

Trends in Area-Socioeconomic and Race-Ethnic Disparities in Breast Cancer Incidence, Stage at Diagnosis, Screening, Mortality, and Survival among Women Ages 50 Years and Over (1987-2005)

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Abstract

Background: Breast cancer is the most commonly diagnosed cancer and the second leading cause of cancer death among women in the United States and varies systematically by race-ethnicity and socioeconomic status. Previous research has often focused on disparities between particular groups, but few studies have summarized disparities across multiple subgroups defined by race-ethnic and socioeconomic position.

Methods: Data on breast cancer incidence, stage, mortality, and 5-year cause-specific probability of death (100 – survival) were obtained from the Surveillance, Epidemiology, and End Results program and data on mammography screening from the National Health Interview Survey from 1987 to 2005. We used four area-socioeconomic groups based on the percentage of poverty in the county of residence (<10, 10-15, 15-20, +20%) and five race-ethnic groups (White, Black, Asian, American Indian, and Hispanic). We used summary measures of disparity based on both rate differences and rate ratios.

Results: From 1987 to 2004, area-socioeconomic disparities declined by 20% to 30% for incidence, stage at diagnosis, and 5-year cause-specific probability of death, and by roughly 100% for mortality, whether measured on the absolute or relative scale. In contrast, relative area-socioeconomic disparities in mammography use increased by 161%. Absolute race-ethnic disparities declined across all outcomes, with the largest reduction for mammography (56% decline). Relative race-ethnic disparities for mortality and 5-year cause-specific probability of death increased by 24% and 17%, respectively.

Conclusions: Our analysis suggests progress towards race-ethnic and area-socioeconomic disparity goals for breast cancer, especially when measured on the absolute scale. However, greater progress is needed to address increasing relative socioeconomic disparities in mammography and race-ethnic disparities in mortality and 5-year cause-specific probability of death. (Cancer Epidemiol Biomarkers Prev 2009;18(1):121–31)

Introduction

Breast cancer is the most commonly diagnosed cancer and the second leading cause of cancer death among women in the United States (1). In addition to its high overall burden of disease, breast cancer and its risk factors have also been shown to vary systematically with indicators of social group status such as race, ethnicity, and socioeconomic status (2, 3). Such disparities are well-documented, and overcoming cancer health disparities is both an overarching goal of the Healthy

People 2010 initiative (4) and one of the National Cancer Institute's key strategic objectives (5).

Given the current policy emphasis on disparities in cancer, it is important to assess the extent of progress toward disparity-related goals for two reasons. First, monitoring disparities is a natural complement to monitoring overall progress in the fight against cancer and is crucial for identifying particular groups that may be experiencing a high burden of cancer-related illness. Second, monitoring disparities is important because it affords an opportunity to reconcile observed trends with prevailing etiologic explanations for the causes of social disparities in cancer (6).

The purpose of our analysis was to assess temporal trends in race-ethnic and socioeconomic disparities across a continuum of breast cancer-related outcomes, including mammography screening, incidence, stage at diagnosis, mortality, and survival. Much of the previous research (e.g.; refs. 7, 8) has focused on disparities between particular groups (e.g., Black/White, poor/rich) and used measures such as rate ratios to quantify

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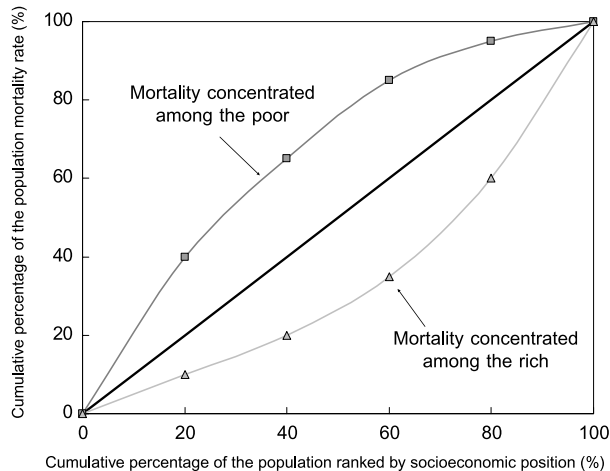


Figure 1. Hypothetical mortality concentration curves.

disparity. However, when considering disparities across multiple subgroups—and how those may change over time—interpreting many rate ratios becomes cumbersome. To overcome this problem, we adopted a statistical perspective congruent with the Healthy People 2010 framework, which seeks to eliminate disparities across the entire range of subgroups defined by characteristics such as race-ethnicity and socioeconomic position (4).

Materials and Methods

Data. We obtained data for the analyses of breast cancer incidence, stage at diagnosis, mortality, and survival from the Surveillance, Epidemiology, and End Results (SEER) program of the U.S. National Cancer Institute using SEER*Stat software (9). Data on incidence, stage at diagnosis, and survival cover ~25% of the U.S. population, whereas mortality data cover the entire nation. Data on mammography were taken from the periodic cancer supplements to the annual U.S. National Health Interview Surveys (NHIS). All analyses were limited to women ages 50 and over and were age-adjusted to the 2000 U.S. standard population. Estimates of screening began in 1987, and data on breast cancer incidence for detailed race-ethnic groups were only available since 1992 (10). Thus, our analyses of socioeconomic disparities cover the years 1987 to 2004 and race-ethnic disparities from 1992 to 2004.

Whether a health outcome is defined in favorable or adverse terms (e.g., survival versus death) can affect the magnitude of measures of health disparity based on ratios (11, 12). Consistent with the Healthy People 2010 framework for comparing across outcomes (13), we measured all breast cancer outcomes in adverse terms.

To analyze trends in screening for breast cancer, we used the proportion of women who reported not having a mammogram in the past 2 years. Changes in the methods for categorizing income over the span of survey years precluded deriving a measure of absolute household income. We therefore created quartiles of household income based on the weighted distribution

across reported income categories for each survey year. Due to small numbers in the early NHIS cancer supplements, we used four race-ethnic groups: White, Black, Other race, and Hispanic (Hispanic is not mutually exclusive of race).

To categorize stage at diagnosis, we used SEER's historic Stage A scheme which defines incident cases as either localized, regional, distant, or unstaged. A comparison of the 1977 and 2000 guidelines for determining how far a cancer has spread from its point of origin did not affect the distribution of stage at diagnosis for breast cancer (14). In order for all outcomes to be defined in terms of adverse events, the outcome was the percentage of cases diagnosed beyond the localized stage, so that improvements over time should register as declines in the percentage of cases diagnosed beyond the localized stage.

To measure survival trends, we used the 5-year cause-specific survival rate instead of the more traditional relative survival rate because relative survival rates require reliable expected life tables that are not currently available by socioeconomic position or for some race-ethnic subgroups (8). The cause-specific survival rate is a net survival statistic that measures the likelihood of surviving 5 years in the absence of other causes of death (15). We used the Kaplan-Meier estimator (16), with individuals dying from other causes treated as censored under the assumption that other causes of death are independent of breast cancer (7). We used the "complete" or "multiple-year cohort" method that includes all patients diagnosed in each 5-year period (excluding those diagnosed in the current data year), which gives better predictions of future survival than does the traditional "cohort" method (17). For example, 5-year cause-specific survival is calculated for diagnosis years 1997 to 2001 based on follow-up data through calendar year 2002. This involves a potential 5 years of survival for those diagnosed in 1997, 4 years for those diagnosed in 1998, and so on to 1 year for those diagnosed in 2001. To define survival in adverse terms (so that improvements over time register as declines in rates), we used 1 minus the 5-year cause-specific survival rate (or 100 – percentage of 5-year cause-specific survival), which is the cause-specific probability of dying from breast cancer within 5 years of diagnosis.

To analyze socioeconomic disparities, we used incidence data from the nine original SEER registries and mortality data from the entire United States. Neither data source includes a measure of individual socioeconomic position, thus, it was not possible to create a measure of household income similar to that used for the screening analysis. Instead, we linked each case's county of residence to the 1990 U.S. Census to assign each case a measure of socioeconomic position based on the proportion of the county population living below the poverty line (<10, 10-14, 15-19, 20%). Previous analyses show that the 1990 county poverty rate is both highly correlated with other socioeconomic measures and generates stable county rankings over time (18-20). Our measure of area-socioeconomic position therefore masks within-area individual variation in individual socioeconomic position but is similar to previous studies with SEER data (19, 21).

For race-ethnic disparities, we used incidence data from 13 SEER registries and U.S. mortality data. Race-ethnicity was defined consistent with the SEER Cancer Statistics Review, 1975 to 2004 (22), i.e., White, Black, American Indian/Alaska Native (AI/AN), Asian/Pacific Islander (API), and Hispanic. Hispanic is not mutually exclusive from the race groupings. Consistent with SEER guidelines for reporting race-ethnicity (10), data for Hispanics excludes cases diagnosed in the Alaska Natives and Kentucky registries, and data for American Indian/Alaska Natives only includes cases diagnosed in a Contract Health Service Delivery Area. Consistent with SEER's policy for calculating Hispanic mortality (23), we excluded states with a large number of individuals with unknown origin/ethnicity (i.e., with a Hispanic

index ≥ 10.00) in any year ($n = 413$; 2.4% of Hispanic deaths). A table of the state-year exclusions can be found on the SEER web site (23).

Statistical Analysis. Many summary measures of health disparity exist, and our choice of measures was based on a previous review (24). We chose population-weighted measures that (a) account for changes over time in the underlying distribution of social groups, (b) measure disparity as differences from the population average rate of health, and (c) place additional weight on the health of socioeconomically disadvantaged groups. We included measures of both relative disparity (i.e., ratios of rates) and absolute disparity (i.e., differences in rates) because these two classes of measures often diverge over time (25).

Table 1. Age-adjusted (year 2000 standard) breast cancer incidence, stage at diagnosis, mammography use, mortality, and 5-y cause-specific death rates among females aged 50 and over, by area-socioeconomic position, 1987 and 2004

	1987		2004		Percentage of change, 1987-2004	
	Rate	Population (%)	Rate	Population (%)	Rate	Population (%)
Incidence (per 100,000)						
+20% in poverty	328.7	13.1	302.2	10.6	-8.1	-19.0
15-19% in poverty	329.4	6.7	330.0	7.0	0.2	4.8
10-14% in poverty	365.5	24.3	329.4	24.2	-9.9	-0.5
00-09% in poverty	381.6	55.8	345.3	58.1	-9.5	4.1
Total	367.5	100.0	335.7	100.0	-8.7	
Late stage at diagnosis*	>Local (%)	Population (%)	>Local (%)	Population (%)	>Local (%)	Population (%)
+20% in poverty	47.8	13.1	39.6	10.6	-17.2	-19.0
15-19% in poverty	42.5	6.7	36.1	7.0	-15.1	4.8
10-14% in poverty	42.1	24.3	35.6	24.2	-15.3	-0.5
00-09% in poverty	40.9	55.8	34.8	58.1	-14.8	4.1
Total	42.1	100.0	35.6	100.0	-15.5	
Without mammography[†]	%	Population (%)	%	Population (%)	%	Population (%)
Bottom quartile [‡]	82.8	25.0	44.8	25.0	-45.9	0.0
Second quartile	76.0	25.0	30.2	25.0	-60.3	0.0
Third quartile	69.4	25.0	26.0	25.0	-62.6	0.0
Top quartile	63.7	25.0	22.6	25.0	-64.5	0.0
Total	73.0	100.0	30.9	100.0	-57.6	
Mortality (per 100,000)	Rate	Population (%)	Rate	Population (%)	Rate	Population (%)
+20% in poverty	85.1	14.1	76.3	12.3	-10.4	-12.9
15-19% in poverty	92.0	18.7	73.1	18.1	-20.6	-3.4
10-14% in poverty	97.0	37.4	75.0	37.2	-22.7	-0.5
00-09% in poverty	102.7	29.8	74.4	32.4	-27.6	8.9
Total	96.1	100.0	74.6	100.0	-22.4	
Cause-specific probability of death (% dying of their cancer within 5 y)[§]	%	Cases (%)	%	Cases (%)	%	Cases (%)
+20% in poverty	20.6	11.9	15.4	9.8	-25.0	-17.5
15-19% in poverty	18.4	6.2	13.7	6.5	-25.7	4.7
10-14% in poverty	16.1	23.8	11.8	24.0	-26.9	0.7
00-09% in poverty	15.3	58.0	10.9	59.7	-28.4	2.8
Total	16.3	100.0	11.8	100.0	-27.9	

NOTE: Based on the proportion of the population in poverty in 1990 in the county of residence for each incident case.

* Percentage of incident cases diagnosed beyond the localized stage.

[†] Percentage of women reporting not having a mammogram in the past 2 y.

[‡] Based on weighted distribution of household income.

[§] Percentage of incident cases dying of their cancer within 5 y of diagnosis. Estimates are for the 5-y cause-specific probability of death in 1992 (cases diagnosed from 1987 to 1991) and 2004 (cases diagnosed from 1999 to 2003).

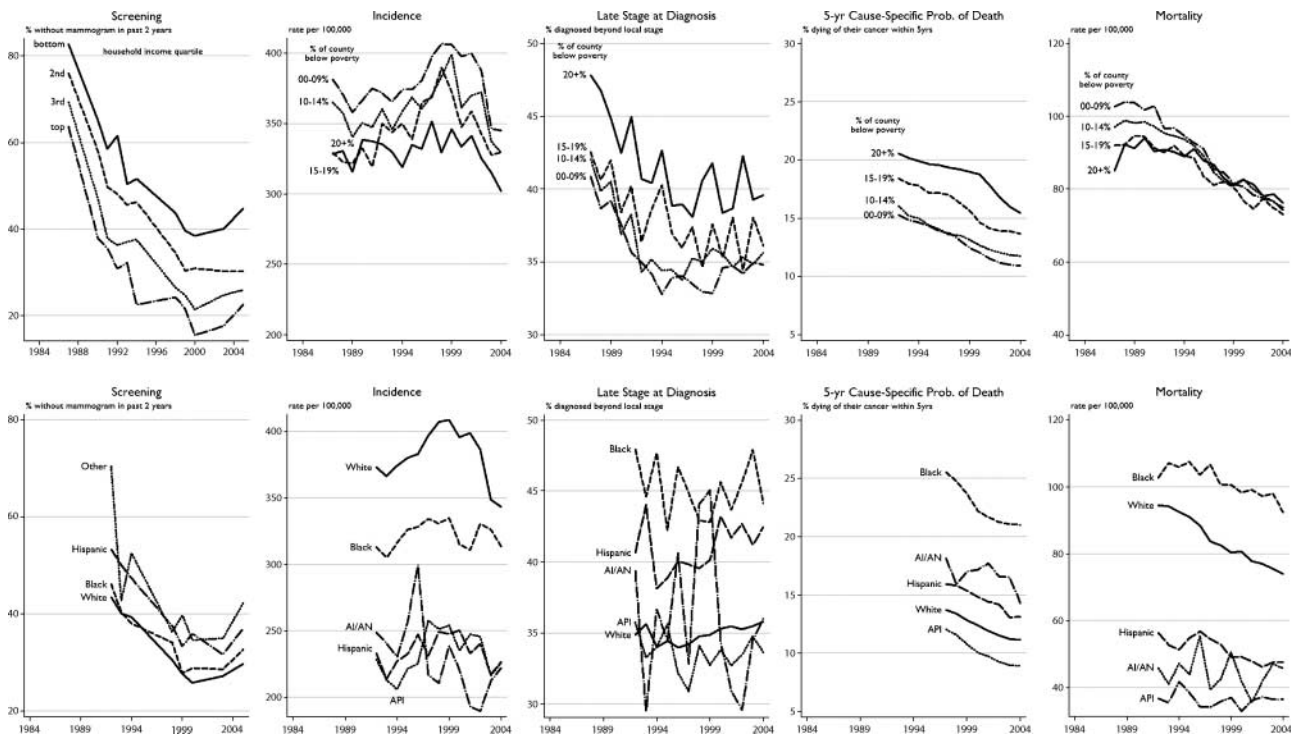


Figure 2. Age-adjusted (year 2000 standard) rates of breast cancer incidence, stage at diagnosis, screening, mortality, and 5-year cause-specific probability of death (100 – 5-y cause-specific survival) among females ages 50 and over, by area-socioeconomic position (1987-2004) and race-ethnicity (1992-2004). The calendar year for the 5-y cause-specific probability of death refers to the data year for cases diagnosed in the previous 5 y (e.g., 2004 on the graph refers to cases diagnosed from 1999 to 2003).

To summarize disparities across area-socioeconomic position, we used the concentration index, measured both on the relative and absolute scale. The concentration index is derived from a concentration curve (Fig. 1) that plots the cumulative proportion of, for example, breast cancer mortality, against the cumulative proportion of the population ranked by socioeconomic position. If the curve lies above the diagonal, the index is negative, indicating that mortality is disproportionately concentrated among the poor, and if the curve is below the diagonal, the index is positive and mortality is more concentrated among the rich. The concentration index is defined as twice the area between the curve and the diagonal, which lies in the interval $(-1, 1)$ and equals zero if the rates of health are equal among all groups. The relative concentration index (RCI) for grouped data (26) may be written as $RCI = (2 / \mu) \times (\sum p_j y_j X_j) - 1$, where μ is the population average level of health, p_j and y_j are the group's population share and average health, and X_j is the relative rank of the j th socioeconomic group, which is defined as $X_j = p_j - 0.5 p_j$, where p_j is the cumulative share of the population up to and including group j and p_j is the share of the population in group j . X_j indicates the cumulative share of the population up to the midpoint of each group interval. The absolute concentration index (ACI) is calculated by multiplying the RCI by the average level of health: $ACI = \mu RCI$, where RCI is defined as above and μ is the mean level of health in the population.

The concentration index only works with ordinal measures of social group status, so to measure disparities across race-ethnic groups, we used the mean log deviation (MLD) as a measure of relative disparity and the between-group variance (BGV) as a measure of absolute disparity. We used these measures because they weight social groups by their population size and are more sensitive to deviations further from the population average health (24, 27). The MLD summarizes the disproportionality between shares of health and shares of population (expressed on the natural logarithm scale). For grouped data (28), it may be written as $MLD = \sum p_j (-\ln r_j)$, where p_j is the proportion of the population in group j and r_j is the ratio of the prevalence or rate of health in group j relative to the total rate, i.e., $r_j = y_j / \mu$ where y_j is the rate of health in group j and μ is the total population rate. The BGV is calculated by squaring the differences in group rates from the population average and weighting by population size: $BGV = \sum p_j (y_j - \mu)^2$, where p_j is group j 's population share, y_j is group j 's average health status, and μ is the average health status of the population.

We used a re-sampling technique described previously (12, 29) to generate estimates of precision for disparity measures. We used the SE (30) of the observed age-adjusted rate for each race-ethnic or socioeconomic subgroup in each year to re-estimate each rate 1,000 times, assuming a random normal

distribution. We then calculated each measure of disparity 1,000 times (in each year) and used the resulting distribution to estimate the SE of each index. We estimated the change in each index from the beginning to the end of the period of observation and calculated a 95% confidence interval (CI) for this change using the formula $\sqrt{SE_{time1}^2 + SE_{time2}^2}$ to estimate the SE of the change (29). However, because the five outcomes we consider are measured on different scales, we compared the overall change in disparity by calculating the percentage change in each index. In order to graphically compare trends in absolute disparity, we calculated the percentage change in each index in each year since the first year of observed data (i.e., since 1987 for area-socioeconomic position and since 1992 for race-ethnicity).

Results

Table 1 shows the rates and distribution of the population for incidence, stage at diagnosis, screening, mortality, and 5-year cause-specific probability of death according to area-socioeconomic position in 1987 and 2004, and the percentage change over the period of study. Figure 2 (*top*) shows trends from 1987 to 2004 for all five outcomes according to area-socioeconomic position. All five breast cancer outcomes have improved across the board since 1987, and particularly for mammography use. For incidence, the improvement was chiefly due to large declines since early 2000 and trends for stage at diagnosis have been relatively stable since the mid-1990s. Incidence and mortality rates were generally higher for the least disadvantaged group

Table 2. Age-adjusted (year 2000 standard) breast cancer incidence, stage at diagnosis, mammography use, mortality, and 5-y cause-specific death rates among females aged 50 and over, by race-ethnicity, 1992 and 2004

	1992		2004		Percentage of change, 1992-2004	
	Rate	Population (%)	Rate	Population (%)	Rate	Population (%)
Incidence (per 100,000)						
White	373.3	76.0	343.4	70.1	-8.0	-7.8
Black	313.1	7.9	313.7	8.4	0.2	6.2
API	228.8	7.6	226.2	10.6	-1.2	39.7
AI/AN	249.0	0.5	222.1	0.6	-10.8	29.4
Hispanic	233.1	8.0	226.8	10.3	-2.7	28.3
Total	346.8	100.0	316.5	100.0	-8.7	
Late stage at diagnosis*	>Local (%)	Population (%)	>Local (%)	Population (%)	>Local (%)	Population (%)
White	34.9	76.0	35.8	70.1	2.7	-7.8
Black	48.0	7.9	44.1	8.4	-8.0	6.2
API	35.8	7.6	33.6	10.6	-5.9	39.7
AI/AN	39.4	0.5	36.0	0.6	-8.6	29.4
Hispanic	40.7	8.0	42.5	10.3	4.4	28.3
Total	36.2	100.0	36.9	100.0	1.8	
Without mammography †	%	Population (%)	Rate	Population (%)	Rate	Population (%)
White	43.4	83.4	29.7	79.4	-31.6	-4.8
Black	46.1	9.5	32.7	9.4	-29.0	-0.4
Other race	70.4	2.5	42.3	4.1	-39.9	61.5
Hispanic	53.3	4.6	37.1	7.1	-30.5	53.6
Total	44.8	100.0	31.0	100.0	-30.8	
Mortality (per 100,000)	Rate	Population (%)	Rate	Population (%)	Rate	Population (%)
White	94.5	84.3	74.0	79.7	-21.7	-5.5
Black	102.7	9.0	92.4	9.5	-10.0	5.5
API	46.0	0.5	45.8	0.7	-0.4	40.4
AI/AN	36.8	2.1	36.6	3.5	-0.5	68.1
Hispanic	56.5	4.1	47.7	6.7	-15.6	62.0
Total	92.7	100.0	73.0	100.0	-21.3	
Cause-specific probability of death (% dying of their cancer within 5 y) ‡	%	Cases (%)	%	Cases (%)	%	Cases (%)
White	13.7	81.5	11.1	78.5	-18.9	-3.8
Black	25.5	7.3	21.0	7.5	-17.7	2.2
API	12.1	5.3	8.9	7.1	-26.0	34.9
AI/AN	18.2	0.4	14.3	0.4	-21.3	-1.1
Hispanic	16.0	5.5	13.1	6.6	-17.9	19.9
Total	14.6	100.0	11.9	100.0	-19.0	

NOTE: Hispanic is not mutually exclusive of White, Black, API, and AI/AN.

* Percentage of incident cases diagnosed beyond the localized stage.

† Percentage of women reporting not having a mammogram in the past 2 y.

‡ Percent of incident cases dying of their cancer within 5 y of diagnosis. Estimates are for the 5-y cause-specific probability of death in 1997 (cases diagnosed from 1992-1996) and 2004 (cases diagnosed from 1999-2003).

Table 3. Change in relative and absolute area-socioeconomic disparity and race-ethnic disparity in female breast cancer incidence, stage at diagnosis, mammography, mortality, and 5-y cause-specific death rates among those ages 50 and over from 1987 to 2004

	Incidence	Late stage at diagnosis*	Without mammography [†]	Mortality	5-y cause-specific probability of death [‡]
Area-socioeconomic position [§]					
Absolute disparity					
ACI, 1987	9.8	-1.0	-4.0	3.1	-0.8
ACI, 2004	6.4	-0.6	-4.4	-0.1	-0.6
Absolute change, 1987-2004	-3.4	0.4	-0.5	-3.2	0.2
95% CI for absolute change	-7.9 to 1.2	-0.3 to 1.1	-1.8 to 0.9	-3.9 to -2.5	-0.1 to 0.4
Percentage of change, 1987-2004	-34.5	-38.6	10.7	-102.3	-19.7
Relative disparity					
RCI (×100), 1987	2.7	-2.3	-5.5	3.3	-4.7
RCI (×100), 2004	1.9	-1.7	-14.3	-0.1	-5.3
Absolute change 1987-2004	-0.8	0.6	-8.8	-3.4	1.5
95% CI for absolute change	-2.0 to 0.5	-1.1 to 2.4	-12.5 to -5.2	-4.2 to -2.5	-0.5 to 2.4
Percentage of change, 1987-2004	-28.4	-27.3	161.4	-103.0	11.3
Race-ethnicity					
Absolute disparity					
BGV, 1992	2,756.9	13.9	21.8	139.9	9.8
BGV, 2004	2,252.0	9.6	9.5	129.9	7.4
Absolute change, 1992-2004	-504.8	-4.4	-12.3	-10.0	-2.4
95% CI for absolute change	-1,099.6 to 89.9	-12.1 to 3.3	-32.9 to 8.4	-33.8 to 13.8	-5.2 to 0.3
Percentage of change, 1992-2004	-18.3	-31.3	-56.3	-7.1	-24.8
Relative disparity					
MLD (×1,000), 1992	14.0	4.9	4.2	12.5	16.6
MLD (×1,000), 2004	13.2	3.4	4.3	15.5	19.5
Absolute change, 1992-2004	-0.8	-1.5	0.1	3.0	2.9
95% CI for change	-4.3 to 2.7	-4.1 to 1.1	-4.6 to 4.7	0.1 to 5.9	-2.4 to 8.2
Percentage of change, 1992-2004	-5.7	-30.8	1.4	24.0	17.2

* Percentage of incident cases diagnosed beyond the localized stage.

[†] Percentage of women reporting not having a mammogram in the past 2 y.

[‡] Percentage of incident cases dying of their cancer within 5 y of diagnosis. First year estimates of 5-y cause-specific probability of death occur in 1992 (cases diagnosed from 1987 to 1991) for area-socioeconomic position and 1997 (cases diagnosed from 1992 to 1996) for race-ethnicity.

[§] For incidence, stage at diagnosis, and mortality, socioeconomic position was based on the proportion of the population in poverty in 1990 in the county of residence for each incident case. For screening, socioeconomic position was based on quartiles of household income.

(<10% poverty), but rates of mammography use were lowest among the more disadvantaged groups, which is likely to contribute to their higher rates of late stage at diagnosis and 5-year cause-specific probability of death.

Table 2 shows rates and population distribution in 1992 and 2004 according to race-ethnicity, and Fig. 2 (*bottom*) shows race-ethnic-specific trends for the entire period. In general terms, improvements in breast cancer-related outcomes were larger for screening, mortality, and the 5-year cause-specific probability of death, and somewhat smaller for incidence and late stage at diagnosis. Incidence rates were highest for Whites whereas Blacks generally had the highest mortality rates, fraction of cases diagnosed beyond the local stage, and 5-year cause-specific probability of death.

Changes in area-socioeconomic disparities are shown in Table 3 (*top*). For measures of both relative and absolute disparity, the table shows estimates of disparity for the first and last years of data, the absolute change in each disparity measure and its 95% CI, and the percentage change for each of the five outcomes. In 1987, breast cancer incidence and mortality were relatively more concentrated among the better-off socioeconomic groups (indicated by a positive RCI), whereas late stage at diagnosis, absence of screening, and 5-year cause-specific probability of death were more concentrated among the worse-off groups (indicated by a negative RCI). From 1987 to 2004, the RCI for all outcomes other than screening moved toward 0, indicat-

ing that area-socioeconomic disparities had declined. This was most notable for mortality, in which the RCI significantly declined by 103% from 3.3 to -0.1, whereas the declines for incidence and late stage at diagnosis were ~30%. If disparities are looked at on the absolute scale, the picture looked much the same, if not better. The ACI declined by roughly 35% for incidence and stage, 20% for the 5-year cause-specific probability of death, and 102% for mortality, the latter of which was statistically different from zero. In contrast to the other outcomes, relative socioeconomic disparities in screening increased by 161% (i.e., the RCI became more negative), from -5.5 in 1987 to -14.3 in 2004. However, this large relative increase should be put in the context of large improvements in screening mammography for all groups. As a result, in terms of absolute disparity, the ACI for screening showed a slight 11% increase.

Figure 3 (*top*) shows the trends in measures of absolute and relative disparity over the entire period and shows that the changes observed in Table 3 generally occurred gradually, with the exception of disparity trends in incidence. Area-socioeconomic disparities in incidence increased during the 1990s and but declined after 2000 to levels below that observed in 1987. Figure 3 (*right*) shows all of the relative disparity measures moving closer to zero with the exception of screening, whereas on the absolute scale (*left*), the area-socioeconomic disparity situation in 2004 was generally better than in 1987, particularly for mortality.

Changes in race-ethnic disparities from 1992 to 2004 are shown in Table 3 (bottom). Relative disparities in 1992 were smallest for absence of screening (MLD = 4.2) and late stage at diagnosis (MLD = 4.9), somewhat larger for breast cancer incidence (MLD = 14.0) and mortality (MLD = 12.5), and largest for the 5-year cause-specific probability of death (MLD = 16.6). Relative race-ethnic disparities in incidence and absence of screening remained approximately the same between 1992 and 2004, declined by 31% for late stage at diagnosis, and increased 24% and 17%, respectively, for mortality and the 5-year cause-specific probability of death. However, when measured on the absolute scale, race-ethnic disparities declined for all five breast cancer outcomes, with the largest proportional reduction in BGV for screening (56% decline) and the smallest for mortality (7% percent decline).

Figure 3 (bottom) shows absolute and relative disparity trends for race-ethnicity. The left graph plots the percentage change in the BGV relative to its first observed value and shows that absolute disparity trends in late stage at diagnosis, 5-year cause-specific probability of death, and mortality have generally declined since the early 1990s. Absolute disparities in screening declined sharply after 1992 and have remained relatively constant thereafter. However, the trends for incidence show that the overall change masked two opposing subrends: the BGV increased 54% (95% CI, 27-81%) from 1992 to 2001 but declined sharply by 47% (95% CI, 31-63%) from 2001 to 2004 (results not shown). A similar pattern was evident for relative disparity in incidence: the MLD increased 41% (95% CI, 13-69%) from 1992 to 2001 but declined by 33% (95% CI, 14-52%) from 2001 to 2004 (results not shown). Relative disparity in mortality showed a similar although less striking pattern

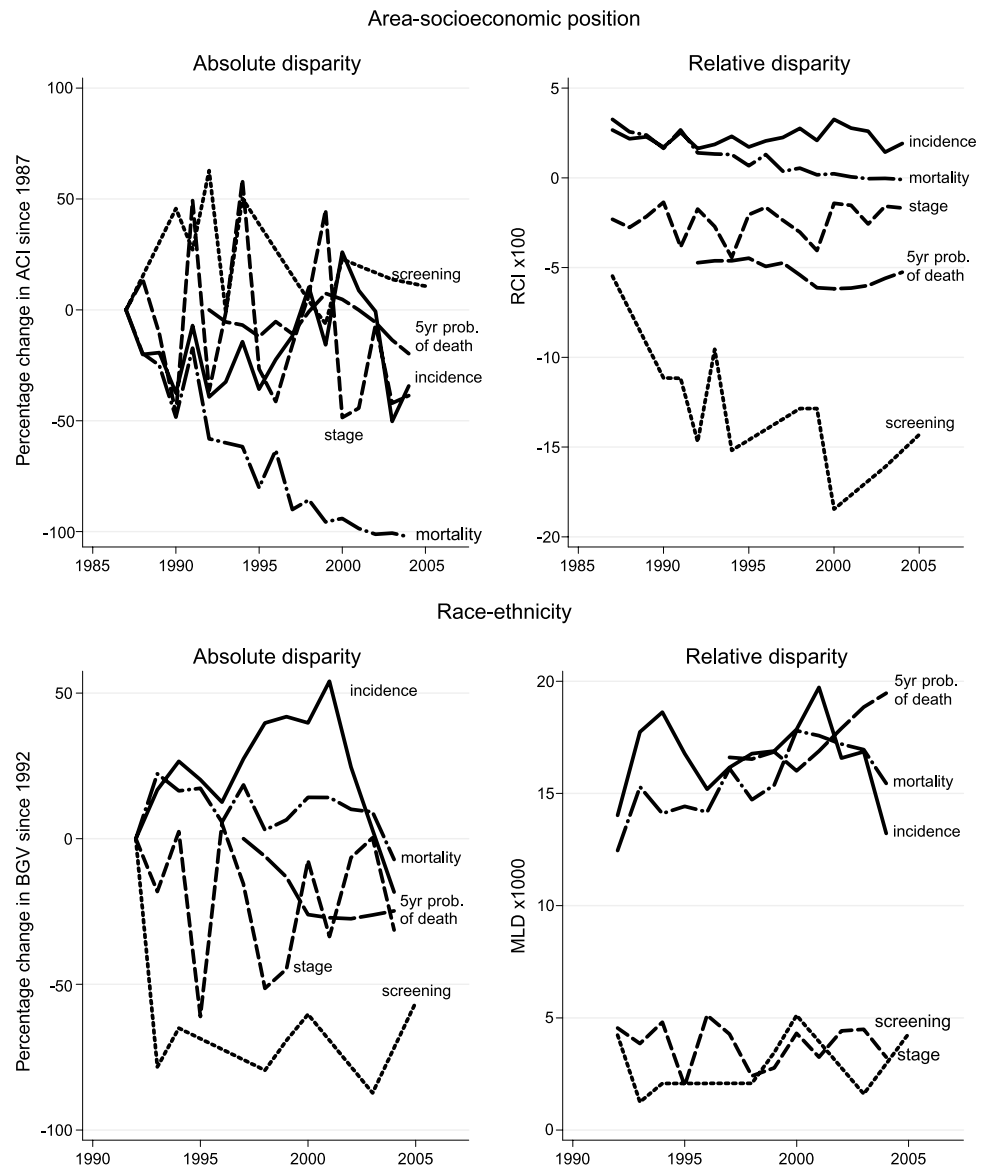


Figure 3. Relative changes from 1987 to 2004 in absolute and relative area-socioeconomic and race-ethnic disparity in breast cancer incidence, stage at diagnosis, screening, mortality, and 5-y cause-specific probability of death among those aged 50 and over. The calendar year for the 5-y cause-specific probability of death refers to the data year for cases diagnosed in the previous 5 y (e.g., 2004 on the graph refers to cases diagnosed from 1999 to 2003).

in which the MLD increased during the 1990s but has declined since 2000.

Discussion

Looking across the entire range of social groups defined by area-socioeconomic position, we find that disparities in breast cancer-related outcomes have generally narrowed since 1987, whether measured on the relative or absolute scale. The only exceptions to this pattern for area-socioeconomic position were for the 5-year cause-specific probability of death and mammography screening. Absolute disparities in the 5-year cause-specific probability of death significantly declined but relative disparities rose slightly, indicating that all groups made progress but more advantaged groups improved at a slightly faster rate. For mammography, absolute disparity remained relatively constant but relative disparity increased substantially. Other studies have also noted persistent or widening socioeconomic differences in mammography, but declining race-ethnic disparities (31, 32). The constant level of absolute disparity reflects population-wide improvements that have been made in cancer screening in the United States since the early 1980s (32), but increasing relative disparity also highlights the relatively slower uptake of screening over time by lower-income groups. Lack of health insurance and having a usual source of health care are likely to be important barriers to mammography among low-income women, and there is evidence that even relatively high-income women without health insurance are less likely to receive mammograms (33). Among women with access to care, wealthier women are more likely to get mammograms, regardless of prognosis (34). Systematic reviews suggest that both access-enhancing (e.g., providing transportation, vouchers) and individual-directed (e.g., counseling, reminders) interventions are effective in increasing mammography use among lower-income women (35, 36). Applied more widely, such interventions could help to reduce socioeconomic disparities that still exist for stage at diagnosis and cause-specific survival rates.

Although overall we found relative race-ethnic disparities in incidence were stable between 1992 and 2004, this masked general increases during the 1990s and a sharp decline in absolute and relative disparity since 2001. This recent decline is largely attributable to a steep decline in incidence in recent years, particularly among White women, the group with the highest incidence rates. Previous reports have documented sharp declines for breast cancer incidence in the United States in recent years, particularly since 2003 (1, 37). Although some of the decline in incidence is potentially attributable to recent declines in the rates of screening mammography (38, 39), the mammography declines do not differ substantially by race and are unlikely to be large enough to account for the recent decline in incidence (37, 40). Furthermore, there is evidence of similarly strong declines in incidence among screened populations (41, 42). A more likely reason may be the sharp declines in the use of postmenopausal hormone replacement therapy (37, 40), which dropped precipitously after the results of the Women's Health Initiative Trial were reported in 2002 (43). Estrogen likely acts as a tumor promoter rather than a direct cause of breast cancer, providing the "fuel" for tumor growth (40, 44, 45); thus, stopping hormone

replacement therapy may slow the growth of tumors that would otherwise be detected. Given that rates of hormone replacement therapy are typically lower among Black than White women (46), larger declines in incidence among White women would be expected. In addition, the recent drop in incidence seems to be larger for estrogen receptor-positive (ER+) breast cancers (37, 39, 41, 42), and White women seem more likely than Black women to have ER+ tumors (47, 48).

Although the bulk of breast cancer-related outcomes showed improvement in terms of race-ethnic disparity, for mortality, relative disparity increased significantly with little improvement in absolute disparity. This was largely due to slower mortality declines among Black women, whose mortality rates declined 10% from 1992 to 2004, compared with a 22% decrease among White women (see Table 2). Several other studies have also noted widening disparities between Blacks and Whites for breast cancer mortality and survival since the early 1980s (21, 49-52). A large body of evidence suggests that multiple factors are associated with poorer survival among Black women, including historically lower rates of mammography screening (53), poorer access to health insurance (54), later stage at diagnosis (55), decreased likelihood of receiving stage-appropriate treatment (56-61), more comorbid conditions (59, 62), and higher rates of obesity (48). More recent studies have also documented that Black women are more likely to present with breast cancer subtypes or tumor characteristics associated with a poorer prognosis such as ER negativity, poorer differentiation, and greater lymph node involvement (47, 48, 59, 63, 64). Socioeconomic differences between race-ethnic groups are also likely to play a role in the observed race-ethnic mortality and survival disparities (56, 65), but a recent meta-analysis of breast cancer survival studies (66) found that a 27% increased mortality risk among Black women remained after adjustment for socioeconomic position. However, many studies included only area-based measures or used a single individual measure of socioeconomic position, and residual differences between race-ethnic groups in lifelong exposure to differing socioeconomic environments are likely to remain (67-69). Furthermore, studies from clinical trials with standardized treatment have generally not shown race to be a prognostic factor after adjustment for stage, tumor characteristics, and socioeconomic position (65).

The extent to which these factors may account for the observed increase in relative disparity in mortality is unclear and it seems unlikely that any single factor can fully explain the trends. Trends in health insurance status (70) do not seem to differ substantially enough to account for the slower mortality declines among Blacks. In addition, race-ethnic survival disparities are also evident among insured populations with access to medical care (71), and there is evidence of widening relative disparities among women where access to care is free (50). Race-ethnic disparities in mammography and stage at diagnosis have generally declined, making them unlikely explanations for widening relative disparities in mortality. Increases in both screening mammography and adjuvant therapy (tamoxifen and chemotherapy) made important contributions to the decline in breast cancer mortality since the mid-1980s (72-74), and studies have generally shown that Blacks and Whites derive similar benefits from therapy when administered appropriately for stage and disease present-

tation (75). However, changes in the availability and access to different types of adjuvant therapy and its relationship to tumor characteristics could play some role in the trends we observed. Jatoi and colleagues recently reported that declines in ER+ breast cancer mortality were roughly twice as large as for ER- cancers from 1990 to 2003 (76), and suggested that this differential decline may be due to the widespread adoption of tamoxifen, which is highly effective in ER+ cancers but less so for ER- disease (77). Thus, it may be that higher proportions of ER- disease among Black women may play some role in the slower mortality declines, but a detailed examination of mortality trends by race-ethnicity and tumor characteristics would seem warranted.

Our analysis has some limitations. We restricted our analysis to women aged 50 and over to focus on both mammography screening and on age groups that account for the bulk of breast cancer cases. Analyses using younger age groups could generate different disparity trends.

Our estimates of declines in area-socioeconomic disparities in breast cancer mortality are generally consistent with previous studies (78, 79). However, with the exception of data on mammography use from the NHIS, measures of individual level socioeconomic position were unavailable and it is possible that disparities in outcomes based on individual socioeconomic position would give different results. Heck and colleagues found individual education positively associated with postmenopausal breast cancer incidence in the National Health and Nutrition Examination Survey I Epidemiologic Follow-up Study (80). Using individual data, Steenland and colleagues showed a generally weak but positive education gradient in breast cancer mortality, which weakened slightly over time, in the Cancer Prevention Studies (81), and a positive gradient based on individual occupational status among 27 U.S. states (82). However, a recent analysis of 2001 vital statistics data from the United States using individual education found that the relative risk of breast cancer death was 40% to 60% higher among women with <12 years of education compared to those with >12 years (83), and a similar analysis found the annual percentage change in breast cancer mortality from 1993 to 2003 was -1.4% for women with <12 years of education compared with -4.3% for women with 16 or more years (84).

We also used summary measures of health disparity in our analysis, which attempt to quantify disparities across all subgroups within a social group such as socioeconomic position or race-ethnicity. Analyses comparing specific groups or using alternative summary measures or different definitions of outcomes could produce different results (85). However, we also analyzed the data using alternative summary measures and found results generally similar to those reported here (available from the authors upon request).

In summary, our analysis is generally suggestive of progress toward disparity-related goals for breast cancer in terms of race-ethnicity and area-socioeconomic position, especially when measured on the absolute scale. This is likely due to a combination of population-wide improvements in mammography screening and the development and application of effective treatment options that has taken place over the past two decades. However, we also identified

important areas in which greater progress is needed, particularly for socioeconomic disparities in mammography and race-ethnic disparities in mortality and 5-year cause-specific death rates. These disparities should remain a priority for breast cancer research, treatment, and policymaking.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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