Neighborhood Environment and Health Status and Mortality Among Veterans

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BACKGROUND: The VHA is the largest integrated US health system and is increasingly moving care into the communities where veterans reside. Veterans who utilize the VA for their care have worse health status than the general population. However, there is limited evidence about the association of neighborhood environment and health outcomes among veterans.

OBJECTIVES: The primary aim of this study is to assess the relative contribution of neighborhood environment, health system, and individual characteristics to health status and mortality of veterans.

METHODS: Information on personal socio-economic indicators, existing medical conditions and health status were obtained from baseline data from a multisite, randomized trial of primary care patients (n=15,889). The physical component scale (PCS) and mental component scale (MCS) summarized health status. Census tracts were used as proxies for neighborhoods. A summary score based on census tract data characterized the neighborhood socio-economic environment and walkability. Data were analyzed with multilevel hierarchical models. Analyses of health status were cross-sectional. Mortality analyses were longitudinal as participants were followed for an average of 722.5 days to ascertain vital status.

RESULTS: Neighborhood SES was associated with PCS and MCS scores, controlling for individual socio-economic status, self-reported co-morbid disease, smoking status, and health care access. In the lowest versus highest quartiles of neighborhood SES, adjusted PCS scores were 34.4 vs. 35.4 (p<0.05) and adjusted MCS scores were 46.2 versus 47.0 (p<0.05). PCS score was also significantly associated with neighborhood walkability (p<0.05). Mortality was lower for veterans living in neighborhoods with the highest decile neighborhood SES (HR 0.78, highest vs. lowest decile 95% CI 0.63, 0.97).

CONCLUSIONS: Veterans living in lower SES neighborhoods have poorer health status and a higher risk of mortality, independent of individual characteristics and health care access. Neighborhood walkability was associated with higher PCS scores.

KEY WORDS: neighborhood; veterans; health status.
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INTRODUCTION

A large literature suggests that neighborhood factors, some of which may be modifiable, play a significant role in population health status.[1] Neighborhood characteristics have been associated with a broad range of health outcomes including mortality, physical functioning and health behaviors.[2–6] Although area-level factors may influence veteran health, this topic has not been previously investigated. The rapidly expanding veteran population highlights the need to understand the array of factors likely to influence their health. Veterans who utilize VA services have worse health status than the general population;[7,8] however, there is limited information about the contribution of area-level factors with health status among this population. While previous studies have documented regional variation in veterans' health status,[7] the relative contributions of neighborhood environment, health system factors, and the characteristics of individual veterans is not clear. The VHA is the largest integrated health system in the US and has the ability to address community health issues (including unhealthy environments) and to utilize community-based strategies to target interventions to veterans living in high risk areas.

Neighborhood environment is thought to influence health on a variety of levels and neighborhood factors may capture information not available at the individual level. The socio-economic status (SES) of a neighborhood is a marker for characteristics that can affect health including availability of public services and access to quality medical care.[9] The mechanisms by which lower SES neighborhoods affect health are thought to include increased physiologic stress, greater perceived strain, lack of resources to lead a healthy lifestyle, and lower levels of social cohesion.[9–12] Measures of the built environment have also been investigated. Neighborhood walkability is a potentially modifiable factor that refers to how conducive the environment is to walking and has been associated with levels of physical activity, reduced risk of disability,

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cardiovascular disease, obesity and depression.[13–16] Key components of walkability include residential density, street pattern or connectivity, mixed land use, and pedestrian infrastructure.[15–20] The number or density of intersections, called street connectivity, captures the directness of routes between destinations and has shown to be a significant predictor of walking.[15] The purpose of this study was to assess the relative association of neighborhood environment, health system factors, and individual characteristics with health status and mortality among veterans who utilize the VHA.

METHODS

Study Design

We conducted a retrospective analysis linking patient demographic and clinical information to data on the census tracts in which they lived. Analysis of health status was cross-sectional from information obtained at baseline enrollment. The mortality analysis was longitudinal, as subjects were followed for a mean of 722.5 +/− 84 days to ascertain vital status.

Study Sample

We used information collected during enrollment in the Ambulatory Care Quality Improvement Project (ACQUIP), a multi-center, randomized trial designed to evaluate quality improvement interventions in primary care conducted from 1997 to 2000.[21] In this study, participants were surveyed about their health status and VA clinical and laboratory data were also collected. Veterans were eligible to enroll in ACQUIP if they were assigned to a primary care provider and had at least one visit during the year prior to enrollment in the general medicine clinics at seven Veterans Affairs (VA) medical centers across the United States (Birmingham, AL; Little Rock, AK; Richmond, VA; San Francisco, CA; Seattle, WA; West Los Angeles, CA; White River Junction, VT).[21] Upon entry into the AQUIP study, a health-screening questionnaire was completed by 30,690 veterans who were then sent the Medical Outcome Study 36-item Short Form (SF-36).[22] Among these veterans, 68% returned the SF-36 (n=21,112). We geo-coded participant addresses at the census tract level to assign each participant a location identifier.[23] Our final study population consisted of those veterans who had an address that could be geo-coded (75%) and linked to data on neighborhood features (n=15,889).

Individual-Level Measures

Our primary dependent variable was self-reported health status, based on the SF-36, which measures eight domains of the impact of disease on health status and is summarized by two component summary scales, the physical component summary (PCS) and mental component summary (MCS).[22] These scales are standardized to the general US population (mean±standard deviation=50±10).[22] The PCS scale captures physical function, role limitations due to physical problems, bodily pain and general health perceptions while the MCS scale measures vitality, social functioning, role limitations due to emotional problems and mental health perception.[22] For both measures, higher scores indicate better perceived health. Our secondary dependent variable was mortality, as ascertained from the VA Beneficiary Identification and Records Locator System (BIRLS) and Veterans Health Affairs electronic medical records.[24,25] This system accurately identifies 90% to 98% of deaths.[24,25]

Neighborhood Environment Measures

Neighborhood characteristics were derived from 2000 Census data. Census tracts were used as proxies for neighborhoods, as they are designed to be demographically homogeneous, are relatively stable over time, and contain 3,000–8,000 residents.[26] We used a previously validated 100-point index of neighborhood SES, consisting of 6 components: 1) adults age 25 years or older with less than a high school education; 2) unemployed males; 3) households with income below the poverty level; 4) households receiving public assistance; and 5) households with children that are headed by a female; and 6) the median household income.[27] For each census tract, the mean and standard deviation (SD) were computed for all of these variables and a Z score was derived for each by subtracting it from the US mean and dividing by the US SD. The Z scores were re-scaled and summed to create index scores in which higher values correspond to higher neighborhood SES. Participants were classified by the SES quartile and decile of the neighborhood in which they lived. Residential instability is considered one of the most important predictors of crime and transience among residents is related to greater social disorganization.[28] Neighborhood stability was measured by the vacancy rate by census tract.

Previous studies have demonstrated that a walkability index that included components of land-use mix, residential density, and intersection density was significantly associated with objectively measured moderate-intensity physical activity in adults.[18] The empirical evaluation of geographic-based measures comes mostly from construct validity.[20] To measure walkability, a street connectivity score was determined by calculating the ratio of the actual number of complete streets loops to the maximum number possible loops given the number of intersections.[13] A higher value indicates a higher level of complexity and connectivity, and more grid-like streets. A smaller value indicates streets that are poorly connected (for example, the presence of cul-de-sacs). Data for creating street connectivity measures was obtained from the census TIGER files, centerline files and census block geography from 1990–2004 and were computed using ArcGIS software (version 9.1). In our study, population density is measured as the total persons in housing units per unit land area, as measured in the 2000 US Census.

Individual Characteristics

Sociodemographic information included age, sex, race/ethnicity, educational status, income, marital status, and individual health habits. Self-reported information included smoking status and a previously validated checklist to describe 24 medical and psychiatric co-morbidities.[29] Depression was assessed using the 5-item Mental Health Index (MHI-5).[30] Because previous studies have documented the importance of access and distance to care on

health outcomes,[31] we included driving distance to the nearest VA facility. The VA provides care based on a set of criteria including military service-connected disability and income level which impact access to care. Low-income patients or those with a service-connected disability receive care free of charge, while others have co-pays for medications and office visits. We classified individuals based on their level of service-connected disability and their income level.

Statistical Analysis

Differences between participants in neighborhood SES quartiles were examined with one-way analysis of variance (ANOVA) for continuous variables and with Chi-square tests for dichotomous variables. We used multilevel hierarchical regression analyses and survival analysis to predict health status and death, respectively.[32] While there were relatively few participants sharing the same neighborhood (80% of participants had five or less other subjects in the same neighborhood), numerous participants shared the same clinic site, with each of the seven sites having between 9-21% of all patients. Therefore we used random effects models to adjust for study site to account for correlated responses among subjects in the same study site. Cox proportional hazard models were utilized for the survival analysis, adjusting for clustering by site. To assess the relative contribution of neighborhood factors, PCS and MCS scores were adjusted for age, sex, individual income, race/ethnicity, education, work status, marital status, self-reported health conditions, smoking status, service connected status, and health care access in multivariate analysis. In addition, the PCS scores were adjusted for MHI-5 scores. For ease of interpretation, the effect of neighborhood score is summarized as the relative risk comparing the 25th percentile of neighborhood score with the 75th percentile.

Previous studies have shown that subjects who returned the SF-36 were more likely to be Caucasian, unemployed, and to have an annual household income of more than $10,000 compared to subjects who did not return the SF-36 (see Appendices, Table 4).[7] Thus, we performed sensitivity analyses to verify the conclusions of the main analyses accounting for missing data using multiple imputations derived from Markov Chain Monte Carlo (MCMC) methods, one of the more widely used and most robust multiple imputation methods.[33] Using IVEware, a system that creates multiple imputations by iterated regressions, we imputed 10 complete data sets and repeated the analyses on each imputed dataset, combining results from the 10 imputed datasets using Rubin's rules.[34] Multiple imputation analyses suggested no systematic bias resulting from missing data. Analyses were conducted with and without the cases with imputed results, with no meaningful differences in the results. Data are, therefore, presented for the entire sample. SAS Windows Version 9.2 was used for the analysis. This study was approved by the institutional review board at the VA Puget Sound Health Care System.

RESULTS

Table 1 displays bivariate analysis of the population characteristics of the sample by neighborhood SES quartiles. Veterans who lived in the lowest quartile neighborhoods were more likely to be younger, African American, current smokers, and report less education and have a lower income compared to those who lived in the higher quartile neighborhoods (Table 1). Veterans living in the lowest quartile neighborhoods had significantly lower PCS and MCS scores and reported more chronic medical conditions, including diabetes, hypertension and depression, compared to veterans in the highest quartiles ($p<0.001$). Veterans living in the highest quartile neighborhoods lived shorter distances from the VA and were more likely to use non-VA care. There were no significant differences in mortality rates by neighborhood SES quartiles.

Tables 2 and 3 display the adjusted association of individual and neighborhood level factors with PCS and MCS scores, respectively. We adjusted for recruitment site as a random effect and found that total variability in the model due to site was close to zero (data not shown). Veterans living in the highest quartile areas for neighborhood SES had higher adjusted PCS scores

Table 1. Population characteristics of veterans by neighborhood SES quartile, (n=15,889)

		Neighborhood Socioeconomic Quartile				
		Lowest ←		→ Highest		
Age ≥65, %		47.2	51.6	52.6	56.2	*
Race/	White	57.7	84.1	87.6	87.6	*
Ethnicity, %	African American	35.7	11.8	7.0	6.2	
	Hispanic	2.2	1.2	1.9	1.9	
	Other	4.5	2.9	3.5	4.4	
Male, %		96.4	96.3	96.0	96.4	
Education, %	Less than High school	31.0	31.5	25.7	16.2	*
	High school	25.4	26.1	22.8	18.9	
	More than high school	43.6	42.4	51.4	64.8	
Annual income, %	<$10,000	34.6	25.3	22.2	18.2	*
	$10-19,999	38.1	41.1	37.8	30.6	
	$20-29,999	16.7	19.3	20.8	22.9	
	> $30,000	10.6	14.3	19.3	28.2	
Marital status, %	Never married	10.8	5.9	7.5	9.1	*
	Separated or divorced	51.6	65.1	61.6	61.6	
	Widowed	29.5	21.8	23.6	22.1	
	Married	8.2	7.2	7.3	7.2	
Employment status, %	Employed	21.7	21.2	24.5	27.4	*
	Retired	44.9	50.5	51.6	52.4	
	Disabled	26.2	23.4	19.3	15.6	
	Unemployed	7.2	4.9	4.6	5.5	
Current smoker		29.9	23.9	22.4	17.3	
Mean number of chronic diseases		3.8	3.9	3.7	3.5	*
Diabetes, %		21.5	21.6	20.9	18.5	*
Hypertension, %		57.5	55.2	52.6	51.1	*
Depression, %		26.3	25.0	24.0	22.7	†
Mental Health Index (MHI), mean		13.0	12.7	12.4	12.0	*
Mean Physical Component Summary (PCS) score		33.8	32.8	34.6	36.7	*
Mean Mental Component Summary (MCS) score		44.8	45.6	47.2	48.1	*
Mortality, %		18.4	18.6	17.5	16.9	
Hospitalizations in the prior year, %		36.5	36.2	34.4	33.4	†
Receive care outside of the VA, %		32.8	38.9	38.9	43.3	*
Distance to VA hospital, mean miles		48.6	59.9	47.1	34.5	*

Missing data: MHI 7.2%, education 7.8%, race/ethnicity 3.8%, employment 7.3%, income 12.5%, marital status 7.3%, chronic health conditions 5.5%, smoking status 7.1%, care outside of VA 8.8%; * $P<0.001$; † $P<0.05$ (from bivariate Likelihood ratio tests)

Table 2. Adjusted association of neighborhood level factors with SF-36 physical component summary (PCS) scores and adjusted mean PCS scores by neighborhood SES index quartiles

Domain		Mean PCS Score	Coefficient	SE	*P* value
Neighborhood SES index quartile	Lowest	34.4	-0.98	0.27	0.001
		34.5	-0.93	0.24	0.0008
		35.4	-0.08	0.23	0.75
	Highest	35.4	reference		
Street Connectivity			5.84	1.25	0.0002
Population density			1.98E-04	1.00E-04	0.08
Vacancy			0.02	0.012	0.06

Adjusted for age, sex, individual income, race/ethnicity, education, work status, marital status, self-reported health conditions, smoking status, service connected status, and health care access

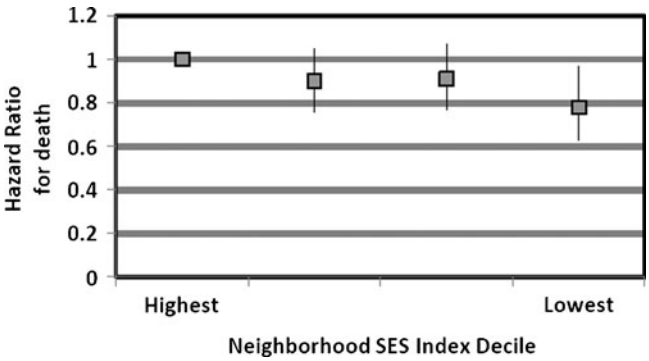

Figure 1. Adjusted Hazard Ratio (HR) for mortality by neighborhood SES index decile. Adjusted for age, sex, individual income, race/ethnicity, education, work status, marital status, self-reported health conditions, smoking status, service connected status, and health care access.

(35.4 vs. 34.4; p=0.001) and MCS scores (47.0 vs. 46.2; p=0.006) compared to veterans living in the lowest quartile areas In addition, veterans living in areas with higher street connectivity reported significantly higher PCS scores. Population density and vacancy rates were not related to PCS or MCS scores. The complete models are presented in the appendix (Tables 5 and 6 available on line). MCS and PCS scores were also significantly related to age, sex, low income, race/ethnicity, education, work status, marital status, self-reported health conditions, smoking status, MHI score and service connection status. We found no association of distance to the nearest VA with either MCS or PCS scores.

Multilevel analysis by neighborhood quartile did not reveal a neighborhood SES effect on mortality (data not shown); however, in examining the hazard ratios for veterans at the extremes of the neighborhood SES distribution, we found that that veterans living in the top decile of neighborhood SES index had a lower adjusted hazard of death (0.78 HR, 95% CI 0.63-0.97, p=0.02) compared to those living in the lowest 10th percentile neighborhood (Fig. 1). Mortality was also significantly associated with increasing age, presence of chronic disease, prior year hospitalization, and service connection status. We did not find any association between mortality and distance to the nearest VA.

Table 3. Adjusted association of neighborhood level factors with SF-36 mental component summary (MCS) scores and adjusted mean MCS scores by neighborhood SES index quartiles

Domain		Mean MCS Score	Coefficient	SE	*P* value
Neighborhood SES index quartile	Lowest	46.2	-0.84	0.28	0.0064
		46.2	-0.84	0.26	0.0034
		46.9	-0.05	0.25	0.83
	Highest	47.0			
Street Connectivity			-2.06	1.31	0.13
Population density			-6.10E-06	1.10E-05	0.59
Vacancy			0.006	0.01	0.62

Adjusted for age, sex, individual income, race/ethnicity, education, work status, marital status, self-reported health conditions, smoking status, service connected status, and health care access

The complete survival analysis is presented in the appendix (Table 7 available on line).

DISCUSSION

We found that neighborhood SES was associated with physical and mental health status and mortality among veterans, even after controlling for individual health risks and demographic factors, as well as health system factors such as access and distance to VA care. We also found that veterans who lived in more walkable neighborhoods had higher PCS scores. The current study allows for detailed analysis of individual, health system and community factors that are associated with health status among veterans who utilize the VHA. To our knowledge, this research provides the first information about the relationship of neighborhood environment and veterans' health. Although the individual effects are modest, these decrements in health status are relevant across the large population of veterans living in areas with low socio-economic status. Self-rated health has been found to be a good predictor of subsequent morbidity and mortality.[22] Our findings are consistent with previous studies from the UK that report the variation in health status by neighborhood SES is modest compared with individual level differences.[35,36] In a study of a community dwelling cohort in England, area of residence was associated with physical functional health, with only a weak association with mental health function.[35] In another study, one standard deviation increase in the Townsend deprivation score, a measure of neighborhood SES, was associated with a drop in PCS score of 0.3 points and a decrease in MCS score by 0.5 points.[36]

The VHA is the largest integrated health system in the United States. During the last several decades, VHA was transformed from a hospital-based system to a primary care system. As part of this process over 800 community-based outpatient clinics have been established to move care closer to where veterans live,[37] and a new VHA initiative is currently being launched to establish Patient Centered Medical Homes. Individuals spend relatively very little time in physicians' offices, and as such, community-based interventions must become a key component of chronic disease management,[38] including efforts to address

modifiable health factors in communities. An understanding of how and to what extent characteristics of one's environment may alter health status are an essential first step to developing interventions to assist veterans who reside in communities with conditions unfavorable to their health. While it may be beyond the scope of the VA mission to change the community environment where veterans live, this study provides the first information about the relative contribution of the neighborhood environment on veteran health status and mortality, relative to health delivery system variables and individuals health risks.

There are several limitations to our study. Although we were able to geo-code 75% of addresses, similar to rates reported in the literature, geo-coding rates for non-metropolitan addresses were lower (50%). Hence, our findings may not be generalizable to veterans living in rural areas. Because the data on health status are cross-sectional, we cannot assume that the relationship with neighborhood SES is causal. Further, we relied on single point-in-time estimates for addresses. However, previous studies have shown low rates of residential mobility among older individuals and, for those who do move, high correlations of neighborhood characteristics over time.[39] There is the potential for response bias from self-report of health status and health conditions. In addition, we cannot exclude the influence of selective migration into lower SES neighborhoods of those with worse health status. We were not able to examine the potential mediators of the relationship between neighborhood SES and health status that may include physiologic stress, perceived strain, resources to lead a healthy lifestyle, and social support.[9–12] Our measures of walkability include residential density and street connectivity, but we do not have information on other features that may determine walking behavior such as land use mix or pedestrian infrastructure.[18] The limitations of the study are balanced by the strengths, which include a large well defined cohort of veterans with extensive health status and biologic data and the use of relatively complete longitudinal data to assess the association of neighborhood SES and veteran mortality.

In conclusion, we found that neighborhood SES was associated with physical and mental health status among veterans and that veterans living in more walk-able communities had higher physical functioning scores. Although the effect size was modest for individual veterans, these results are useful in identifying factors that impact veteran health-related quality of life at the population level and targeting interventions to veterans living in high risk areas. Our results add to the growing body of evidence that both social context and individual characteristics provide a more complete understanding of the determinants of health. Further research is required to examine to impact of neighborhood environment on chronic disease management and healthy lifestyles among veterans and to determine how to prioritize VA public health activities.[40]

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