Area Deprivation and Widening Inequalities in US Mortality, 1969–1998

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Objectives. This study examined age-, sex-, and race-specific gradients in US mortality by area deprivation between 1969 and 1998.

Methods. A census-based area deprivation index was linked to county mortality data.

Results. Area deprivation gradients in US mortality increased substantially during 1969 through 1998. The gradients were steepest for men and women aged 25 to 44 years and those younger than 25 years, with higher mortality rates observed in more deprived areas. Although area gradients were less pronounced for women in each age group, they rose sharply for women aged 25 to 44 and 45 to 64 years.

Conclusions. Areal inequalities in mortality widened because of slower mortality declines in more deprived areas. Future research needs to examine population-level social, behavioral, and medical care factors that may account for the increasing gradient. (*Am J Public Health.* 2003;93:1137–1143)

Studies involving individual social class data have shown increasing socioeconomic inequalities in US infant and adult mortality rates.[1–3] However, these studies have compared social class inequalities in mortality at only 2 distant time points (e.g., 1960 and 1986). This limitation is primarily because of limited availability of socioeconomic information in US mortality statistics, which generally include only educational attainment and usual occupation/industry of the decedent.[4–9] Moreover, analyses of socioeconomic differentials in mortality are hampered by incomplete and poorly reported socioeconomic data on death certificates as well as by the lack of relevant denominator data.[5,7,9,10]

Whereas US mortality statistics are frequently provided by age, sex, race, and cause of death, temporal analyses of socioeconomic differentials in mortality are less common.[1–3,5,6,9,10] Similarly, although a substantial number of ecological studies have examined the cross-sectional association between areal social conditions and US mortality,[8,11–20] temporal analyses of mortality differentials in relation to area-based deprivation or inequality measures remain scarce.[9,21–28] Area-based composite deprivation indices have been used extensively in analyzing and monitoring health and mortality differentials in Europe, Australia, and New Zealand.[29–38] Despite the lack of a consensus deprivation index in the United States, it is possible to construct a comprehensive, composite census-based socioeconomic index that, when linked to mortality data at an aggregate geographic level (e.g., county), could allow the monitoring of population health inequalities across time and space.[8,9,21]

In this article, I use census tract data to describe a composite area–based deprivation index for the United States. By linking the index to national mortality data, I examine the extent to which differentials in all-cause mortality rates by area deprivation have changed over time. Specifically, I use the areal index to stratify all 3097 US counties into 5 area deprivation groups and examine trends in areal gradients in mortality between 1969 and 1998 for men and women of all ages as well as for those in specific age groups (less than 25 years, 25–44 years, 45–64 years, and 65 years or older).

METHODS

Constructing an Index of Area Deprivation

Community socioeconomic measures describe important aspects of social organization, structure, stratification, or environment, such as socioeconomic deprivation, economic inequality, resource availability, and opportunity structure.[8,9,21,39–41] Although single measures representing an area's educational and occupational composition, income and employment distributions, or housing conditions can be used to classify communities, a composite index consisting of several key indicators drawn from these domains would more accurately reflect the multidimensional characterization of a community's socioeconomic position.[8,9,21] Such a composite index should have greater validity, robustness, and explanatory power than single areal measures in documenting the extent of social disparities in health and mortality.

In constructing an index, I considered 21 socioeconomic indicators that may be viewed as approximating the material and social conditions and relative socioeconomic disadvantage in a given community. Indicators were selected on the basis of their theoretical relevance and on the basis of previous empirical research.[8,9,21,29,37–40] These indicators, drawn from the 1990 census, included educational distribution (percentage of the population with less than 9 years and with 12 or more years of education), median family income, income disparity, occupational composition, unemployment rate, family poverty rate, percentage of the population below 150% of the poverty rate, single-parent household rate, home ownership rate, median home value, median gross rent, median monthly mortgage, and household crowding. Other indicators were percentages of households without access to a telephone, plumbing, or motor vehicles; English language proficiency; divorce rate; percentage of urban population; and percentage of immigrant population.[21,42,43] Factor analysis and principal-components analysis were used in index construction.[44,45]

The initial factor analysis provided 2 factors that respectively accounted for 43% and 17% of the variance in the data. Seventeen of the indicators were clustered and had consid-

erably larger loadings (>0.45) on the first than on the second factor. However, 3 indicators—English language proficiency, percentage of urban population, and percentage of immigrant population—had much smaller loadings (<0.25) on the first factor but larger loadings on the second factor. Divorce rate did not load highly on either factor. Whereas the first factor clearly indicated a theoretically and empirically meaningful clustering of the given indicators, the second factor, with only a few substantial loadings, did not lend itself to any obvious theoretical interpretation. In the final phase of the index construction, the 17 indicators were factor analyzed with a single-factor solution. Table 1 contains these results.

The factor loadings for the census tract deprivation index ranged from 0.92 for percentage of population below 150% of the poverty rate to 0.45 for percentage of households without access to plumbing (Table 1). The factor score coefficients were used to weight the 17 indicators comprising the index. Poverty, income, and education had the largest relative weights in generating the 1990 index. The index accounted for 52% of the variance in the data. The factor scale was transformed into a standardized index by arbitrarily setting the index mean and standard deviation at 100 and 20, respectively. The tract index scores were averaged to allow computation of index scores for each of the 3097 US counties. The 1990 county index scores ranged from a low of 70.22 to a high of 160.32. Higher index scores denote higher levels of deprivation.

The reliability coefficient (α) for the census tract index was 0.95, indicating a high degree of internal consistency among the indicators comprising the index.[46] The reliability of the tract index was further evaluated by factor analyzing the 17 variables for different random subsamples of the US population. The factor structure matrix containing the factor loadings for the different subsamples remained essentially unchanged, indicating a high degree of index reliability for various subsets of the US population.[21]

The validity of the 1990 deprivation index was tested by comparing factor loadings for the same set of 17 indicators computed at the census tract, zip code, and county levels (Table 1). The factor loadings for the 3 geographic levels were generally similar in magnitude and relative importance. The percentages of explained variance and reliability coefficients were almost identical for the 1990 census tract and county indices.

The predictive validity of the 1990 deprivation index was checked by examining its correlation with a variety of county-level health outcomes for the period 1990 through 1996. The weighted correlations of the index with health outcomes were in the expected direction. The correlations with infant mortality rate and low birthweight rate were 0.48

TABLE 1—Factor Loadings and Factor Score Coefficients for the Census Variables Comprising the Area Deprivation Index: United States, 1970 and 1990[21]

Census Variable	Factor Loading: Tract Index, 1990	Factor Loading: Zip Code Index, 1990	Factor Loading: County Index, 1990	Factor Score Coefficient: Tract Index, 1990	Factor Loading: County Index, 1970
Population aged ≥ 25 y with < 9 y of education, %[a]	0.7498	0.7383	0.7885	0.0849	0.8340
Population aged ≥ 25 y with at least a high school diploma, %	–0.8562	–0.8089	–0.8231	–0.0970	–0.8788
Employed persons aged ≥ 16 y in white-collar occupations, %	–0.7721	–0.7118	–0.6890	–0.0874	–0.6075
Median family income, $	–0.8629	–0.8690	–0.9218	–0.0977	–0.8694
Income disparity[b]	0.8262	0.7054	0.8827	0.0936	0.7559
Median home value, $	–0.6074	–0.6764	–0.6740	–0.0688	–0.6703
Median gross rent, $	–0.6896	–0.7081	–0.7876	–0.0781	–0.7872
Median monthly mortgage, $	–0.6795	–0.7362	–0.7812	–0.0770	. . .
Owner-occupied housing units, % (home ownership rate)	–0.5431	–0.4688	–0.4408	–0.0615	. . .
Civilian labor force population aged ≥16 y unemployed, % (unemployment rate)	0.7117	0.5231	0.5679	0.0806	0.2195
Families below poverty level, %	0.8623	0.7996	0.8796	0.0977	0.9480
Population below 150% of the poverty threshold, %	0.9157	0.8781	0.9266	0.1037	0.9503
Single-parent households with children aged < 18 y, %	0.6346	0.3487	0.3329	0.0719	0.5520
Households without a motor vehicle, %	0.6126	0.4335	0.4549	0.0694	0.7540
Households without a telephone, %	0.7748	0.6837	0.7830	0.0877	0.8745
Occupied housing units without complete plumbing, % (log)	0.4505	0.4863	0.6392	0.0510	0.8921
Households with more than 1 person per room, % (crowding)	0.4910	0.3963	0.4018	0.0556	0.6854
Proportion of total variance explained by factor	0.5195	0.4432	0.5140	. . .	0.5990
Cronbach α (reliability coefficient)	0.9484	0.9311	0.9473	. . .	0.9573

Note. Values were derived from a principal-components analysis of census ecological data for 59 525 census tracts, 29 320 zip codes, and 3097 counties.
[a]For the 1970 index, percentage of population with less than 5 years of education was used.
[b]Income disparity in 1990 was defined as the log of 100 × ratio of number of households with < $10 000 income to number of households with ≥$50 000 income. Income disparity in 1970 was defined as the log of 100 × ratio of number of households with < $3000 income to number of households with ≥$15 000 income.

and 0.46, respectively, and correlations with age-adjusted mortality rates from various cause-of-death categories were as follows: all causes combined, 0.58; heart disease, 0.45; stroke, 0.24; all cancers, 0.20; lung cancer, 0.27; breast cancer, –0.19; cervical cancer, 0.51; melanoma, –0.20; diabetes, 0.44; chronic obstructive pulmonary disease, 0.14; cirrhosis, 0.25; unintentional injury, 0.66; suicide, 0.27; and homicide, 0.39.

Table 1 also presents the factor loadings associated with 15 indicators comprising the 1970 county deprivation index. Census tract data for all variables and county data for mortgage and home ownership rates were not available for the 1970 census.[43] The 1990 index was highly correlated with the 1970 index (r=0.87). The quintile classifications of the 1970 and 1990 deprivation indices also corresponded closely with each other (γ=0.88).

Computing Annual Rates and Modeling Areal Gradients Over Time

The weighted population quintile distribution of the 1990 deprivation index, which classified all US counties into 5 equal population groups, was used to analyze time trends. The groups thus created ranged from representing the least-deprived to the most-deprived areas. National mortality data files were used to obtain age-, sex-, race-, and county-specific deaths recorded from 1969 through 1998.[4,5] Age-, sex-, race-, and county-specific census population estimates from 1969 to 1998 served as denominators for computing rates.[47,48] Each of the 3097 counties was assigned 1 of the 5 areal deprivation categories. In the case of Alaska and Hawaii, state- rather than county-level data were used. Mortality rates for each deprivation category were age adjusted via the direct method, using the age composition of the 1970 US population as a standard and 5-year age-specific death rates.

Log-linear models were used to estimate annual exponential rates of declines in mortality rates.[1] Poisson regression models were fitted to age-, sex-, race-, and county-specific death counts and populations to estimate areal gradients in mortality for 15 time periods of 2 years each.[49] Areal gradients (relative mortality risks) were estimated for men and women separately after adjustment for age and race (coded White, Black, or other). In all Poisson models, the least-deprived area was selected as the reference category. There was no statistically significant interaction between race and area deprivation.

All models, estimated via the SAS GENMOD procedure, showed reasonable fit, as determined by the likelihood ratio statistic or deviance.[50] In all of the models, 95% confidence intervals were adjusted for overdispersion. Trend tests were conducted by the use of χ^2 statistics derived through Poisson models that included age, race, and area deprivation (coded as a continuous variable).

RESULTS

The descriptive socioeconomic data presented in Table 2 indicate the relative stability of the area deprivation groups between 1970 and 1990. The relative educational standing of each deprivation group remained similar during 1970 to 1990. Median family incomes were 40% to 48% lower in the most-deprived than in the least-deprived area during this period. Median home values were 58% to 69% lower, white-collar employment rates were 27% to 29% lower, and the poverty rate was at least 3 times greater in the most-deprived than in the least-deprived area. More deprived areas had substantially higher proportions of Black and rural residents. Moreover, 62% of the population in the most-deprived areas was located in the South, in contrast to only 19% of the population in the least-deprived areas.

Figure 1 shows increasing areal gradients in mortality for both men and women over the past 3 decades. The areal classification based on 20% of counties (rather than 20% of the population) in each quintile produced almost identical gradients. Not only did more deprived areas have higher mortality rates than less-deprived areas during each year examined, but the gradient generally increased over time, especially for men. Although mortality rates for all deprived groups declined during 1969 to 1998, the more-deprived groups experienced slower mortality declines. Mortality among men in the least- through the most-deprived groups declined at average annual rates of 1.64%, 1.51%, 1.40%, 1.34%, and 1.13%, respectively, between 1969 and 1998. The corresponding annual rates of decline among women were 1.23%, 1.19%, 1.04%, 1.08%, and 0.97%.

Figure 1 also contains separate trends for Whites and Blacks. Consistently increasing areal gradients in mortality were observed among White men and women. Among Black men, areal gradients were somewhat less consistent but were as pronounced as those for White men, and they showed an increasing trend. Areal gradients were also less consistent for Black women and remained generally stable over time.

Age- and sex-specific areal gradients in mortality were computed with the 1970 deprivation index as well (data not shown). Temporal trends were generally similar to those based on the 1990 index. However, areal gradients based on the 1970 index were somewhat less consistent than those based on the 1990 index.

Figure 2 presents age- and race-adjusted relative mortality risks in 5 deprivation groups (based on the 1990 index) derived from Poisson regression analyses. During 1969 through 1998, there was a positive and generally increasing gradient in mortality by area deprivation for both men and women. The increase in areal gradients was particularly marked between 1985 and 1998. The gradients were steepest for men and women aged 25–44 years, followed by those aged younger than 25 years, those aged 45 to 66 years, and those aged 65 years or older. In 1969–1970, mortality rates among men aged younger than 25 years and men aged 25 to 44 years, respectively, were 40% and 56% greater in the most-deprived than in the least-deprived area. The corresponding differentials were 46% and 67% in 1989–1990 and 55% and 77% in 1997–1998.

The gradients were less pronounced for women than for men in each age group. However, the mortality differentials between deprivation groups rose sharply during 1969 to 1998 for women aged 25 to 44 and aged 45 to 64 years. In 1969–1970, mortality rates among women aged 25 to 44 and aged 45 to 64 years, respectively, were 32% and 9% greater in the most-deprived than in the least-deprived area. In 1989–1990, the correspon-

TABLE 2—Selected Social and Demographic Characteristics of 5 Area Deprivation Categories: United States, 1970–1990

Characteristic	1st Quintile (Least Deprived)	2nd Quintile (2nd Least Deprived)	3rd Quintile (3rd Most Deprived)	4th Quintile (2nd Most Deprived)	5th Quintile (Most Deprived)
Mean 1990 area deprivation index score	83.96	93.95	99.99	105.29	116.71
1990 area deprivation index score range	70.22–89.41	89.41–96.98	96.98–102.52	102.52–108.02	108.02–160.32
Median county population size, 1990	225 338	86 793	41 588	20 844	15 709
Minimum county population size, 1990	6 012	2 526	1 025	107	460
Maximum county population size, 1990	2 498 016	8 863 164	1 852 810	5 102 993	2 300 664
No. of counties, 1990	141	226	486	760	1 484
No. of counties in South, 1990	37	53	105	212	1 002
Population in South, 1990, %	18.60	21.85	29.65	42.31	62.25
Black population, 1990, %	7.03	9.00	9.63	14.39	20.79
Hispanic population, 1990, %	7.18	12.27	5.50	9.27	10.35
Asian/Pacific Islander population, 1990, %	5.24	4.87	1.53	1.72	1.19
Urban population, 1990, %	87.93	84.31	74.19	72.84	56.57
Foreign-born population, 1990, %	10.00	12.29	4.30	7.16	5.67
Non-English-speaking population, 1990, %	2.71	4.44	1.48	2.89	2.90
Education ≥ 12 years, 1990, %	83.48	78.40	76.90	72.55	64.21
Education ≥ 12 years, 1980, %	76.43	71.62	68.07	63.53	53.97
Education ≥ 12 years, 1970, %	62.90	58.64	53.79	49.45	40.28
Median family income, $, 1990	45 754	36 853	32 025	28 231	23 774
Median family income, $, 1980	24 034	20 715	19 085	17 141	14 442
Median family income, $, 1970	11 006	9 553	8 686	7 760	6 129
Median home value, $, 1990	125 650	77 700	58 000	45 500	39 500
Median home value, $, 1980	63 600	47 550	39 900	33 500	26 650
Median home value, $, 1970	21 215	16 390	13 742	11 322	8 642
White-collar occupation, 1990, %	66.67	60.82	56.32	54.49	48.78
White-collar occupation, 1980, %	61.26	56.17	51.37	49.72	44.40
White-collar occupation, 1970, %	56.74	52.14	46.82	45.00	40.43
Families below poverty level, 1990, %	4.35	7.81	8.82	11.47	17.83
Families below poverty level, 1980, %	5.13	7.78	8.17	10.34	16.01
Families below poverty level, 1970, %	5.07	7.57	8.81	10.80	19.39
Unemployment rate, 1990	4.43	5.70	5.83	7.08	8.78
Unemployment rate, 1980	4.74	5.43	6.14	6.48	7.42
Unemployment rate, 1970	4.67	4.52	4.30	4.26	5.10

Note. Data were derived from the 1990 census,[42] 1996 area resource file,[43] and Singh and Siahpush.[21]

ding differentials for women in these age groups were 49% and 21%; in 1997–1998, the differentials were 67% and 29%. Areal gradients in mortality among the elderly, although considerably smaller than those for the other age groups, increased consistently in the 1990s.

DISCUSSION

This study involved the use of a composite area–based deprivation index to analyze temporal trends in the extent of inequalities in US mortality during 1969 through 1998 among men and women in different age groups. The present analysis extended an earlier study that focused exclusively on the 25- to 64-year age group in its examination of temporal area socioeconomic inequalities in US all-cause and cardiovascular mortality.[21] The findings of the present study are also consistent with investigations showing increasing inequalities in mortality by single areal socioeconomic measures.[24–28]

An important limitation of the study relates to the use of the 1990 deprivation index to analyze areal inequalities in mortality from 1969 to 1998. Ideally, to allow for temporal sequencing between area deprivation and mortality, a deprivation index defined at the earliest decennial time point (i.e., 1970) was preferable. However, the 1970 and 1990 indices were highly correlated, and use of the 1970 index produced mortality trends similar to those based on the 1990 index. The small degree of areal misclassifica-

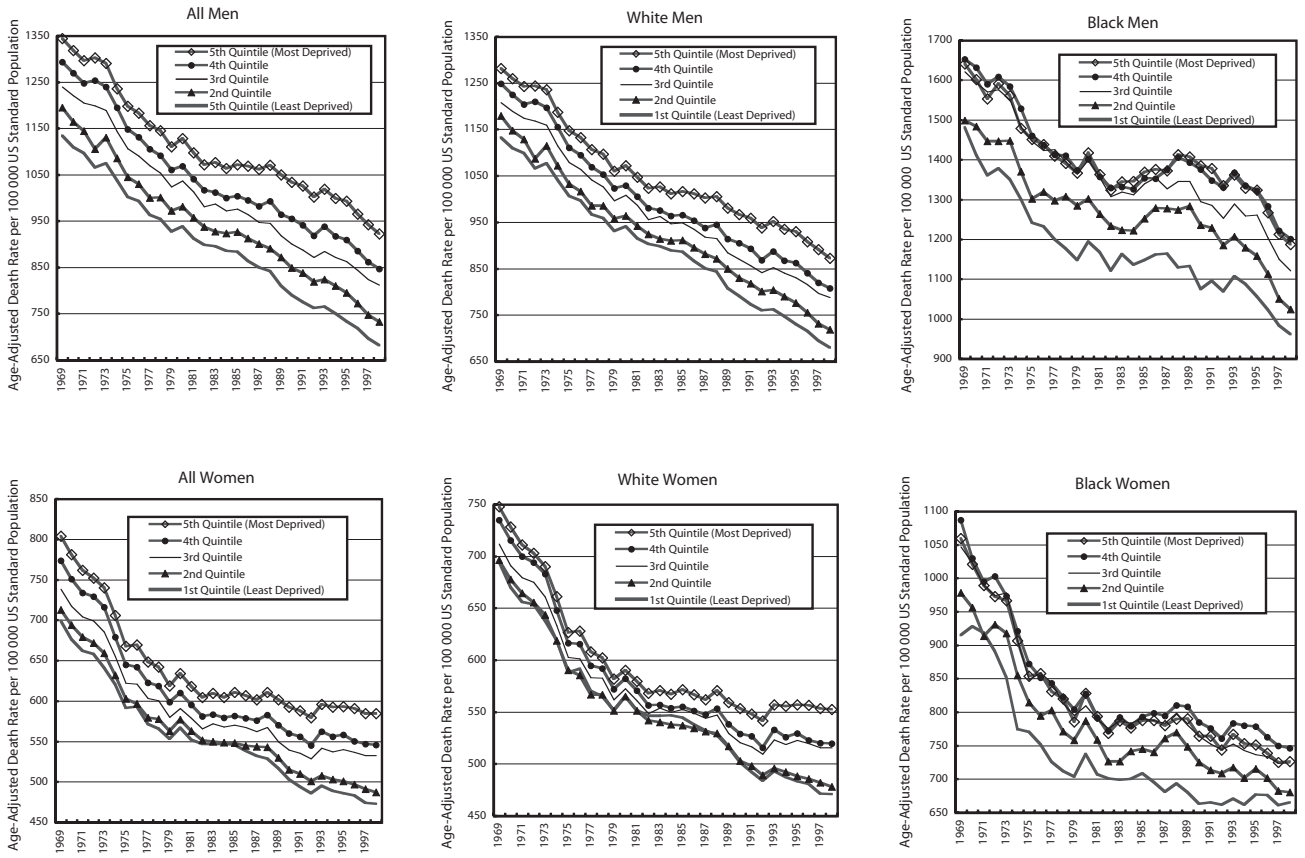


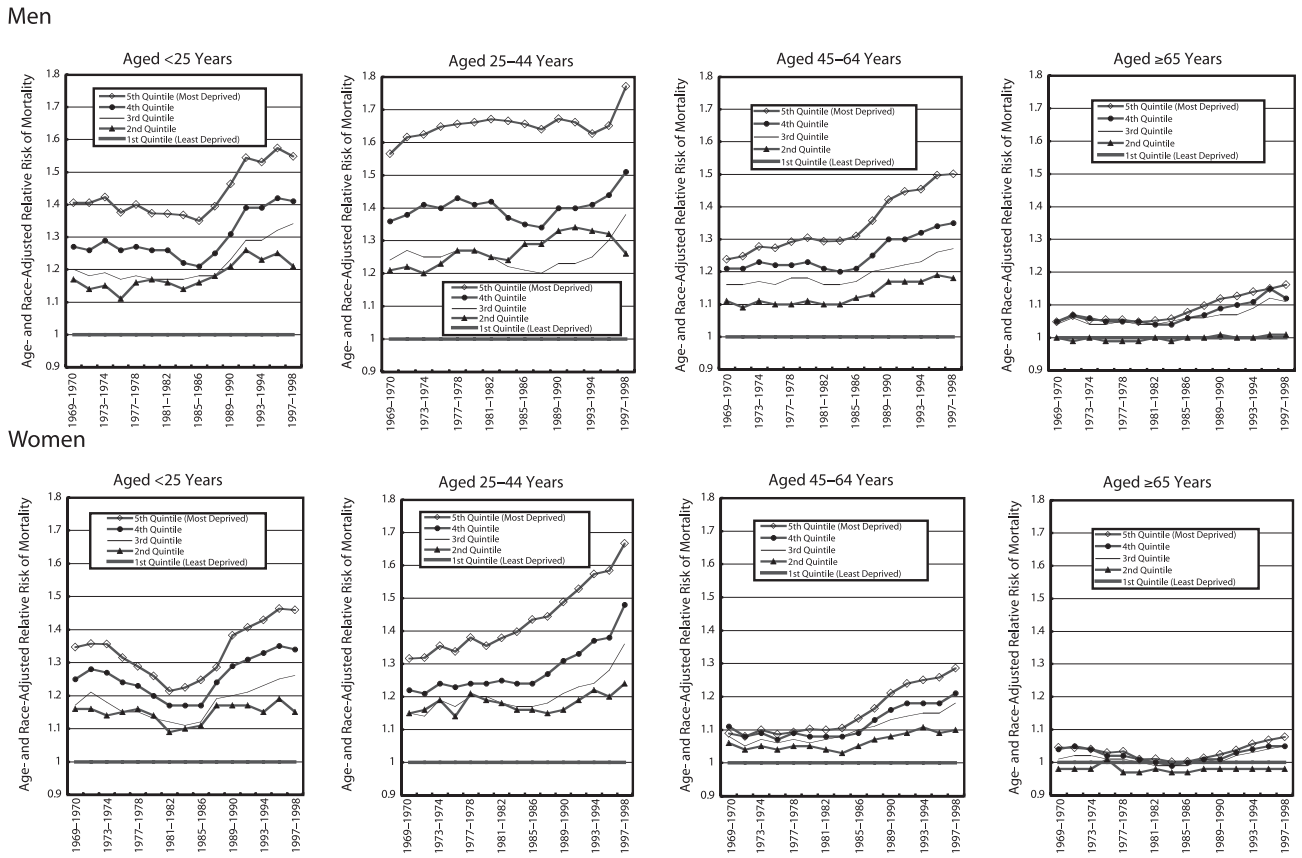
FIGURE 1—Sex- and race-specific all-cause mortality rates, by 1990 area deprivation index: United States, 1969–1998 (1970 US Standard Population).

tion that may arise from using the 1990 index is therefore unlikely to significantly affect the general trend of increasing areal inequalities in mortality.[9,21]

Because of the lack of census tract or block group geocodes, it is not possible to analyze national mortality data at smaller geographic levels.[9,21] Although there is a substantial degree of intracounty heterogeneity in sociodemographic conditions, it is unclear whether temporal mortality trends would differ if area deprivation were to be linked to tract-level mortality data. Nevertheless, it is advantageous to use temporal county data. Although census tracts are socioeconomically homogeneous geographic units with an average population of 4000, they are subject to change in every decennial census. Counties, on the other hand, not only are more stable sociopolitical and geographic entities, but also provide an appropriate socioeconomic, political, and community context within which many social and public health policies are formulated and implemented.[9,21]

Areal inequalities in US mortality have widened because of slower mortality declines among residents of more deprived areas. Although the relative standing of deprivation groups remained fairly stable during the study period, increasing inequalities in absolute deprivation between areas can be noted in Table 2, which may have contributed to increasing inequalities in mortality.[21] It would be useful to examine the magnitude of temporal social inequalities in major causes of death (such as cardiovascular disease, cancer, injuries, and infectious diseases) to better understand the specific social, behavioral, and health care mechanisms involved.[21,22] Currently, ecological studies of socioenvironmental, behavioral, and health care disparities by area deprivation are lacking in the United States. Future research needs to examine the roles of population distributions of smoking and alcohol use rates, diet, obesity, physical inactivity, environmental pollution, and accessibility and use of health services in explaining the increasing areal gradients shown here.[8]

Census-based deprivation indices could serve as an important, cost-effective analytic tool for documenting social inequalities in health and for monitoring trends in the extent of inequality over time.[9,21] In the absence of routinely collected individual social class data, evaluation of health and mortality data through the use of deprivation indices



Note. All relative risks for men and women aged younger than 25 years and 25 to 44 years and for men aged 45 to 64 years were significant at $P < .01$. Relative risks for women aged 45 to 64 years were significant at $P < .05$. Whereas most relative risks were significant for men aged 65 years or older at $P < .05$, only those associated with the fourth and fifth deprivation quintiles between 1993 and 1998 were significant for women aged 65 years or older.

FIGURE 2—Age- and race-adjusted relative risks of all-cause mortality among US men and women, by 1990 area deprivation index derived from Poisson regression models: 1969–1998.

holds much promise for the public health community's efforts to reduce health disparities. Caution should be exercised, however, when comparing areal variations in mortality with individual-level socioeconomic differentials.[9,14,21,24,31,51] Equating differentials at the 2 levels may lead to an ecological bias. This study analyzed areal variations in mortality as a function of an ecological variable, area deprivation. Although areal deprivation patterns in mortality by age, race, and sex are consistent with those at the individual level, the individual socioeconomic effects are generally larger than those at the area level, and temporal trends in individual socioeconomic inequalities in mortality may differ as well.[2,3,14,21,31,52–55] ■

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Human Participant Protection

Ethical clearance was not needed because this study used only secondary data and public-use vital statistics and census data. No human participants were contacted as part of this research.

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