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Built Environment and Depression in Low-Income African Americans and Whites

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Abstract

Introduction—Urban environments are associated with a higher risk of adverse mental health outcomes; however, it is unclear which specific components of the urban environment drive these associations.

Methods—Using data collected in 2002–2009 from 73,225 low-income, racially diverse individuals across the Southeastern U.S., analyses evaluated the cross-sectional relationship between a walkability index and depression. Walkability was calculated from population density, street connectivity, and destination count in the 1,200-meter area around participants' homes, and depression was measured using the Center for Epidemiologic Studies Depression Scale for depression symptomatology and questionnaire responses regarding doctor-diagnosed depression and antidepressant use. Data were analyzed in 2015.

Results—Participants living in neighborhoods with the highest walkability index had 6% higher odds of moderate or greater depression symptoms (score ≥ 15, 95% CI=0.99, 1.14), 28% higher odds of doctor-diagnosed depression (95% CI=1.20, 1.36), and 16% higher odds of current antidepressant use (95% CI=1.08, 1.25) compared with those in the lowest walkability index. Higher walkability was associated with higher odds of depression symptoms only in the most deprived neighborhoods, whereas walkability was associated with lower odds of depression symptoms in the least deprived neighborhoods.

Conclusions—Living in a more walkable neighborhood was associated with modestly higher levels of doctor-diagnosed depression and antidepressant use, and walkability was associated with

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greater depression symptoms in neighborhoods with higher deprivation. Although dense urban environments may provide opportunities for physical activity, they may also increase exposure to noise, air pollution, and social stressors that could increase levels of depression.

Introduction

Depression is a disabling psychiatric disorder that is the fourth leading cause of disability worldwide and the leading cause of nonfatal disease burden.¹ Approximately 9% of U.S. adults meet the criteria for current depression,² although depression prevalence varies by race and SES. African Americans are at lower lifetime risk of depression, but are over-represented in underserved populations, have reduced access to mental health services, and often receive poorer-quality care than whites.³ Meta-analyses demonstrate that low-SES individuals have 80% increased odds of being depressed compared with higher-SES individuals.⁴ However, little is known about the environmental drivers of depression in these populations.

The social-ecologic model of health⁵ explains that individual behavior shapes, and is shaped by, the context in which an individual lives. Research indicates that health may be related to the contextual built environment, defined as land use patterns, transportation systems, and urban design.⁶ Although this conceptual definition has not been standardized, the measures of population density, land use mix, and street connectivity have commonly been linked to health outcomes.^{7,8}

A growing literature demonstrates associations between the built environment and mental health⁹; however, there is sparse research on the built environment and mental health in minority and low-SES populations. Qualitative studies report that the built environment is perceived as a critical determinant of mental health in African American populations,¹⁰ and built environment quality (e.g., deteriorating buildings) has been linked to depression, psychiatric symptoms, and psychosocial distress.^{11–15}

The built environment could influence mental health through multiple mechanisms. Research demonstrates that population density, land use mix, and street connectivity are associated with utilitarian walking,^{16–18} and a clear inverse relationship between physical activity and depression risk exists.¹⁹ Higher population density may increase social interactions that may decrease depression risk.²⁰ Conversely, indicators of walkability may correlate with adverse mental health: Higher population density, land use mix, and street connectivity can increase air pollution and noise by concentrating traffic,²¹ and studies have reported associations between these exposures and depression and stress.^{22–25} Urbanicity has been correlated with adverse mental health, potentially due to social disorganization, selective migration, increased infection, and overcrowding.^{26,27}

The objective of this analysis is to contribute to the growing literature on the the built environment and depression. The authors hypothesized that more-walkable environments would be associated with lower prevalence of depression for reasons outlined above. The built environment may be particularly relevant for mental health in minority and lower-SES

populations, where exposures to poor quality built environments are more prevalent²⁸ and chronic stress levels are higher.²⁹

Methods

Study Population

The Southern Community Cohort Study (SCCS) is a study of >85,000 adults aged 40–79 years designed to investigate health disparities in low-income African Americans and whites.^{30,31} Enrollment largely occurred at community health centers in 12 states in the Southeastern U.S.

Participants provided residential addresses on the baseline questionnaire (2002–2009). Addresses were geocoded using a protocol developed to maximize assignment to an address-level geographic coordinate.³² Briefly, addresses were parsed, cleaned, and standardized before applying a combination of automated (e.g., TeleAtlas, Lebanon, NH) and interactive (e.g., Google Earth) geocoding tools. Overall, 99.96% of participant addresses were geocoded.

For this analysis, participants were excluded if they had no geocoded address at the street level ($n=4,802$); lived on rural routes with inaccurate geocodes ($n=207$); or were missing information on the following: depression ($n=3,905$), race, income, smoking, marital status, or employment ($n=2,207$), or built environment measures ($n=373$). Excluded participants were more likely to report doctor-diagnosed depression and were more likely to be married, but had similar prevalence of antidepressant use. There were 73,225 participants eligible for this analysis (66.9% African American, 59.6% female). The SCCS was approved by the IRB at Vanderbilt University and Meharry Medical College, and this project was approved by the Human Subjects Committee at the Harvard T.H. Chan School of Public Health. All participants provided written informed consent.

Measures

A series of built environment measures were developed as indicators of neighborhood walkability using ArcGIS, version 10.4. Based on previous work evaluating the stability of associations between built environment measures and physical activity across different buffer sizes, 1,200-meter line-based network buffers were created around each participant's geocoded address.³³ Although there is uncertainty over the geographic area most relevant to health,³⁴ previous analyses have identified this buffer size as holding the strongest energy balance associations.³⁵ The buffering process involved identifying streets accessible to pedestrians and evaluating the portion of the street network within 1,200 meters from each subject's home, adding a 50-meter buffer on either side of the road. The elements of walkability were detailed as follows.

Street information came from ArcGIS, version 10.1 StreetMap® USA data, which is based on the TIGER 2007 road network. The number of three-way or greater intersections were calculated within each participant's network buffer as a measure of street connectivity.

Business data were obtained from the commercially available InfoUSA 2009 database. The database included points of interest such as grocery stores, restaurants, banks, and hospitals. Geographic coordinates were assigned to destinations based on addresses in this database. Recent studies assessed the validity of similar commercial facility databases using field audits and found good to moderate agreement and sensitivity for correctly locating facilities.^{36–38}

Population density was defined as the number of individuals per square mile based on the 2000 U.S. Census for the Census tract of each participant's geocoded address.

Because measures of the built environment were correlated (Spearman correlation coefficients, 0.7–0.8), a standardized walkability index was created from Z-scores of each measure with a mean of 0 and a SD of 1. Scores were summed to create a walkability index with a mean of 0 (range, –2.7 to 18.1), with higher values indicating higher levels of neighborhood walkability. Similar indices have been used previously.^{39–41}

To measure depression symptoms, the Center for Epidemiologic Studies ten-item Depression Scale (CES-D) was included on the baseline SCCS questionnaire. The CES-D is a validated instrument for depression symptoms^{42–44} and has demonstrated measurement equivalency across a broad range of ages and ethnicities.^{45,46} This analysis used a CES-D score (range, 0–30) cut off of 15, which indicates moderate or greater depression symptoms.^{47,48}

Two self-reported, dichotomous measures of depression were used. Doctor-diagnosed depression was recorded based on positive responses to: *Has a doctor ever told you that you have had depression?* Antidepressant use was coded based on positive responses to: *Are you currently taking any antidepressant or antianxiety prescription medication, such as Prozac, Zoloft, Paxil, or Buspar?*

Statistical Analysis

The cross-sectional association between each built environment measure and moderate or greater depression symptomatology (CES-D ≥ 15), self-reported depression (ever), or current antidepressant use was determined using logistic regression. Although the walkability index was the main exposure of interest, each component of the index was examined separately to see which component had the greatest influence on depression outcomes. Each exposure metric was divided into quintiles and ORs and 95% CIs were calculated for each quintile compared to the lowest quintile. Covariates were selected a priori based on being related to both the built environment and depression. Models were adjusted for age, sex, race, household income, marital status, smoking, and employment status from questionnaires. Models were additionally adjusted for a deprivation index used previously within the SCCS,^{49,50} which combines Census 2000 tract-level education, employment, housing, occupation, poverty, race, and residential stability variables. Further analyses adjusted for self-reported walking MET hours per day,⁵¹ based on responses to questions about time per day walking fast or slow. Because patients using antidepressants may have lower depression symptoms or not report doctor-diagnosed depression, additional analyses were conducted for these outcomes adjusting for antidepressant use. To account for the temporal mismatch

between walkability based on the current neighborhood and doctor-diagnosed depression that could have occurred years earlier, sensitivity analyses were conducted focusing on doctor-diagnosed depression within the past year. Effect modification by sex, race, age, marital status, years in current home, household income, Census tract deprivation index, and whether the participant lived in a metropolitan (urban area $\geq 50,000$ people)/micropolitan (urban cluster of 10,000–49,999)/small town or rural (urban cluster of $<10,000$) area⁵² was evaluated by testing interaction terms using Wald tests, as well as through stratified models. Analyses were conducted in SAS, version 9.4 in 2015.

Results

The mean age of the 73,225 participants was 52.0 years (Table 1). Household income for the majority of participants was $<\$15,000$ per year and 60.9% were unemployed. More than 18.1% had moderate or greater symptoms of depression (CES-D 15), 19.1% reported current antidepressant use, and 25.1% reported ever being diagnosed with depression. Participants with symptoms of depression were younger, less likely to be married, more likely to smoke, more likely to be white, had lower incomes, and lived in areas with higher levels of walkability.

The relationship between each exposure metric and depression outcomes are shown in Figure 1. All point estimates indicated that higher levels of walkability were associated with higher odds of all depression outcomes. Although the walkability index was not statistically significantly associated with moderate or greater depression symptoms, the relationship between population density (a component of the walkability index) and depression symptoms was statistically significant. Participants in areas with the highest versus lowest quintile of population density had 10% higher odds of moderate or greater depression symptoms (95% CI=1.03, 1.17). ORs for doctor-diagnosed depression and current antidepressant use were consistently stronger than those for depression symptoms. Participants living in neighborhoods with the highest quintile walkability index had 28% higher odds of doctor-diagnosed depression (95% CI=1.20, 1.36) and 16% higher odds of current antidepressant use (95% CI=1.08, 1.25) compared with those living in neighborhoods with the lowest quintile walkability index. Of the walkability index components, doctor-diagnosed depression and antidepressant use were most strongly related to total destination count. Further adjustment of these models for total MET hours of self-reported walking per day resulted in negligible changes to effect estimates (Appendix Table 1). In analyses additionally adjusted for antidepressant use (Appendix Table 2), no appreciable differences in effect size were observed when compared to the main multivariable models. Analyses restricted to doctor-diagnosed depression showed slightly attenuated associations; however, results were consistent with main analyses (Appendix Table 3).

Stratified analyses showed little evidence of effect modification by sex, years in current home, or household income; however, there was evidence that the relationship between the walkability index and depression symptoms differed by Census tract deprivation index (p for interaction=0.014). Table 2 shows that an adverse relationship between the walkability index and depression symptoms was highest in areas with the highest deprivation (OR comparing

the highest quintile of walkability to the lowest in the most deprived neighborhoods, 2.13; 95% CI=1.13, 4.01). Conversely, higher levels of walkability appeared protective for depression symptoms only in areas with the least deprivation (OR comparing the highest quintile of walkability to the lowest, 0.77; 95% CI=0.60, 0.99). This pattern was not present for doctor-diagnosed depression or current antidepressant use. In addition, the association between walkability and antidepressant use (p for interaction=0.0005), as well as walkability and depression symptoms (p for interaction=0.033), was weaker in metropolitan areas compared with non-metropolitan areas (Table 3). Slightly stronger associations were detected among African American participants than white participants across all depression outcomes, although there was no statistically significant effect modification by race (Table 3). Statistically significant effect modification was observed by age and marital status (Appendix Tables 4–5), where associations were generally strongest among older individuals and those who were never married.

Discussion

In this cohort of largely low-income African American and white individuals across the Southeastern U.S., participants who lived in more-walkable neighborhoods had slightly higher odds of doctor-diagnosed depression and antidepressant medication use, but not depression symptoms, after accounting for a number of individual- and neighborhood-level covariates. There was suggestive evidence, however, that neighborhood walkability was associated with higher odds of moderate or greater depression symptoms in the most economically deprived neighborhoods, whereas walkability was protective for depression symptoms in the least deprived neighborhoods.

A growing body of research has shown that various features of the urban environment are associated with a higher risk of adverse mental health outcomes,^{9,53–55} although findings are inconsistent.^{56,57} The majority of research on this topic has focused on neighborhood SES as driving the relationship between urban environments and depression; however, some studies have examined neighborhood walkability. Berke et al.⁵⁸ studied participants aged 65 years who completed a CES-D questionnaire. The investigators created a walkability index based on distance to amenities, block size, and number of dwelling units in buffers around participants' homes. Contrary to the current findings, they saw reduced odds of moderate depression symptoms in men living in neighborhoods with higher walkability indices, but not in women. Running counter to the current analysis, Garipey and colleagues⁵⁹ examined the association between built environment factors and depression symptoms over a 10-year period and found that the presence of stores and restaurants was associated with a lower probability of depression symptom episodes among those with a trajectory of low prevalence of depression symptoms.

Consistent with the current analysis, a study applying a geriatric depression scale among older men living in Western Australia reported that higher degrees of land use mix and retail availability were associated with higher odds of depression.⁴¹ Duncan et al.⁶⁰ conducted an analysis of a racially diverse group of youth across schools in Boston and found that higher levels of destination availability and street connectivity were correlated with higher levels of depression symptoms. Similar to the current results, the authors did not find that these

associations differed between white and African American participants. In sum, the sparse literature on neighborhood walkability and depression is inconsistent.

The observed association between higher levels of neighborhood walkability and increased odds of depression could be explained by multiple mechanisms.⁶¹ Dense and walkable areas may have higher levels of psychosocial stressors, such as derelict buildings, traffic noise, graffiti, litter, and crime, that can create psychosocial strain and leave individuals psychologically vulnerable to depression. Within the SCCS data set, individuals in the highest quintile of the walkability index were more likely to report higher perceived stress than those in the lowest quintile; however, adjustment for perceived stress did not meaningfully alter the observed association between walkability and depression (Appendix Table 6). Additionally, compact neighborhoods may also lead to concentrated disadvantage, where population density can magnify physical and social problems and result in poor mental health outcomes. Finally, the social drift theory posits that individuals with mental health problems may relocate to dense urban areas.⁶²

Greater walkability was associated with higher depression symptoms among those in higher deprivation areas, but was linked to lower depression symptoms among people residing in more-affluent neighborhoods. This sub-finding is consistent with research suggesting that dense built environments can be damaging to mental health only when they occur in conjunction with other risk factors, including socioeconomic deprivation.⁶¹ This result must also be interpreted with some caution, because it was not reflected consistently across all outcome measures of depression.

Limitations

The current study was limited by its cross-sectional design; therefore, reverse causality cannot be ruled out. This analysis relied on self-reported measures for depression outcomes, although the likelihood for differential bias was low because the built environment was assessed objectively independent of the baseline interview. Because questionnaires were completed from 2002 to 2009, there may be a temporal mismatch between questionnaire data and street connectivity data (collected in 2007) and destination count data (collected in 2009). Because the built environment does not change rapidly over time,⁶³ it is likely that this exposure misclassification would not be major. It is unclear which specific spatial scale of the built environment may be most relevant for depression, and therefore exposure may have been misclassified by exploring only one spatial scale. The uncertain geographic context problem³⁴ explains the complexity of defining areas that might be most relevant to health while spatial polygamy theory⁶⁴ explains how individuals can simultaneously be exposed to multiple nested and non-nested contexts. Therefore, the observed relationships might change with different spatial scales. Future analyses should investigate multiple scales of the built environment, as well as test whether relevant scales differ according to demographic (e.g., race) or geographic factors (e.g., urban–rural). In addition, individuals spend more than 50% of their time away from home,⁶⁵ so further analyses should explore activity space-based measures of the built environment and the complex ways that they might interact with depression.⁶⁶ An alternative interpretation of these findings might be that neighborhood walkability is linked to increased detection and treatment of depression,

although this would not explain the observed association between walkability and depression symptoms in deprived neighborhoods. In addition, enrollment of participants largely occurred at community health centers; therefore, healthcare access is unlikely to play a large role as a confounder for the association between the built environment and depression in this population. The authors cannot rule out residual confounding by unmeasured differences in populations in walkable versus nonwalkable areas, as well as by other aspects of the built and natural environment that may covary spatially with walkability.

This analysis had a number of strengths, foremost its large sample size of low-SES and minority adults, who may be most susceptible to the health effects of urban environments, across a large region of the U.S. Additionally, questionnaire and geocoded residential information on this cohort allowed adjustment for potential confounding by both individual- and neighborhood-level factors. A detailed geocoding protocol enabled the development of measures that accurately modeled the built environment around each participant's residential address. Finally, the inclusion of a multifactor deprivation index allowed analyses to account for neighborhood-level SES.

Conclusions

This analysis contributes to the literature on the built environment and depression, and provides the first estimates from a large sample of minority and low-SES adults. Modest positive associations were observed between neighborhood walkability measures and depression symptomatology, doctor-diagnosed depression, and antidepressant use; however, neighborhood walkability appeared harmful for depression symptoms in lower-SES neighborhoods and beneficial in higher-SES neighborhoods. Although dense, walkable places may provide opportunities for physical activity, these environments may increase exposure to noise, air pollution, and social stressors.^{21,67} Future studies should include prospective analyses that explore multiple scales of exposure, as well as specific mechanisms that might explain associations between the built environment and depression.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

ORs and 95% CIs for walkability characteristics and depression outcomes (n=73,225).

Note: All models adjusted for age, gender, household income, marital status, smoking status, race, individual employment status, and Census tract deprivation.

^aWalkability index is based on summed z-scores of population density, intersection count, and business count.

^bCount within 1,200m network buffer around residential address.

Table 1
Participant Characteristics Overall and by Category of the CES-D (n=73,225) from Baseline, 2002–2009

Characteristics	Overall (n=73,225)		No depression symptoms (CES-D<10; n=43,494)		Mild depression symptoms (10 CES-D<15; n=16,401)		Moderate depression symptoms (15 CES-D<20; n=8,319)		Severe depression symptoms (CES-D ≥20; n=5,011)	
	Mean (SD)	N (%)	Mean (SD)	N (%)	Mean (SD)	N (%)	Mean (SD)	N (%)	Mean (SD)	N (%)
Age at enrollment	52.0 (8.7)	13,962 (19.1)	53.0 (9.1)	4,942 (11.4)	51.0 (8.3)	3,603 (22.0)	50.4 (7.6)	2,959 (35.6)	49.8 (6.9)	2,458 (49.1)
Deprivation index	0.7 (1.2)	18,361 (25.1)	0.7 (1.2)	6,252 (14.4)	0.9 (1.2)	4,927 (30.0)	0.8 (1.2)	3,933 (47.3)	0.7 (1.2)	3,249 (64.8)
Walkability index	0.0 (2.5)	43,658 (59.6)	-0.1 (2.4)	24,714 (56.8)	0.2 (2.5)	9,765 (59.5)	0.2 (2.5)	5,448 (65.5)	0.0 (2.5)	3,731 (74.5)
Population density (persons per sq mi)	887.7 (902.3)	40,985 (56.0)	848.8 (878.0)	20,806 (47.8)	948.3 (925.0)	10,656 (65.0)	958.4 (937.7)	5,808 (69.8)	909.2 (955.8)	3,715 (74.1)
Intersection count ^a	80.9 (68.5)	15,501 (21.2)	77.9 (67.8)	9,718 (22.3)	86.4 (69.6)	3,440 (21.0)	85.8 (68.3)	1,552 (18.7)	81.5 (68.7)	791 (15.8)
Total destination count ^a	111.8 (196.3)	10,106 (13.8)	106.4 (191.6)	7,375 (17.0)	122.3 (208.3)	1,627 (9.9)	119.4 (195.3)	204 (2.5)	111.9 (189.3)	393 (7.8)
CES-D score	9.0 (6.1)	4,988 (6.8)	4.9 (2.6)	4,126 (9.5)	11.8 (1.4)	567 (3.5)	16.7 (1.4)	21 (0.4)	22.7 (2.5)	91 (1.8)
Walking (MET hrs/day) ^b	11.4 (10.2)	1,645 (2.2)	11.5 (10.0)	1,469 (3.4)	11.5 (10.6)	111 (0.7)	11.2 (10.4)	44 (0.5)	10.3 (10.4)	21 (0.4)
Household income										
<\$15,000	40,985 (56.0)	25,081 (34.3)	20,806 (47.8)	16,896 (38.8)	10,656 (65.0)	4,709 (28.7)	5,808 (69.8)	2,220 (26.7)	3,715 (74.1)	1,256 (25.1)
\$15,000–<\$25,000	15,501 (21.2)	25,050 (34.2)	9,718 (22.3)	13,690 (31.5)	3,440 (21.0)	5,897 (36.0)	1,552 (18.7)	3,224 (38.8)	791 (15.8)	2,239 (44.7)
\$25,000–<\$50,000	10,106 (13.8)	7,043 (9.6)	7,375 (17.0)	4,233 (9.7)	1,627 (9.9)	1,570 (9.6)	711 (8.5)	765 (9.2)	393 (7.8)	475 (9.5)
\$50,000–<\$100,000	4,988 (6.8)	16,051 (21.9)	4,126 (9.5)	8,675 (19.9)	567 (3.5)	4,225 (25.8)	204 (2.5)	2,110 (25.4)	91 (1.8)	1,041 (20.8)
\$100,000	1,645 (2.2)	30,765 (42.0)	1,469 (3.4)	15,855 (36.5)	111 (0.7)	7,883 (48.1)	44 (0.5)	4,294 (51.6)	21 (0.4)	2,733 (54.5)
Marital status										
Married, or living as married with partner	25,081 (34.3)	25,081 (34.3)	16,896 (38.8)	16,896 (38.8)	4,709 (28.7)	4,709 (28.7)	2,220 (26.7)	2,220 (26.7)	1,256 (25.1)	1,256 (25.1)
Separated or divorced	25,050 (34.2)	25,050 (34.2)	13,690 (31.5)	13,690 (31.5)	5,897 (36.0)	5,897 (36.0)	3,224 (38.8)	3,224 (38.8)	2,239 (44.7)	2,239 (44.7)
Widowed	7,043 (9.6)	7,043 (9.6)	4,233 (9.7)	4,233 (9.7)	1,570 (9.6)	1,570 (9.6)	765 (9.2)	765 (9.2)	475 (9.5)	475 (9.5)
Single, never married	16,051 (21.9)	16,051 (21.9)	8,675 (19.9)	8,675 (19.9)	4,225 (25.8)	4,225 (25.8)	2,110 (25.4)	2,110 (25.4)	1,041 (20.8)	1,041 (20.8)
Smoking status										
Current	30,765 (42.0)	30,765 (42.0)	15,855 (36.5)	15,855 (36.5)	7,883 (48.1)	7,883 (48.1)	4,294 (51.6)	4,294 (51.6)	2,733 (54.5)	2,733 (54.5)

Characteristics	Overall (n=73,225)	No depression symptoms (CES-D<10; n=43,494)	Mild depression symptoms (10 CES-D<15; n=16,401)	Moderate depression symptoms (15 CES-D<20; n=8,319)	Severe depression symptoms (CES-D 20; n=5,011)
Former	16,578 (22.6)	10,964 (25.2)	3,149 (19.2)	1,576 (18.9)	889 (17.7)
Never	25,882 (35.3)	16,675 (38.3)	5,369 (32.7)	2,449 (29.4)	1,389 (27.7)
Race					
White	21,435 (29.3)	12,610 (29.0)	4,200 (25.6)	2,600 (31.3)	2,025 (40.4)
Black/African American	48,996 (66.9)	29,341 (67.5)	11,595 (70.7)	5,366 (64.5)	2,694 (53.8)
Other racial or ethnic group	2,794 (3.8)	1,543 (3.5)	606 (3.7)	353 (4.2)	292 (5.8)
Employed	28,611 (39.1)	20,087 (46.2)	5,474 (33.4)	2,096 (25.2)	954 (19.0)
Years in current home					
> 1 Year	55,008 (75.1)	33,738 (77.6)	11,924 (72.7)	5,908 (71.0)	3,438 (68.6)
<1 Year	18,085 (24.7)	9,683 (22.3)	4,441 (27.1)	2,395 (28.8)	1,566 (31.3)
Missing	132 (0.2)	73 (0.2)	36 (0.2)	16 (0.2)	7 (0.1)
Rural urban commuting area code					
Metropolitan Area (50, 000 people)	58,045 (79.3)	34,112 (78.4)	13,049 (79.6)	6,763 (81.3)	4,121 (82.2)
Micropolitan Area (10,000– 49,999 people)	12,457 (17.0)	7,677 (17.7)	2,801 (17.1)	1,273 (15.3)	706 (14.1)
Small Town or Rural (<10, 000 people)	2,723 (3.7)	1,705 (3.9)	551 (3.4)	283 (3.4)	184 (3.7)

^aCount within 1,200m network buffer around residential address.

^bN=72,940 for walking question.

CES-D, Center for Epidemiologic Studies Depression Scale

Table 2

ORs for Walkability Characteristics and Depression Outcomes Stratified by Census Tract Deprivation Index (n=73,225)

Exposure	Deprivation index Q1 (Least deprived)	Deprivation index Q2	Deprivation index Q3	Deprivation index Q4	Deprivation index Q5 (Most deprived)
Walkability Index ^a	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Moderate or greater depression symptoms (CES-D >15)					
Q1 (-2.7, -2.2)	Ref	Ref	Ref	Ref	Ref
Q2 (-2.2, -1.1)	1.01 (0.89, 1.13)	0.94 (0.84, 1.06)	1.21 (1.06, 1.39)	1.29 (1.04, 1.59)	2.09 (1.09, 4.01)
Q3 (-1.1, 0.1)	1.04 (0.91, 1.18)	0.99 (0.87, 1.12)	1.29 (1.13, 1.48)	1.23 (1.00, 1.50)	2.04 (1.07, 3.86)
Q4 (0.1, 1.9)	1.01 (0.86, 1.20)	0.95 (0.82, 1.10)	1.32 (1.15, 1.53)	1.35 (1.11, 1.64)	1.92 (1.02, 3.62)
Q5 (1.9, 18.1)	0.77 (0.60, 0.99)	1.00 (0.84, 1.18)	1.28 (1.10, 1.48)	1.23 (1.01, 1.50)	2.13 (1.13, 4.01)
P for interaction			0.014		
Doctor diagnosed depression (Ever)					
Q1 (-2.7, -2.2)	Ref	Ref	Ref	Ref	Ref
Q2 (-2.2, -1.1)	1.11 (1.00, 1.22)	1.01 (0.91, 1.11)	1.07 (0.94, 1.21)	0.99 (0.82, 1.20)	1.52 (0.85, 2.71)
Q3 (-1.1, 0.1)	1.11 (1.00, 1.24)	1.04 (0.93, 1.16)	1.21 (1.07, 1.36)	1.04 (0.86, 1.24)	1.67 (0.95, 2.94)
Q4 (0.1, 1.9)	1.10 (0.96, 1.27)	1.18 (1.04, 1.34)	1.29 (1.13, 1.47)	1.15 (0.97, 1.37)	1.65 (0.94, 2.90)
Q5 (1.9, 18.1)	1.44 (1.18, 1.74)	1.16 (0.99, 1.35)	1.39 (1.21, 1.58)	1.15 (0.96, 1.37)	1.84 (1.05, 3.24)
P for interaction			0.489		
Current antidepressant use					
Q1 (-2.7, -2.2)	Ref	Ref	Ref	Ref	Ref
Q2 (-2.2, -1.1)	1.11 (1.01, 1.24)	1.02 (0.92, 1.14)	1.08 (0.94, 1.23)	0.99 (0.80, 1.23)	1.29 (0.69, 2.40)
Q3 (-1.1, 0.1)	1.11 (0.99, 1.25)	1.02 (0.91, 1.15)	1.14 (0.99, 1.30)	1.07 (0.87, 1.32)	1.17 (0.64, 2.15)
Q4 (0.1, 1.9)	1.15 (0.99, 1.34)	1.17 (1.02, 1.34)	1.14 (0.99, 1.32)	1.14 (0.94, 1.40)	1.28 (0.70, 2.34)
Q5 (1.9, 18.1)	1.18 (0.95, 1.46)	1.12 (0.95, 1.32)	1.27 (1.10, 1.47)	1.07 (0.88, 1.32)	1.38 (0.75, 2.51)
P for interaction			0.930		

Note: Boldface indicates statistical significance ($p < 0.05$). All models adjusted for age, gender, household income, marital status, smoking status, race, and individual employment status.

^aWalkability index is based on summed z-scores of population density, intersection count, and business count.

Table 3

ORs for Walkability Characteristics and Depression Outcomes Stratified by Metropolitan vs. Non-Metropolitan Area and Race

Exposure	Non-metropolitan	Metropolitan	White	African American
Walkability Index ^a	OR (95% CI) ^b	OR (95% CI) ^b	OR (95% CI) ^c	OR (95% CI) ^c
Moderate or greater depression symptoms (CES-D >15)				
Q1 (-2.7, -2.2)	Ref	Ref	Ref	Ref
Q2 (-2.2, -1.1)	1.12 (0.99, 1.25)	1.00 (0.93, 1.08)	1.02 (0.93, 1.12)	1.10 (1.00, 1.20)
Q3 (-1.1, 0.1)	1.08 (0.94, 1.24)	1.03 (0.95, 1.11)	1.07 (0.96, 1.18)	1.10 (1.01, 1.21)
Q4 (0.1, 1.9)	1.22 (1.03, 1.44)	1.00 (0.93, 1.09)	1.10 (0.98, 1.23)	1.09 (1.00, 1.20)
Q5 (1.9, 18.1)	1.26 (1.03, 1.54)	0.99 (0.91, 1.07)	0.98 (0.86, 1.11)	1.14 (1.03, 1.25)
P for interaction	0.033			0.325
Doctor diagnosed depression (Ever)				
Q1 (-2.7, -2.2)	Ref	Ref	Ref	Ref
Q2 (-2.2, -1.1)	0.94 (0.85, 1.04)	1.10 (1.03, 1.18)	1.05 (0.97, 1.14)	1.09 (1.00, 1.19)
Q3 (-1.1, 0.1)	0.99 (0.87, 1.12)	1.15 (1.08, 1.24)	1.09 (1.00, 1.19)	1.17 (1.07, 1.27)
Q4 (0.1, 1.9)	1.12 (0.96, 1.30)	1.22 (1.13, 1.31)	1.18 (1.07, 1.31)	1.24 (1.13, 1.35)
Q5 (1.9, 18.1)	1.10 (0.91, 1.33)	1.32 (1.22, 1.42)	1.21 (1.08, 1.34)	1.35 (1.23, 1.48)
P for interaction		0.072		0.837
Current antidepressant use				
Q1 (-2.7, -2.2)	Ref	Ref	Ref	Ref
Q2 (-2.2, -1.1)	0.89 (0.80, 1.00)	1.14 (1.06, 1.23)	1.08 (1.00, 1.17)	1.08 (0.98, 1.19)
Q3 (-1.1, 0.1)	0.93 (0.81, 1.07)	1.13 (1.05, 1.22)	1.09 (1.00, 1.20)	1.09 (0.99, 1.20)
Q4 (0.1, 1.9)	1.08 (0.91, 1.28)	1.18 (1.09, 1.27)	1.15 (1.04, 1.27)	1.19 (1.08, 1.31)
Q5 (1.9, 18.1)	1.24 (1.01, 1.53)	1.20 (1.10, 1.30)	1.08 (0.96, 1.21)	1.25 (1.13, 1.39)
P for interaction	0.0005			0.130

Note: Boldface indicates statistical significance ($p < 0.05$).

^aWalkability index is based on summed z-scores of population density, intersection count, and business count.

^bN=73,225. Models adjusted for age, gender, household income, marital status, smoking status, race, individual employment status, and Census tract deprivation.

^cN=70,431 due to restriction to black and white participants. Models adjusted for age, gender, household income, marital status, smoking status, individual employment status, and Census tract deprivation.