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Neighborhood socioeconomic status and mortality in the nurses' health study (NHS) and the nurses' health study II (NHSII)

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Background: Few studies have prospectively examined long-term associations between neighborhood socioeconomic status (nSES) and mortality risk, independent of demographic and lifestyle risk factors.

Methods: We assessed associations between nSES and all-cause, nonaccidental mortality among women in the Nurses' Health Study (NHS) 1986–2014 (N = 101,701) and Nurses' Health Study II (NHSII) 1989–2015 (N = 101,230). Mortality was ascertained from the National Death Index (NHS: 19,228 deaths; NHSII: 1556 deaths). Time-varying nSES was determined for the Census tract of each residential address. We used principal component analysis (PCA) to identify nSES variable groups. Multivariable Cox proportional hazards models were conditioned on age and calendar period and included time-varying demographic, lifestyle, and individual SES factors.

Results: For NHS, hazard ratios (HRs) comparing the fifth to first nSES quintiles ranged from 0.89 (95% confidence interval [CI] = 0.84, 0.94) for percent of households receiving interest/dividends, to 1.11 (95% CI = 1.06, 1.17) for percent of households receiving public assistance income. In NHSII, HRs ranged from 0.72 (95% CI: 0.58, 0.88) for the percent of households receiving interest/dividends, to 1.27 (95% CI: 1.07, 1.49) for the proportion of households headed by a single female. PCA revealed three constructs: education/income, poverty/wealth, and racial composition. The racial composition construct was associated with mortality (HR_{NHS}: 1.03; 95% CI = 1.01, 1.04).

Conclusion: In two cohorts with extensive follow-up, individual nSES variables and PCA component scores were associated with mortality. nSES is an important population-level predictor of mortality, even among a cohort of women with little individual-level variability in SES.

Keywords: mortality; neighborhood socioeconomic status; principal component analysis; women's health

Introduction

Associations between individual-level socioeconomic status (SES) and mortality are well-documented, and a growing body of literature supports associations between area-level (i.e., neighborhood) SES variables and mortality, even after accounting for individual SES and other known risk factors.[1–7] Neighborhood effects are increasingly recognized as important contributors to health disparities,[8,9] and research shows that socioeconomic indicators tend to cluster at the neighborhood level (e.g., Census tracts).[10,11] In addition to mortality, residing in socioeconomically disadvantaged neighborhoods is associated with a wide range of health behaviors and outcomes, such as obesity, mental health, cardiovascular health, pregnancy and birth outcomes, self-rated health, physical activity, substance use, sexual health, stress, and smoking, among others.[2,3,5,12–14] Potential mechanisms by which neighborhood socioeconomic status (nSES) may affect mortality include the physical/built environment, environmental exposures, social cohesion/social norms, access to health care, and lifestyle and behavioral risk factors (e.g., physical activity, diet, and smoking).[15–17] For instance, lower nSES is associated with lower quality built environments,[18,19] higher levels of air pollution,[20] noise,[21] less access to and lower quality green spaces,[22] and extreme temperatures,[23] lower social cohesion,[24,25] lower physical activity,[14,26] and poorer diet quality.[27,28] Additionally, the weathering hypothesis—which posits that persistent exposure to economic and social disadvantage contributes to accelerated decline in health—could account

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The data used in our analyses are not publicly available. Researchers interested in obtaining access to NHS and NHSII data and computing code will be required to submit an external collaborator form (https://nurseshealthstudy.org/researchers).

SDC Supplemental digital content is available through direct URL citations in the HTML and PDF versions of this article (www.environepidem.com).

What this study adds

Neighborhood effects are increasingly recognized as important contributors to health disparities, though few long-term studies exist that account for time-varying individual factors. Time-varying nSES measures over three decades, including neighborhood racial composition, were associated with mortality. Limited variability in individual SES and race/ethnicity and extensive time-varying information on potential confounders was a strength of the study. nSES is an important population-level predictor of mortality, even among women with little individual-level variability in SES.

for mortality disparities.[29] However, these complex, multilevel pathways are not clearly understood.[12,30]

Several nSES and neighborhood deprivation domains are consistently represented in the literature: poverty/income, racial/ethnic composition, education, employment, and occupation.[2,12,30,31] Domains appearing less frequently are housing/crowding, residential stability, economic inequality, affluence, and racial residential segregation.[12] Most studies include one or more variables from multiple domains to estimate nSES; however, the use of domain-specific variables lacks consistency. Sources of neighborhood-level indicators also vary, from publicly-available databases to study-specific questionnaires. The use of publicly-available United States Census data offers one approach to examining nSES in a systematic, replicable manner.[32]

Few long-term studies exist that examine the effects of nSES on mortality, and most are unable to account for many individual factors, particularly those that may vary over time and may be subject to residual confounding. More research in populations with less variability in individual SES is needed as well as studies to understand the indices of nSES most relevant to health.

Objective and hypothesis

Our objective is to examine associations between nSES and nonaccidental mortality in two prospective cohorts of US women, the Nurses' Health Study (NHS) and Nurses' Health Study II (NHSII), which have relatively little variability in individual SES and extensive data on potential confounders over decades of follow-up. We hypothesize that lower nSES will be associated with higher mortality over time, even after control for time-varying individual-level risk factors, and that these associations would be mediated by health behaviors.

Methods

Study population and data sources

NHS is a prospective cohort established in 1976 that assesses risk factors for chronic disease. At baseline, 121,701 female registered nurses (ages 30–55 years old) were recruited from 11 states based on the return of an initial questionnaire, which collected information on health-related exposures and medical diagnoses. In 1989, 116,249 female nurses (ages 25–42 years old) were recruited to the NHSII from 14 states. Follow-up is conducted biennially in both cohorts via questionnaire with response rates consistently above 90%.[33] For this study, individual-level characteristics were obtained from baseline and biennial follow-up questionnaires between 1986 and 2014 for NHS and 1989 and 2015 for NHSII. Residential addresses for each questionnaire cycle were geocoded and used to assign time-varying nSES exposures.

The study protocol was approved by the institutional review boards of the Brigham and Women's Hospital and Harvard T.H. Chan School of Public Health. Informed consent is implied based on the return of questionnaires.

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Definition of neighborhoods: census tract

We examined SES at the neighborhood level, which is hypothesized to contain material and social characteristics relevant to many health outcomes.[3] Previous research has utilized Census tract data to represent neighborhood factors and validated their utility in studies of mortality and other chronic disease outcomes.[12,30] Census tracts are small statistical subdivisions of counties, which are designed to be fairly homogenous units with respect to sociodemographics.[34] We obtained the Census tract variables from the Neighborhood Change Database (NCDB), which provides Census data from 1970, 1980, 1990, 2000, and 2010, normalized to the 2010 tract geographies.[35]

Neighborhood socioeconomic status score

Variable selection

Socioeconomic variables at the neighborhood level represent aspects of community stratification, opportunity structures, and social conditions.[36,37] We considered 17 Census-tract level variables that have been used widely to approximate neighborhood environments for possible inclusion in our nSES score (Supplemental Table 1; http://links.lww.com/EE/A210). These measures included three education variables (percent with a college degree, percent completed high school, and percent with less than high school); two employment variables (percent of the total and male population unemployed); two housing-related variables (median home value and percent of occupied housing units); five poverty/wealth variables (median household income, percent in poverty, percent receiving public assistance, percent of families with children headed by a single female, and percent of families receiving interest/dividends); three racial composition variables (percent non-Hispanic White, non-Hispanic Black, and foreign-born residents); and two population age composition variables (percent of children under age five, or over age 65 years).

Component and simple nSES scores

We used principal component analysis (PCA) to obtain an empirical summary of total neighborhood-level variance explained by selected Census variables. Our goal was to confirm the underlying factor structure composed of previously or newly identified neighborhood socioeconomic domains. Using an eigenvalue = 1 and scree-plot analysis, we retained three principal components. Variables were assessed for inclusion based on a loading of 0.60 or greater. To create nSES component scores, optimal regression weights from the final PCA were multiplied by participant values for each variable, and the products were summed for each of the three components.

To compose a simple nSES score, we z-standardized (i.e., subtracted the mean from each variable and divided by the standard deviation) each variable retained in the PCA and summed the values. We reversed the scale for the poverty/wealth measures by subtracting from one to create a summary score where increasing values were associated with affluence.

Outcome: all-cause mortality

Our primary outcome was nonaccidental, all-cause mortality. We assessed deaths occurring between the return of the first follow-up questionnaire in both cohorts and 2014 for NHS and 2015 for NHSII. Mortality was ascertained from reports from the US Postal Service and next-of-kin, supplemented with National Death Index searches.[38]

Statistical analyses

We assessed associations between mortality and each nSES exposure (both continuously per standard deviation increase and in quintiles) in unadjusted and adjusted models. We used Cox proportional hazards regression models, conditioned on current age (in months) and follow-up cycle in basic models. Adjusted analyses included the following covariates (as parameterized in Table 1): age, race, individual-level SES variables (marital status, living alone, husband's education, mother's and father's occupation at age 16 years, educational attainment, income [NHSII only]), BMI at age 18 year, BMI change from age 18 years, physical activity, smoking status and pack-years, and overall diet quality (measured via the Alternate Healthy Eating Index [AHEI]).[39] Missing covariate information was assigned using values from the last available questionnaire. Participants missing information on any of the individual nSES variables were excluded from analyses. We estimated hazard ratios (HR) with 95% confidence intervals (95% CI) and *P*-values for trend. Finally, to assess if the associations were mediated by health behaviors, we compared associations between nSES and all-cause mortality following adjustment for smoking, diet, physical activity, and BMI individually and jointly. Analyses were performed using SAS (SAS version 9.4).

Results

Study population characteristics

Most participants in both cohorts were White (94% in NHS and 96% in NHSII), with a mean age of 64.9 years (SD = 10.4) in NHS and 46.0 (SD = 8.9) in NHSII (Table 1). In both cohorts, women who lived in higher nSES areas (e.g., Quintile 5 versus Quintile 1) were more likely to be past smokers, report moderately higher levels of physical activity, have higher AHEI scores, and live in more densely populated areas. In NHS, most participants lived in the Northeast region (51%) of the United State, whereas women in NHSII predominantly lived in the Northeast (33%) and Midwest (32%) regions of the United States. The proportions of residents aged 5 years, residents aged 65, White residents, and Black residents were similarly distributed among nSES quintiles in both cohorts.

Associations with individual neighborhood socioeconomic status variables

Among the 101,701 NHS participants, there were 19,228 deaths during follow-up from 1986 to 2014 (person-years = 2,385,561). In NHSII, there were 1,556 deaths among 101,230 study participants during follow-up from 1989 to 2015 (person-years = 2,177,646). In both cohorts, many individual nSES measures were statistically significantly associated with mortality (Supplemental Table 2; http://links.lww.com/EE/A210). Mantel-Haenszel rate ratios and Breslow-Day tests for trend (Supplemental Figure 1; http://links.lww.com/EE/A210) indicated linear trends with most nSES variables. Larger effect sizes were observed in NHSII than in NHS.

Principal components analysis of neighborhood socioeconomic status variables

For both cohorts, 12 out of 17 variables had loadings of 0.60 or greater (Supplemental Table 3; http://links.lww.com/EE/A210). For NHS, variable loadings on the first principal component ranged from –0.76 to 0.87. The three components accounted for approximately 64% of the total variance. For NHSII, loadings on the first principal component ranged from –0.73 to 0.87. The three components account for approximately 63% of the total variance.

Neighborhood socioeconomic status score and associations with all-cause mortality

To create the simple nSES score, we z-standardized and summed nine variables: median household income, median home value, percent with a college degree, percent non-Hispanic White, percent non-Hispanic Black, percent of foreign-born residents, percent of families receiving interest or dividends, percent of occupied housing units, and percent unemployed. We excluded the percent with a high school education and the percent with less than a high school education as these would add similar information as the percent with a college degree. Percent of males unemployed was excluded because of its similarity to the total percent unemployed. Increasing nSES score was associated with small decreased risks of all-cause mortality in NHS (HR_{crude} = 0.97; 95% CI = 0.96, 0.98 for a 1-SD increase [3.45 units]) (Table 2). Similar patterns were observed in NHSII, where increasing nSES was associated with decreased risk of all-cause mortality (HR_{crude} = 0.96; 95% CI = 0.94, 0.97 for a 1-SD increase [3.39]). Adjustment for potential confounders, including individual SES, attenuated the relationships in both cohorts.

In NHS and NHSII, increasing education/income component scores were associated with decreased mortality risk (Table 3), though the association was attenuated after adjustment for potential confounders. In NHS, the racial composition was associated with increased mortality risk ($HR_{adjusted}$ = 1.03; 95% CI = 1.01, 1.04). However, in NHSII, mortality risk (HR = 1.09; 95% CI = 1.04, 1.14) was attenuated after covariate adjustment ($HR_{adjusted}$ = 1.04; 95% CI = 0.99, 1.09). Poverty/wealth scores were also associated with an increased risk of all-cause mortality, with larger effect estimates in NHSII ($HR_{adjusted}$ = 1.06; 95% CI = 1.00, 1.11) than in NHS ($HR_{adjusted}$ = 1.01; 95% CI = 1.00, 1.03).

Analysis of potential lifestyle mediators of nSES and all-cause mortality

The percent of exposure effect (PTE) mediated by smoking was 9.4% (95% CI = 4.0%, 20.7%) in NHS and 10.7% (95% CI = 5.0%, 21.6%) in NHSII, and for physical activity was 27.9% (NHS, 95% CI = 18.3%, 40.2%) and 22.0% (NHSII, 95% CI = 10.7%, 39.7%). In both cohorts, the results did not suggest mediation of the nSES-mortality association by BMI (PTE <0%). The PTE for diet was substantially larger in NHS (53.3% [95% CI = 35.1%, 70.8%] vs. 23.5% [95% CI = 11.2%, 42.8%] in NHSII). Considering all mediators simultaneously, they accounted for 38.9% (NHS, 95% CI = 24.0%, 56.1%) and 35.0% (NHSII, 95% CI = 16.1%, 60.0%) of the nSES-mortality association (Supplemental Table 4; http://links.lww.com/EE/A210).

Discussion

This study examined associations between time-varying nSES measured for nearly three decades and all-cause mortality in two cohorts of US women. In both cohorts, increasing nSES, regardless of parameterization, was associated with a small decreased risk of mortality. Adjustment for individual-level confounding variables attenuated associations. A substantial percentage of the observed effects were mediated through lifestyle factors.

Our results are consistent with previous studies investigating nSES and mortality. Associations between specific nSES variables and mortality were generally in the expected direction, though adjustment for individual SES and other risk factors often attenuated the effects. For example, we observed decreased mortality risk with standard deviation increases in median household

Table 1.

Age-standardized characteristics of Nurses' Health Study (NHS, 1986–2014) and Nurses' Health Study II (NHSII, 1989–2015) participants throughout follow-up overall and by quintile of neighborhood socioeconomic status

	Mean ± SD or %							
			NHS (N = 101,701)				NHSII (N = 101,230)	
	Overall	Quintile 1	Quintile 3	Quintile 5	Overall	Quintile 1	Quintile 3	Quintile 5
Age (years)[a]	64.9 ± 10.4	64.5 ± 10.0	64.3 ± 10.5	66.6 ± 10.5	46.0 ± 8.9	45.0 ± 8.9	45.4 ± 8.9	48.4 ± 8.4
Married	68	70	68	68	49	49	49	50
Race								
White	94	95	94	93	96	97	96	94
Black	1	1	1	2	2	1	2	2
Other/more than one race	5	4	4	5	2	1	2	4
Husband's highest level of education								
High school or less	33	45	34	20	15	23	14	7
More than high school	40	30	39	54	67	59	67	77
Live alone	16	16	16	16	9	7	9	9
Smoking status								
Never smoker	44	47	44	42	65	66	65	63
Past smoker	44	40	43	48	26	22	25	30
Current smoker	12	12	12	10	9	12	10	6
Pack-years of smoking								
Never smoker	44	47	44	42	65	66	65	63
<10 packs/yearr	17	15	16	20	16	14	15	18
10–24 packs/year	15	13	15	16	14	14	14	14
25+ packs/year	22	23	23	20	5	6	5	4
Body mass index at age 18 years (kg/m^2)								
<18.5	11	11	11	11	15	14	15	16
18.5–24.9	69	67	68	71	74	72	74	76
25–29.9	7	8	7	5	8	9	8	5
30+	1	2	1	1	2	3	2	1
Neighborhood SES variables (census-tract level)								
Median household income (per $1,000)	61.2 ± 27.7	40.2 ± 12.1	55.8 ± 15.0	94.7 ± 31.9	65.6 ± 29.5	42.5 ± 12.8	60.2 ± 16.5	102.0 ± 34.1
Median home value (per $1,000)	186.4 ± 15.2	92.3 ± 63.3	147.7 ± 70.4	369.9 ± 196.4	189.0 ± 159.3	90.0 ± 57.4	146.9 ± 68.1	393.6 ± 218.1
% College degree or more (≥ 25 years)	26	14	24	45	25	13	24	40
% High school degree (≥ 25 years)	30	39	30	18	28	38	29	16
% Less than high school degree (≥ 25 years)	14	21	14	7	13	21	12	7
% Households receiving interest dividends or rent income	42	29	42	54	39	27	39	49
% Households headed by single female	18	22	19	13	18	22	19	13
% Population aged under 5 years	7	7	7	6	7	7	7	6
% Population aged over 65 years	16	17	16	16	14	15	13	14
% Occupied housing units	92	83	94	96	93	86	94	96
% Proportion living in poverty	8	12	7	4	8	12	7	5
% White	89	92	89	86	88	91	88	84
% Black	5	4	6	5	6	5	6	5
% Foreign-born	8	3	7	14	7	3	6	14
% Unemployed (≥ 16 years)	5	6	5	4	5	6	5	5
% Unemployed males (≥ 16 years)	31	36	30	27	28	33	28	26
% Households receiving public assistance income	4	6	4	2	4	6	4	2
Population density (1,000 per km^2)	1.23 ± 2.66	0.65 ± 1.09	1.16 ± 1.63	1.94 ± 4.81	1.37 ± 3.92	0.48 ± 1.10	1.14 ± 2.21	2.84 ± 7.40
Total physical activity (MET-hours/week)								
<3	20	21	20	17	15	18	15	12
3 to <9	20	21	21	19	19	21	20	16
9 to <18	18	18	18	18	18	18	19	18
18 to <27	11	11	11	12	12	11	12	12
27 to <42	10	9	9	11	11	9	11	13
42+	9	9	8	11	13	11	12	16
AHEI diet score	55.0 ± 11.9	52.6 ± 11.4	54.6 ± 11.6	58.3 ± 12.1	53.9 ± 13.3	50.1 ± 12.5	53.1 ± 12.8	59.8 ± 13.3
Region								
Northeast	51	46	53	55	33	27	33	39
Midwest	18	23	18	8	32	38	35	18
West	17	25	17	12	20	31	19	13
South	13	6	12	25	15	5	13	30
Father's occupation professional/manager	26	21	25	33	23	15	22	32
Father's occupation other	74	79	75	67	75	83	76	66
Mother's occupation housewife	64	67	64	63	53	50	54	56
Mother's occupation other	36	33	36	37	45	48	45	43

Values are means(SD) or medians(Q25, Q75) for continuous variables; percentages or ns or both for categorical variables, and are standardized to the age distribution of the study population. Some percentages totals do not sum to 100 due to missing values and rounding.

[a]Value is not age adjusted.

NHS indicates Nurses' Health Study; SES, socioeconomic status; AHEI, Alternate Healthy Eating Index.

Table 2.

Associations between simple neighborhood socioeconomic status score and all-cause mortality among Nurses' Health Study (NHS, 1986–2014, N = 101,701, deaths = 19,228, person-years = 2,385,561) and Nurses' Health Study II (NHSII, 1989–2015, N = 101,230, deaths = 1,556, person-years = 2,177,646)

	NHS	NHSII
	HR (95% CI)	HR (95% CI)
Simple nSES score (per 1 SD increase)	0.97 (0.96 – 0.98)	0.96 (0.94 – 0.97)
Simple nSES score + race	0.98 (0.98 – 0.99)	0.96 (0.94 – 0.97)
Simple nSES score + race + smoking	0.98 (0.98 – 0.99)	0.96 (0.95 – 0.98)
Simple nSES score + race + diet	0.99 (0.99 – 1.00)	0.97 (0.95 – 0.98)
Simple nSES score + race + physical activity	0.99 (0.99 – 1.00)	0.97 (0.95 – 0.98)
Simple nSES score + race + individual SES	0.99 (0.98 – 0.99)	0.97 (0.96 – 0.99)
Simple nSES score + full set of covariates	0.99 (0.98 – 1.00)	0.98 (0.97 – 1.00)

Models were adjusted for the following participant characteristics: age, calendar year, marital status, race, education, smoking status, diet, physical activity, body mass index, husband's education, maternal occupation, and paternal occupation.

CI indicates confidence interval; HR, hazard ratio; NHS indicates Nurses' Health Study; nSES, neighborhood socioeconomic status, SD, standard deviation.

income, median home value, percentage with a college degree, and percent households receiving interest dividends or rent income. The nSES measures included in this study could represent distinct pathways through which nSES influences mortality. For instance, participants living in neighborhoods with higher median household income and home values and more college graduates could be living in neighborhoods with better quality built environments, have easier access to resources, and experience less adverse environmental exposures (e.g., air pollution). Overall, effect sizes for nSES variables were larger in the NHSII cohort, which may be partially explained by these participants being slightly more diverse (racially and socioeconomically) and residing in more diverse census tracts than NHS participants.

The PCA in NHS yielded three principal components that have been observed in several other studies: education/income, racial composition, and poverty/wealth.[2,3,12,30] The first component could be categorized as education/income and included median income, median home value, and three education variables. The observed loadings were as expected across the three components in both cohorts, with high positive loadings for median income, median home value, and percent with a college degree and negative loadings for percent with high school education and percent with less than high school education. The second component, categorized as racial composition, showed a high negative loading for the proportion of white residents and positive loadings for percent black and percent foreign-born residents. Finally, the third component, which could be classified as a combination of poverty and wealth, included positive loadings for unemployment and negative loadings for the percentage of occupied housing units and the percentage of families receiving interest/dividends.

Our effect estimates are consistent in direction, though smaller in size, than those from other studies examining nSES and mortality. A meta-analysis of 18 studies in high-income countries yielded a relative risk for mortality of 1.05 (95% CI = 1.04, 1.06) in neighborhoods of lower SES compared to higher SES, after adjustment for age and biological sex.[30] In a longitudinal examination of mortality in the Black Women's Health Study between 1995 and 2011, women in the lowest nSES quartile (compared to the highest) had a substantially higher risk for all-cause mortality (HR = 1.42; 95% CI = 1.18, 1.71), after adjustment for age, educational attainment, marital status, smoking status, and physical activity.[2] Another study conducted among term life policyholders from 2002 to 2010 indicated a 9.8% (95% CI = 6.0, 13.7%) increase in the hazard of dying per standard deviation increase in neighborhood disadvantage, with area-level poverty and mortgage delinquency serving as important predictors of mortality.[40] In our study, all participants were nurses at baseline and most were non-Hispanic White. Neighborhood effects likely vary by race, consistent with the weathering hypothesis,[29] which may partially explain the small associations observed in this study. However, with limited variability in individual SES and an extensive list of potential time-varying confounders, we may have been able to better isolate the effects of nSES on all-cause mortality than in previous studies.

Table 3.

Hazard ratios and 95% confidence intervals for associations between neighborhood socioeconomic status component scores and all-cause mortality among Nurses' Health Study (NHS, 1986–2014, N = 101,701, deaths = 19,228, person-years = 2,385,561) and Nurses' Health Study II (NHSII, 1989–2015, N = 101,230, deaths = 1,556, person-years = 2,177,646)

	NHS			NHSII		
	Education/income	Racial composition	Poverty/wealth	Education/income	Racial composition	Poverty/wealth
Unadjusted individual component models	0.93 (0.92 – 0.95)	1.03 (1.01 – 1.04)	1.02 (1.00 – 1.03)	0.83 (0.78 – 0.87)	1.09 (1.04 – 1.14)	1.13 (1.07 – 1.19)
Unadjusted model with all components	0.93 (0.92 – 0.95)	1.03 (1.01 – 1.04)	1.01 (0.99 – 1.02)	0.85 (0.80 – 0.90)	1.09 (1.04 – 1.14	1.09 (1.03 – 1.15)
All components + race	0.93 (0.92 – 0.95)	1.04 (1.03 – 1.05)	1.01 (0.99 – 1.02)	0.85 (0.80 – 0.90)	1.07 (1.02 – 1.12)	1.09 (1.03 – 1.15)
All components + race + smoking	0.94 (0.92 – 0.95)	1.03 (1.02 – 1.05)	1.00 (0.98 – 1.01)	0.86 (0.81 – 0.91)	1.06 (1.01 – 1.11)	1.07 (1.02 – 1.13)
All components + race + diet	0.97 (0.96 – 0.99)	1.05 (1.03 – 1.06)	1.02 (1.00 – 1.03)	0.89 (0.84 – 0.94)	1.08 (1.03 – 1.13)	1.09 (1.03 – 1.15)
All components + race + physical activity	0.97 (0.96 – 0.99)	1.03 (1.02 – 1.05)	1.02 (1.00 – 1.03)	0.89 (0.84 – 0.94)	1.06 (1.01 – 1.11)	1.09 (1.03 – 1.15)
All components + race + individual SES	0.95 (0.93 – 0.97)	1.03 (1.01 – 1.04)	1.01 (1.00 – 1.03)	0.91 (0.85 – 0.96)	1.04 (0.99 – 1.09)	1.07 (1.01 – 1.13)
All components + full set of covariates	0.98 (0.96 – 1.00)	1.03 (1.01 – 1.04)	1.01 (1.00 – 1.03)	0.95 (0.90 – 1.02)	1.04 (0.99 – 1.09)	1.06 (1.00 – 1.11)

The first component (Education/Income) represents the constructs of education and income and includes median income, median home value, and three education variables (percent with a college degree, percent with high school education, and percent with less than high school education). The second component (Racial Composition) includes proportions of white, black, and foreign-born residents. The third component (Poverty/Wealth) includes percent unemployment, percent of occupied housing units, and percent of families receiving interest or dividends.

Models were adjusted for the following participant characteristics: age, calendar year, marital status, race, education, smoking status, diet, physical activity, body mass index, husband's education, maternal occupation, and paternal occupation.

NHS indicates Nurses' Health Study; SES, socioeconomic status.

There are several potential limitations in our study. First, although we adjusted for important sociodemographic, clinical, and lifestyle factors, bias in our estimates may exist due to unmeasured confounding. A second potential limitation is the lack of information on other neighborhood characteristics, such as neighborhood social context, that could aid in further understanding possible mechanisms (e.g., social cohesion) that drive associations with mortality. Another limitation is the relative homogeneity of the members of both cohorts with respect to race and education. This could make these results less generalizable to populations with lower levels of nSES, but the limited variability in the individual race and SES limits potential confounding through these pathways and is a major strength in isolating the effects of nSES. Moreover, participants live in Census tracts across the country, so our findings may be applicable to residents from a wide range of neighborhoods.[41]

This study has several important strengths. We accounted for individual-level socioeconomic factors as potential confounders and assessed potential mediators (i.e., diet, smoking, and physical activity). This study is among the first of US-wide longitudinal examinations of the association between nSES and all-cause mortality in women with extensive covariates available. We had detailed information on the residential history and captured time-varying nSES over almost three decades. Future work incorporating information on time spent around the residential address and other more specific aspects of the neighborhood environment would be informative. Adjustment for multiple behavioral factors (e.g., diet and physical activity) may explain the smaller associations we observed relative to previous analyses unable to include these potential confounders/mediators.

Conclusion

We examined associations between nSES and mortality in two cohorts of US women. Lower nSES was associated with a small increased risk of all-cause mortality, after adjustment for time-varying individual-level socioeconomic and lifestyle risk factors. This study adds to the existing literature on nSES by demonstrating associations with individual measures (e.g., home value) and an nSES score with all-cause mortality in two relatively homogeneous cohorts composed of predominantly white women with higher levels of education and individual SES.

Conflicts of interest statement

The authors declare that they have no conflicts of interest with regard to the content of this report.

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