	0.06
Broken windows[a,b]	45	15	0	<0.01

All *P* values were derived from ANOVAs
Income levels: (1) low; (2) middle; (3) high
[a]1 versus 2 posthoc test
[b]1 versus 3 posthoc test
[c]2 versus 3 posthoc test

($p=0.01$). The density of the middle-income neighborhoods (5,677±2,612) was not significantly different from the densities of the low-income ($p=0.17$) and high-income ($p=0.99$) neighborhoods. The findings are consistent with the hypothesis that population density and income are negatively related.

Hypothesis Two—Land-use Diversity Auditors' answers to the question, "Are residential and non-residential land uses visible in this segment?" differed significantly among the three income levels ($p<0.001$). The low-income neighborhoods had the most land-use diversity and the high-income neighborhoods had the least. Compared to the middle- and high-income neighborhoods, respectively, the low-income neighborhoods had more gas stations ($p=0.17$; $p=0.06$), restaurants ($p=0.002$; $p=0.01$), convenience or small grocery stores ($p=0.001$; $p<0.001$), strip malls or shopping centers ($p=0.008$; $p=0.03$), warehouses, factories or industrial buildings ($p=0.03$; $p=0.03$), auto shops ($p<0.0001$; $p=0.001$), other retail stores (e.g., bakeries and video rental stores; $p=0.02$; $p=0.02$), and other services (e.g., dental clinics, notary public, fortune tellers, and massage parlors; $p=0.05$; $p=0.005$). The findings are consistent with the hypothesis that land-use diversity and income are negatively related.

Hypothesis Three—Street Design Among the neighborhoods at the three different income levels, there were significant differences in the number of street shoulders or wide outside lanes ($p=0.01$), bus stops or transit stops ($p=0.01$), and paths or trails ($p=0.04$). Compared to the middle- and low-income neighborhoods, the high-income neighborhoods had more street shoulders or wide outside lanes ($p=0.03$ for both) and more paths or trails ($p=0.08$ for both). Compared to the high-income neighborhoods, the low-income neighborhoods had more bus stops or transit stations ($p=0.01$). For the question about specific street characteristics, among the seven comparisons, there were no significant differences among the low-, middle-, and high-income neighborhoods. The findings do not support the hypothesis that street design and income are positively related.

Hypothesis Four—Physical Disorder/Incivilities Auditors' answers to the question, "Is physical disorder visible in this segment?" differed significantly among the three income levels ($p=0.01$). The high-income neighborhoods had significantly fewer bottles and cans ($p<0.001$), less garbage and litter ($p=0.02$), fewer abandoned cars ($p<0.001$) and fewer broken windows ($p=0.001$) than the low-income neighborhoods. Middle-income neighborhoods had significantly fewer abandoned cars ($p=0.001$) and broken windows ($p=0.03$) than the low-income neighborhoods. The findings support the hypothesis that physical disorder/incivilities and income are negatively related.

DISCUSSION

Three of the four hypotheses (1, 2, and 4) were supported. The third hypothesis was not supported, in that there were no consistent differences and patterns among street design and income levels of the block groups. Although we found differences among the three income levels related to population density, land-use diversity, street design and physical disorder/incivilities in the physical environment, no one income level was associated with an environment that was unequivocally the best in terms of being conducive to physical activity.[17–28] For example, we found that the low-income areas had greater population density and land-use diversity—features positively associated with physical activity—[17–28] than the high-income areas. On the other hand, the high- and middle-income neighborhoods had less physical disorder and fewer incivilities than the low-income areas; less physical disorder and fewer incivilities are associated with greater physical activity.[17–28] Additionally, there

were no consistent differences among the three income levels in terms of the street or physical design of neighborhoods.

Our findings are similar to those of other community field audit studies[15,16] in that both favorable and unfavorable conditions were associated with low-income areas. A study of the areas surrounding 73 public elementary schools found that poverty was associated with many adverse conditions and with two favorable conditions (shorter distances to school and lower traffic volumes).[16] In another study, poverty was not independently associated with sidewalk unevenness and obstruction; however, there was a 21-times-greater likelihood of physical disorder in the block groups with the highest poverty rates versus lowest poverty rates.[15] Brownson et al.[14] found greater physical disorder in low-income areas.

Estabrooks et al.[9] found differences among income levels in terms of free-for-use and pay-for-use facilities. We did not specifically investigate access to free- and pay-for-use facilities. However, we found no differences among income levels in terms of park availability and street design features.

From a neighborhood setting perspective, our findings do not support the original hypothesis of "deprivation amplification," which states that in places where people have fewer personal resources, the local facilities that enable people to lead healthy lives are poorer than they are in non-impoverished and non-socially-deprived areas.[8] In our study, the low-income neighborhoods had significantly greater population density and land-use diversity than the high-income neighborhoods. Research shows that in some countries, population density puts "eyes on the streets" to protect residents who engage in physical activity in the neighborhoods. Land-use diversity facilitates utilitarian walking to stores, restaurants, coffee shops, and other service-related businesses.[17–28] However, in a study of cities (e.g., Bogota, Colombia) where density and land-use diversity are commonplace and there is little appreciable variation, these attributes of the built environment were not associated with physical activity.[33]

In a more recently published study,[34] "deprivation amplification" was revisited because empirical studies of the distribution of facilities and resources show that location does not always disadvantage poorer neighborhoods, which is consistent with our findings. The spatial distribution of physical activity resources by socioeconomic status may vary by types of resources, countries, and time periods. The quality, meaning, perceived accessibility, and relevance of these resources as well as perceived safety from crime and traffic may be more important than the presence or absence of physical activity resources.[34]

Taken together, our findings, the revised hypothesis of "deprivation amplification,"[34] and findings from other community field audit studies[15,16] strongly reinforce the dictum that interventions tailored to the local area are essential to promoting active living. A careful assessment of community assets and barriers related to physical activity for each target area is recommended. Furthermore, our data are a strong caution to researchers, practitioners, and community activists to avoid overgeneralizing about neighborhoods on the basis of their sociodemographic characteristics, particularly income level.

The potential limitations of this study include its limited sample size: 30 block groups in one United States county. Despite this potential limitation, we found statistically significant results. Also, we did not account for the number of intersections per block group; therefore, the influence of these characteristics on traffic density and safety is unknown. Another possible limitation of our study is that we did not assess the perceptions of residents, even though such perceptions are

important. Macintyre[34] emphasized that perceptions and social meanings attributed to features of the environment can influence the behavior of residents. Data on the social environment (e.g., perceptions of safety and crime)[35] and community-level factors (e.g., social capital and cohesiveness)[36] can be critical in understanding physical activity disparities. Moreover, perceived and objective measures of the environment may be differently associated with physical activity.[31,37] Additionally, it may be useful to distinguish between recreational and utilitarian physical activities and the unique factors and features associated with each.[18,31] We did not measure the age of housing for each block group in the three income levels. In this study, the age of neighborhood housing may be a potential but unlikely confounding factor. In contrast to many cities in the Northeast, over 95% of Harris County (which includes Houston) housing and neighborhoods were built after 1960. Large age differences in neighborhood housing are unlikely or rare.[38]

Another potential limitation is the checklist audit used in this study. Perhaps a more detailed analytic audit (e.g., the St. Louis, San Diego or South Carolina environmental audits)[39] would yield more comprehensive data. Because of budgetary constraints, we randomly selected block groups and audited two areas per block group, which is an accepted procedure. However, an alternative approach to enhancing the quality of the data would have been to audit all areas in the block group. Also, reliability analyses were not conducted after the audit training. Moreover, instead of GIS, we chose to use walking, environmental audits to capture the salient street-scale characteristics of the environment related to physical activity and to alleviate the challenges related to the time stamp (i.e., not capturing recent changes in a neighborhood) of street views.

Although there is consistent support in the literature for using the four factors we measured (i.e., population density, land-use diversity, street design, and physical disorder/incivilities),[17–28] additional factors such as average block size, proximity and type of destinations, and other street-scale characteristics should be assessed in future studies. A walkable environment may be best represented by a formal equation that includes intersection density, net residential density, retail floor area ratio, and land use diversity.[40] Additionally, density and diversity, which are high in low-income areas, are associated mainly with utilitarian physical activity. In contrast, environmental attractiveness, which is high in high-income areas, is associated mainly with recreational physical activity. We recommend that future studies distinguish between transportation and recreation physical activities and environments. One study of a single city found that people of lower income were more physically active for transportation purposes than people of higher income.[41]

Our study is the first that we know of to systematically investigate four neighborhood environmental factors most related to physical activity and street-scale audits in 30 randomly selected geographic areas with various median income levels. There are no known national data sets for such audits. The strengths of our study include the fact that Harris County is the third largest county in the United States and has diverse sociodemographic characteristics.

CONCLUSIONS

According to a systematic review of published studies,[21] interventions that provide a safer, more inviting outdoor environment for physical activity can increase physical activity levels by 35%. The interventions that were reviewed focused on street-scale

urban design and land use policies that support physical activity in small geographic areas, generally limited to a few blocks. Our findings suggest that generalizations based on income levels of neighborhoods can be misleading. Irrespective of income level, for each target community, the challenge is to understand the specific social, cultural, and environmental contexts of the neighborhoods.

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REFERENCES

1. U.S. Department of Health and Human Services. *Healthy people 2010, 2nd ed. With Understanding and Improving Health and Objectives for Improving Health*. 2 vols. Washington, DC: U.S. Government Printing Office; 2000.
2. Parks SE, Housemann RA, Brownson RC. Differential correlates of physical activity in urban and rural adults of various socioeconomic backgrounds in the United States. *J Epidemiol Community Health*. 2003;57(1):29-35.
3. Whitt-Glover MC, Taylor WC, Heath GW, Macera CA. Self-reported physical activity among Blacks: estimates from national surveys. *Am J Prev Med*. 2007;33 (5):412-417.
4. Crespo CJ, Smit E, Andersen RE, Carter-Pokras O, Ainsworth BE. Race/ethnicity, social class and their relation to physical inactivity during leisure time: results from the Third National Health and Nutrition Examination Survey, 1988–1994. *Am J Prev Med*. 2000;18(1):46-53.
5. Centers for Disease Control. Neighborhood safety and the prevalence of physical inactivity-selected states, 1996. *MMWR Morb Mortal Wkly Rep*. 1999;48(7):143-146.
6. Taylor WC, Poston WSC, Jones L, Kraft MK. Environmental justice: obesity, physical activity and healthy eating. *J Phys Act Health*. 2006;3(S1):S30-S54.
7. Taylor WC, Floyd MF, Whitt-Glover MC, Brooks J. Environmental justice: a framework for collaboration between the public health and parks and recreation fields to study disparities in physical activity. *J Phys Act Health*. 2007;4(1):S50-S63.
8. Macintyre S. The social patterning of exercise behaviours: the role of personal and local resources. *Br J Sports Med*. 2000;34(1):6.
9. Estabrooks PA, Lee RE, Gyurcsik NC. Resources for physical activity participation: does availability and accessibility differ by neighborhood socioeconomic status? *Ann Behav Med*. 2003;25(2):100-104.
10. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*. 2006;117 (2):417-424.
11. Powell LM, Slater S, Chaloupka FJ, Harper D. Availability of physical activity-related facilities and neighborhood demographic and socioeconomic characteristics: a national study. *Am J Public Health*. 2006;96(9):1676-1680.
12. Powell LM, Slater S, Chaloupka FJ. The relationship between community physical activity settings and race, ethnicity and socioeconomic status. *Evid Based Prev Med*. 2004;1(2):135-144.
13. Moore LV, Diez Roux AV, Evenson KR, McGinn AP, Brines SJ. Availability of recreational resources in minority and low socioeconomic status areas. *Am J Prev Med*. 2008;34(1):16-22.

14. Brownson RC, Hoehner CM, Brennan LK, Cook RA, Elliott MB, McMullen KM. Reliability of 2 instruments for auditing the environment for physical activity. *J Phys Act Health*. 2004;1:191-208.
15. Kelly CM, Schootman M, Baker EA, Barnidge EK, Lemes A. The association of sidewalk walkability and physical disorder with area-level race and poverty. *J Epidemiol Community Health*. 2007;61(11):978-983.
16. Zhu X, Lee C. Walkability and safety around elementary schools economic and ethnic disparities. *Am J Prev Med*. 2008;34(4):282-290.
17. Cervero R, Kockelman K. Travel demand and the 3Ds: density, diversity, and design. *Transp Res D*. 1997;2(3):199-219.
18. Pikora TJ, Giles-Corti B, Knuiman MW, Bull FC, Jamrozik K, Donovan RJ. Neighborhood environmental factors correlated with walking near home: using SPACES. *Med Sci Sports Exerc*. 2006;38(4):708-714.
19. Brennan Ramirez LK, Hoehner CM, Brownson RC, Cook R, Orleans CT, Hollander M, et al. Indicators of activity-friendly communities: an evidence-based consensus process. *Am J Prev Med*. 2006;31(6):515-524.
20. Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. *Annu Rev Public Health*. 2006;27:297-322.
21. Task Force on Community Preventive Services. Recommendations to increase physical activity in communities. *Am J Prev Med*. 2002;22(4):67-72.
22. Humpel N, Owen N, Leslie E. Environmental factors associated with adults' participation in physical activity: a review. *Am J Prev Med*. 2002;22(3):188-199.
23. Saelens BE, Sallis JF, Frank LD. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Ann Behav Med*. 2003;25(2):80-91.
24. Brownson RC, Haire-Joshu D, Luke DA. Shaping the context of health: a review of environmental and policy approaches in the prevention of chronic diseases. *Annu Rev Public Health*. 2006;27:341-370.
25. Duncan MJ, Spence JC, Mummery WK. Perceived environment and physical activity: a meta-analysis of selected environmental characteristics. *Int J Behav Nutr Phys Act*. 2005;2:11.
26. Kahn EB, Ramsey LT, Brownson RC, et al. The effectiveness of interventions to increase physical activity: a systematic review. *Am J Prev Med*. 2002;22(S4):73-107.
27. Heath GW, Brownson RC, Kruger J, et al. The effectiveness of urban design and land-use and transport policies and practices to increase physical activity: a systematic review. *J Phys Act Health*. 2006;3(S1):S55-S76.
28. Frank LD, Engelke PO, Schmid TL. *Health and Community Design: the Impact of the Built Environment on Physical Activity*. Washington, DC: Island Press; 2003.
29. U.S. Census Bureau. State and county quick facts: Harris County, Texas. http://quickfacts.census.gov/qfd/states/48/48201.html. Accessed January 11, 2008.
30. Kitchen R, Tate N. *Conducting Research into Human Geography*. Essex, England: Pearson Educated Limited; 2000.
31. Hoehner CM, Brennan Ramirez LK, Elliott MB, Handy SL, Brownson RC. Perceived and objective environmental measures and physical activity among urban adults. *Am J Prev Med*. 2005;28(S2):105-116.
32. Viera AJ, Garrett JM. Understanding interobserver agreement: the Kappa statistic. *Fam Med*. 2005;37(5):360-363.
33. Cervero R, Sarmiento OL, Jacoby E, Gomez LF, Neiman A. Influences of built environment on walking and cycling: lessons from Bogota. *Int J Sustain Transp*. 2009;3(4):203-226.
34. Macintyre S. Deprivation amplification revisited; or, is it always true that poorer places have poorer access to resources for healthy diets and physical activity? *Intl J Behav Nutr Phys Act*. 2007;4:32.
35. Taylor WC, Sallis JF, Lees E, et al. Changing social and built environments to promote physical activity: recommendations from low income, urban women. *J Phys Act Health*. 2007;4(1):54-65.

36. Duncan SC, Duncan TE, Strycker LA, Chaumeton NR. Neighborhood physical activity opportunity: a multilevel contextual model. *Res Q Exerc Sport*. 2002;73(4):457-463.
37. Boehmer TK, Hoehner CM, Deshpande AD, Brennan Ramirez LK, Brownson RC. Perceived and observed neighborhood indicators of obesity among urban adults. *Int J Obes*. 2007;31:968-977.
38. Garreau J. *Edge City: Life on the New Frontier*. New York, NY: Anchor Books; 2006.
39. Brownson RC, Chang JJ, Eyler AA, et al. Measuring the environment for friendliness toward physical activity: a comparison of the reliability of 3 questionnaires. *Am J Public Health*. 2004;94(3):473-483.
40. Frank LD, Schmid TL, Sallis JF, Chapman J, Saelens BE. Linking objectively measured physical activity with objectively measured urban form: findings from SMARTRAQ. *Am J Prev Med*. 2005;28(S2):117-125.
41. Lee C. Environment and active living: the roles of health risk and economic factors. *Am J Health Promot*. 2007;21(S4):293-304.