Mortality Effects of Community Socioeconomic Status

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We linked data from the National Longitudinal Mortality Study to census tract information on 239,187 persons to assess 11-year mortality risk among black and white men and women associated with median census tract income, adjusted for individual family income from the Current Population Survey. We stratified Cox proportional hazards models by ages 25–64 years and 65 years and older. We used a robust covariance matrix to obtain standard errors for the model coefficients that account for correlation among individuals in the same census tract. Both income indicators were independently related to all-cause mortality. Among persons age 25–64 years, the rate ratios (RR) for individual family income and the median census tract income, respectively, for low income relative to high income were RR = 2.10 *vs* 1.49 for black men, RR = 2.03 *vs* 1.26 for white men; and RR = 1.92 *vs* 1.30 for black women and RR = 1.61 *vs* 1.16 for white women. Among persons age 65 years or greater, only individual family income was associated with mortality, and only for white men. Although family income has a stronger association with mortality than census tract, our results indicate that, more broadly, area socioeconomic status makes a unique and substantial contribution to mortality and should be explored in health policy and disease prevention research. (Epidemiology 1997;8:42–47)

Keywords: socioeconomic status, environment, mortality rate, the National Longitudinal Mortality Study, age, gender.

Lower socioeconomic status (SES) is associated with increased mortality risk from all causes, as well as specific causes of death that occur in a population.[1–4] For nearly all causes examined, this pattern has been robust across populations, geographical regions, and measures of SES.[3,5–7]

In epidemiologic research, measurement of SES has been conducted at both individual and aggregate levels, depending largely upon opportunities or resources for data collection and quality of SES data in available sources. In the literature, SES has mostly been viewed as an intrinsic property of individuals, such as amounts of financial and material resources,[5] and can be interpreted as affecting health by providing access to health care, adequacy of housing and nutrition, general living conditions, opportunities for health education, and exposure to emotional stress. Within this view, when an individual's information is not available, ecologic-level indicators of SES (for example, median income of persons living within counties, zip code areas, or census tracts) are thought to be useful surrogate measures. Associated with these measures is the potential cost of misclassification and loss of power to detect differences in rates of morbidity or mortality.[8–10]

Alternatively, other salient facets of SES may be conceptualized as being rooted in socioenvironmental conditions. Some of these considerations may include characteristics of housing, availability of local medical care and health-related resources in an area, environmental exposures to various noxious agents such as noise, stress, pollution, or contaminants,[11–16] and behaviors regulated through local social norms or elicited through social and economic pressures. From this viewpoint, an area's SES may summarize an area's potential for health risk from ecologic exposures such as from the concentration of poverty, unemployment, economic disinvestment, and social disorganization. Thus, whether an individual engages in specific health risk behaviors (for example, high-risk diets and tobacco and alcohol consumption), is exposed to social stress, or is isolated from preventive medical care may be conditioned upon social and community contexts,[17,18] not just the social position of individuals.

Few studies have included both kinds of SES indicators in their analyses.[16,19,20] Only one of these has examined mortality as an outcome.[16] In the National Longitudinal Mortality Study (NLMS), the availability of both area-based (median income for census tracts) and individual-level (family income) indicators of SES provides a unique opportunity to estimate distinct SES effects on mortality, both separately and jointly for each class of SES indicator. The NLMS is a large national

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database of the U.S. noninstitutionalized population assembled from survey data collected from February 1978 to March 1985. Follow-up of the sample was done using the National Death Index (NDI) for the years 1979–1989. This paper is one of a series of analyses based on the NLMS that seeks to describe the profound effect that socioeconomic status has on mortality.[2,21–23]

Methods

Sample

The sample population for the NLMS was selected from the Bureau of Labor Statistics Current Population Survey (CPS).[23] The CPS is a complex national sample of households that are surveyed monthly to obtain demographic, economic, and social information about the U.S. population, with an emphasis on employment, unemployment, and other labor force characteristics.[24] It is used by the Bureau of Labor Statistics to prepare monthly estimates of the unemployment rate. The survey is conducted by personal and telephone interview and has a response rate close to 96%. For this study, 10 CPS surveys have been selected for mortality assessment, with follow-up from the NDI.[25] The surveys chosen were conducted in February 1978, March 1979, April 1980, August 1980, December 1980, March 1981, March 1982, March 1983, March 1984, and March 1985.

Ascertainment of Death

Each survey in the NLMS was matched to the NDI of the National Center for Health Statistics for the period 1979–1989. The NDI is a computer file of all deaths in the United States since 1979, and it has been shown to be an effective and accurate means of ascertaining deaths when personal identifying information is collected.[26] Data records with up to 14 personal identifying items are submitted to the NDI, and possible matches are produced based on 12 criteria established by the National Center for Health Statistics. From the NDI matches, a determination of high-quality matches *vs* false-positive matches was made by a careful review of the matching items, using methods described by Rogot and colleagues.[27] Except for the younger age group (under 15 years), mortality rates for the NLMS are consistent with, although slightly lower than, estimates from the noninstitutional population of the United States, indicating that only a small proportion of deaths were missed in this study.

Census Tracts

Census tracts (CT) are relatively permanent geographical areas designed to encompass between 3,000 and 6,000 people in urbanized areas and are intended to be homogeneous with respect to general economic conditions, ethnicity, and living conditions of small areas (that is, neighborhood communities).[28] Information on census tract median income was linked to the NLMS database through information provided in 1980 Census data (file STF3A). Census tracts are formed mostly for Standard Metropolitan Statistical Areas (SMSAs), and for the following designations outside SMSAs: cities of 50,000 or more population, counties of 100,000 or more, and counties adjacent to SMSAs. Because the NLMS represents a national sample, part of the NLMS population (about 25%) did not live in areas with designated census tracts. Additionally, because the NLMS was based on 1970 geography codes but the census tract data desired were based on 1980 codes, a link between 1970 and 1980 tract identifiers was required. In some cases, a 1980 tract did not replicate a 1970 tract. This occurred when population changes, mostly growth, led to the creation of new tracts either from previously untracted areas or by dividing existing (1970) boundaries into their 1980 components. The final database includes all persons in the NLMS residing within 1980 census tracts that either had not changed between the 1970 and 1980 Censuses or that were split from a single 1970 census tract and thus could be reassembled.

SES Indicators

For this study, we chose family income as the indicator of an individual's SES, as it reflects financially determined opportunities for adequate housing, nutrition, and medical care. We chose median family income for census tracts as an analogous indicator of SES exposures to explore contextual effects not attributable to individual income.

In the CPS, family income (CPS income) is the reported total combined income of all members of the respondent's family residing in the household. Since the samples were drawn across a period of 7 years, we adjusted reported income to 1980 dollars by using the consumer price index. We divided CPS family income into the following categories based on the groupings stated in the CPS interview: low (<$10,000), middle ($10,000 to $25,000), and high (>$25,000). For levels of median census tract income (CT income), we located the cutpoints that yielded distributions similar to that of CPS income in white men and applied them to all race and gender groups (low = <$16,200, middle = $16,200 to $22,900, and high = >$22,900). The use of a single set of cutpoints across race and gender makes them comparable with each other in terms of actual dollar amounts and, hypothetically, captures similar levels of economic resources in areas indexed through average household earnings.

Statistical Methods

We calculated death rates by income level for each age, race, and sex grouping by dividing the number of deaths by the number of person-years during the same time period. A person contributed 1 person-year if he or she was alive at the beginning of the period and followed for 1 year; otherwise, the fraction of time alive in the year is contributed. We standardized for age,[29] using weights determined from the U.S. Bureau of Census for 1980 (see Appendix 1).[30]

We estimated relative mortality rates using the Cox proportional hazards model.[31] We saw no serious viola-

TABLE 1. Percentage of NLMS Population with Linked Census Tract Information

Characteristics	Number of Persons: NLMS	Number of Persons: Matched to 1980 Census Tract Data	% Matched
Total population	625,301	239,187	38
In SMSA	391,465	216,633	55
Not in SMSA	233,836	22,554	10
Population in SMSA			
Sex			
Men	181,375	99,298	55
Women	210,090	117,335	56
Race			
White	337,958	186,743	55
Black	42,190	24,655	58
Other	11,317	5,235	46
Location			
Central city	167,252	98,173	59
Suburb	224,213	118,460	53
Family income			
<$10,000	83,635	50,348	60
$10,000–$24,999	160,898	89,540	56
≥$25,000	130,428	67,509	52
Unknown	16,504	9,236	56
Age (years)			
25–44	192,257	98,330	51
45–64	131,115	76,652	58
≥65	68,093	41,651	61

tion of the proportional hazard assumption by graphical examination of the complementary log-log of the hazard function for each demographic group. In the NLMS data, CPS income is observed at the individual level, but the value of CT income is common to all individuals within the same census tract. Owing to the multilevel nature of the data, survival times for individuals within each tract are correlated, violating the usual regression assumption of independence of observations.[32–34] This problem may lead to underestimated standard errors for the model coefficients. To account for intratract correlation in our analysis, we used a robust covariance matrix estimated using a technique first proposed by Lee *et al*[35] and generalized into a repeated events framework by Lin.[36] We used the MULCOX2 program of Lin[37] to estimate the robust covariance matrix.

Results

The census tract matched sample included 239,187 persons (38%) of the NLMS population of 625,310 persons age 25 years and older in the selected files (Table 1). For the NLMS population residing within an SMSA, approximately 55% were linked with census tract information. We obtained a slightly higher proportion of matches for persons who were black, lived within a central city, had a relatively low family income, or were older. Substantially fewer persons (10%) from the NLMS population residing in areas outside SMSAs had linked census tract information, as these areas are mostly not tracted. The final analytical sample included

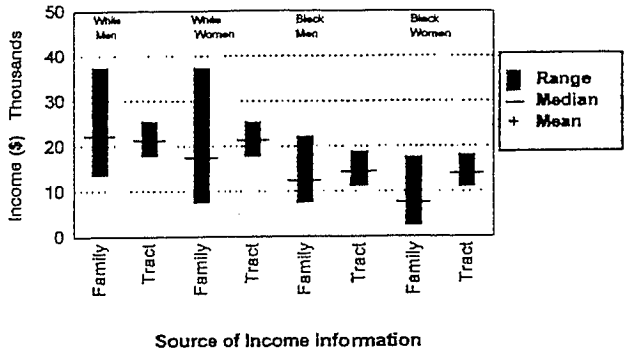

FIGURE 1. Interquartile range, median, and mean income by race and sex (NLMS and census tract data, 10 files).

233,600 persons who, in the 1980 Census, reported their annual family income, specified their race as being either "black" or "white," and could be linked with tract information.

Figure 1 shows the interquartile range of CPS and median CT income by race and gender in terms of 1980 dollars. The upper quartile of family income is much larger among whites than blacks, and a large proportion of blacks reported family incomes below the mean family income obtained for whites. The results for CT (tract) income show that a majority of whites also live in tracts more affluent than those resided in by blacks.

Income and Mortality

A total of 24,508 deaths were identified in the 11-year NDI follow-up period across the age and race groups studied. Tables 2 and 3 present the age-adjusted mortality rates for men and women, for two age groups (25–64 years and 65 years and older), and for two race groups (white and black). The characteristic income gradients of mortality are evident for all age, race, and gender groups, both for CPS income and CT income (with the exception of black women 65 years and older). As shown in Table 2, the mortality rates for low CPS income are appreciably larger than those for low CT income for both white and black men age 25–64 years (889 *vs* 662, and 1,263 *vs* 985, respectively). Among women (Table 3), there is a similar pattern, although the absolute difference between rates is smaller in magnitude.

Tables 4 and 5 present age-adjusted proportional hazards model estimates of rate ratios (RR) for low income relative to high income, and 95% confidence intervals (CI) for CPS and CT income. For each race and sex group, the effect of CPS income level is altered only trivially when adjustment is made for median CT income. Among persons 25–64 years of age, the mortality ratios for persons with low CPS income relative to high income, adjusted for CT income, ranged from RR = 1.61 to RR = 2.10 across race and gender groups. In comparison, in the same model, the estimated effect of low CT income on mortality is reduced, but not removed, after adjusting for CPS income level. Among men 25–64 years of age, the mortality rate ratio for the period associated with low CT income was RR = 1.26

TABLE 2. Indirect Age-Adjusted Mortality Rates by Age Group, Race, and Income Level: Men (NLMS 1979–1989)

Race, Age, and Income Level	CPS Family Income			Median Census Tract Income		
	Person-Years	Number of Deaths*	Rate × 100,000 Person-Years	Person-Years	Number of Deaths	Rate × 100,000 Person-Years
White men						
Age 25–64 years						
High	235,307	1,103	364	237,097	1,182	407
Mid	265,846	1,477	528	259,839	1,514	518
Low	68,076	632	889	97,111	693	662
Age ≥65 years						
High	36,693	1,216	4,440	60,041	2,775	5,066
Mid	70,185	3,383	5,300	77,331	4,224	5,605
Low	49,567	3,638	6,490	29,525	1,803	5,974
Black men						
Age 25–64 years						
High	14,489	77	497	7,749	42	541
Mid	33,192	270	773	21,216	158	713
Low	19,947	284	1,263	41,677	462	985
Age ≥65 years						
High	1,161	51	5,694	1,028	52	5,175
Mid	5,479	270	5,586	3,835	214	6,118
Low	8,861	589	6,451	11,433	687	6,205

* Number of deaths shown for CPS income excludes the approximately 5% of deaths for which income was unknown.

TABLE 3. Direct Age-Adjusted Mortality Rates by Age Group, Race, and Income Level: Women (NLMS 1979–1989)

Race, Age, and Income Level	CPS Family Income			Median Census Tract Income		
	Person-Years	Number of Deaths*	Rate × 100,000 Person-Years	Person-Years	Number of Deaths	Rate × 100,000 Person-Years
White women						
Age 25–64 years						
High	233,490	615	212	257,090	737	231
Mid	283,987	883	274	282,939	953	281
Low	102,829	522	406	108,076	413	331
Age ≥65 years						
High	35,215	1,003	3,069	82,204	2,717	3,084
Mid	84,363	2,512	3,088	117,537	4,173	3,182
Low	110,223	4,550	3,319	47,471	1,799	3,302
Black women						
Age 25–64 years						
High	14,434	47	332	8,860	33	377
Mid	39,479	156	388	27,095	126	476
Low	41,619	334	749	63,453	398	584
Age ≥65 years						
High	1,459	42	3,127	1,325	50	3,744
Mid	6,055	208	3,645	5,791	211	3,721
Low	16,483	646	3,719	18,083	666	3,574

* Number of deaths shown for CPS income excludes the approximately 5% of deaths for which income was unknown.

for whites, and RR = 1.49 for blacks. The estimated ratios for white women and black women are RR = 1.16 and RR = 1.30, respectively. Among those 65 years of age and older, the mortality associated with either low CPS or CT income is, by and large, not different from unity in the race and gender groups. The only exception is for white men with low CPS income, for whom the mortality ratio is RR = 1.38.

Discussion

An impressive feature of the NLMS-based comparison of area- and individual-based indicators of SES is the large numbers of both black and white adults that may be cross-classified according to both family income and census tract. Furthermore, levels of CT and CPS incomes were not highly correlated with each other.

Although SES has traditionally been treated as an intrinsic characteristic of individuals, contextual effects of SES on health are theoretically important.[14,15,38,39] Our analyses included both census tract and individual family income to examine the heretofore largely unexplored effects of local area on mortality risk beyond the effects of an individual's income level. Comparing the risk ratios before and after adjustment, approximately one-quarter to one-third of the mortality associated with residence in low-income areas was found to be independent of level of personal income. After accounting for family income effects, black men and women (age 25–64 years) residing in low-income areas had, respectively, 40% and 30% higher mortality than those residing in areas with higher SES. The respective mortality rates for white men and women residing in low-income areas were 26% and 16% larger than among those residing in high-income areas. Adjustment for residence in central city *vs* non-central city (results not shown) did not appreciably alter the general pattern of results presented here.

There is other evidence that SES pathways to health risk go beyond individuals and involve their communities. In a study of mortality rates in Harlem, in New York City, the age-adjusted all-cause rate of mortality was 50% higher than that of U.S. blacks.[40] It was hypothesized that much of this excess risk might be from environmental impoverishment. Area socioecologic stress has been linked to individual mean blood pressure,[41] and hypertension-related deaths overall,[42] independently of median income of the area studied.[43] Wing and colleagues[11] and Tyroler *et al*[13] have shown that changes in socioenvironmental char-

TABLE 4. Age- and Income-Adjusted Relative Risk for All-Cause Mortality: Men (NLMS 1979–1989)

Race, Age, and Income Level	CPS Family Income* RR (95% CI) Adjusted for:		Median Census Tract Income† RR (95% CI) Adjusted for:	
	Age	Age, Tract $‡	Age	Age, CPS $‡
White men				
Age 25–64 years				
High§	1.00	1.00	1.00	1.00
Mid	1.44 (1.35–1.54)	1.37 (1.28–1.47)	1.26 (1.18–1.35)	1.12 (1.05–1.20)
Low	2.22 (2.05–2.41)	2.03 (1.85–2.22)	1.60 (1.48–1.74)	1.26 (1.15–1.38)
Age ≥65 years				
High§	1.00	1.00	1.00	1.00
Mid	1.19 (1.10–1.29)	1.18 (1.09–1.28)	1.10 (1.04–1.16)	1.04 (0.98–1.10)
Low	1.42 (1.31–1.53)	1.38 (1.28–1.49)	1.15 (1.07–1.23)	1.06 (0.99–1.14)
Black men				
Age 25–64 years				
High§	1.00	1.00	1.00	1.00
Mid	1.52 (1.21–1.90)	1.41 (1.12–1.77)	1.37 (1.00–1.88)	1.24 (0.93–1.65)
Low	2.34 (1.87–2.92)	2.10 (1.67–2.64)	1.83 (1.37–2.46)	1.49 (1.14–1.95)
Age ≥65 years				
High§	1.00	1.00	1.00	1.00
Mid	0.96 (0.65–1.40)	0.94 (0.64–1.38)	1.25 (0.88–1.77)	1.23 (0.86–1.76)
Low	1.09 (0.76–1.56)	1.06 (0.74–1.53)	1.19 (0.86–1.65)	1.16 (0.83–1.62)

* Low = $0–9.9, mid = $10.0–24.9, high = ≥$25.0 (in thousands of dollars).
† Median tract income levels based on CPS income distribution for white men. Low = $16.2, mid = $16.2–22.9, high = ≥$23.0 (in thousands of dollars).
‡ Based on robust standard error using MULCOX2 (Lin[37]).
§ Reference category.

TABLE 5. Age- and Income-Adjusted Relative Risk for All-Cause Mortality: Women (NLMS 1979–1989)

Race, Age, and Income Level	CPS Family Income* RR (95% CI) Adjusted for:		Median Census Tract Income† RR (95% CI) Adjusted for:	
	Age	Age, Tract $‡	Age	Age, CPS $‡
White women				
Age 25–64 years				
High§	1.00	1.00	1.00	1.00
Mid	1.25 (1.14–1.36)	1.21 (1.11–1.32)	1.14 (1.05–1.23)	1.05 (0.97–1.14)
Low	1.70 (1.54–1.87)	1.61 (1.45–1.79)	1.36 (1.23–1.51)	1.16 (1.04–1.29)
Age ≥65 years				
High§	1.00	1.00	1.00	1.00
Mid	0.99 (0.91–1.07)	0.98 (0.90–1.07)	1.03 (0.98–1.09)	1.02 (0.96–1.08)
Low	1.03 (0.95–1.11)	1.01 (0.93–1.10)	1.02 (0.96–1.09)	1.02 (0.95–1.09)
Black women				
Age 25–64 years				
High§	1.00	1.00	1.00	1.00
Mid	1.27 (0.94–1.71)	1.21 (0.89–1.65)	1.35 (0.94–1.94)	1.21 (0.83–1.76)
Low	2.06 (1.55–2.73)	1.92 (1.42–2.60)	1.63 (1.16–2.29)	1.30 (0.91–1.87)
Age ≥65 years				
High§	1.00	1.00	1.00	1.00
Mid	1.09 (0.75–1.58)	1.12 (0.77–1.63)	0.95 (0.68–1.34)	0.93 (0.66–1.31)
Low	1.14 (0.81–1.62)	1.18 (0.83–1.68)	0.92 (0.67–1.27)	0.90 (0.66–1.24)

* Low = $0–9.9, mid = $10.0–24.9, high = ≥$25.0 (in thousands of dollars).
† Median tract income levels based on CPS income distribution for white men. Low = $16.2, mid = $16.2–22.9, high = ≥$23.0 (in thousands of dollars).
‡ Based on robust standard error using MULCOX2 (Lin[37]).
§ Reference category.

acteristics such as an area's economic profile and average educational attainment predict declines in ischemic heart disease mortality. In the only study of mortality considering both area and individual SES data, Haan and colleagues[16] found an excess of mortality among residents of a designated poverty area in Oakland, CA, after considering personal income status and major behavioral risk factors. Humphreys and Carr-Hill,[19] in the UK, used a multilevel modeling technique to demonstrate "ward" effects of SES on health status after adjusting for individual status on level of health. The still rather limited evidence reported on small-area effects on putative mechanisms, such as propensity for health risk behaviors,[17,20] exposure to social stress,[18,42] and access to health care programs and services,[44] is indicative that exposures deleterious to health may cluster within areas, perhaps synergistically.[39] Our analyses found that, although the magnitude of the relative risk for low CPS income was similar for black men and white men (2.03 *vs* 2.10), the risk associated with CT income was higher in black men than white men. This result appears to support the findings of Massey and Fong[45] that low-status blacks may experience qualitatively inferior residential environments compared with low-status whites.

A limitation of the data used to link census tract information to the NLMS for persons was an overselection of residents in urban areas that underwent little population change between 1970 and 1980. Despite this shortcoming, the distribution of sociodemographic status shown was highly similar between NLMS samples matched and unmatched to census tracts. Furthermore, we note that the mortality risks obtained by individual family income are very similar to those reported in the literature for general population samples and to estimates based on the complete NLMS sample reported elsewhere.[2,22] In a series of additional analyses (not shown), sample match status (match *vs* nonmatch) was not strongly associated with all-cause mortality risk in our sample. Another potential limitation is that we could not study the pathways that presumably affect mortality. It is possible that risks that operate entirely independent of area characteristics were nonetheless clustered within low-income census tracts. In such a diverse sample of tracts studied, such an occurrence probably would not be systematic.

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Appendix 1

The weights used in this study for direct adjustment, from the 1980 U.S. Census figures, are listed in Table A1. These were applied to all sex and race groups.

TABLE A1. Weights Used for Direct Standardization

Age Group (Years)	Weight
25–29	0.181404
30–34	0.164994
35–39	0.130171
40–44	0.108679
45–49	0.102712
50–54	0.109072
55–59	0.108548
60–64	0.09442