Changing Area Socioeconomic Patterns in U.S. Cancer Mortality, 1950–1998: Part II—Lung and Colorectal Cancers

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Background: **Lung cancer and colorectal cancer are leading causes of U.S. cancer mortality. Because mortality rates for many cancers vary by socioeconomic characteristics, we used area socioeconomic indices to examine patterns in U.S. lung and colorectal cancer mortality between 1950 and 1998.** ***Methods:*** **A factor-based area socioeconomic index was linked to 1950–1998 county mortality data to generate annual lung and colorectal cancer mortality rates for each area socioeconomic group. Joinpoint regression analysis was used to model and identify statistically significant changes in the mortality trends.** ***Results:*** **Area socioeconomic patterns in U.S. lung cancer mortality changed dramatically between 1950 and 1998. Men aged 25–64 years and those aged 65 years or older in higher socioeconomic areas generally had higher lung cancer mortality than did those in lower socioeconomic areas during 1950–1964 and 1950–1980, respectively. Area socioeconomic differences in lung cancer mortality began to reverse and widen by the early 1970s for younger men and by the mid-1980s for older men. In 1998, lung cancer mortality was 56% (95% confidence interval [CI] = 49% to 64%) higher for younger men and 38% higher (95% CI = 34% to 43%) for older men in the lowest area socioeconomic group than for the same age groups in the highest area socioeconomic group. Lung cancer mortality among older women in all socioeconomic groups increased sevenfold to eightfold between 1950 and 1998, with higher mortality in higher area socioeconomic groups. The positive socioeconomic gradient in colorectal cancer mortality diminished substantially over time. Although colorectal cancer mortality among women in all area socioeconomic groups showed a consistent downward trend, colorectal cancer mortality among men in low area socioeconomic groups, but not in high area socioeconomic groups, showed an upward trend.** ***Conclusions:*** **Socioeconomic gradients in male lung cancer mortality reversed between 1950 and 1998, and those in colorectal cancer mortality narrowed over that time. Area measures may be useful for monitoring socioeconomic disparities in cancer mortality and for identifying areas for potential cancer control interventions. [J Natl Cancer Inst 2002;94:916–25]**

Lung and colorectal cancers are the first and second leading causes, respectively, of cancer death in the United States *(1)*. In 1998, 154 561 Americans died from lung cancer and 56 785 died from colorectal cancer, accounting for 29% and 11%, respectively, of all cancer deaths *(1,2)*. Although U.S. colorectal cancer mortality has declined consistently over time, lung cancer mortality has risen dramatically in the past five decades, especially among women *(1,3–6)*. Both lung and colorectal cancer mortality rates vary substantially by a number of sociodemographic characteristics, including age, sex, race/ethnicity, and geographic area *(1–4,7)*. Although an inverse relationship exists between socioeconomic characteristics and lung cancer incidence and mortality, no consistent relationship exists between socioeconomic status (SES) and colorectal cancer incidence and mortality *(8,9)*.

Because of the lack of reliable socioeconomic data on U.S. death certificates or in the medical records of cancer patients, socioeconomic differences in cancer incidence or mortality cannot be readily examined *(1,2,10–13)*. Socioeconomic analyses of cancer can, however, be conducted by linking census socioeconomic data with cancer incidence and mortality data at the ecological level. In the United States, such analyses are rarely done in a temporal fashion *(8,13–15)*. In Europe, Australia, and New Zealand, trends in population health variations are often examined in relation to area socioeconomic deprivation *(16–27)*.

In the accompanying article *(28)*, we used selected census variables to develop an area-based composite socioeconomic index that classified U.S. counties into five socioeconomic categories. We illustrated the use of the area index by examining changes in socioeconomic patterns in all-cancer mortality among U.S. men from 1950 through 1998 *(28)*.

All-cancer mortality is important from the perspective of measuring the total cancer burden and cancer-related health disparities. However, lung and colorectal cancers are leading causes of U.S. cancer mortality, and examination of trends in mortality from these two cancers in relation to area socioeconomic characteristics may provide important insights into the differential impact of major risk factors and cancer control interventions at the population level.

In this study, we use the area index to examine the extent to which socioeconomic differences in lung and colorectal cancer mortality among U.S. men and women changed during the second half of the 20th century. We analyze temporal socioeconomic patterns during 1950–1998 for men and women aged 25–64 years and those aged 65 years or older.

Methods

The area socioeconomic index was constructed by applying a principal components analysis to 11 variables drawn from the 1990 census that were taken to adequately represent general living standards and socioeconomic conditions in a given county *(12,16,28–35)*. The 11 census variables were education distribution (two variables: percentage of population with less than 9 years of education and percentage of population with at least

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See "Note" following "References."

12 years of education), median family income, income disparity (measured as a logged ratio of the number of households with less than $10 000 income to those with at least $50 000), occupational composition (percentage with a white collar occupation), unemployment rate, family poverty rate, median home value, median gross rent, percentage of households without access to phone, and percentage of households without complete plumbing *(36,37).* Four other census variables—single-parent household rate, household crowding, home ownership rate, and English language proficiency—were also considered but were dropped from the final analysis because of their low correlations or factor loadings (correlations of individual indicators with the index). The resultant single-factor solution indicated a theoretically and empirically meaningful clustering of the 11 census variables. The estimated factor loadings for the 11 variables, in the order listed above, were –0.83, 0.86, 0.90, –0.84, 0.71, –0.57, –0.87, 0.66, 0.80, –0.80, and –0.65.

The variables that make up the 1990 index (factor) were weighted using the factor score coefficients derived from the principal components analysis. 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 index scores indicate high levels of socioeconomic status/position and low levels of deprivation. Low index scores indicate low levels of socioeconomic status/position and high levels of deprivation.

The socioeconomic index had a high degree of reliability, with a reliability coefficient (α) of 0.94 *(38).* The index was also found to be highly reliable across time, with the 1990, 1980, and 1970 indices constructed with the same set of variables showing high interindex correlations (>0.89) and similar factor loadings. The index appeared to be equally valid across county, ZIP code, and census tract levels, with the factor loadings for the 11 variables being generally similar in magnitude and relative importance for the three geographic levels *(28).* For predictive validity, the index also performed adequately on the basis of estimated correlations of the index with a variety of county-level health outcomes during 1990–1996, 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), prostate cancer (–0.13), and colorectal cancer (0.06).

To analyze time trends in mortality, we used the quintile distribution of the 1990 socioeconomic index and classified 3097 U.S. counties into five categories of approximately equal numbers of counties. Because we were interested in comparing the mortality patterns of areas (counties) rather than people, we constructed quintiles of counties rather than overall population *(13,28,39).* The county groups thus created ranged from being the most disadvantaged (1^{st} quintile) to the least disadvantaged areas (5^{th} quintile). 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. The five area socioeconomic groups (from lowest to highest) accounted for the following respective percentages of the total U.S. population in 1990: 4.4%, 5.7%, 8.5%, 17.5%, and 63.9%.

Using national mortality data files, we obtained age-, sex-, and county-specific annual lung and colorectal cancer deaths from 1950 through 1998 *(2,40).* 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 mortality rates *(41,42).* Each of the 3097 counties in the mortality dataset was assigned one of the five area socioeconomic categories. For Alaska and Hawaii, state-level rather than county-level data were used. Annual age-adjusted lung and colorectal cancer mortality rates were calculated for men and women aged 25–64 years and those aged 65 years or older for each of the five area socioeconomic groups. Separate analyses were carried out by age because socioeconomic patterns in mortality have been shown to vary for the two broad age cohorts. Moreover, behavioral and health care access and use patterns vary greatly for the two age cohorts *(9,43,44).* The age adjustment of mortality rates was performed by the direct method using the age composition of the 1970 U.S. standard population and 5-year age-specific death rates. In addition, a sensitivity analysis was conducted to evaluate the impact of large, more heterogeneous counties on mortality trends and to assess whether mortality trends based on the 1970 area index differed from those based on the 1990 area index *(28).*

Joinpoint regression models *(3,45,46)* were used to estimate annual rates of change in mortality trends associated with each socioeconomic category. 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 time segment after identifying the best fitting model. Essentially, within each time segment, the logs of the mortality rates are modeled as a linear function of time (calendar year), thereby yielding annual exponential 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 on line at the following Web site: http://srab.cancer.gov/joinpoint.

Results

Socioeconomic Patterns in Lung Cancer Mortality Among Men

Area socioeconomic patterns in lung cancer mortality among men aged 25–64 years have changed over the last five decades (Fig. 1, A). During 1950–1964, there was a positive association between area socioeconomic position and lung cancer mortality. In 1950, lung cancer mortality was about two times greater in the highest area socioeconomic group than in the lowest. The positive gradient narrowed with time, and by the late 1960s, there was little difference in lung cancer mortality among socioeco-

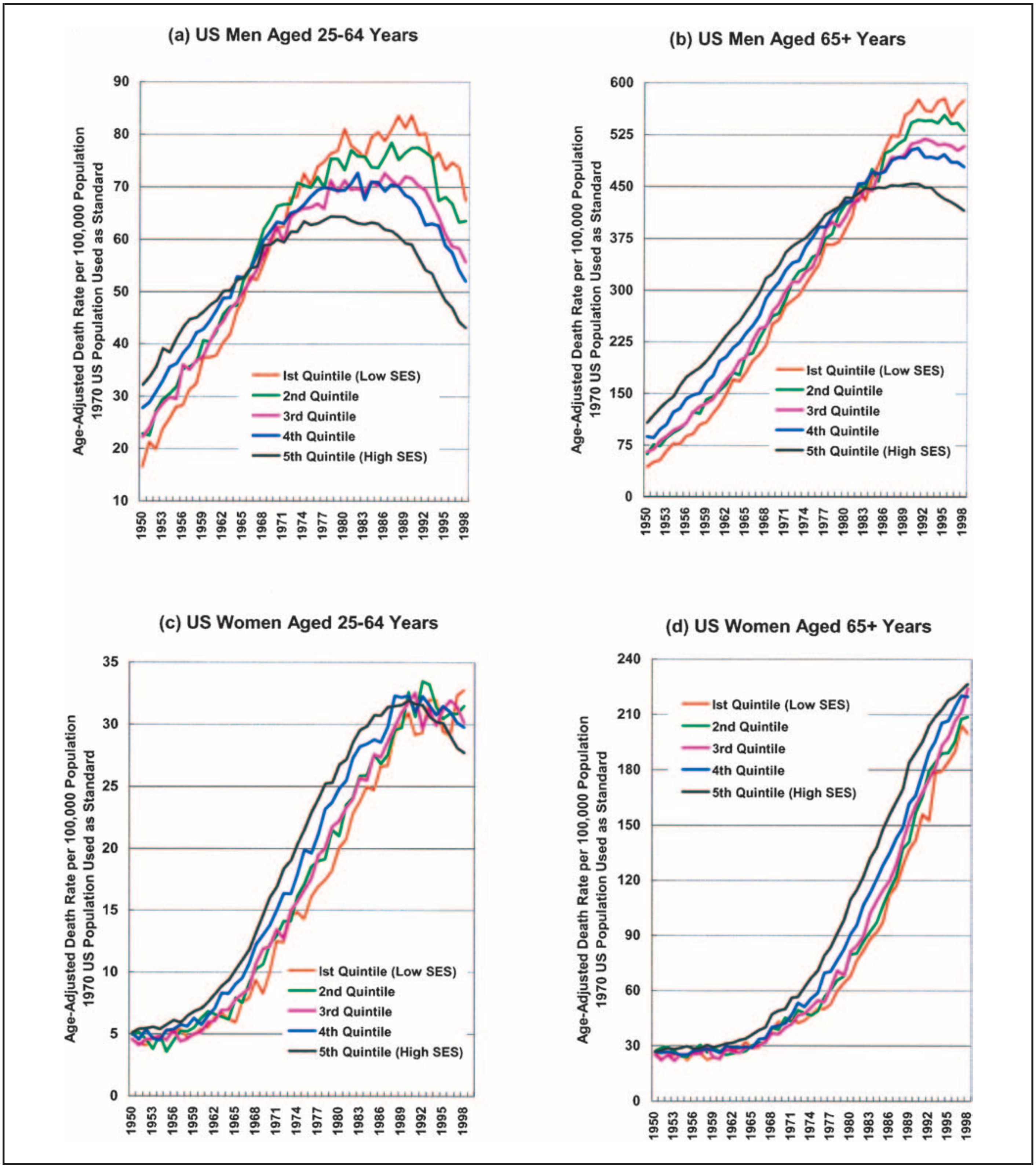

Fig. 1. Lung cancer mortality rates for U.S. men and women aged 25–64 years and those aged 65 years or older by the 1990 area socioeconomic status (SES) index, 1950–1998.

nomic groups. However, by the early 1970s, socioeconomic differences began to reverse and widen, with statistically significantly higher lung cancer mortality rates observed for men in lower socioeconomic areas than for men in higher socioeconomic areas. By 1998, lung cancer mortality for men aged 25–64 years was 56% (95% confidence interval [CI] = 49% to 64%) greater in the lowest area socioeconomic group than in the highest.

During 1950–1980, lung cancer mortality among older men was generally high in high area socioeconomic groups, with socioeconomic differences narrowing consistently throughout this period (Fig. 1, B). Mortality was 148% (95% CI = 111% to

186%) greater in 1950 and 12% (95% CI = 7% to 16%) greater in 1980 in the highest area socioeconomic group than in the lowest. The reversal of the socioeconomic patterns started in the mid-1980s, with the negative socioeconomic gradient in lung cancer mortality widening consistently thereafter. By 1998, mortality for older men was 38% (95% CI = 34% to 43%) greater in the lowest area socioeconomic group than in the highest.

Among men in the highest socioeconomic group, lung cancer mortality declined faster and at an earlier point in time for men aged 25–64 years than for men aged 65 years or older. Indeed, all socioeconomic groups experienced faster and earlier decreases in mortality for younger men than for older men, as evident from annual rates of change (Table 1). Lung cancer mortality for men aged 25–64 years in the highest socioeconomic group began to decline as early as 1974 at a rate of 0.33% (95% CI = 0.14% to 0.52%) per year during 1974–1989 and 3.82% (95% CI = 3.44% to 4.19%) annually during 1989–1998, whereas mortality for men aged 65 years or older in the highest socioeconomic group did not begin to decline until 1991 (at a rate of 1.31% [95% CI = 0.90% to 1.72%] per year during 1991–1998).

Socioeconomic Patterns in Lung Cancer Mortality Among Women

Lung cancer mortality trends also changed between 1950 and 1998 among women aged 25–64 years and those aged 65 years or older (Fig. 1, C and D, respectively). Mortality among women rose dramatically in the last four decades. Women aged 25–64 years in higher area socioeconomic groups had higher mortality rates than did those in lower area socioeconomic groups in the 1950s, 1960s, 1970s, and through the mid-1980s. However, by the early 1990s, socioeconomic patterns had reversed. In 1998, younger women had an 18% (95% CI = 10% to 26%) higher rate in the lowest socioeconomic group than in the highest. Although mortality among younger women in the lowest socioeconomic group had increased throughout the study period, mortality in the highest socioeconomic group decreased by 1.48% (95% CI = 1.11% to 1.84%) per year during 1988–1998 (Table 1).

Women aged 65 years or older in higher socioeconomic areas had higher mortality than did women in lower socioeconomic areas between 1976 and 1998, but these socioeconomic differences generally diminished during this time period. Lung cancer mortality was 37% (95% CI = 30% to 44%) lower in 1976 and 12% (95% CI = 8% to 16%) lower in 1998 in the lowest area socioeconomic group than in the highest. During 1950–1976, lung cancer mortality among older women increased much faster in higher socioeconomic areas than in lower socioeconomic areas (Table 1). However, during 1991–1998, mortality increased more rapidly in the lowest area socioeconomic group than it did in the highest (4.00% [95% CI = 2.89% to 5.11%] versus 1.91% [95% CI = 1.53% to 2.29%] per year).

Socioeconomic Patterns in Colorectal Cancer Mortality Among Men

Colorectal cancer mortality trends among men aged 25–64 years (Fig. 2, A) show that at the beginning of the study period, there was a substantial positive socioeconomic gradient in colorectal cancer mortality, with the rate in 1950 being 129% (95% CI = 96% to 162%) greater in the highest area socioeconomic group than in the lowest. The positive gradient diminished over time, so that by 1980, mortality was only 29% (95% CI = 13% to 45%) higher in the highest socioeconomic group than in the lowest. Socioeconomic patterns reversed in the 1990s. In 1998, mortality was 26% (95% CI = 13% to 39%) greater in the lowest area socioeconomic group than in the highest.

Socioeconomic patterns in colorectal cancer mortality changed because of different rates at which mortality in specific socioeconomic groups increased or decreased. During 1950–1998, mortality among men aged 25–64 years in the lowest and second lowest area socioeconomic groups increased consistently, at annual rates of 1.05% (95% CI = 0.92% to 1.18%) and 0.33% (95% CI = 0.24% to 0.43%), respectively (Table 2). The two highest area socioeconomic groups, by contrast, showed a consistently downward trend during the entire period, with mortality declining at an accelerated pace after the mid-1980s (the annual rates of decline were 2.00% [95% CI = 1.71% to 2.29%] and 1.40% [95% CI = 0.88% to 1.84%], respectively).

During 1950–1990, there was a positive but diminishing socioeconomic gradient in colorectal cancer mortality among older men (Fig. 2, B). In 1950, mortality was 150% (95% CI = 121% to 179%) greater in the highest area socioeconomic group than in the lowest, and by 1990, the difference had narrowed to 29% (95% CI = 20% to 38%). In the 1990s, differences continued to decrease, with little differentiation between area socioeconomic groups in 1998. Mortality among older men in the highest area socioeconomic group leveled off during 1950–1978, declined at 0.87% (95% CI = 0.46% to 1.28%) per year during 1978–1987, and declined at a substantial rate of 2.56% (95% CI = 2.32% to 2.80%) during 1987–1998. Mortality among men in the lowest area socioeconomic group, however, increased during 1950–1992 at an annual rate of 1.19% (95% CI = 1.09% to 1.30%), with the rate leveling off thereafter (Table 2).

Socioeconomic Patterns in Colorectal Cancer Mortality Among Women

Trends in colorectal cancer mortality among women aged 25–64 years (Fig. 2, C) show that, like men, women in high area socioeconomic groups had higher mortality than did women in low area socioeconomic groups, but the difference generally decreased during 1950–1980. Mortality was 80% (95% CI = 57% to 103%) higher in 1950 and 16% (95% CI = 2% to 30%) higher in 1980 in the highest area socioeconomic group than in the lowest. In the 1990s, socioeconomic patterns among younger women also reversed, with mortality in 1998 being 22% (95% CI = 7% to 36%) higher in the lowest area socioeconomic group than in the highest.

Colorectal cancer mortality for women aged 25–64 years in all socioeconomic groups showed a consistently decreasing trend between 1950 and 1998, although the rate of decline was substantially greater for women in the higher area socioeconomic groups than for women in the lower area socioeconomic groups. For example, colorectal cancer mortality declined during 1950–1998 at an annual rate of 2.25% (95% CI = 2.13% to 2.38%) for the highest area socioeconomic group and at 0.26% (95% CI = 0.14% to 0.38%) and 0.94% (95% CI = 0.82% to 1.06%), respectively, for the two lowest area socioeconomic groups (Table 2).

Trends in colorectal cancer mortality among women aged 65 years or older (Fig. 2, D) show that the positive socioeconomic gradient in colorectal cancer mortality among older women generally declined during 1950–1998. Colorectal cancer

Table 1. Estimated annual percent change (EAPC) for socioeconomic status (SES)-, age-, and sex-specific lung cancer mortality trends, United States, 1950–1998*

	Time period	EAPC (95% CI)	Time period	EAPC (95% CI)	Time period	EAPC (95% CI)	Time period	EAPC (95% CI)
Men aged 25–64 years								
SES I (low)	1950–1959†	7.81‡§ (6.39 to 9.25)	1959–1974	4.83§ (4.34 to 5.31)	1974–1990	0.78§ (0.45 to 1.11)	1990–1998	−2.13§ (−2.94 to −1.32)
SES II	1950–1970	5.28§ (4.96 to 5.60)	1970–1991	0.70§ (0.48 to 0.91)			1991–1998	−3.36§ (−4.33 to −2.38)
SES III	1950–1956	7.37§ (5.43 to 9.35)	1956–1972	4.10§ (3.76 to 4.44)	1972–1990	0.57§ (0.36 to 0.78)	1990–1998	−3.25§ (−3.90 to −2.60)
SES IV	1950–1968	4.09§ (3.85 to 4.35)	1968–1977	1.64§ (1.00 to 2.29)	1977–1989	−0.01 (−0.38 to 0.36)	1989–1998	−2.96§ (−3.47 to −2.45)
SES V (high)	1950–1956	5.08§ (3.94 to 6.22)	1956–1974	2.20§ (2.02 to 2.37)	1974–1989	−0.33§ (−0.52 to −0.14)	1989–1998	−3.82§ (−4.19 to −3.44)
Men aged 65 years or older								
SES I (low)	1950–1962	10.01§ (8.87 to 11.17)	1962–1971	7.09§ (5.90 to 8.28)	1971–1989	3.99§ (3.75 to 4.24)	1989–1998	0.20 (−0.29 to 0.68)
SES II	1950–1969	7.28§ (6.87 to 7.69)	1969–1980	4.31§ (3.73 to 4.90)	1980–1991	2.38§ (1.94 to 2.82)	1991–1998	−0.30 (−0.96 to 0.37)
SES III	1950–1967	7.65§ (7.26 to 8.04)	1967–1978	4.45§ (3.97 to 4.94)	1978–1990	2.29§ (1.97 to 2.60)	1990–1998	−0.25 (−0.68 to 0.18)
SES IV	1950–1961	7.73§ (6.91 to 8.56)	1961–1974	5.09§ (4.66 to 5.52)	1974–1988	2.12§ (1.86 to 2.39)	1988–1998	−0.35§ (−0.67 to −0.03)
SES V (high)	1950–1968	5.71§ (5.47 to 5.95)	1968–1980	2.61§ (2.32 to 2.90)	1980–1991	0.39§ (0.12 to 0.66)	1991–1998	−1.31§ (−1.72 to −0.90)
Women aged 25–64 years								
SES I (low)	1950–1965	2.84§ (1.64 to 4.06)	1965–1973	10.08§ (7.24 to 12.99)	1973–1988	5.10§ (4.45 to 5.76)	1988–1998	0.78§ (0.01 to 1.58)
SES II	1950–1955	−4.20 (−10.60 to 2.65)	1955–1979	7.24§ (6.74 to 7.74)	1979–1992	3.22§ (2.51 to 3.95)	1992–1998	−1.33 (−3.03 to 0.39)
SES III	1950–1958	0.48 (−2.14 to 3.17)	1958–1977	7.87§ (7.32 to 8.42)	1977–1989	3.90§ (3.26 to 4.55)	1989–1998	−0.16 (−0.88 to 0.56)
SES IV	1950–1958	2.20 (−0.28 to 4.73)	1958–1978	7.47§ (7.03 to 7.92)	1978–1989	2.88§ (2.22 to 3.54)	1989–1998	−0.78§ (−1.46 to −0.09)
SES V (high)	1950–1958	2.34§ (0.75 to 3.96)	1958–1976	7.76§ (7.43 to 8.09)	1976–1988	2.68§ (2.32 to 3.04)	1988–1998	−1.48§ (−1.84 to −1.11)
Women aged 65 years or older								
SES I (low)	1950–1958	−0.66 (−3.99 to 2.78)	1958–1976	4.40§ (3.59 to 5.22)	1976–1991	7.71§ (7.12 to 8.31)	1991–1998	4.00§ (2.89 to 5.11)
SES II	1950–1962	−0.46 (−1.84 to 0.93)	1962–1975	5.42§ (4.36 to 6.51)	1975–1992	7.46§ (7.09 to 7.84)	1992–1998	2.73§ (1.68 to 3.79)
SES III	1950–1965	0.97§ (0.07 to 1.87)	1965–1990	7.35§ (7.12 to 7.59)			1990–1998	4.14§ (3.53 to 4.76)
SES IV	1950–1965	1.08§ (0.43 to 1.74)	1965–1984	7.65§ (7.34 to 7.94)	1984–1993	5.69§ (5.18 to 6.20)	1993–1998	2.31§ (1.48 to 3.15)
SES V (high)	1950–1964	1.41§ (0.84 to 1.99)	1964–1983	7.62§ (7.40 to 7.84)	1983–1991	5.30§ (4.82 to 5.78)	1991–1998	1.91§ (1.53 to 2.29)

*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 mortality trend associated with men aged 25–64 years in SES I, there were three joinpoints (1959, 1974, and 1990) yielding four time segments.

‡The mortality rate for men aged 25–64 years in SES I increased, on average, by 7.81% per year during 1950–1959.

§The estimated annual percentage change is statistically significantly different from 0 (two-sided $P<.05$).

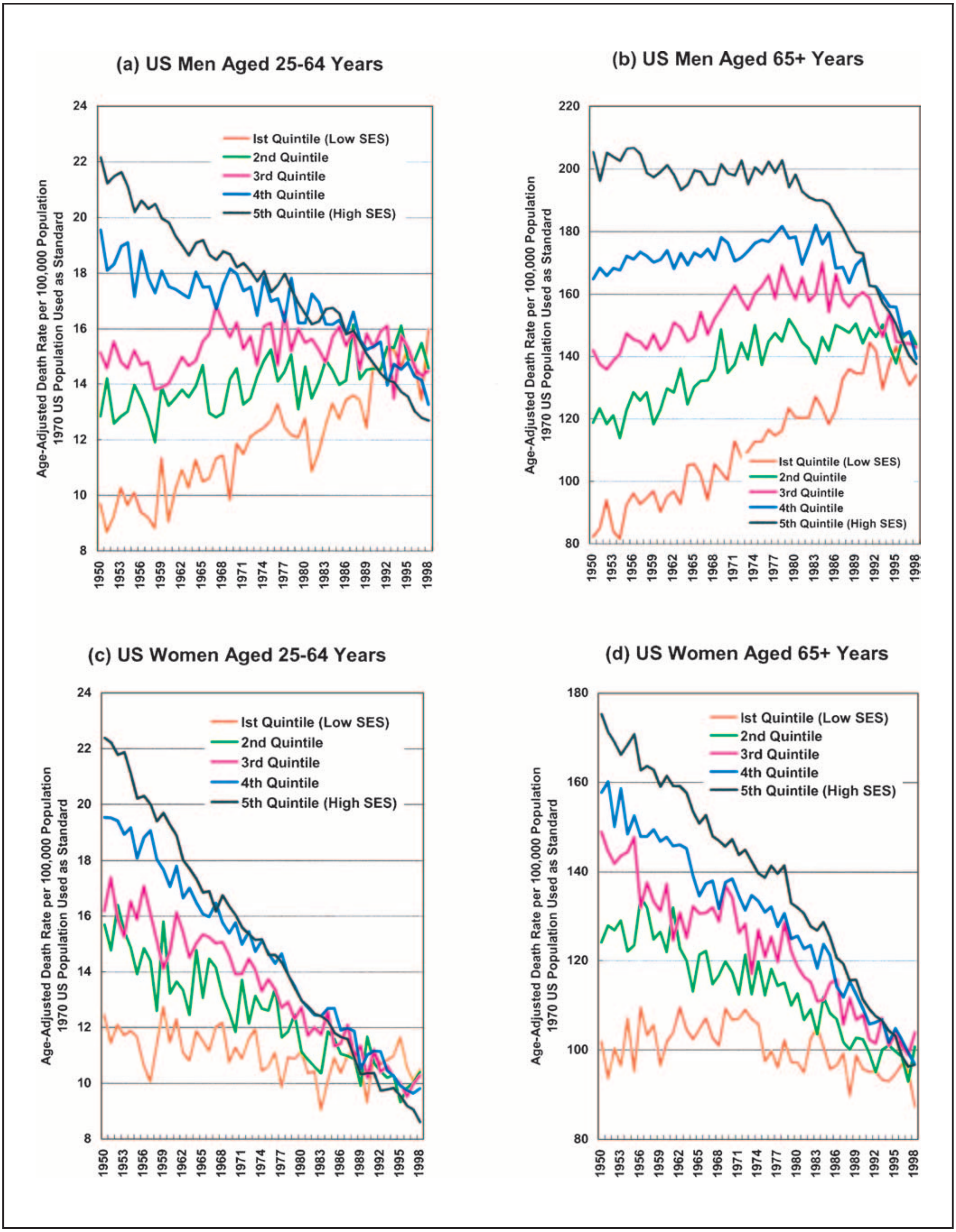

Fig. 2. Colorectal cancer mortality rates for U.S. men and women aged 25–64 years and those aged 65 years or older by the 1990 area socioeconomic status (SES) index, 1950–1998.

Table 2. Estimated annual percent change (EAPC) for socioeconomic status (SES)-, age-, and sex-specific colorectal cancer mortality trends, United States, 1950–1998*

	Time period	EAPC (95% CI)	Time period	EAPC (95% CI)	Time period	EAPC (95% CI)
Men aged 25–64 years						
SES I (low)	1950–1998	1.05† (0.92 to 1.18)				
SES II	1950–1998	0.33† (0.24 to 0.43)				
SES III	1950–1977	0.33† (0.10 to 0.56)	1978–1998	−0.33† (−0.64 to −0.02)		
SES IV	1950–1985‡	−0.35†§ (−0.46 to −0.24)	1985–1998	−1.40† (−1.84 to −0.88)		
SES V (high)	1950–1986	−0.81† (−0.87 to −0.75)	1986–1998	−2.00† (−2.29 to −1.71)		
Men aged 65 years or older						
SES I (low)	1950–1992	1.19† (1.09 to 1.30)	1992–1998	−0.57 (−2.09 to 0.97)		
SES II	1950–1977	0.83† (0.64 to 1.01)	1977–1998	−0.03 (−0.24 to 0.18)		
SES III	1950–1984	0.53† (0.43 to 0.63)	1984–1998	−1.09† (−1.40 to −0.77)		
SES IV	1950–1983	0.19† (0.11 to 0.27)	1983–1995	−1.13† (−1.45 to −0.81)	1995–1998	−3.48† (−5.79 to −1.12)
SES V (high)	1950–1978	−0.06 (−0.13 to 0.02)	1978–1987	−0.87† (−1.28 to −0.46)	1987–1998	−2.56† (−2.80 to −2.32)
Women aged 25–64 years						
SES I (low)	1950–1998	−0.26† (−0.38 to −0.14)				
SES II	1950–1998	−0.94† (−1.06 to −0.82)				
SES III	1950–1968	−0.61† (−0.95 to −0.26)	1968–1998	−1.37† (−1.53 to −1.20)		
SES IV	1950–1975	−1.21† (−1.35 to −1.08)	1975–1998	−1.81† (−1.97 to −1.65)		
SES V (high)	1950–1998	−2.25† (−2.38 to −2.13)				
Women aged 65 years or older						
SES I (low)	1950–1969	0.31 (−0.08 to 0.70)	1969–1998	−0.49† (−0.64 to −0.33)		
SES II	1950–1998	−0.64† (−0.71 to −0.57)				
SES III	1950–1978	−0.61† (−0.77 to −0.44)	1978–1998	−1.02† (−1.25 to −0.79)		
SES IV	1950–1980	−0.72† (−0.81 to −0.63)	1980–1998	−1.38† (−1.54 to −1.21)		
SES V (high)	1950–1981	−0.86† (−0.92 to −0.80)	1981–1998	−1.89† (−2.01 to −1.76)		

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

†The estimated annual percentage change is statistically significantly different from 0 (two-sided $P<.05$).

‡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 mortality trend associated with men aged 25–64 years in SES IV, there was one joinpoint (1985) yielding two time segments.

§The mortality rate for men aged 25–64 years in SES IV decreased, on average, by 0.35% per year during 1950–1985.

mortality was 72% (95% CI = 54% to 90%) higher in 1950 and only 13% (95% CI = 6% to 20%) higher in 1992 in the highest area socioeconomic group than in the lowest. Although annual rates of decline were substantially greater for higher socioeconomic areas, colorectal cancer mortality trends decreased in all socioeconomic areas (Table 2). Mortality in the highest area socioeconomic group declined by 0.86% (95% CI = 0.80% to 0.92%) per year during 1950–1981 and by 1.89% (95% CI = 1.76% to 2.01%) during 1981–1998. Mortality in the lowest area socioeconomic group declined by 0.49% (95% CI = 0.33% to 0.64%) per year during 1969–1998 and by 0.64% (95% CI = 0.57% to 0.71%) for the second lowest area socioeconomic group during 1950–1998.

Sensitivity Analysis

The exclusion of counties with populations of at least 500 000 did not alter the general patterns in lung and colorectal cancer mortality observed for the total population. Socioeconomic differences were somewhat smaller during the first three decades of the study period for the analysis limited to counties with populations of less than 100 000. We also used median family income and education (percentage of population with at least a high school diploma) individually to derive area mortality trends. The area quintile classification based on median family income produced trends similar to those based on the 1990 area index. The quintile classification based on education produced less consistent trends.

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 area socioeconomic index to analyze the extent to which socioeconomic patterns in lung and colorectal cancer mortality among U.S. men and women have changed over the past five decades. The census-based area index provides a succinct representation of diverse socioeconomic and living conditions characterizing various U.S. counties *(28)*. The 1990 area index has previously been shown to provide a stable socioeconomic classification of counties over time *(28)*. The 1970 area index produced socioeconomic mortality patterns similar to those based on the 1990 index.

The results of this study indicate that the temporal association between area socioeconomic position and lung and colorectal cancer mortality is a dynamic one and that the association varies greatly for men and women. The temporal association between area socioeconomic position and mortality also varies for two age cohorts, but a more formal age–period–cohort analysis may be needed to identify the differential socioeconomic effects for various age cohorts.

Temporal socioeconomic patterns in U.S. lung and colorectal cancer mortality may be influenced by changing socioeconomic patterns in smoking, diet, and health care access and use, including cancer screening *(3,4,7,47,48)*. Although exposure to radon, asbestos, and air pollution are also associated with increased risks of lung cancer, tobacco smoking is the most prominent cause of lung cancer, accounting for about 90% of all lung cancer deaths *(4–6)*. Temporal socioeconomic patterns in lung cancer mortality appear to be consistent with the increasing socioeconomic disparities in cigarette smoking, with a substantial time lag (perhaps 20 to 30 years) between the start of regular smoking and occurrence of cancer death *(4,6,11,49–51)*. The reversal of the area socioeconomic gradient in lung cancer mortality among men in particular may reflect changing socioeconomic gradients in smoking behaviors over the long run. According to the National Health Interview Survey (NHIS) data, the rate of ever smoking (those who reported having smoked at least 100 cigarettes in their lifetime) remained virtually unchanged at 56% between 1966 and 1998 for those in the lowest educational group, whereas the rate declined from 57% in 1966 to 36.5% in 1995 for those in the highest educational group *(6,11,52)*. Although current smoking rates (the most commonly used smoking measure for assessing trends) have decreased for all social class groups in the United States over the past 35 years, the disparities in smoking prevalence have increased substantially. The NHIS data show that the current smoking rate for those with less than a high school education was 18% greater in 1966 and 117% greater in 1998 than that of college graduates *(6,11)*.

Gender-specific educational trends in current smoking are also revealing. Ratios of smoking rates between those with less than a high school education and college graduates increased from 1.8 in 1974 to 3.4 in 1998 for men and from 1.4 in 1974 to 2.9 in 1998 for women *(11)*. Given the latency period between smoking and lung cancer death, socioeconomic disparities in U.S. lung cancer mortality among all men and among younger women will likely continue to widen during the first decade of the 21st century.

Dietary factors, such as fat intake, red meat consumption, inadequate vegetable consumption, and high caloric intake, have been suggested as important risk factors for colorectal cancer. Other lifestyle factors such as physical inactivity, obesity, smoking, and alcohol consumption have also been mentioned as possible risk factors *(3,47,48,53–55)*. However, not all social class differences in this complex array of risk factors are consistent with the socioeconomic gradients in colorectal cancer mortality *(54)*.

Although trend data on socioeconomic differences in dietary factors are lacking, the recent cross-sectional data from the Behavioral Risk Factor Surveillance System indicate higher rates of fat and meat intake and lower vegetable intake among low socioeconomic groups *(56,57)*. The data from the 1989–1991 and 1994–1996 Continuing Survey of Food Intake by Individuals (CSFII) also indicate lower mean numbers of daily servings of fruits and vegetables among lower socioeconomic groups than among higher socioeconomic groups *(58)*. The less favorable dietary pattern among the low socioeconomic groups may be a result of the lower availability of high-quality, low-fat foods and fresh fruits and vegetables and less access to dietary and nutrition information *(58)*. Lack of physical activity or sedentary lifestyle is much more common in low socioeconomic groups than in high socioeconomic groups *(11,57)*. Although heavy alcohol use is inversely related to socioeconomic position, moderate alcohol use increases with increasing educational levels *(11)*.

Social class patterns in dietary factors in the 1950s and 1960s, the decades during which there was a substantial positive socioeconomic gradient in colorectal cancer mortality, may have been quite different from the more recent patterns. Just as smoking was more prevalent among higher socioeconomic groups in the 1950s, it is conceivable that individuals from higher socioeconomic groups consumed more meat and fat (which cost more) during this period, although no empirical data are available to support this contention.

Health care may have little impact on lung cancer mortality trends, given that lung cancer has a relatively poor prognosis and socioeconomic differences in survival tend to be small. However, access to and use of health care services may have played an important role in socioeconomic trends in colorectal cancer mortality *(3)*. Residents of low socioeconomic areas have been shown to have a substantially higher rate of late-stage diagnosis of colorectal cancer than do those in high socioeconomic areas *(59)*. Because a late-stage diagnosis is associated with reduced survival, colorectal cancer mortality might be expected to be higher in low socioeconomic areas than in high socioeconomic areas, all else being equal. Area socioeconomic position has been shown to be positively related to colorectal cancer survival *(60–62)*. Those living in less affluent or more disadvantaged communities have lower rates of survival from colorectal cancer than do those living in more affluent communities, even after controlling for stage of disease at diagnosis *(60–62)*. The relatively low rates of survival of cancer patients in low socioeconomic areas partly may be the result of the less favorable cancer treatment or medical care available to residents of such disadvantaged communities *(60,61)*.

Cancer screening may reduce mortality by detecting cancer at an earlier stage *(3)*. Differential use of cancer screening may have contributed to recent colorectal cancer mortality trends by area socioeconomic position. However, screening could not have been responsible for the trends in the first four decades of the study period *(3)*. Colorectal cancer mortality has been declining steadily among women in all socioeconomic areas and among younger men in high socioeconomic areas since the 1950s and among older men in high socioeconomic areas since the late 1970s, long before the publication of colorectal cancer screening guidelines *(3,63)*. Rates of screening tests, fecal occult blood testing, and sigmoidoscopy/colonoscopy remain low for both U.S. men and women in all socioeconomic groups, although low socioeconomic groups are at a higher risk for not getting screened *(3,63–65)*. Moreover, screening rates, as derived from the NHIS, showed only modest increases between 1987 and 1998 *(3)*.

The results of our ecological study should not be generalized to those studies based on individual-level data. Doing so may lead to the ecological fallacy *(28)*. Moreover, counties—the ecological units for which the area index was developed—are not internally homogenous areas and may indeed contain considerable socioeconomic variability *(28)*. The most affluent areas may consist of many poor individuals or households. Conversely, the lowest socioeconomic areas may also contain individuals and households that are quite well off *(22,66)*. This composition or heterogeneity problem may have underestimated the reported temporal association between area socioeconomic position and cancer mortality *(31)*.

Increasing area socioeconomic gradients in lung cancer mortality among U.S. men and, more recently, among younger U.S. women, are consistent with those reported for Britain, Canada, and Australia *(16,20,27,67)*. Temporal area patterns in colorectal cancer mortality were not available for Britain and Australia and were inconsistent for Canada *(67).* Area socioeconomic patterns in lung and colorectal cancer mortality shown here may differ from socioeconomic differences at the individual level. A recent analysis of individual mortality data from the National Longitudinal Mortality Study (NLMS) showed almost a twofold greater risk of lung cancer mortality among U.S. men aged 25 years or older in low education and income groups during 1979–1989 *(9),* which is substantially greater than the area socioeconomic effect reported in this study. Similarly, in the NLMS, U.S. women with 12 or fewer years of education had substantially higher lung cancer mortality than did women with a college degree. In the 1960 Matched Records Study, white men aged 25 years or older with less than 8 years of education had a 60% higher lung cancer mortality rate than did those with at least 13 years of education; the corresponding excess risk for the least educated white women was 20% *(68).* Thus, individual-level socioeconomic effects on lung cancer mortality differed in size and sometimes in direction from those observed at the area level. In the NLMS, no statistically significant differences in colorectal cancer mortality were found by individual education and income. Furthermore, in the 1960 Matched Records Study, no consistent relationship between individual education and colorectal cancer mortality was found. The individual-level associations between socioeconomic position and colorectal cancer mortality thus differed from the positive area associations observed during the same time period. The inconsistent social patterning in mortality between area- and individual-level studies poses important empirical and interpretive challenges for future research.

Substantial area socioeconomic disparities are shown in lung cancer mortality among U.S. men and women and in colorectal cancer mortality among younger men and women. These disparities will likely widen in the future if current socioeconomic differences in smoking, dietary patterns, cancer screening, and cancer survival continue to persist or increase. However, the recent declines in mortality achieved for lung cancer and, to some extent, for colorectal cancer in high socioeconomic areas may be attainable in low socioeconomic areas through appropriate use of cancer control resources. In the absence of individual socioeconomic data, area measures such as the socioeconomic index may be used effectively for the purpose of monitoring socioeconomic disparities in cancer mortality and for identifying areas that may be targeted for specific cancer control interventions *(28).*

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Note

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