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ORIGINAL RESEARCH

Effect of Social Environments on Cardiovascular Disease in the United States

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BACKGROUND: This study aims to examine the effect of time-variant perceived neighborhood social cohesion, perceived neighborhood physical disorder, and local crime on cardiovascular disease (CVD) incidence from 2006 through 2016.

METHODS AND RESULTS: We obtained data from the Health & Retirement Study. Respondents aged ≥50 years and with no recorded history of CVD until 2006 (N=8826) were included and followed for 10 years. Cox proportional hazards models were estimated with CVD incidence as an outcome variable and time-variant social environment factors (perceived neighborhood social cohesion, perceived neighborhood physical disorder, and local crime) as exposures, after controlling for sociodemographic factors and CVD-related risk/protective factors. Our results showed that perceived neighborhood social cohesion was associated with CVD among Black respondents, but not Hispanic and White respondents. Perceived neighborhood physical disorder and local crime rates were not associated with CVD incidence across all racial and ethnic groups.

CONCLUSIONS: The results demonstrate that perceptions of favorable social environments need to be considered to reduce CVD risk among Black adults. Further research is needed to identify different pathways through which living in favorable social environments benefits cardiovascular health by racial and ethnic groups.

Key Words: cardiovascular disease ■ neighborhood effects on health ■ social environments

In 2017, the first leading cause of death in the United States was heart disease, which accounted for 647 457 deaths and 23% of total deaths.[1] Although a vast literature has found biological, sociodemographic, and behavioral factors to significantly increase the risk of cardiovascular disease (CVD),[2–4] relatively less attention has been paid to social contexts of CVD incidence. A social environment, often defined as neighborhood social cohesion, safety, physical disorder, social support, and social connectedness, is one of the social contexts that can impact cardiovascular health.[5,6] Favorable features of social environments, such as social cohesion, safety, and low level of physical disorder, provide opportunities for individuals to interact with each other and encourage them to access their neighborhood resources (eg, parks, recreational centers, and food stores),[7] which can in turn improve health behaviors and reduce stress and isolation. Scholars proposed psychological, biological, and behavioral pathways to explain how social environments affect CVD development.[8–12] For example, unfavorable features of the social environment increase psychological stress,[13] which can develop into stress-related dysregulation of cardiovascular, metabolic, and neuroendocrine processes[14] and methylation of genes,[4,9,15,16] and subsequently increase risk for CVD incidence.[9,17] In addition, residents in unfavorable social environments are less likely to use a wide range of health care services[18] and are more likely to have health-compromising lifestyles such as insufficient physical activity and obesity,[12,19] which relate to developing CVD.[20]

While a growing number of longitudinal studies have demonstrated associations between social environments and cardiovascular behavioral and biological risk factors,[5,21–29] relatively less prospective research has explored the effect of social environments on cardiovascular events.[8,27,30–34] Within the limited available

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CLINICAL PERSPECTIVE

What Is New?

- Time-variant perceived neighborhood social cohesion was associated with risk of cardiovascular disease incidence among Black respondents, but not among Hispanic and White respondents, after adjusting for age, sex, education, family income, behavioral and biomedical factors (alcohol consumption, smoking status, depression symptoms, moderate-to-vigorous physical activity, hypertension, and diabetes), and area socioeconomic status.
- Time-variant perceived neighborhood physical disorder and local crime rates were not associated with risk of cardiovascular disease incidence across all racial and ethnic groups.

What Are the Clinical Implications?

- Our findings provide evidence that more efforts to intervene on social environments might benefit Black adults' cardiovascular health and reduce racial and ethnic disparities in cardiovascular health.
- Further studies are essential to elucidate the mechanisms by which social environments impact cardiovascular disease incidence among Black adults.

Nonstandard Abbreviations and Acronyms

HRS	Health & Retirement Study

prospective research on events, some have used data collected from a few geographic locations or 1 racial and ethnic group,[8,33,34] which limits the ability to generalize results to other US populations. In addition, most of the prospective studies have measured time-invariant characteristics of the social environment,[8,27,30–32,35] which fails to capture residential mobility (eg, moving from a low to highly cohesive area) and changes in context over time (eg, improving neighborhood social cohesion in recent years). For example, 2 studies[30,31] examined the association between perceived neighborhood social cohesion and stroke and myocardial infarction incidence over the 4-year follow-up using a nationally representative sample of US adults. These studies,[30,31] however, measured neighborhood social cohesion at baseline, which assumes no residential moves between neighborhoods and static neighborhood conditions over the study period, and followed up diseases for a short period of time. Another study[33] used data from adults in 6 US cities and created measures of perceived neighborhood safety and social cohesion by averaging the values measured at 2 time points (safety: 2003–2005 and 2010–2011; social cohesion: 2000–2002 and 2010–2011). However, their study results from a few urban areas cannot be generalized to the United States, and social environments measured at 2 time points may not be enough to reflect contextual changes during a decade.[33]

The association between social environment and CVD incidence can differ by race and ethnicity. Social environments can be especially important for racial and ethnic minority groups who often experience everyday discrimination, institutional racism, and oppression. According to the socioecological theory, experiences of discrimination can diminish coping mechanisms and damage immune, physiological, and neuronal systems.[36,37] In that sense, social environments can play a stronger protective role for racial and ethnic minority groups to buffer the detrimental effect of chronic stress from racism and discrimination with the adoption of healthy behaviors.[38] To date, while limited literature has examined the association between social environments and cardiovascular risk factors by race and ethnicity,[39–41] the disparate effect of social environment on CVD incidence by race and ethnicity has not yet been investigated.

This prospective study builds upon earlier research. We first examined whether time-variant measures of perceived neighborhood social cohesion, perceived neighborhood physical disorder, and objectively measured local crime rates were associated with risk of CVD incidence over 10 years of follow-up (2006–2016). We also examined whether the association between social environments and CVD incidence differs across racial and ethnic groups. Based on prior literature, we hypothesized that favorable social environments (ie, greater perceived neighborhood social cohesion, lower perceived neighborhood physical disorder, and lower local crime rates) would reduce the risk for CVD incidence. We also hypothesized that the association between social environments and CVD incidence would be stronger for non-Hispanic Black and Hispanic adults than non-Hispanic White adults.

METHODS

Data

All data and materials for this study have been made available through the Institute for Social Research at the University of Michigan, Ann Arbor and can be accessed at https://hrsdata.isr.umich.edu. Data were extracted from the HRS (Health & Retirement Study). The HRS recruited US adults over the age of 50 years in 1992 to 1993, 1998, and 2008 by using a multistage area probability sampling design[42] and surveyed respondents every 2 years.[43] The HRS includes the Core Survey, the

Left Behind Survey, and the Contextual Datasets linked to the Core Survey. The Core Survey was conducted to collect information on a variety of health and socioeconomic status. The Left Behind Survey is a written survey packet with additional questions (such as perceptions of neighborhood social cohesion and physical disorder), and it was left with respondents after completion of the Core Survey assessment. Participants completed it every 4 years because it was given to half the entire sample at each biennial wave. The HRS also provides restricted use contextual datasets by linking administrative data files based on respondents' residential addresses at each wave. The contextual datasets include information on county-level crime rates and census tract-level socioeconomic status.

The present study uses the data collected in 2006, 2008, 2010, 2012, 2014, and 2016. Our analytic sample includes respondents who did not have a CVD diagnosis until 2006 and who ever participated in the HRS's Left Behind Survey before a participant was diagnosed with CVD or the 2016 data collection (N=10 109). We excluded the data if they did not have a valid geographic location of residential neighborhood (n=289) and were missing information on primary exposures (n=313), race (n=24), education (n=123), behavioral and biomedical risk and protective factors (n=282), and neighborhood socioeconomic status (n=27). We also excluded respondents who self-identified as non-Hispanic other (n=225) because of the small sample size, which resulted in 8826 respondents in our analytic sample. In comparison to respondents who remained in the study, respondents excluded from the sample were more likely to be younger (65 years old versus 66 years old), male (44% versus 36%), and Hispanic (21% versus 9%), had a lower educational level (12 years versus 13 years), and reported a greater frequency of moderate-to-vigorous physical activity and a greater level of depression. There were no significant differences in family income, smoking status, presence or absence of hypertension, and presence or absence of diabetes, which were measured in 2006. Our analytic sample contributed a total of 72 211 years of time at risk, and on average, respondents contributed 8.2 years of person-time. Among our analytic sample, 1389 CVD events occurred during the observation period. All participants provided informed consent, and this study was approved by the institutional review board of the University of Texas at Arlington.

Measures

Outcome

The main outcome is 10-year CVD incidence between 2006 and 2016. CVD incidence was obtained through collecting self-reported doctor diagnosis of heart conditions (ie, heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems) during biennial follow-up surveys. CVD events as of the 2016 data collection time were included in this study.

Primary Exposures

The primary exposures include perception of neighborhood social cohesion, perception of neighborhood physical disorder, and local crime. First, the measure of perception of neighborhood social cohesion was examined based on responses to the following 4 questions about their perception of local neighborhood (defined as everywhere within a 20-minute walk or about a mile from their houses) on a 1-to-7 Likert scale, which was adapted from the English Longitudinal Study of Aging[44,45]: (1) I really feel part of this area, (2) Most people in this area can be trusted, (3) Most people in this area are friendly, and (4) If you were in trouble, there are lots of people in this area who would help you. All the items for perceived neighborhood social cohesion were measured every 4 years. We averaged and normalized the scores across the 4 items, and a higher score indicates a greater level of neighborhood social cohesion. Second, perception of neighborhood physical disorder was calculated based on the following 4 questions about perception of their neighborhood within a 20-minute walk or around a mile of their houses with a score ranging from 1 to 7, which was derived from the English Longitudinal Study of Aging[45,46]: (1) Vandalism and graffiti are a big problem in this area, (2) People would be afraid to walk alone in this area after dark, (3) This area is always full of rubbish and litter, and (4) There are many vacant or deserted houses or storefronts in this area. We averaged and normalized the scores of the 4 items with higher scores indicating a greater level of neighborhood physical disorder. Third, local crime was measured using an annual murder rate per 100 000 residents at the county level, which was obtained from the Uniform Crime Reports data files. The Uniform Crime Reports files were created by the National Archive of Criminal Justice Data based on citizens' crime records collected by the Federal Bureau of Investigation, which are subject to overreporting and underreporting.[47] Because most criminologists consider homicides the most accurately reported crime,[48] we standardized an annual murder rate, with greater values indicating greater local crime. All 3 measures of social environments were considered time-dependent to account for participant moves during the study period and contextual changes.

Covariates

Covariates include age, sex (men, women), self-identified race and ethnicity (non-Hispanic Black,

non-Hispanic White, Hispanic), education (in years), family income (in $10 000s), and area socioeconomic status. We also included frequency of alcohol consumption per week (0 day, 1 day, 2 days, 3 days and more), smoking status (smoker, nonsmoker), depression (continuous, measured by an 8-item subset of the 20-item Center for Epidemiologic Studies Depression Scale[49]), frequency of moderate-to-vigorous physical activity (more than once a week, once a week, less than once a week), hypertension (yes, no), and diabetes (yes, no) as covariates because these factors have been known to impact CVD incidence.[20] Age, sex, race and ethnicity, education, frequency of alcohol consumption, smoking status, depression, frequency of moderate-to-vigorous physical activity, hypertension, and diabetes were defined based on self-reports at the 2006 data collection. Family income was measured at each data collection point as the sum of self-reported labor income, income from assets, and income from any other sources defined by the HRS. Area socioeconomic status was calculated by summating and normalizing the *z*-scores of 5 census tract-level socioeconomic indicators representing wealth, income, education, and occupation based on geocoded addresses at each data collection point, which were utilized to create neighborhood socioeconomic status in past literature[50–54]: (1) median household income, (2) median value of housing units, (3) the percentage of adults 25 years of age or older who had completed high school, (4) the percentage of adults 25 years of age or older who had completed college, and (5) the percentage of employed persons 16 years of age or older in executive, managerial, or professional specialty occupations. Family income and area socioeconomic status were time-dependent to account for change in family and neighborhood socioeconomic status over time.

Statistical Analysis

Descriptive statistics were used to assess demographic and health-related characteristics. We also conducted a bivariate analysis using a χ^2 test and *t* test to compare sample characteristics across racial and ethnic groups. Cox proportional hazards models were estimated including the 3 measures of social environments as exposures and CVD incidence as an outcome variable after controlling for individual sociodemographic factors (age, sex, and education), economic status (family income), behavioral and biomedical risk and protective factors (alcohol consumption, smoking status, depression, frequency of moderate-to-vigorous physical activity, hypertension, and diabetes), and area socioeconomic status. We first tested whether the assumption of proportionality is met. The results consistently indicate that the assumption is not violated; thus, the use of survival analysis is appropriate. In the Cox proportional hazards models, social environment measures, family income, and area socioeconomic status were considered time-dependent by splitting each study respondent into several observations over time intervals, providing an observation for each unique location of residence and year of exposure.[55] Records were censored if a respondent had no CVD event by the 2016 data collection, withdrew from the study, or died. Survival time was calculated by subtracting the year of CVD or censoring from the year when the 2006 data collection was conducted.

Cox proportional hazards models were built sequentially using a series of models, to determine the "final" model. Initially, we included the main exposures and covariates one at a time in separate bivariate models. Within the bivariate models, we assessed higher-ordered (up to cubic) forms of each exposure/covariate to capture potential nonlinearity between exposure/covariate and CVD incidence, and we removed nonsignificant terms. Second, we included all the covariates and evaluated the significant functional form of covariates based on model fits. The best-fitted model included squared continuous age, sex, continuous years of education, continuous family income, dichotomized smoking status, continuous depression level, continuous moderate-to-vigorous physical activity level, dichotomized hypertension, dichotomized diabetes, and continuous area socioeconomic status. The third model included 3 social environment measures while adjusting for individual- and neighborhood-level covariates. In addition, we tested an interaction between race and ethnicity and 3 social environments measures. We found a significant interaction effect between race and ethnicity and perceived neighborhood social cohesion, but not between race and ethnicity and perceived neighborhood physical disorder and between race and ethnicity and local crime rates. Although the interaction effects by race and ethnicity were not significant for perceived neighborhood physical disorder and local crime rates, past literature has shown differential neighborhood effects by race and ethnicity.[39–41] Also, residential racial and ethnic segregation is likely to lead to dramatic differences in social environments according to race and ethnicity, which may result in racial and ethnic differences in the neighborhood effects on health. To account for racial and ethnic differences in the neighborhood effects on health, we stratified the data by race and ethnicity in all analyses. In addition, because early release files for HRS 2018 are available, we conducted a sensitivity analysis to assess the effect of social environments on CVD incidence over 12 years of follow-up (2006–2018). Throughout the model fitting process, the Akaike information criterion and the Bayesian information criterion were assessed to provide evidence for the fit of the model, with lower

Akaike information criterion and Bayesian information criterion values indicating a better model fit. A complex sample design was considered in these univariate, bivariate, and survival analyses.

Existing statistical software does not allow a multilevel survival analysis with time-varying exposures/covarites while also considering both the complex sample design and data clustering at the neighborhood level. Therefore, we conducted a survival analysis while considering the complex sample design as described above and, as a sensitivity analysis, we conducted a multilevel analysis while considering data clustering at the census tract level, but not considering the complex sample design, because respondents were nested within census tracts with a relatively substantial intraclass correlation coefficient (intraclass correlation coefficient >0.10) and we included census tract-level covariates. We did not conduct 3-level multilevel modeling (ie, level 1=individuals, level 2=census tracts, level 3=counties) because of the low intraclass correlation coefficient between counties (intraclass correlation coefficient <0.01). Analyses were conducted using the StataSE 16 software program.

RESULTS

Table 1 presents sample characteristics measured at the 2006 data collection point. The sample consisted of 42% men and 58% women. More than three-quarters of respondents self-identified their race and ethnicity as non-Hispanic White, and 9% self-identified as non-Hispanic Black. The average years of education was 13 years, and the average annual income was $80 000. One-sixth of respondents were a current smoker, one-fifth drank alcohol 3 days and more per week, and two-thirds engaged in moderate-to-vigorous physical activity more than once a week. About half had hypertension, and one-sixth had diabetes. In comparison to non-Hispanic White respondents, a greater proportion of non-Hispanic Black respondents had a higher depression score (Black: 1.6, Hispanic: 2.0, White: 1.2), engaged in moderate-to-vigorous physical activity less than once a week (Black: 27%, Hispanic: 24%, White: 19%), and had hypertension (Black: 63%, Hispanic: 46%, White: 45%) or diabetes (Black: 23%, Hispanic: 21%, White: 13%).

Table 2 provides results of Cox proportional hazards modeling. We found that perceived neighborhood social cohesion, perceived neighborhood physical disorder, and local crime were not significantly associated with CVD incidence in the total sample. In the race and ethnicity-stratified models, we observed that perception of neighborhood social cohesion had a significant inverse association with CVD incidence only for non-Hispanic Black respondents (hazard ratio [HR], 0.80 [95% CI, 0.66–0.97]) when adjustment was made for age, sex, education, family income, and area socioeconomic status. Additional adjustment for behavioral and biomedical factors attenuated the magnitude of the association, but the association remained statistically significant (Black respondents: HR, 0.82 [95% CI, 0.68–1.00]). Perception of neighborhood physical disorder and local crime were not significantly associated with CVD incidence across the 3 racial and ethnic groups.

As shown in Table S1, a sensitivity test shows that the results of 12-year follow-up analysis were similar to the results of 10-year follow-up analysis. Three measures of social environments were not significantly associated with CVD incidence in the total sample, Hispanic respondents, and non-Hispanic White respondents. Perceived neighborhood social cohesion was significantly associated with CVD incidence among non-Hispanic Black respondents (HR, 0.81 [95% CI, 0.67–0.98]) when adjusting for age, sex, education, income, and area socioeconomic status. With adjustment for behavioral and biomedical factors, the association remained significant among non-Hispanic Black respondents (HR, 0.82 [95% CI, 0.68–0.99]).

As a second sensitivity analysis, we conducted a multilevel survival analysis while accounting for data clustering at the census tract level, not adjusting for the complex study design (Table S2). Results showed that perceived neighborhood social cohesion was significantly associated with CVD incidence among non-Hispanic Black respondents (HR, 0.83 [95% CI, 0.71–0.98]) and Hispanic respondents (HR, 0.81 [95% CI, 0.65–1.00]). Perceived neighborhood physical disorder was also significantly associated with CVD incidence among non-Hispanic Black respondents (HR, 1.18 [95% CI, 1.01–1.38]) and Hispanic respondents (HR, 1.28 [95% CI, 1.03–1.58]). Local crime rates were significantly associated with CVD incidence across 3 racial and ethnic groups.

DISCUSSION

This study extends past literature by measuring time-varying variables of perceived neighborhood social cohesion, perceived neighborhood physical disorder, and objectively measured local crime and investigating their associations with CVD incidence over 11 years of follow-up (2006–2016). Our study findings showed that perceived neighborhood social cohesion was significantly associated with risk of CVD incidence among Black respondents, after adjustment for individual-level demographic, behavioral, and biomedical factors, and area socioeconomic status. In addition, in the results of multilevel survival analysis not adjusting for complex sample designs, for Black and Hispanic respondents,

Table 1. Sociodemographic Characteristics of Respondents at the 2006 Data Collection (N=8826)

Characteristics	Total sample unweighted N (%)	Racial and ethnic subgroups			
		NH White (n=6883)	NH Black (n=1163)	Hispanic (n=780)	*P* value
Age, y (M±SE)	63.9±0.16	64.1±0.20	63.2±0.39	62.5±0.69	0.03
Sex					0.12
Men	3217 (42.0)	2564 (42.4)	379 (38.9)	274 (41.0)	
Women	5609 (58.0)	4319 (57.6)	784 (61.1)	506 (59.0)	
Years of education (M±SE)	13.2±0.07	13.6±0.05	12.4±0.17	9.9±0.32	<0.001
Family income (in $10 000) (M±SE)	8.0±0.20	8.6±0.23	4.7±0.21	4.5±0.37	<0.001
Number of days drinking per week					<0.001
0 d	5575 (60.2)	4125 (57.9)	867 (72.7)	583 (71.7)	
1 d	1016 (12.6)	825 (13.0)	102 (8.9)	89 (12.9)	
2 d	573 (6.9)	456 (7.0)	70 (7.0)	47 (6.2)	
3 d and more	1662 (20.2)	1477 (22.1)	124 (11.5)	61 (9.2)	
Current smoker	1217 (14.3)	885 (13.7)	222 (20.8)	110 (13.4)	<0.001
Depression (M±SE, range 0–8)	1.3±0.03	1.2±0.03	1.6±0.09	2.0±0.13	<0.001
Moderate-to-vigorous physical activity					<0.001
More than once a week	5954 (68.7)	4780 (69.9)	672 (59.8)	502 (66.0)	
Once a week	1012 (11.6)	763 (11.5)	165 (13.5)	84 (9.9)	
Less than once a week	1860 (19.7)	1340 (18.6)	326 (26.7)	194 (24.2)	
Presence of hypertension	4440 (46.7)	3290 (45.0)	772 (63.1)	378 (46.4)	<0.001
Presence of diabetes	1358 (14.1)	890 (12.6)	287 (23.1)	181 (21.0)	<0.001
Perceived neighborhood social cohesion (M±SE, range 1–7)	5.5±0.03	5.6±0.03	5.0±0.07	5.2±0.11	<0.001
Perceived physical disorder (M±SE, range 1–7)	3.2±0.02	3.2±0.02	3.6±0.07	3.7±0.06	<0.001
Local crime rates per 100 000 residents (M±SE)	5.2±0.25	4.5±0.24	11.2±0.60	6.2±0.34	<0.001

M indicates weighted mean; NH, non-Hispanic; and SE, standard error. All characteristics were measured at the 2006 data collection point. We obtained *P* values from χ^2 tests for categorical variables (ie, sex, number of days drinking per week, current smoker, moderate-to-vigorous physical activity, presence of hypertension, and presence of diabetes) and ANOVA for continuous variables (ie, age, years of education, family income, and depression). Nonstandardized perceived neighborhood social cohesion and physical disorder were used in Table 1.

greater neighborhood social cohesion was a protective factor of CVD, and greater neighborhood physical disorder was a risk factor of CVD incidence, after adjustment for individual-level demographic, behavioral, and biomedical factors, and area socioeconomic status. On the other hand, all 3 measures of social environments were not significantly associated with CVD incidence for White respondents. The findings are consistent with a study conducted by Sprung et al.[41] reporting a significant association between perceived social environments and cardiometabolic risk (ie, blood pressure and glucose level) among Black respondents but not among White respondents. The disparate effect of social environments on CVD incidence by race and ethnicity is possibly because social environments play a protective role in discriminatory situations for racial and ethnic minority groups who face stressors related to discrimination and systematic racism in their daily lives.[37,56] Residing in neighborhoods with greater social cohesion, lower physical disorder, and greater safety may buffer anxiety, depression, and distress from racism and discrimination.[57–59] Also, favorable features of the social environment may play an enabling role in the development of self-efficacy, which is considered significant to facilitate engagement in healthy behaviors, such as physical activity.[59,60]

We also found that neighborhood safety measured by local crime rates was not associated with CVD incidence in the total sample and across all racial and ethnic groups, which is consistent with some previous studies.[19,61,62] For example, Powell-Wiley et al.[19] reported that objectively measured neighborhood safety was not associated with adiposity while perception of safety was related to lower body mass index over 10 years. This is possibly because we defined areas at a large scale (ie, county level), which is likely to mask considerable spatial heterogeneity within the county.[63] The explanation is consistent with past studies reporting a stronger neighborhood effect on health when measured at a smaller level.[64,65] Another potential reason for the insignificant association between local crime and CVD incidence might be the relative

Table 2. Results of Models Assessing the Effects of Social Environments on CVD Incidence: United States, 2006 to 2016 (N=8826)

Variables	Adjusted for age, sex, education, and income*		Adjusted for age, sex, education, income, and area socioeconomic status†		Adjusted for age, sex, education, income, area socioeconomic status, and behavioral and biomedical factors‡	
	HR	95% CI	HR	95% CI	HR	95% CI
All race and ethnicity						
Perceived neighborhood social cohesion	0.94	0.85–1.04	0.94	0.85–1.04	0.97	0.88–1.08
Perceived physical disorder	1.07	0.97–1.18	1.08	0.98–1.19	1.07	0.97–1.18
Local crime	0.96	0.88–1.03	0.95	0.88–1.03	0.95	0.87–1.03
Non-Hispanic White						
Perceived neighborhood social cohesion	0.96	0.85–1.08	0.96	0.85–1.08	1.00	0.89–1.13
Perceived physical disorder	1.05	0.93–1.18	1.06	0.94–1.20	1.05	0.94–1.18
Local crime	0.93	0.84–1.02	0.93	0.84–1.02	0.92	0.83–1.01
Non-Hispanic Black						
Perceived neighborhood social cohesion	0.80*,§	0.66–0.97	0.80*,§	0.66–0.97	0.82*,§	0.68–1.00
Perceived physical disorder	1.09	0.95–1.25	1.10	0.97–1.26	1.10	0.97–1.26
Local crime	0.99	0.88–1.12	0.98	0.86–1.11	0.99	0.88–1.10
Hispanic						
Perceived neighborhood social cohesion	0.89	0.64–1.25	0.90	0.64–1.26	0.90	0.64–1.28
Perceived physical disorder	1.26	0.95–1.68	1.25	0.96–1.69	1.23	0.90–1.68
Local crime	1.14	0.75–1.74	1.14	0.75–1.73	1.19	0.80–1.77

CVD indicates cardiovascular disease; and HR, hazard ratio.

*Education was calculated in years of schooling at the 2006 data collection time. Family income was calculated at each data collection point as the sum of self-reported labor income, income from assets, and income from any other sources and was considered time-dependent.

†Area socioeconomic status was calculated by summating and normalizing the *z*-scores of 5 census tract-level socioeconomic indicators representing wealth, income, education, and occupation, based on geocoded addresses at each data collection point: (1) median household income, (2) median value of housing units, (3) the percentage of adults 25 years of age or older who had completed high school, (4) the percentage of adults 25 years of age or older who had completed college, and (5) the percentage of employed persons 16 years of age or older in executive, managerial, or professional specialty occupations. Area socioeconomic status was considered time-dependent.

‡Behavioral and biomedical factors included alcohol consumption, current smoking status (yes, no), depression symptoms, frequencies of moderate-to-vigorous physical activity (categorized as more than once a week, once a week, less than once a week), presence or absence of hypertension, and presence or absence of diabetes.

§Statistically significant result at α 0.05.

importance of perceived social environments over objective social environment features. As De Donder et al.[66] described that feelings of unsafety is a result of various daily insecurities, rather than a single result of crime, county-level crime rates may not fully capture what residents actually experience in their daily lives. In addition, because of potential underreporting in citizens' reports of other crime types (such as robbery, assault, burglary, theft, and motor vehicle theft) in the Uniform Crime Reports data files, we operationalized local crime as murder rates, which is a very restrictive definition. Thus, to clarify underlying reasons of insignificant association between local crime and CVD incidence, future research needs to use a broader definition of local crime, to compare the effect of crime measures across different neighborhood sizes (eg, comparing 1-km buffer, block group, census tract, and county), and to investigate mediating mechanisms how perceived and objectively measured social environments impact CVD incidence.

Our findings have several implications for policy and research. It was found that social environments are important to racial and ethnic minority groups who experience systematic discrimination and often live in a deprived neighborhood. The findings suggest that programs and policies aimed to promote cardiovascular health need to focus on promoting perceived social environments of minority communities. For example, regular community gatherings and health fairs can be an approach to promote social cohesion in the neighborhoods, and community vitalization programs can be conducted to remove neighborhood physical disorder. In order to inform targeted public health policy, further research is warranted to examine the psychological, biological, and behavioral mechanisms of how social environments affect CVD incidence of racial and ethnic minority groups.

This study had several limitations. There are important features of neighborhood environments associated with health that this study could not capture such as

segregation, inequality, and built environments. Further investigations are needed using a comprehensive set of neighborhood environment measures. In addition, we have some methodological limitations. Asian and other ethnic and racial groups were excluded from the analysis because of small sample size. Also, perceived neighborhood social cohesion and physical disorder were measured every 4 years, which would not be adequate for capturing rapid and extensive neighborhood changes. Because 271 of 758 counties (36%) and 2028 of 3798 census tracts (53%) had only 1 participant, we did not aggregate the individual-level measures of neighborhood social cohesion and physical disorder to the census tract or county level; thus, we were not able to examine a difference between individual perceptions and aggregated perceptions in the association between social environments and CVD incidence. Future research needs to investigate whether the effect of individual perceptions of social environments on CVD incidence is different from the effect of aggregated perceptions of social environments. In addition, because multilevel Cox proportional hazards models failed to converge when the complex sample design was also considered, we conducted nonmultilevel Cox proportional hazards modeling while considering the complex sample design (as the main analysis) and multilevel Cox proportional hazards modeling while not considering the complex sample design (as a sensitivity analysis). Further research is needed to consider a complex sample design and nested data structure in 1 model. Finally, as mentioned above, county-level crime rate might be too broad to capture residents' perceptions of neighborhood safety. Measuring the effect of neighborhood safety at different levels (eg, census tracts, block groups, 1-km buffer) on CVD incidence needs to be studied in future research.

CONCLUSIONS

Despite these limitations, this study extends current understanding by showing the association between time-variant measures of social environment and CVD incidence by race and ethnicity. Our study findings suggest that efforts to intervene on social environments might benefit racial and ethnic minority groups' cardiovascular health. Given evidence that perceptions of social environments are associated with risk of CVD incidence for certain racial and ethnic groups, researchers and policymakers should identify different pathways through which favorable social environments benefit cardiovascular health by racial and ethnic groups.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Tables S1–S2.

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SUPPLEMENTAL MATERIAL

Table S1. Results of sensitivity analysis assessing the effects of social environments on CVD incidence: United States, 2006-2018 (N=8,826)

Variables	Adjusted for age, sex, education, and income*		Adjusted for age, sex, education, income, and area socioeconomic status†		Adjusted for age, sex, education, income, area socioeconomic status, and behavioral and biomedical factors‡	
	HR	95% CI	HR	95% CI	HR	95% CI
All race/ethnicity						
Perceived neighborhood social cohesion	0.97	0.88-1.07	0.97	0.88-1.07	1.00	0.91-1.11
Perceived physical disorder	1.05	0.96-1.16	1.06	0.97-1.17	1.06	0.96-1.16
Local crime	0.97	0.90-1.04	0.96	0.90-1.04	0.96	0.89-1.04
Non-Hispanic White						
Perceived neighborhood social cohesion	1.00	0.89-1.12	1.00	0.90-1.13	1.05	0.93-1.18
Perceived physical disorder	1.03	0.92-1.05	1.04	0.93-1.16	1.03	0.93-1.15
Local crime	0.95	0.87-1.04	0.95	0.87-1.04	0.95	0.86-1.04
Non-Hispanic Black						
Perceived neighborhood social cohesion	**0.80****	0.66-0.97	**0.81***	0.67-0.98	**0.82***	0.68-0.99
Perceived physical disorder	1.08	0.92-1.26	1.10	0.95-1.27	1.11	0.96-1.28
Local crime	0.97	0.87-1.09	0.96	0.85-1.08	0.96	0.86-1.07
Hispanic						
Perceived neighborhood social cohesion	0.88	0.64-1.20	0.88	0.64-1.21	0.88	0.63-1.22
Perceived physical disorder	1.24	0.93-1.66	1.24	1.02-1.67	1.22	1.01-1.65
Local crime	1.02	0.68-1.55	1.02	0.68-1.54	1.05	0.71-1.55

* Education was calculated in years of schooling at the 2006 data collection time. Family income was calculated at each data collection point as the sum of self-reported labor income, income from assets, and income from any other sources and was considered time-dependent.

† Area socioeconomic status was calculated by summating and normalizing the z-scores of five census tract-level socioeconomic indicators representing wealth, income, education, and occupation, based on geocoded addresses at each data collection point: (1) median household income, (2) median value of housing units, (3) the percentage of adults 25 years of age or older who had completed high school, (4) the percentage of adults 25 years of age or older who had completed college, and (5) the percentage of employed persons 16 years of age or older in executive, managerial, or professional specialty occupations. Area socioeconomic status was considered time-dependent.

‡ Behavioral and biomedical factors included alcohol consumption, current smoking status (yes, no), depression symptoms, frequencies of moderate-to-vigorous physical activity (categorized as more than once a week, once a week, less than once a week), presence or absence of hypertension, and presence or absence of diabetes.

HR indicates hazard ratio, and CI indicates confidence interval. Bold indicates a statistically significant result at alpha 0.05.

Table S2. Results of multilevel survival analysis assessing the effects of social environments on CVD incidence when the complex sample design was not adjusted: United States, 2006-2016 (N=8,826)

Variables	Adjusted for age, sex, education, and income*		Adjusted for age, sex, education, income, and area socioeconomic status†		Adjusted for age, sex, education, income, area socioeconomic status, and behavioral and biomedical factors‡	
	HR	95% CI	HR	95% CI	HR	95% CI
All race/ethnicity						
Perceived neighborhood social cohesion	**0.92***	0.86-0.99	**0.92***	0.86-0.98	0.95	0.88-1.01
Perceived physical disorder	1.05	0.98-1.13	1.07	0.99-1.15	1.06	0.99-1.14
Local crime	1.00	0.94-1.07	1.00	0.94-1.06	1.00	0.94-1.06
Non-Hispanic White						
Perceived neighborhood social cohesion	0.97	0.89-1.05	0.97	0.89-1.05	1.00	0.92-1.08
Perceived physical disorder	1.00	0.92-1.09	1.02	0.94-1.10	1.02	0.94-1.10
Local crime	0.97	0.90-1.05	0.97	0.90-1.05	0.96	0.88-1.03
Non-Hispanic Black						
Perceived neighborhood social cohesion	**0.80***	0.68-0.95	**0.81***	0.69-0.95	**0.83***	0.71-0.98
Perceived physical disorder	**1.17***	1.00-1.37	**1.19***	1.02-1.39	**1.18***	1.01-1.38
Local crime	1.05	0.94-1.17	1.04	0.93-1.16	1.05	0.94-1.18
Hispanic						
Perceived neighborhood social cohesion	**0.80***	0.64-0.99	**0.80***	0.64-1.00	**0.81***	0.65-1.00
Perceived physical disorder	**1.30***	1.05-1.61	**1.29***	1.04-1.60	**1.28***	1.03-1.58
Local crime	1.25	0.91-1.71	1.24	0.91-1.71	1.26	0.92-1.73

* Education was calculated in years of schooling at the 2006 data collection time. Family income was calculated at each data collection point as the sum of self-reported labor income, income from assets, and income from any other sources and was considered time-dependent.

† Area socioeconomic status was calculated by summating and normalizing the z-scores of five census tract-level socioeconomic indicators representing wealth, income, education, and occupation, based on geocoded addresses at each data collection point: (1) median household income, (2) median value of housing units, (3) the percentage of adults 25 years of age or older who had completed high school, (4) the percentage of adults 25 years of age or older who had completed college, and (5) the percentage of employed persons 16 years of age or older in executive, managerial, or professional specialty occupations. Area socioeconomic status was considered time-dependent.

‡ Behavioral and biomedical factors included alcohol consumption, current smoking status (yes, no), depression symptoms, frequencies of moderate-to-vigorous physical activity (categorized as more than once a week, once a week, less than once a week), presence or absence of hypertension, and presence or absence of diabetes.

HR indicates hazard ratio, and CI indicates confidence interval. Bold indicates a statistically significant result at alpha 0.05.