# Changing Area Socioeconomic Patterns in U.S. Cancer Mortality, 1950–1998: Part I—All Cancers Among Men

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*Background:* **Area socioeconomic deprivation indices are widely used to monitor health disparities in Europe. However, such indices have not been used in cancer surveillance in the United States. We developed an area socioeconomic index to examine area socioeconomic patterns in all-cancer mortality among U.S. men between 1950 and 1998.** ***Methods:*** **Principal components analysis on 11 census variables was used to develop an area socioeconomic index that was then used to stratify all U.S. counties into one of five socioeconomic categories. The index was linked to 1950–1998 county mortality data to generate annual mortality rates for each area socioeconomic group. Joinpoint regression analysis was used to model mortality trends, and Poisson regression analysis was used to estimate socioeconomic gradients in mortality over time.** ***Results:*** **Area socioeconomic patterns in U.S. male cancer mortality changed dramatically between 1950 and 1998. Throughout the 1950s and 1960s, there was a positive socioeconomic gradient, with higher cancer mortality rates in high area socioeconomic groups than in low area socioeconomic groups. For example, in 1950–1952, cancer mortality was 49% (95% confidence interval [CI] = 41% to 59%) greater in the highest area socioeconomic group than in the lowest. The positive gradient narrowed in the 1970s, and by the late 1980s, socioeconomic differences in cancer mortality began to reverse and widen. In 1997–1998, cancer mortality was 19% (95% CI = 11% to 28%) higher in the lowest area socioeconomic group than in the highest. Gradients were steeper for men aged 25–64 years than for men aged 65 years or older.** ***Conclusions:*** **Socioeconomic patterns in male cancer mortality have reversed over time in the United States. Area socioeconomic indices could serve as a powerful surveillance tool for monitoring health disparities in cancer outcomes. [J Natl Cancer Inst 2002;94:904–15]**

The national vital statistics mortality data system is based on information from death certificates of every death occurring in the United States each year. It is the only source for computing annual cancer mortality statistics across time for the entire nation and for all states and counties *(1–3)*. In fact, the national mortality data system is one of the few administrative sources of health statistics in the United States that is publicly available, that covers all deaths, and that is comparable at international, national, state, and local levels *(4–5)*. The availability of a relatively long time series on U.S. mortality statistics by age, sex, race/ethnicity, cause of death, and county of residence makes the mortality data system especially suitable for analyzing trends over time of all-cause and cause-specific mortality across demographic groups and geographic areas *(1,2,4,6,7)*.

A limited number of social and demographic characteristics are reported on U.S. death certificates, including age, sex, race/ethnicity, marital status, place of birth and residence, level of education, and usual occupation/industry of the decedent *(2–5,8)*. However, the quality of data on education and occupation/industry remains poor, incomplete, and not consistently available prior to 1985 *(2,4,9)*. Moreover, information on income, a key indicator of the individual's socioeconomic position, is not recorded on the death certificate. Although age-, sex-, race-, and geographic area-specific population data representing the population at risk are available annually, the population data needed to calculate socioeconomic status (SES)-specific mortality rates are generally not available *(5)*.

Consequently, while time trends in U.S. cancer mortality are frequently shown by age, race, and sex, temporal analyses of socioeconomic disparities in cancer mortality are rarely conducted *(10–12)*. Furthermore, there are few studies that monitor trends in health and mortality differences in relation to area-based socioeconomic deprivation measures in the United States *(13–17)*. On the other hand, area-based socioeconomic deprivation indices have been widely used in studies that analyze and monitor health disparities in Europe, Australia, and New Zealand *(18–29)*. These studies have shown high mortality rates at high levels of area socioeconomic deprivation, with social inequalities in mortality generally increasing over time. Total cancer and site-specific (stomach, lung, cervix, and esophagus) cancer mortality is high in areas with high socioeconomic deprivation, whereas breast cancer and melanoma mortality is low in these areas *(18,22,29,30–34)*. Some studies have shown increasing socioeconomic differences in all-cancer and lung cancer mortality during the last three decades of the 20th century *(18,22,29,30)*.

Although consensus, composite indices of socioeconomic deprivation do not exist in the United States, it is possible to use analytic approaches that link mortality data with census-based socioeconomic and demographic variables at an aggregate geographic level for the surveillance and monitoring of cancer mortality among area socioeconomic groups *(8)*. In this study, we provide a detailed methodology for developing a composite area-based socioeconomic index for the United States using census data. We illustrate its use by linking the index to national mortality data at the county level, and we examine the extent to which socioeconomic differences in all-cancer mortality among U.S. men changed during the second half of the 20th century. We use the area socioeconomic index to stratify all 3097 U.S. counties into five socioeconomic area groups, whose relative standings are shown to be stable during the study period. We examine trends in socioeconomic differences in all-cancer mortality from

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*See* "Notes" following "References."

1950 through 1998 for the overall male population and for men aged 25–64 years and aged 65 years or older.

By using the area socioeconomic index, the present study demonstrates the concept of ecologic surveillance in cancer. The term "ecologic surveillance," as used here, refers to the use of community-level data obtained from the census and potentially from other population data sources (i.e., those that contain area-based social, demographic, behavioral, and environmental data) to provide further insight into cancer rates and trends, particularly with regard to the possible differences in the impact of cancer control interventions by socioeconomic characteristics. Implicit in such an analysis is the likelihood of identifying patterns of cancer rates that may reflect health disparities associated with living in areas characterized by unfavorable socioeconomic conditions. Although our concern here is in using area socioeconomic position as a covariate in the analysis of cancer rates, it is important to note that other ecological measures, such as urbanization or indices for medically underserved populations, could be used in a similar fashion.

## METHODS

### Constructing an Index of Area Socioeconomic Position

Socioeconomic position is a multidimensional concept that can be measured at both community (structural) and individual levels. The community-level measures of socioeconomic position describe some essential features of social organization, structure, stratification, or environment, such as socioeconomic deprivation, economic inequality, resource availability, or opportunity structure. At the individual or social group level, measures of socioeconomic position generally include education, occupation, income, wealth, and home ownership *(8,35–37)*. Although single measures of area socioeconomic position such as education distribution, occupational composition, income inequality, poverty rate, or housing condition can be used to classify communities in a given population, we used a multiple indicators approach to create an index that reflects the multidimensional nature of a community's socioeconomic position *(8)*.

For the initial index construction, we considered 15 social and economic indicators that approximate the material living conditions and the more extreme aspects of the social and economic advantage or disadvantage in a community. The indicators or variables were selected on the basis of their theoretical relevance and prior empirical research *(8,18,26,28,35,37)*. These indicators, all drawn from the 1990 census, included education distribution (two variables: percentage of population with <9 years of education and percentage of population with at least 12 years of education), median family income, income disparity, occupational composition, unemployment rate, family poverty rate, single parent household rate, home ownership rate, median home value, median gross rent, household crowding (percentage of households with more than one person per room), percentage of households without access to phone, percentage of households without access to plumbing, and English language proficiency *(38,39)*. The index was constructed by applying factor and principal components analysis methods to the above 15 social and economic indicators *(40–42)*. Specifically, principal components analysis, principal factor analysis, and maximum likelihood factor analysis were performed, all yielding very similar results. However, only the results from the principal components analysis are reported in this study.

The initial statistics from the principal components analysis provided two principal components or factors that accounted for 47% and 20% of the variance in the data. Eleven of 15 indicators clustered together and had considerably larger factor loadings (>0.60) on the first factor than on the second factor. However, four indicators (household crowding, home ownership rate, single parent household rate, and English language proficiency) had much smaller loadings (<0.50) on the first factor but larger loadings on the second factor. Although the first factor clearly indicates a theoretically and empirically meaningful clustering of the given indicators, the second factor, with only a few substantial loadings, does not lend itself to any obvious theoretical interpretation. Orthogonal and oblique rotations were also performed, but they did not produce any meaningful, interpretable factors. Because the aim of our study was to develop a single summary index that accounted for the maximum variance in the data, we reran a principal components analysis on 11 indicators (with the largest loadings) with a single factor solution in the final phase of constructing the index (Table 1).

The factor loadings (correlations of indicators with the index) for the 1990 socioeconomic index ranged from 0.9029 for median family income to 0.5749 for unemployment rate (Table 1). The 11 indicators that make up the index (factor) were weighted using the factor score coefficients derived from the principal components analysis. Specifically, the index scores were calculated by multiplying the standardized values of the observed variables by the corresponding factor score coefficients. Median family income, family poverty rate, and percentage of population with at least 12 years of education had the largest relative weights in generating the index. The index accounted for 61% of the variance in the data. Because the original factor scale was a standard normal variate, with a mean of 0 and a standard deviation of 1, the factor was transformed into a standardized index by arbitrarily setting the mean of the index to be 100 and the standard deviation equal to 20. The index scores thus ranged from a low of –7.74 to a high of 172.65. High scores on the index denote high levels of socioeconomic status/position and low levels of deprivation. Low scores on the index denote low levels of socioeconomic status/position and high levels of deprivation.

Using the results of the principal components analysis, we computed the reliability coefficient Cronbach's alpha ($\alpha$) for the 1990 index to be 0.94, which indicates a high degree of internal consistency among the indicators that make up the index *(43)*. To further test the reliability of the index, we performed principal components analysis on the 11 variables for different subsets of the U.S. population (e.g., for counties with populations of <50 000, <100 000, <150 000, <250 000, <500 000, and <1 000 000, which would represent 17%, 27%, 35%, 43%, 58%, and 76% of the total U.S. population, respectively). The factor structure matrix containing the factor loadings for the different subsets remained essentially unchanged, indicating a high degree of index reliability for the indicated cross-sections of the 1990 population.

To examine the extent to which the 1990 index is reliable over time, we computed the index for the 1980 and 1970 censuses using the same set of variables (Table 1). The factor loadings for the 1990, 1980, and 1970 indices were quite similar in magnitude and relative importance, and the percentage of variance explained by each factor and the reliability coefficient were nearly identical. In fact, the correlation coefficient was 0.94 between the 1990 and 1980 indices, 0.89 between the 1990 and

**Table 1.** Factor loadings and factor score coefficients for the census variables that make up the area socioeconomic index derived at county, census tract, and ZIP code levels, United States, 1990, 1980, and 1970*

| Census variable | Factor loadings | | | | | Factor score coefficients county index |
|---|---|---|---|---|---|---|
| | County index | | | Tract index | ZIP code index | |
| | 1990 | 1980 | 1970 | 1990 | 1990 | 1990 |
| % Population aged ⩾25 years with <9 years of education† | –0.8319 | –0.8743 | –0.7924 | –0.7714 | –0.7674 | –0.12462 |
| % Population aged ⩾25 years with at least a high school diploma | 0.8569 | 0.8730 | 0.8862 | 0.8691 | 0.8323 | 0.12835 |
| % Employed persons aged ⩾16 years in white collar occupations | 0.7058 | 0.6862 | 0.6661 | 0.8276 | 0.7533 | 0.10573 |
| Median family income, $ | 0.9029 | 0.8923 | 0.8975 | 0.8725 | 0.8683 | 0.13525 |
| Income disparity‡ | –0.8438 | –0.7070 | –0.7810 | –0.8292 | –0.7213 | –0.12639 |
| Median home value, $ | 0.6601 | 0.7626 | 0.7245 | 0.6571 | 0.7040 | 0.09888 |
| Median gross rent, $ | 0.7977 | 0.8390 | N.A.§ | 0.7422 | 0.7384 | 0.11949 |
| Unemployment rate (% civilian labor force aged ⩾16 years unemployed) | –0.5749 | –0.2809 | –0.2115 | –0.6675 | –0.4996 | –0.08611 |
| % Families below poverty level | –0.8700 | –0.8748 | –0.8524 | –0.8107 | –0.7587 | –0.13031 |
| % Occupied housing units without telephone | –0.8013 | –0.7424 | –0.8480 | –0.7691 | –0.6573 | –0.12002 |
| % Occupied housing units without complete plumbing | –0.6502 | –0.7524 | –0.8766 | –0.5006 | –0.5104 | –0.09739 |
| Proportion of total variance explained by each factor | 0.6069 | 0.5946 | 0.6056 | 0.5829 | 0.5165 | |
| Cronbach's alpha (reliability coefficient) | 0.9444 | 0.9416 | 0.9389 | 0.9389 | 0.9216 | |

*Principal components analysis of aggregate census data for 3097 counties, 59 525 census tracts, and 29 320 ZIP codes.

†In the 1970 census, percentage population aged ⩾25 years with <5 years of education was used.

‡Income disparity in 1990 was defined as 100 × the ratio of number of households with <$10 000 income to number of households with ⩾$50 000 income. Income disparity in 1980 was defined as 100 × the ratio of number of households with <$5000 income to number of households with ⩾$25 000 income. Income disparity in 1970 was defined as 100 × the ratio of number of households with <$3000 income to number of households with ⩾$15 000 income.

§N.A. = not available.

1970 indices, and 0.94 between the 1980 and 1970 indices. When assessing the correspondence between the categorical (quintile) classification of the area indices in 1980 and 1990, we found that, of all the counties in the lowest socioeconomic quintile in 1990, 81.4% were also in the lowest quintile and 17.6% were in the second lowest quintile in 1980. Conversely, of all the counties in the highest socioeconomic quintile in 1990, 78.7% were in the highest quintile and 18.8% were in the second highest quintile in 1980. The gamma ($\gamma$) statistic, measuring the strength of association between the 1990 and 1980 socioeconomic quintile classifications, was 0.94. Similar correspondence ($\gamma = 0.88$) was observed when comparing the quintile classification of the index in 1990 and 1970. More than 97% of the counties in the lowest quintile in 1990 were in the lowest and second lowest quintiles in 1970. More than 91% of the counties in the highest quintile in 1990 were in the highest and second highest quintiles in 1970. No counties crossed over from the lowest to the highest quintiles during the time period 1970–1990.

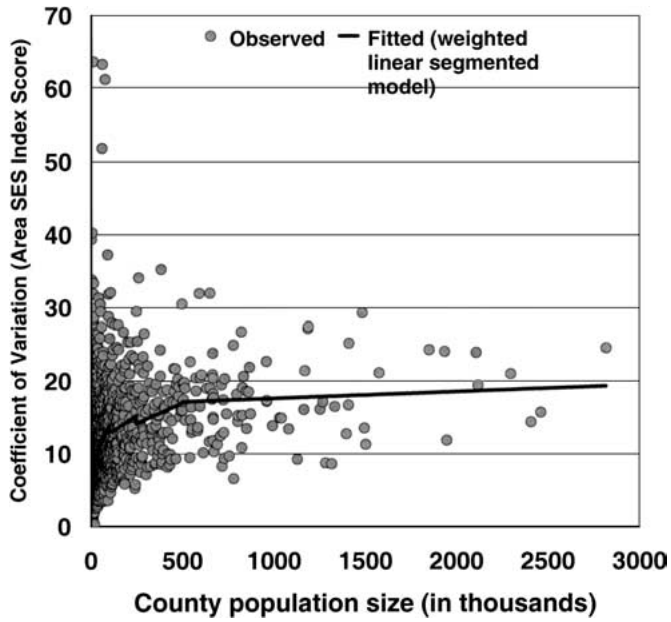
To determine the extent to which the 1990 socioeconomic index was valid across different geographic units, we compared factor loadings for the same set of 11 indicators computed at the census tract, ZIP code, and county levels in 1990 (Table 1). The factor loadings for the three geographic levels were generally similar in magnitude and relative importance. The percentage of variance explained and the reliability coefficient were almost identical for the tract and county indices.

The predictive validity of the 1990 socioeconomic index was adequate on the basis of estimated correlations of the index with a variety of county-level health outcomes during the time period from 1990 through 1996, such as rates of infant mortality (–0.39); all-cause mortality (–0.49); mortality from heart disease (–0.40), stroke (–0.29), diabetes (–0.40), chronic obstructive pulmonary disease (–0.21), unintentional injuries (–0.73), suicide (–0.33), and homicide (–0.20); all-cancer mortality for men (–0.30); all-cancer mortality for women (0.12); lung cancer mortality for men (–0.45); lung cancer mortality for women (0.16); and mortality from cervical cancer (–0.45); breast cancer (0.26); and prostate cancer (–0.13).

### Relationship Between Index Variability and County Population Size

Because the counties differ considerably in population size, we examined the extent to which the socioeconomic composition of the larger counties was more heterogeneous than that of smaller counties. The association between area socioeconomic position and cancer mortality may be affected if counties differ greatly in their socioeconomic heterogeneity. We considered two measures of intracounty heterogeneity (variability) of the socioeconomic index: the standard deviation and coefficient of variation (each based on census tract-level index scores). The two variance measures were calculated for 2952 counties, each of which had two or more census tracts. The measures could not be calculated for 145 counties with only a single census tract. The standard deviation of the index varied from 0.01 to 38.46, and the coefficient of variation for the index varied from 0.01% to 63.66%.

The visual inspection of the scatter plot in Fig. 1 appeared to indicate increasing index variability with increasing county population size for small and midsize counties but not for larger counties. The larger counties had relatively stable variances. To further examine this relationship, we fitted linear segmented models to the observed data. The segmented models were estimated by weighted least squares, with weights being the number of census tracts in each county. We modeled the standard deviation and coefficient of variation of the index as linear functions of county population size for the following population segments: <15 000, 15 000–24 999, 25 000–49 999, 50 000–99 999, 100 000–149 999, 150 000–249 999, 250 000–499 999, and ⩾500 000. Because the results for the standard deviation and coefficient of variation were almost identical, we show only the results for the coefficient of variation in Fig. 1. The above popu-




Segmented model statistics for coefficient of variation (CV) for the area socioeconomic status index

| Population segment | Intercept (*t* value)* | Slope × 100000 (*t* value)* | Correlation coefficient | Mean level (CV) | N |
|---|---|---|---|---|---|
| 0–14 999 | 4.383 (8.10) | 24.594 (4.66) | 0.148 | 6.760 | 978 |
| 15 000–24 999 | 5.807 (4.25) | 12.458 (1.81) | 0.079 | 8.262 | 522 |
| 25 000–49 999 | 6.676 (6.55) | 8.182 (2.96) | 0.119 | 9.645 | 612 |
| 50 000–99 999 | 7.727 (4.42) | 6.200 (2.66) | 0.135 | 12.297 | 383 |
| 100 000–149 999 | 11.781 (3.23) | 1.188 (0.41) | 0.034 | 13.254 | 145 |
| 150 000–249 999 | 11.017 (3.18) | 1.705 (0.99) | 0.094 | 14.410 | 113 |
| 250 000–499 999 | 11.409 (4.11) | 1.112 (1.50) | 0.149 | 15.496 | 101 |
| ≥500 000 | 16.705 (24.28) | 0.092 (3.86) | 0.366 | 18.486 | 98 |

**Fig. 1. Upper panel—**Relationship between intracounty variability (coefficient of variation) of the area socioeconomic status (SES) index and county population size, United States, 1990. Note: observed and fitted index coefficient of variation values for Los Angeles County, CA (1990 population = 8.85 million) were 22.531 and 24.816; for Cook County, IL (1990 population = 5.10 million), values were 25.487 and 21.382, respectively. The table associated with Fig. 1 (**lower panel**) presents the results of the weighted least squares regression of coefficient of variation on county population size for each population segment. * = Slope/SE.

lation segment cutoffs were chosen because we were interested in examining the variance estimates for county groups with varying population sizes while ensuring that there were sufficient numbers of counties in each segment. The variability of the socioeconomic index increased generally with increasing population size for counties up to a population of 100 000, but the two variance measures showed only a moderate increase for counties with a population of more than 100 000. Although the mean levels of the standard deviation and the coefficient of variation for the socioeconomic index were consistently higher for larger county population groups, the slope of the index variability declined substantially for the largest population groups relative to the smallest population groups. To address the problem of increased index heterogeneity, we undertook a sensitivity analysis in which the impact of larger, more heterogeneous counties on cancer mortality trends was evaluated. This is presented later in this article.

### Computing Annual Mortality Rates and Modeling Socioeconomic Gradients Across Time

To analyze time trends in socioeconomic differences in all-cancer mortality among men, we used the quintile distribution of the 1990 area socioeconomic index and classified 3097 U.S. counties into five categories of equal numbers of counties (Fig. 2). The area groups thus created ranged from being the most disadvantaged or the lowest socioeconomic position/status group (SES I) to being the least disadvantaged or the highest socioeconomic position/status group (SES V). A majority of the lowest socioeconomic areas were concentrated in the southern region of the United States, whereas many of the highest socioeconomic areas were located in the northeastern and western regions of the United States. In 1990, the five area socioeconomic groups (SES I–V) accounted for the following percentages of the total U.S. population: 4.4%, 5.7%, 8.5%, 17.5%, and 63.9%, respectively. Clearly, a majority of the counties in the two lowest socioeconomic groups tended to have relatively small populations. Because counties are genuine ecologic units and because we were interested in comparing the cancer mortality patterns of low socioeconomic areas (counties) with those for high socioeconomic areas rather than population groups, we did not weight by population in constructing the quintiles *(44).* Rather than using quintiles based on different time periods, we used the 1990 quintiles and ensured that the classification of counties into specific area socioeconomic groups remained fixed over time.

Using national mortality data files, we obtained age- and county-specific annual cancer deaths among men from 1950 through 1998 *(1,2).* Age-, sex-, and county-specific population estimates from 1950 to 1998 prepared by the U.S. Bureau of the Census served as denominators for computing rates *(45,46).* Each of the 3097 counties on the mortality dataset was assigned to one of the five area socioeconomic categories. For Alaska and Hawaii, state-specific rather than county-specific data were used. We calculated annual age-adjusted and age-specific (25–64 years and 65 years or older) mortality rates for all cancers combined for each of the five socioeconomic groups. The age adjustment of cancer mortality rates was performed by the direct method with the use of the age composition of the 1970 U.S. standard population and 5-year age-specific death rates.

Joinpoint regression models *(10,11,47)* were used to estimate annual rates of change in cancer mortality for each socioeconomic group. Joinpoint regression is a statistical technique that describes changing trends over successive segments of time and the magnitude of an increase or decrease within each segment after identifying the best fitting model. Essentially, within each time segment, the log of the mortality rates is modeled as a linear function of time (calendar year), thereby yielding annual expo-

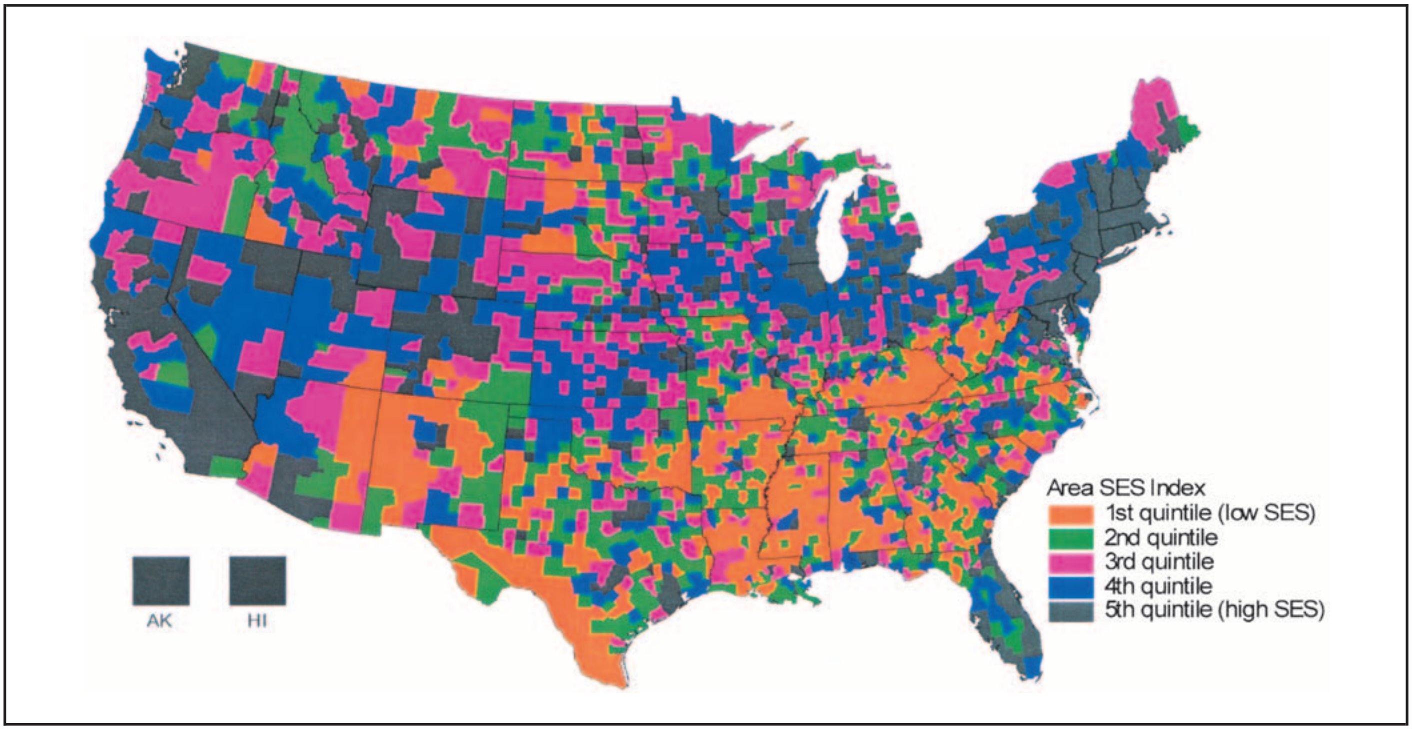



**Fig. 2.** The index of area (county) socioeconomic status (SES), United States, 1990.

nential rates of change in mortality rates. The technique identifies the timepoint(s), also referred to as joinpoint(s), at which there is a statistically significant change in the mortality trend. A maximum of three joinpoints was allowed in the model fitting. Statistical significance was assessed by use of two-sided $P = .05$. The Joinpoint Regression Program, version 2.5.2, was used for estimation. The most current version of the program is available online at http://srab.cancer.gov/joinpoint.

Poisson regression models were fitted to age- and county-specific data to estimate area socioeconomic gradients in all-cancer mortality among U.S. men for fifteen 3-year time periods and two 2-year periods: 1950–1952, 1953–1955, 1956–1958, 1959–1961, 1962–1964, 1965–1967, 1968–1970, 1971–1973, 1974–1976, 1977–1979, 1980–1982, 1983–1985, 1986–1988, 1989–1991, 1992–1994, 1995–1996, 1997–1998. Socioeconomic gradients (the overall effect [slope] of area socioeconomic position on cancer mortality) were estimated for all men and separately for men aged 25–64 years and those aged 65 years or older. To estimate relative risks (RRs) of cancer mortality for each socioeconomic group, we fitted Poisson regression models to the age- and county-specific cancer death data with a log link function and the corresponding stratum-specific log population as an offset variable for each of the 17 time periods *(48)*. Data for 2- or 3-year intervals were pooled to provide more stable RR estimates. In all Poisson models, the highest area socioeconomic group was selected as the reference category. All models, fitted by the SAS GENMOD procedure, version 8 *(49)*, showed reasonable fit, as determined by the likelihood ratio statistic or deviance. Nevertheless, for robustness in all models, 95% confidence intervals (CIs) were adjusted for overdispersion (i.e., extra-Poisson variation) *(49)*. Trend tests were based on the $\chi^2$ statistic derived through Poisson models that included age and area socioeconomic position coded as a continuous variable. Reported $P$ values are two-sided.

## Results

Table 2 presents descriptive sociodemographic data that indicate the relative stability and robustness of the area socioeconomic groups from 1950 to 1990. Although all area socioeconomic groups experienced an improvement in their overall educational levels, their relative educational standing remained virtually unchanged. The difference in the proportion of high school graduates between the lowest and highest socioeconomic groups was similar in 1980 and in 1990. The proportion of adults with less than 5 years of education was approximately four times greater in the lowest than in the highest socioeconomic group in 1960 and in 1970. Similarly, the proportion of adults with less than 9 years of education was about three times greater in the lowest than in the highest socioeconomic group in 1980 and in 1990.

During 1960–1990, median family income in the highest socioeconomic group was at least 1.64 times that in the lowest socioeconomic group. Similarly, median home value during 1970–1990 was more than two times higher in the highest socioeconomic group than in the lowest. The proportion of the population employed in white collar occupations in the highest socioeconomic group was at least 1.50 times that in the lowest socioeconomic group during 1970–1990. Moreover, the family poverty rate was about three times higher in the lowest socioeconomic group than in the highest. The infant mortality rate, an important social indicator, in the lowest socioeconomic group was at least 1.38 times greater than that in the highest socioeconomic group during 1956–1992.

Fig. 3 shows changing area socioeconomic patterns in male cancer mortality over the past five decades. From the 1950s through the 1970s, there was generally a positive socioeconomic gradient, with higher cancer mortality in higher socioeconomic areas. The differences among the area socioeconomic groups

**Table 2.** Selected social and demographic characteristics of five area (county) socioeconomic status (SES) categories (quintiles), United States, 1950–1990*

| Characteristic | SES I (low) | SES II | SES III | SES IV | SES V (high) |
|---|---|---|---|---|---|
| County population size, 1990 | | | | | |
| Median | 13 345 | 15 079 | 19 066 | 32 508 | 108 078 |
| Minimum | 460 | 107 | 462 | 354 | 467 |
| Maximum | 383 545 | 591 610 | 1 203 789 | 2 300 664 | 8 863 164 |
| Range (SES index score), 1990 | −7.742–85.234 | 85.234–96.990 | 96.990–105.113 | 105.113–114.611 | 114.611–172.653 |
| % Population | | | | | |
| 1990 | 4.39 | 5.70 | 8.47 | 17.51 | 63.93 |
| 1980 | 4.81 | 6.13 | 9.08 | 18.38 | 61.60 |
| 1970 | 4.71 | 6.10 | 9.23 | 19.07 | 60.89 |
| 1960 | 5.64 | 6.58 | 10.21 | 20.36 | 57.22 |
| 1950 | 7.38 | 7.87 | 11.56 | 21.32 | 51.87 |
| % With at least 12 years of education | | | | | |
| 1990 | 54.92 | 63.13 | 65.59 | 72.31 | 79.30 |
| 1980 | 44.07 | 52.21 | 58.44 | 63.17 | 71.77 |
| 1970 | 30.06 | 37.97 | 44.38 | 48.95 | 57.97 |
| 1960 | 22.38 | 29.70 | 34.65 | 38.40 | 46.27 |
| % With <9 years of education | | | | | |
| 1990 | 24.94 | 17.89 | 14.07 | 11.20 | 8.10 |
| 1980 | 37.89 | 29.19 | 24.09 | 19.88 | 14.34 |
| % With <5 years of education | | | | | |
| 1970 | 16.91 | 9.93 | 6.97 | 5.68 | 3.95 |
| 1960 | 23.69 | 14.87 | 10.39 | 8.54 | 5.99 |
| Median years of education, 1950 | 7.60 | 8.50 | 8.80 | 9.20 | 9.80 |
| Median family income, $ | | | | | |
| 1990 | 21 008 | 24 865 | 27 159 | 30 262 | 36 626 |
| 1980 | 12 617 | 14 976 | 16 493 | 18 235 | 20 682 |
| 1970 | 5307 | 6545 | 7473 | 8267 | 9602 |
| 1960 | 2566 | 3446 | 4223 | 4806 | 5590 |
| Median home value, $ | | | | | |
| 1990 | 35 900 | 40 400 | 43 250 | 50 500 | 78 500 |
| 1980 | 24 100 | 27 500 | 32 200 | 37 100 | 48 550 |
| 1970 | 7500 | 8898 | 10 479 | 10 851 | 16 651 |
| % White-collar occupation | | | | | |
| 1990 | 40.83 | 44.16 | 47.49 | 52.76 | 62.38 |
| 1980 | 36.67 | 39.88 | 43.17 | 48.03 | 57.42 |
| 1970 | 32.33 | 35.41 | 39.02 | 43.34 | 52.94 |
| % Families below poverty level | | | | | |
| 1990 | 24.24 | 16.17 | 13.47 | 11.76 | 7.59 |
| 1980 | 21.27 | 14.45 | 12.13 | 10.62 | 7.59 |
| 1970† | 23.66 | 15.58 | 12.25 | 8.86 | 6.02 |
| Unemployment rate | | | | | |
| 1990 | 10.24 | 7.99 | 7.52 | 7.17 | 5.59 |
| 1980 | 7.75 | 6.76 | 7.05 | 7.01 | 5.49 |
| 1970 | 5.85 | 4.90 | 4.73 | 4.57 | 4.18 |
| Infant mortality rate‡ | | | | | |
| 1988–1992 | 11.21 | 9.88 | 9.05 | 8.71 | 8.11 |
| 1976–1980 | 16.87 | 14.60 | 13.10 | 12.54 | 12.13 |
| 1966–1970 | 28.31 | 23.87 | 21.31 | 20.96 | 20.16 |
| 1956–1960 | 34.69 | 28.41 | 25.20 | 24.95 | 25.03 |

*Source: 1996 Area Resource File *(39)*.
†Data available only for white families.
‡Rate per 1000 live births.

decreased with time and by the early 1980s, cancer mortality was similar in all groups. However, by the late 1980s, differences among socioeconomic groups began to reverse and widen, with statistically significantly higher cancer mortality rates associated with lower socioeconomic areas.

Fig. 3 also presents separate mortality trends for men aged 25–64 years and those aged 65 years or older. Area socioeconomic differences were substantially greater for younger men than for older men. Moreover, the socioeconomic gradient reversed more rapidly for the younger cohort, so that by the early 1970s, the positive gradient had disappeared. The reversal of the socioeconomic patterns (from a positive to a negative association between area socioeconomic position and cancer mortality) for the older cohort did not start until the late 1980s. Indeed, all socioeconomic groups experienced faster and earlier decreases in cancer mortality for younger men than for older men (Table 3). For example, cancer mortality for younger men in the highest socioeconomic group began to decline as early as 1970 and declined at a rate of 0.20% (95% CI = 0.11% to 0.28%) per year during 1970–1988 and 2.08% (95% CI = 1.90% to 2.26%) annually during 1988–1998, whereas mortality for older men in the highest socioeconomic group did not begin to decline until

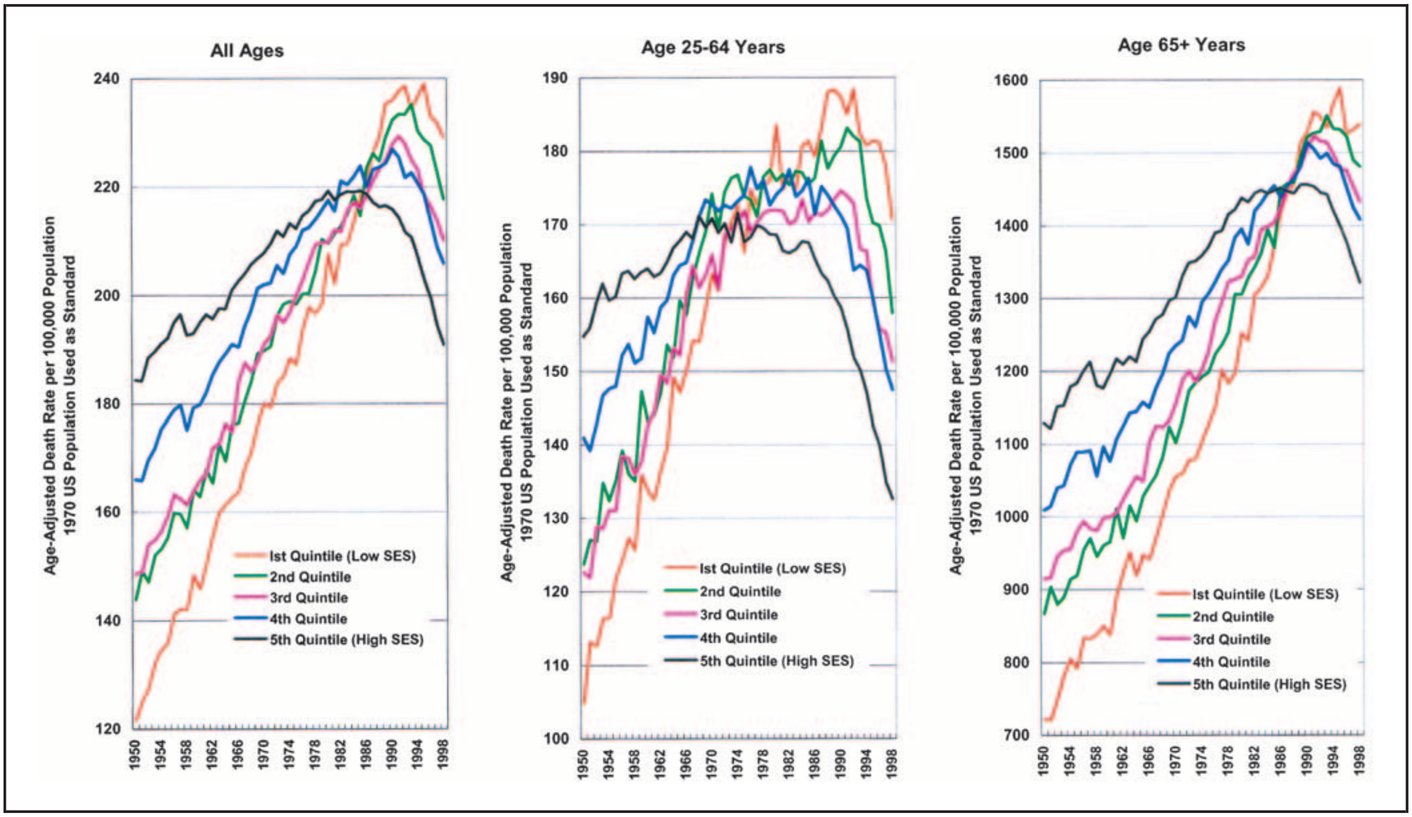



**Fig. 3.** Cancer mortality rates for U.S. men by age and the 1990 area socioeconomic status (SES) index, 1950–1998.

**Table 3.** Estimated annual percent change (EAPC) for socioeconomic status (SES)- and age-specific cancer mortality trends, U.S. men, 1950–1998*

| | Time period | EAPC (95% CI) | Time period | EAPC (95% CI) | Time period | EAPC (95% CI) |
|---|---|---|---|---|---|---|
| All ages | | | | | | |
| SES I (low) | 1950–1968† | 1.83‡ (1.70 to 2.00) | 1968–1991 | 1.42 (1.34 to 1.50) | 1991–1998 | −0.44 (−0.81 to −0.06) |
| SES II | 1950–1973 | 1.33 (1.25 to 1.42) | 1973–1993 | 0.94 (0.85 to 1.03) | 1993–1998 | −1.56 (−2.15 to −0.97) |
| SES III | 1950–1977 | 1.22 (1.16 to 1.27) | 1977–1992 | 0.71 (0.59 to 0.82) | 1992–1998 | −1.43 (−1.80 to −1.06) |
| SES IV | 1950–1978 | 0.92 (0.87 to 0.97) | 1978–1991 | 0.41 (0.27 to 0.55) | 1991–1998 | −1.27 (−1.56 to −0.97) |
| SES V (high) | 1950–1981 | 0.56 (0.53 to 0.59) | 1981–1992 | −0.26 (−0.37 to −0.14) | 1992–1998 | −1.86 (−1.56 to −0.97) |
| Aged 25–64 years | | | | | | |
| SES I (low) | 1950–1972 | 1.99 (1.85 to 2.14) | 1972–1992 | 0.55 (0.40 to 0.70) | 1992–1998 | −1.36 (−2.14 to −0.57) |
| SES II | 1950–1971 | 1.59 (1.47 to 1.72) | 1971–1993 | 0.21 (0.10 to 0.31) | 1993–1998 | −2.46 (−3.35 to −1.56) |
| SES III | 1950–1970 | 1.57 (1.45 to 1.69) | 1970–1991 | 0.19 (0.09 to 0.29) | 1991–1998 | −2.00 (−2.48 to −1.52) |
| SES IV | 1950–1970 | 1.06 (0.96 to 1.16) | 1970–1989 | 0.05 (−0.05 to 0.15) | 1989–1998 | −1.74 (−2.02 to −1.46) |
| SES V (high) | 1950–1970 | 0.42 (0.34 to 0.49) | 1970–1988 | −0.20 (−0.28 to −0.11) | 1988–1998 | −2.08 (−2.26 to −1.90) |
| Aged 65 years or older | | | | | | |
| SES I (low) | 1950–1981 | 1.77 (1.69 to 1.85) | 1981–1991 | 2.19 (1.85 to 2.54) | 1991–1998 | −0.25 (−0.70 to 0.21) |
| SES II | 1950–1964 | 1.09 (0.88 to 1.31) | 1964–1992 | 1.53 (1.47 to 1.59) | 1992–1998 | −0.82 (−1.28 to −0.36) |
| SES III | 1950–1960 | 0.87 (0.53 to 1.21) | 1960–1991 | 1.37 (1.32 to 1.42) | 1991–1998 | −0.93 (−1.27 to −0.59) |
| SES IV | 1950–1984 | 1.08 (1.03 to 1.14) | 1984–1993 | 0.55 (0.21 to 0.89) | 1993–1998 | −1.38 (−2.03 to −0.74) |
| SES V (high) | 1950–1982 | 0.82 (0.77 to 0.87) | 1982–1993 | 0.001 (−0.19 to 0.19) | 1993–1998 | −1.78 (−2.27 to −1.29) |

*Derived from the joinpoint regression models. A negative number indicates a decline. CI = confidence interval.

†Joinpoint models were used to determine time segments and joinpoints, the timepoints at which there were statistically significant changes in mortality trends for each SES category. For example, for the all-age mortality trend associated with SES I, there were two joinpoints, 1968 and 1991, yielding three time segments.

‡The mortality rate for SES I increased, on average, by 1.83% per year during 1950–1968.

1993 and declined at a rate of 1.78% (95% CI = 1.29% to 2.27%) per year during 1993–1998.

To confirm the differences in the socioeconomic patterns, we used Poisson regression analysis to show the RRs of cancer mortality (Table 4). During 1950–1979, there was a positive but diminishing socioeconomic gradient in male cancer mortality. During 1950–1952, cancer mortality in the highest socioeconomic group was 49% (95% CI = 41% to 59%) greater than that in the lowest socioeconomic group. During 1974–1976, cancer mortality was 11% (95% CI = 4% to 17%) and 6% (95% CI = 1% to 12%) lower in the two lowest socioeconomic groups than it was in the highest socioeconomic group. During the 1990s, not only was cancer mortality statistically significantly lower in higher socioeconomic groups, but the differences among socioeconomic groups also widened. During 1997–1998, cancer mortality was 19% (95% CI = 11% to 28%) and 14% (95% CI =

**Table 4.** Age-adjusted relative risks of cancer mortality among U.S. men by age and the 1990 area socioeconomic (SES) index (derived from Poisson regression models), 1950–1998*

| Time period | SES I (low) RR (95% CI) | SES II RR (95% CI) | SES III RR (95% CI) | SES IV RR (95% CI) | SES V (high) RR | $P_{trend}$ |
|---|---|---|---|---|---|---|
| All ages | | | | | | |
| 1950–1952 | 0.67 (0.63 to 0.71) | 0.79 (0.75 to 0.83) | 0.81 (0.77 to 0.84) | 0.90 (0.87 to 0.93) | 1.00 | <.001 |
| 1953–1955 | 0.70 (0.66 to 0.74) | 0.80 (0.77 to 0.84) | 0.82 (0.79 to 0.86) | 0.92 (0.89 to 0.95) | 1.00 | <.001 |
| 1956–1958 | 0.73 (0.69 to 0.77) | 0.82 (0.78 to 0.85) | 0.83 (0.80 to 0.87) | 0.92 (0.89 to 0.95) | 1.00 | <.001 |
| 1959–1961 | 0.76 (0.72 to 0.80) | 0.85 (0.81 to 0.89) | 0.85 (0.82 to 0.89) | 0.93 (0.90 to 0.96) | 1.00 | <.001 |
| 1962–1964 | 0.81 (0.76 to 0.85) | 0.86 (0.82 to 0.90) | 0.88 (0.85 to 0.92) | 0.95 (0.92 to 0.99) | 1.00 | <.001 |
| 1965–1967 | 0.81 (0.77 to 0.87) | 0.88 (0.84 to 0.93) | 0.90 (0.86 to 0.94) | 0.95 (0.92 to 0.98) | 1.00 | <.001 |
| 1968–1970 | 0.85 (0.80 to 0.91) | 0.91 (0.86 to 0.96) | 0.92 (0.87 to 0.96) | 0.97 (0.94 to 1.01) | 1.00 | <.001 |
| 1971–1973 | 0.87 (0.81 to 0.93) | 0.93 (0.88 to 0.99) | 0.93 (0.88 to 0.98) | 0.97 (0.94 to 1.01) | 1.00 | <.001 |
| 1974–1976 | 0.89 (0.83 to 0.96) | 0.94 (0.88 to 0.99) | 0.94 (0.89 to 0.99) | 0.99 (0.95 to 1.03) | 1.00 | <.001 |
| 1977–1979 | 0.91 (0.85 to 0.98) | 0.95 (0.89 to 1.01) | 0.97 (0.92 to 1.02) | 0.99 (0.95 to 1.03) | 1.00 | .002 |
| 1980–1982 | 0.95 (0.88 to 1.01) | 0.97 (0.91 to 1.03) | 0.97 (0.92 to 1.03) | 1.00 (0.96 to 1.04) | 1.00 | .061 |
| 1983–1985 | 0.98 (0.91 to 1.05) | 0.99 (0.93 to 1.05) | 0.99 (0.94 to 105) | 1.02 (0.98 to 1.06) | 1.00 | .492 |
| 1986–1988 | 1.04 (0.97 to 1.11) | 1.04 (0.98 to 1.10) | 1.02 (0.97 to 1.07) | 1.03 (0.99 to 1.06) | 1.00 | .080 |
| 1989–1991 | 1.09 (1.02 to 1.17) | 1.07 (1.01 to 1.14) | 1.06 (1.01 to 1.11) | 1.05 (1.01 to 1.09) | 1.00 | <.001 |
| 1992–1994 | 1.13 (1.06 to 1.20) | 1.11 (1.05 to 1.17) | 1.08 (1.02 to 1.13) | 1.06 (1.02 to 1.10) | 1.00 | <.001 |
| 1995–1996 | 1.17 (1.09 to 1.26) | 1.13 (1.06 to 1.21) | 1.08 (1.02 to 1.14) | 1.07 (1.03 to 1.12) | 1.00 | <.001 |
| 1997–1998 | 1.19 (1.11 to 1.28) | 1.14 (1.07 to 1.21) | 1.10 (1.04 to 1.16) | 1.08 (1.03 to 1.12) | 1.00 | <.001 |
| Aged 25–64 years | | | | | | |
| 1950–1952 | 0.71 (0.65 to 0.77) | 0.81 (0.75 to 0.87) | 0.80 (0.75 to 0.85) | 0.90 (0.86 to 0.95) | 1.00 | <.001 |
| 1953–1955 | 0.74 (0.68 to 0.81) | 0.84 (0.78 to 0.91) | 0.82 (0.76 to 0.87) | 0.92 (0.88 to 0.97) | 1.00 | <.001 |
| 1956–1958 | 0.77 (0.70 to 0.85) | 0.84 (0.78 to 0.91) | 0.85 (0.79 to 0.91) | 0.94 (0.89 to 0.99) | 1.00 | <.001 |
| 1959–1961 | 0.82 (0.75 to 0.90) | 0.89 (0.82 to 0.97) | 0.87 (0.81 to 0.94) | 0.95 (0.90 to 1.00) | 1.00 | <.001 |
| 1962–1964 | 0.86 (0.78 to 0.96) | 0.92 (0.84 to 1.00) | 0.92 (0.85 to 0.99) | 0.98 (0.92 to 1.03) | 1.00 | <.001 |
| 1965–1967 | 0.90 (0.81 to 1.00) | 0.96 (0.87 to 1.05) | 0.95 (0.88 to 1.03) | 0.99 (0.93 to 0.05) | 1.00 | .029 |
| 1968–1970 | 0.94 (0.83 to 1.06) | 1.00 (0.90 to 1.11) | 0.96 (0.88 to 1.06) | 1.02 (0.95 to 1.09) | 1.00 | .377 |
| 1971–1973 | 0.99 (0.87 to 1.13) | 1.03 (0.93 to 1.15) | 0.99 (0.90 to 1.09) | 1.02 (0.95 to 1.10) | 1.00 | .814 |
| 1974–1976 | 1.02 (0.89 tot1.17) | 1.04 (0.92 to 1.17) | 1.01 (0.91 to 1.12) | 1.04 (0.96 to 1.12) | 1.00 | .463 |
| 1977–1979 | 1.04 (0.90 to 1.20) | 1.04 (0.92 to 1.17) | 1.02 (0.92 to 1.13) | 1.04 (0.96 to 1.12) | 1.00 | .356 |
| 1980–1982 | 1.07 (0.93 to 1.23) | 1.06 (0.94 to 1.20) | 1.03 (0.93 to 1.15) | 1.05 (0.97 to 1.14) | 1.00 | .138 |
| 1983–1985 | 1.07 (0.93 to 1.24) | 1.06 (0.94 to 1.20) | 1.03 (0.92 to 1.15) | 1.05 (0.97 to 1.14) | 1.00 | .154 |
| 1986–1988 | 1.13 (0.99 to 1.28) | 1.09 (0.93 to 1.22) | 1.05 (0.96 to 1.16) | 1.06 (0.99 to 1.14) | 1.00 | .010 |
| 1989–1991 | 1.19 (1.04 to 1.35) | 1.15 (1.02 to 1.29) | 1.11 (1.01 to 1.22) | 1.09 (1.01 to 1.17) | 1.00 | <.001 |
| 1992–1994 | 1.24 (1.09 to 1.40) | 1.20 (1.08 to 1.34) | 1.13 (1.03 to 1.25) | 1.10 (1.03 to 1.19) | 1.00 | <.001 |
| 1995–1996 | 1.30 (1.13 to 1.49) | 1.22 (1.08 to 1.38) | 1.13 (1.01 to 1.26) | 1.13 (1.03 to 1.22) | 1.00 | <.001 |
| 1997–1998 | 1.32 (1.14 to 1.52) | 1.23 (1.08 to 1.39) | 1.16 (1.03 to 1.30) | 1.12 (1.03 to 1.23) | 1.00 | <.001 |
| Aged 65 years or older | | | | | | |
| 1950–1952 | 0.63 (0.58 to 0.70) | 0.77 (0.71 to 0.83) | 0.81 (0.76 to 0.86) | 0.89 (0.85 to 0.94) | 1.00 | <.001 |
| 1953–1955 | 0.67 (0.61 to 0.73) | 0.77 (0.72 to 0.82) | 0.82 (0.77 to 0.87) | 0.91 (0.87 to 0.95) | 1.00 | <.001 |
| 1956–1958 | 0.69 (0.64 to 0.74) | 0.79 (0.75 to 0.84) | 0.82 (0.78 to 0.86) | 0.90 (0.86 to 0.94) | 1.00 | <.001 |
| 1959–1961 | 0.72 (0.68 to 0.76) | 0.82 (0.78 to 0.86) | 0.84 (0.80 to 0.87) | 0.91 (0.88 to 0.95) | 1.00 | <.001 |
| 1962–1964 | 0.76 (0.72 to 0.81) | 0.82 (0.78 to 0.86) | 0.86 (0.82 to 0.89) | 0.94 (0.91 to 0.97) | 1.00 | <.001 |
| 1965–1967 | 0.76 (0.72 to 0.80) | 0.83 (0.79 to 0.87) | 0.87 (0.83 to 0.90) | 0.92 (0.90 to 0.95) | 1.00 | <.001 |
| 1968–1970 | 0.80 (0.76 to 0.84) | 0.85 (0.82 to 0.89) | 0.88 (0.85 to 0.91) | 0.94 (0.92 to 0.97) | 1.00 | <.001 |
| 1971–1973 | 0.80 (0.76 to 0.84) | 0.87 (0.84 to 0.90) | 0.89 (0.86 to 0.92) | 0.94 (0.92 to 0.96) | 1.00 | <.001 |
| 1974–1976 | 0.82 (0.78 to 0.87) | 0.88 (0.84 to 0.92) | 0.90 (0.86 to 0.94) | 0.96 (0.93 to 0.99) | 1.00 | <.001 |
| 1977–1979 | 0.85 (0.80 to 0.90) | 0.90 (0.86 to 0.95) | 0.94 (0.89 to 0.98) | 0.97 (0.93 to 1.00) | 1.00 | <.001 |
| 1980–1982 | 0.89 (0.83 to 0.95) | 0.93 (0.87 to 0.99) | 0.94 (0.89 to 0.99) | 0.97 (0.94 to 1.02) | 1.00 | <.001 |
| 1983–1985 | 0.93 (0.86 to 1.01) | 0.96 (0.89 to 1.02) | 0.97 (0.91 to 1.03) | 1.00 (0.96 to 1.05) | 1.00 | .029 |
| 1986–1988 | 1.00 (0.92 to 1.09) | 1.01 (0.94 to 1.08) | 1.01 (0.94 to 1.07) | 1.01 (0.96 to 1.06) | 1.00 | .814 |
| 1989–1991 | 1.06 (0.97 to 1.15) | 1.04 (0.97 to 1.13) | 1.04 (0.97 to 1.11) | 1.03 (0.98 to 1.09) | 1.00 | .064 |
| 1992–1994 | 1.08 (1.00 to 1.18) | 1.07 (1.00 to 1.15) | 1.05 (0.99 to 1.12) | 1.04 (0.99 to 1.09) | 1.00 | .002 |
| 1995–1996 | 1.12 (1.02 to 1.24) | 1.10 (1.01 to 1.19) | 1.06 (0.99 to 1.15) | 1.06 (1.00 to 1.12) | 1.00 | <.001 |
| 1997–1998 | 1.14 (1.05 to 1.24) | 1.11 (1.03 to 1.19) | 1.08 (1.01 to 1.15) | 1.06 (1.01 to 1.11) | 1.00 | <.001 |

*RR = relative risk; CI = confidence interval. SES V was treated as the reference category. *P* values are two-sided.

7% to 21%) higher in the two lowest socioeconomic groups than it was in the highest socioeconomic group.

Table 4 also shows mortality RRs that were estimated for men aged 25–64 years and those aged 65 years or older. During 1950–1952, socioeconomic differences were somewhat similar for the two age cohorts; cancer mortality for men aged 25–64 years and those aged 65 years or older was 29% (95% CI = 23% to 35%) and 37% (95% CI = 30% to 42%), respectively, lower in the lowest socioeconomic group than in the highest. However, socioeconomic patterns changed more quickly for men in the younger age cohort than for men in the older one. For example, in 1968–1970, cancer mortality for younger men in different socioeconomic groups did not differ statistically significantly, whereas in 1968–1970, cancer mortality for older men was 20% (95% CI = 16% to 24%) lower in the lowest socioeconomic group than in the highest. In 1989–1991, cancer mortality in the lowest socioeconomic group was 19% (95% CI = 4% to 35%) higher than that in the highest socioeconomic group for younger men, but among older men, there were no statistically significant differences in cancer mortality by area socioeconomic group. In 1997–1998, cancer mortality in the lowest socioeconomic group was 32% (95% CI = 14% to 52%) higher than that in the highest socioeconomic group for younger men and 14% (95% CI = 5% to 24%) higher for older men.

### Sensitivity Analysis

We evaluated the extent to which trends in the differences in mortality among socioeconomic groups was affected by the inclusion of large counties. Cancer mortality trends from 1950 through 1998 were derived for each socioeconomic group after sequentially excluding counties with populations of ⩾100 000, ⩾500 000, and ⩾1 million. The exclusion of larger counties did not change the general trends (data not shown).

Because median family income and percentage of population with at least a high school diploma had the largest correlations with the area index (Table 1), we used them individually to derive area mortality trends. The area classification based on 1990 median family income produced cancer mortality trends similar to those for the 1990 index. However, the differences in the cancer mortality trends for the first four income quintiles in the years prior to 1985 were not as pronounced as those based on the 1990 index (data not shown). Education did not produce trends consistent with those for median family income or with those for the 1990 index, especially during 1950–1990.

Because of temporal proximity, the 1970 socioeconomic index is more likely than the 1990 index to accurately characterize socioeconomic position of areas in the 1950s, 1960s, and 1970s. However, mortality trends based on the 1970 index were almost identical to those based on the 1990 index (data not shown).

## Discussion

In this study, we used a composite measure of area socioeconomic status/position to analyze the extent to which socioeconomic patterns in cancer mortality among U.S. men have changed over the past five decades. To our knowledge, this is the first study that has systematically examined national temporal trends in socioeconomic differences in male cancer mortality by using an area socioeconomic index. The 1990 index, a summary representation of material and distributive aspects of area socioeconomic position, seems to provide a stable socioeconomic classification of counties during 1950–1998 (Table 2). The sensitivity analysis indicates that possible area misclassification associated with the use of the 1990 index has little impact on the general trend observed in socioeconomic inequalities in male cancer mortality.

National cancer mortality data do not permit analysis for smaller geographic areas, such as census tracts or block groups. Although there is a substantial degree of socioeconomic and demographic heterogeneity within counties, the extent to which trends in socioeconomic differences in cancer mortality would be altered if the area index were based on census tract or block group data is an empirical question. Our analysis did show a moderate increase in index heterogeneity, especially among counties with populations of at least 100 000. However, the general trend of changing socioeconomic patterns in male cancer mortality holds for counties with populations of less than 100 000 and less than 500 000.

There are certain advantages to using county-level data. Census tracts, homogenous geographic areas with a mean population size of 4000, may change between decennial censuses. U.S. counties, on the other hand, maintain fairly stable social, political, administrative, and geographic boundaries across time. They are considerably less likely than census tracts to experience substantial fluctuations in their sociodemographic composition during a specific decade or over time. Moreover, counties provide an appropriate socioeconomic, political, and community context within which many public health and social policies are formulated and implemented.

Dramatic changes in socioeconomic patterns in U.S. male cancer mortality have occurred in the past five decades. The positive socioeconomic gradient (i.e., higher mortality rates for higher socioeconomic areas) diminished consistently throughout the 1950s, 1960s, and 1970s, largely as a result of a faster increase in mortality among men in low socioeconomic areas and a slower increase in mortality among men in high socioeconomic areas. Furthermore, high socioeconomic areas began to experience a leveling off or a decline in mortality at least a decade earlier than did low socioeconomic areas. Because of this dynamic, the socioeconomic gradients reversed in the late 1980s, indicating higher mortality for lower socioeconomic areas than for higher socioeconomic areas. In the 1990s, socioeconomic differences continued to widen as high socioeconomic areas experienced relatively larger mortality declines than did low socioeconomic areas. Similar patterns in all-cancer mortality have been observed for Britain, Canada, and Australia *(18,22,29,30)*.

Inverse socioeconomic gradients in U.S. cancer mortality were steeper for younger men than for older men, especially in the 1990s. Social inequalities in cancer mortality generally diminish with age, a pattern that has been observed for all-cause mortality and for mortality from several major causes of death *(50,51)*. Smaller socioeconomic disparities in older age groups may primarily be the result of differential survival of very healthy persons in the disadvantaged groups, because the poorest and least healthy individuals may have died early in life. The universal provision of Medicare and Social Security may also reduce social inequalities, resulting in flatter socioeconomic gradients in mortality among the elderly *(50)*.

Although the focus of this study is on men, it is important to mention temporal trends in all-cancer mortality among U.S. women, which have been greatly influenced over time by changes in female breast and lung cancer mortality rates *(10,52)*. As shown in Fig. 4, women aged 65 years or older in higher socioeconomic areas had higher cancer mortality than did those in lower socioeconomic areas, but the socioeconomic differences generally diminished over time. Cancer mortality among older women was 24% (95% CI = 21% to 27%) lower in 1950 and 5% (95% CI = 3% to 7%) lower in 1998 in the lowest socioeconomic group than it was in the highest. In the 1950s, 1960s, 1970s, and midway through the 1980s, women aged 25–64 in higher socioeconomic areas had higher cancer mortality than did those in lower socioeconomic areas. However, by the early 1990s, the socioeconomic gradient had reversed. In 1998, younger women in the lowest socioeconomic group had 13% (95% CI = 9% to 16%) higher cancer mortality than did those in the highest socioeconomic group, a finding consistent with that for Australia and Canada *(29,30)*.

Temporal socioeconomic patterns in male cancer mortality, as shown in this study, appear consistent with the increasing socioeconomic inequalities in cigarette smoking among men,

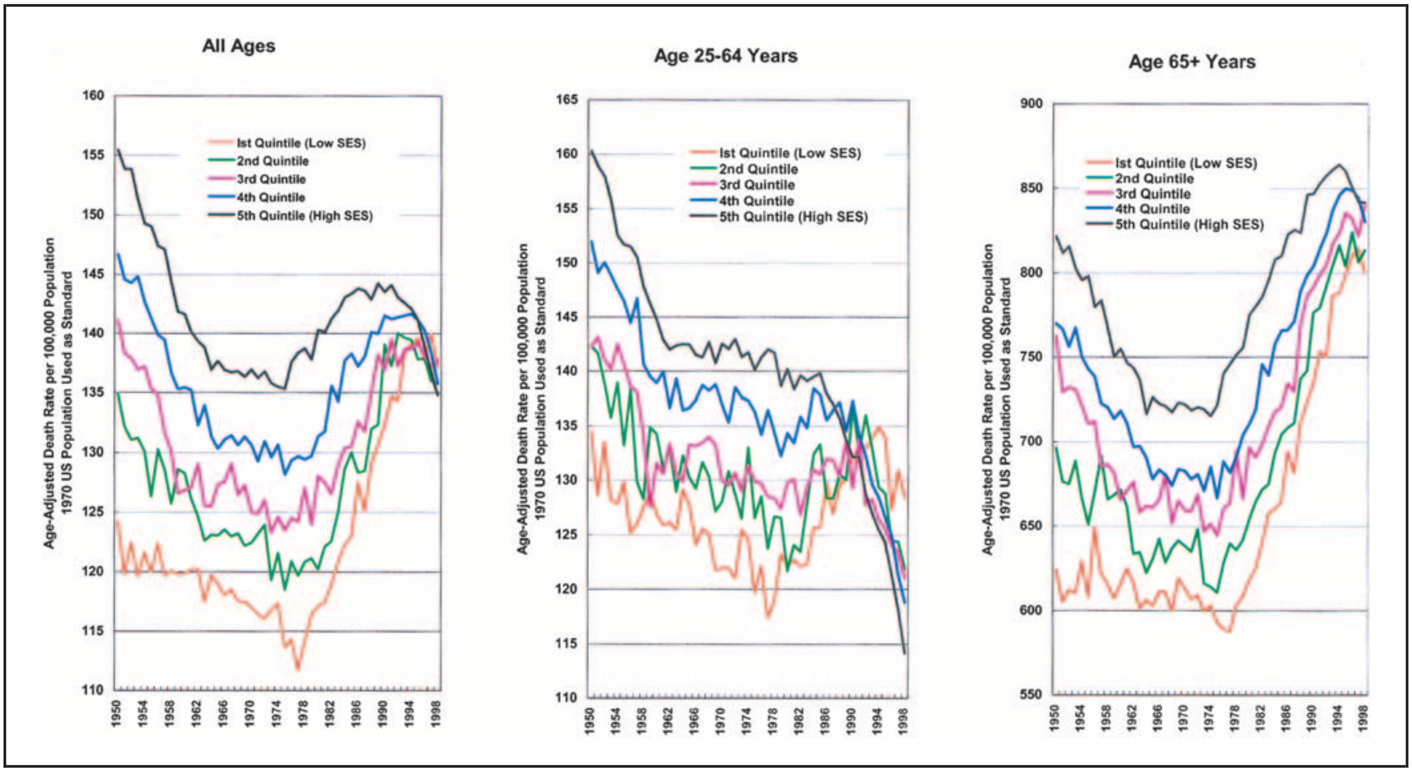



**Fig. 4.** Cancer mortality rates for U.S. women by age and the 1990 area socioeconomic status (SES) index, 1950–1998.

with an expected 20- to 30-year lag between the start of regular smoking and cancer mortality *(9,53,54)*. Although current smoking rates have fallen for all social classes in the United States over the past 25 years, the relative social class disparities in smoking prevalence have grown markedly. In 1998, men with less than a high school education were 3.4 times more likely to smoke than were men with a college degree. In 1974, men with less than a high school education were only 1.8 times more likely to smoke than were men with a college degree *(9)*. Given the latency period between the start of regular smoking and cancer death, we should expect socioeconomic disparities in male cancer mortality to continue to widen in the near future.

The long-term trend in total cancer mortality among U.S. men is driven primarily by changes in lung cancer mortality, although recent trends in colorectal and prostate cancer mortality have also contributed, to some extent, to the overall cancer mortality trend *(10,52)*. Although trend analyses of specific major sites such as lung, colon/rectum, prostate, and stomach would be more insightful in terms of trying to understand the role of specific health behaviors and cancer control measures, the analysis of all cancers combined is important from the perspective of measuring how the total cancer mortality burden among men has changed across various socioeconomic segments of the U.S. population. Another reason for focusing on overall cancer mortality is that the lack of studies showing social gradients in cancer incidence or mortality may lead one to the erroneous conclusion that, unlike overall health status, cardiovascular disease, injuries, and childhood diseases, socioeconomic gradients in cancer do not exist or are not important enough to warrant the attention of researchers *(51)*.

Area socioeconomic gradients in cancer mortality should not be considered proxies for socioeconomic differences at the individual level *(16,55–58)*. Such consideration may lead to an ecologic fallacy, implying that the socioeconomic effects estimated at the aggregate community level are being interpreted as those occurring at the individual level. Our study design was ecologic in that we analyzed area variations in cancer mortality rates as a function of an ecologic variable, area socioeconomic position. Consequently, our analysis is not likely to be characterized by an ecologic fallacy. Generally, individual socioeconomic effects are larger than those at the societal level, and temporal trends in individual socioeconomic differences in cancer mortality may differ from those presented here *(20,51, 55,58)*.

Social disparities in tobacco use, diet, exposure to environmental pollutants, and access to and use of medical care may partially account for the area socioeconomic differences in cancer mortality shown here. However, to the extent that the trend in overall male cancer mortality is driven by trends in lung cancer mortality, medical care would have less of an impact, because for lung cancer, survival is poor and mortality parallels incidence *(10,12)*. The fact that trends in the social distribution of cigarette smoking may be associated with changing socioeconomic patterns in male cancer mortality does not necessarily suggest that community differences in social characteristics are not important in their own regard. In fact, social characteristics do provide a context within which many of the behavioral risk factors, such as smoking, alcohol use, fatty diet, and lack of physical activity, occur *(8,55)*. Reducing inequalities in education, income, housing, and the workforce may thus be an important policy goal toward reducing health disparities, including those in cancer mortality *(36,59)*.

Finally, in the absence of reliable individual socioeconomic data in the current national cancer databases, including the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER)[1] program, the census-based socioeconomic indices could serve as important surveillance tools for documenting socioeconomic and health disparities in a wide range of cancer outcomes and for monitoring progress toward eliminating such disparities in the future. Area socioeconomic indices, when used in the context of ecologic surveillance, could be particularly useful for identifying the potential impact of cancer control interventions, health services needs, and resource allocation for socioeconomically disadvantaged areas, as well as for generating specific research hypotheses that may require the collection of detailed sociodemographic, behavioral, health care, medical, and biologic data for individuals. In the accompanying article, we have carried out temporal analyses of U.S. mortality differentials in relation to area socioeconomic position for lung and colorectal cancer *(60).* Subsequent analyses will focus on additional specific sites, such as breast, cervix, and prostate, for which cancer control interventions have been introduced into the general population. In the future, we also intend to use the area index, linked at the census tract level to individual patient data in SEER, to examine socioeconomic differences in site-specific cancer incidence, treatment, disease stage, and survival.

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## Notes

[1]*Editor's note:* SEER is a set of geographically defined, population-based, central cancer registries in the United States, operated by local nonprofit organizations under contract to the National Cancer Institute (NCI). Registry data are submitted electronically without personal identifiers to the NCI on a biannual basis, and the NCI makes the data available to the public for scientific research.

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