Selected Comparisons of Measures of Health Disparities Using Databases Containing Data Relevant to Healthy People 2010 Cancer-Related Goals

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The purpose of this report is to empirically evaluate the performance and suitability of various measures of health disparity for the purpose of monitoring disparities in cancer-related health outcomes. As such, it extends the work of a prior monograph in which we evaluated several measures of health disparity on theoretical grounds (1), and it is worthwhile to briefly revisit the overall conclusions of that report.

Overall Conclusions from the Theoretical Review(1)

First, we concluded that all measures of health disparity implicitly or explicitly contain value judgments concerning the relative importance of capturing different aspects of health disparity. Two of the most important considerations concern -

1) How much weight to give to individuals? For example, if we measure the disparity in prostate cancer mortality among U.S. states in 2000 without weighting states by their population size, California and Wyoming receive equal weight despite the fact that California has nearly 70 times as many males as Wyoming. Thus, in an unweighted analysis of U.S. states *individual* males in California receive approximately $1/70^{th}$ the weight of males in Wyoming. Both are correct but they reflect contrasting values about how to treat groups and individuals in measuring health disparity.

2) How much to weight the health of individuals of different social groups? Should our measures of health disparity be more sensitive to health improvement among the socially disadvantaged than the advantaged?

It would be advantageous if such value judgments were made more explicit by researchers when measuring health disparities.

Second, for the purpose of measuring and monitoring trends in health disparities we argued for a population health-oriented approach, which is characterized by measuring health disparities as differences from the population average, taking account of the population size of the social groups under consideration, and measuring disparities on both the absolute and relative scale. Some measures of health disparity use the "best" rate or prevalence as their reference point. This may be problematic in some circumstances in cancer-related disparities when the best rate is among a very small, or heterogeneous population sub-group, such as American Indians and Alaska Natives.

The Empirical Assessment

Despite these conclusions from the theoretical review, it remains an empirical question whether, given a particular set of data, the particular method for measuring health disparity makes any substantive difference or would lead to different conclusions about the disparity.

This report presents the results of 22 separate analyses in 10 case studies of trends in selected cancer-related health disparities, for which we empirically compared various summary measures of health disparities. We included assessments of socioeconomic, race ethnic and geographic disparities in a selected range of cancer-related outcomes, including mortality, incidence, risk factors and screening. The goal of these analyses was to examine the consistency of different measures of health disparity across a range of cancer-related outcomes.

Summaries of selected results are shown in Figure S1. The numbers in the table represent % changes in the value of the disparity measure over the specified period. Overall, these graphical examples reinforce the conclusion that it matters how you measure disparity. For instance, for race ethnic disparity in mammography screening, no firm conclusion can be reached about whether disparity got better or worse between 1987 and 2003. The only sensible way to make a conclusion on race ethnic disparity trends in mammography screening is to decide whether disparity should be measured on a relative or the absolute scale. This is not the case for obesity which show declining socioeconomic disparities or for smoking, where one can reasonably conclude that socioeconomic disparity increased regardless of which measure is used.

To summarize the results of these analyses:

1. **Does the choice of a measure of disparity matter for assessing cancer-related disparity trends?**

Yes. The 10 case studies revealed a number of situations where substantively different interpretations concerning the level and trend in disparity resulted from using different measures of health disparity on the exact same data. Such differences in interpretation could not be reconciled without reference to consideration of which underlying dimensions of disparity are emphasized in the measures.

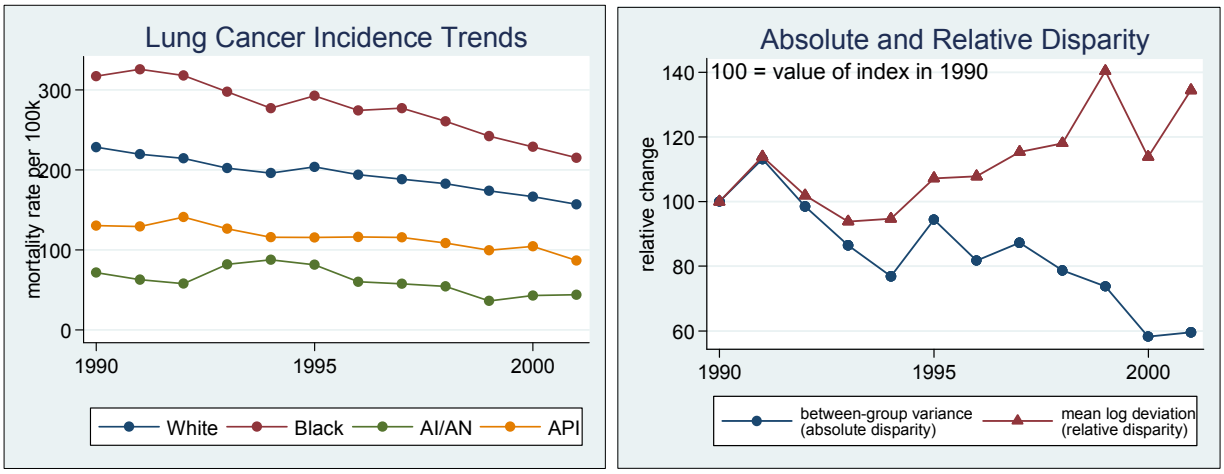
2. **How often does the choice of disparity measure matter?**

Of the 22 separate analyses conducted, 9 (41%) revealed situations where the overall conclusion about the trend in disparity was difficult to make without some apriori judgment about what dimensions of disparity are important. e.g., relative or absolute disparity

3. **Why does the choice of disparity measure matter?**

Most of the cases of disagreement between measures of disparity depended on two issues. One is the scale on which disparity should be evaluated. In many cases relative measures of disparity moved in one direction, while absolute measures moved in the opposite direction. For example, the left side of the Figure S2 below shows trends in lung cancer incidence among males for 4 race groups (Whites, Blacks, American Indian/Alaska Natives, and Asian Pacific Islanders) and the right side shows the percentage change since 1990 in two summary measures of absolute and relative disparity. Over this period, absolute disparity declined by roughly 40% while relative disparity increased by roughly 40%. Whether, given this data, one concludes that the situation with respect to racial disparity in lung cancer incidence among males is getting better or worse depends on whether one thinks of disparity as absolute or relative. Thus, specifying whether absolute or relative disparities are more important *prior* to undertaking any analyses will assist in minimizing disagreement about disparity trends.

Figure S2. Trends in lung cancer incidence among males by race and trends in overall absolute and relative racial disparity, 1990-2001



The second source of disagreement among disparity measures was whether they weight social groups by population size. In several cases we found that population-weighted disparity measures differed in either magnitude or direction from unweighted disparity measures. In particular, and as might be expected, unweighted measures of disparity appear to be more sensitive to the movement of rates of disease, especially those of smaller population groups whose rates of disease may be less stable over time.

4. What are the implications for monitoring health disparities?

There is currently a strong emphasis in the US public health policymaking community on monitoring of progress toward eliminating health disparities. The results of the case studies presented in this report demonstrate that it is easily possible to come to fundamentally different conclusions about the extent of progress toward eliminating health disparities using the same data but different measures of health disparity. The naïve use of summary measures of health disparity thus has the potential to lead to confusion among both policymakers and researchers as to whether disparities are increasing or decreasing, which cancer-related outcomes show the largest disparities, and which health disparities might be specifically targeted for increased study. Such confusion will be minimized and health disparity measurement will be advanced by increased debate and discussion of the issues that generate differences among measures of health disparity:

- How much weight should we give individuals of different social groups when measuring disparity? Counting each individual's health equally implies population-weighted measures of disparity among social groups. Counting each social group's health the same means using unweighted disparity measures (and implies differential weighting of individuals from social groups with different population sizes).

- How much to weight different parts of the health distribution? At any given time some social groups are on-average healthier than others. Over time health changes, and some measures of disparity will give equal consideration (i.e., equal weight) to a given health change, regardless of in which group that change occurs; other measures are more sensitive (i.e., give

more weight) to changes in health among the least healthy or among the poor. Which of these perspectives is consistent with our concerns about social disparities in health?

- Should we be more concerned about absolute or relative disparities? Diseases and conditions that exact a large burden on the population, because of their high prevalence, often generate smaller relative disparities, while rare conditions can generate exceedingly high relative disparities. Which of these perspectives is the appropriate scale on which to measure disparity trends?

In sum, our recommendations from the previous report (1), further clarified here, suggest giving priority to disparity measures on the absolute scale that weight for population size and, where possible, consider the direction of the social gradient in health. That recommendation stands but it does not exclude consideration of issues of relative disparity or what is happening among smaller population groups. For those reasons it may always be useful to adopt a "suite" of health disparity indicators that make clear which aspects of health disparity are changing over time.

Figure S1 Graphical summary of selected disparity trends

	Relative Disparity*			Absolute Disparity*			
	RR	IDisp	RCI	RD	ACI	BGV	Conclusion and Interpretation
Socioeconomic Disparity in Colorectal Cancer Mortality 1950-2000							
Female	-74.9	-71.1	-172.7	-80.4	-136.6	-92.4	Disparity is clearly numerically smaller among both males and females, but the RCI and ACI indicate an increase in disparity is because the socioeconomic gradient reversed.
Male	-83.2	-76.9	-156.9	-77.6	-139.1	-89.5	
Socioeconomic Disparity in Smoking 1965-2003							
Female	143.1	136.3	-279	-2.6	-199.8	-27	Large increases in disparity with reversal of socioeconomic gradient
Male	346.6	390.1	715.5	28.5	274	121.9	Large increases in disparity
Socioeconomic Disparity in Obesity 1960-2000							
Female	-86	-82	-71.6	-48.4	-40.6	-67.3	Large decreases in disparity
Male	-75.4	-77.3	-89.1	-33.0	-73.8	-54.1	Large decreases in disparity
Mammography Screening 1987-2003							
Education Disparity	191.4	262.1	332.7	-1.4	-25.6		? Depends on value position on absolute vs. relative disparity
Income Disparity	178.4	200.7	443.4	-8.0	-9.1		? Depends on value position on absolute vs. relative disparity
Race / ethnic Disparity	91.8	22.3	125.4	-19.4	-56.5		? Depends on value position on absolute vs. relative disparity

Legend	Disparity Increasing		Disparity Decreasing		
	+30%	+11-29%	+/-0-10%	-11-29%	-30%

* Relative Disparity. RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index

* Absolute Disparity. RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance

INTRODUCTION

There are currently two overarching public health goals for the United States, as laid out in the Department of Health and Human Services blueprint, *Healthy People 2010*: to increase the span of healthy life and to eliminate health disparities across the categories of gender, race or ethnicity, education or income, disability, geographic location, and sexual orientation (2). This report is concerned with the practical implementation of the second goal of eliminating health disparities. Despite broad consensus on the public health importance of social disparities in health there is as yet no consensus on how to measure and monitor progress toward the goal of eliminating health disparities. The lack of consensus could potentially make it difficult to communicate to policymakers the extent of cancer-related health disparities and hinder the ability of public health organizations to monitor progress toward the *Healthy People 2010* cancer objectives. Thus, there is a need for a greater understanding of the benefits and drawbacks of various strategies for measuring health disparities.

There are a number of ways to conceptualize and measure health disparities, and a previous report systematically reviewed several potential disparity measures on theoretical grounds (1). The purpose of this report is to complement that review by empirically evaluating several potential measures of health disparity for the purposes of measuring progress toward reducing social disparities in cancer-related health outcomes. It should be emphasized that it is *not* the purpose of this report to provide a comprehensive assessment across all cancer-related outcomes or health disparity measures. Nor is it the goal of this report to make substantive conclusions about trends in disparities for the selected cancer-related health outcomes. The examples contained herein were chosen to reflect a variety of types of cancer-related data such as incidence, mortality, and health behaviors, and do not reflect cancer-related disparities thought to be of particular etiologic or policy interest. Thus, interpretation of the case studies reported here is limited to comparing the performance of the selected measures of health disparity.

METHODS

The previous review of measures of health disparity gave two broad recommendations for the purpose of monitoring health disparity trends. First, any assessment of health disparity trends should include both an absolute and a relative measure of health disparity. Second, the review generally recommended the use of population-weighted measures of health disparity to account for changes in the distribution of the population that inevitably occur over time. Here, we provide a brief recapitulation of the measures of health inequality used in this report.

Measures of Absolute Disparity

Rate Difference (RD)

The absolute disparity between two health status indicators is the simple arithmetic difference. It is calculated as:

$$RD = r_1 - r_2$$

where r_1 and r_2 are indicators of health status in two social groups. In this case r_2 serves as the reference population and the RD is expressed in the same units as r_1 and r_2. A typical disparity measure that uses the absolute difference between two rates for an entire population is the range,

in which case r_1 above corresponds to the least healthy group and r_2 the healthiest group. In the context of measuring health disparities the RD is often used to compare the health of less-advantaged social groups to more-advantaged. However, in this we use RD as a summary measure of the gap between the best rate and worst rate for a given outcome (i.e., the absolute range), regardless of which two social groups are being compared.

Between-Group Variance (BGV)

The variance is a commonly used statistic that summarizes all squared deviations from a population average. In the case of grouped data this is the Between-Group Variance (*BGV*), and it is simply calculated according to the following formula that squares the differences in group rates from the population average and weights by their population sizes:

$$BGV = \sum_{j=1}^{J} p_j (y_j - \mu)^2 ,$$

where p_j is group j's population size, y_j is group j's average health status, and μ is the average health status of the population. One way to interpret the BGV is as the variance that would exist in the population if each individual had the mean health of their social group (i.e., no within-social group variation) (3). The Between-Group Variance may be a useful indicator of absolute disparity for unordered group data because it weights by population group size and is sensitive to the magnitude of larger deviations from the population average (4).

Absolute Concentration Index (ACI)

The Absolute Concentration Index (ACI) measures the extent to which health or illness is concentrated among particular social groups on the absolute scale. It may only be used with social groups that have a natural ordering, such as income or education groups. It is a measure of the covariance between social rank and health, and is derived by plotting the cumulative share of the population, ranked by social status, against the cumulative amount of ill health (i.e., the cumulative contribution of each subgroup to the mean level of health in the population). The absolute version of the concentration index is calculated by multiplying the relative concentration index (RCI) – described below - by the mean rate of the health variable:

$$ACI = \mu RCI ,$$

where RCI is the Relative Concentration Index defined below and μ is the mean level of health in the population.

Slope Index of Inequality (SII)

Formally the SII, which was introduced by Preston, Haines and Pamuk (5) may be obtained via regression of the mean health variable on the mean relative rank variable. To calculate relative rank the social groups are first ordered from lowest to highest. The population of each social group category covers a range in the cumulative distribution of the population, and so is given a score based on the midpoint of their range in the cumulative distribution in the population. The regression equation is specified as follows:

$$\bar{y}_j = \beta_0 + \beta_1 \bar{R}_j$$

where j indexes social group, $\bar{y}_j$ is the average health status and $\bar{R}_j$ the average relative ranking of social group j in the cumulative distribution of the population, β_0 is the estimated health status of a hypothetical person at the bottom of the social group hierarchy (i.e., a person whose relative rank R_j in the social group distribution is zero), and β_1 is the difference in average health status between the hypothetical person at the bottom of the social group distribution and the hypothetical person at the top (i.e. R_j=0 vs. R_j=1). Because the relative rank variable is based on the cumulative proportions of the population (from 0 to 1), a "one-unit" change in relative rank is equivalent to moving from the bottom to the top of the social group distribution. Because this regression is run on grouped data (as opposed to individual data) it is estimated via *weighted* least squares, with the weights equal to the population share p_j of group j (6). The coefficient β_1 is the SII, which is interpreted as the absolute difference in health status between the bottom and top of the social group distribution.

Measures of Relative Disparity

Rate Ratio (RR)

The RR is virtually identical to the RD described above, but is calculated by dividing r_1 by r_2 rather than subtracting:

$$RR = r_1 / r_2$$

where, again, r_2 is the reference population. While in the context of social group comparisons the RR is typically based on comparing, for example, the least advantaged group (e.g., the lowest socioeconomic group) to the highest group, in the context of comparing it to summary measures of health disparity we calculate it as one would a range measure. That is, at each time point it measures the relative difference in the rates of the best and worst group (i.e., the relative range), regardless of their social group status.

Index of Disparity (IDisp)

The Index of Disparity summarizes the difference between several group rates and a reference rate, and expresses the summed differences as a proportion of the reference rate. This measure was formally introduced by Pearcy and Keppel (7) and is calculated as:

$$ID_{isp} = \left(\sum_{j=1}^{J-1} \left| r_j - r_{ref} \right| / J \right) / r_{ref} \times 100 ,$$

where r_j indicates the measure of health status in the jth group, r_{ref} is the health status indicator in the reference population, and J is the number of groups compared. While in principle, any reference group may be chosen, the authors recommend the best group rate as the comparison since that represents the rate desirable for all groups to achieve. In this case it is not necessary to take the absolute value of the rate differences since they will all be positive.

Relative Concentration Index (RCI)

The Relative Concentration Index (RCI) measures the extent to which health or illness is concentrated among particular social groups. The RCI may only be used with social groups that have an inherent ranking, such as income or education groups. The general formula for the RCI for grouped data is given by Kakwani and colleagues (8) as:

$$RCI = \frac{2}{\mu}\left[\sum_{j=1}^{J} p_j \mu_j R_j\right] - 1$$

where p_j is the group's population share, μ_j is the group's mean health, and R_j is the relative rank of the jth socioeconomic group, which is defined as:

$$R_j = \sum_{j=1}^{J} p_\gamma - \frac{1}{2} p_j$$

where p_γ 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. R_j essentially indicates the cumulative share of the population up to the midpoint of each group interval, similar to the categorization used for the Slope Index of Inequality above. In fact, the RCI has a specific mathematical relationship with the SII (6), such that $HCI = 2\,\mathrm{var}(x)(\beta / \mu)$,where β is the slope parameter identified in the equation for the SII above. One of the reasons the RCI (and, by extension, the SII) is favored by some is that it "reflects the socioeconomic dimension to inequalities in health" (6, p.548). That is, a downward health gradient (such that health worsens with social group rank) results in a positive RCI, whereas an upward health gradient results in a negative RCI.

Relative Index of Inequality

The SII discussed above is a measure of absolute disparity. However, dividing this estimated slope by the mean population health gives a relative disparity measure, the Relative Index of Inequality or RII (9):

$$RII = SII / \mu = \beta_1 / \mu$$

where μ is mean population health and the SII is the estimate of β_1 from the regression that generates the SII. Its interpretation is similar to the SII, but it now measures the proportionate (in regard to the average population level) rather than absolute increase or decrease in health between the highest and lowest socioeconomic group.

Theil Index (T) and Mean Log Deviation (MLD)

The Theil Index and Mean Log Deviation are measures of general disproportionality, developed by the economist Henri Theil (10). They are both summaries of the difference between the natural logarithm of shares of health and shares of population. They may be written (11) as follows:

$$T = \sum_{j=1}^{J} p_j r_j \ln r_j$$

$$MLD = \sum_{j=1}^{J} p_j \left[-\ln r_j\right]$$

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 prevalence of the outcomes in group j and μ is the total prevalence. Both measures are population-weighted, are more sensitive to health differences further from the average rate (by the use of the logarithm), and may be used for both ordered social groups (education) and unordered groups (gender, race).

Presentation of Results

What follows are several case studies that use data relevant to the Healthy People 2010 cancer-related goals. For each example there is a brief description of the data and the measures of health disparity used in the example. In presenting each analysis we generally follow the series of steps for analyzing health disparity trends outlined in the previous review of measures of health disparity (1).

- First, the underlying data are presented in graphical and tabular form to give an overall sense of the sub-group trends.
- Second, we estimate the change in health disparity for selected time points using the disparity measures listed above. As the measures of disparity are often measured on different scales, when comparing the magnitude of change in disparity we focus primarily on the relative or percent change in disparity. As many of the disparity measures used here have been used relatively infrequently in the literature, it is difficult to know how meaningful the relative changes in these indicators are. Nevertheless, we generally compare the relative changes in the measures (i.e., % change) to assess their agreement.
- Third, we present graphs of the trend in disparity to compare selected disparity measures over time (e.g., Index of Disparity vs. Mean Log Deviation for measuring relative disparity).
- Finally, for selected case studies where there is disagreement between either the magnitude or the direction of the change in disparity over time, we present some diagnostic simulations to help understand the nature of the disagreement among the measures. In doing so we attempt to minimize some of the differences among the measures, such as population weighting or which reference group is used for comparison, and determine whether such factors account for the observed difference in disparity change.

Random Variation

In the context of evaluating changes in health disparities over time it is often of interest to know the extent to which a given change in disparity may be due to random chance. This is an important issue for any substantive analysis of change in health disparity, but the focus of this report is not on statistical inference about changes in health disparities, nor is it our intention to draw substantive conclusions about any particular health disparity. For this reason we do not typically include estimates of precision for the various measures of disparity used in this report. Our primary interest is in simply comparing the magnitude and direction of estimated trends and changes in disparities. Since the various measures of disparity for a given case study all use the same underlying data, the precision of the underlying estimates will affect all the disparity measures and is less relevant for comparing of the magnitude and direction of change in disparity. However, as an example for Case Study 1 we include estimates of precision and hypothesis tests for the change in disparity. However, while this report does not focus on statistical testing it should be noted that methods to calculate indicators of precision (e.g., 95% confidence interval) for most of the measures reviewed here may be found in the source publications detailed in the references. A very brief description of the general methods for calculating standard errors for the various measures of disparity used in this analysis are presented in the Appendix.

RESULTS

Case Study 1: Racial Disparities In Lung Cancer Incidence, 1990-2001.

The data source for this analysis come from the SEER database called: *Incidence - SEER 18 Regs, Nov 2003 Sub for Expanded Races (1990-2001 varying)*. Individuals for whom race was coded as "Unknown" are excluded from this analysis, and Hispanics are not identified in this database. The analysis is stratified by gender and restricted to ages 45-74. Rates are not age-adjusted so as to reflect the existing absolute burden of lung cancer.

Males

Rates of lung cancer incidence by race-ethnicity for males 45-74 years of age are shown graphically in Figure 1, and the underlying raw data on rates and population proportions are shown in Table 1. Generally speaking, lung cancer rates are declining for all race-ethnic groups, and the relative magnitude of the decline is fairly similar for all groups.

Figure 1. Lung cancer incidence by race among males 45-74.

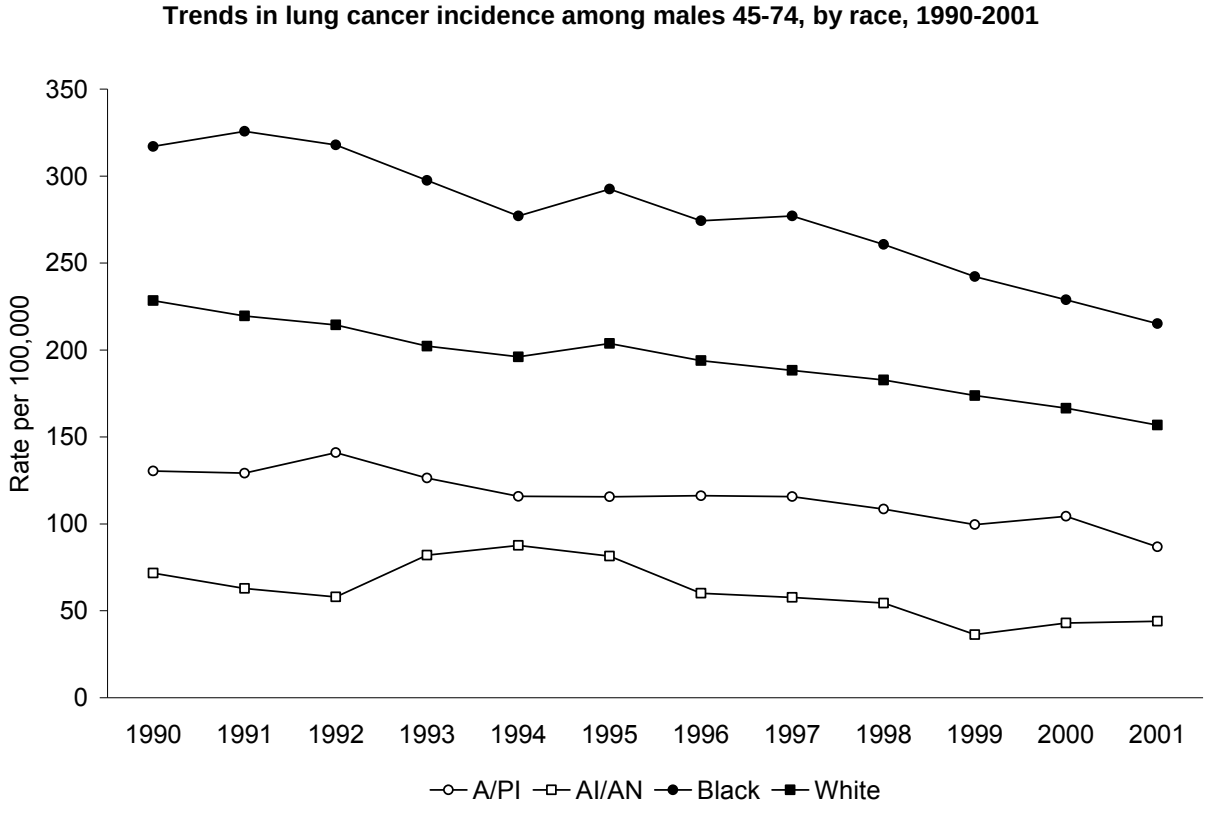


Table 1. Trends in lung cancer incidence and population distribution, by race, among males 45-74, 1990-2001.

	Rate per 100,000				Percent of Total Population			
	A/PI	AI/AN	Black	White	A/PI	AI/AN	Black	White
1990	130.4	71.7	317.1	228.4	0.066	0.010	0.073	0.851
1991	129.2	62.8	325.7	219.6	0.068	0.010	0.074	0.848
1992	141.0	57.9	317.9	214.5	0.070	0.011	0.074	0.845
1993	126.4	82.0	297.6	202.2	0.073	0.011	0.074	0.842
1994	115.8	87.7	277.1	196.0	0.076	0.011	0.075	0.838
1995	115.5	81.5	292.6	203.7	0.070	0.011	0.084	0.835
1996	116.2	60.1	274.3	193.9	0.073	0.011	0.085	0.831
1997	115.6	57.7	277.1	188.3	0.075	0.011	0.086	0.828
1998	108.6	54.4	260.7	182.7	0.077	0.012	0.087	0.825
1999	99.6	36.3	242.2	173.9	0.079	0.012	0.088	0.822
2000	104.4	42.9	228.8	166.5	0.081	0.012	0.088	0.819
2001	86.7	44.0	215.1	156.9	0.082	0.013	0.089	0.816
Δ90 to 01	-43.6	-27.7	-101.9	-71.5	0.017	0.003	0.015	-0.035
%Δ	-33.5%	-38.6%	-32.1%	-31.3%	25.3%	27.8%	21.2%	-4.1%

The change in race-ethnic disparity among males is presented in Table 2. Focusing on the line at the bottom of the table, the measures of relative and absolute disparity seem to be moving in different directions (decreasing for absolute and increasing for relative). For males, all of the relative measures of disparity registered an increase since 1990, but T and MLD appear to show a relatively larger increase (about twice as large). Table 2 also includes measures of precision for each measure of disparity. The first row marked 'SE' contains standard measures of precision for the total rate, the RR and the RD (see the Appendix for formulas). The next row marked 'SE_{boot}' contains standard errors of the each disparity measures based on 5000 replications of the underlying rates, assuming a random normal distribution (12). This leads to 5000 estimates of each disparity measure, the distribution of which is used to estimate the standard error. Based on the SE_{boot}, Z-statistics were calculated for the change in disparity using the general formula: $Z = (D_{2001} - D_{1990}) / \sqrt{(SE_{2001}^2 + SE_{1990}^2)}$, where D indicates the disparity measure and ($|Z|>1.96$) indicates statistical significance at the $\alpha=0.05$ level (12). By this measure the approximately 30% increases in relative disparity measured by T and MLD are statistically significant, while the 10-15% increase measured by the RR and IDisp are not statistically significant. In terms of absolute disparity, the RD decreases by 30% and the BGV decreases by 40%. Both of these declines are statistically significant.

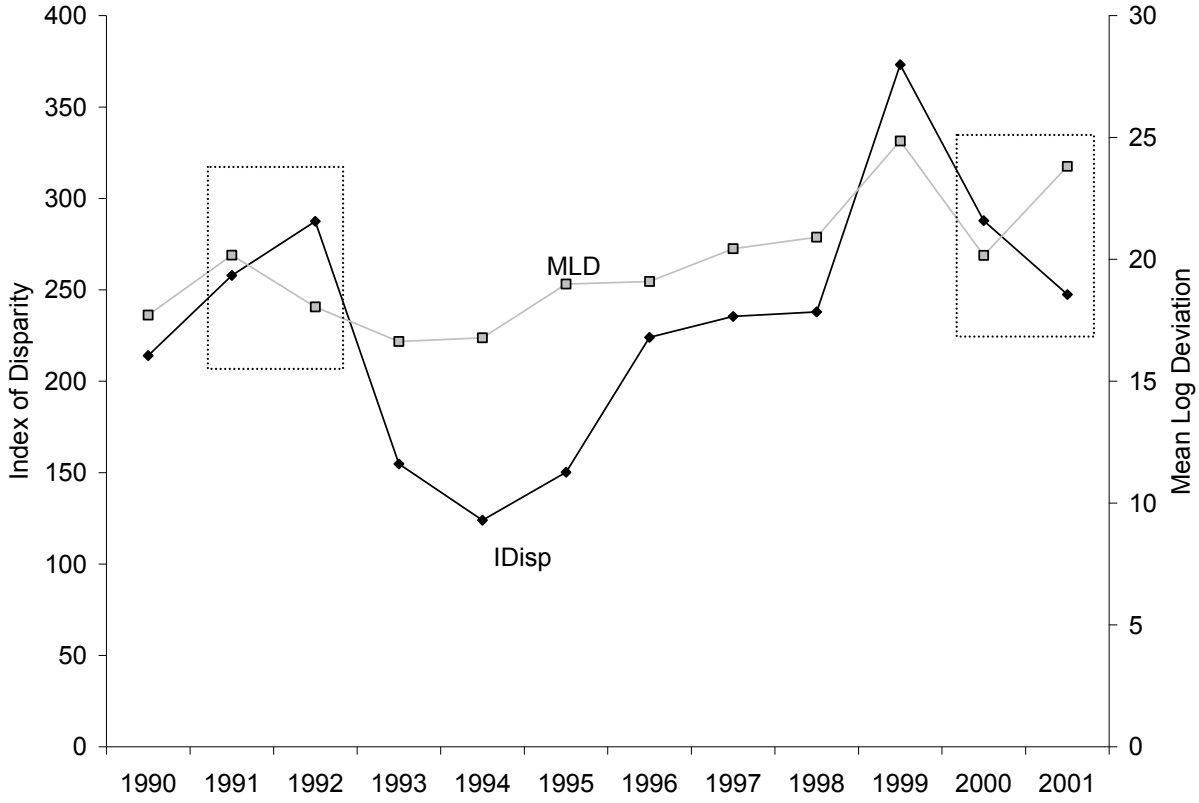
Table 2. Changes in racial disparity in lung cancer incidence between 1990 and 2001 among males 45-74.

	Raw Data			Measures of Relative Disparity				Measures of Absolute Disparity	
Race	Rate	SE	% Pop	RR*	IDisp	T	MLD	RD*	BGV
1990									
AI/AN	71.7	10.4	1.0	1.0	0.0	-3.6	11.5	0	239.9
A/PI	130.4	5.4	6.6	1.8	19.5	-20.9	36.3	58.6	611.1
Black	317.1	8.0	7.3	4.4	81.8	34.2	-24.5	245.3	595
White	228.4	2.0	85.1	3.2	52.2	5.6	-5.6	156.7	1.9
Total	**226.9**	**1.8**		**4.4**	**214.0**	**15.4**	**17.7**	**245.3**	**1447.9**
SE_{trad}	**1.8**			**0.7**				**13.1**	
SE_{boot}	**1.9**			**0.7**	**49.2**	**1.3**	**1.7**	**13.0**	**132.0**
2001									
AI/AN	44.0	5.9	1.2	1.0	0	-4.6	16	0	156.4
A/PI	86.7	3.3	8.1	2.0	14.2	-26.7	47.6	42.7	381.1
Black	215.1	1.4	8.8	4.9	57	40.5	-29.2	171.1	322.4
White	156.9	4.9	81.9	3.6	37.6	10.8	-10.6	112.9	3.4
Total	**154.8**	**1.2**		**4.9**	**247.4**	**20.1**	**23.8**	**171.1**	**863.2**
SE_{trad}	**1.2**			**0.7**				**6.0**	
SE_{boot}	**1.2**			**0.7**	**50.2**	**1.5**	**2.0**	**7.7**	**66.2**
Δ90 to 01	-72.1			0.5	33.4	4.7	6.1	-74.2	-584.6
SE of Δ	2.2			1.0	70.3	2.0	2.7	15.1	147.7
Z-statistic	-32.4			0.5	0.5	2.3	2.3	-4.9	-4.0
%Δ	-31.8%			10.6%	15.6%	30.8%	34.5%	-30.2%	-40.4%

*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance; SE_{trad}=traditional standard error; SE_{boot}=bootstrap standard error

The trend in relative race-ethnic disparity among males, as measured by the IDisp and the MLD is shown in Figure 2. The two measures of relative disparity generally give the same picture of the overall trend in racial disparity in lung cancer incidence among males. From 1991 to 1992 (shown in the box) the IDisp showed an increase in disparity but the MLD showed a decrease; the opposite was true from 2000 to 2001. This latter change seems likely due to the sharp decline of the rate among the A/PI group for 2001, which moved closer toward the referent group for the IDisp (the best rate), but away from the referent group for the MLD (the population average).

Figure 2. Trends in racial disparity in lung cancer incidence among males 45-74, 1990-2001



Females

Rates of lung cancer incidence among females are shown in Figure 3, and the corresponding annual rates and population shares are shown in Table 3. The incidence of lung cancer has declined among all race-ethnic groups, but the absolute and relative decline has been larger among blacks and whites than for the A/PI and AI/AN groups.

Figure 3. Lung cancer incidence among females 45-74.

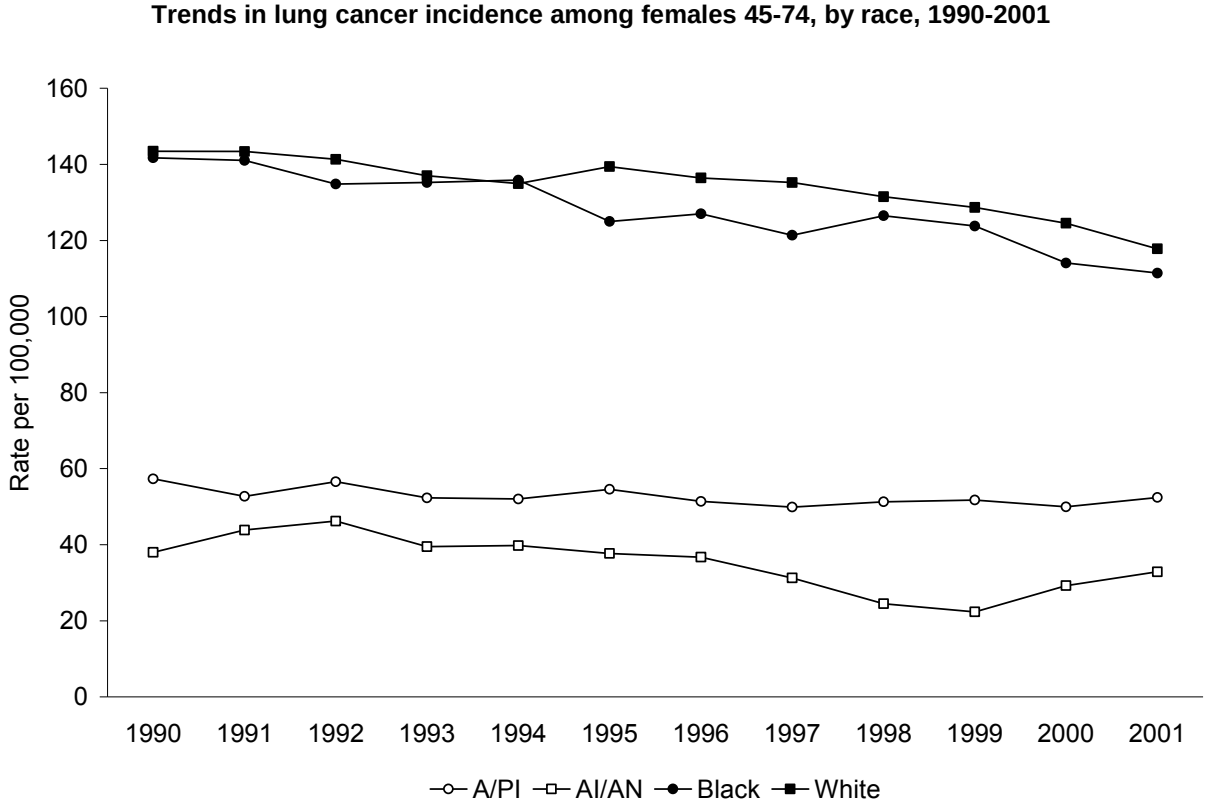


Table 3. Trends in lung cancer incidence and population distribution, by race, among females 45-74, 1990-2001.

	Rate per 100,000				Percent of Total Population			
	A/PI	AI/AN	Black	White	A/PI	AI/AN	Black	White
1990	57.3	38.0	141.7	143.4	0.069	0.010	0.080	0.841
1991	52.7	43.9	141.0	143.4	0.072	0.011	0.081	0.837
1992	56.6	46.2	134.8	141.3	0.075	0.011	0.081	0.834
1993	52.3	39.5	135.2	137.0	0.078	0.011	0.082	0.829
1994	52.0	39.8	135.8	135.0	0.081	0.012	0.083	0.825
1995	54.6	37.7	125.0	139.4	0.075	0.011	0.094	0.821
1996	51.4	36.8	127.0	136.4	0.078	0.011	0.095	0.816
1997	49.9	31.3	121.4	135.2	0.080	0.011	0.096	0.812
1998	51.3	24.5	126.5	131.5	0.083	0.012	0.097	0.809
1999	51.7	22.4	123.8	128.7	0.085	0.012	0.098	0.805
2000	50.0	29.3	114.1	124.5	0.087	0.013	0.098	0.802
2001	52.5	32.9	111.4	117.8	0.089	0.013	0.099	0.799
Δ90 to 01	-4.9	-5.1	-30.3	-25.7	0.020	0.003	0.019	-0.042
%Δ	-8.5%	-13.5%	-21.4%	-17.9%	29.2%	26.3%	23.9%	-5.0%

The overall change in racial disparity among females is presented in Table 4. Similar to males, absolute racial disparity in lung cancer incidence declined, with statistically significant declines of 20% and 27% in the RD and BGV, respectively. For relative disparity, the Rate Ratio and Index of Disparity indicate declines in disparity whereas T and MLD indicate disparity has increased, but none of these changes are statistically significant. Generally speaking their was little change in the magnitude of relative racial disparity among females, less than 10% change for any of the relative measures. In comparing the extent of racial disparity in lung cancer across gender groups (Table 2, Table 4),the Rate Ratio and Index of Disparity indicate that the racial disparity in lung cancer incidence is slightly larger among males ($IDisp_{2001}$=247.4) compared to females ($IDisp_{2001}$=185.5), but T and MLD indicate larger disparity among females (MLD_{2001}=23.8 for males vs. 27.8 for females). This is likely due to the fact the RR and IDisp are unweighted indexes and use the "best rate" as the reference group, while the T and MLD are weighted by population size and use the population average as the reference point. Thus, despite the fact that all racial groups are relatively closer to the best rate among females, incidence in the largest population group (whites) is 7% (117.8/110.2) higher than the population average in females, compared to only 1% higher (156.9/154.8) in males.

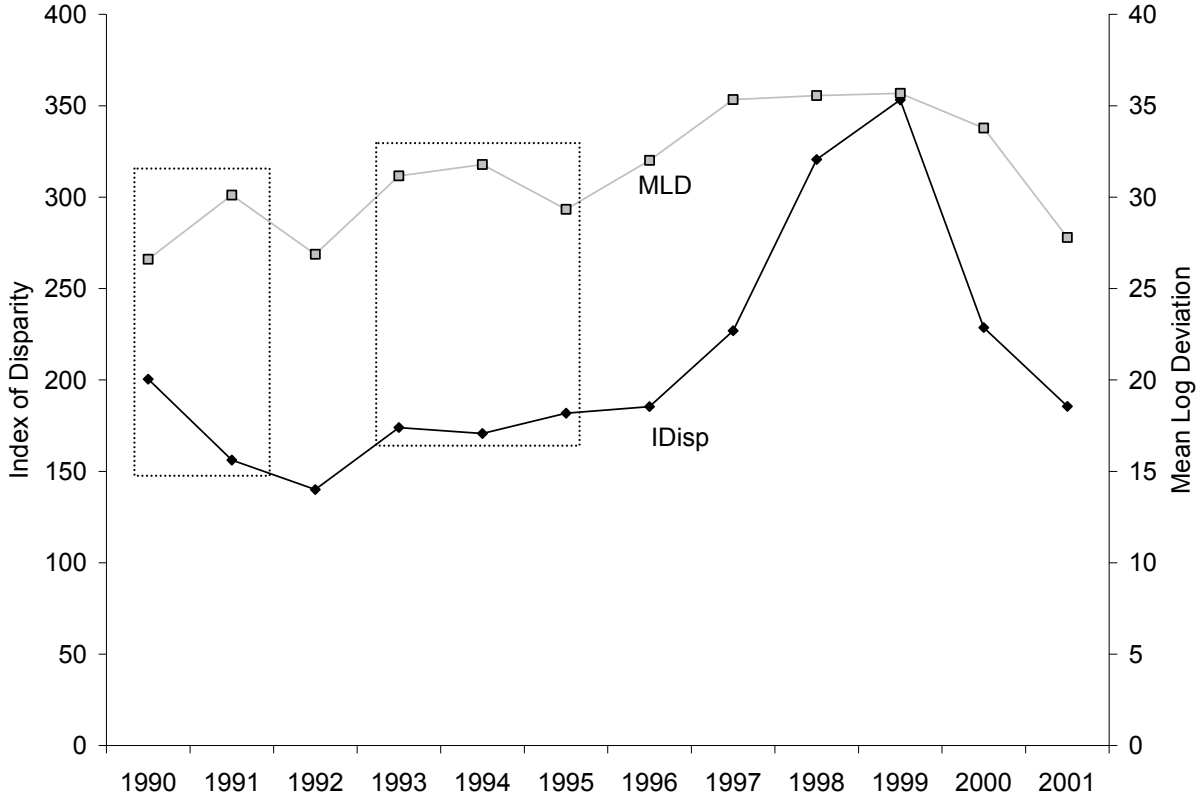
Table 4. Changes in racial disparity in lung cancer incidence between 1990 and 2001 among females 45-74.

	Raw Data			Measures of Relative Disparity				Measures of Absolute Disparity	
Race	Rate	SE	% Pop	RR*	IDisp	T	MLD	RD*	BGV
1990									
AI/AN	38.0	7.1	1	1	0	-3.6	13.1	0	98.7
A/PI	57.3	3.3	6.9	1.5	6.4	-25.1	59.6	19.3	429.4
Black	141.7	4.9	8	3.7	34.6	3.2	-3.1	103.7	2.3
White	143.4	1.5	84	3.8	35.1	45.2	-43	105.4	43
Total	**136.3**	**1.4**		**3.8**	**200.4**	**19.7**	**26.6**	**105.4**	**573.5**
SE_{trad}	**1.4**			**0.7**				**7.2**	
SE_{boot}	**1.3**			**0.8**	**66.2**	**1.7**	**2.9**	**7.5**	**44.4**
2001									
AI/AN	32.9	4.8	1.3	1	0	-4.7	15.6	0	77.2
A/PI	52.5	2.3	8.9	1.6	6.5	-31.4	66.1	19.6	297.1
Black	111.4	3.2	9.9	3.4	26.2	1.1	-1.1	78.6	0.1
White	117.8	1.2	79.9	3.6	28.3	56.4	-52.8	84.9	45.4
Total	**110.2**	**1.0**		**3.6**	**185.5**	**21.4**	**27.8**	**84.9**	**419.9**
SE_{trad}	**1.0**			**0.5**				**5.0**	
SE_{boot}	**1.0**			**0.6**	**46.8**	**1.7**	**2.6**	**4.9**	**29.8**
Δ90 to 01	-26.1			-0.2	-14.9	1.7	1.2	-20.5	-153.6
SEΔ	1.7			1.0	81.1	2.4	3.9	9.0	53.5
Z-statistic	-15.6			-0.2	-0.2	0.7	0.3	-2.3	-2.9
%Δ	-19.1%			-5.1%	-7.4%	8.5%	4.5%	-19.5%	-26.8%

*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance; SE_{trad}=traditional standard error; SE_{boot}=bootstrap standard error

The trend in relative racial disparity among females is presented in Figure 4. The trend in relative racial disparity generally follows the same trajectory whether measured with the Index of Disparity or the Mean Log Deviation, despite the former showing a modest decline and the latter a modest increase in disparity from 1990 to 2001. From 1990 to 1991 and 1993 to 1994 the IDisp shows a decline and the MLD an increase in racial disparity; the opposite is true from 1994 to 1995. This is likely to be due to the different referent groups used by the two measures. For disagreement between 1990 and 1991, the increase in the AI/AN rate brings the rate for the "best group" closer to the other rates (and thus the decline in the IDisp), but because this group is a small proportion of the population this has little effect on the reference rate for the T and MLD (the population average rate) and so the MLD registers a small increase in disparity.

Figure 4. Trends in relative racial disparity in lung cancer incidence among females 45-74.



Case Study 2: Area-Socioeconomic Disparities in Lung Cancer Incidence, 1988-99

The data for this analysis come from the SEER database, "Incidence - SEER 11 Regs, Nov 2001 Sub (1988-1999) with Socio-Economic Attributes by County." The measure of socio-economic position for each individual case was based on county of residence in the 1990 US Census. All counties in the SEER database (n=201) were ranked according the percentage of the population ages 25 and over with at least a high school degree, estimated from the 1990 US Census. Educational attainment ranged from 57.8% in Guadalupe County, NM to 94.7% in Los Alamos County, NM. The 201 counties were classified into five categories of an equal number of counties to create quintiles of socioeconomic position based on educational attainment. The unweighted average percent of the population with at least a high school education in the five quintiles (low to high) was 68.0%, 75.3%, 78.2%, 81.0%, and 86.4%. The analysis is restricted to individuals 45-74 years of age and rates are not age-adjusted.

Males

Rates of lung cancer mortality from 1988 to 1999 for males, by area socioeconomic position, are shown in Figure 5. Lung cancer incidence has declined for all socioeconomic groups, and the magnitude of the decline was generally similar (~30%). Table 5 shows the rates for each year and the fraction of the male population in each socioeconomic group. It is worth noting that between 1988 and 1999 the entire population experienced an upward shift in the socioeconomic distribution reflecting secular trends in increasing education—i.e., the fraction of the population in the highest education quintile increased by 12% while the fraction in the lowest quintile declined by 7%.

Figure 5. Lung cancer incidence among males 45-74.

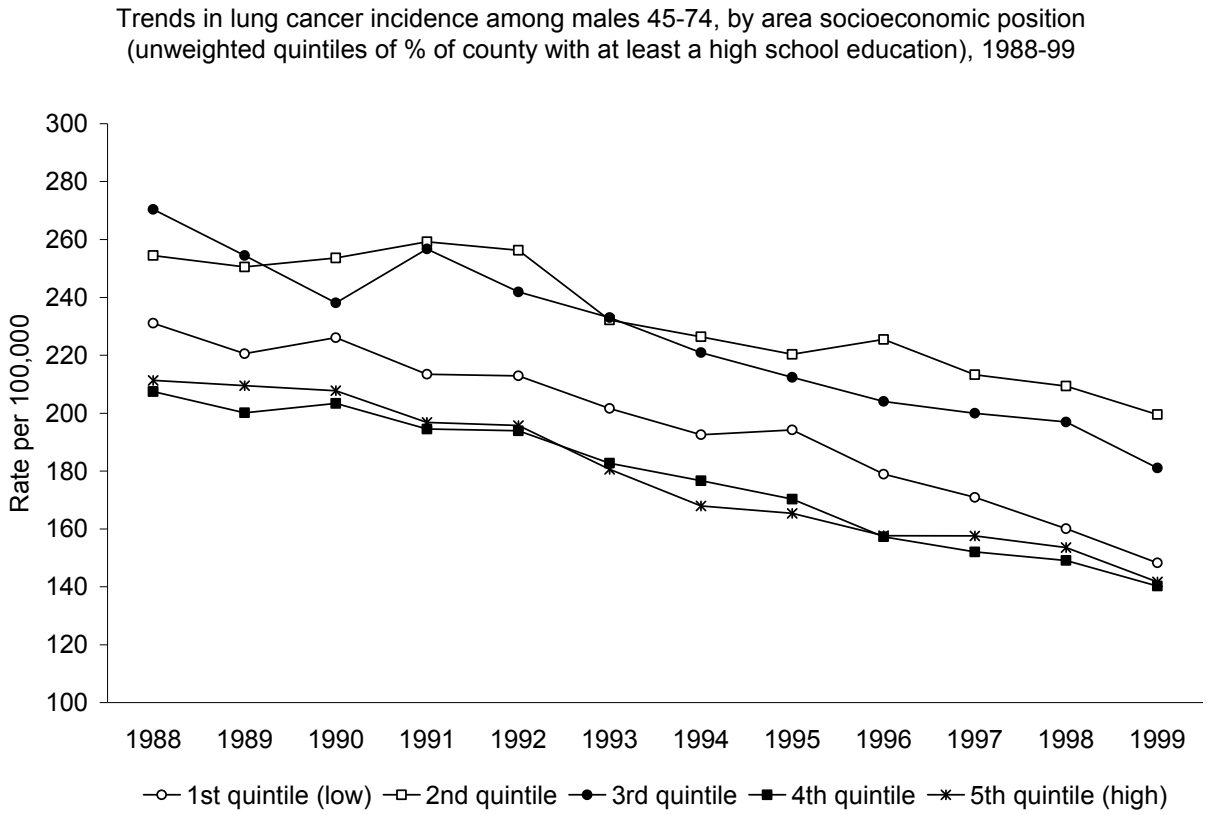


Table 5. Lung cancer incidence and population distribution among males 45-74, by quintile of socioeconomic position, 1988-99.

	Rate per 100,000					Percent of Total Population				
	Q1 (low)	Q2	Q3	Q4	Q5 (high)	Q1 (low)	Q2	Q3	Q4	Q5 (high)
1988	231.0	254.5	270.4	207.5	211.3	0.333	0.058	0.130	0.205	0.274
1989	220.6	250.5	254.5	200.1	209.5	0.330	0.057	0.129	0.206	0.278
1990	226.1	253.6	238.1	203.4	207.7	0.326	0.057	0.128	0.207	0.282
1991	213.5	259.2	256.7	194.5	196.8	0.324	0.058	0.127	0.207	0.285
1992	212.9	256.3	241.9	193.9	195.7	0.322	0.058	0.126	0.206	0.289
1993	201.6	232.2	233.0	182.7	180.6	0.319	0.058	0.125	0.206	0.292
1994	192.5	226.4	220.9	176.6	167.9	0.317	0.057	0.124	0.206	0.296
1995	194.2	220.3	212.4	170.3	165.4	0.314	0.057	0.123	0.206	0.299
1996	179.0	225.5	204.0	157.3	157.7	0.313	0.058	0.122	0.206	0.301
1997	170.9	213.3	199.9	152.1	157.6	0.311	0.058	0.121	0.206	0.304
1998	160.1	209.3	196.9	149.1	153.6	0.311	0.057	0.120	0.206	0.306
1999	148.3	199.5	181.1	140.2	141.7	0.311	0.057	0.120	0.206	0.307
Δ88 to 99	-82.8	-55.0	-89.3	-67.2	-69.5	-0.022	-0.001	-0.011	0.000	0.033
%Δ	-35.8%	-21.6%	-33.0%	-32.4%	-32.9%	-6.6%	-1.2%	-8.3%	0.1%	12.1%

The change in socioeconomic disparity for males is shown in Table 6. The relative disparity in lung cancer incidence favors the better off (RCI/ACI and the RII/SII, which are sensitive to the direction of the gradient, are negative). For example, in 1988 the RII indicates that moving from the bottom to the top of the educational distribution is associated with a 16.9% decline (RII=-0.169) in lung cancer incidence. For males, the Rate Ratio and the Index of Disparity show increases in disparity of 9.2% and 18.1%, respectively, while the Relative Concentration Index and the Relative Index of Inequality both register approximately a 20% decline. The increases in the RR and IDisp appear to result from the smaller decline in incidence among those in the 2nd SEP quintile, which, it should be noted, accounts for about 6% of the SEER population. The similarity of the change in the RCI and the RII should not be surprising as they are mathematically related (RCI = 2var(x)*RII, where x is relative socioeconomic rank, see Methods section). All of the measures of absolute disparity indicate that socioeconomic disparity has declined, but the magnitude of the decline is much smaller for the Rate Difference (-5.7%) than for the summary measures (33-46%).

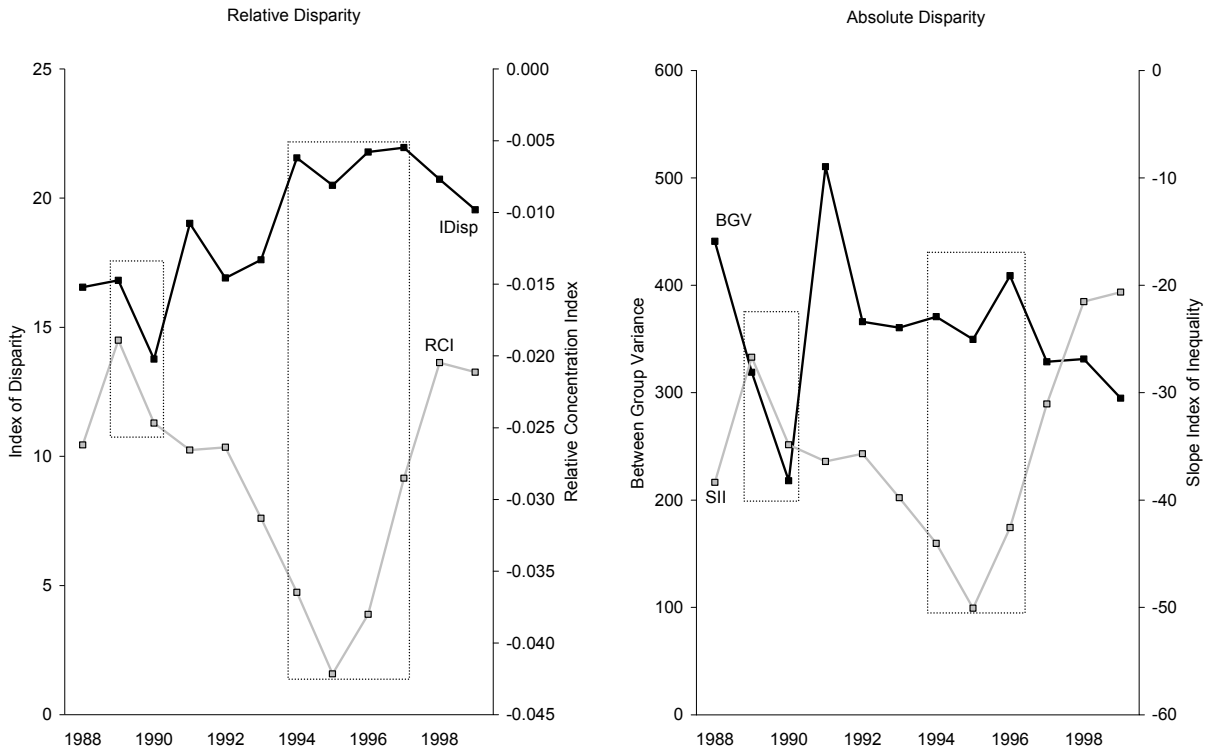
Table 6. Changes in socioeconomic disparity in lung cancer incidence among males 45-74.

	Raw Data		Measures of Relative Disparity				Measures of Absolute Disparity			
SEP quintile	Rate	% Pop	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1988										
1st quintile	231.0	0.333	1.11	5.9	-0.2256		23.6	-51.28	4.7	
2nd quintile	254.5	0.058	1.23	11.8	-0.0179		47.0	-4.07	42.8	
3rd quintile	270.4	0.130	1.30	15.7	-0.0138		62.9	-3.14	242.8	
4th quintile	207.5	0.205	1.00	0.0	0.0463		0.0	10.51	80.6	
5th quintile	211.3	0.274	1.02	1.0	0.1849		3.8	42.02	70.1	
Total	**227.3**		**1.30**	**16.6**	**-0.0262**	**-0.169**	**62.9**	**-5.95**	**440.9**	**-38.4**
1999										
1st quintile	148.3	0.311	1.06	2.0	-0.2096		8.1	-31.75	3.2	
2nd quintile	199.5	0.057	1.42	14.8	-0.0242		59.3	-3.66	131.7	
3rd quintile	181.1	0.120	1.29	10.2	-0.0208		40.9	-3.14	105.0	
4th quintile	140.2	0.206	1.00	0.0	0.0343		0.0	5.19	25.9	
5th quintile	141.7	0.307	1.01	0.4	0.1991		1.5	30.16	29.1	
Total	**151.5**		**1.42**	**19.6**	**-0.0211**	**-0.136**	**59.3**	**-3.20**	**294.8**	**-20.6**
Δ88 to 99	-75.8		0.1	3.0	0.0051	0.032	-3.6	2.8	-146.1	17.7
%Δ	-33.3%		9.2%	18.1%	-19.3%	-19.2%	-5.7%	-46.2%	-33.1%	-46.2%

*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

Trends in the Index of Disparity and Relative Concentration Index are shown in Figure 6, and are only moderately consistent over time. The IDisp shows a continuous increase in disparity until 1997, while the RCI begins decreasing in 1995. From 1989-90 and 1994-97 the IDisp and the RCI move in opposite directions (highlighted in boxes in Figure 6), with one measure indicating increasing disparity and the other indicating decreasing disparity. For absolute disparity, the BGV and SII generally agree with respect to the magnitude of the change in disparity over time, but from 1989-90 and 1994-95 the SII shows an increase in disparity while the BGV shows a decrease (highlighted in boxes), while the opposite is true from 1996-97.

Figure 6. Trends in relative and absolute socioeconomic disparity in lung cancer incidence among males 45-74, 1988-99.



DIAGNOSTICS

Why do the results differ for the RR/IDisp and RCI/RII?

Based on the results in Table 6 **Error! Reference source not found.**one would conclude that area-socioeconomic disparity in lung cancer incidence among males is increasing when measured by the RR or IDisp, but decreasing when measured by the RCI or RII. Given that each of these measures purport to measure "disparity" why do they give different results? To gain some leverage on this issue it is worth reconsidering two basic differences between the IDisp and the RCI as described in the Methods section. The IDisp uses the "best rate" as the reference point and does not weight social groups by their population size, while the RCI uses the total

population rate as the reference group and is population-weighted. Thus, the source of the difference could potentially be either 1) the use of different reference groups; 2) population-weighting; or 3) changes in population distribution over time. Table 7 shows a simulation of the change in disparity after making some adjustments that attempt to eliminate the differences between the IDisp and the RCI. For example, one might ask: Is the difference between the IDisp and the RCI due to the fact that the IDisp uses the "best rate" as the reference group and the RCI uses the population average? Apparently not, because if we calculate the IDisp using the population average as the reference rate, one would still conclude that disparity has increased. The most likely answer to why the two measures differ is the effect of population weighting (See columns 5 and 6 in Table 7 – labeled Population Weighted IDisp and Unweighted RCI). In column 7, if the RCI is calculated without weighting by population size[1] it also shows an increase in disparity, and if we weight the IDisp by population shares the relative change in disparity is quite similar to that for the observed changes for the RCI and RII.

Table 7. Changes in socioeconomic disparity in lung cancer incidence among males 45-74 using alternative measures of disparity.

	Observed IDisp	Observed RCI	IDisp with population average as reference group	Population Weighted IDisp	Unweighted RCI	Weighted RCI with 1988 population shares fixed
1988	16.6	-0.0262	9.7	2.4	-0.1881	-0.0262
1999	19.6	-0.0211	13.4	2.0	-0.4270	-0.0191
Δ88 to 99	3.0	0.0051	3.8	-0.4	-0.2390	0.0071
%Δ	18.1%	-19.3%	39.0%	-16.2%	127.1%	-27.0%

Females

Rates of lung cancer incidence for females 45-74 are presented in Figure 7. Similar to the trend for males, rates of lung cancer incidence declined from 1988-99 for all socioeconomic groups, but the magnitude of the decline was generally larger for males than for females. In addition, lung cancer incidence was slightly higher among the worse-off socioeconomic groups, as they were for males. However, both absolute and relative area-socioeconomic disparities in lung cancer incidence were smaller among females compared to males in 1988 by all measures of disparity (compare the upper panels of Table 6 and Table 9). For example, the RCI and ACI for males were, respectively, -0.0262 and -5.95, while for females the corresponding values were -0.0056 and -0.71.

[1] It should be pointed out that calculating the RCI without population weights may generate values outside the normal range of the RCI (-1,1). Nevertheless, for our purposes it could be thought of as a potential disparity measure that summarizes the ratio of each group's health relative to the total population and attaches higher weight to the health of lower-ranked social groups.

Figure 7. Lung cancer incidence among females 45-74.

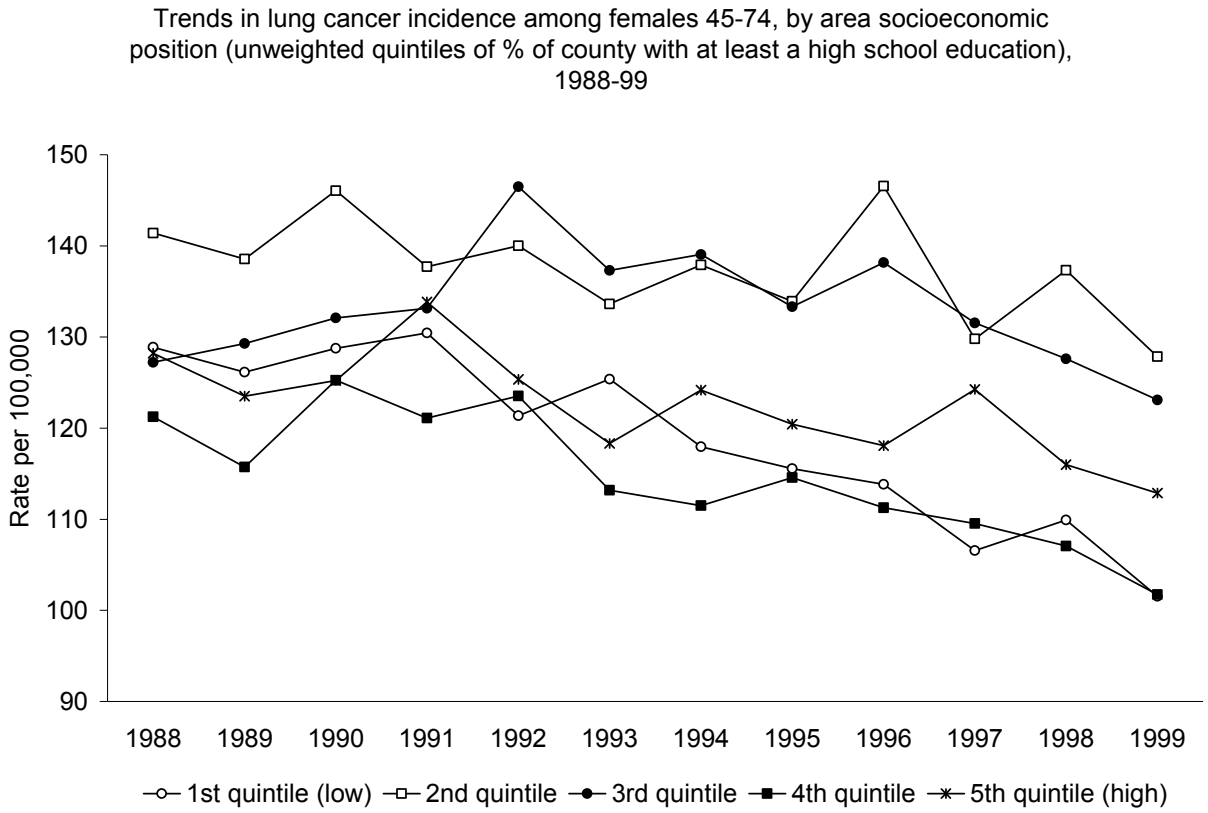


Table 8. Lung cancer incidence and population distribution among females 45-74, by quintile of socioeconomic position, 1988-99.

	Rate per 100,000					Percent of Total Population				
	Q1 (low)	Q2	Q3	Q4	Q5 (high)	Q1 (low)	Q2	Q3	Q4	Q5 (high)
1988	128.9	141.4	127.2	121.2	128.2	0.339	0.058	0.133	0.203	0.267
1989	126.2	138.5	129.3	115.7	123.5	0.336	0.058	0.132	0.204	0.271
1990	128.8	146.1	132.1	125.3	125.2	0.332	0.058	0.130	0.204	0.275
1991	130.4	137.7	133.2	121.1	133.8	0.331	0.058	0.129	0.204	0.278
1992	121.4	140.0	146.5	123.5	125.4	0.329	0.058	0.128	0.204	0.281
1993	125.4	133.6	137.3	113.2	118.3	0.327	0.058	0.127	0.204	0.285
1994	118.0	137.9	139.1	111.5	124.2	0.324	0.057	0.126	0.204	0.288
1995	115.6	133.9	133.3	114.6	120.4	0.322	0.058	0.125	0.204	0.291
1996	113.8	146.6	138.2	111.3	118.1	0.320	0.058	0.124	0.204	0.293
1997	106.6	129.8	131.5	109.5	124.2	0.319	0.057	0.123	0.205	0.295
1998	109.9	137.3	127.6	107.1	116.0	0.319	0.057	0.123	0.205	0.297
1999	101.6	127.9	123.1	101.7	112.9	0.319	0.057	0.122	0.204	0.298
Δ88 to 99	-27.3	-13.6	-4.1	-19.5	-15.3	-0.019	-0.001	-0.012	0.001	0.031
%Δ	-21.2%	-9.6%	-3.2%	-16.1%	-12.0%	-5.7%	-1.6%	-8.8%	0.6%	11.6%

Changes in socioeconomic disparities in lung cancer incidence for females are presented in Table 9. From 1988 to 1999 the disparity measures that are sensitive to the *direction* of the gradient (RCI/ACI and RII/SII) indicate that the gradient changed from favoring the better off socioeconomic groups (higher incidence generally among the lower SEP groups) to favoring the worse off (higher incidence generally among the higher SEP groups). This reversal is likely due to the faster decline in incidence among those in the low-SEP quintile 1 (21.2% decline) compared to the high-SEP quintile 5 (12.0% decline). Generally speaking, all the measures of relative disparity appear consistent in showing that socioeconomic disparities are increasing (the change in sign makes this difficult to see with the RCI and RII). The RR, IDisp, and RD all show increases over this time period, and the absolute value of the RCI, RII, ACI, and SII increased as well. However, the magnitude of the increase in disparity differed across the summary indicators. The size of the positive gradient in 1999 as measured by the population-weighted measures—the RCI, RII, ACI, BGV, and SII—is nearly three times as large as the negative gradient observed in 1988 (~300% change) while the RR, IDisp, and RD show more moderate increases.

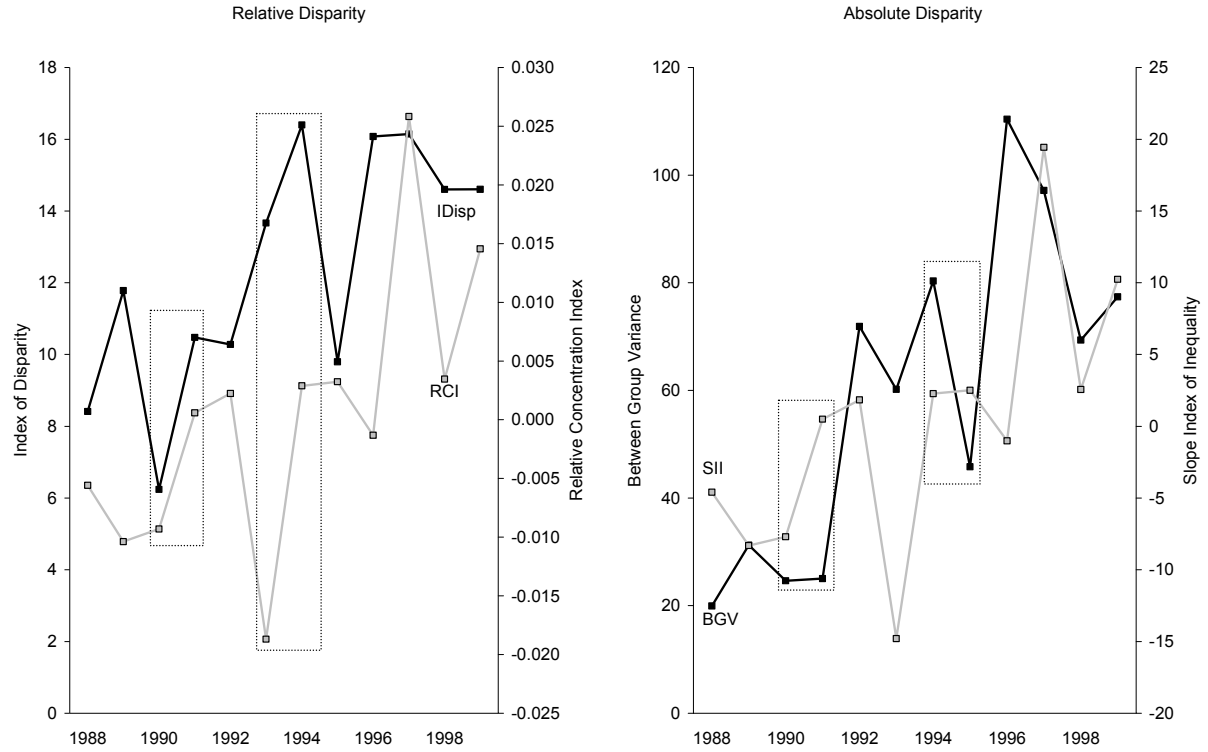
Table 9. Changes in socioeconomic disparity in lung cancer incidence among females 45-74.

	Raw Data		Measures of Relative Disparity				Measures of Absolute Disparity			
SEP quintile	Rate	% Pop	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1988										
1st quintile	128.9	0.339	1.06	1.9	0.0000		7.7	-28.86	0.5	
2nd quintile	141.4	0.058	1.17	5.1	-0.0019		20.2	-2.17	11.0	
3rd quintile	127.2	0.133	1.05	1.5	0.0014		6.0	-1.25	0.0	
4th quintile	121.2	0.203	1.00	0.0	0.0072		0.0	6.46	8.4	
5th quintile	128.2	0.267	1.06	1.8	-0.0012		7.0	25.11	0.1	
Total	**127.7**		**1.17**	**8.4**	**-0.0056**	**-0.036**	**20.2**	**-0.71**	**19.9**	**-4.6**
1999										
1st quintile	101.6	0.319	1.00	0.0	0.0000		0.0	-22.07	18.1	
2nd quintile	127.9	0.057	1.26	6.6	-0.0044		26.3	-2.22	20.1	
3rd quintile	123.1	0.122	1.21	5.4	-0.0074		21.5	-1.89	23.9	
4th quintile	101.7	0.204	1.00	0.0	0.0076		0.1	4.15	11.0	
5th quintile	112.9	0.298	1.11	2.8	-0.0104		11.3	23.62	4.3	
Total	**109.1**		**1.26**	**14.6**	**0.0146**	**0.094**	**26.3**	**1.59**	**77.4**	**10.2**
Δ88 to 99	-18.6		0.09	6.2	0.020	0.130	6.1	2.3	57.5	14.8
%Δ	-14.6%		7.7%	73.8%	-360.7%	-360.9%	30.2	-322.8%	288.2%	-323.0%

*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

Figure 8 shows the trends in absolute and relative socioeconomic disparity in lung cancer incidence among females. For relative disparity (left panel) both the Relative Concentration Index and the Index of Disparity generally show increases in lung cancer disparity over time, but during the periods 1990-91 and 1993-94 the RCI shows disparity decreasing (i.e., moving towards zero) while the IDisp shows disparity increasing (boxed areas on right panel of Figure 8). A similar situation is seen for the trend in absolute disparity. The Between Group Variance and the Slope Index of Inequality show similar increases in absolute disparity over time, but from 1990-91 the SII shows little change while the BGV shows an increase (boxed areas on graph); the opposite is true from 1994-95.

Figure 8. Trends in relative and absolute socioeconomic disparity in lung cancer incidence among females 45-74, 1988-99.



Case Study 3: Area-Socioeconomic Disparities In Colorectal Cancer Mortality, 1950-2000

The data for this analysis come from the following two SEER databases, "Mortality - Cancer, Total U.S. (1950-2000)" and "Socio-Economic Attributes - Total U.S. (1969+ county definitions)." The measure of socio-economic position for each individual case, derived from the SEER variable "SES Index 1990 unweighted quintile," was based on state and county of residence in the 1990 US Census. An index of socioeconomic position, based on 11 aspects of material, social, and economic environment (e.g., education, employment, income, housing, etc.) reported in the 1990 US Census was created for each county. The detailed methods for the construction of the index are given in Singh GP et al., "Changing Area Socioeconomic Patterns in U.S. Cancer Mortality, 1950-1998: Part I—All Cancers Among Men." *JNCI* 2002;94:904-15 (13). All counties in the United States were classified into five categories of equal number of counties to create quintiles of socioeconomic position based on the value of the SEP index. Similar to Singh et al., the categorization of counties in 1990 was used in all years, as Singh et al. found very the 1990 ranking to be very reliable over time. The detailed analyses are presented for individuals ages 45-74, but a summary of results for those ages 75 and over are also presented. Rates are not age-adjusted.

Males

Rates of colorectal cancer mortality among socioeconomic groups are plotted in Figure 9. It is clear that in 1950 mortality rates were higher among residents of higher-SEP areas, but while rates among the higher-SEP 4th and 5th quintiles declined slowly over the next 40 years rates among the lower-SEP 1st-3rd quintiles increased. It also appears that since 1990 the rates have been declining for all socioeconomic groups. Table 10 shows the underlying data documenting two major changes in the distribution of colorectal cancer mortality from 1950-2000: 1) colorectal cancer mortality rates declined among higher area-SEP groups and increased among lower area-SEP groups, and 2) the fraction of the population living in the highest SEP area (5th quintile) increased while decreasing in all other quintiles.

Figure 9. Trends in colorectal cancer mortality among males 45-74 by area-socioeconomic position, 1950-2000.

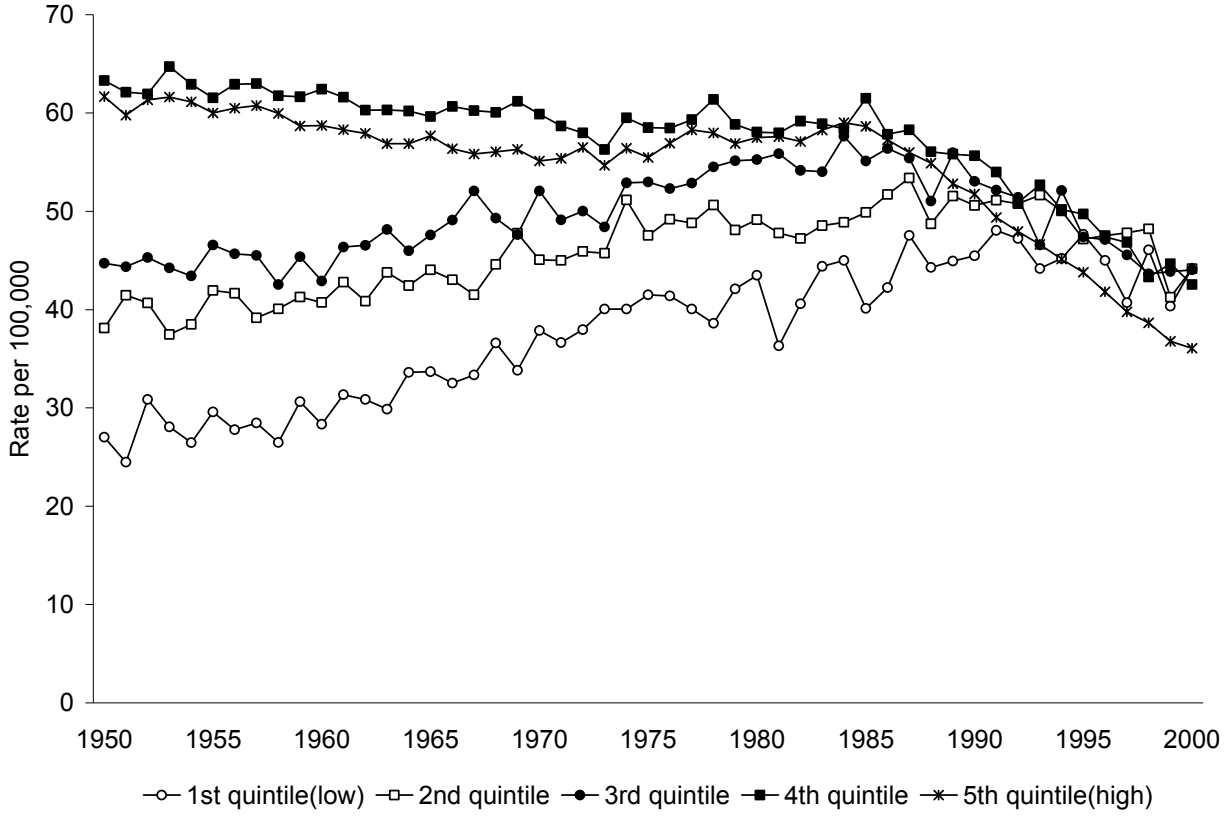


Table 10. Rates of colorectal cancer mortality and population share by area socioeconomic quintile among males 45-74, 1950-2000

	1st quintile (low)		2nd quintile		3rd quintile		4th quintile		5th quintile (high)	
Year	Rate	% Pop	Rate	% Pop	Rate	% Pop	Rate	% Pop	Rate	% Pop
1950	27.0	6.2	38.1	8.0	44.7	10.3	63.3	25.1	61.7	50.4
1960	28.3	5.5	40.7	7.3	42.9	9.6	62.4	23.8	58.7	53.9
1970	37.9	4.9	45.1	6.6	52.1	9.0	59.9	22.3	55.1	57.2
1980	43.5	4.8	49.2	6.5	55.2	9.3	58.1	18.6	57.5	60.8
1990	45.5	4.5	50.6	6.1	53.0	8.9	55.7	17.9	51.8	62.6
2000	44.2	4.5	44.2	6.1	44.0	8.7	42.6	17.2	36.1	63.5
Δ1950 to 2000	17.2	-1.7	6.0	-1.9	-0.7	-1.6	-20.7	-7.9	-25.6	13.1
%Δ	63.5	-27.2	15.8	-24.0	-1.5	-15.9	-32.8	-31.4	-41.5	26.0

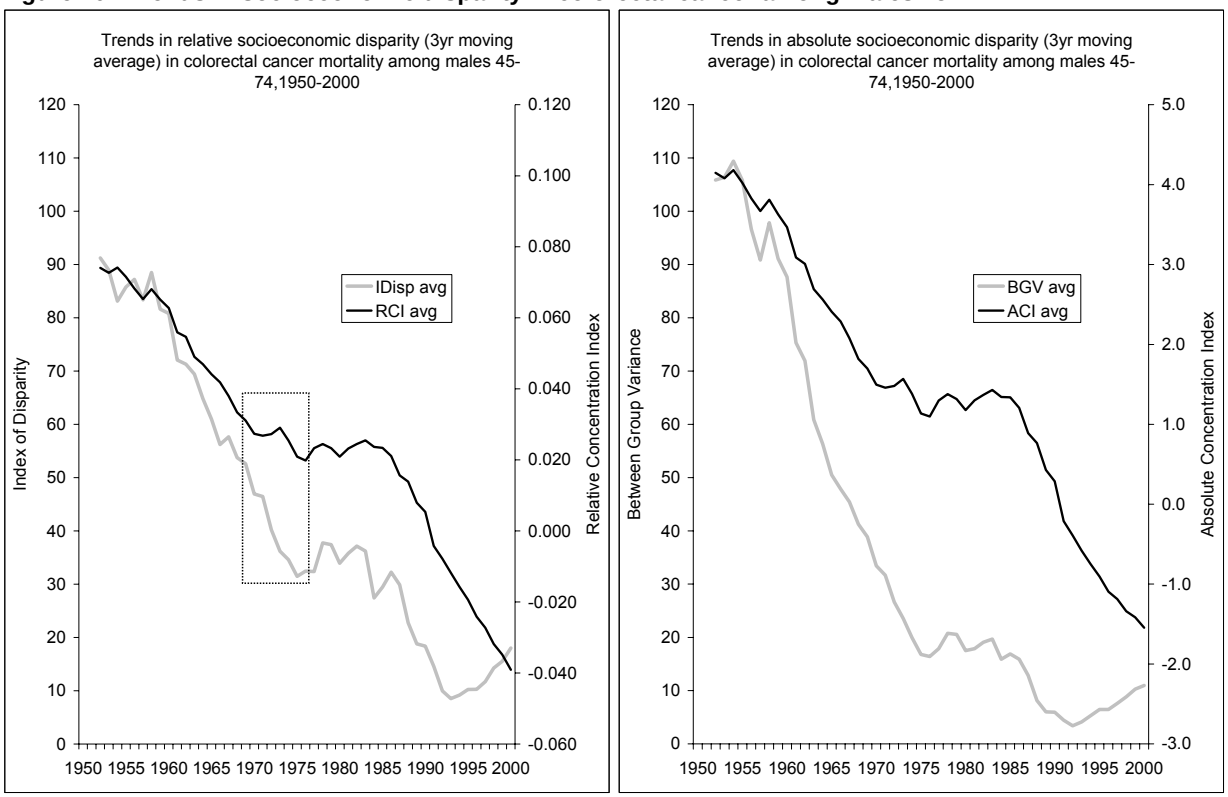
Table 11. Measures of disparity in each decade and percent change in disparity by decade among males 45-74, 1950-2000

	Measures of Relative Disparity				Measures of Absolute Disparity			
Year	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1950	2.34	92.1	0.0792	0.557	36.25	4.5	119.6	31.3
1960	2.20	80.6	0.0607	0.440	34.08	3.3	88.3	24.2
1970	1.58	40.0	0.0213	0.160	22.02	1.2	26.7	8.7
1980	1.34	26.5	0.0213	0.166	14.58	1.2	12.8	9.3
1990	1.22	16.0	-0.0010	-0.008	10.19	-0.1	4.5	-0.4
2000	1.23	21.3	-0.0451	-0.367	8.13	-1.7	12.6	-14.2
Δ1950 to 2000	-1.12	-70.9	-0.1243	-0.924	-28.12	-6.2	-107.0	-45.6
%Δ1950 to 2000	-83.2%	-76.9%	-156.9%	-165.9%	-77.6%	-139.1%	-89.5%	-145.3%
%Change in Disparity								
%Δ1950 to 1960	-10.3%	-12.5%	-23.3%	-21.0%	-6.0%	-25.0%	-26.2%	-22.7%
%Δ1960 to 1970	-51.6%	-50.3%	-64.9%	-63.7%	-35.4%	-65.3%	-69.7%	-64.1%
%Δ1970 to 1980	-42.3%	-33.9%	-0.2%	4.1%	-33.8%	3.1%	-52.3%	7.5%
%Δ1980 to 1990	-33.2%	-39.4%	-104.6%	-104.7%	-30.1%	-104.3%	-64.5%	-104.4%
%Δ1990 to 2000	0.7%	32.7%	4494.0%	4562.6%	-20.2%	3307.9%	178.4%	3358.8%

*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

All of the measures of relative disparity indicate that the magnitude of disparity is lower in 2000 than in 1950 (Table 11, row labeled "%Change1950 to 2000"). However, note that the Index of Disparity does not distinguish between positive gradients (i.e. higher mortality among higher area-SEP individuals from 1950-1980) and negative gradients (i.e. higher mortality among lower area-SEP individuals), while the RCI and RII capture the reversal of the gradient that occurs between 1980 and 1990. During the 1970s both the Rate Ratio and the Index of Disparity registered strong declines (-22.1% and -33.9%, respectively), whereas the RCI and RII showed virtually no decline. This seems likely due to the worsening of the mortality rate in the reference group for these measures (i.e., the 1st quintile). All of the measures of absolute disparity also registered lower values in 2000 than in 1950, strongly suggesting that absolute area-socioeconomic disparities in colorectal cancer have declined. However, the magnitude of the decline was greater when measured with the SII, which additionally captures the reversal of the gradient over time. For absolute disparity, between 1970 and 1980 both the ACI and the Slope Index show very small increases in disparity, but the RD and the BGV show declines.

Figure 10. Trends in socioeconomic disparity in colorectal cancer among males 45-74.



Trends for the absolute and relative disparity measures among males are presented in Figure 10. Generally, for relative disparity the IDisp and the RCI show similar trends, but note that the RCI crosses the zero line around 1990, demonstrating the reversal of the socioeconomic gradient in colorectal cancer mortality. The boxed area in the left panel of **Figure 10** shows that during the approximate period of 1970-80 the IDisp declines but the RCI shows little change. It seems likely that this is due to the increase in the rate among the 1st quintile, which is the referent group for the IDisp, but only accounts for about 5% of the total population, which would have less effect on a population-weighted measure such as the RCI. In terms of absolute disparity, the BGV and the ACI tend to follow similar trajectories, but again, the period of the 1970s shows continued declines in the BGV but little change in the SII, as the movement of the group furthest away from the population rate (the 1st quintile), which receives additional weight in the calculation of the BGV, contributes to declines in the BGV.

Females

Rates of colorectal cancer mortality by socioeconomic groups are plotted for females in Figure 11. Overall the rates are slightly lower than for males, but the general temporal pattern is the same. In 1950 colorectal cancer mortality rates were substantially higher among women living in higher-SEP areas, but over the next 50 years rates declined fastest for this group and slowest for women living in lower-SEP areas. In fact, rates of colorectal cancer mortality were relatively flat for women living in the bottom 3 quintiles until they began sustained declines around 1990.

Figure 11. Trends in colorectal cancer mortality among females 45-74 by area-socioeconomic position, 1950-2000.

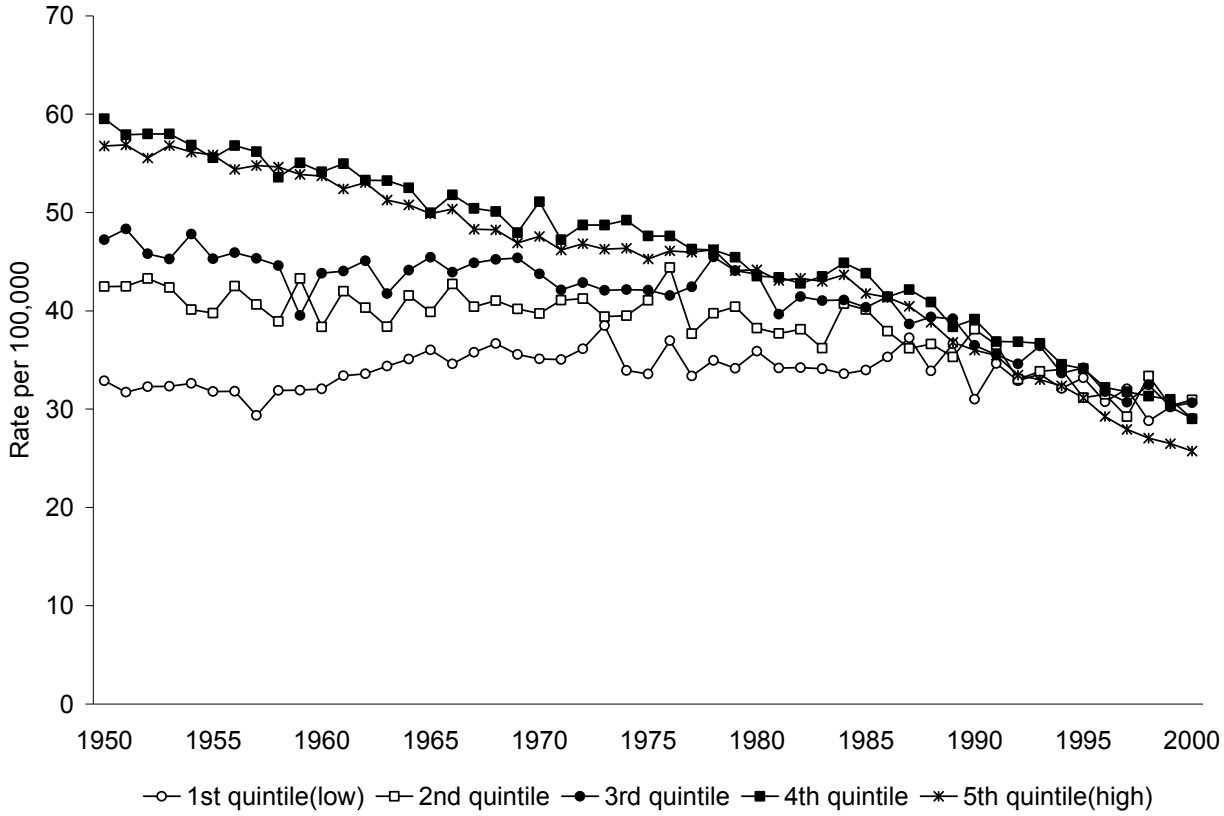


Table 12. Rates of colorectal cancer mortality and population share by area socioeconomic quintile among females 45-74, 1950-2000

	1st quintile		2nd quintile		3rd quintile		4th quintile		5th quintile	
Year	Rate	% Pop	Rate	% Pop	Rate	% Pop	Rate	% Pop	Rate	% Pop
1950	32.9	5.9	42.5	7.8	47.2	10.0	59.5	24.8	56.8	51.5
1960	32.1	5.3	38.4	7.2	43.8	9.3	54.1	23.8	53.7	54.4
1970	35.1	4.9	39.7	6.6	43.7	8.8	51.1	22.7	47.6	57.1
1980	35.9	4.9	38.2	6.5	43.7	9.4	43.5	18.9	44.2	60.4
1990	31.0	4.6	38.1	6.2	36.5	8.9	39.1	18.2	36.0	62.1
2000	29.1	4.4	30.9	6.0	30.7	8.6	29.0	17.4	25.7	63.6
Δ1950 to 2000	-3.8	-1.4	-11.5	-1.9	-16.6	-1.5	-30.5	-7.4	-31.0	12.1
%Δ	-11.6	-24.3	-27.1	-23.8	-35.1	-14.5	-51.3	-29.8	-54.7	23.6

Table 12. Rates of colorectal cancer mortality and population share by area socioeconomic quintile among females 45-74, 1950-2000

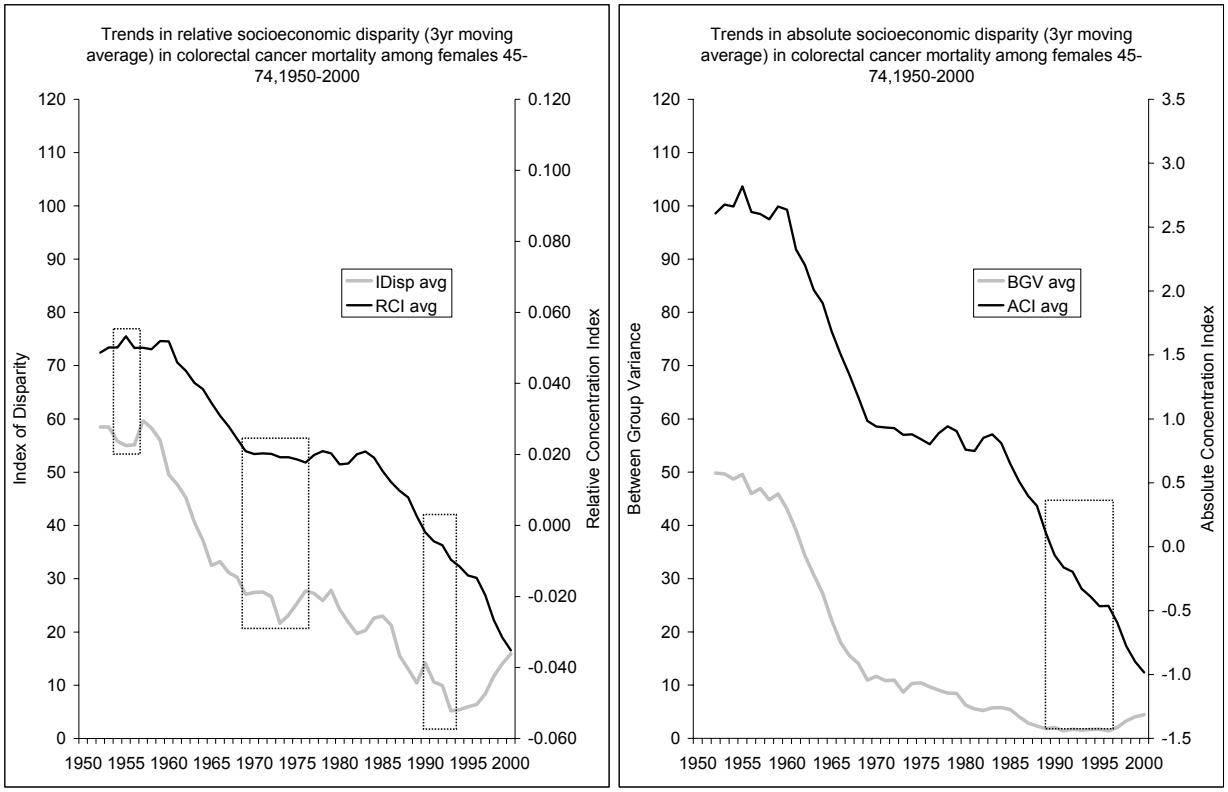
	Measures of Relative Disparity				Measures of Absolute Disparity			
Year	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1950	1.81	56.6	0.0487	0.345	26.63	2.63	52.7	18.6
1960	1.69	48.2	0.0508	0.369	22.07	2.57	41.6	18.7
1970	1.45	29.7	0.0201	0.151	15.97	0.94	15.2	7.1
1980	1.23	18.2	0.0182	0.142	8.31	0.79	4.9	6.1
1990	1.26	20.8	-0.0046	-0.037	8.14	-0.17	3.0	-1.3
2000	1.20	16.4	-0.0354	-0.289	5.23	-0.96	4.0	-7.8
Δ1950-2000	-0.61	-40.2	-0.0841	-0.634	-21.40	-3.59	-48.7	-26.5
%Δ1950-2000	-74.9%	-71.1%	-172.7%	-183.6%	-80.4%	-136.6%	-92.4%	-142.1%
%Change in Disparity								
%Δ1950 to 1960	-14.9%	-14.8%	4.2%	7.0%	-17.1%	-2.2%	-21.1%	0.4%
%Δ1960 to 1970	-34.0%	-38.5%	-60.4%	-59.3%	-27.7%	-63.3%	-63.4%	-62.3%
%Δ1970 to 1980	-49.1%	-38.5%	-9.2%	-5.8%	-48.0%	-16.3%	-68.0%	-13.2%
%Δ1980 to 1990	13.4%	13.9%	-125.3%	-125.9%	-2.0%	-121.3%	-38.8%	-121.9%
%Δ1990 to 2000	-22.6%	-21.2%	668.8%	686.7%	-35.8%	472.2%	33.6%	485.5%

*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

Changes in area-socioeconomic disparities for females are presented in Table 13. All of the relative measures show declines in socioeconomic disparity, but the RCI and RII register larger declines and demonstrate that the gradient in 2000 favors the better off while the gradient in 1950 favored the worse off. Between 1950 and 1960 both the RR and the IDisp showed approximately 15% declines in relative disparity, while the RCI and RII showed increases of 5-7%. In terms of absolute disparity, all measures showed declines in the magnitude of disparity over time, but the change was slightly larger for the ACI and SII as for the RD and BGV. Similar to the results for relative disparity, from 1950-60 the SII increased slightly while all three other measures of disparity declined. In 2000 the relative gradient, as measured by the RII, was almost as large in favoring the better off (-0.29) as it was in 1950 (0.35) when it favored the worse off. In absolute terms, however, the SII in 2000 is less than half the magnitude (-7.8) it was in 1950 (18.6). This reflects the fact that rates for all socioeconomic groups have generally been declining among women 45-74.

Trends in disparity for females 45-74 are presented in Figure 12. For relative disparity, the IDisp and the RCI generally show similar trends. However, from 1951-55 there is a sharp increase in the RCI but a sharp decrease in the IDisp. Additionally, from the late 1960s to the late 1970s the RCI remained approximately constant while the IDisp continued to decline. In terms of absolute disparity, the BGV and the SII generally show similar trends, except for the period from the late 1980s to the late 1990s, which the BGV remained approximately constant but the SII continued to decline (boxed area on right panel graph).

Figure 12. Trends in socioeconomic disparity in colorectal cancer among females 45-74.



DIAGNOSTICS

Why do some results differ for the IDisp and the RCI?

For three different decades among females 45-74 (1950-60, 1980-90, 1990-2000) the RR and IDisp suggest that the change in disparity is in the opposite direction than the RCI and RII. For example, the percent change in socioeconomic disparity from 1990 to 2000, shown in the last row of Table 13 indicates disagreement for both relative and absolute measures of disparity. The RR and IDisp indicate a 20% reduction in disparity, while the RII and RCI indicate a substantial increase in disparity. In absolute terms the RD also shows a decline in absolute disparity, but the BGV indicates a 34% increase and the SII and ACI indicate a much larger increase. Is it possible to reconcile these observed differences?

Again, recall that the RCI and IDisp differ by both the reference group they use and the weights attached to each group's health. Table 14 shows results of a simulation for hypothetical disparity measures that attempt to minimize these differences. Simply weighting the standard IDisp (column 4) by population size actually increases the magnitude of the decrease in disparity (-68% change compared to -21% for unweighted). Using the population average as the reference group for the IDisp generates an increase in disparity (63%), while population weighting plus using the population average as the reference group further magnifies the disparity increase (115% change). Nevertheless, even in this case the relative change in the IDisp is quite a bit lower than the near 700% increase shown by the RCI. Thus, unlike the hypothetical results given for lung cancer incidence in Table 7, simply weighting the IDisp does not provide results similar to the observed values of the RCI and RII.

Table 14. Changes in socioeconomic disparity in colorectal cancer incidence among females 45-74 using alternative measures of disparity.

	Observed IDisp	Observed RCI	Population Weighted IDisp	Unweighted IDisp with population average as reference group	Weighted IDisp with population average as reference group	Unweighted RCI
1990	20.8	-0.0046	4.44	5.64	0.63	-2.47
2000	16.4	-0.0354	1.42	9.16	1.36	-2.92
Δ90 to 00	-4.4	-0.0308	-3.03	3.53	0.73	-0.45
%Δ	-21.2%	668.8%	-68.1%	62.6%	115.2%	18.2%

The reason that the RCI and the IDisp may not be reconcilable in this example has to do with the fact that, in addition to weighting each subgroup by its population fraction, the RCI (and RII) also gives additional weight to the health of the worst-off social groups. This is what makes such measures sensitive to the direction of the socioeconomic gradient (6). Figure 13 shows the observed mortality change by area-socioeconomic quintile from 1990 to 2000, and Table 15 below demonstrates the sensitivity of the RII/RCI to different orderings of socioeconomic groups. For example, the worst off group (quintile 1) had the lowest mortality rate in 1990 but the slowest decline in mortality from 1990-2000. Table 15 shows that, if the position of quintile 1 and quintile 4 are reversed (i.e., if "Q1" and "Q4" are exchanged in **Figure 13**), the estimated RCI in 1990 increases (-0.0137 vs. -0.0046 observed) and the magnitude of the increase the RCI over time is reduced (140.8% vs. 668.8% observed). The change in the ACI is similar, but note that both the IDisp and the BGV are insensitive to the ordering of the socioeconomic groups. Thus, because measures like the RCI/RII and ACI/SII are sensitive to *which* groups are changing, there may be cases for which it is impossible to reconcile their results with that of disparity measures (e.g., the Index of Disparity) that are not sensitive to which groups change.

Figure 13. Observed change in colorectal cancer mortality among females 45-74 by area-socioeconomic position, 1990 and 2000.

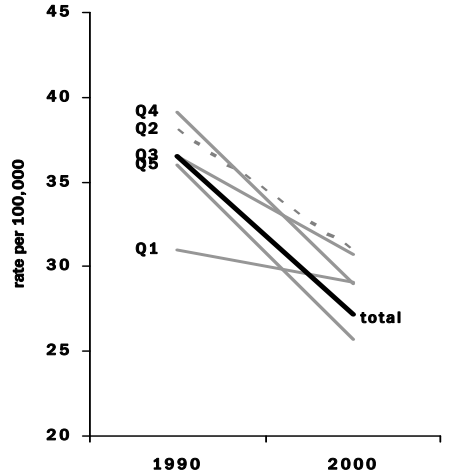


Table 15. Changes in socioeconomic disparity in colorectal cancer incidence among females 45-74 for different orderings of socioeconomic groups.

		Relative Disparity		Absolute Disparity	
Scenario*	Year	IDisp	RCI	BGV	ACI
Observed change	1990	20.8	-0.0046	2.98	-0.17
	2000	16.4	-0.0354	3.98	-0.96
	%Δ	-21.2%	668.8%	33.6%	472.2%
	1990	20.8	-0.0057	2.98	-0.21
Exchange 1st and 2nd quintiles	2000	16.4	-0.0358	3.98	-0.97
	%Δ	-21.2%	526.6%	33.6%	366.4%
	1990	20.8	-0.0065	2.98	-0.24
Exchange 1st and 3rd quintiles	2000	16.4	-0.0361	3.98	-0.98
	%Δ	-21.2%	459.9%	33.6%	316.7%
	1990	20.8	-0.0137	2.98	-0.50
Exchange 1st and 4th quintiles	2000	16.4	-0.0329	3.98	-0.89
	%Δ	-21.2%	140.8%	33.6%	79.2%
	1990	20.8	0.0071	2.98	0.26
Exchange 1st and 5th quintiles	2000	16.4	0.0320	3.98	0.87
	%Δ	-21.2%	350.4%	33.6%	235.2%

*Alternative scenarios exchange the rate and population size of different socioeconomic quintiles and recalculate mortality disparity.

Case Study 4: Area-Socioeconomic Disparities in Prostate Cancer Mortality, 1950-2000

The data for this analysis come from the following two SEER databases, "Mortality - Cancer, Total U.S. (1950-2000)" and "Socio-Economic Attributes - Total U.S. (1969+ county definitions)." The measure of socio-economic position for each individual case, derived from the SEER variable "SES Index 1990 unweighted quintile," was based on state and county of residence in the 1990 US Census. An index of socioeconomic position, based on 11 aspects of material, social, and economic environment (e.g., education, employment, income, housing, etc.) reported in the 1990 US Census was created for each county. The detailed methods for the construction of the index are given in Singh GP et al., "Changing Area Socioeconomic Patterns in U.S. Cancer Mortality, 1950-1998: Part I—All Cancers Among Men." *JNCI* 2002;94:904-15 (13). All counties in the United States were classified into five categories of equal number of counties to create quintiles of socioeconomic position based on the value of the SEP index. The analyses are stratified by age (45-74, 75 and over) and rates are not age-adjusted.

Ages 45-74

Rates of prostate cancer mortality from 1950-2000 among those ages 45-74 by area-socioeconomic position are shown in Figure 14. In 1950 mortality rates were relatively equal across income quintiles, but began to diverge around 1960, as the highest income quintile experienced a decline in mortality as rates began rising for lower-income quintiles. Rates for all groups began increasing rather steeply after 1970 or so but have declined dramatically since the early 1990s. Over the entire period from 1950 to 2000, Table 16 shows that the 5th quintile (high area-SEP) experienced the largest decline in prostate cancer mortality rates (-9.1 deaths per 100,000), while the 1st quintile (low area-SEP) experienced the smallest (-1.3 deaths per 100,000). In addition, a considerable shift is noticeable in the distribution of the population over time, with the 5th quintile increasing its share of the population from 50.4% to 63.5% while all other quintiles lost population.

Figure 14. Trends in prostate cancer mortality among males 45-64, by quintile of area-socioeconomic position, 1950-2000.

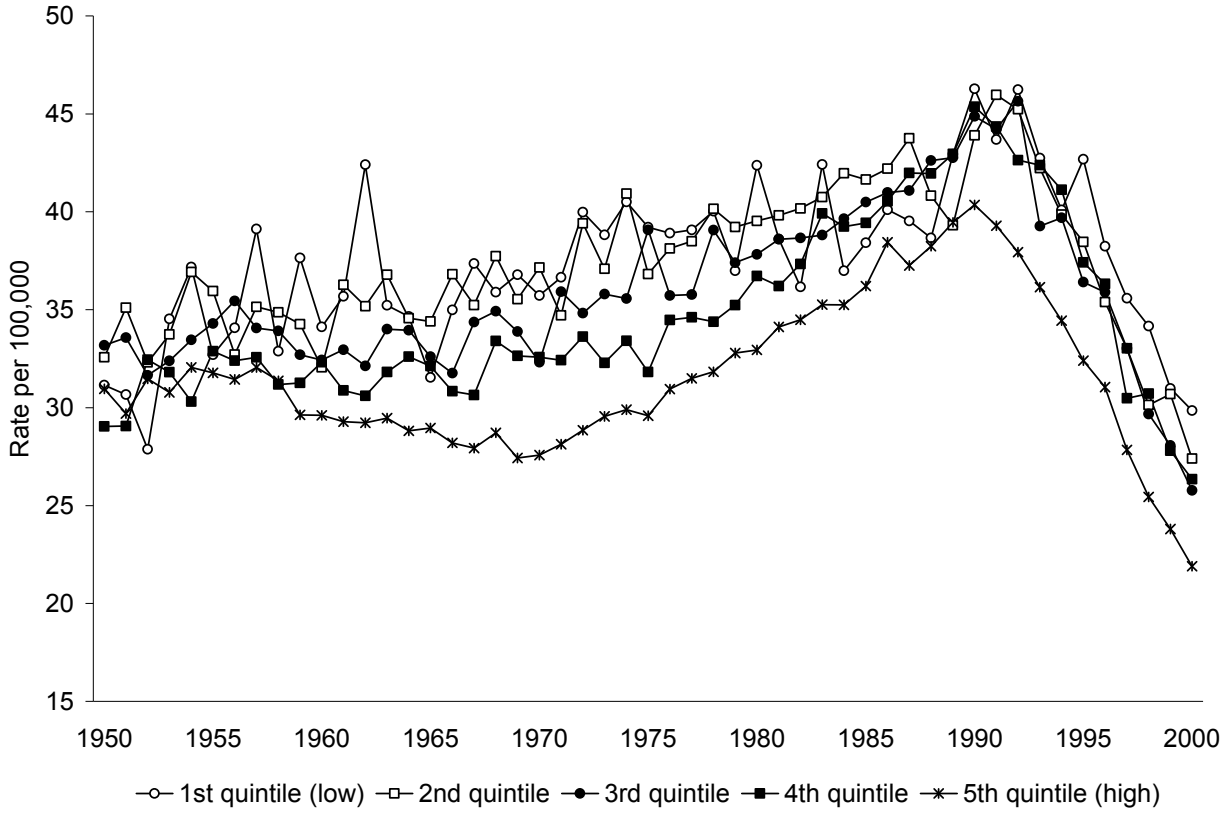


Table 16. Rates of prostate cancer mortality and population share by area socioeconomic quintile among those 45-74, 1950-2000

	1st quintile		2nd quintile		3rd quintile		4th quintile		5th quintile	
Year	Rate	% Pop	Rate	% Pop	Rate	% Pop	Rate	% Pop	Rate	% Pop
1950	31.1	6.2	32.6	8.0	33.2	10.3	29.0	25.1	31.0	50.4
1960	34.1	5.5	32.1	7.3	32.4	9.6	32.3	23.8	29.6	53.9
1970	35.7	4.9	37.2	6.6	32.3	9.0	32.6	22.3	27.6	57.2
1980	42.4	4.8	39.5	6.5	37.8	9.3	36.7	18.6	32.9	60.8
1990	46.3	4.5	43.9	6.1	44.9	8.9	45.4	17.9	40.4	62.6
2000	29.9	4.5	27.4	6.1	25.8	8.7	26.3	17.2	21.9	63.5
Δ1950 to 2000	-1.3	-1.7	-5.2	-1.9	-7.4	-1.6	-2.7	-7.9	-9.1	13.1
%Δ	-4.2%	-27.2%	-15.9%	-24.0%	-22.3%	-15.9%	-9.3%	-31.4%	-29.3%	26.0%

Relative and absolute disparities in prostate cancer mortality and the percentage change in each decade from 1950-2000 are presented in Table 17. In general, all of the relative measures show increases in socioeconomic disparity in prostate cancer mortality. However, the magnitude of the increase in relative disparity is considerably larger for the RCI and RII (on the order of 1000% increase) than for the RR or the IDisp (~150% increase). This is likely due to both the steeper decline in the mortality rate among the highest (5^{th}) quintile, which is the most populous and is the only quintile that gained population over this time period.

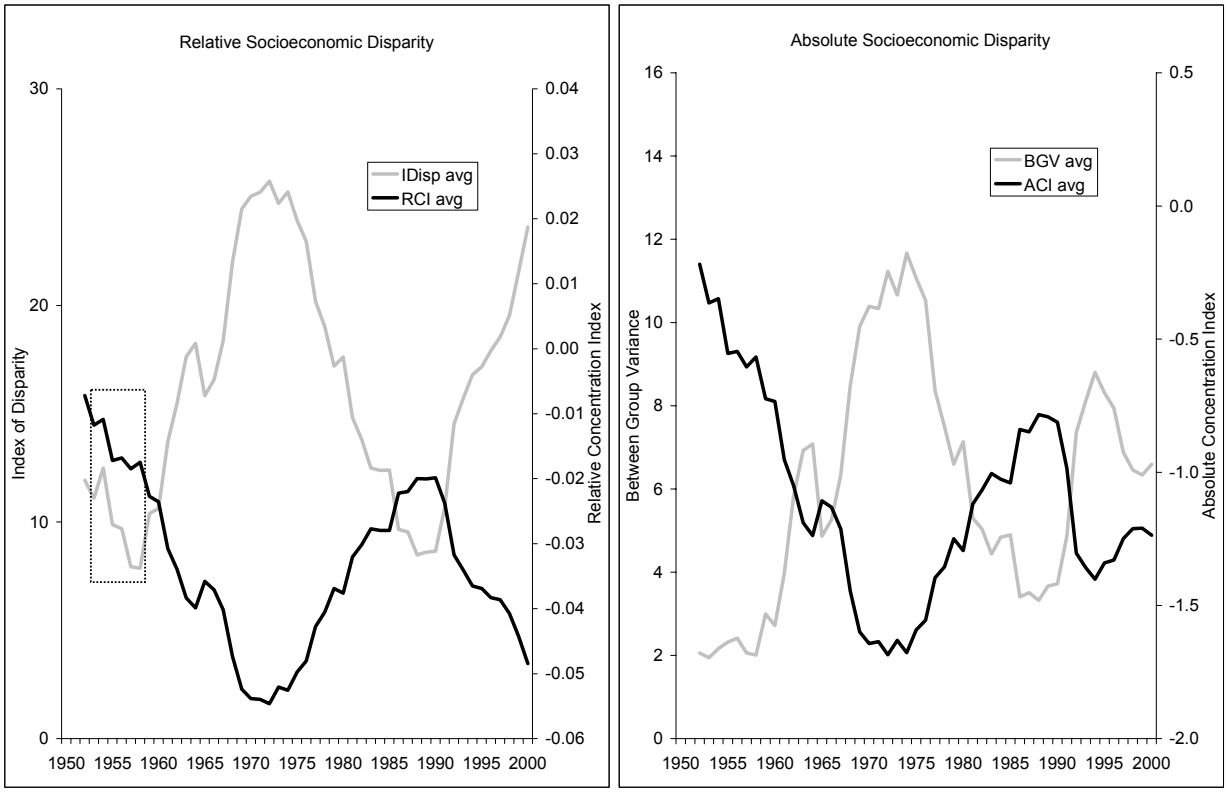
The long term trends in relative and absolute disparity for males 45-74 are shown in Figure 15. In general, the IDisp and the RCI show similar trends for relative socioeconomic disparity in prostate cancer mortality from 1950-2000. However, during the period from the early to the late 1950s (highlighted in boxed area in left panel of Figure 4-2), the RCI was increasing while the IDisp was decreasing. This may have occurred because the referent group in the early 1950s (1^{st} quartile) experienced a sharp increase in prostate cancer mortality. In terms of absolute disparity among males 45-74, the BGV and the SII give very similar pictures of the disparity trend.

Table 17. Measures of socioeconomic disparity in prostate cancer mortality in each decade and percent change in disparity by decade among those 45-74, 1950-2000

	Measures of Relative Disparity				Measures of Absolute Disparity			
Year	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1950	1.14	10.1	-0.004	-0.029	4.2	-0.13	1.6	-0.90
1960	1.15	10.6	-0.025	-0.178	4.5	-0.76	2.3	-5.50
1970	1.35	24.9	-0.053	-0.400	9.6	-1.61	10.3	-12.07
1980	1.29	18.7	-0.040	-0.309	9.4	-1.38	7.8	-10.80
1990	1.15	11.8	-0.026	-0.211	5.9	-1.11	5.5	-8.87
2000	1.36	24.9	-0.051	-0.412	8.0	-1.20	6.2	-9.77
Δ50 to 00	0.22	14.8	-0.05	-0.38	3.8	-6.1	4.5	-8.9
%Δ50 to 00	154.2%	146.4%	1120.6%	1313.7%	91.7%	837.5%	277.2%	986.0%
%Change in Disparity								
%Δ50 to 60	6.7%	4.7%	491.1%	509.3%	8.8%	493.0%	38.8%	511.4%
%Δ60 to 70	128.0%	136.1%	117.8%	125.4%	112.3%	112.3%	354.7%	119.6%
%Δ70 to 80	-17.7%	-24.9%	-26.1%	-22.9%	-1.7%	-14.2%	-24.4%	-10.5%
%Δ80 to 90	-48.7%	-37.1%	-33.5%	-31.8%	-37.1%	-19.9%	-29.7%	-17.8%
%Δ90 to 00	147.4%	111.2%	92.9%	95.8%	34.3%	8.5%	12.4%	10.1%

*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

Figure 15. Trends in area socioeconomic disparity in prostate cancer mortality among those 45-74, 1950-2000



Ages 75 and Over

Rates of prostate for those 75 and over are shown in Figure 16. Rates are notably higher than for males ages 45-74, but the broad trend appears similar, with moderate rise in mortality until the early 1990s, after which rates have steeply declined. Mortality was lower among those living the lower income quintiles in 1950, but lower among those living in the highest income quintiles in 2000. This is a consequence of the overall increase in mortality rates from 1950 to 2000, during which the increase over time was largest among the lowest income quintiles.

Figure 16. Trends in prostate cancer mortality by area socioeconomic position among males 75 and over, 1950-2000.

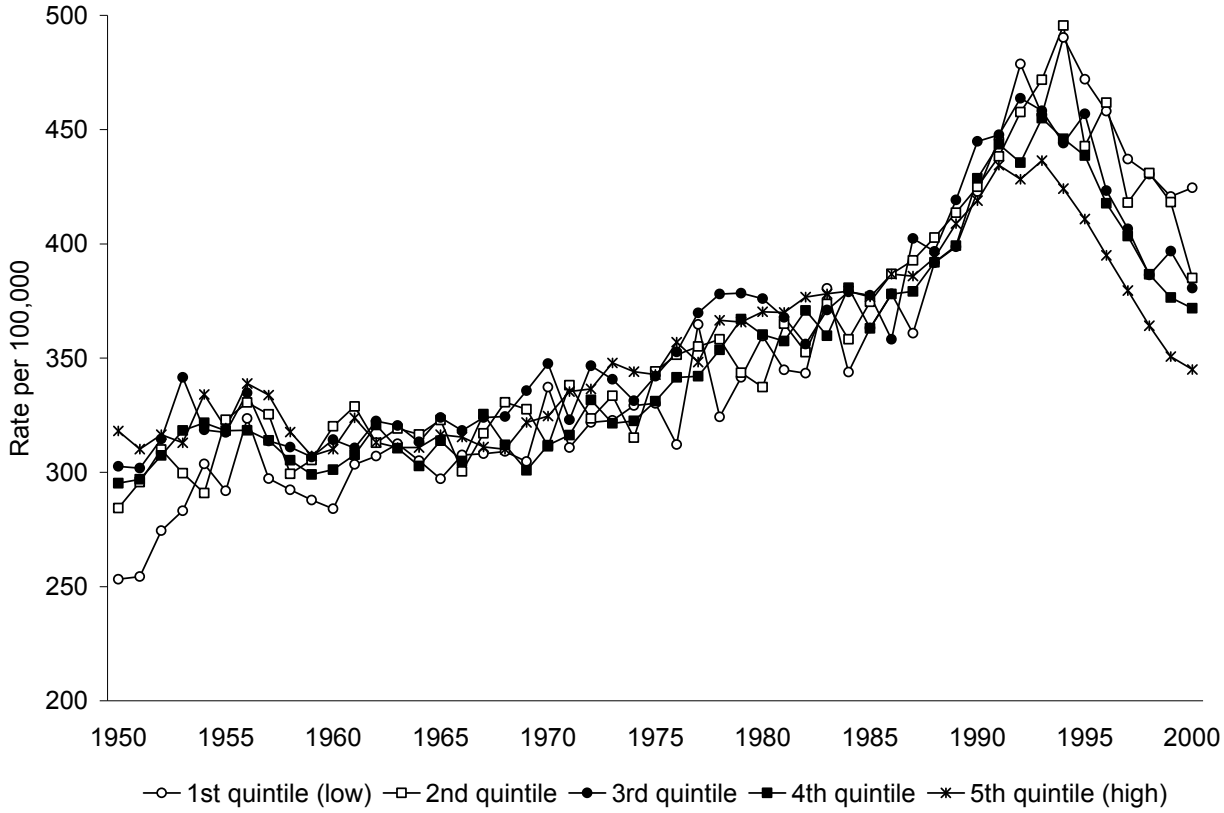


Table 18. Rates of prostate cancer mortality and population share by area socioeconomic quintile among those 75 and over, 1950-2000

	1st quintile		2nd quintile		3rd quintile		4th quintile		5th quintile	
Year	Rate	% Pop	Rate	% Pop	Rate	% Pop	Rate	% Pop	Rate	% Pop
1950	253.2	7.0	284.3	9.3	302.6	12.3	295.2	23.4	318.1	48.0
1960	284.1	6.7	320.1	8.8	314.3	11.4	301.2	23.1	310.2	50.0
1970	337.2	6.0	311.4	7.9	347.6	10.3	311.9	23.2	324.6	52.6
1980	359.7	5.8	337.3	7.6	376.1	10.5	360.2	19.6	370.3	56.5
1990	422.9	5.3	425.0	7.2	444.8	10.0	428.7	19.2	419.0	58.4
2000	424.6	4.5	385.0	6.3	380.6	9.1	371.9	18.6	345.1	61.5
Δ1950 to 2000	171.4	-2.6	100.7	-3.0	77.9	-3.1	76.7	-4.8	26.9	13.5
%Δ	67.7	-36.9	35.4	-31.9	25.8	-25.5	26.0	-20.6	8.5	28.2

In general, Table 19 shows that all of the measures of relative disparity indicate that socioeconomic inequality in prostate cancer among those 75 and over has declined. However, the magnitude of the decline is substantially greater when measured by the RCI and RII (~200%) than when measured by either the RR or the IDisp (10-30% decline).
Additionally, both the RCI and RII show that the gradient has changed from favoring the worse off area-socioeconomic groups to favoring the better off, but the RR and IDisp do not.
In each decade from 1960 to 1990 the magnitude of decline in disparity is considerably greater when measured by the RCI and RII than with the RR and IDisp. For the 1990s the magnitude of increase is similar. All of the measures of absolute disparity show increases, but only the SII indicates that the absolute gradient changed direction over the past 50 years.

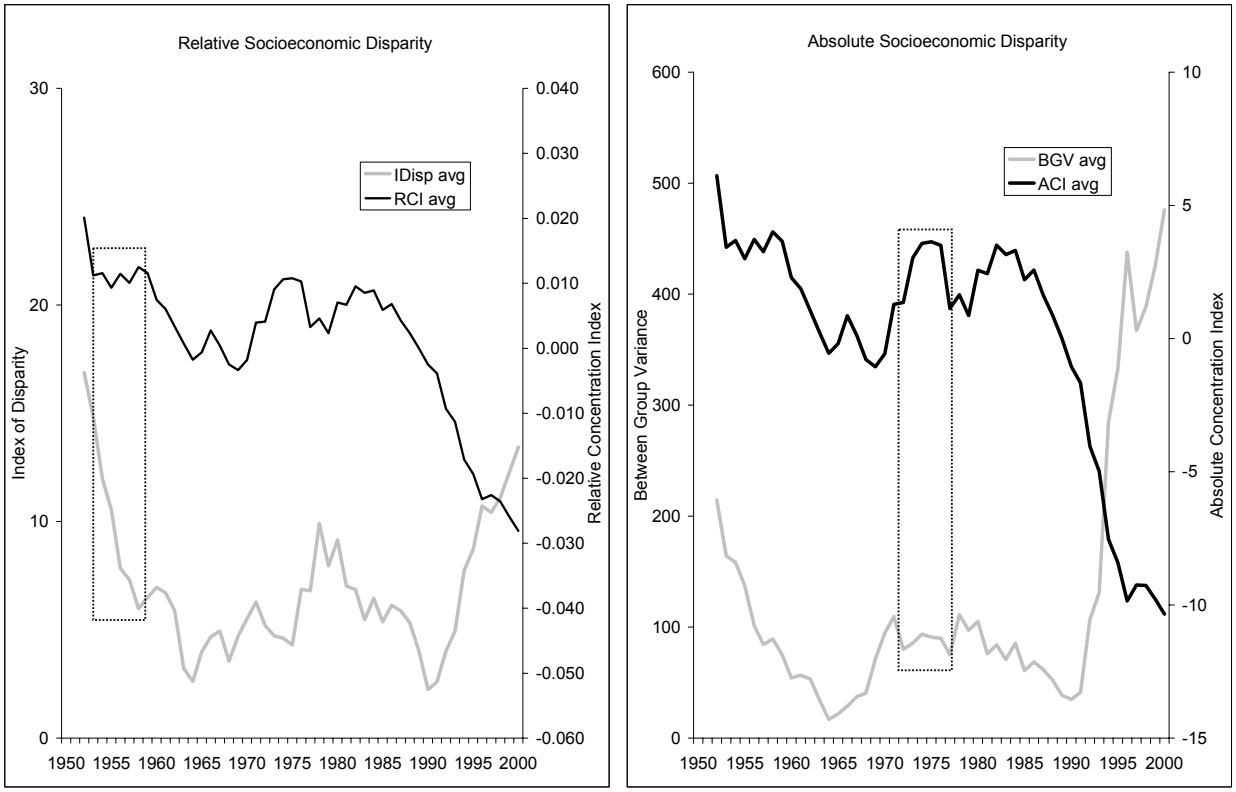
Table 19. Measures of disparity in each decade and percent change in disparity by decade among those 75 and over, 1950-2000

	Measures of Relative Disparity				Measures of Absolute Disparity			
	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1950	1.26	18.5	0.029	0.1982	64.9	8.75	331.4	60.1
1960	1.13	9.6	0.004	0.0261	36.1	1.15	68.7	8.0
1970	1.12	6.1	-0.002	-0.0108	36.2	-0.49	114.1	-3.5
1980	1.11	8.7	0.008	0.0582	38.8	2.88	92.6	21.3
1990	1.06	2.7	-0.007	-0.0519	25.9	-2.90	62.5	-22.0
2000	1.23	13.2	-0.027	-0.2164	79.5	-9.85	427.1	-77.8
Δ50 to 00	-0.03	-5.34	-0.06	-0.41	14.6	-18.6	95.6	-137.8
%Δ50 to 00	-10%	-28.9%	-195.0%	-209.2%	22.4%	-212.6%	28.9%	-229.4%
%Change in Disparity								
%Δ50 to 60	-50.5%	-48.0%	-87.1%	-86.8%	-44.5%	-86.9%	-79.3%	-86.6%
%Δ60 to 70	-8.5%	-36.9%	-140.6%	-141.6%	0.3%	-142.7%	66.0%	-143.7%
%Δ70 to 80	-1.0%	42.8%	-618.4%	-637.1%	7.2%	-685.7%	-18.8%	-706.9%
%Δ80 to 90	-46.2%	-68.7%	-187.1%	-189.1%	-33.2%	-201.0%	-32.6%	-203.3%
%Δ90 to 00	273.0%	384.4%	300.3%	317.3%	207.2%	239.2%	583.7%	253.6%

*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

Trends in relative and absolute disparities in prostate cancer mortality are shown in Figure 17. The IDisp and RCI generally agree with respect to the trend in relative socioeconomic disparity, but the boxed area suggests that during the 1950 the RCI remained approximately constant while the IDisp continued to decline. Overall the BGV and the ACI demonstrate that disparity fell steadily from 1950 to 1970, then remained approximately constant until the mid 1980s, after which absolute disparity has been increasing. However, during the mid 1970s the ACI indicated rising disparity that favored the worse off socioeconomic groups, while the BGV stayed about the same.

Figure 17. Trends in area socioeconomic disparity in prostate cancer mortality among those 75 and over, 1950-2000



Case Study 5: Socioeconomic Disparities in Smoking, 1965-2003

Trends in current smoking were investigated using smoking supplements to the National Health Interview Survey (NHIS), beginning in 1965 and ending in 2003 (n=876,280). Sample weights were used in each survey to account for unequal sampling probabilities and nonresponse. Individuals missing information on age, gender, race, and education were excluded (2.0%), leaving an analytic sample of 859,014. Individuals who reported ever smoking 100 or more cigarettes in their lifetime and who currently smoke were considered "current smokers." Education was categorized as <12 years, 12 years, 13-15 years, 16 years or more, and the analysis was restricted to individuals ages 25 and over.

Males

Rates of current smoking among males 25 and over, by educational status, are presented in Figure 18. In 1965 rates of smoking were clearly lowest among those with 16 or more years of education but relatively similar among other education groups. Since 1965 smoking has declined among all groups, but the decline in smoking appears to have been strongest among those with more education. Table 20 shows that the proportionate decline in smoking from 1965 to 2003 is graded by education, with the least educated group declining by 36.8% and the most educated group by 71.2%. In addition, Table 20 shows the proportion of the male population in each education group from 1965 to 2003 and demonstrates the important secular shifts in education over time. In 1965 roughly 78% of the male population had a high school education or below, but by 2003 this proportion had declined to only 47%.

Figure 18. Trends in the prevalence of smoking by years of education among males, 1965-2003.

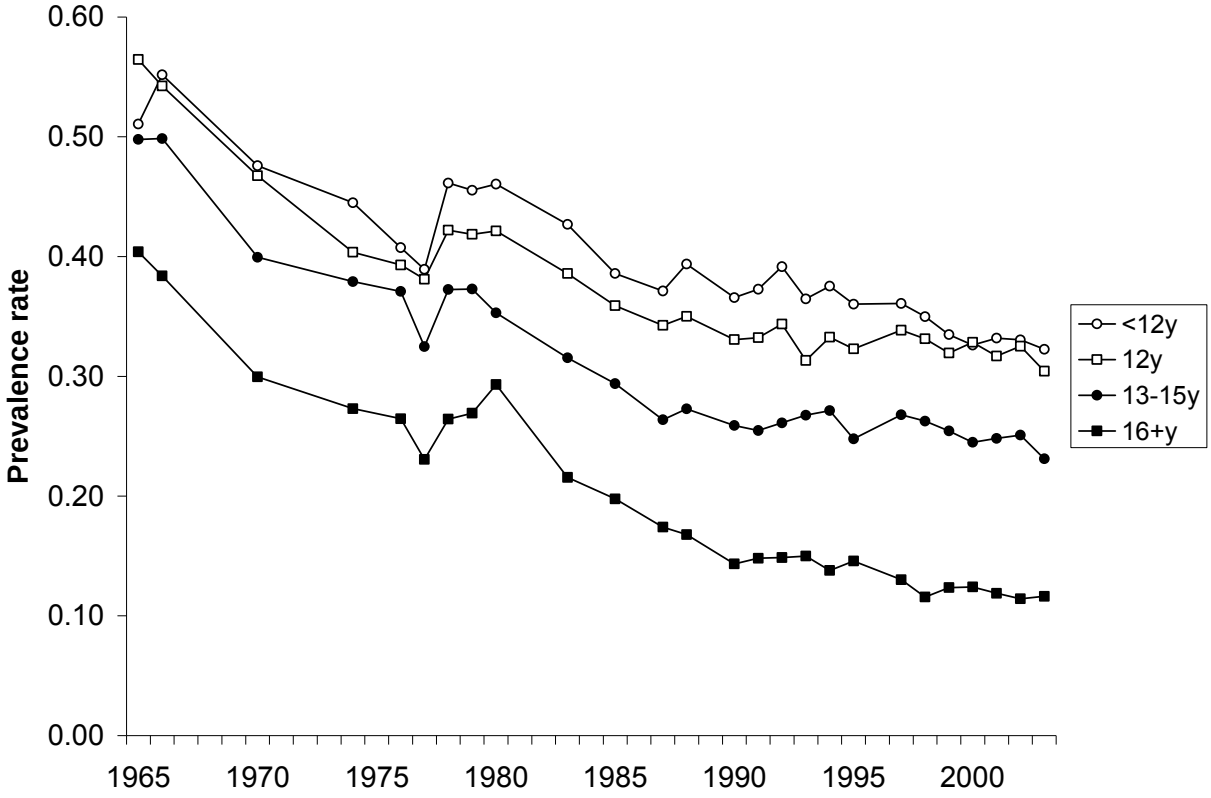


Table 20. Prevalence of current smoking and population distribution among males age 25 and over, by years of education, NHIS selected years 1965-2003

	Prevalence of Current Smoking				Percent of Total Population			
Year	<12y	12y	13-15y	16+y	<12y	12y	13-15y	16+y
1965	0.511	0.564	0.498	0.404	0.296	0.479	0.089	0.136
1970	0.476	0.467	0.399	0.300	0.418	0.309	0.141	0.132
1976	0.407	0.393	0.371	0.265	0.339	0.319	0.163	0.178
1980	0.461	0.421	0.353	0.293	0.283	0.346	0.182	0.189
1985	0.386	0.359	0.294	0.198	0.238	0.357	0.194	0.211
1990	0.366	0.331	0.259	0.143	0.210	0.357	0.203	0.230
1995	0.360	0.323	0.248	0.146	0.182	0.343	0.220	0.255
2000	0.326	0.328	0.245	0.124	0.184	0.299	0.274	0.244
2001	0.332	0.317	0.248	0.119	0.179	0.285	0.282	0.254
2002	0.330	0.325	0.251	0.114	0.166	0.291	0.280	0.263
2003	0.323	0.304	0.231	0.116	0.172	0.292	0.280	0.256
Δ65 to 03	-0.188	-0.260	-0.267	-0.288	-0.124	-0.187	0.191	0.120
%Δ	-36.8%	-46.1%	-53.6%	-71.2%	-42.0%	-39.0%	214.9%	88.4%

Changes in relative and absolute disparity in smoking are given in Table 21. All relative measures show increases in educational disparity over this time period (based on the % change from 1965-2003), but the magnitude of the increase is approximately twice as large for the RCI and RII (~700%) as for the RR or IDisp (~400%). This is likely to be related to both larger declines in smoking among the population with greater than 12 years of education and the substantial increases in the share of the population in these groups, to which the RCI and RII, as population-weighted measures, would be more sensitive. The RCI and RII indicate that educational disparities in smoking among men increased most during the early part of this period, from 1965-76 and the pace of increase has slowed considerably by 2003. On the other hand, the RR and the IDisp show approximately the same relative increase in all periods, with the exception of 1995-2003. In terms of absolute disparity, all of the measures indicate that disparity has increased, but the magnitude of the increase varies. The magnitude of the increase is about twice as large for the ACI and SII (~250%) as for the BGV (122%), while the RD shows only a marginal increase (29%). While the BGV and SII are both population-weighted measures of absolute disparity, the BGV indicates a decrease in disparity from 1965-76, while the SII indicates a strong increase.

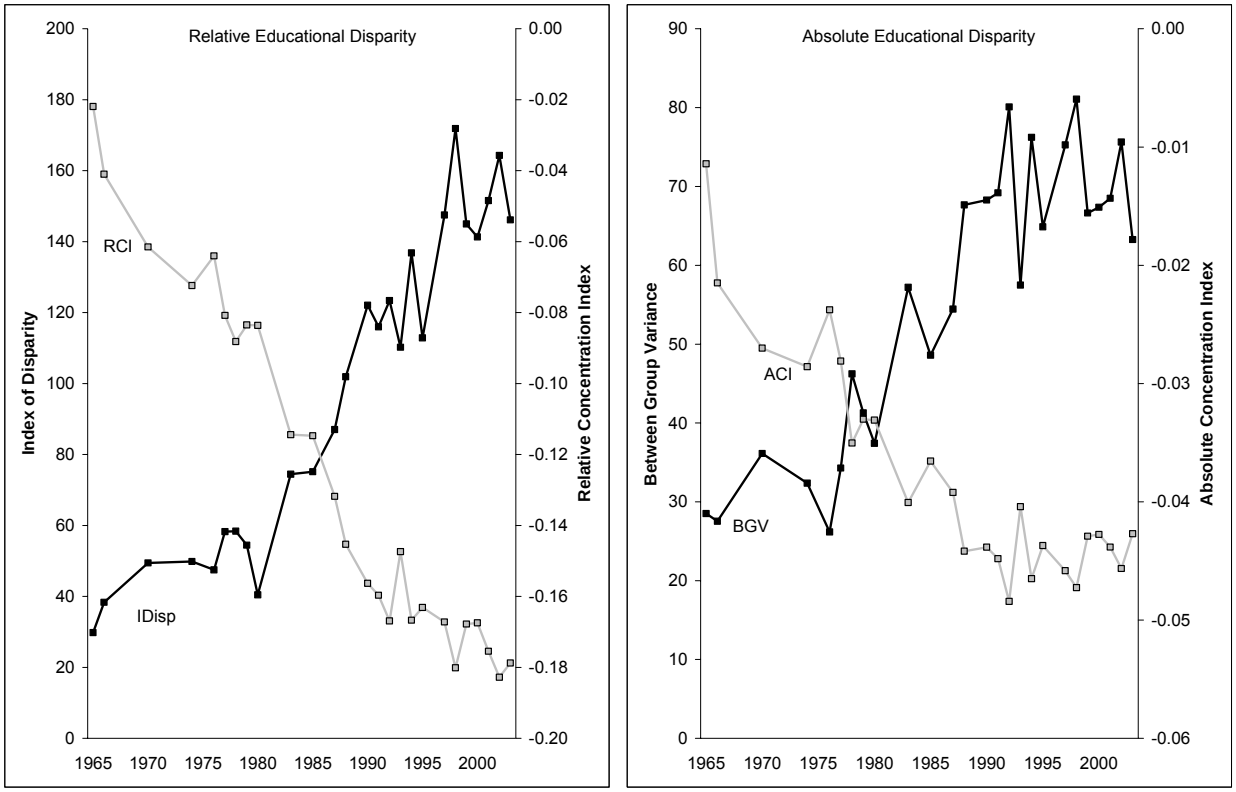
Table 21. Measures of educational disparity in current smoking in selected years and percent change in disparity by year among males 25 and over, 1965-2003

	Measures of Relative Disparity				Measures of Absolute Disparity			
Year	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1965	1.40	29.8	-0.022	-0.153	0.161	-0.0114	28.5	-0.080
1976	1.54	47.5	-0.064	-0.418	0.143	-0.0238	26.2	-0.155
1985	1.95	75.2	-0.115	-0.744	0.188	-0.0366	48.6	-0.237
1995	2.47	112.9	-0.163	-1.056	0.214	-0.0437	64.9	-0.283
2003	2.78	146.1	-0.179	-1.152	0.206	-0.0427	63.3	-0.275
Δ65 to 03	1.38	116.3	-0.157	-0.999	0.046	-0.0313	34.8	-0.196
%Δ	346.6%	390.1%	715.5%	653.8%	28.5%	274.0%	121.9%	245.7%
Δ65 to 76	35.6%	59.3%	192.0%	173.7%	-11.1%	108.2%	-8.1%	95.2%
Δ76 to 85	76.5%	58.3%	79.2%	78.0%	31.8%	53.8%	85.6%	52.8%
Δ85 to 95	54.5%	50.2%	42.2%	41.9%	13.9%	19.5%	33.5%	19.2%
Δ95 to 03	20.7%	29.5%	9.6%	9.0%	-3.7%	-2.3%	-2.5%	-2.8%

*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

Disparity trends among males are shown in Figure 19. Overall, the graphs for relative disparity (left panel) show that the IDisp and the RCI are relatively consistent with respect to the trend in relative educational disparity in smoking, though there are some particular years (e.g., 1979-80) when they indicate disparity is moving in opposite directions. With respect to absolute educational disparity in smoking, Figure 19 generally indicates that absolute disparity increased rather sharply from the mid 1960s to the late 1980s, and has shown minimal increase as the rate of decline in current smoking among all groups has slowed.

Figure 19. Trends in educational disparity in smoking among males 25 and over, 1965-2003.



Females

Rates of current smoking among females from 1965-2003 are shown in Figure 20 and are given, along with the population distribution, in Table 22. While in 1965 differences in smoking appear considerably smaller than for men, the overall pattern of smoking looks similar over time, with the strongest declines in smoking occurring among women with 16 or more years of education. The population distribution of women across educational groups also demonstrates a trend similar to that for men, with substantial increases in the proportion of women with greater than 12 years of education.

Figure 20. Trends in the prevalence of smoking by years of education among females, 1965-2003.

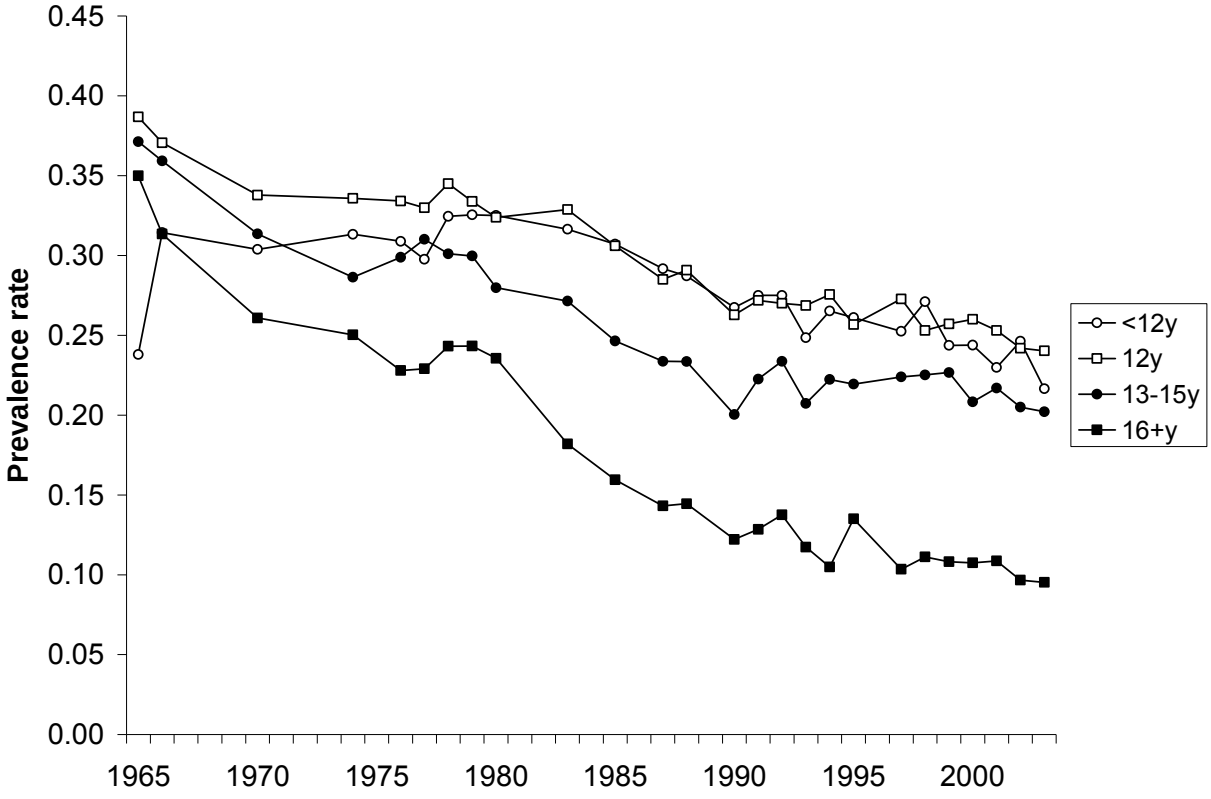


Table 22. Prevalence of current smoking and population distribution among females age 25 and over, by years of education, NHIS selected years 1965-2003

	Prevalence of Current Smoking				Percent of Total Population			
Year	<12y	12y	13-15y	16+y	<12y	12y	13-15y	16+y
1965	0.238	0.387	0.371	0.350	0.267	0.568	0.079	0.086
1970	0.304	0.338	0.314	0.261	0.412	0.384	0.123	0.081
1976	0.309	0.334	0.299	0.228	0.337	0.404	0.144	0.115
1980	0.325	0.324	0.280	0.236	0.291	0.420	0.165	0.124
1985	0.307	0.306	0.247	0.160	0.247	0.420	0.188	0.145
1990	0.267	0.263	0.200	0.122	0.214	0.407	0.207	0.172
1995	0.261	0.257	0.219	0.135	0.189	0.388	0.224	0.199
2000	0.244	0.260	0.208	0.108	0.177	0.313	0.293	0.217
2001	0.230	0.253	0.217	0.109	0.173	0.304	0.301	0.222
2002	0.246	0.242	0.205	0.097	0.166	0.306	0.301	0.227
2003	0.217	0.240	0.202	0.095	0.165	0.299	0.304	0.232
Δ65 to 03	-0.021	-0.147	-0.169	-0.255	-0.101	-0.270	0.225	0.146
%Δ	-9.0%	-37.9%	-45.5%	-72.8%	-38.0%	-47.5%	284.9%	170.1%

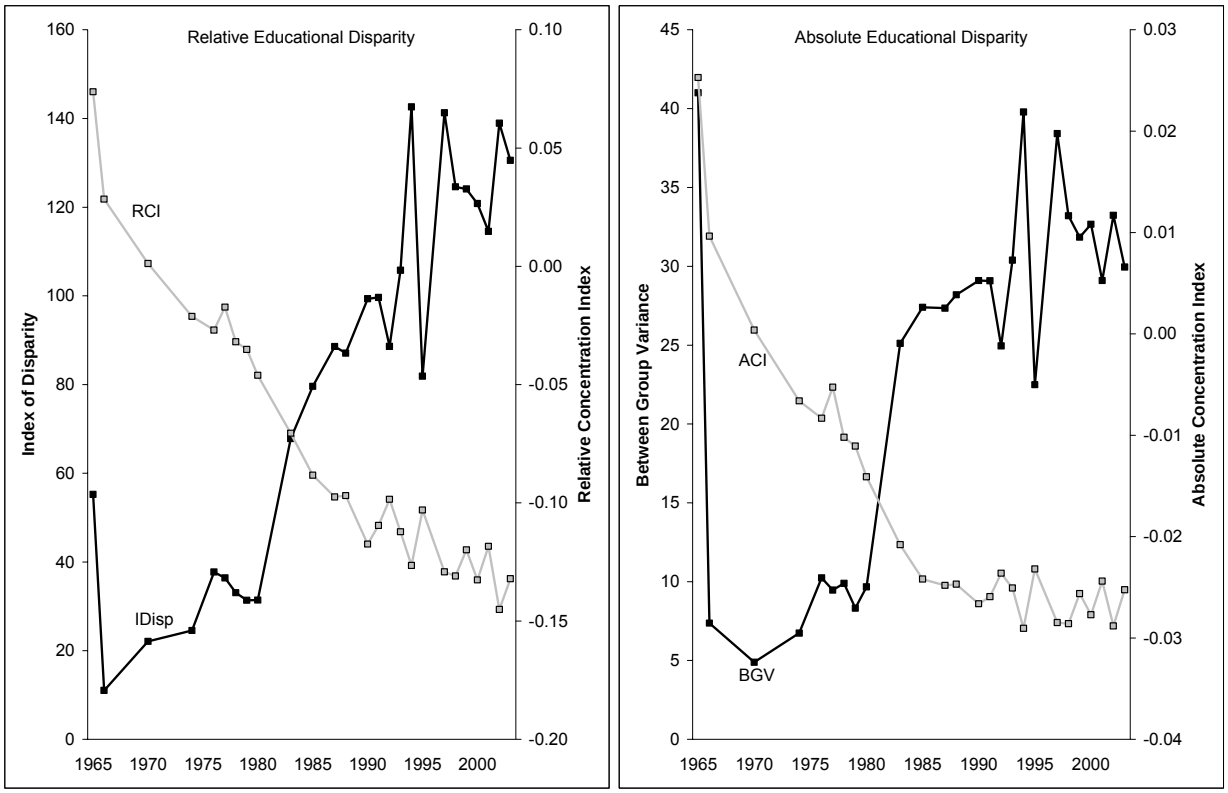
Measures of relative and absolute disparity for females are presented in Table 23. All of the relative measures show increases in educational disparity over this time period (based on the % change from 1965-2003), but similar to the results for males, the magnitude of the increase is approximately twice as large for the RCI and RII as for the RR or IDisp. However, only the RCI and RII indicate that the direction of the gradient changed over this time period (in fact the sign of the % change for the RCI and RII is negative because the gradient changed direction over time, but there is clearly an increase in socioeconomic disparity over time). The RCI and RII indicate that educational disparities in smoking among females (as for males) increased most during the early part of this period, from 1965-85, and the pace of increase has slowed considerably by 2003. On the other hand, the RR and the IDisp show a large increase in disparity from 1995-2003, most likely because the rate in the reference group (16+ years) has continued to decline. In terms of absolute disparity, both the RD and the BGV indicate that educational disparity has declined among females. On the other hand, the ACI and SII show that in 1965 smoking was more concentrated among the better educated but over time this gradient reversed and by 2003 the gradient was similar in magnitude but smoking was more concentrated among the less educated. While the BGV and SII are both population-weighted measures of absolute disparity, the BGV indicates a greater increase (33%) in disparity from 1995-2003 than does the SII (7%). This seems likely due to the fact that the BGV squares deviations further from the population average, and the rate for the 16 and over group declined strongly over this period.

Table 23. Measures of educational disparity in current smoking in selected years and percent change in disparity by year among females 25 and over, 1965-2003

	Measures of Relative Disparity				Measures of Absolute Disparity			
Year	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1965	1.63	55.2	0.074	0.556	0.15	0.0253	41.0	0.191
1976	1.47	37.7	-0.027	-0.182	0.11	-0.0083	10.2	-0.056
1985	1.92	79.6	-0.088	-0.588	0.15	-0.0242	27.4	-0.161
1995	1.93	81.9	-0.103	-0.675	0.13	-0.0232	22.5	-0.152
2003	2.52	130.5	-0.132	-0.854	0.14	-0.0252	30.0	-0.163
Δ65 to 03	0.90	75.3	-0.206	-1.410	0.0	-0.051	-11.054	-0.354
%Δ	143.1%	136.3%	-279.0%	-253.5%	-2.6%	-199.8%	-27.0%	-185.6%
Δ65 to 76	-25.6%	-31.7%	-136.6%	-132.7%	-28.7%	-132.9%	-75.0%	-129.4%
Δ76 to 85	98.6%	111.0%	227.3%	223.7%	39.0%	190.8%	167.6%	187.6%
Δ85 to 95	0.8%	2.9%	16.7%	14.8%	-14.6%	-4.1%	-17.9%	-5.6%
Δ95 to 03	63.2%	59.4%	28.2%	26.5%	15.1%	8.9%	33.2%	7.4%

*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality

Figure 21. Trends in educational disparity in smoking among females 25 and over, 1965-2003.



Overall, the graphs for relative disparity (left panel of Figure 21) show that the IDisp and the RCI are generally consistent with respect to the trend in relative educational disparity in smoking. With respect to absolute educational disparity in smoking, Figure 21 generally indicates that absolute disparity increased rather sharply from the mid-70s and early 80s to the mid-1990s, and has shown smaller increases as the rate of decline in current smoking among all groups has slowed. The BGV appears to exhibit substantially more variation around the mid-1990s than does the SII, but given the differences in scale it is difficult to judge whether or not this is of any consequence.

DIAGNOSTICS

Why is the increase in disparity larger for the RCI and RII than for the IDisp?

For both males and females, the proportionate increase in relative disparity is approximately twice as large when measured by the RCI/RII as when measured by the IDisp or RR. Given that one of the differences between these sets of measures is that the RCI and RII are population-weighted and there were dramatic shifts in the distribution of education over this period, it is worth investigating the potential impact of population shifts on the disparity measures. Table 24 below shows measures of relative and absolute disparity for males and females assuming no change in the distribution of education groups over time (i.e., the level of disparity was recalculated in 2003 using the 1965 population distribution). Holding population distribution constant, there is now far more agreement between the IDisp and RCI. For males the proportionate change in the RCI is now 163%, compared to 716% increase when the actual 2003 educational distribution is used. For women the RCI increase is now 136% compared to the 280% using the 2003 distribution. Naturally, the values for the RR, IDisp, and RD are exactly the same since these measures ignore population distribution. Holding constant the distribution of education in this case serves to reduce the magnitude of the increase in the RCI and ACI because this gives less weight in 2003 to the larger-than-average decline in smoking among those with >16 years of education.

Table 24. Change in educational disparity from 1965 to 2003 in current smoking holding constant the population distribution equal to that observed in 1965

	Measures of Relative Disparity				Measures of Absolute Disparity		
	Total Rate	RR	IDisp	RCI	RD	ACI	BGV
Males							
1965	0.52	1.40	29.8	-0.0219	0.16	-0.0114	28.5
2003	0.26	2.78	146.1	-0.0577	0.21	-0.0149	50.3
Δ65 to 03	-0.26	1.38	116.3	-0.0358	0.05	-0.0035	21.8
%Δ	-50.3%	346.6%	390.1%	163.4%	28.5%	30.9%	76.5%
Females							
1965	0.34	1.63	55.2	0.0738	0.15	0.0253	41.0
2003	0.22	2.52	130.5	-0.0263	0.14	-0.0058	16.0
Δ65 to 03	-0.12	0.90	75.3	-0.1001	0.00	-0.0311	-25.1
%Δ	-36.0%	143.1%	136.3%	-135.6%	-2.6%	-122.8%	-61.1%

*Based on regression analysis (see methods section).Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

Case Study6: Race-Ethnic Disparities in Breast Cancer Incidence, 1990-2001

Data and Methods

The data source for this analysis come from the SEER database called: *Incidence - SEER 18 Regs, Nov 2003 Sub for Expanded Races (1990-2001 varying)*. Individuals for whom race was coded as "Unknown" are excluded from this analysis. Because of the difficulties in obtaining accurate estimates for Hispanics, the analysis was confined to the following 12 registries, consistent with the categorization used in the *Annual Report to the Nation on the Status of Cancer* (14): SEER 12 registries = 'San Francisco-Oakland SMSA - 1990+','Connecticut - 1990+','Detroit (Metropolitan) - 1990+','Hawaii - 1990+','Iowa - 1990+','New Mexico - 1990+','Seattle (Puget Sound) - 1990+','Utah - 1990+','Atlanta (Metropolitan) - 1990+','San Jose-Monterey - 1990+','Los Angeles - 1990+','Alaska Natives - 1990+'. The analysis is stratified by age and rates are not age-adjusted.

Ages 45-74

Trends in the incidence of breast cancer among females 45-74, by race-ethnicity are shown in Figure 22, and the underlying data and population distribution are given in Table 25. White females have the highest incidence rates across all years, and rates are lowest among Asian/Pacific Islanders. Overall incidence rates generally remained constant over the period from 1990-2001, though there is some suggestion that rates have begun to decline since the late 1990s.

Figure 22. Trends in breast cancer incidence by race-ethnicity among women ages 45-74, 1990-2001.

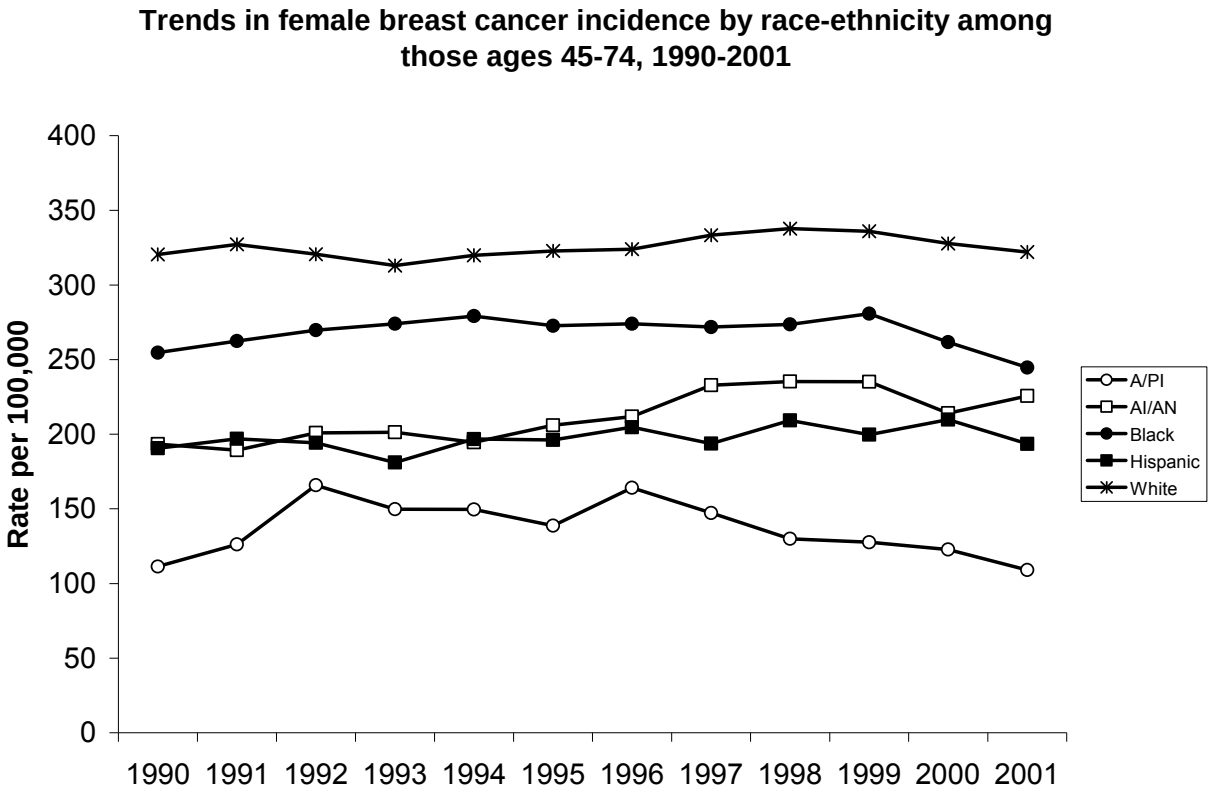


Table 25. Incidence of female breast cancer and population distribution among those ages 45-74, by race-ethnicity, 1990-2001

	Incidence Rate per 100,000					Percent of Total Population				
Year	A/PI	AI/AN	Black	Hispanic	White	A/PI	AI/AN	Black	Hispanic	White
1990	111.4	193.4	254.6	190.6	320.5	0.008	0.078	0.083	0.086	0.744
1991	126.1	189.3	262.5	196.9	327.2	0.008	0.081	0.083	0.088	0.739
1992	165.9	200.9	269.7	194.3	320.5	0.008	0.084	0.083	0.089	0.735
1993	149.7	201.3	274.0	181.1	312.9	0.009	0.087	0.084	0.091	0.730
1994	149.7	194.6	279.1	196.8	319.9	0.009	0.090	0.085	0.092	0.725
1995	138.8	206.0	272.6	196.3	322.8	0.009	0.093	0.085	0.094	0.719
1996	164.1	211.9	274.0	204.7	324.0	0.009	0.095	0.086	0.096	0.714
1997	147.3	232.9	271.8	193.7	333.3	0.010	0.098	0.087	0.098	0.708
1998	129.9	235.4	273.6	209.2	337.7	0.010	0.100	0.087	0.101	0.703
1999	127.7	235.2	280.7	199.6	336.0	0.010	0.101	0.088	0.103	0.697
2000	122.7	214.1	261.7	209.8	327.7	0.011	0.104	0.088	0.106	0.691
2001	109.1	225.7	244.7	193.6	322.1	0.011	0.105	0.089	0.109	0.686
Δ90 to 01	-2.3	32.3	-9.9	3.0	1.6	0.003	0.027	0.006	0.022	-0.058
%Δ	-2.1%	16.7%	-3.9%	1.6%	0.5%	37.0%	34.2%	6.8%	25.7%	-7.7%

The changes in race-ethnic disparity in breast cancer incidence are given in Table 26. Overall, the measures of both relative and absolute disparity generally agree with respect to the overall change in race-ethnic disparity (bottom row of Table 26). All four measures of relative disparity register an increase, as do the two measures of absolute disparity. The magnitude of the change in disparity differs, primarily for measures of relative disparity. For example, from 1995-2001 the Rate Ratio increases from 2.3 to 3.0, a relative increase of 47%, the Index of Disparity registers nearly a 60% increase, but both the Theil Index and the Mean Log Deviation show only modest increases, on the order of 15%. In general, the Index of Disparity appears to be more variable than either T or MLD, which likely reflects the fact that it is not weighted by population size.

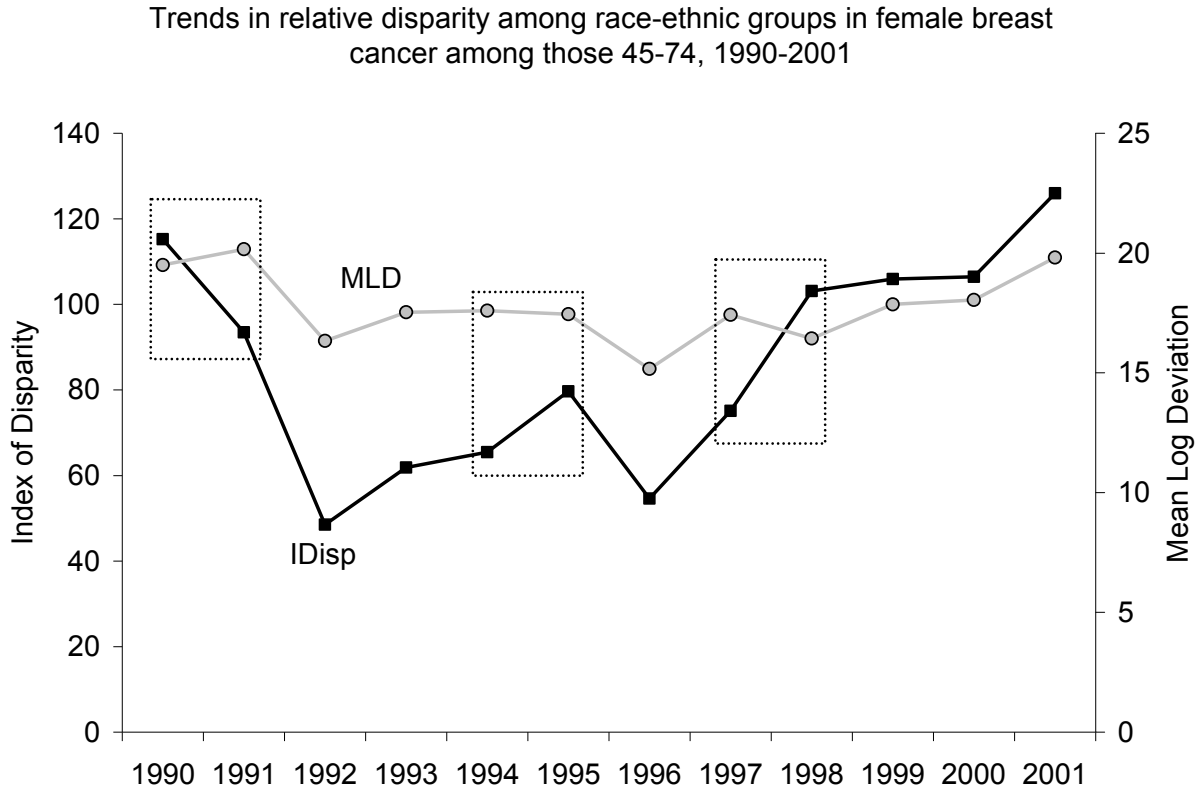
Table 26. Changes in Race-Ethnic Disparity in Female Breast Cancer Incidence Among those 45-74.

	Underlying Data		Measures of Relative Disparity				Measures of Absolute Disparity	
Race	Rate	% Pop	RR*	IDisp	T	MLD	RD*	BGV
1990								
A/PI	111.4	0.008	1.0	0	-2.9	7.7	0	260.0
AI/AN	193.4	0.078	1.7	18.4	-21.4	32.4	82.0	765.2
Black	254.6	0.083	2.3	32.1	-10.0	11.4	143.2	117.3
Hispanic	190.6	0.086	1.7	17.8	-24.1	36.9	79.2	891.0
White	320.5	0.744	2.9	46.9	75.6	-68.9	209.1	597.5
Total	**292.1**		**2.9**	**115.3**	**17.2**	**19.5**	**209.1**	**2631.0**
1995								
A/PI	138.8	0.009	1.0	0	-3.2	6.9	0.0	220.5
AI/AN	206.0	0.093	1.5	12.1	-23.1	33.0	67.2	720.3
Black	272.6	0.085	2.0	24.1	-6.0	6.5	133.8	39.7
Hispanic	196.3	0.094	1.4	10.3	-25.3	37.9	57.5	898.3
White	322.8	0.719	2.3	33.1	73.3	-66.8	184.0	589.7
Total	**294.2**		**2.3**	**79.7**	**15.7**	**17.5**	**184.0**	**2468.4**
Δ90 to 95	2.1		-0.6	-35.6	-1.5	-2.1	-25.1	-162.7
%Δ	0.7%		-29.4%	-30.9%	-8.8%	-10.5%	-12.0%	-6.2%
2001								
A/PI	109.1	0.011	1.0	0	-4.0	10.6	0.0	352.0
AI/AN	225.7	0.105	2.1	26.7	-20.3	26.0	116.6	419.1
Black	244.7	0.089	2.2	31.1	-12.5	14.7	135.6	172.5
Hispanic	193.6	0.109	1.8	19.4	-29.1	43.4	84.5	984.4
White	322.1	0.686	3.0	48.8	83.5	-74.9	213.0	760.9
Total	**288.8**		**3.0**	**126.0**	**17.7**	**19.8**	**213.0**	**2688.9**
Δ95 to 01	-5.4		0.6	46.3	2.0	2.4	29.0	220.6
%Δ	-1.8%		47.3%	58.1%	12.8%	13.5%	15.7%	8.9%
Δ90 to 01	-3.4		0.1	10.8	0.5	0.3	3.9	57.9
%Δ	-1.2%		4.0%	9.3%	2.9%	1.6%	1.9%	2.2%

*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance.

The analysis of changes in race-ethnic disparities in breast cancer above showed general agreement in the overall change in disparity from 1990-2001. Figure 23 shows trends in relative and absolute disparity and also suggests broad agreement with respect to the trends in disparity. Both the MLD and the IDisp show declines from 1990 to 1996, and rising disparity thereafter. Despite broad agreement with respect to the trend in race-ethnic disparity, the plot of the trends also shows disagreement for specific periods. For three specific periods (boxed areas on Figure 23), 1990-1, 1994-5, and 1997-8, the MLD and the IDisp move in opposite directions, with one measure indicating and increase in disparity and one suggesting a decrease.

Figure 23. Trends in race-ethnic disparity in breast cancer incidence among those 45-74.



Ages 75 and Over

Trends in breast cancer incidence among those 75 and over are shown in Figure 24. The overall patterning by race-ethnicity is similar to that seen for women 45-74, with Whites having the highest mortality rates and Asian/Pacific Islanders the lowest. On the whole, incidence rates appear to be roughly constant over the period 1990-2001.

Figure 24. Trends in breast cancer incidence by race-ethnicity among those 75 and over, 1990-2001.

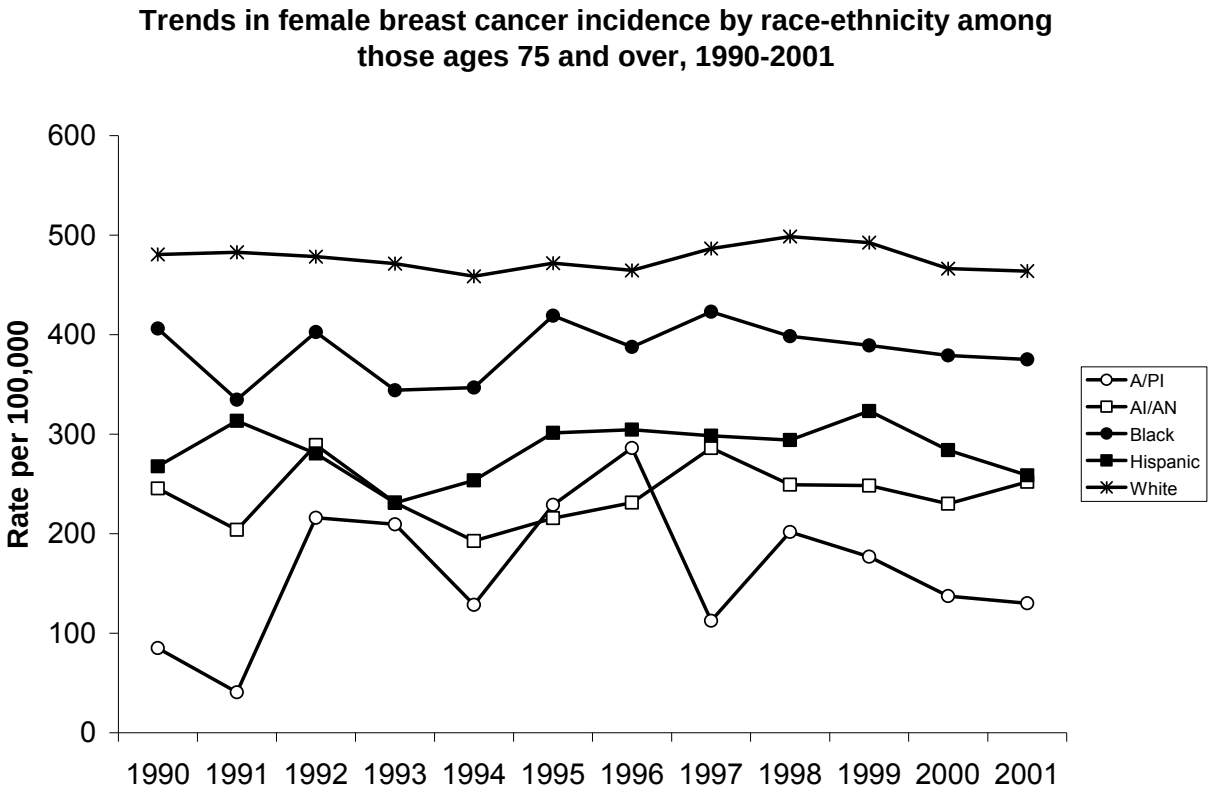


Table 27. Incidence of female breast cancer and population distribution among those ages 75 and over, by race-ethnicity, 1990-2001

	Incidence Rate per 100,000					Percent of Total Population				
	A/PI	AI/AN	Black	Hispanic	White	A/PI	AI/AN	Black	Hispanic	White
1990	85.1	245.5	406.1	267.7	480.7	0.004	0.046	0.064	0.053	0.833
1991	40.6	204.0	334.8	313.3	482.8	0.004	0.048	0.064	0.053	0.830
1992	216.0	289.2	402.6	280.7	478.4	0.004	0.050	0.064	0.054	0.827
1993	209.4	231.1	344.2	231.0	471.5	0.004	0.053	0.065	0.054	0.824
1994	128.6	192.7	346.9	253.6	458.6	0.005	0.056	0.065	0.054	0.820
1995	229.1	215.5	419.0	301.4	471.9	0.005	0.059	0.065	0.055	0.816
1996	286.2	231.2	387.6	304.6	464.7	0.005	0.062	0.065	0.056	0.812
1997	112.6	286.1	423.2	298.5	486.5	0.005	0.065	0.066	0.056	0.808
1998	201.8	249.3	398.4	294.0	498.8	0.005	0.069	0.066	0.057	0.803
1999	177.0	248.3	389.2	323.2	492.5	0.005	0.072	0.066	0.059	0.798
2000	137.4	230.0	379.1	284.1	466.4	0.005	0.076	0.066	0.061	0.791
2001	130.0	252.1	375.1	258.6	463.9	0.005	0.080	0.066	0.065	0.784
Δ90 to 01	44.9	6.6	-31.0	-9.1	-16.7	0.001	0.034	0.002	0.012	-0.049
%Δ	52.8%	2.7%	-7.6%	-3.4%	-3.5%	26.1%	75.5%	2.8%	22.0%	-5.9%

Changes in race-ethnic relative and absolute disparity are shown in Table 28. In contrast to the overall pattern of results for women 45-74, there is generally disagreement among both relative and absolute measures for the change in race-ethnic disparity from 1990-2001 (bottom row of Table 28). Both the Rate Ratio and the Index of Disparity suggest that race-ethnic disparity has declined, by 37% and 49%, respectively, while the Theil Index and Mean Log Deviation indicate increases in relative disparity of around 20-25%. With respect to absolute disparity, from 1990-2001 the Rate Difference declined from 395.6 to 333.9, a 16% decline, while the Between Group Variance showed an increase of nearly 17%. Given that the referent group for the RR, IDisp, and RD is the group with the lowest rate (A/PI), the increase in the rate reported among this group from 1990 to 2001 seems the likeliest explanation for why each of these measures registered a decline over this period.

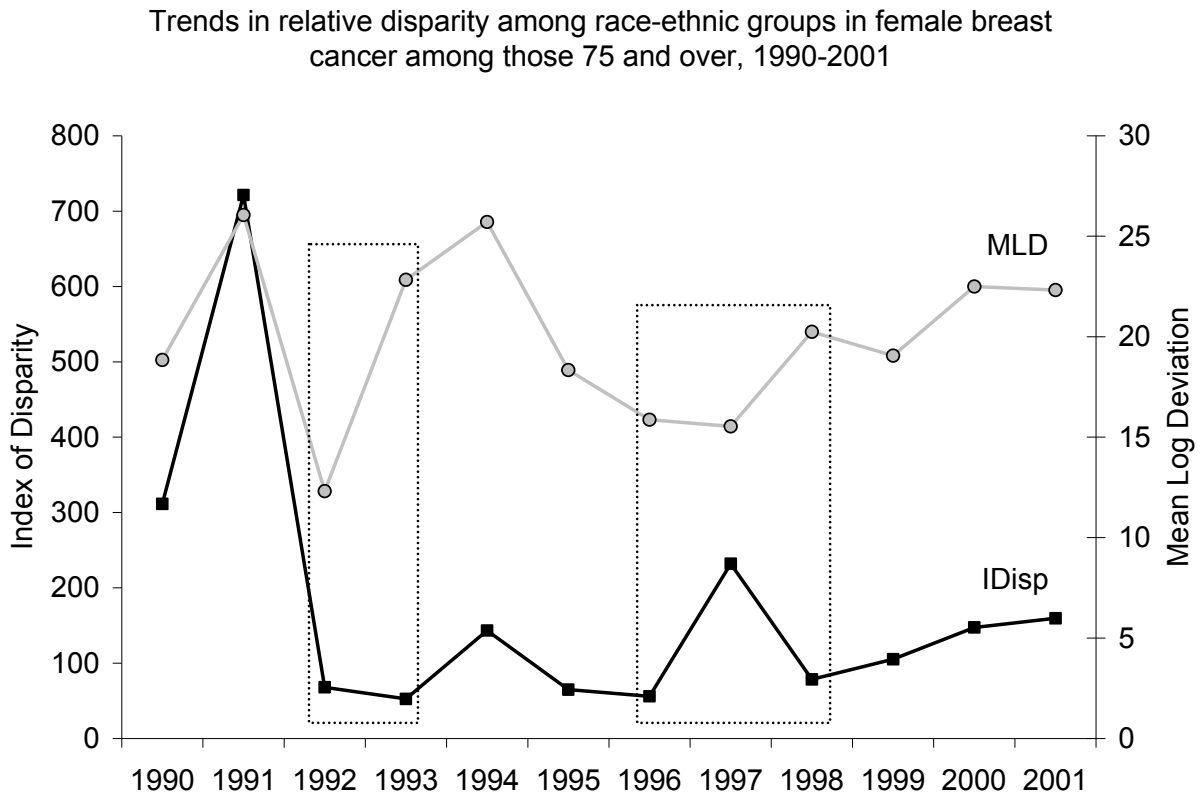
Table 28. Changes in Race-Ethnic Disparity in Female Breast Cancer Incidence Among those 75+.

	Underlying Data		Measures of Relative Disparity				Measures of Absolute Disparity	
Race	Rate	% Pop	RR*	IDisp	T	MLD	RD*	BGV
1990								
A/PI	85.1	0.004	1.0	0	-1.4	7.3	0.0	586.6
AI/AN	245.5	0.046	2.9	47.1	-15.1	27.9	160.4	1949.5
Black	406.1	0.064	4.8	94.3	-6.2	6.9	321.0	135.5
Hispanic	267.7	0.053	3.1	53.7	-16.4	27.7	182.6	1800.2
White	480.7	0.833	5.7	116.3	54.1	-50.9	395.6	675.7
Total	**452.2**		**5.7**	**311.4**	**15.0**	**18.8**	**395.6**	**5147.4**
1995								
A/PI	229.1	0.005	1.1	1.6	-1.6	3.1	19.0	211.9
AI/AN	215.5	0.059	1.0	0	-20.6	42.3	0.0	3035.7
Black	419.0	0.065	1.9	23.6	-3.4	3.6	17.2	37.1
Hispanic	301.4	0.055	1.4	10.0	-14.4	21.2	6.2	1101.0
White	471.9	0.816	2.2	29.7	55.2	-51.8	75.8	687.1
Total	**442.9**		**2.2**	**64.9**	**15.2**	**18.3**	**75.8**	**5072.8**
Δ90 to 95	-9.3		-3.5	-246.5	0.2	-0.5	-319.8	-74.6
%Δ	-2.1%		-74.4%	-79.2%	1.2%	-2.7%	-80.8%	-1.4%
2001								
A/PI	130.0	0.005	1.0	0	-2.0	6.5	0.0	481.0
AI/AN	252.1	0.080	1.9	23.5	-24.9	42.0	122.1	2423.4
Black	375.1	0.066	2.9	47.1	-7.4	8.4	245.1	170.3
Hispanic	258.6	0.065	2.0	24.7	-19.6	32.2	128.6	1810.3
White	463.9	0.784	3.6	64.2	72.7	-66.8	333.9	1125.6
Total	**426.0**		**3.6**	**159.6**	**19.0**	**22.3**	**333.9**	**6010.7**
Δ95 to 01	-16.8		1.4	94.7	3.8	4.0	258.1	937.9
%Δ	-3.8%		116.0%	146.0%	24.8%	21.7%	340.7%	18.5%
Δ90 to 01	-26.1		-2.1	-151.9	4.0	3.5	-61.7	863.3
%Δ	-5.8%		-36.8%	-48.8%	26.3%	18.5%	-15.6%	16.8%

*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance.

Trends in relative disparity among those 75 and over are shown in Figure 25. The MLD and the IDisp generally follow similar patterns over time, but the boxed regions show that from 1992-3 and 1997-8 the MLD suggests an increase in disparity while the IDisp suggests a decrease; the opposite is true for 1996-7. The steep decline in the IDisp from 1991-2 is likely to be related to the sharp increase in the rate for the A/PI group that year, which became the reference group for the IDisp.

Figure 25. Trends in race-ethnic disparities in breast cancer incidence, 1990-2001.



Case Study 7: Socioeconomic Disparities in Obesity, 1960-2000

Trends in obesity were assessed using data from five adult samples of the National Health Examination Surveys (NHANES): the Health Examination Survey (1959-62), NHANES I (1971-74), NHANES II (1976-80), NHANES III (1988-94), and NHANES 1999-2002 (n=56,311). Sample weights were used in each survey to account for unequal sampling probabilities and nonresponse. For ease of presentation, the midpoint of data collection years for each survey was used as the survey year (1961, 1973, 1978, 1991, and 2000). While the examination surveys are not conducted as frequently as the NHIS, they have the advantage of obtaining measured, rather than self-reported, height and weight. Self-reported height and weight are subject to bias and the extent of bias differs with social group characteristics (15), which makes using self-reported data for assessing disparities difficult. Pregnant women were excluded, and individuals were categorized as obese if they had a body mass index (BMI) of 30 or greater. The analysis was restricted to individuals 18-74 years of age with no missing data on age, gender, race, or education. In order to minimize the effect of extreme or implausible values of BMI individuals falling outside the 1st and 99th percentiles of the BMI distribution in each survey year were excluded. The above exclusions yielded an analytic sample of 54,066 individuals. In order to maintain a consistent grouping across surveys, education was categorized as <12 years, 12 years, or greater than 12 years (NHANES 1999-2002 did not disaggregate those with >12 years of education).

Males

Obesity trends by education among males are shown in Figure 26. Rates of obesity have increased substantially in all educational groups, particularly since 1978.

Figure 26. Trends in obesity by years of education among males, 1960-2000

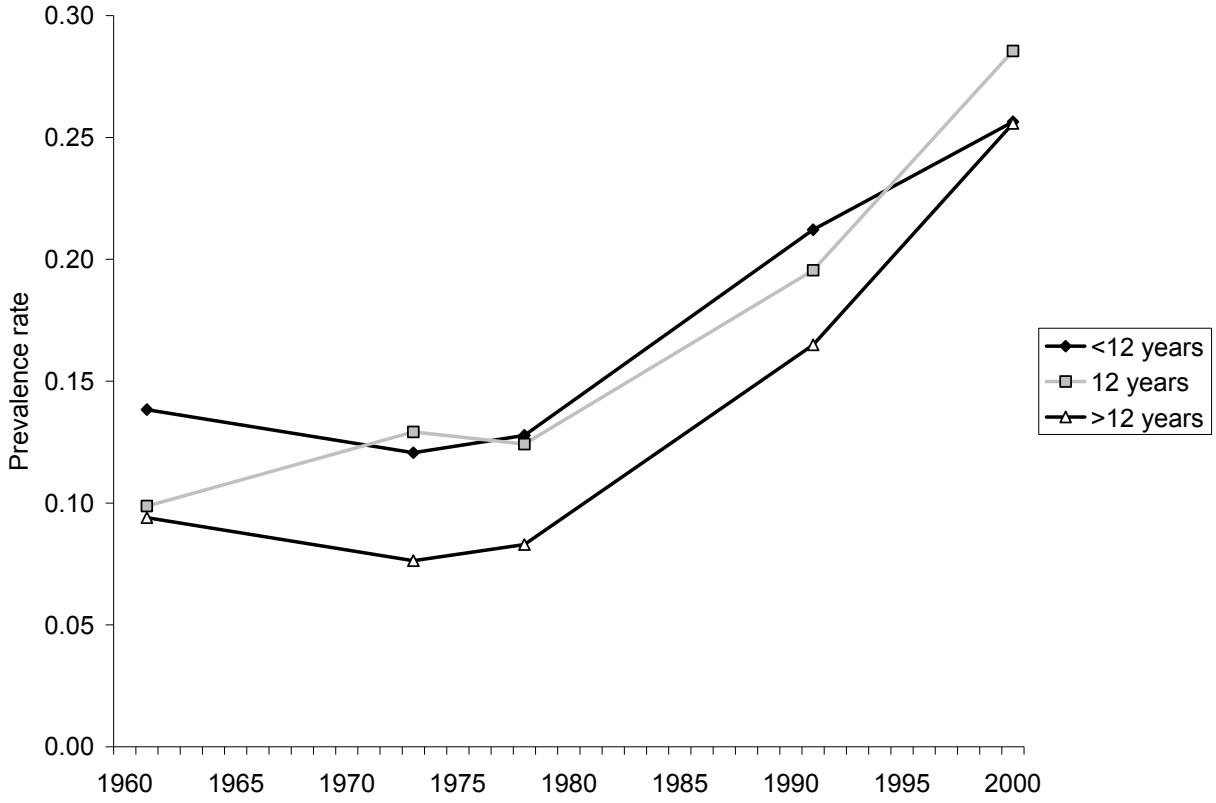


Table 29. Prevalence of obesity and population distribution by education among males, 1960-2000

	Prevalence of obesity			Percent of Total Population		
	<12 years	12 years	>12 years	<12 years	12 years	>12 years
1961	0.138	0.099	0.094	0.311	0.473	0.216
1973	0.121	0.129	0.076	0.356	0.297	0.347
1978	0.128	0.124	0.083	0.306	0.297	0.398
1991	0.212	0.196	0.165	0.246	0.318	0.436
2000	0.256	0.286	0.256	0.220	0.259	0.521
Δ61 to 00	0.118	0.187	0.162	-0.091	-0.214	0.305
%Δ	85.4%	189.1%	172.2%	-29.2%	-45.3%	141.3%

Changes in disparity are shown in Table 30. Relative disparity among education groups in the prevalence of obesity has declined according to all four measures, and the magnitude of the decline is similar across all the measures. For absolute disparity all the measures suggest that disparity has declined, but the magnitude of the increase is slightly larger for the ACI and SII.

Table 30. Changes in educational disparity in obesity among males, 1960-2000.

	Raw Data		Measures of Relative Disparity				Measures of Absolute Disparity			
Education	Rate	% Pop	RR*	IDisp	RCI	RII†	RD*	ACI	BGV	SII†
1960										
<12 years	0.138	0.311	1.47	23.6	-0.269		0.044	-0.0296	2.49	
12 years	0.099	0.473	1.05	2.5	0.040		0.005	0.0044	0.60	
>12 years	0.094	0.216	1.00	0.0	0.145		0.000	0.0159	0.56	
Total	**0.110**		**1.47**	**26.1**	**-0.084**	**-0.593**	**0.044**	**-0.0093**	**3.65**	**-0.065**
2000										
<12 years	0.256	0.220	1.00	0.1	-0.167		0.001	-0.0440	0.11	
12 years	0.286	0.259	1.12	5.8	-0.085		0.030	-0.0223	1.24	
>12 years	0.256	0.521	1.00	0.0	0.242		0.000	0.0638	0.32	
Total	**0.264**		**1.12**	**5.9**	**-0.009**	**-0.067**	**0.030**	**-0.0024**	**1.67**	**-0.018**
∆60 to 00	0.154		-0.36	-20.2	0.075	0.526	-0.015	0.007	-1.97	0.048
%∆	139.6%		-75.4%	-77.3%	-89.1%	-88.8%	-33.0%	-73.8%	-54.1%	-73.0%

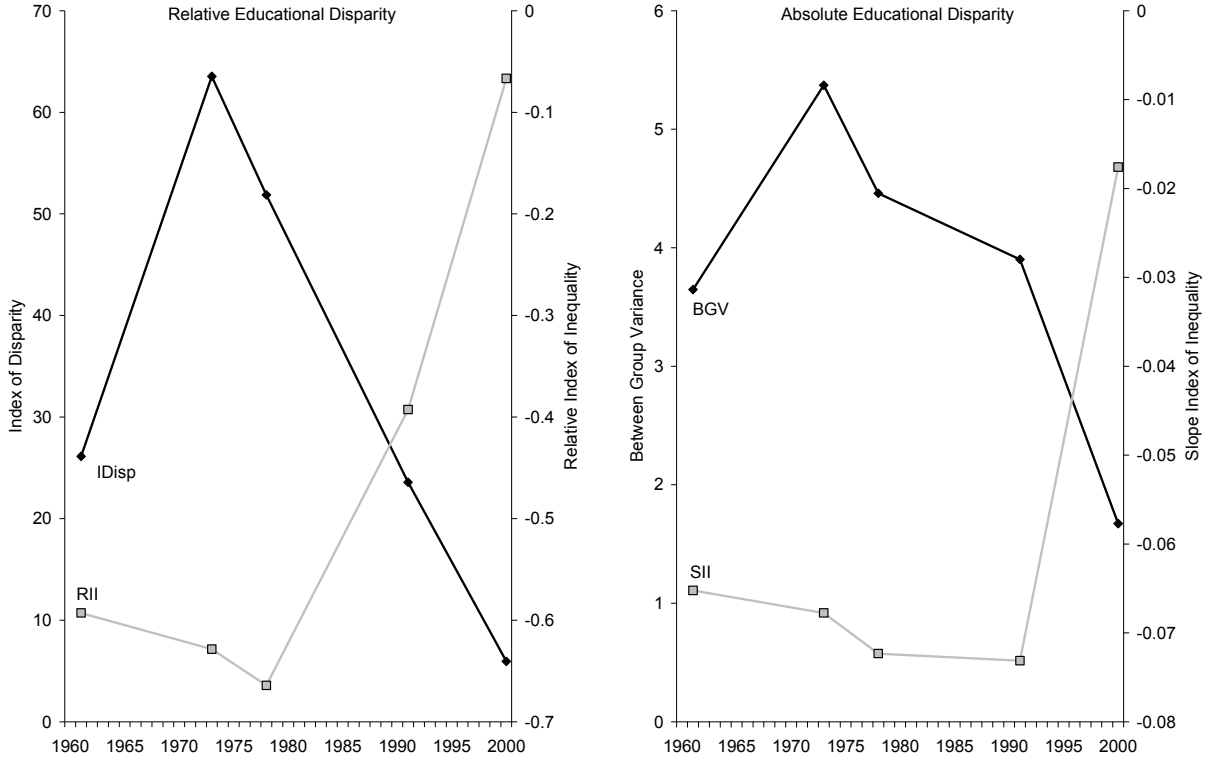
*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range

†Based on regression analysis (see methods section).

Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

Disparity trends are shown in Figure 27. For relative disparity both the IDisp and the RII show educational disparity in obesity among males first increasing then decreasing from 1961 to 2000. However, from 1973 to 1978 the IDisp shows a decline in disparity while the RII shows a small increase. This may be due to the small increase in obesity during this period among those with >12 years of education, the referent group for the IDisp. For absolute disparity, both the BGV and the SII indicate that educational disparity among males increased from 1960 but decreased thereafter, but between 1973 and 1978 the BGV shows a decline while the SII shows an increase (i.e., the SII becomes more negative, indicating the gap in obesity rates between the most and least educated has grown). Additionally, the magnitude of the increase in absolute disparity from 1961 to 1973 appears much larger for the BGV than for the SII.

Figure 27. Trends in educational disparity in obesity among males, 1960-2000



Females

Trends in the prevalence of obesity among female education groups are shown in Figure 28. Similar to the pattern for males, rates of obesity have increased dramatically since 1978. However, among females the rates of obesity clearly increase with decreasing education.

Figure 28. Trends in obesity by years of education among females, 1960-2000

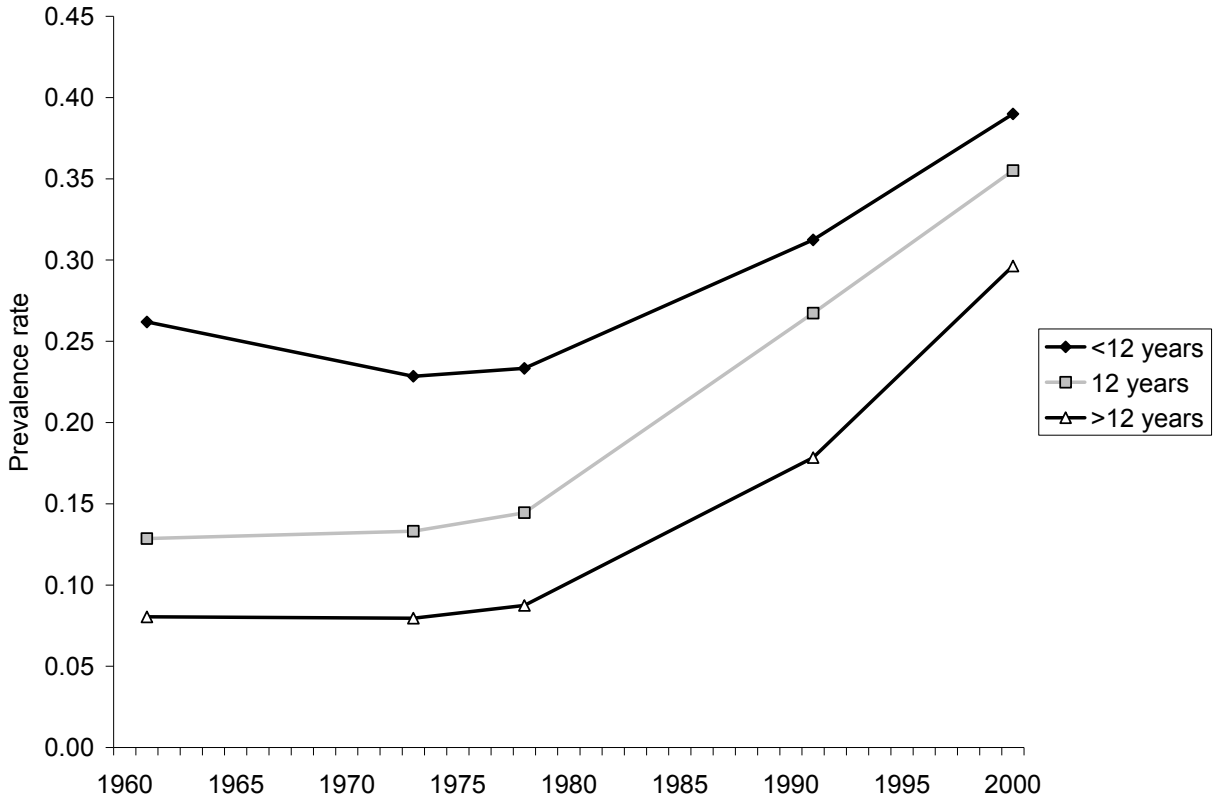


Table 31.Prevalence of obesity and population distribution by education among females, 1960-2000

	Prevalence of obesity			Percent of Total Population		
	<12 years	12 years	>12 years	<12 years	12 years	>12 years
1961	0.262	0.129	0.080	0.288	0.536	0.176
1973	0.228	0.133	0.080	0.357	0.380	0.263
1978	0.233	0.144	0.087	0.308	0.375	0.317
1991	0.312	0.267	0.178	0.225	0.377	0.398
2000	0.390	0.355	0.296	0.209	0.258	0.533
Δ61 to 00	0.128	0.226	0.216	-0.079	-0.278	0.358
%Δ	48.9%	176.0%	268.4%	-27.5%	-51.9%	203.3%

Relative disparity among education groups in the prevalence of obesity has declined according to all four measures, and the magnitude of the decline is very similar across all the measures (Table 32). For absolute disparity the RD, ACI, and SII all indicate that educational disparity has declined by around 40%, with the BGV indicating a slightly larger decline (67%).

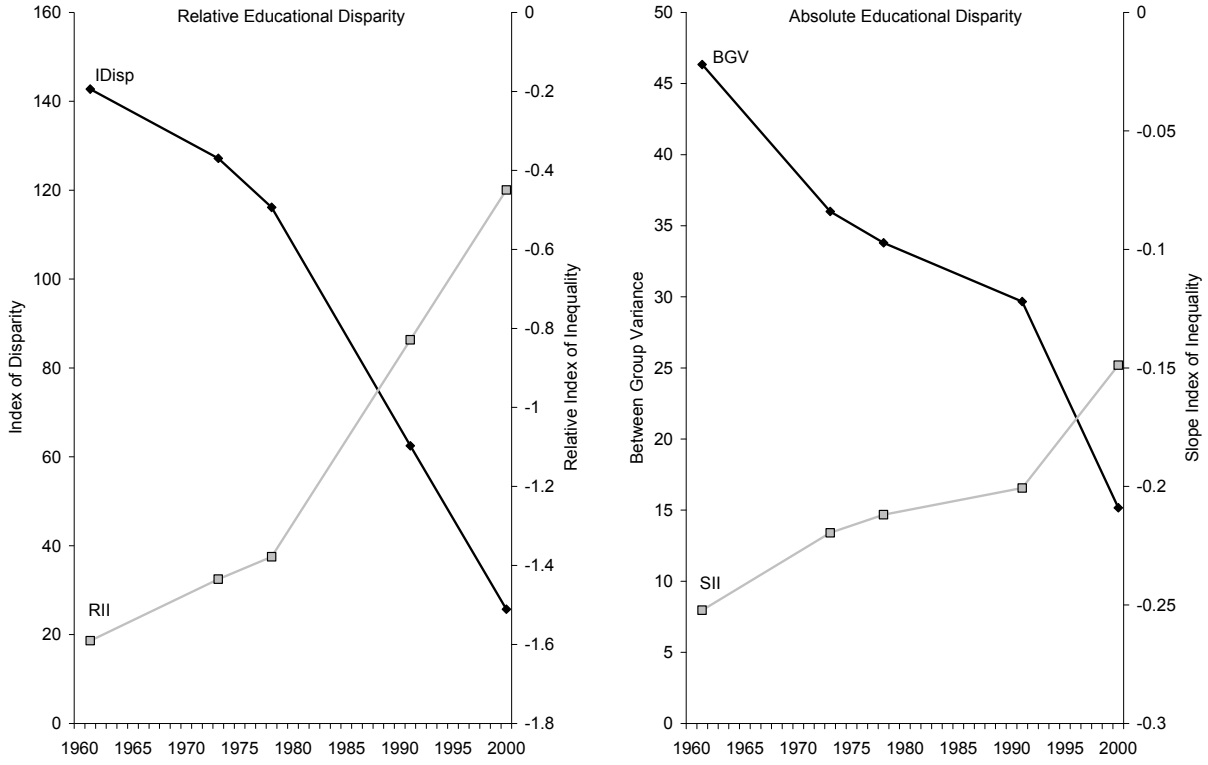
Table 32. Changes in educational disparity in obesity among females, 1960-2000.

	Raw Data		Measures of Relative Disparity				Measures of Absolute Disparity			
Education	Rate	% Pop	RR*	IDisp	RCI	RII†	RD*	ACI	BGV	SII†
1960										
<12 years	0.262	0.288	3.26	112.8	-0.339		0.181	-0.0537	30.79	
12 years	0.129	0.536	1.60	30.0	0.049		0.048	0.0077	4.81	
>12 years	0.080	0.176	1.00	0.0	0.074		0.000	0.0117	10.74	
Total	**0.159**		**3.26**	**142.8**	**-0.217**	**-1.590**	**0.181**	**-0.0343**	**46.33**	**-0.252**
2000										
<12 years	0.390	0.209	1.32	15.8	-0.195		0.094	-0.0645	7.26	
12 years	0.355	0.258	1.20	9.9	-0.090		0.059	-0.0297	1.49	
>12 years	0.296	0.533	1.00	0.0	0.223		0.000	0.0738	6.42	
Total	**0.331**		**1.32**	**25.7**	**-0.062**	**-0.449**	**0.094**	**-0.0204**	**15.16**	**-0.149**
Δ60 to 00	0.172		-1.94	-117.0	0.155	1.141	-0.088	0.014	-31.17	0.103
%Δ	108.8%		-86.0%	-82.0%	-71.6%	-71.7%	-48.4%	-40.6%	-67.3%	-41.0%

*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range
†Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

The overall trends in absolute and relative disparity for females are shown in Figure 29. . For relative disparity both the IDisp and the RCI give similar pictures of the trend in relative educational disparity, while for absolute disparity both the BGV and the SII give similar pictures of the trend in absolute educational disparity in obesity among females.

Figure 29. Trends in educational disparity in obesity among females, 1960-2000



Case Study 8: Race-Ethnic Disparities in Cervical Cancer Incidence, 1990-2001

The data source for this analysis come from the SEER database called: *Incidence - SEER 18 Regs, Nov 2003 Sub for Expanded Races (1990-2001 varying)*. Individuals for whom race was coded as "Unknown" are excluded from this analysis. Because of the difficulties in obtaining accurate estimates for Hispanics, the analysis was confined to the following 12 registries, consistent with the categorization used in the Annual Report to the Nation on the Status of Cancer (14): SEER 12 registries = 'San Francisco-Oakland SMSA - 1990+','Connecticut - 1990+','Detroit (Metropolitan) - 1990+','Hawaii - 1990+','Iowa - 1990+','New Mexico - 1990+','Seattle (Puget Sound) - 1990+','Utah - 1990+','Atlanta (Metropolitan) - 1990+','San Jose-Monterey - 1990+','Los Angeles - 1990+','Alaska Natives - 1990+'. The analysis is stratified by age and rates are not age-adjusted.

Ages <45

Trends the incidence of cervical cancer among women less than 45 according to race-ethnicity are shown in Figure 30, and the underlying rates and population distribution are given in Table 33. Rates of cervical cancer incidence appear to be declining among most race-ethnic groups. Hispanics have higher rates of incidence than other groups for the entire period from 1990-2001.

Figure 30. Trends in cervical cancer incidence by race-ethnicity among those <45 years of age, 1990-2001

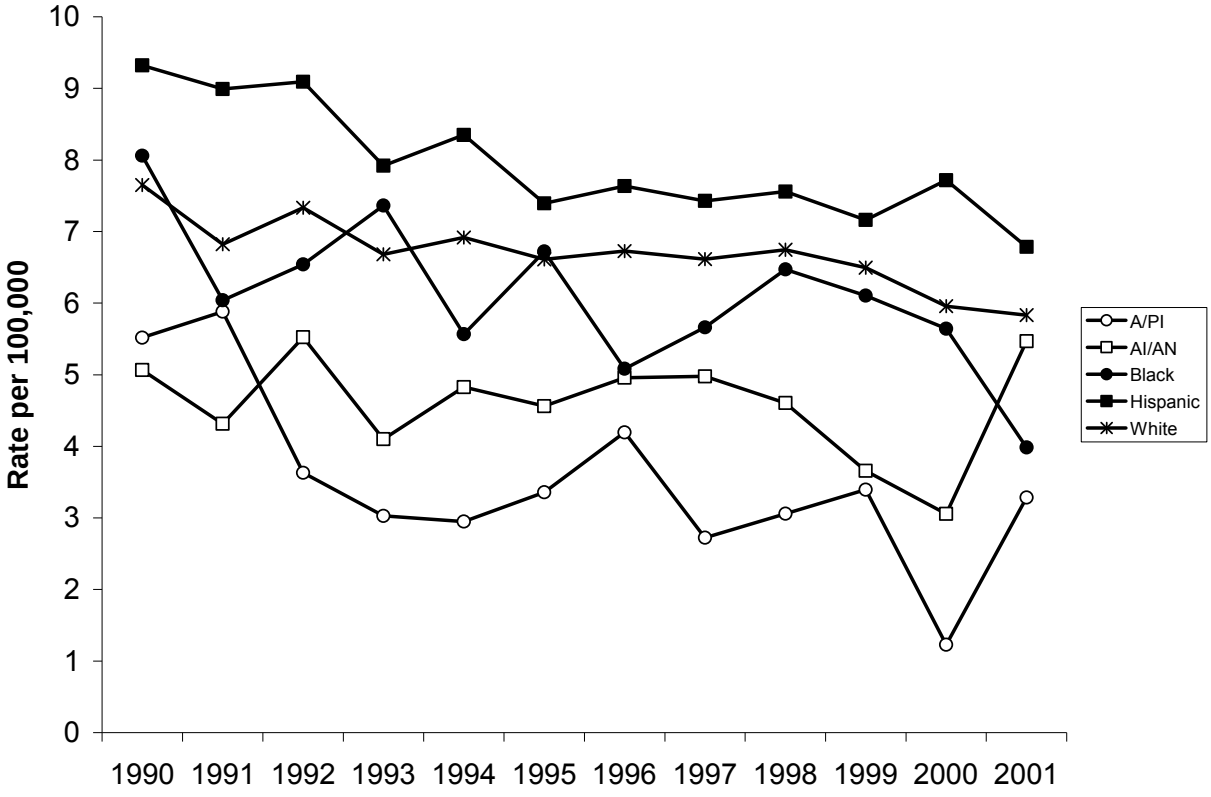


Table 33. Incidence of cervical cancer and population distribution among those ages <45, by race-ethnicity, 1990-2001

	Incidence Rate per 100,000					Percent of Total Population				
	A/PI	AI/AN	Black	Hispanic	White	A/PI	AI/AN	Black	Hispanic	White
1990	5.5	5.1	8.1	9.3	7.6	0.013	0.081	0.103	0.152	0.651
1991	5.9	4.3	6.0	9.0	6.8	0.013	0.083	0.104	0.154	0.646
1992	3.6	5.5	6.5	9.1	7.3	0.013	0.085	0.104	0.158	0.641
1993	3.0	4.1	7.4	7.9	6.7	0.013	0.087	0.104	0.161	0.635
1994	2.9	4.8	5.6	8.4	6.9	0.014	0.088	0.104	0.164	0.630
1995	3.4	4.6	6.7	7.4	6.6	0.014	0.090	0.104	0.167	0.625
1996	4.2	5.0	5.1	7.6	6.7	0.014	0.091	0.104	0.171	0.620
1997	2.7	5.0	5.7	7.4	6.6	0.014	0.092	0.104	0.174	0.615
1998	3.1	4.6	6.5	7.6	6.7	0.015	0.093	0.104	0.178	0.610
1999	3.4	3.7	6.1	7.2	6.5	0.015	0.094	0.104	0.182	0.605
2000	1.2	3.1	5.6	7.7	6.0	0.015	0.095	0.104	0.186	0.600
2001	3.3	5.5	4.0	6.8	5.8	0.015	0.096	0.104	0.189	0.595
Δ90 to 01	-2.2	0.4	-4.1	-2.5	-1.8	0.003	0.015	0.001	0.037	-0.056
%Δ	-40.5%	8.0%	-50.6%	-27.2%	-23.8%	20.8%	18.4%	0.8%	24.6%	-8.6%

Table 34. Changes in race-ethnic disparity in cervical cancer incidence among those <45 years of age.

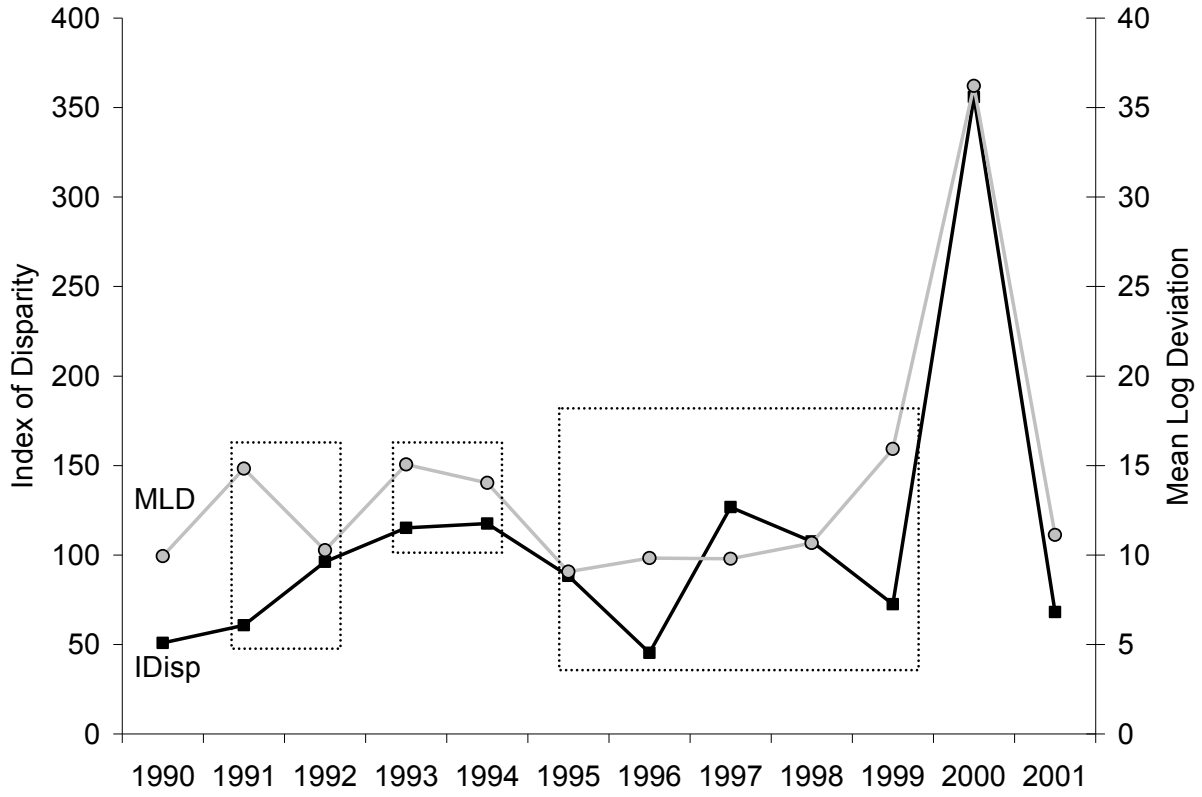
	Underlying Data		Measures of Relative Disparity				Measures of Absolute Disparity	
Race	Rate	% Pop	RR*	IDisp	T	MLD	RD*	BGV
1990								
A/PI	5.5	0.013	1.09	2.2	-3.0	4.2	0.45	0.06
AI/AN	5.1	0.081	1.00	0.0	-22.4	34.1	0.00	0.57
Black	8.1	0.103	1.59	14.8	4.8	-4.6	2.99	0.01
Hispanic	9.3	0.152	1.84	21.0	34.9	-28.9	4.26	0.40
White	7.6	0.651	1.51	12.8	-5.0	5.0	2.58	0.00
Total	**7.7**		**1.84**	**50.8**	**9.2**	**9.9**	**4.26**	**1.04**
1995								
A/PI	3.4	0.014	1.00	0.0	-4.7	9.2	0.00	0.14
AI/AN	4.6	0.090	1.36	9.0	-22.5	32.2	1.20	0.35
Black	6.7	0.104	2.00	25.1	3.2	-3.1	3.36	0.00
Hispanic	7.4	0.167	2.20	30.1	23.7	-20.9	4.04	0.13
White	6.6	0.625	1.97	24.2	8.4	-8.3	3.26	0.00
Total	**6.5**		**2.20**	**88.3**	**8.1**	**9.1**	**4.04**	**0.62**
Δ90 to 95	-1.2		0.4	37.6	-1.2	-0.9	-0.2	-0.4
%Δ	-15.4%		43.1%	73.9%	-12.9%	-8.8%	-5.2%	-40.3%
2001								
A/PI	3.3	0.015	1.00	0	-4.9	8.5	0.00	0.09
AI/AN	5.5	0.096	1.67	16.7	-4.5	4.8	2.19	0.01
Black	4.0	0.104	1.21	5.3	-26.4	38.0	0.70	0.32
Hispanic	6.8	0.189	2.07	26.7	37.1	-31.4	3.50	0.20
White	5.8	0.595	1.78	19.4	8.9	-8.8	2.55	0.00
Total	**5.7**		**2.07**	**68.1**	**10.2**	**11.1**	**3.50**	**0.63**
Δ95 to 01	-0.8		-0.14	-20.3	2.2	2.1	-0.54	0.01
%Δ	-11.9%		-11.3%	-23.0%	27.0%	22.7%	-13.3%	1.7%
Δ90 to 01	-2.0		0.23	17.3	1.0	1.2	-0.75	-0.41
%Δ	-25.5%		12.3%	34.0%	10.6%	11.9%	-17.7%	-39.3%

*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance.

Changes in the relative and absolute race-ethnic disparity in cervical cancer incidence are shown in Table 34. In terms of the overall change in race-ethnic disparity from 1990 to 2001 for women <45, there is generally agreement among both relative and absolute measures, with all relative measures indicating an increase and both absolute measures showing a decrease. Between 1990 and 1995 both the RR and the IDisp suggest that race-ethnic disparity has increased by >40% but T and MLD suggest a moderate decrease (~ -10%). The opposite is true between 1995 and 2001, with RR and IDisp suggesting a 10-20% decrease but T and MLD suggesting a 23-27% increase in relative disparity. For absolute disparity the magnitude of the

overall decline is greater for the BGV (-39%) than for the RD (-18%). Between 1995 and 2001 the RD suggest a decline in disparity while the BGV suggest minimal change. The disagreement between the RD and BGV is likely due to the fact that, while Hispanics consistently had the highest rate, the lowest rate shifted from AI/AN to the A/PI group, which would affect the RD more than the BGV.

Figure 31. Trends in relative race-ethnic disparity in cervical cancer incidence among those <45 years of age, 1990-2001.



The trends in relative disparity for the IDisp and the MLD are plotted in Figure 31. Overall both the MLD and the IDisp show that race-ethnic relative disparity increased marginally between 1990 and 2001, but this hides considerable year-to-year variation during this period. Specifically, for several periods (highlighted by boxes in Figure 31), specifically 1991-2, 1993-4, and 1995-99, the MLD and the IDisp moved in opposite directions, with one measure indicating an increase in relative disparity and the other indicating a decrease.

Ages 45-74

Trends in cervical cancer incidence among females 45-74 are shown in Figure 32, and the rates and population distribution over time are given inTable 35. Rates are substantially higher among women in this age group compared to those <45 years of age, but the general trend for this group is also one of declining incidence. Hispanics also have higher rates than other race-ethnic groups at ages 45-74.

Figure 32. Trends in cervical cancer incidence by race-ethnicity among those 45-74, 1990-2001.

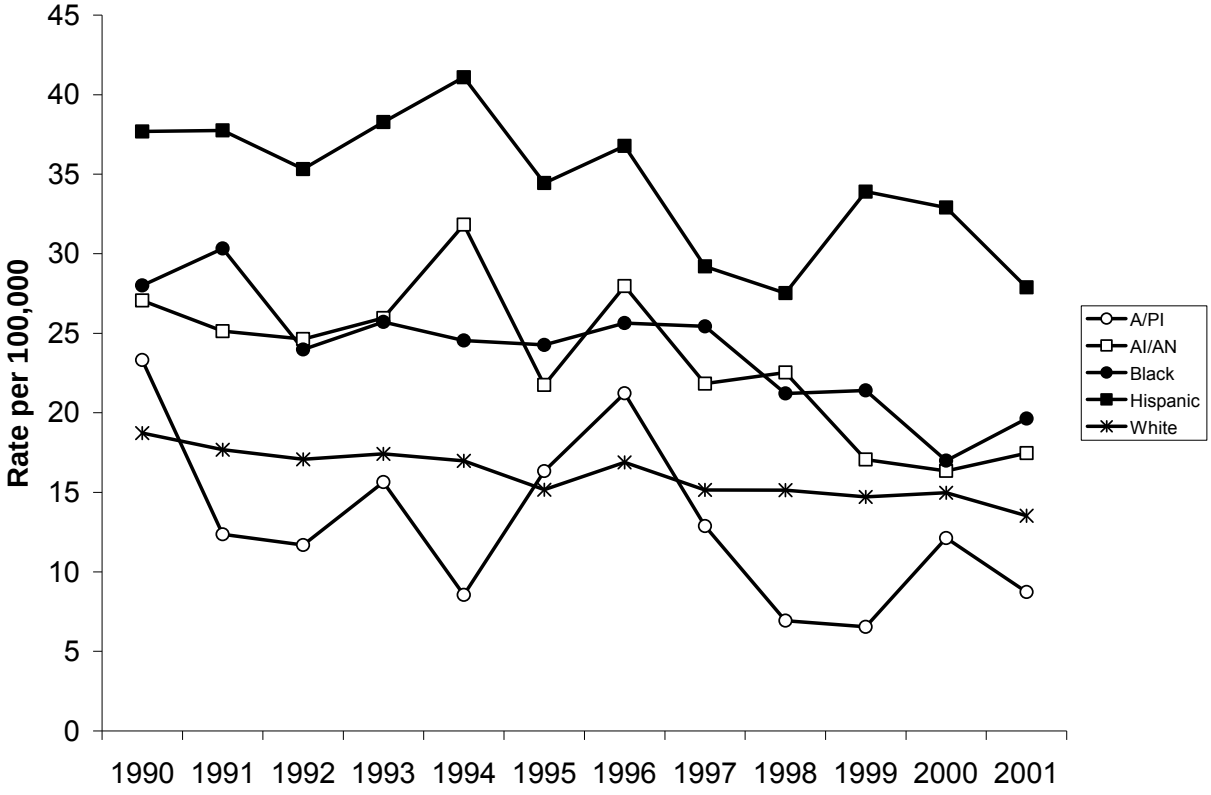


Table 35. Incidence of cervical cancer and population distribution among those ages 45-74, by race-ethnicity, 1990-2001

	Incidence Rate per 100,000					Percent of Total Population				
Year	A/PI	AI/AN	Black	Hispanic	White	A/PI	AI/AN	Black	Hispanic	White
1990	23.3	27.1	28.0	37.7	18.7	0.008	0.078	0.083	0.086	0.744
1991	12.4	25.1	30.3	37.8	17.7	0.008	0.081	0.083	0.088	0.739
1992	11.7	24.6	24.0	35.3	17.1	0.008	0.084	0.083	0.089	0.735
1993	15.6	26.0	25.7	38.3	17.4	0.009	0.087	0.084	0.091	0.730
1994	8.6	31.8	24.5	41.1	17.0	0.009	0.090	0.085	0.092	0.725
1995	16.3	21.7	24.3	34.4	15.2	0.009	0.093	0.085	0.094	0.719
1996	21.2	28.0	25.6	36.8	16.9	0.009	0.095	0.086	0.096	0.714
1997	12.9	21.8	25.4	29.2	15.2	0.010	0.098	0.087	0.098	0.708
1998	6.9	22.5	21.2	27.5	15.1	0.010	0.100	0.087	0.101	0.703
1999	6.5	17.1	21.4	33.9	14.7	0.010	0.101	0.088	0.103	0.697
2000	12.1	16.3	17.0	32.9	15.0	0.011	0.104	0.088	0.106	0.691
2001	8.7	17.5	19.6	27.9	13.5	0.011	0.105	0.089	0.109	0.686
Δ90 to 01	-14.6	-9.6	-8.4	-9.8	-5.2	0.003	0.027	0.006	0.022	-0.058
%Δ	-62.6%	-35.5%	-29.9%	-26.0%	-27.7%	37.0%	34.2%	6.8%	25.7%	-7.7%

Changes in race-ethnic disparity in cervical cancer incidence among those 45-74 are shown in Table 36. Overall, the measures of both relative disparity generally agree with respect to the overall change in race-ethnic disparity: relative disparity has increased. However, the magnitude of the increase is considerably larger for the RR and IDisp (~120%) than for the T or MLD (~17%). Between 1995 and 2001 both the RR and the IDisp indicate increases in relative disparity of 70-110%, while the T and MLD suggest a decrease in relative disparity of approximately 20%. This would appear to be the result of a strong decline in cervical cancer incidence among the A/PI group, which after 1996 becomes the referent group for the IDisp. The strong change in this group has less impact on the T and MLD because it accounts for only about 1% of the SEER population in this database.

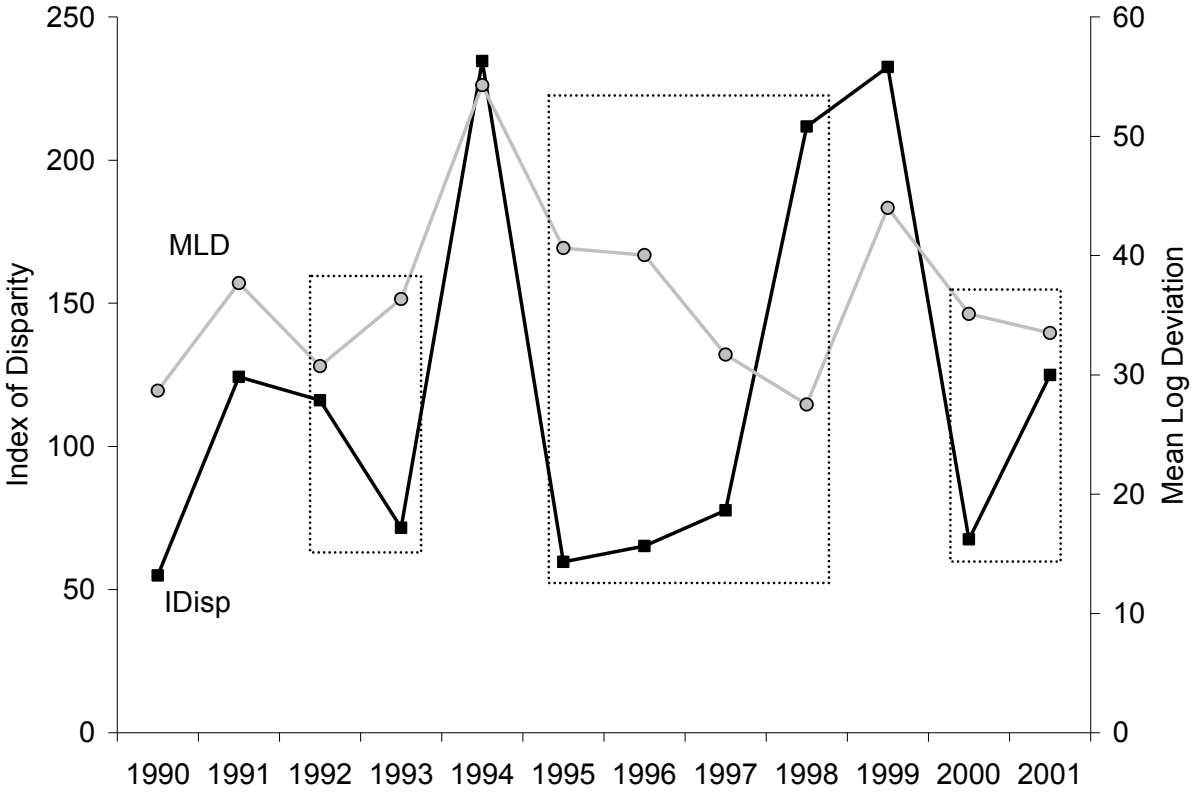
Table 36. Changes in race-ethnic disparity in cervical cancer incidence among those 45-74.

	Underlying Data		Measures of Relative Disparity				Measures of Absolute Disparity	
Race	Rate	% Pop	RR*	IDisp	T	MLD	RD*	BGV
1990								
A/PI	23.3	0.008	1.2	6.1	0.6	-0.5	4.6	0.0
AI/AN	27.1	0.078	1.4	11.1	20.9	-16.9	8.3	2.1
Black	28.0	0.083	1.5	12.4	26.6	-20.7	9.3	3.2
Hispanic	37.7	0.086	2.0	25.3	81.5	-47.2	19.0	21.7
White	18.7	0.744	1.0	0.0	-97.8	114.0	0.0	7.2
Total	**21.8**		**2.0**	**54.9**	**31.8**	**28.7**	**19.0**	**34.2**
1995								
A/PI	16.3	0.009	1.1	1.9	-1.0	1.1	1.2	0.0
AI/AN	21.7	0.093	1.4	10.9	18.6	-15.7	6.6	1.1
Black	24.3	0.085	1.6	15.0	31.4	-23.8	9.1	3.0
Hispanic	34.4	0.094	2.3	31.8	110.5	-58.9	19.3	24.2
White	15.2	0.719	1.0	0.0	-113.8	137.9	0.0	7.4
Total	**18.4**		**2.3**	**59.6**	**45.7**	**40.6**	**19.3**	**35.6**
Δ90 to 95	-3.5		0.3	4.7	13.9	11.9	0.3	1.4
%Δ	-15.9%		25.6%	8.5%	43.8%	41.7%	1.7%	4.1%
2001								
A/PI	8.7	0.011	1.0	0	-3.6	6.6	0.0	0.6
AI/AN	17.5	0.105	2.0	25.0	10.1	-9.3	8.7	0.2
Black	19.6	0.089	2.3	31.3	22.4	-18.2	10.9	1.2
Hispanic	27.9	0.109	3.2	54.9	105.2	-60.3	19.2	15.3
White	13.5	0.686	1.6	13.8	-97.1	114.7	4.8	4.2
Total	**16.0**		**3.2**	**125.0**	**37.0**	**33.5**	**19.2**	**21.5**
Δ95 to 01	-2.4		0.9	65.3	-8.7	-7.1	-0.1	-14.2
%Δ	-12.9%		72.6%	109.6%	-18.9%	-17.5%	-0.6%	-39.7%
Δ90 to 01	-5.8		1.2	70.0	5.2	4.8	0.2	-12.7
%Δ	-26.7%		116.9%	127.4%	16.5%	16.9%	1.0%	-37.2%

*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance

Trends in relative disparity are shown in Figure 33. The analysis of changes in race-ethnic disparities in cervical cancer above showed general agreement in the overall change in disparity from 1990-2001 (increasing), but the figure above suggests more limited agreement with respect to the annual changes in disparity. For a number of periods (highlighted by boxes in Figure 8-4), specifically 1992-3, 1995-98, and 2000-01, the MLD and the IDisp give different answers with respect to the change in disparity. In particular, from 1995-98 the IDisp shows a striking rise in disparity, likely due to the large decline in the rates for the A/PI groups (referent group), while the MLD shows a moderate decline.

Figure 33. Trends in relative race-ethnic disparity in cervical cancer incidence among those 45-74.



Case Study 9: Social Disparities in Mammography Screening, 1987-2003

The data for this analysis come from screening supplements to the National Health Interview Survey. Supplements asked about mammography screening in 1987, 1992, 1995-8, 2000, and 2003. In addition, to facilitate comparison with the results for education, household income was collapsed into four groups, generally similar to quartiles of the weighted population distribution of income for the entire sample over the period 1987-96. The analysis is restricted to individuals 45-74 years of age, and rates are not age-adjusted.

Prevalence Trends

Trends in the proportion of women 40 and over not reporting not receiving a mammogram within the past 2 years by education and income are shown in Figure 34, and by race-ethnicity in Figure 35. There have clearly been sharp declines in the proportion of women not receiving a mammogram, but it appears that the bulk of the decline occurred between 1987 and 2000 and rates appear to have changed little from 2000 to 2003. For virtually all years Non-Hispanic whites, those with 16 or more years of education, and those in the top income quartile are more likely to report having received a mammogram during the past two years.

Figure 34. Trends in the proportion of women age 40 and over not receiving a mammogram within the past 2 years, by education and income, 1987-2003 National Health Interview Surveys.

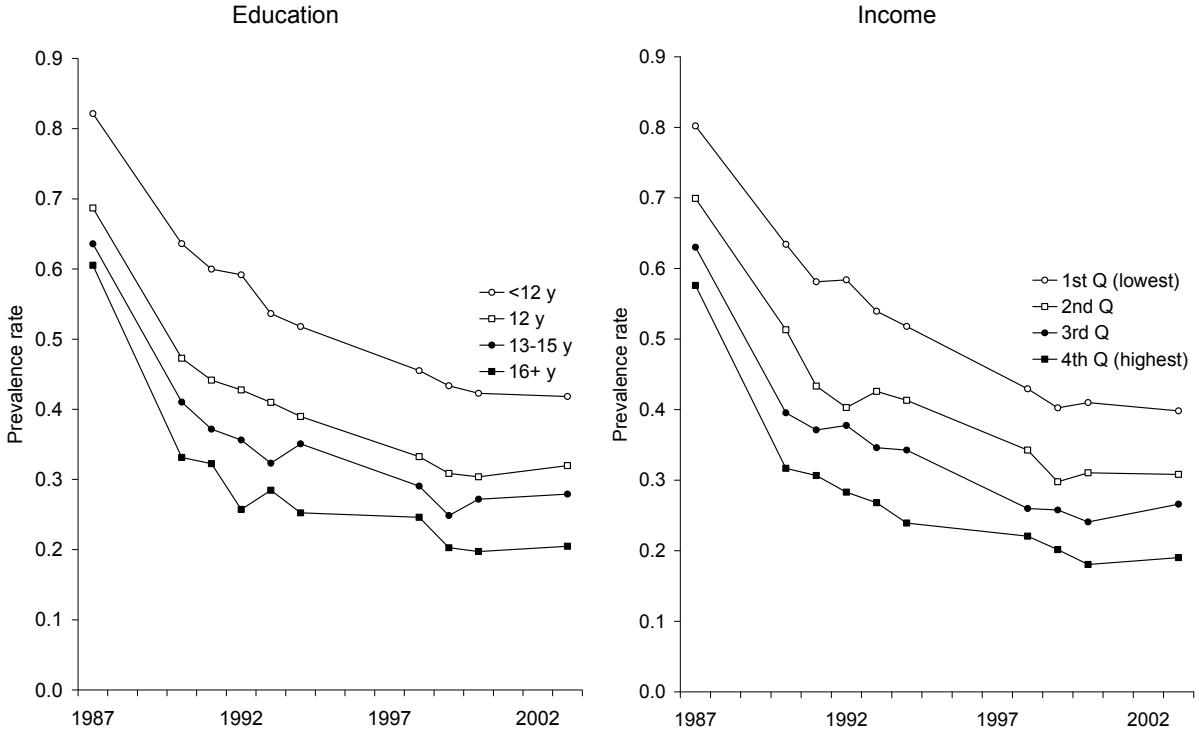
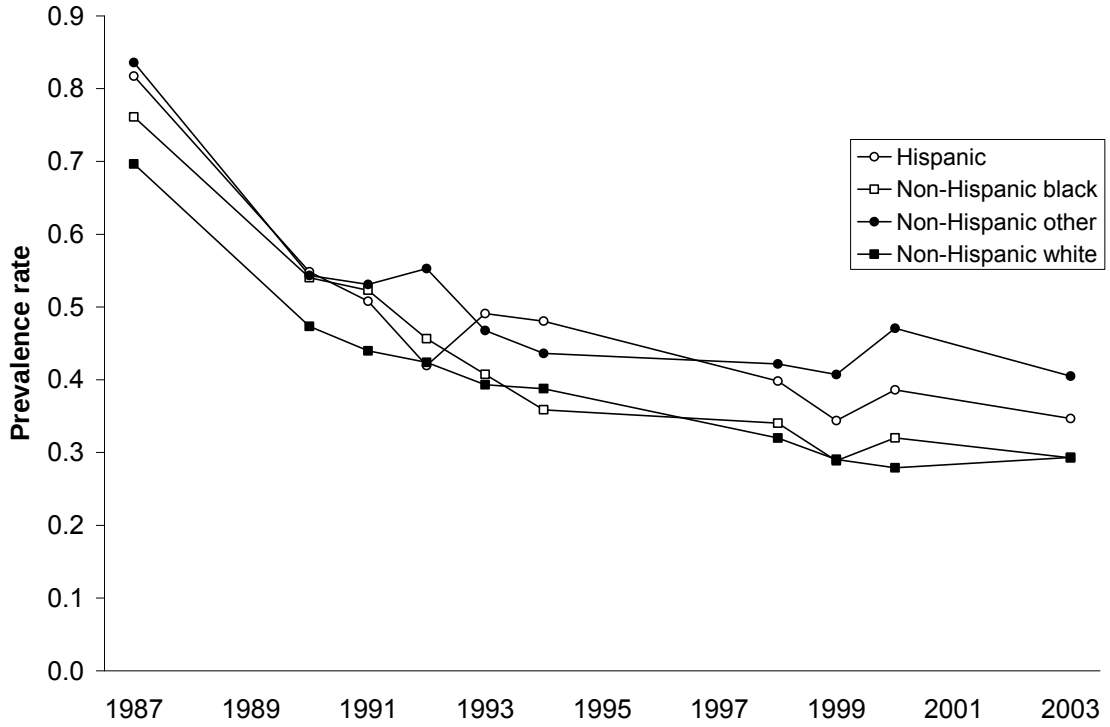


Figure 35. Trends in the proportion of women age 40 and over not receiving a mammogram within the past 2 years, by race-ethnicity, 1987-2003 National Health Interview Surveys.



Generally speaking, there is broad agreement among all of the disparity measures with respect to which social group demonstrates the largest disparity in mammography screening (Table 37). Both relative and absolute disparities are clearly larger across socioeconomic groups than across race-ethnic groups regardless of which measure is used, and disparities appear to be marginally larger across income than education groups. However, it might also be pointed out that the degree to which relative socioeconomic disparities are larger than relative race-ethnic disparities differs across disparity measures. Income-related disparities in 2003 are roughly 3.7 (70.33/19.00) times larger than race-ethnic disparities when measured by the Index of Disparity, but nearly 13.6 times larger when measured by the Mean Log Deviation. This reflects the fact that the MLD weights social group deviations by their population size while the IDisp does not. Since the population distribution of race-ethnicity is heavily dominated by Non-Hispanic whites (77% of the 2003 population), the deviations of other race-ethnic groups receive relatively less weight than do deviations among income groups that roughly correspond to quartiles. Table 37 also includes two additional modifications of the Index of Disparity, one which simply weights the Index by population size (wIDisp) and another that weights by population size and uses the population average as the referent group (wIDispP). We can see that even using these modified versions of the IDisp do not lead to results that are similar to the change observed by the MLD, so this is not simply a function of using a weighted vs. unweighted measure of disparity. It seems more likely that the difference is attributable to the fact that the MLD uses the natural logarithm, which gives additional weight to observations further from the population average, while the IDisp weights all deviations from the referent group equally.

Table 37. Changes in education, income, and race-ethnic disparity in the proportion of women 40 and over not receiving a mammogram in the past 2 years, 1987 and 2003 NHIS.

	Relative Disparity					Absolute Disparity	
	RR	IDisp	wIDisp	wIDispP	MLD	RD	BGV
1987							
Education	1.36	18.09	5.89	2.44	6.10	0.216	63.04
Income	1.39	23.38	7.59	2.54	7.04	0.226	69.02
Race-Ethnicity	1.20	15.54	0.76	0.92	1.25	0.139	13.59
2003							
Education	2.04	65.51	15.53	4.49	26.38	0.213	46.88
Income	2.09	70.33	18.12	5.74	38.27	0.208	62.73
Race-Ethnicity	1.38	19.00	0.98	1.20	2.81	0.112	5.91
%Δ87 to 03							
Education	191.4%	262.1%	163.6%	84.2%	332.7%	-1.4%	-25.6%
Income	178.4%	200.7%	138.7%	126.5%	443.4%	-8.0%	-9.1%
Race-Ethnicity	91.8%	22.3%	29.5%	30.6%	125.4%	-19.4%	-56.5%

Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; wIDisp=Population-weighted IDisp; wIDispP=Population-weighted IDisp with population mean as referent group; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance.

Case Study 10: Geographic Disparities in Stomach Cancer Mortality, 1950-2001

The data for this analysis come from the SEER database, "Mortality - Cancer, Total U.S. (1950-2001)." Rates of stomach cancer for those ages 60 years and over were calculated for each state from 1950-2001 to calculate the relative and absolute disparity across geographic areas. Two similar analyses were carried out after aggregating total deaths and population in each state by US Division and US Region as defined by the US Census Bureau (16). Overall rates and trends were similar among males and females, and were combined for all analyses. Rates are not age-adjusted.

Stomach cancer mortality rates for the three levels of geographic aggregation (region, division, state) are presented in Figure 36. Mortality from stomach cancer has declined impressively over the past half-century, but note that there is considerable variation in mortality across US states that is hidden by looking only at differences between the four US regions.

Figure 36. Mortality from stomach cancer among those 60 and over, US geographic areas 1950-2001.

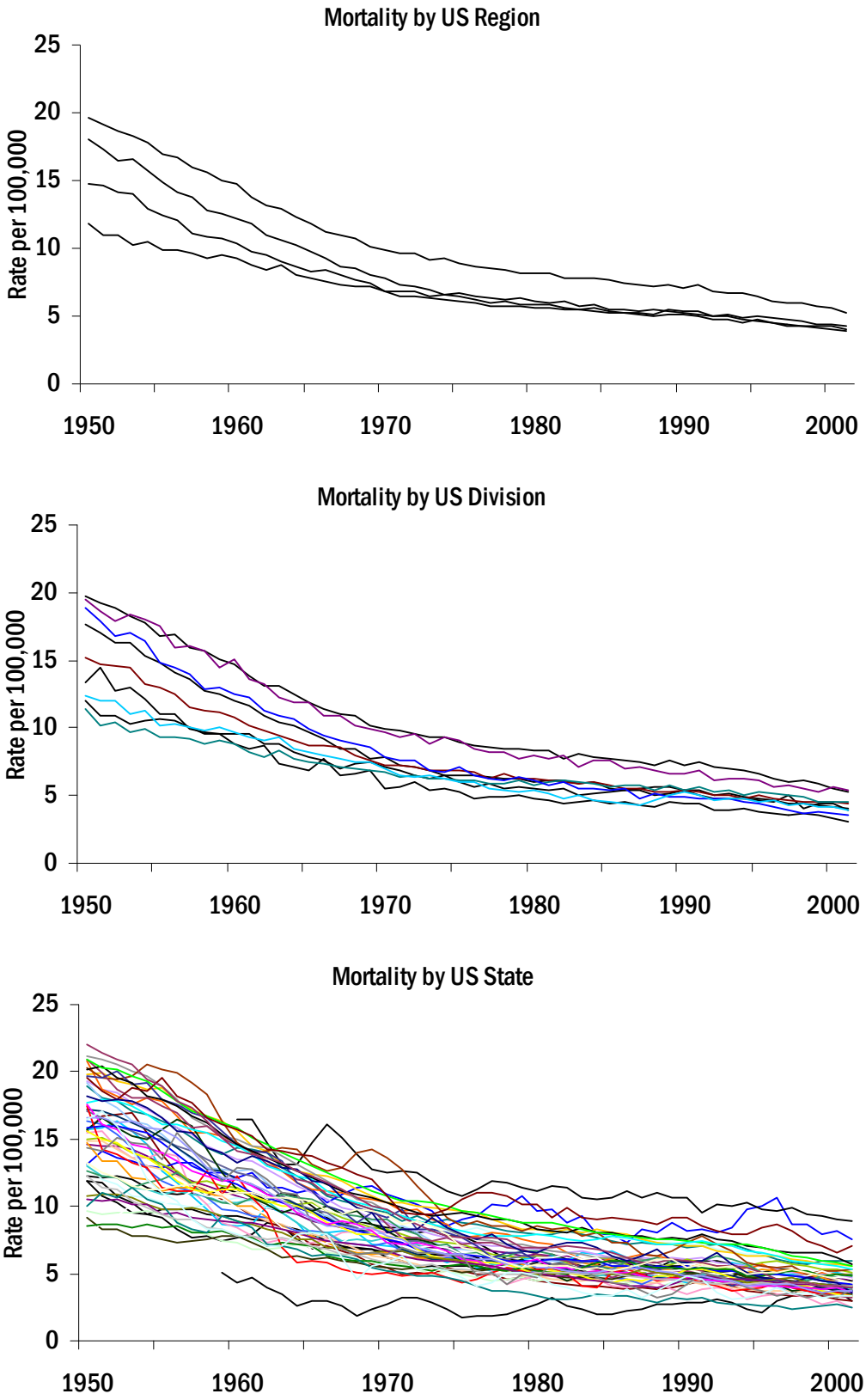


Table 38. Changes in geographic disparity in stomach cancer mortality by different levels of geographic aggregation, 1950-2000.

Geographic Area	Year	Measures of Relative Disparity				Measures of Absolute Disparity	
		RR	IDisp	T	MLD	RD	BGV
Region (n=4)	1950	1.7	47.5	20.5	21.3	7.8	10.3
	1960	1.6	34.4	16.6	16.5	5.5	4.5
	1970	1.4	19.7	11.0	10.7	3.0	1.4
	1980	1.5	20.4	11.9	11.3	2.6	1.0
	1990	1.4	16.3	8.6	8.2	2.0	0.6
	2000	1.4	18.9	7.2	6.9	1.6	0.3
	Δ1950 to 00	-0.3	-28.6	-13.3	-14.4	-6.2	-10.0
	%Δ	-38.9%	-60.2%	-64.8%	-67.6%	-79.5%	-97.1%
Division (n=9)	1950	1.7	40.7	21.0	21.8	8.3	10.5
	1960	1.7	31.8	17.3	17.4	6.3	4.7
	1970	1.8	44.2	12.1	12.0	4.4	1.5
	1980	1.8	35.7	13.3	12.9	3.6	1.1
	1990	1.7	30.5	9.8	9.4	2.9	0.7
	2000	1.7	37.9	9.7	9.7	2.3	0.4
	Δ1950 to 00	0.0	-2.8	-11.3	-12.2	-5.9	-10.1
	%Δ	-2.8%	-6.8%	-53.8%	-55.8%	-71.7%	-96.3%
State (n=51)	1950	2.8	102.6	28.0	29.9	14.2	13.9
	1960	4.6	219.0	24.4	25.5	12.9	6.5
	1970	4.3	158.5	20.7	21.1	9.7	2.5
	1980	4.3	125.5	23.6	23.7	8.8	1.9
	1990	3.8	98.4	19.1	19.1	7.7	1.2
	2000	4.3	98.4	18.6	18.6	7.3	0.8
	Δ1950 to 00	1.4	-4.2	-9.4	-11.3	-7.0	-13.1
	%Δ	77.8%	-4.1%	-33.7%	-37.8%	-49.0%	-94.5%

Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance

Table 38 shows the trends in relative and absolute geographic disparity for the three levels of aggregation. At the regional level (n=4) there is substantial agreement between the measures of disparity. The RR, IDisp, and measures of entropy (T/MLD) indicate that relative geographic disparity has declined by around 60% from 1950-2000, and the RD and BGV suggest slightly larger absolute declines, on the order of 80-100%. Disaggregating regions down to US divisions (n=9) gives a slightly different picture, especially for measures of relative inequality. The RR shows virtually no change in disparity (-2.8%) and the IDisp shows only a 7% decline, but the T and MLD both continue to suggest a 50-60% decline in disparity. Finally, if states are used as the unit of analysis (n=51), the RR suggests that disparity has increased by 78%, the IDisp shows virtually no change (4% decline), and the T and MLD still suggest that disparity has declined, but by approximately 40% as opposed to 60% when measured across divisions or regions. In terms of absolute disparity among states, the RD shows a 50% decline and the BGV a 95% decline from 1950-2000. In fact, the change in the BGV over time is virtually identical for all three levels of aggregation.

Table 39. Ratio of level of disparity in stomach cancer mortality calculated across US states relative to disparity calculated across US regions, 1950-2000.

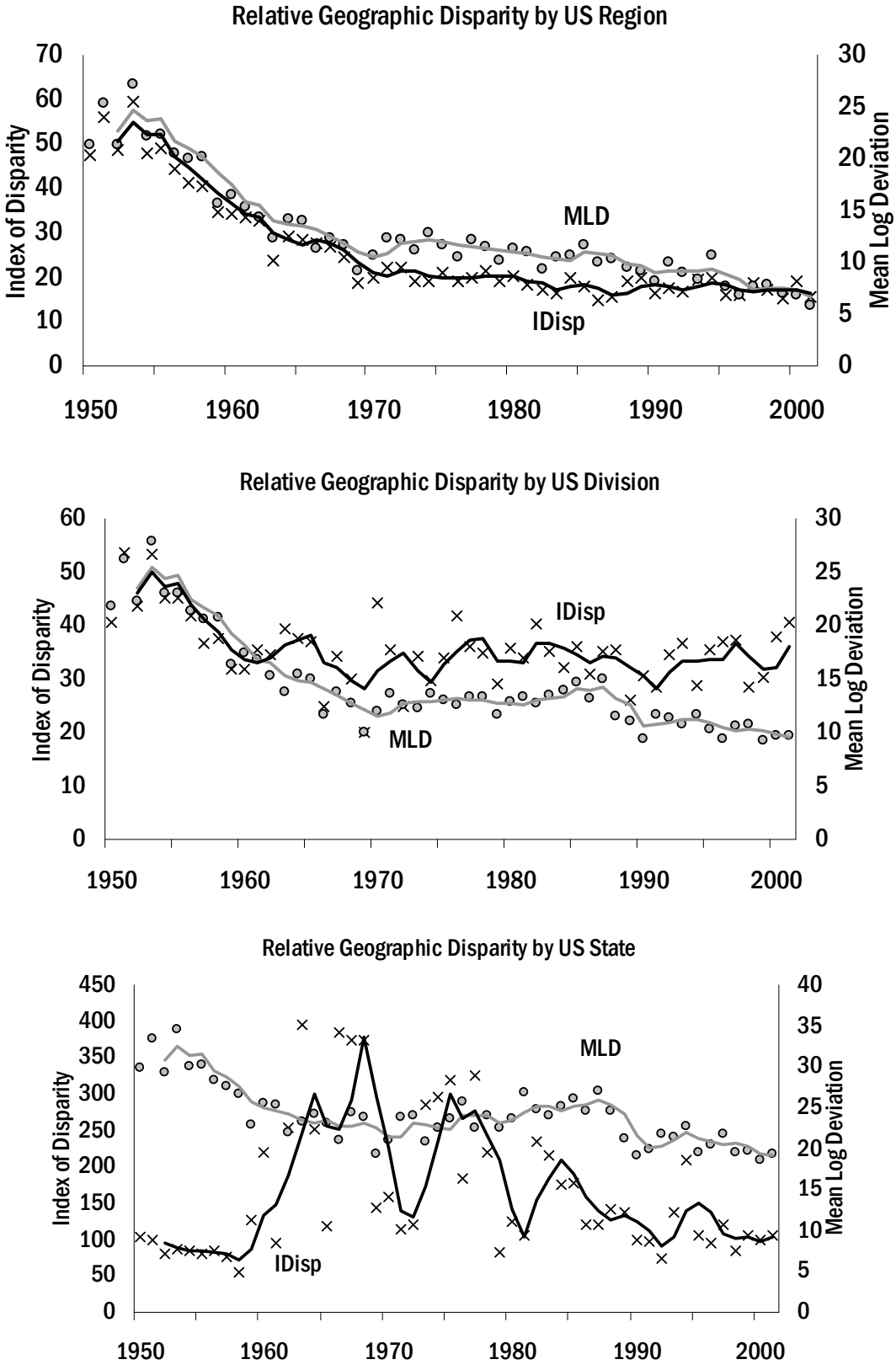
	Measures of Relative Disparity				Measures of Absolute Disparity	
	RR	IDisp	T	MLD	RD	BGV
1950	1.71	2.16	1.37	1.40	1.83	1.35
1960	2.91	6.37	1.48	1.54	2.34	1.43
1970	2.98	8.06	1.87	1.97	3.24	1.80
1980	2.89	6.15	1.97	2.09	3.35	1.90
1990	2.70	6.03	2.21	2.33	3.78	2.13
2000	3.03	5.21	2.58	2.70	4.55	2.52

Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance.

Because the RR, IDisp, and RD do not weight social groups (in this case geographic areas) by population size, it might be expected that they would be more sensitive to the unit of aggregation in this analysis. Overall, the results in Table 38 tend to confirm this assertion. For example, in 1970 the IDisp is about 8 times higher when measured across states (19.7) than when measured across regions (158.5). In contrast, the MLD changes by about 2-fold, from 10.7 to 21.1. Table 39 shows for each year and disparity measure the ratio of disparity measured across states to disparity measured across regions, and it is clear that this has a more dramatic effect on the RR, IDisp, and RD. It is worth pointing out that for all three analyses the total number of deaths, population, and the total mortality rate are exactly the same—only the method of aggregation changes.

Trends in relative disparity for the three levels of aggregation are presented in Figure 37, with three-year moving averages plotted for the IDisp and the MLD. The general trend is very similar across regions whether measured by the IDisp or the MLD, but further aggregating the data leads to some inconsistencies. Across divisions, both measures indicate a decline in disparity until about 1960, after which the IDisp remains approximately constant and the MLD shows a moderate decline. The difference is more pronounced among US states, as the IDisp shows a steep increase in disparity from the late-1950s to the late-1960s while the MLD declines.

Figure 37. Geographic disparities in stomach cancer mortality among those 60 and over, 1950-2001 (3-year moving average).



RESULTS SUMMARY

The purpose of this report was to empirically evaluate different methods for measuring social disparities in cancer-related health outcomes, primarily with respect to evaluating disparity trends. The purpose was to determine whether the choice of disparity measure makes a difference for answering the question of whether social disparities in cancer-related outcomes are increasing or decreasing.

With that purpose in mind it is useful to summarize whether interpretations of the trend in disparity are consistent across selected measures of disparity for the 10 case studies used in this report. **Figure 38** provides a graphical comparative summary of the 10 case studies. In each case we have classified the percent change in the magnitude of each disparity measure as either large (≥30%), moderate (10-29%), or small (<10%). This categorization is admittedly arbitrary, but it seems reasonable to classify relative changes of 30% or greater as more than moderate. We also give an overall substantive interpretation of the change in disparity based on the (in)consistency of the different measures.

Socioeconomic Disparity Trends

Lung Cancer Incidence

The first two rows of Figure 38 show the summary for area-socioeconomic disparities in lung cancer incidence for males and females. For females there is broad agreement among almost all of the measures that both relative and absolute area-socioeconomic disparities have substantially increased from 1988 to 1999. In this case, the general conclusion about the disparity trend (i.e., is disparity increasing or decreasing?) does not depend on which measure of disparity is used. Of course, the magnitude of the change varies across measures but this is simply because of the different mathematical properties inherent in each measures calculation.

For lung cancer incidence in males, however, the results across measures are inconsistent. This is a clear example of the importance of choosing a disparity measure based on apriori principles because the empirical result cannot inform the reader about which measure is "right". Any substantive conclusion is therefore entirely dependent on which measure is chosen.

In this case, the value position rests on whether or not disparity measures should be weighted by population size. The unweighted disparity measures (RR, IDisp, RD) would generally suggest that the area-socioeconomic disparity situation is worse in 1999 than 1988 (little change in absolute disparity and increasing relative disparity). On the other hand, population weighted disparity measures (RCI, ACI) suggest improvement: moderate decrease in relative disparity and strong decreases in absolute disparity. This happened because the incidence rate declined more slowly in the 2nd area-socioeconomic quintile (see Figure 5), which only contained about 5% of the SEER population. This smaller-population group had less influence on population-weighted disparity measures and greater influence on the unweighted disparity measures.

Colorectal Cancer Mortality

For area-socioeconomic disparities in both female and male colorectal cancer mortality, the results are consistent, which we explain below. By going back to the plots of the raw data shown

in Figure 9 and Figure 11 it is obvious to the naked eye that both absolute and relative disparities have decreased. Thus, all of the disparity measures register numerical declines. Note however, that the cells for the RCI and ACI show increases, and the magnitude of change is greater than for the other measures. This is because these measures are sensitive to the direction of the socioeconomic gradient, and only these measures indicate that the socioeconomic gradient shifted from favoring the poor in 1950 to favoring the rich in 2000. The other measures of disparity indicate a reduction but only the RCI and ACI tell us that the social gradient in colorectal cancer mortality actually reversed over this time period and they show that, according to the way they are calculated, disparity worsened.

This highlights the value of understanding the difference between asking whether disparity "has increased or decreased" and asking whether disparity has become "worse or better." Answers to these seemingly innocuous questions are not straightforward and are often dependent on prior principles of what is important to know about disparity. In this case, even though disparity is smaller in magnitude, for both the RCI and ACI it could be argued that the disparity situation is now "worse" since it is the poor who now have the highest rates of mortality. But, according to a strict interpretation of the *Healthy People 2010* disparity goals it could also be argued that this situation represents progress towards eliminating disparity. Such alternative interpretations beg the question whether we care more about health disparities where the burden is on the disadvantaged than when the burden is on the advantaged.

Prostate Cancer Mortality

Another interesting example in Figure 38 is the trend in area-socioeconomic disparity for prostate cancer mortality. Among men 45-74 years of age there is consistency among all the measures that disparity has increased (though they differ with respect to the magnitude of the change). But for men 75 and over it is more difficult to come to a firm conclusion. The measures of relative disparity suggest a moderate decline but the measures of absolute disparity suggest a moderate increase. Thus, the conclusion about the trend in socioeconomic disparity in prostate cancer in this age group in this case depends on an apriori value position concerning relative and absolute disparity. Is it more important that we see improvements in relative or absolute disparity? Only when that question is answered can we reach a substantive conclusion about prostate cancer mortality trends in those over 75.

Smoking and Obesity

For some outcomes there is a great deal of consistency among all the measures. For example, it seems clear that socioeconomic disparities in current smoking are increasing among both men and women, while socioeconomic disparities in obesity are decreasing. Given the magnitude of the changes in the prevalence of these two outcomes for virtually all social groups—declining for smoking and rising for obesity—this result may not be surprising.

Race and Ethnic Disparity Trends

Lung Cancer Incidence

For female lung cancer incidence among race and ethnic groups, most relative measures suggest little or no change (though note that the IDisp and MLD move in different directions because the most populous group, whites, moved away from the population average), but rates

have moderately declined for most groups, leading to moderate declines in absolute disparity. For males, however, it is a bit more difficult to judge whether the disparity situation is better or worse in 2001 than in 1999. Relative disparity increased according to all three measures, but, as rates of lung cancer incidence have been declining among males, absolute disparity among race and ethnic groups has also declined. Thus, the overall conclusion about this disparity again depends on whether absolute or relative disparity is thought to be more important.

Breast Cancer Incidence

For racial disparities in the incidence of breast cancer there is virtually no change in disparity among women ages 45-74, regardless of how it is measured. On the contrary, among women ages 75 and over, there is substantive divergence among the measures and it appears that one's interpretation of the disparity trend will depend on the value position with respect to population weighting. The unweighted relative disparity measures (RR, IDisp) indicated strong declines in relative disparity, while the RD declines moderately. Using unweighted measures would therefore lead one to conclude that there has been considerable improvement in race/ethnic disparities in breast cancer incidence. On the contrary, the population weighted measures (MLD, BGV) both indicate that disparity actually increased by around 20% during the 1990s. This difference is very likely due to the fact that the initially low rate among Asian/Pacific Islander women in 1990 increased over the decade. This group represents 0.4% of the population and so had less impact on the population-weighted measures. Thus, the issue of population-weighting is central to interpreting the disparity trend in this case.

Cervical Cancer Incidence

For trends in race and ethnic disparity in cervical cancer incidence disparity trends for both younger and older women are difficult to interpret without specifying whether one thinks absolute or relative disparities are more important. As cervical cancer incidence has been generally declining but declining faster among those with lower rates, relative disparity is increasing, but absolute disparities are decreasing.

Geographic Disparity Trends

Stomach Cancer Mortality

Geographic disparities in stomach cancer mortality appear to have declined, but the unit of geographic aggregation affects the degree of consistency across the measures of relative disparity. For the 4 U.S. regions (Midwest, Northeast, South, West) there has been considerable reduction of disparity across regions, whether measured on the relative or absolute scale. However, as the unit of aggregation moves from regions to divisions to states the extent of disagreement across the measures increases. Among the 50 states, the unweighted disparity measures suggest either a strong increase or no change in disparity, while the population-weighted MLD consistently suggests that relative disparity has declined. Thus, at the level of US states, the issue of whether disparity measures should be weighted by population size has important implications for interpreting the disparity trend.

Comparing Socioeconomic and Race and Ethnic Disparity Trends

Mammography Screening

Finally, the last rows of Figure 38 show a direct comparison of income, education, and race/ethnic disparity for the same outcome: the proportion of women not receiving a mammogram in the past two years. For all of these cases we find that interpreting the trend in disparity depends on how much emphasis is place on relative or absolute disparities. Generally speaking, as the rates of not receiving a mammogram have declined, they tend to have declined faster among those with initially lower rates in 1987 (see Figure 34 and Figure 35). Relative disparities have thus increased but absolute disparities have declined. With respect to the direct comparison between race/ethnic disparity and socioeconomic disparity, there is general agreement among all of the measures that relative disparities have increased more among socioeconomic than among race/ethnic groups. Similarly, absolute disparity has declined more across race/ethnic groups than across socioeconomic groups, regardless of which disparity measure is used.

Figure 38. Graphical summary of disparity trends.

	Relative Disparity			Absolute Disparity			
Breast Cancer Incidence 1990-2001							
Ages 45-74	4	9.3	1.6	1.9	2.2		No change
Ages 75+	-36.8	-48.8	18.5	-15.6	16.8	?	Depends on value position on population weighting
Cervical Cancer Incidence 1990-2001							
Ages < 45	12.3	34	11.9	-17.7	-39.3	?	Depends on value position on absolute vs. relative disparity
Ages 45-74	116.9	127.4	16.9	1.0	-37.2	?	Depends on value position on absolute vs. relative disparity

Geographic Disparity

	Relative Disparity			Absolute Disparity			
	RR	IDisp	MLD	RD	BGV		
Stomach Cancer Mortality 1950-2001							
Region	-38.9	-60.2	-67.6	-79.5	-97.1		Large decrease in disparity
Division	-2.8	-6.8	-55.8	-71.7	-96.3		Large decrease in disparity
State	77.8	-4.1	-37.8	-49.0	-94.5		Large decrease in absolute disparity but relative disparity goes up, down or is stable and depends on your value position on population weighting

Comparing Socioeconomic and Race/ethnic Disparity

	Relative Disparity			Absolute Disparity			
	RR	IDisp	MLD	RD	BGV		
Mammography Screening 1987-2003							
Education Disparity	191.4	262.1	332.7	-1.4	-25.6	?	Depends on value position on absolute vs. relative disparity
Income Disparity	178.4	200.7	443.4	-8.0	-9.1	?	Depends on value position on absolute vs. relative disparity
Race / ethnic Disparity	91.8	22.3	125.4	-19.4	-56.5	?	Depends on value position on absolute vs. relative disparity

Legend	Disparity Increasing			Disparity Decreasing	
	+30%	+11-29%	+/-0-10%	-11-29%	-30%

CONCLUSIONS

We will briefly attempt to summarize the analyses of the case studies in this report by answering the series of questions that framed its development:

5. Does the choice of a measure of disparity matter for assessing disparity trends?

Yes. The 10 case studies showed a number of situations where substantively different interpretations concerning the level and trend in disparity resulted from using different measures of health disparity. Such differences in interpretation could not be reconciled without reference to consideration of which underlying dimensions of disparity are emphasized in the measures. That is, absolute vs. relative disparity; whether or not disparity measures are weighted by population size, and whether measures are sensitive to the direction of the social gradient in health.

6. How often does the choice of disparity measure matter?

Of the 22 separate analyses summarized in Figure 38, 9 (41%) revealed situations where the overall substantive conclusion about the trend in disparity was difficult to make without some apriori judgment about what dimensions of disparity are important. It is impossible to know what this percentage would be across all relevant cancer -related outcomes, but it is clear from these analyses that the issue is likely to be reasonably common.

7. Why does the choice of disparity measure matter?

It is crucial to reiterate the conclusions of our theoretical review of disparity measures, that different disparity measures often contain implicit or explicit value judgments about what dimensions of disparity are important. These value judgments play an important role in understanding why different measures of disparity may give different answers to questions about disparity trends.

In particular, most of the cases of disagreement between measures of disparity depended on two issues. One is the scale on which disparity should be evaluated. In many cases relative measures of disparity moved in one direction, while absolute measures moved in the opposite direction. Thus, specifying whether absolute or relative disparities are more important prior to undertaking any analyses will assist in minimizing disagreement about disparity trends. The second issue is whether to weight social groups by population size. In several cases we found that population-weighted disparity measures differed in either magnitude or direction from unweighted disparity measures. In particular, and as might be expected, unweighted measures of disparity appear to be more sensitive to the movement of rates of disease, especially those of smaller population groups whose rates of disease may be less stable over time.

8. The Index of Disparity

As the Index of Disparity has been proposed as a measure of progress toward relative disparity goals for *Healthy People 2010*, we thought it important to comment specifically on its performance in the case studies. In general terms, the Index of Disparity was more volatile in

cases where there are large differences in the population size of sub-groups across which disparity is being measured, such as in comparisons across different race/ethnic groups. When the size of the social groups is fairly similar, as in the case of socioeconomic disparities in smoking and obesity (see Figure 38 for a summary), the Index of Disparity is usually consistent with other relative disparity indicators. The instability of the Index of Disparity in cases where social groups differ substantially in population size is most easily seen in the example of stomach cancer mortality disparities across differing aggregations of geographic areas (see Figure 37). Among the four US regions, which are all relatively populous, there is generally agreement between the Index of Disparity and population-weighted measures. But using the same data measured across US states, which vary dramatically in population size, the Index of Disparity becomes much less stable and is inconsistent with population-weighted measures.

9. What are the limitations of applying measures of economic disparity to health disparity?

Part of the reason for this evaluation of measures of health disparity was the notion that the quantification of disparity is a phenomenon that has a long history in other disciplines, particularly in economics. We have thus attempted to evaluate some traditional measures of economic disparity (e.g., measures of entropy, the concentration index) as measures of health disparity. While these measures have much that is to be recommended, one potential limitation is that most measures of economic disparity use the population average as the reference point from which to measure disparity. This makes sense in economics because income is a fungible good, and disparity may decline through the transfer of income from the rich to the poor, bringing the incomes of the rich closer to the population average. But health (i.e., health status) is not a transferable good. The analogous situation for health disparity, where declines in disparity come about by worsening health among the healthiest groups, is difficult to cast in a positive light. Other things being equal, it is hard to imagine policymakers viewing declines in health among the healthiest groups as positive, even if it reduces health disparity. Thus, applying traditional measures of economic disparity to health requires acknowledging and understanding this limitation. It should be noted that another proposed measure of health disparity, the Index of Disparity, overcomes this specific limitation by using the healthiest group as the reference group, but has other limitations as well. At present it appears that no currently-used measure of disparity is entirely free from limitations for monitoring disparity trends, as we pointed out in our previous review. While additional research on alternative measures of health disparity may bear fruit, we can, in fact, apply measures of economic disparity to health but should remember that, as the *Healthy People 2010* dual goals make clear, disparity is not our only health concern.

10. What are the implications for monitoring health disparities?

There is currently a strong emphasis in the US public health policymaking community on monitoring of progress toward eliminating health disparities. The results of the case studies presented in this report demonstrate that it is easily possible to come to fundamentally different conclusions about the extent of progress toward eliminating health disparities using the same data but different measures of health disparity. The naïve use of summary measures of health disparity thus has the potential to lead to confusion among both policymakers and researchers as to whether disparities are increasing or decreasing, which cancer-related outcomes show the

largest disparities, and which health disparities might be specifically targeted for increased study. Such confusion will be minimized and health disparity measurement will be advanced by increased debate and discussion of the issues that generate differences among measures of health disparity:

- How much weight should we give individuals of different social groups when measuring disparity? Counting each individual's health equally implies population-weighted measures of disparity among social groups. Counting each social group's health the same means using unweighted disparity measures (and implies differential weighting of individuals from social groups with different population sizes).

- How much to weight different parts of the health distribution? At any given time some social groups are healthier than others. Over time health changes, and some measures of disparity weight health improvements among all groups the same, while others are more sensitive to health improvements among the least healthy or among the poor. Which of these perspectives is consistent with our concerns about social disparities in health?

- Should we be more concerned about absolute or relative disparities? Diseases and conditions that exact a large burden on the population, because of their high prevalence, often generate smaller relative disparities, while rare conditions can generate exceedingly high relative disparities. Which of these perspectives is the appropriate scale on which to measure disparity trends?

In sum, our recommendations from the original report, further clarified here, suggest giving priority to disparity measures on the absolute scale, that weight for population size and where possible consider the direction of the social gradient in health. That recommendation stands but it does not exclude consideration of issues of relative disparity or what is happening among smaller population groups. For those reasons it may always be useful to adopt a "suite" of health disparity indicators that make clear which aspects of health disparity are changing over time.

APPENDIX: RANDOM VARIATION

While this report did not focus on statistical inference about changes in health disparities, it is likely to be of interest to many researchers and policymakers. Therefore, in this Appendix we provide a very basic introduction to the various methods used for calculating standard errors for the summary measures of disparity discussed in this report. We would encourage those interested to consult the source publications referenced here for more details.

Underlying Rates

Most of the underlying data in this report are based on either incidence or mortality rates and are assumed to come from a Poisson distribution (17). The general formula for the standard error for crude or age-specific mortality and incidence rates is:

$$SE_r = \frac{\sqrt{d}}{n}$$

where *SE* is standard error, *d* is the number of incident cases or deaths, and *n* is the estimated population size (17).

Rate Ratio and Rate Difference

The general formula for calculating the standard error of the Rate Difference (RD) is (12):

$$SE_{RD} = \frac{r_1 - r_0}{\sqrt{SE_{r1}^2 + SE_{r0}^2}}$$

where r_0 is the reference rate and *SE* indicates the standard error of the rates being compared. Similarly, the standard error for the rate ratio, assuming the two estimates are independent, may be written as (18):

$$SE_{RR} = \frac{r_1}{r_0}\sqrt{\left(\frac{SE_{r1}}{r_1}\right)^2 + \left(\frac{SE_{r0}}{r_0}\right)^2}$$

though it is often more convenient to work with the natural log of the RR for generating confidence intervals:

$$SE_{\log(RR)} = \sqrt{\frac{1}{d_1} - \frac{1}{n_1} + \frac{1}{d_0} - \frac{1}{n_0}}$$

Slope and Relative Index of Inequality

Recall that the SII can be easily obtained via regression on grouped data:

$$\bar{y}_j = \beta_0 + \beta_1 \overline{R}_j$$

where *j* indexes social group, $\bar{y}_j$ is the average health status and $\overline{R}_j$ the average relative ranking of social group *j* in the cumulative distribution of the population, β_0 is the estimated health status of a hypothetical person at the bottom of the social group hierarchy (i.e., a person whose relative rank R_j in the social group distribution is zero), and β_1 is the difference in average health status between the hypothetical person at the bottom of the social group distribution and the hypothetical person at the top (i.e. R_j=0 vs. R_j=1). However, because this regression is on grouped data, the standard errors are heteroskedastic, and Kakwani and colleagues, and Low and

Low (19), among others, note that the following transformation should be used, which is equivalent to running weighted ordinary least squares:

$$\bar{y}_j\sqrt{p_j} = \sqrt{p_j} + \beta_1\bar{R}_j\sqrt{p_j}$$

where p_j is the proportion of the population in the jth group. However, this transformation does not account for the correlation of error terms induced by the relative ranking variable. See Kakwani and colleagues (8), Wagstaff (20), or Low and Low (19) for additional details.

Hayes and Berry (21) have also developed a formula for the standard error for the Relative Index of Inequality (RII) for grouped data, using the Kunst-Mackenbach version of the RII, which may, via substitution, be re-written as:

$$RII_{KM} = \gamma = \frac{\alpha}{\alpha+\beta} = \frac{\bar{y}-\beta\bar{R}}{\bar{y}-\beta\left(1-\bar{R}\right)}$$

in which case the estimated variance and standard error of γ are:

$$\text{var}(\gamma) = \frac{\beta^2\ \text{var}(\bar{y}) + \bar{y}^2\ \text{var}(\beta)}{\left[\bar{y}+\beta\left(1-\bar{R}\right)\right]^4}$$

$$SE(\gamma) = \sqrt{\text{var}(\gamma)}$$

Relative Concentration Index

The formula for the standard error for the Relative Concentration Index (RCI) for grouped data is given by Kakwani and colleagues, which accounts for the autocorrelation in error terms, as:

$$\text{var}(RCI) = \frac{1}{n}\left[\sum_{j=1}^{J} p_j a_j^2 - \left(1+RCI\right)^2\right] + \frac{1}{n\mu^2}\sum_{j=1}^{J} p_j\sigma_j^2\left(2R_j - 1 - RCI\right)^2$$

where σ_j^2 is the variance of μ_j,

$$a_j = \frac{\mu_j}{\mu}\left(2R_j - 1 - C\right) + 2 - q_{j-1} - q_j$$

$$q_j = \frac{1}{\mu}\sum_{\gamma=1}^{j}\mu_\gamma p_\gamma$$

where n is the sample size, J is the number of groups, p_j is the proportion of the total population in group j, μ_j is the mean value of the health variable in group j, and RCI is the Relative Concentration Index. A very useful guide for calculating the RCI and its standard error is available at the World Bank's 'Poverty and Health' website at: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTHEALTHNUTRITIONANDPOPULATION/EXTPAH/0,,contentMDK:20216933~menuPK:400482~pagePK:148956~piPK:216618~theSitePK:400476,00.html

Other Summary Measures

To our knowledge, details of standard formulas for calculating standard errors for other summary measures used in this report, including the Index of Disparity, the Theil Index and Mean Log Deviation, and the Between-Group Variance, are not widely available. Cowell (22, 23) gives an overview for various measures of income inequality, and Biewen and Jenkins (24) recently derived methods for estimating various inequality measures with complex survey data.

However, recent developments in computing power and resampling methods (25) have led many authors to suggest calculating standard errors via bootstrapping (12, 26-29), which was the approach we took in Case Study 1.

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