Relationship of Neighborhood Greenness to Heart Disease in 249 405 US Medicare Beneficiaries

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***Background*—**Nature exposures may be associated with reduced risk of heart disease. The present study examines the relationship between objective measures of neighborhood greenness (vegetative presence) and 4 heart disease diagnoses (acute myocardial infarction, ischemic heart disease, heart failure, and atrial fibrillation) in a population-based sample of Medicare beneficiaries.

***Methods and Results*—**The sample included 249 405 Medicare beneficiaries aged 65 years and older whose location (ZIP+4) in Miami-Dade County, Florida, did not change from 2010 to 2011. Analyses examined relationships between greenness, measured by mean block-level normalized difference vegetation index from satellite imagery, and 4 heart disease diagnoses. Hierarchical regression analyses, in a multilevel framework, assessed the relationship of greenness to each heart disease diagnosis, adjusting successively for individual sociodemographics, neighborhood income, and biological risk factors (diabetes mellitus, hypertension, and hyperlipidemia). Higher greenness was associated with reduced heart disease risk, adjusting for individual sociodemographics and neighborhood income. Compared with the lowest tertile of greenness, the highest tertile of greenness was associated with reduced odds of acute myocardial infarction by 25% (odds ratio, 0.75; 95% CI, 0.63–0.90), ischemic heart disease by 20% (odds ratio, 0.80; 95% CI, 0.77–0.83), heart failure by 16% (odds ratio, 0.84; 95% CI, 0.80–0.88), and atrial fibrillation by 6% (odds ratio, 0.94; 95% CI, 0.87–1.00). Associations were attenuated after adjusting for biological risk factors, suggesting that cardiometabolic risk factors may partly mediate the greenness to heart disease relationships.

***Conclusions*—**Neighborhood greenness may be associated with reduced heart disease risk. Strategies to increase area greenness may be a future means of reducing heart disease at the population level. **(*J Am Heart Assoc*. 2019;8:e010258. DOI: 10.1161/JAHA.118.010258.)**

Key Words: cardiovascular disease • greenness • heart disease • Medicare beneficiaries • natural environment • neighborhood environment • population health

Cardiovascular diseases (CVDs) including heart disease continue to be the leading cause of death both in the United States and worldwide.[1,2] Currently, there are well-established guidelines for preventing CVD—including lifestyle factors such as physical activity, diet, nonsmoking, and body mass index, and biomedical indicators such as blood pressure, cholesterol, and blood glucose.[3] At the same time, there is a growing awareness that environmental factors, such as air pollution,[4] and characteristics of the built and social environment[5–7] may also be important modifiable risk and/or protective factors for preventing CVD.

Neighborhood greenness or vegetative presence is an emerging risk and/or protective factor for health outcomes,[8–16] including CVD.[17–20] It has been theorized that greenness including tree canopy and green spaces may promote cardiovascular health by increasing physical activity, social interaction, air quality, heat regulation, restoration from mental fatigue, and/or stress reduction.[8,9,21–29] Indeed, recent findings suggest that greenness

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Clinical Perspective

What Is New?

- This is the first study to document the relationship between neighborhood greenness and heart disease among Medicare beneficiaries using objective measures of heart disease and greenness at the block level.
- Because this method uses nationally available data from the Centers for Medicare & Medicaid Services to determine heart disease diagnoses and National Aeronautics and Space Administration satellite imagery to determine greenness at the block level, the study can be replicated/repeated in any neighborhood in the United States.

What Are the Clinical Implications?

- This study identifies a potential new protective factor, block-level greenness, that may reduce heart disease at the population level.
- Strategies to increase greenness, such as tree planting, may reduce the risk for heart disease, perhaps by increasing physical activity opportunities.

may be related to increased levels of physical activity,[21–30] reduced body mass index and risk for overweight/obesity,[26,31–33] reduced exposure to air pollution,[25] and reduced stress symptoms,[28,29] and a reduced risk of cardiometabolic conditions such as diabetes mellitus, hypertension, and hyperlipidemia,[11,34] as well as CVD.[17–19]

The current study examines whether mean block-level greenness (measured by the normalized difference vegetation index [NDVI] from satellite imagery)[35,36] is related to odds of CVD diagnoses[37] in a population-based sample of US Medicare beneficiaries aged 65 years and older.[11] Prior studies in this area have been limited,[17–19] and this is the first study to examine the relationship of block-level greenness (NDVI) and specific heart disease diagnoses.[37]

Methods

Study Design

A cross-sectional study was conducted to investigate the relationship between neighborhood greenness (mean NDVI at the Census block level) and the odds of each of 4 types of CVD (acute myocardial infarction [AMI], ischemic heart disease [IHD], heart failure [HF], and atrial fibrillation [AF]) among Medicare beneficiaries aged 65 years and older in Miami-Dade County, Florida, whose location did not change from 2010 to 2011.[11] Additionally, the analyses examined the relationship between neighborhood greenness and overall odds of *any* form of heart disease, defined as having any of the 4 types of CVD described above. Descriptive analyses were used to find the pattern of CVD rates across different levels of neighborhood greenness, followed by 3 rigorous sets of hierarchical regression models examining the relationship between CVDs and neighborhood greenness, before and after successive addition of covariates in the model (unadjusted, individual sociodemographics, and neighborhood income). A fourth, final model further adjusted for biological risk factors (diabetes mellitus, hypertension, and hyperlipidemia).

The data, analytic methods, and study materials will not be made available by the authors to other researchers for purposes of reproducing the results or replicating the procedures, because of the Data Privacy Board requirements of the US Centers for Medicare & Medicaid Services (CMS), which limit data sharing. However, these CMS data may be requested directly from CMS' Research Data Assistance Center at https://www.resdac.org/. The satellite imagery used in this study may be requested at https://asterweb.jpl.nasa.gov/.

Data

Data were obtained for this retrospective cohort study from the CMS' Master Beneficiary Summary File, which provided for each beneficiary annual data on each of the 4 cardiovascular health outcomes, age, sex, race/ethnicity, and location for the calendar years 2010–2011 (available at https://www.resdac.org). The CMS Master Beneficiary Summary File Chronic Conditions Segment provides indications of 27 chronic conditions, using CMS' chronic conditions algorithms,[37] based on Medicare claims of all types for each beneficiary in a calendar year. The present study assessed the relationship between neighborhood greenness (NDVI) and each of 4 types of CVD in 2011—AMI, IHD, HF, and AF—as well as the overall likelihood of having *any* of these 4 types of CVD.

US National Aeronautics and Space Administration Advanced Spaceborne Thermal Emission and Reflection Radiometer satellite imagery at a 15×15-meter spatial resolution was used to calculate greenness or vegetative presence by NDVI, a validated measure of neighborhood greenness.[35,36,38] Mean NDVI at the block level was assessed, with continuous measurements that ranged from -1 to $+1$, with higher values indicating more greenness.[35,36] Mean NDVI was derived for each of the 36 563 Miami-Dade County Census blocks for 2011 and was categorized into 3 levels to create meaningful exposure categories based on tertiles of block-level greenness: low NDVI (-0.40 to -0.06, the lowest third), middle NDVI (-0.06 to 0.006), and high NDVI (0.006–0.429).[11]

US Census Bureau 2011 data provided neighborhood median household income at the level of the Census block group. For analytic purposes, neighborhood median household income was a continuously measured variable (measured in thousands of dollars).

The final study sample (Figure) was derived in stages, as described elsewhere.[11] Starting with the 2011 CMS Master Beneficiary Summary File for Miami-Dade County, of 407 296 unique Medicare beneficiaries, the following exclusions were made. First, beneficiaries who lived outside of Miami-Dade County were excluded (n=11 507), as were those who died (n=14 296), had end-stage renal disease as the reason for enrollment (n=3572), were younger than 65 years or born before 1900 (n=64 109), could not be matched to a specific ZIP code+4 location associated with a Census block (n=14 401), and were members of an ethnic/racial group comprising <1% of the Miami-Dade County senior population (n=12 132). Finally, beneficiaries whose location changed from 2010 to 2011 were excluded (n=34 584), as well as those with nursing home claims, who may have been in a nursing home for all or part of the year, in which case their location may have been a billing address rather than an actual residence (n=3650). This resulted in a final cohort of 249 405 Medicare beneficiaries, aged 65 years and older who had the same location (based on ZIP code+4-digit locator) across 2 calendar years (2010–2011). ZIP+4 data from CMS data were linked to a Census block for each beneficiary, using GeoLytics ZIP+4 software (GeoLytics, Inc), which provides the area centroid of the ZIP+4 with latitude and longitude coordinates, and assigns the corresponding 2010 Census block, block group, and tract identification numbers.[39] This study was approved by the University of Miami's institutional review board and CMS' privacy board.

Results

Statistical Analysis

Univariate descriptive analyses were conducted to observe the pattern of individual sociodemographics (age, sex, and race/ethnicity), neighborhood median household income, the CVD outcomes, and biological risk factors (diabetes mellitus, hypertension, and hyperlipidemia) in the overall study sample, as well as across tertiles of NDVI.

To fit the hierarchical structure of data, multilevel logistics regressions were run using SAS version 9.3 software (SAS Institute) with dichotomous variables presence/absence of cardiovascular conditions as outcomes and NDVI tertiles (low NDVI, the lowest tertile as reference) as predictors. A generalized estimating equation model with the assumption of compound symmetric working correlation structure was used to specify the hierarchical models. Specifically, neighborhood median household income was included in the model at the Census block-group level (consisting of multiple Census blocks, and the smallest geographic scale at which this variable is available from the US Census Bureau); mean NDVI was included in the model at the Census block level (ie, for a single block, nested within the block-group level, above); and age, sex, race, and ethnicity were included at the individual level (ie, nested within block). To test the hypotheses that block-level greenness (measured by NDVI) is related to each of the CVD outcomes, 4 multilevel logistics regression analyses were run, one for each of AMI, IHD, HF, and AF, adjusting for potential explanatory factors. Model 1 was unadjusted, model 2 was adjusted for individual-level sociodemographics as covariates (age, sex, and race/ethnicity), and model 3 was additionally adjusted for a block-group level covariate (neighborhood median household income). In addition, to assess for possible attenuation of greenness impact on CVD outcomes, a fourth model (model 4) further added biological risk factors of diabetes mellitus, hypertension, and hyperlipidemia.

Of the 249 405 Miami-Dade Medicare beneficiaries, we found that the race/ethnicity composition in each tertile of NDVI well represents the sociodemographic pattern of Miami-Dade county—a multiracial metropolitan area with a large Hispanic population—and such distributions of NDVI across racial/ethnic levels correlated with median household incomes in each NDVI tertile. There were significantly more Hispanics in low-NDVI neighborhoods (80.3%) compared with high-NDVI neighborhoods (47.7%, P<0.0001). Average median household incomes were lowest in low-NDVI neighborhoods and highest in high-NDVI neighborhoods ($40 100 versus $65 800, P<0.0001). Additionally, rates of all biological risk factors and cardiovascular outcomes were generally lower with progressively higher tertiles of NDVI (P<0.001) (Table 1).

We observed that the higher level of greenery as indicated by upper tertiles of mean NDVI measurements was generally associated with a notable reduction in the odds of all 4 types of cardiovascular-related chronic conditions (Table 2).

The unadjusted models (model 1) show that, compared with low NDVI, high NDVI is associated with lower odds of AMI (odds ratio [OR], 0.70; 95% CI, 0.58–0.83), IHD (OR, 0.75; 95% CI, 0.72–0.78), and HF (OR, 0.77; 95% CI, 0.74–0.81)—as well as *any* form of heart disease (OR, 0.76; 95% CI, 0.74–0.79). In addition, compared with low NDVI, medium NDVI is associated with lower odds of AF (OR, 0.73; 95% CI, 0.68–0.78), as well as *any* form of heart disease (OR, 0.93; 95% CI, 0.90–0.96).

In the models adjusting for individual-level sociodemographics (model 2), the results of the analyses for all cardiovascular outcomes are consistent with the unadjusted models (model 1, reported above).

Of greatest interest for the present analyses are the results for the main model (model 3), which adjusted for individual sociodemographics and neighborhood income. These main analyses showed that compared with low NDVI, high NDVI was associated with statistically significantly (P<0.01) lower odds of AMI (OR, 0.75; 95% CI, 0.63–0.90), IHD (OR, 0.80;

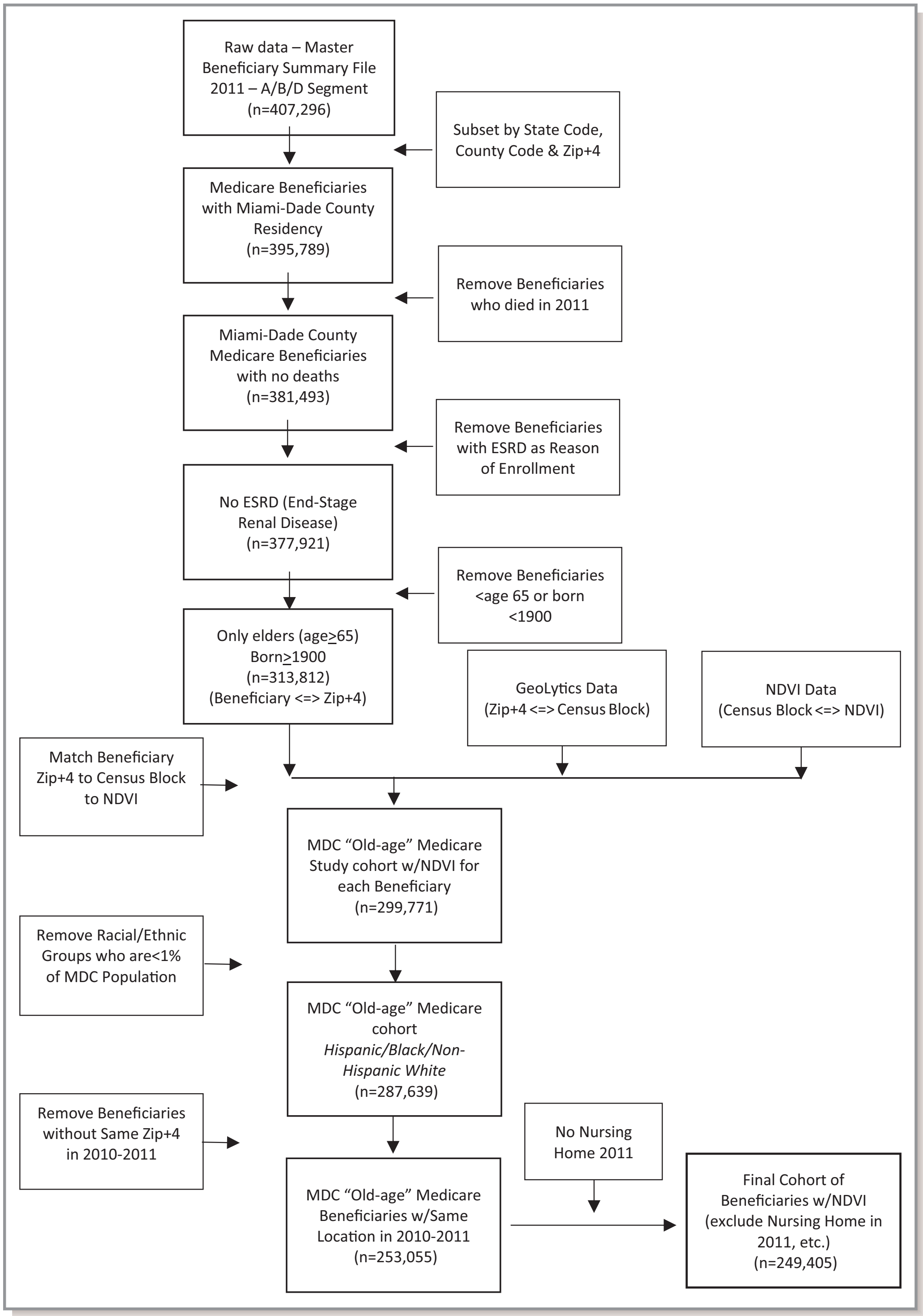

Figure. Flow diagram for deriving final cohort of 249 405 Medicare beneficiaries aged 65 years and older with the same location in Miami-Dade County, Florida, in 2010–2011. ESRD indicates end-stage renal disease; MDC, Miami-Dade County; NDVI, normalized difference vegetation index. Reproduced in part from Brown et al[11] with permission. Copyright ©2016, Elsevier.

95% CI, 0.77–0.83), HF (OR, 0.84; 95% CI, 0.80–0.88), and *any* form of heart disease (OR, 0.81; 95% CI, 0.78–0.84), as well as a marginally significantly lower odds of AF (OR, 0.94; 95% CI, 0.87–1.00 [P=0.067]). Additionally, compared with low NDVI, medium NDVI was associated with lower odds of AF (OR, 0.91; 95% CI, 0.84–0.97 [P<0.01]).

To test for potential attenuation of the impact of greenness on each of the 4 CVDs, when adjusting for biological risk

Table 1. Descriptive Statistics for the Overall Sample and by Neighborhood Greenness Level (ie, Lowest, Middle, and Highest Tertiles on Block-Level NDVI)

Variable	Overall Sample (−0.40 to 0.429) (All NDVI)		Low NDVI (−0.40 to −0.06) (Lowest Tertile on NDVI)		Medium NDVI (−0.06 to 0.006) (Middle Tertile on NDVI)		High NDVI (0.006–0.429) (Highest Tertile on NDVI)		F (χ^2) Test	*P* Value
	No. (%)	Mean (SD)	No. (%)	Mean (SD)	No. (%)	Mean (SD)	No. (%)	Mean (SD)		
No. (beneficiaries)	249 405 (100.00)	···	82 790 (33.20)	···	83 314 (33.41)	···	83 301 (33.40)	···	···	···
Main predictor: NDVI*	···	−0.02 (0.09)	···	−0.11 (0.04)	···	−0.03 (0.02)	···	0.07 (0.06)	376 387*	<0.0001
Neighborhood median household income†	···	51.4 (30.7)	···	40.1 (21.9)	···	48.4 (23.8)	···	65.8 (37.9)	17 167.3*	<0.0001
Individual sociodemographics										
Age	···	76.33 (7.50)	···	76.71 (7.55)	···	76.30 (7.43)	···	75.98 (7.51)	196.40*	<0.0001
Female sex	58.33	···	58.79	···	58.66	···	57.53		(32.9*)	<0.0001
Race/ethnicity (RTI)‡									(21 963.2*)	<0.0001
Hispanic, %	65.56	···	80.29	···	68.77	···	47.71	···		
Non-Hispanic white, %	23.29	···	16.25	···	18.21	···	35.35	···		
Black, %	11.15	···	3.45	···	13.02	···	16.94	···		
Biological risk factors§										
Diabetes mellitus diagnosis, %	15.55	···	18.12	···	14.42	···	14.14	···	(623.3*)	<0.0001
Hypertension diagnosis, %	27.88	···	31.21	···	25.72	···	26.74	···	(703.1*)	<0.0001
Hyperlipidemia diagnosis, %	22.72	···	25.23	···	20.51	···	22.43	···	(533.2*)	<0.0001
Outcome variables‖										
AMI, %	0.29		0.36		0.25		0.26		(21.4*)	<0.0001
IHD, %	20.68		23.92		18.92		19.22		(793.0*)	<0.0001
HF, %	7.56		9.06		7.05		6.58		(412.4*)	<0.0001
AF, %	2.61		2.37		1.89		3.02		(90.3*)	<0.0001
Any heart disease, %‖	22.41		25.58		20.55		21.12		(721.6*)	<0.0001

RTI, Research Triangle Institute race code.
*Mean normalized difference vegetation index (NDVI) was used to assess greenness/vegetative presence/absence at the Census block level (possible theoretical range of −1 to +1).
†Neighborhood median household income is reported in thousands of dollars at the Census block-group level using 2011 US Census data.
‡Race and ethnicity was assessed by US Centers for Medicare & Medicaid Services (CMS) for each beneficiary.
§Biological risk factors and outcome variables were identified for each Medicare beneficiary, using CMS Beneficiary Summary File, Chronic Conditions segment.
‖Any heart disease refers to having any of the 4 forms of heart disease in the CMS Chronic Conditions Segment (acute myocardial infarction [AMI], ischemic heart disease [IHD], heart failure [HF], and atrial fibrillation [AF]).

Table 2. NDVI Relationships to Health Outcomes in Unadjusted and Adjusted Models Adjusting for Individual Sociodemographics, Neighborhood Income, and/or Biological Risk Factors

	Model 1 (No Adjustment)		Model 2 (Individual Sociodemographic Covariates)*		Model 3 (Individual Sociodemographic Covariates, Plus Neighborhood-Level Income)†		Model 4 (Individual Sociodemographic Covariates, Neighborhood-Level Income, Plus Biological Risk Factors)‡	
Health Outcome Variables (Models)	OR and (95% CI)	*P* Value	OR and (95% CI)	*P* Value	OR and (95% CI)	*P* Value	OR and (95% CI)	*P* Value
AMI								
Low NDVI	1		1		1		1	
Medium NDVI	0.97 (0.80–1.17)	0.7459	0.97 (0.80–1.17)	0.7163	0.94 (0.77–1.14)	0.5231	0.96 (0.79–1.17)	0.7086
High NDVI	0.70 (0.58–0.83)§	<0.0001§	0.74 (0.62–0.88)§	0.0008§	0.75 (0.63–0.90)§	0.0018§	0.87 (0.73–1.04)	0.1357
P value linear trends‖		0.0003§		0.0035§		0.0231§		0.2909
IHD								
Low NDVI	1		1		1		1	
Medium NDVI	0.94 (0.91–0.97)§	0.0003§	0.92 (0.89–0.96)§	<0.0001§	0.97 (0.94–1.01)	0.0961	1.03 (0.99–1.07)	0.1809
High NDVI	0.75 (0.72–0.78)§	<0.0001§	0.81 (0.79–0.84)§	<0.0001§	0.80 (0.77–0.83)§	<0.0001§	0.86 (0.83–0.90)§	<0.0001§
P value linear trends‖		<0.0001§		<0.0001§		<0.0001§		<0.0001§
HF								
Low NDVI	1		1		1		1	
Medium NDVI	1.09 (1.04–1.14)§	0.0003§	1.03 (0.99–1.08)	0.1559	1.02 (0.97–1.07)	0.4930	1.03 (0.98–1.08)	0.2277
High NDVI	0.77 (0.74–0.81)§	<0.0001§	0.83 (0.79–0.87)§	<0.0001§	0.84 (0.80–0.88)§	<0.0001§	0.95 (0.91–1.00)§	0.0318§
P value linear trends‖		<0.0001§		<0.0001§		<0.0001§		0.0015§
AF								
Low NDVI	1		1		1		1	
Medium NDVI	0.73 (0.68–0.78)§	<0.0001§	0.82 (0.77–0.88)§	<0.0001§	0.91 (0.84–0.97)§	0.0062§	0.92 (0.86–0.98)§	0.0133§
High NDVI	0.93 (0.86–1.00)	0.0603	0.98 (0.91–1.05)	0.5053	0.94 (0.87–1.00)	0.0674	1.07 (1.00–1.14)	0.0634
P value linear trends‖		<0.0001§		<0.0001§		0.3435		<0.0001§
Any heart disease								
Low NDVI	1		1		1		1	
Medium NDVI	0.93 (0.90–0.96)§	<0.0001§	0.92 (0.89–0.95)§	<0.0001§	0.97 (0.94–1.01)	0.1177	1.03 (0.99–1.07)	0.1676
High NDVI	0.76 (0.74–0.79)§	<0.0001§	0.83 (0.80–0.86)§	<0.0001§	0.81 (0.78–0.84)§	<0.0001§	0.88 (0.84–0.91)§	<0.0001§
P value linear trends‖		<0.0001§		<0.0001§		<0.0001§		<0.0001§

Tertiles for mean greenness: low (reference level), medium, and high normalized difference vegetation index (NDVI; see Table 1). AF indicates atrial fibrillation; AMI, acute myocardial infarction; HF, heart failure; IHD, ischemic heart disease; OR, odds ratio.

*Individual sociodemographics: age, sex, and race/ethnicity.

†Neighborhood-level income: neighborhood median household income.

‡Biological risk factors: diabetes mellitus, hypertension, and hyperlipidemia.

§Statistically significant results ($P<0.05$).

‖*P* value for linear trends reported across the 3 tertiles of greenness.

factors (model 4), consistent results were observed in IHD, HF, and AF models, although the magnitude of these relationships were attenuated compared with the main model (model 3). However, high NDVI was no longer associated with lower odds of AMI.

The adjusted linear trends test—which includes the 3-category NDVI variable as a continuous variable for each model—supports the linear trends hypotheses. The odds of having CVDs generally decrease across progressively higher tertiles of greenness in the main analyses (model 3; Table 2). There is a clear linear dose or gradient of relationship of greenness to odds of disease for every outcome except for AF. Otherwise, we observed significant linear trends statistics in all 4 models for the 4 types of CVD, except for the biological model (model 4) for AMI.

Discussion

Higher levels of neighborhood greenness (ie, vegetative presence, measured by NDVI at the Census block level) were generally associated with lower odds of heart disease, adjusting for individual sociodemographics and neighborhood income. Specifically, higher greenness was associated with lower odds of 3 of 4 forms of CVD—AMI, IHD, and HF, respectively—as well as *overall* odds of heart disease. In further analyses adjusting for 3 common cardiometabolic conditions—diabetes mellitus, hypertension, and hyperlipidemia—which have also been linked to neighborhood greenness,[11] the associations between greenness and the 4 types of heart disease were attenuated. This study builds on prior findings that higher levels of neighborhood greenness—measured by mean NDVI—are related to better health outcomes.[11–16,18,20,26,28,31–33] Moreover, this is the first study of which we are aware, that has linked block-level greenness to heart disease, in any population.

Results show a less consistently strong relationship between greenness and AF, as compared with AMI, IHD, and HF. It is possible that the less strong relationship of AF with greenness occurred because at least 1 form of AF—familial AF—may be less strongly impacted by environmental factors and more strongly related to genetics when compared with the other heart disease diagnoses.[40,41]

Although the present findings are correlational in nature, they add to the literature suggesting that greenness or vegetative presence may be associated with reduced odds of CVD at the population level.[17–19] In communities with subtropical climates, such as Miami-Dade County, the presence of more tree canopies may increase the amount of shade and thus the attractiveness of walking and other outside activities. Thus, the increased canopy may increase the likelihood of residents engaging in physical activity and/or positive social interaction—all of which may be associated with reduced odds of CVD.[21,42–44] Additionally, evidence supports that greenness may also benefit health by restoring attention and/or reducing perceived stress,[22,23,45] which, in turn, may lead to better cardiovascular health outcomes.[46,47] Moreover, neighborhood greenness may also mitigate impacts of air pollution[25] and urban heat island effects,[27] and hence reduce the odds of CVD outcomes.[4,18,47,48]

Study Strengths

This is the first study to show that higher levels of block-level greenness (mean NDVI) are associated with lower odds of heart disease. Moreover, it does so in a population-based sample of older adults—specifically, those enrolled in Medicare for a single large county in the United States. Few prior studies have identified the relationship of the neighborhood built and/or natural environment with heart disease, which is the leading cause of morbidity and mortality in the United States, and may be impacted by changes in land use, such as greenness and destinations for walking and recreation—which may be an area for possible interventions. Changes in policy to promote the addition of vegetation and green spaces to increase opportunities for physical activity—and possibly reduce air pollution—may potentially reduce the risk of CVD at the population level. However, future work is needed to elucidate the specific mechanisms through which neighborhood greenness may impact cardiovascular health.

Study Limitations

The present study focused on a single large US county, so the present findings require replication in similar, and different, populations and locales, including those in other climates. Additionally, Medicare data did not provide moves or reasons for moves, although the sample was restricted to individuals who had the same location for 2 calendar years. The cross-sectional nature of the present analyses limits assertions about causality, as does the lack of information about environmental exposures beyond the residential block. Self-selection is a known issue in the built environment and health literature, and healthier individuals, or those who are physically active or prefer nature exposure, may have selected greener environments. Specific behavioral mechanisms through which greenness may impact CVD were not available, such as increased physical activity and social interaction, and decreases in attentional fatigue, perceived stress, and/or more restorative sleep. Similarly, other mediating or moderating factors by which greenness may impact health, such as safety or aesthetics, or smoking behavior or other cardiovascular risk factors, were not available. Other unmeasured variables such as potentially lower levels of air or noise pollution, reduced temperatures, or buffered noise exposure may account for the observed relationships between greenness and heart disease outcomes in the present study. A further limitation is that those individuals who could not be matched to a specific residential ZIP code, who had nursing home claims or moved to a nursing home, and/or those who moved within the 2 years were likely different than those included in the study. Future research is needed that assesses the health impacts of greenness in those who move as well as nursing home residents, which may be important for generalizability. Moreover, the specific measure of greenness in this study—NDVI—does not identify specific types of vegetation or greenery or whether the greenness was publicly accessible. Therefore, future work should examine specific types of vegetation and green spaces, as well as changes in individuals' residence over time, in relation to cardiovascular outcomes, and thus further elucidate the nature of the relationships observed in this study.

Conclusions

Higher levels of greenness (measured by mean block-level NDVI) were associated with reduced overall odds of *any* form of heart disease, as well as 3 specific forms of heart disease (AMI, IHD, and HF). These relationships were obtained in a population-based sample of 249 405 Medicare beneficiaries aged 65 years and older, who represent a large and growing population at risk for CVD and associated healthcare utilization in the coming years. Prior work suggests that nature exposure, as well as increased opportunities for walking, socializing, and/or stress reduction—which may occur through increased vegetation or greenness—may promote the health of senior populations. This study suggests that adding greenness or vegetation at the block level—even a limited or small amount—may be a useful strategy for combatting CVD at the population level, and hence increase the quality and quantity of life for residents.

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Disclosures

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