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, 1990-2001

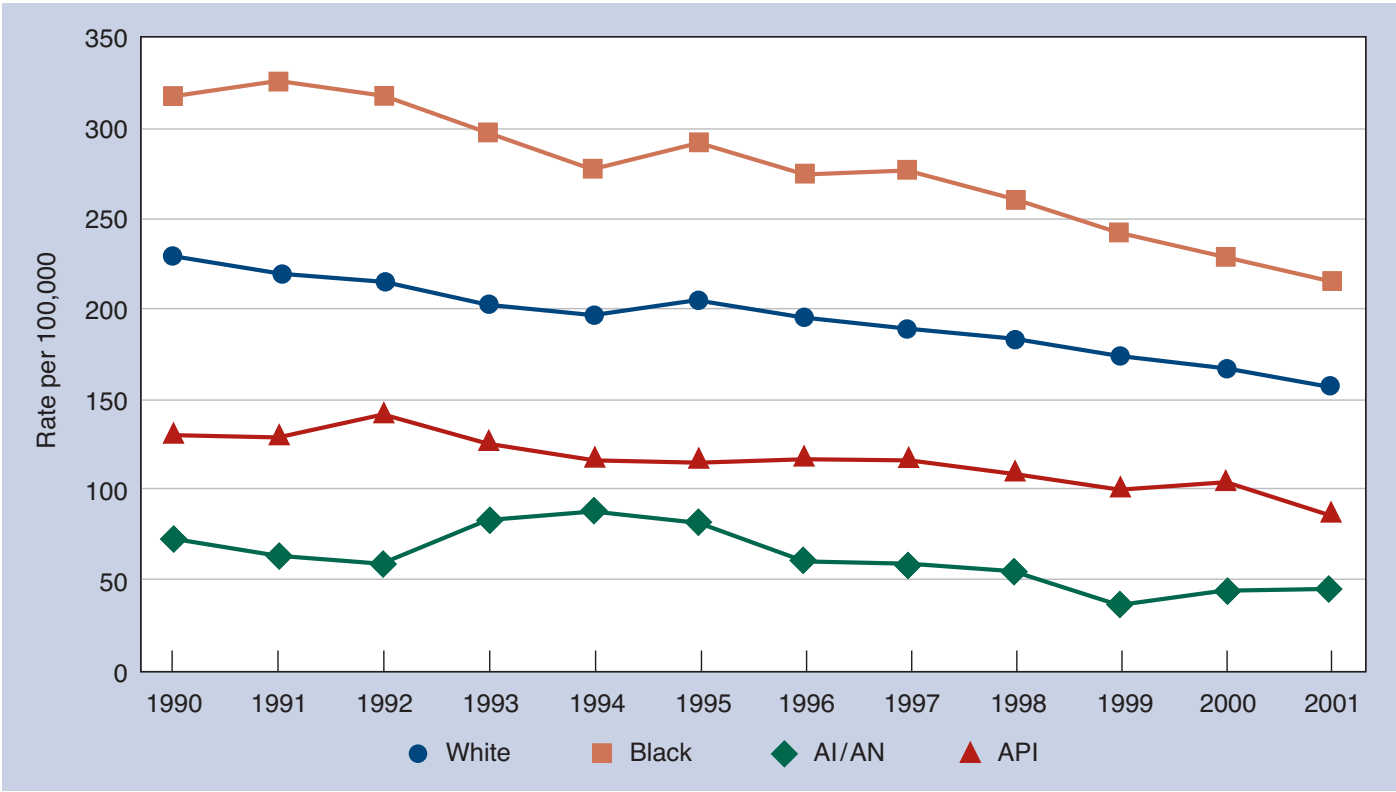


Table 1. Trends in Lung Cancer Incidence and Population Distribution, by Race, among Males 45-74, 1990-2001

	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
Δ1990 to 2001	-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 shaded 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:

$$Z = (D_{2001} - D_{1990}) / \sqrt{(SE^2_{2001} + SE^2_{1990})},$$

where D indicates the disparity measure and ($|Z|>1.96$) indicates statistical significance at the =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. The trend in relative race / ethnic disparity among males, as measured by the IDisp and the MLD is shown in

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**
Δ1990 to 2001	-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

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).

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 2. Trends in Racial Disparity in Lung Cancer Incidence among Males 45-74, 1990-2001

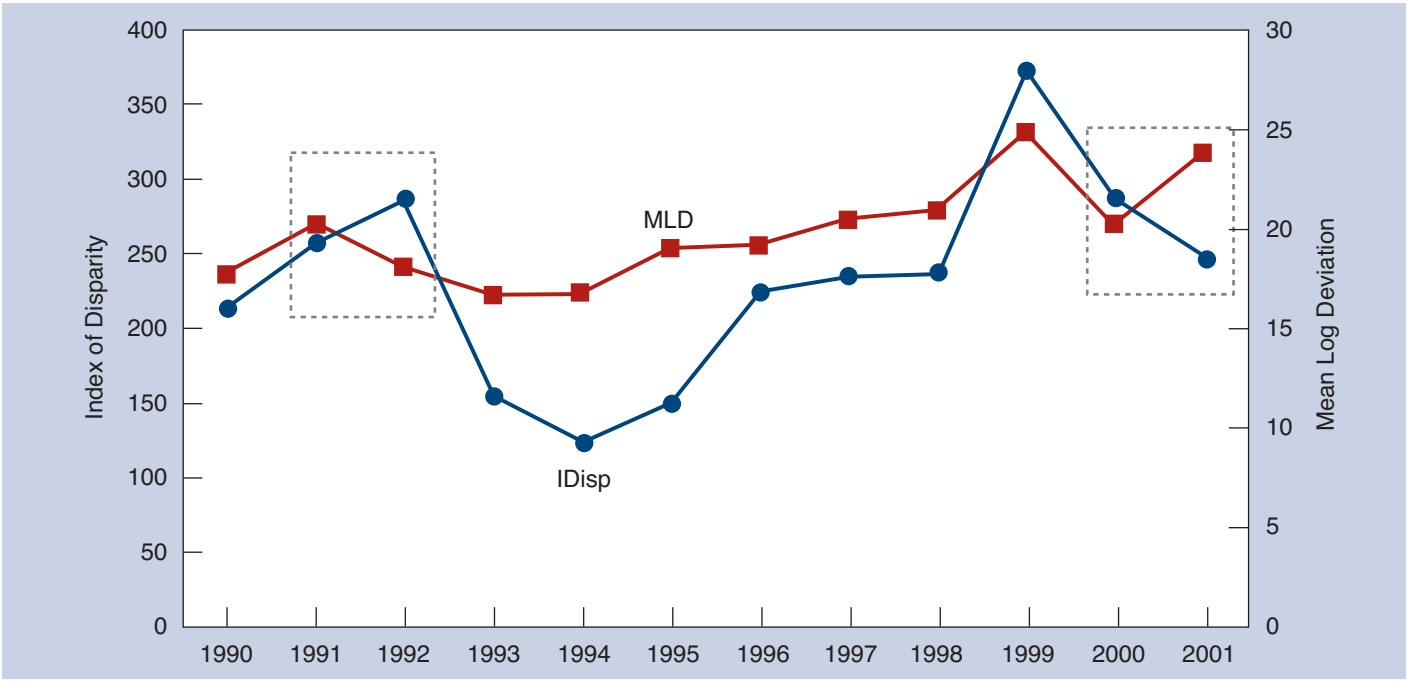


Figure 3. Lung Cancer Incidence among Females 45-74, 1990-2001

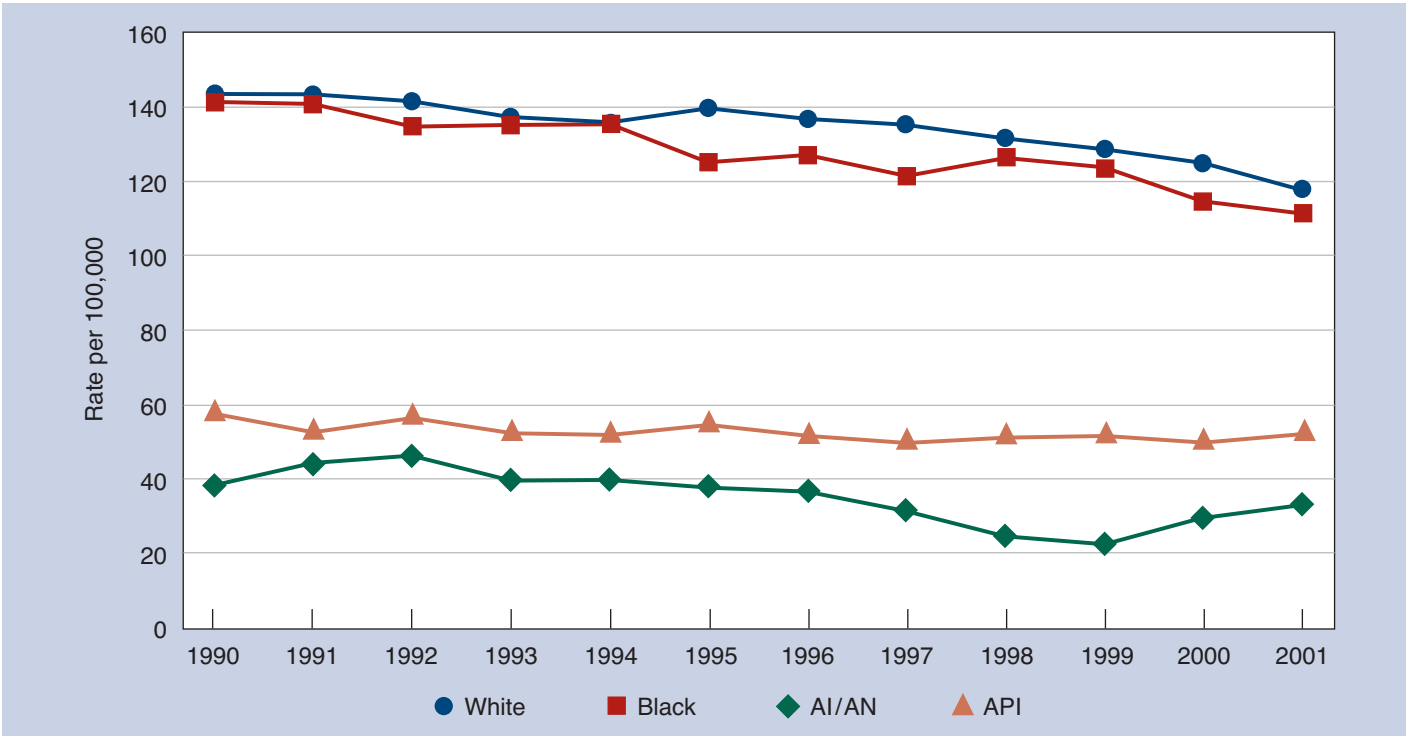


Table 3. Trends in Lung Cancer Incidence and Population Distribution, by Race, among Females 45-74, 1990-2001

	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
Δ1900 to 2001	-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** for males, **Table 4** for females), 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.

The trend in relative racial disparity among females in 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

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**
Δ1900 to 2001	-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%

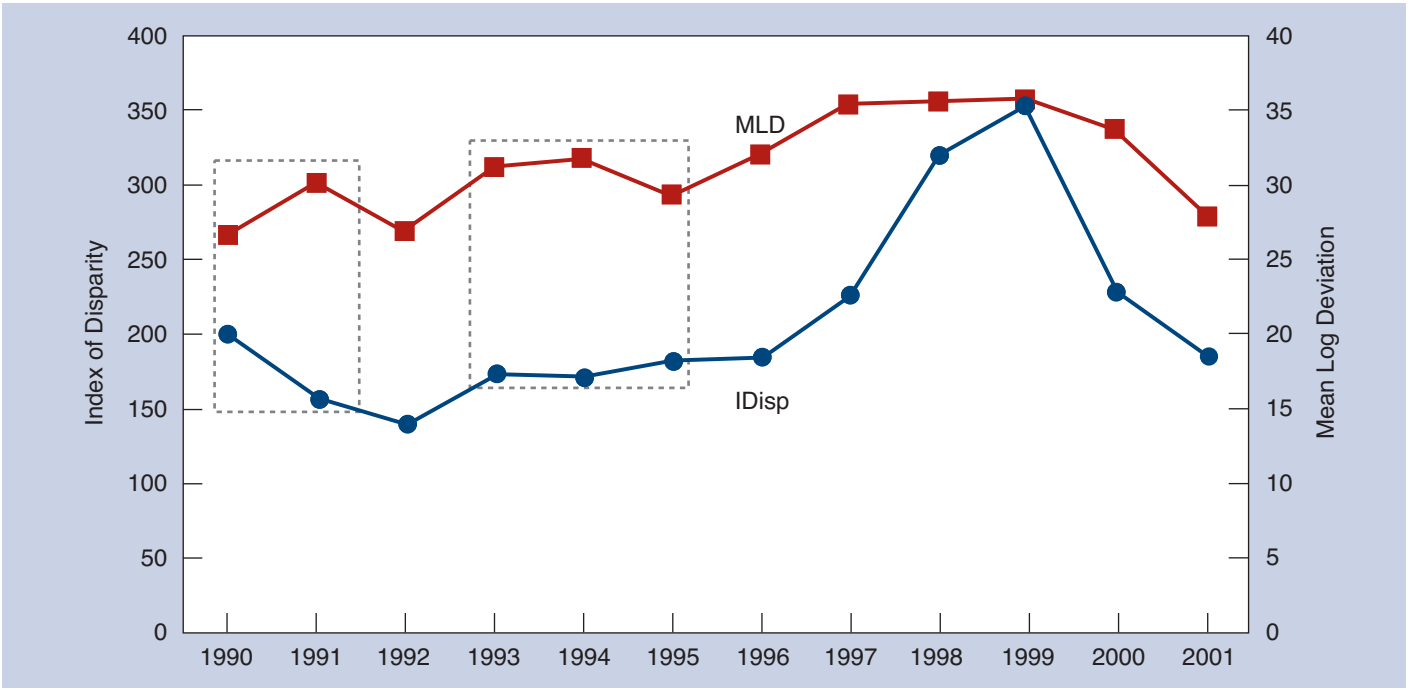
*For the RR and RD the row marked 'Total' contains the maximum of RR or RD, a measure of the range
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; T=Theil Index; MLD=Mean Log Deviation; RD=Rate Difference; BGV=Between Group Variance; SE_{trad}=traditional standard error; SE_{boot}=bootstrap standard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

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.

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 (SEP) 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

Figure 4. Trends in Relative Racial Disparity in Lung Cancer Incidence among Females 45-74, 1990-2001

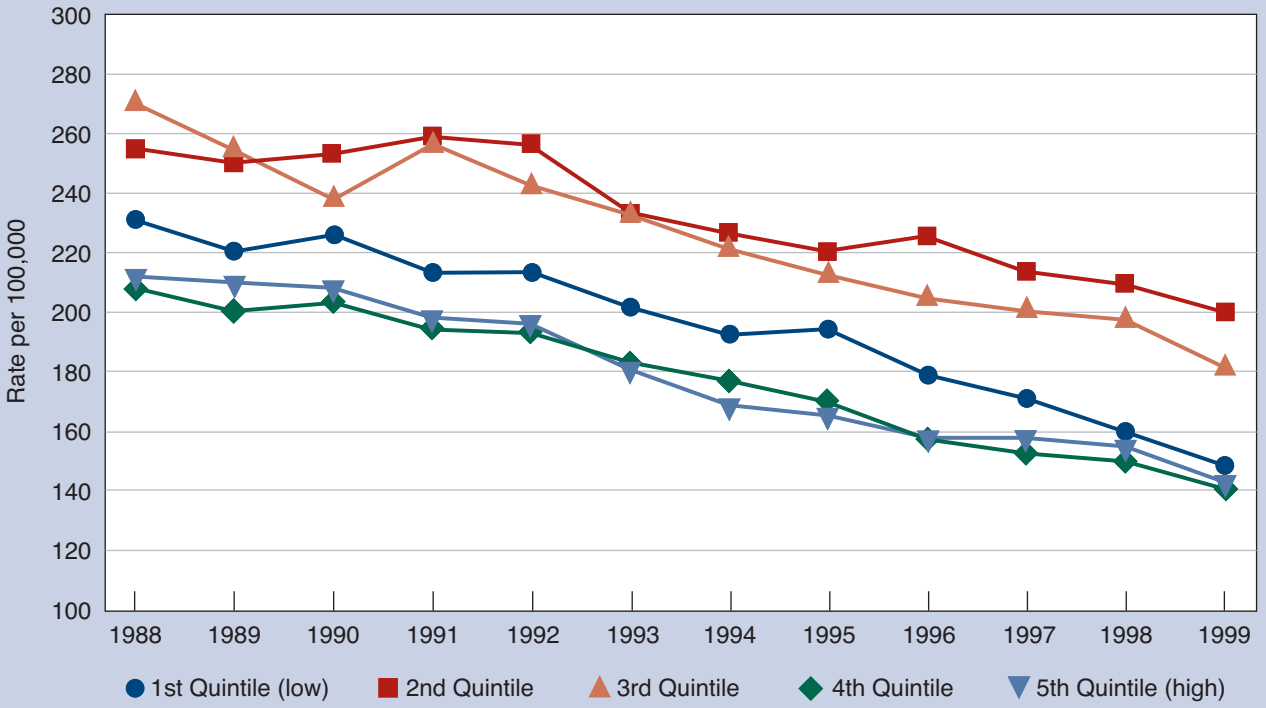


percentage of the population ages 25 and over with at least a high school degree, estimated from the 1990 US Census. Educational attainment ranged from 57.8% in Guadalupe County, NM to 94.7% in Los Alamos County, NM. The 201 counties were classified into five categories of an equal number of counties to create quintiles of SEP 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, by Area Socioeconomic Position, 1988-1999



(Unweighted quintiles of % of county with at least a high school education)

Table 5. Lung Cancer Incidence and Population Distribution among Males 45-74, by Quintile of Socioeconomic Position, 1988-1999

	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
Δ1988 to 1999	-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 other summary measures (33-46%). 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

Table 6. Changes in Socioeconomic Disparity in Lung Cancer Incidence between 1988 and 1999 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**
Δ1988 to 1999	-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.

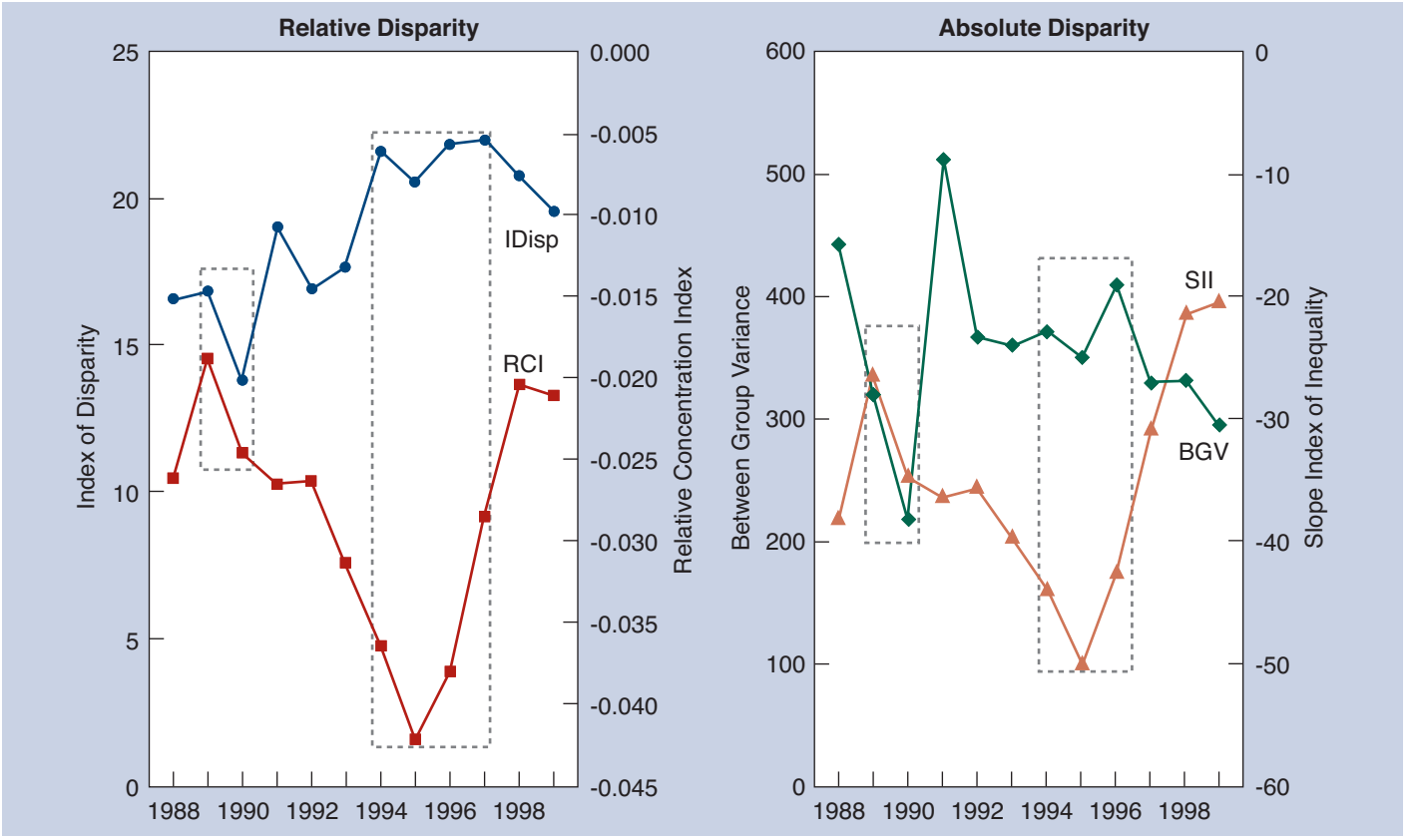
increase in disparity while the BGV shows a decrease (highlighted in boxes), while the opposite is true from 1996-97.

DIAGNOSTICS

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

Based on the results in **Table 6**, 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

Figure 6. Trends in Relative and Absolute Socioeconomic Disparity in Lung Cancer Incidence among Males 45-74, 1988-1999



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 shaded columns 5 and 6 in **Table 7**). In column 6, 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.

Females

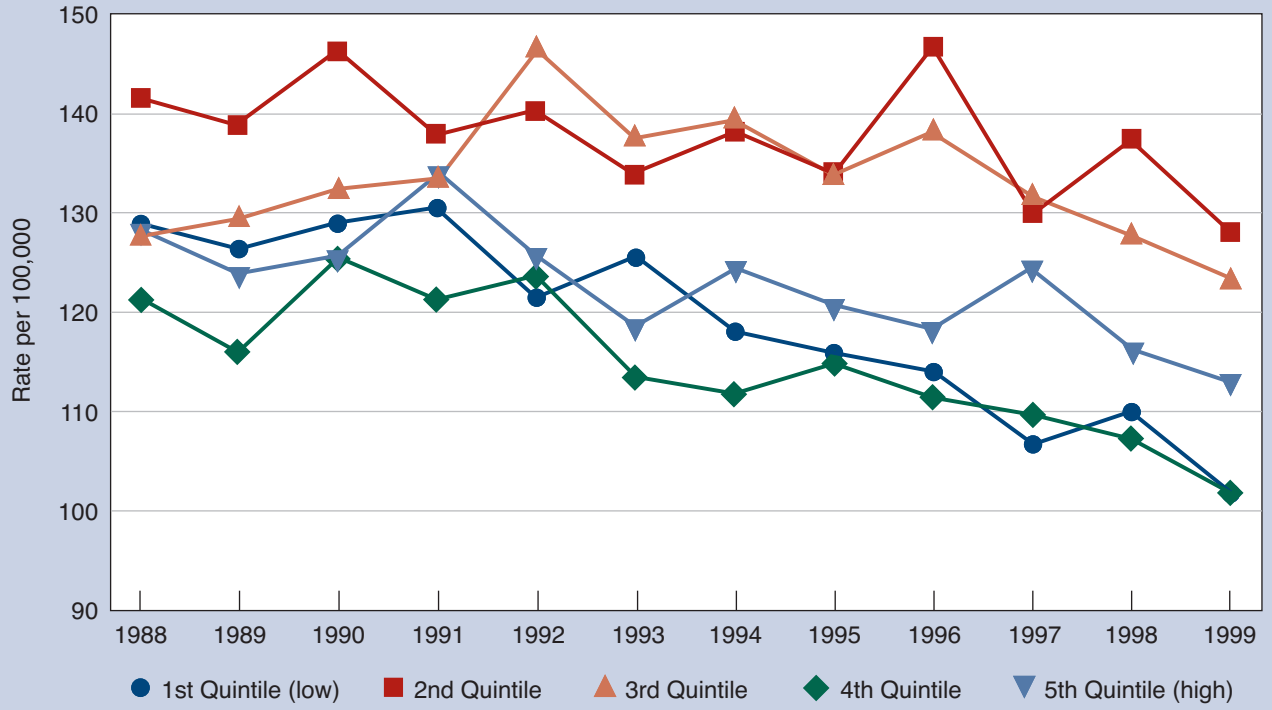
Rates of lung cancer incidence for females 45-74 are presented in **Figure 7**. Similar to the trend for males, rates of lung cancer incidence declined from 1988-99 for all socioeconomic groups, but the magnitude of the decline was generally larger for males than for females. In addition, lung cancer 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.

Table 7. Changes in Socioeconomic Disparity in Lung Cancer Incidence between 1988 and 1999 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
Δ1988 to 1999	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%

[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, by Area Socioeconomic Position, 1988-1999



(Unweighted quintiles of % of county with at least a high school education)

Table 8. Lung Cancer Incidence and Population Distribution among Females 45-74, by Quintile of Socioeconomic Position, 1988-1999

	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
Δ1988 to 1999	-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.

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

Table 9. Changes in Socioeconomic Disparity in Lung Cancer Incidence between 1988 and 1999 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**
Δ1988 to 1999	-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%

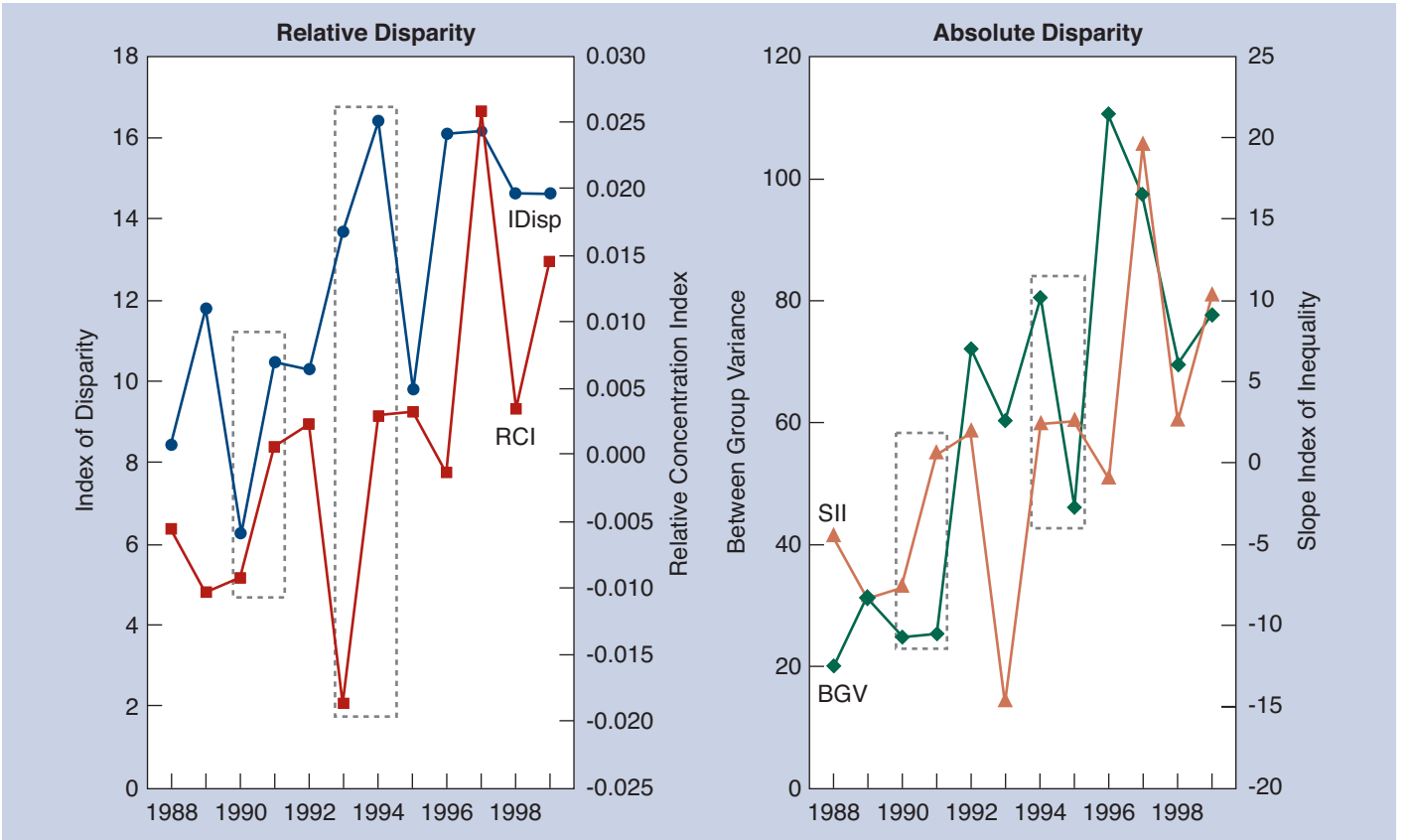
*Based on regression analysis (see methods section).
Abbreviations: RR=Rate Ratio; IDisp=Index of Disparity; RCI=Relative Concentration Index; RII=Relative Index of Inequality; RD=Rate Difference; ACI=Absolute Concentration Index; BGV=Between Group Variance; SII=Slope Index of Inequality.

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.

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

Figure 8. Trends in Relative and Absolute Socioeconomic Disparity in Lung Cancer Incidence among Females 45-74, 1988-1999



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 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

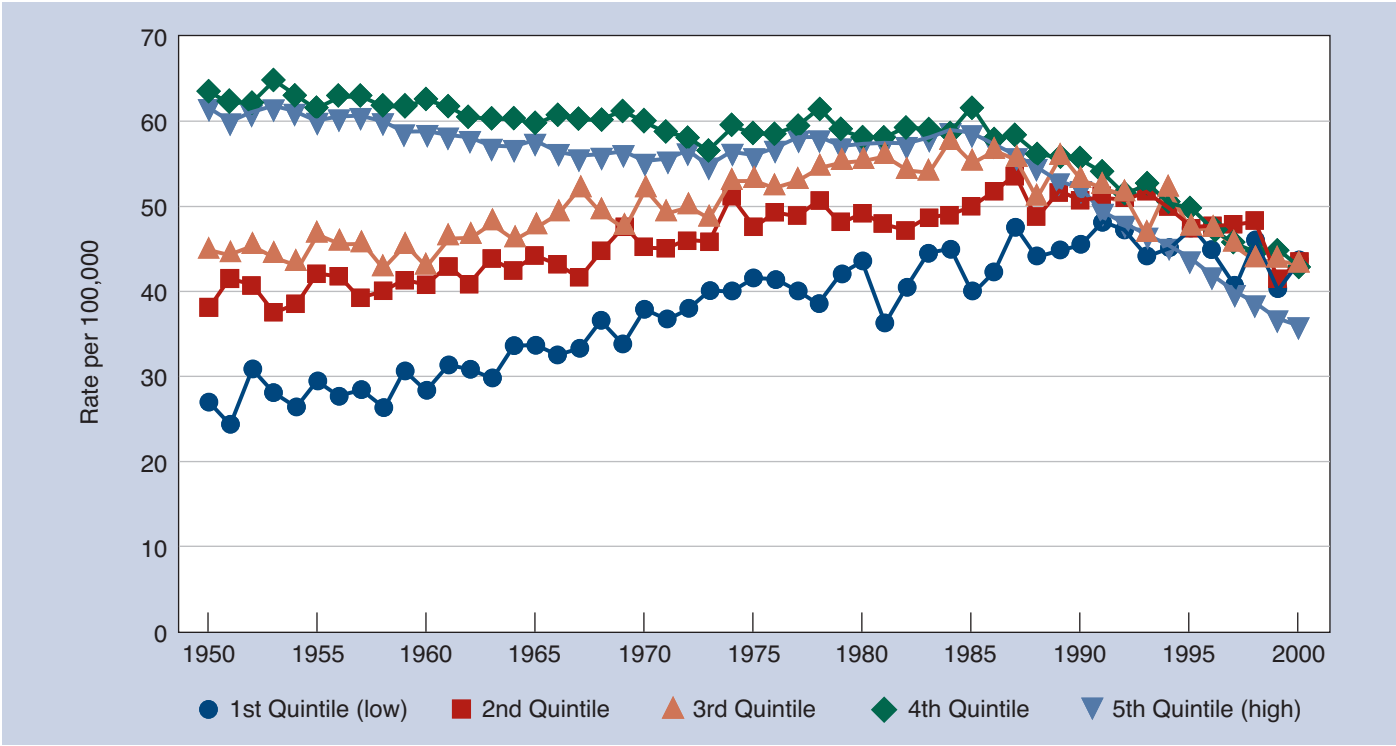


Table 10. Rates of Colorectal Cancer Mortality and Population Share by Area Socioeconomi Quintile among Males 45-74, 1950-2000

	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

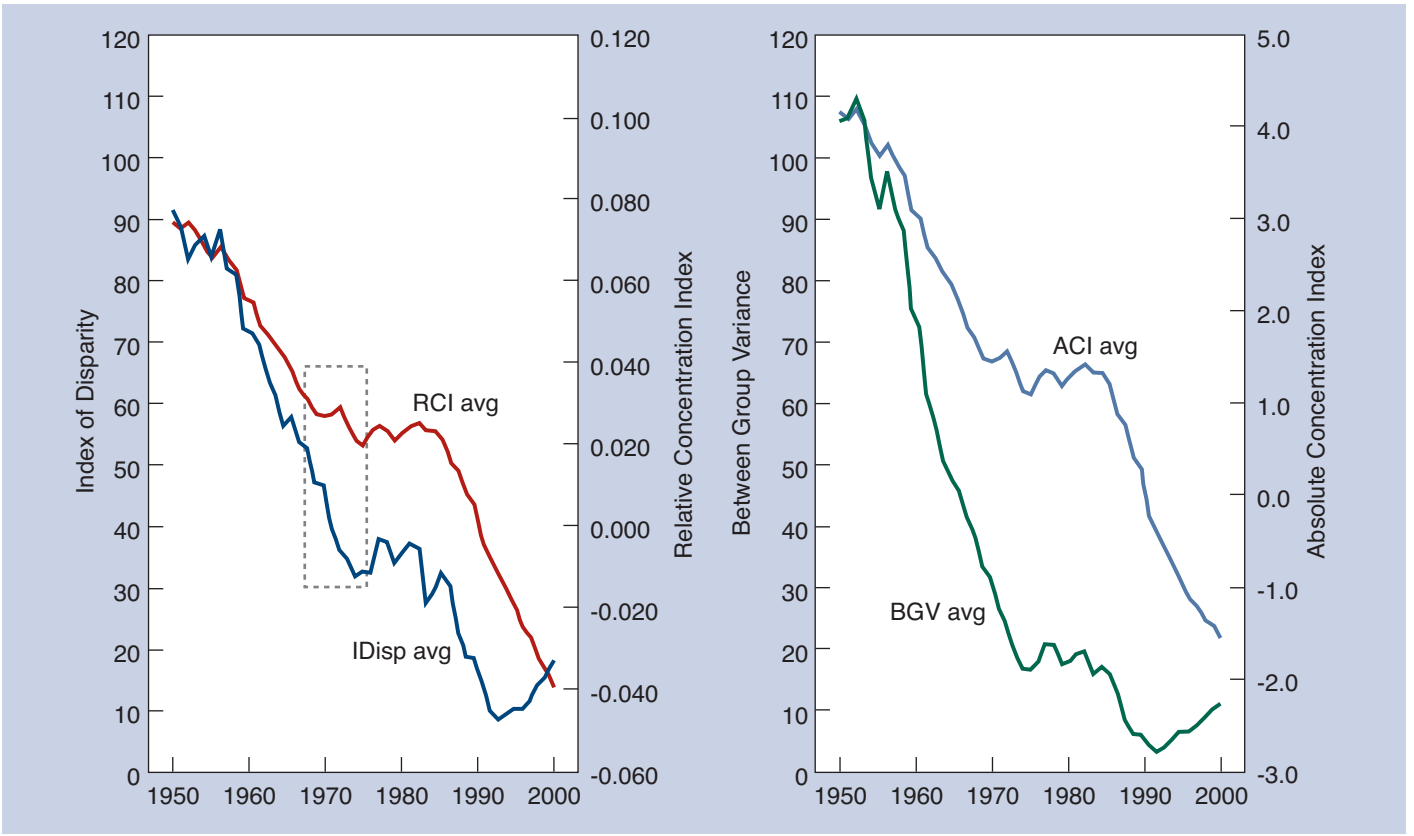
	Measures of Relative Disparity				Measures of Absolute Disparity			
Year	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1950	2.34	92.1	0.0792	0.557	36.25	4.5	119.6	31.3
1960	2.20	80.6	0.0607	0.440	34.08	3.3	88.3	24.2
1970	1.58	40.0	0.0213	0.160	22.02	1.2	26.7	8.7
1980	1.34	26.5	0.0213	0.166	14.58	1.2	12.8	9.3
1990	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**, shaded cells). 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 (-42.3% 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.

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

Figure 10. Trends in Relative Socioeconomic Disparity in Colorectal Cancer among Males 45-74, 1950-2000 (3-Year Moving Average)



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 ACI, 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

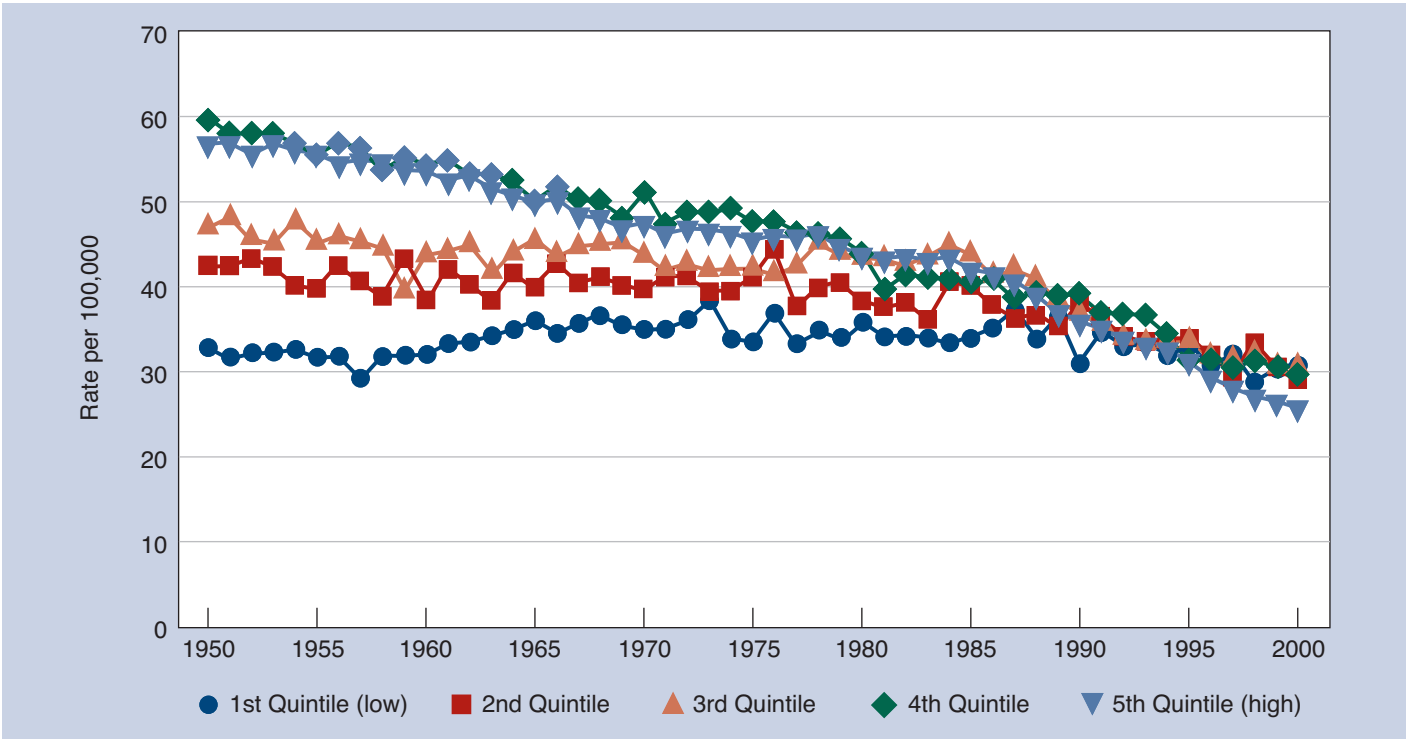


Table 12. Rates of Colorectal Cancer Mortality and Population Share by Area Socioeconomic Quintile among Females 45-74, 1950-2000

	1st Quintile (low)		2nd Quintile		3rd Quintile		4th Quintile		5th Quintile (high)	
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 13. Measures of Disparity in Each Decade and Percent Change in Disparity by Decade among Females 45-74, 1950-2000

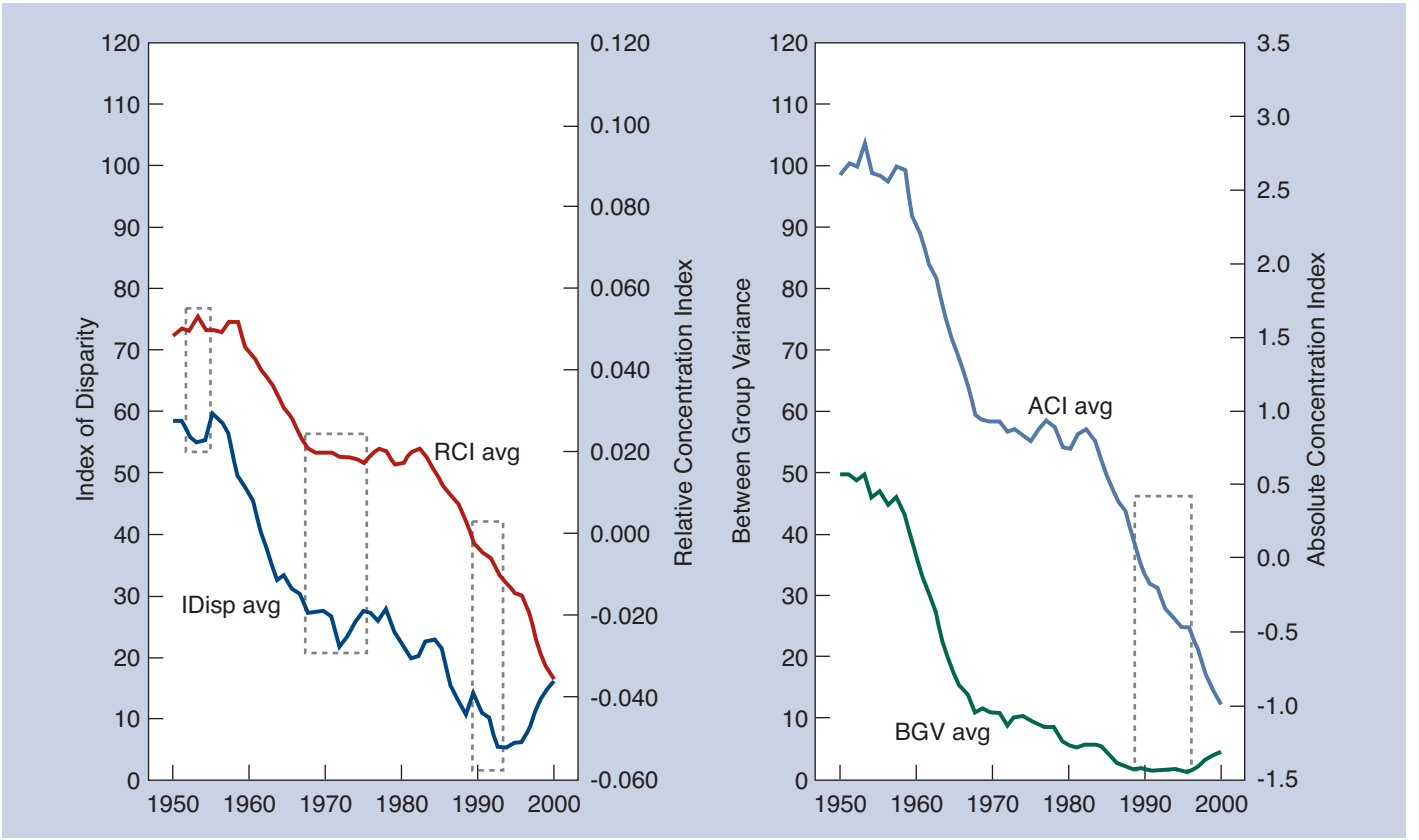
	Measures of Relative Disparity				Measures of Absolute Disparity			
Year	RR	IDisp	RCI	RII*	RD	ACI	BGV	SII*
1950	1.81	56.6	0.0487	0.345	26.63	2.63	52.7	18.6
1960	1.69	48.2	0.0508	0.369	22.07	2.57	41.6	18.7
1970	1.45	29.7	0.0201	0.151	15.97	0.94	15.2	7.1
1980	1.23	18.2	0.0182	0.142	8.31	0.79	4.9	6.1
1990	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 to 2000	-0.61	-40.2	-0.0841	-0.634	-21.40	-3.59	-48.7	-26.5
%Δ1950 to 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 (shaded cells), 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

Figure 12. Trends in Relative Socioeconomic Disparity in Colorectal Cancer among Females 45-74, 1950-2000 (3-Year Moving Average)



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).

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.

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.,

Table 14. Changes in Socioeconomic Disparity in Colorectal Cancer Incidence between 1990 and 2000 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
Δ1990 to 2000	-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%

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.

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

Figure 13. Observed Change in Colorectal Cancer Mortality among Females 45-74, by Area Socioeconomic Position, 1990 and 2000

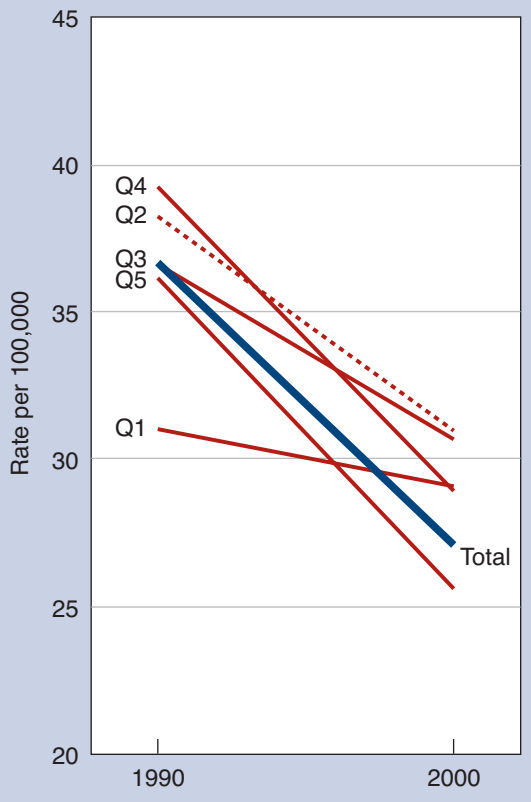


Table 15. Changes in Socioeconomic Disparity in Colorectal Cancer Incidence between 1990 and 2000 among Females 45-74 for Different Orderings of Socioeconomic Groups

		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%
Exchange 1st and	1990	20.8	-0.0057	2.98	-0.21
2nd quintiles	2000	16.4	-0.0358	3.98	-0.97
	%Δ	-21.2%	526.6%	33.6%	366.4%
Exchange 1st and	1990	20.8	-0.0065	2.98	-0.24
3rd quintiles	2000	16.4	-0.0361	3.98	-0.98
	%Δ	-21.2%	459.9%	33.6%	316.7%
Exchange 1st and	1990	20.8	-0.0137	2.98	-0.50
4th quintiles	2000	16.4	-0.0329	3.98	-0.89
	%Δ	-21.2%	140.8%	33.6%	79.2%
Exchange 1st and	1990	20.8	0.0071	2.98	0.26
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.

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

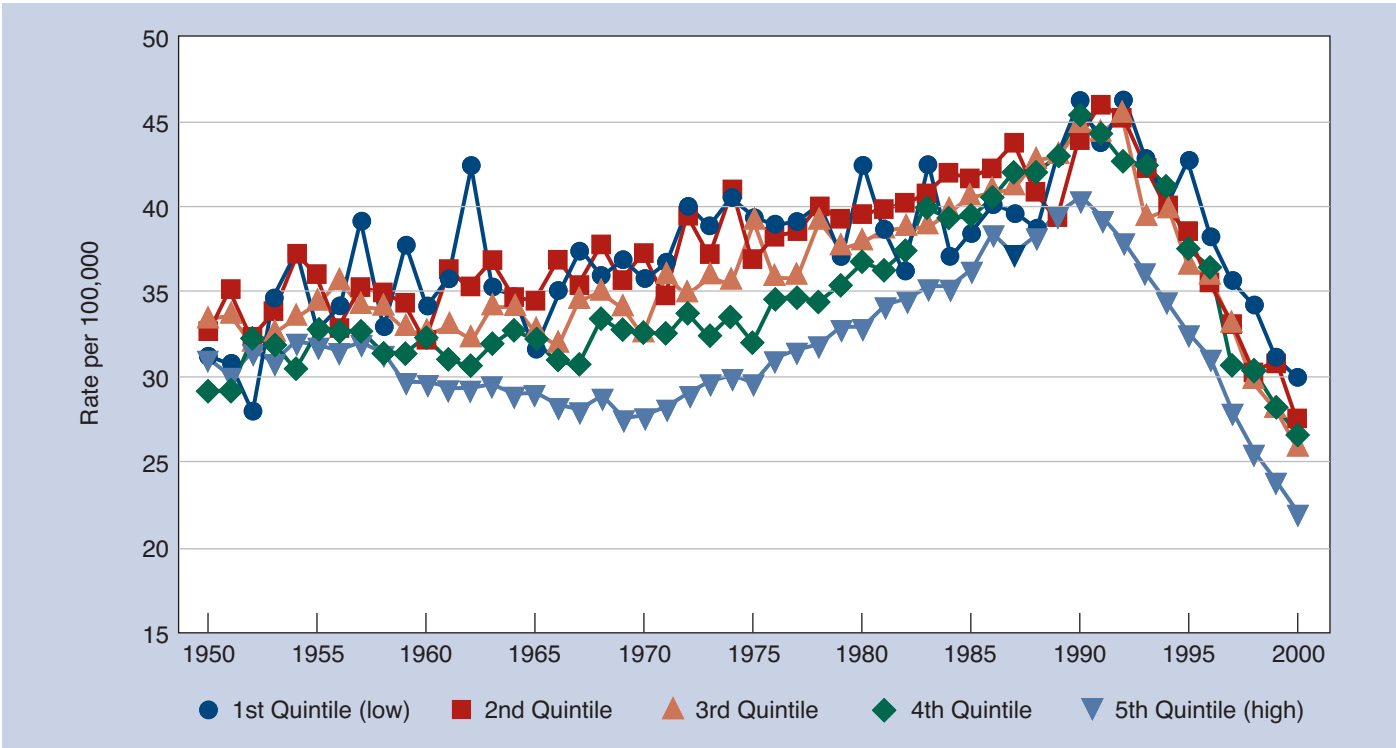


Table 16. Rates of Prostate Cancer Mortality and Population Share by Area Socioeconomic Quintile among Males 45-74, 1950-2000

	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 (5th) quintile, which is the most populous and is the only quintile that gained population over this time period.

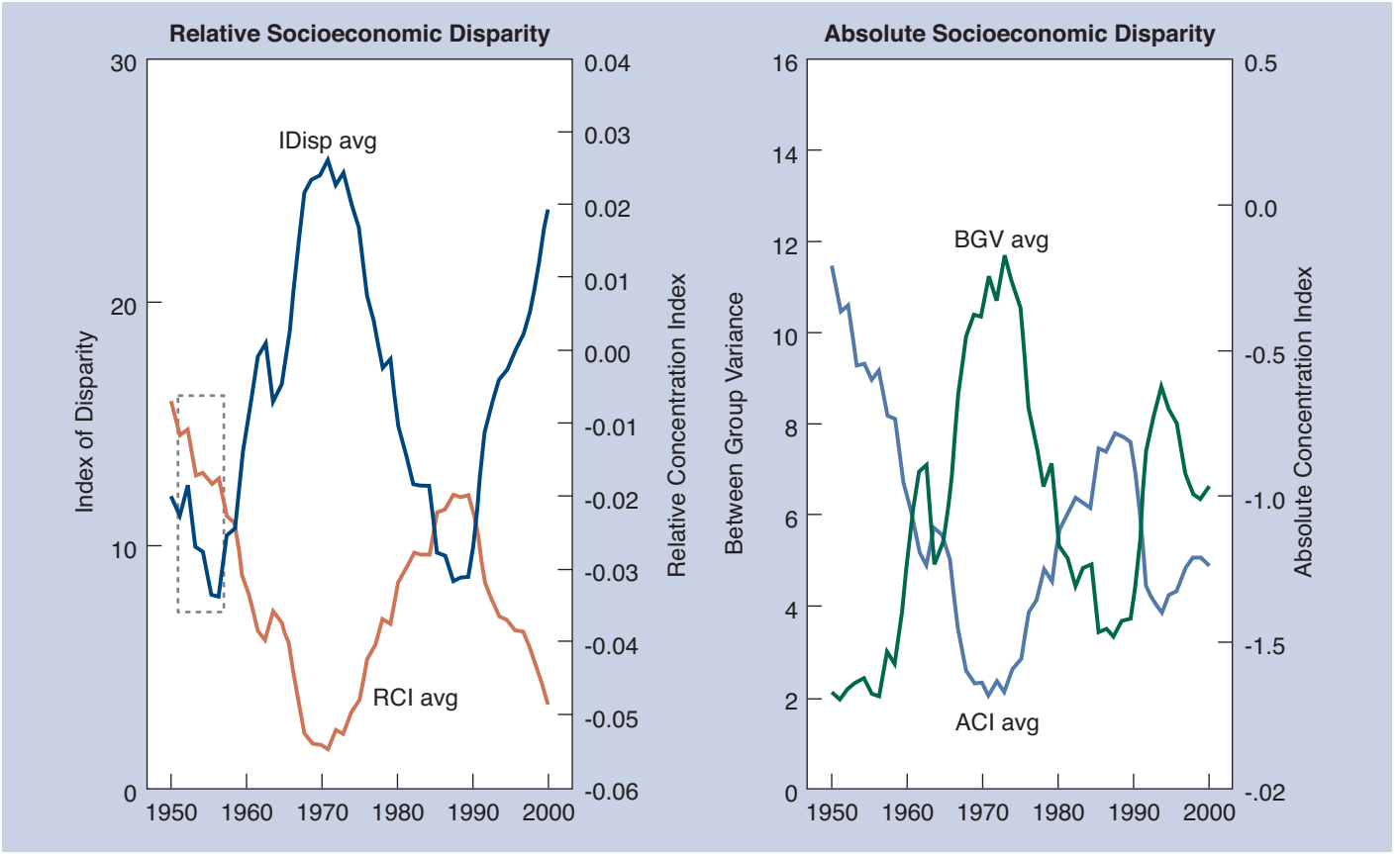
The long term trends in relative and absolute disparity for males 45-74 are shown in Figure 15. In general, the IDisp and the RCI show similar trends for relative socioeconomic disparity in prostate cancer mortality from 1950-2000. However, during the period from the early to the late 1950s (highlighted 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 (1st 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 Males 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
Δ1950 to 2000	0.22	14.8	-0.05	-0.38	3.8	-6.1	4.5	-8.9
%Δ1950 to 2000	154.2%	146.4%	1120.6%	1313.7%	91.7%	837.5%	277.2%	986.0%
%Change in Disparity								
%Δ1950 to 1960	6.7%	4.7%	491.1%	509.3%	8.8%	493.0%	38.8%	511.4%
%Δ1960 to 1970	128.0%	136.1%	117.8%	125.4%	112.3%	112.3%	354.7%	119.6%
%Δ1970 to 1980	-17.7%	-24.9%	-26.1%	-22.9%	-1.7%	-14.2%	-24.4%	-10.5%
%Δ1980 to 1990	-48.7%	-37.1%	-33.5%	-31.8%	-37.1%	-19.9%	-29.7%	-17.8%
%Δ1990 to 2000	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 Males 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

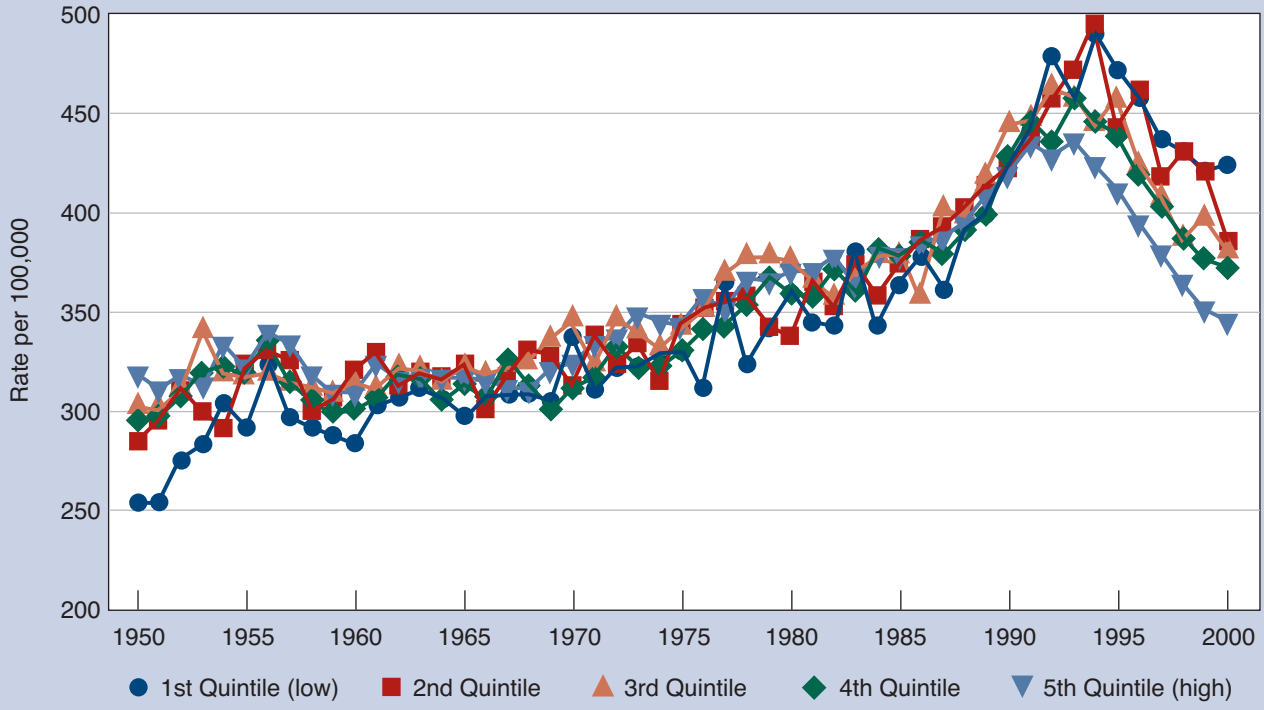


Table 18. Rates of Prostate Cancer Mortality and Population Share by Area Socioeconomic Quintile among Males 75 and Over, 1950-2000

	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, whereas the RR and IDisp do not indicate the direction of the gradient. 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.

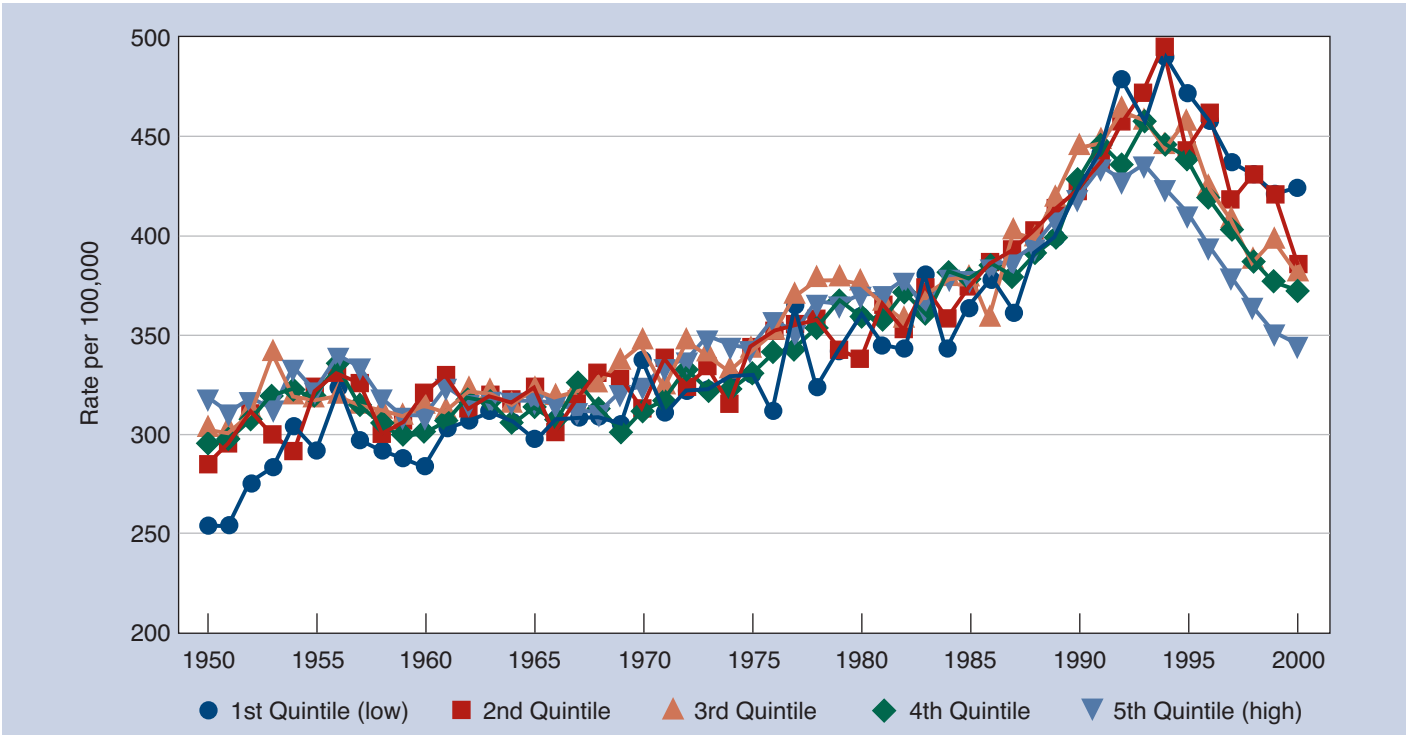
Trends in relative and absolute disparities in prostate cancer mortality are shown in **Figure 17**. The IDisp and RCI generally agree with respect to the trend in relative socioeconomic disparity, but the boxed area suggests that during the 1950 the RCI remained approximately constant while the IDisp 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.

Table 19. Measures of Disparity in Each Decade and Percent Change in Disparity by Decade among Males 75 and Over, 1950-2000

	Measures of Relative Disparity				Measures of Absolute Disparity			
Year	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
Δ1950 to 2000	-0.03	-5.34	-0.06	-0.41	14.6	-18.6	95.6	-137.8
%Δ1950 to 2000	-10%	-28.9%	-195.0%	-209.2%	22.4%	-212.6%	28.9%	-229.4%
%Change in Disparity								
%Δ1950 to 1960	-50.5%	-48.0%	-87.1%	-86.8%	-44.5%	-86.9%	-79.3%	-86.6%
%Δ1960 to 1970	-8.5%	-36.9%	-140.6%	-141.6%	0.3%	-142.7%	66.0%	-143.7%
%Δ1970 to 1980	-1.0%	42.8%	-618.4%	-637.1%	7.2%	-685.7%	-18.8%	-706.9%
%Δ1980 to 1990	-46.2%	-68.7%	-187.1%	-189.1%	-33.2%	-201.0%	-32.6%	-203.3%
%Δ1990 to 2000	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.

Figure 17. Trends in Area Socioeconomic Disparity in Prostate Cancer Mortality among Males 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

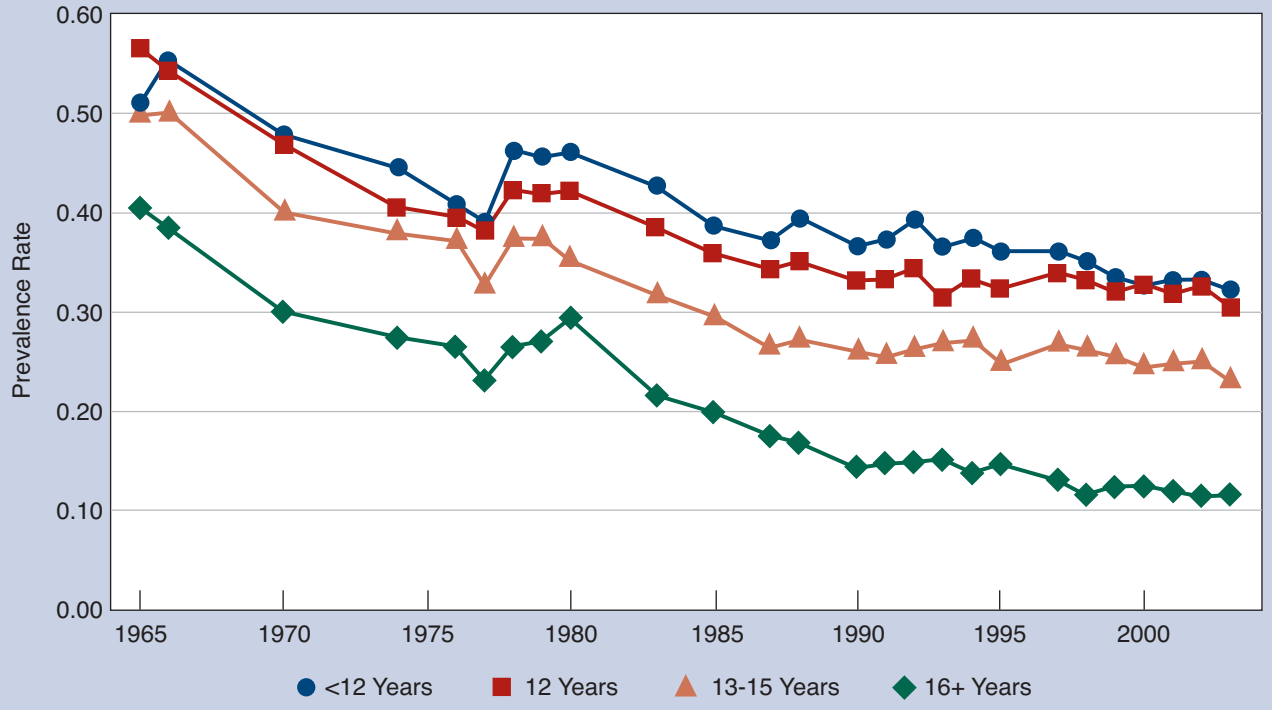


Table 20. Prevalence of Current Smoking and Population Distribution among Males 25 and Over, by Years of Education, NHIS Selected Years 1965-2003

	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
Δ1965 to 2003	-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
Δ1965 to 2003	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%
Δ1965 to 1976	35.6%	59.3%	192.0%	173.7%	-11.1%	108.2%	-8.1%	95.2%
Δ1976 to 1985	76.5%	58.3%	79.2%	78.0%	31.8%	53.8%	85.6%	52.8%
Δ1985 to 1995	54.5%	50.2%	42.2%	41.9%	13.9%	19.5%	33.5%	19.2%
Δ1995 to 2003	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.

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 19. Trends in Educational Disparity in Smoking among Males 25 and Over, 1965-2003

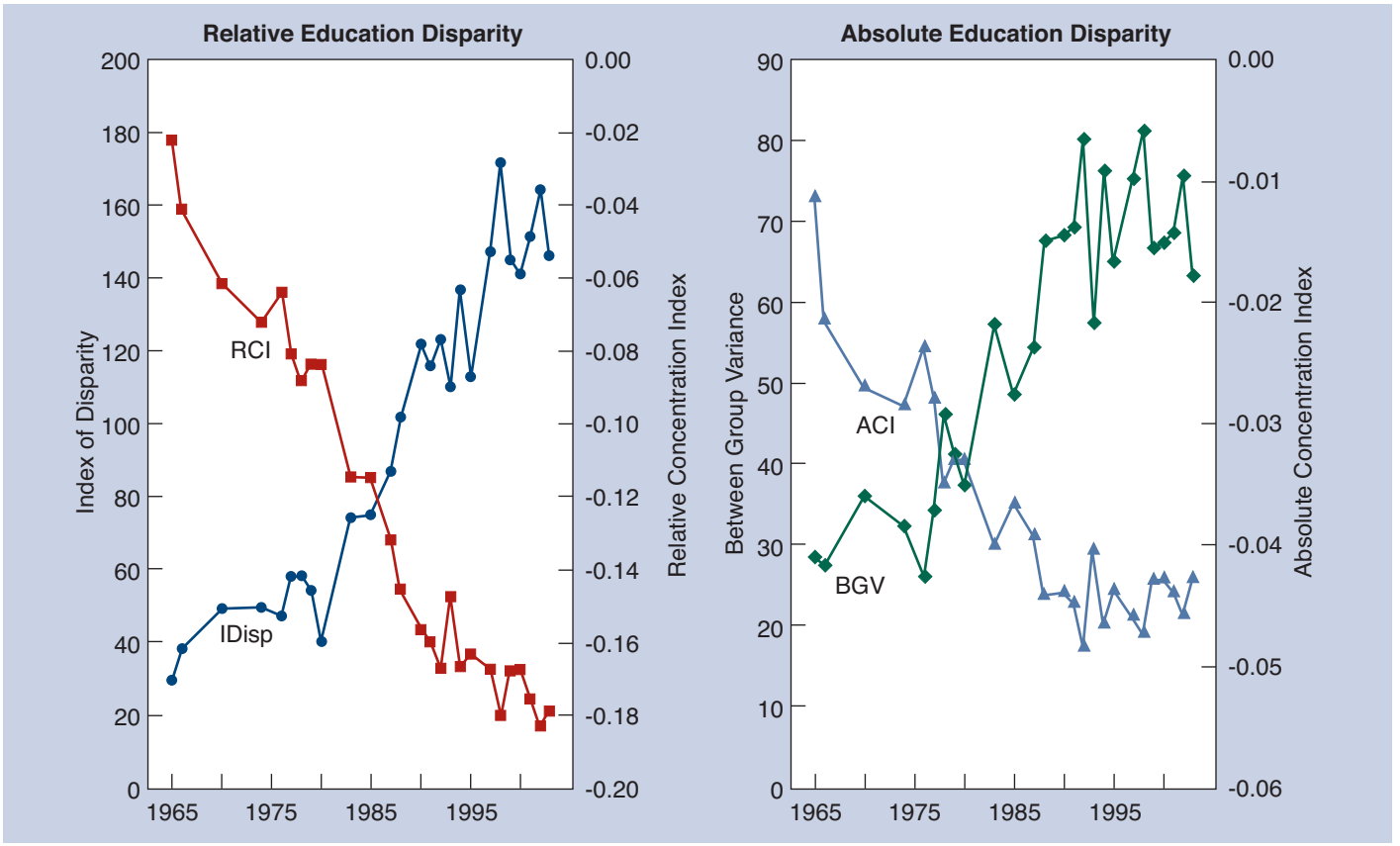


Figure 20. Trends in the Prevalence of Smoking by Years of Education among Females, 1965-2003

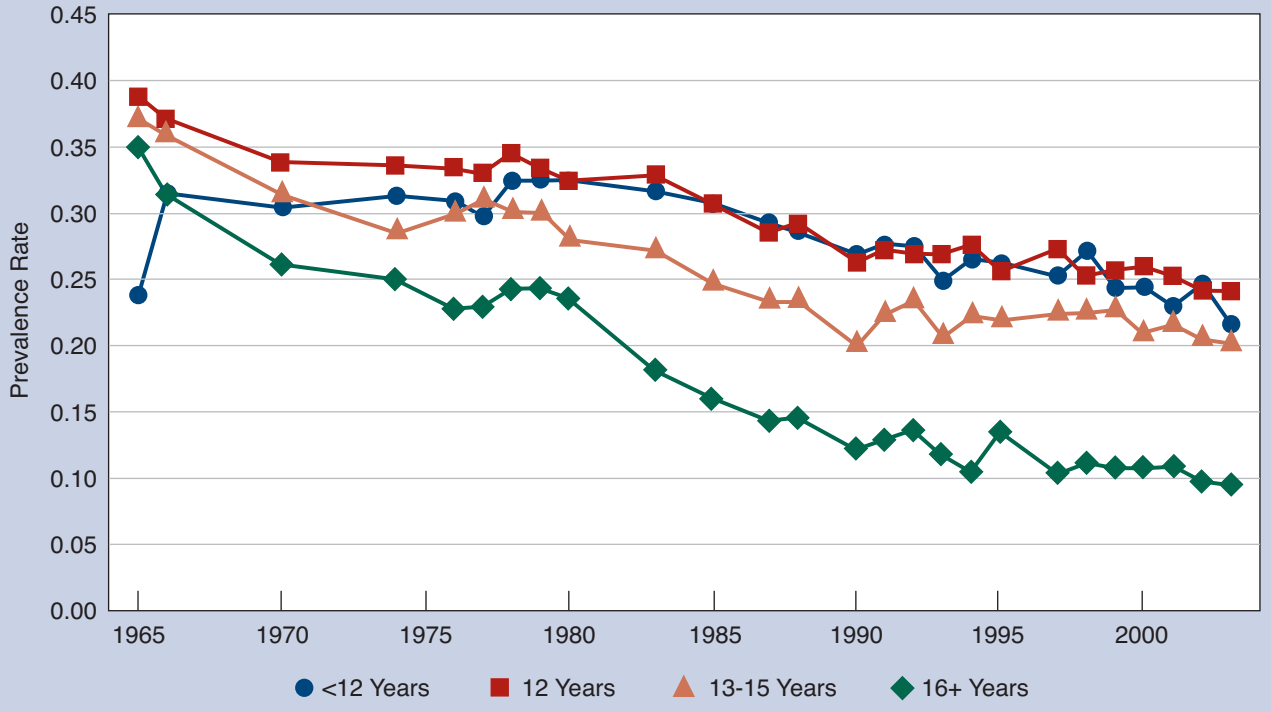


Table 22. Prevalence of Current Smoking and Population Distribution among Females Age 25 and Over, by Years of Education, NHIS Selected Years 1965-2003

	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
Δ1965 to 2003	-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.

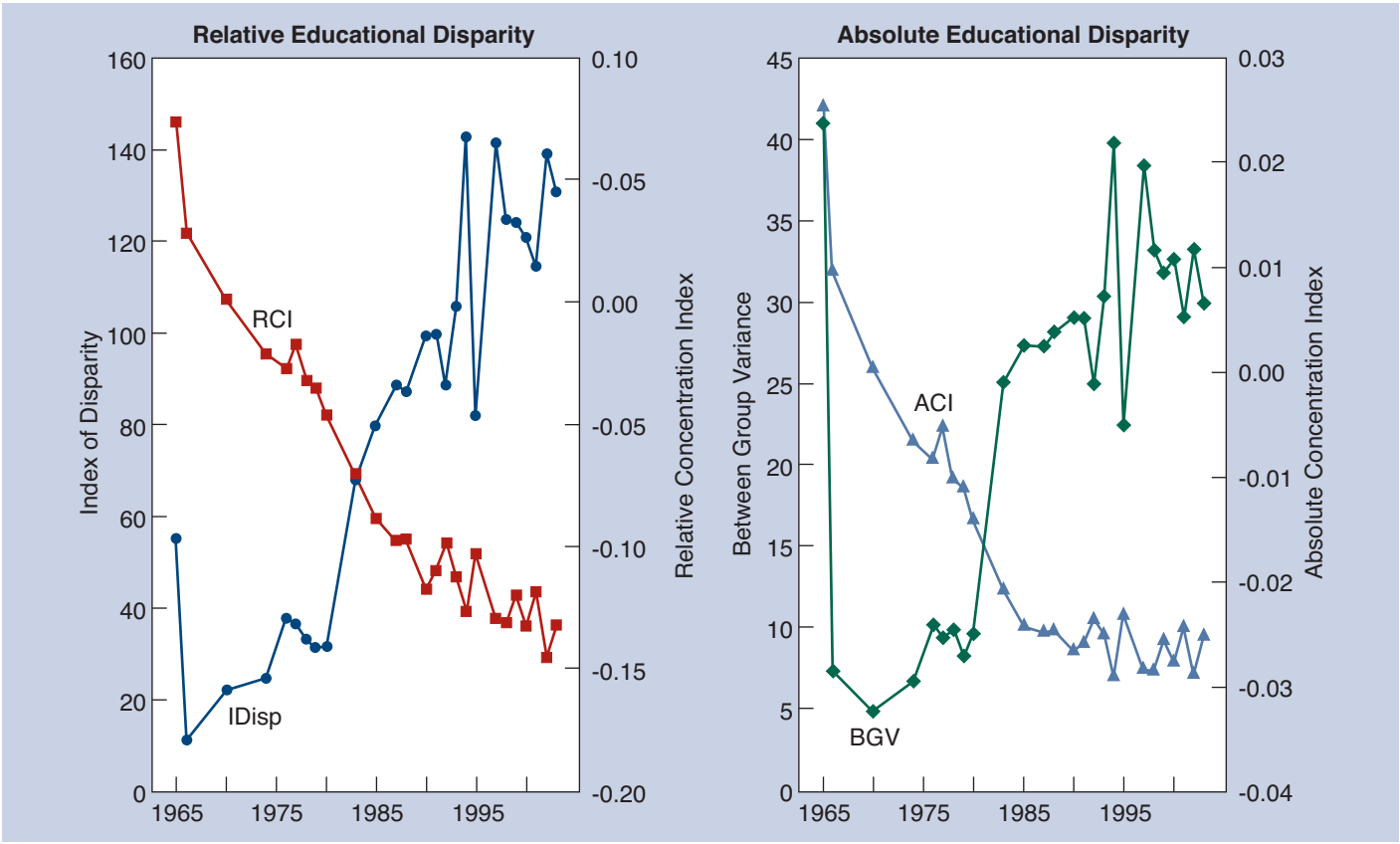
Overall, the graphs for relative disparity (left panel of **Figure 21**) show that the IDisp and the RCI are generally consistent with respect to the trend in relative educational disparity in smoking. With respect to absolute educational disparity in smoking, **Figure**

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
Δ1965 to 2003	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%
%Δ1965 to 1976	-25.6%	-31.7%	-136.6%	-132.7%	-28.7%	-132.9%	-75.0%	-129.4%
%Δ1976 to 1985	98.6%	111.0%	227.3%	223.7%	39.0%	190.8%	167.6%	187.6%
%Δ1985 to 1995	0.8%	2.9%	16.7%	14.8%	-14.6%	-4.1%	-17.9%	-5.6%
%Δ1995 to 2003	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



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

Table 24. Changes in Educational Disparity between 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
Δ1965 to 2003	-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
Δ1965 to 2003	-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.

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.

Case Study 6: Race and 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.

The changes in race / ethnic disparity in breast cancer incidence are given in **Table 26**. Overall, the measures of both relative and absolute disparity

Figure 22. Trends in Breast Cancer Incidence by Race and Ethnicity among Women 45-74, 1990-2001

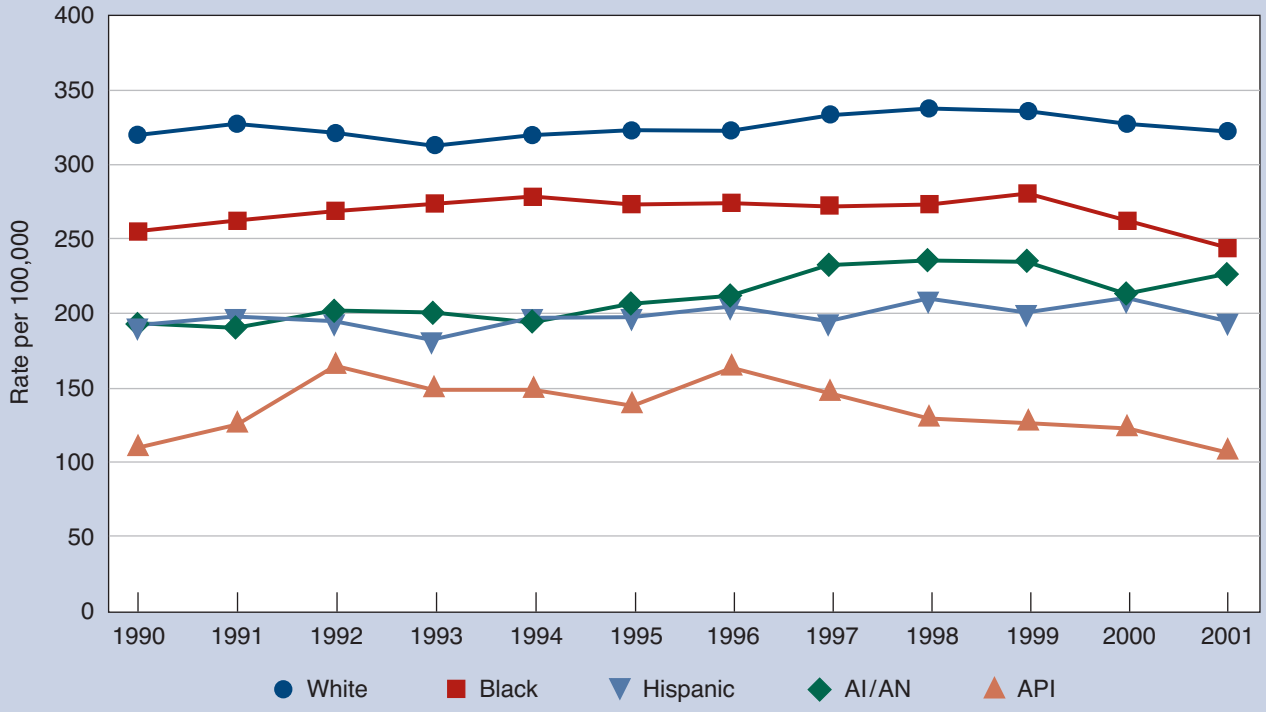


Table 25. Incidence of Female Breast Cancer and Population Distribution among Females 45-74, by Race and Ethnicity, 1990-2001

	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
Δ1990 to 2001	-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%

Table 26. Changes in Race and Ethnic Disparity in Female Breast Cancer Incidence among Females 45-74, 1990-2001

	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**
Δ1990 to 1995	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**
Δ1995 to 2001	-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%
Δ1990 to 2001	-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.

generally agree with respect to the overall change in race / ethnic disparity (bottom shaded 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.

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 an increase in disparity and one suggesting a decrease.

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 23. Trends in Race and Ethnic Disparity in Breast Cancer Incidence among Women 45-74, 1990-2001

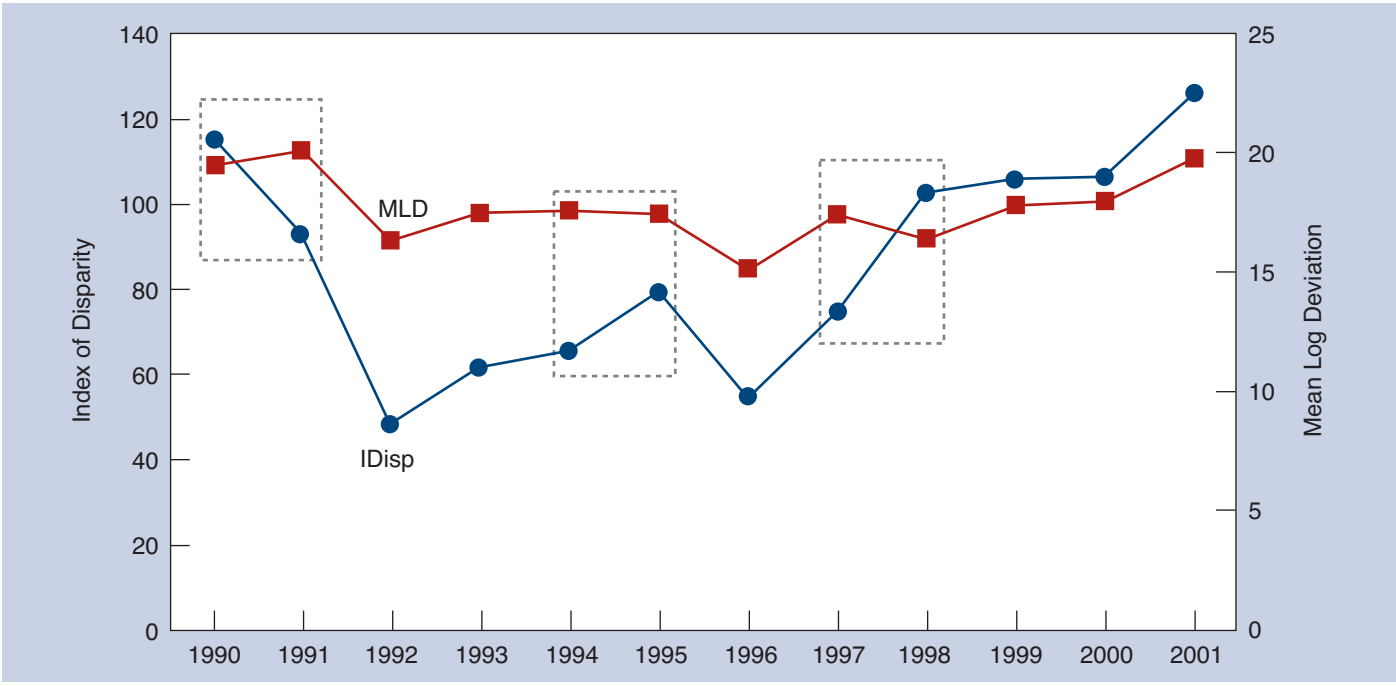


Figure 24. Trends in Breast Cancer Incidence by Race and Ethnicity among Women 75 and Over, 1990-2001

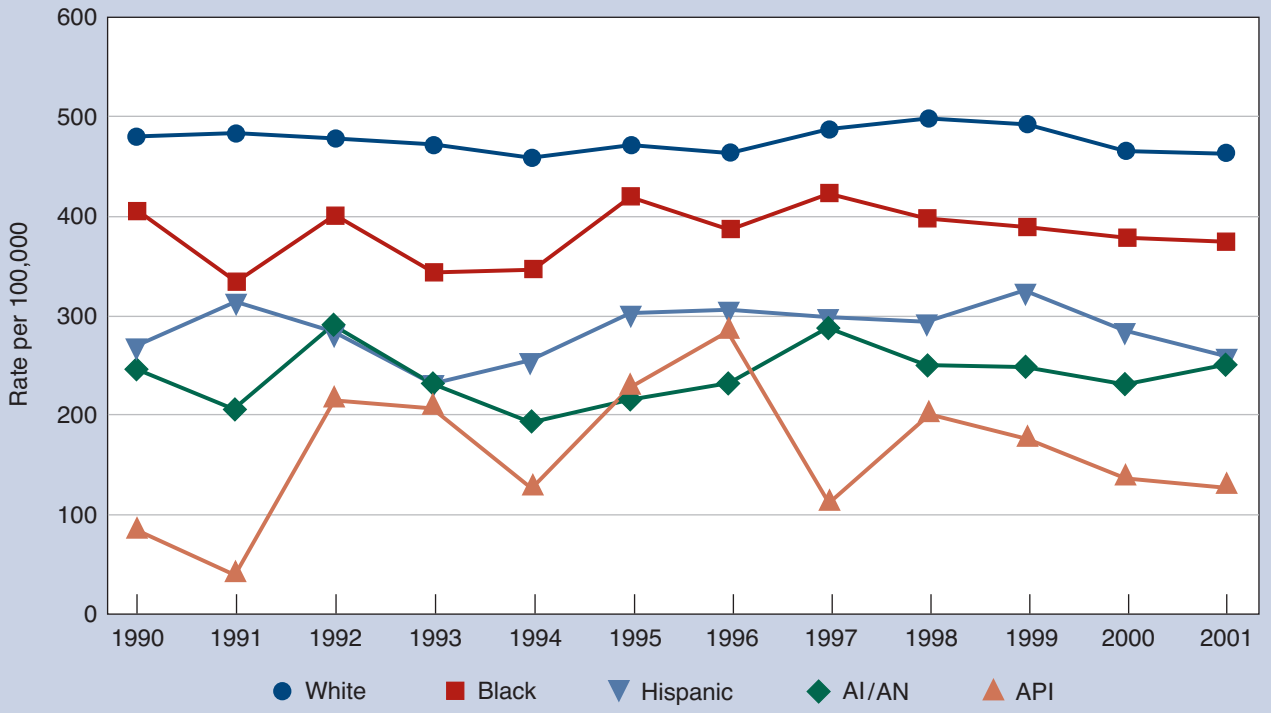


Table 27. Incidence of Female Breast Cancer and Population Distribution among Females 75 and Over, by Race and Ethnicity, 1990-2001

	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	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
Δ1990 to 2001	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%

Table 28. Changes in Race and Ethnic Disparity in Female Breast Cancer Incidence among Females 75 and Over, 1990-2001

	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**
Δ1990 to 1995	-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**
Δ1995 to 2001	-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%
Δ1990 to 2001	-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.

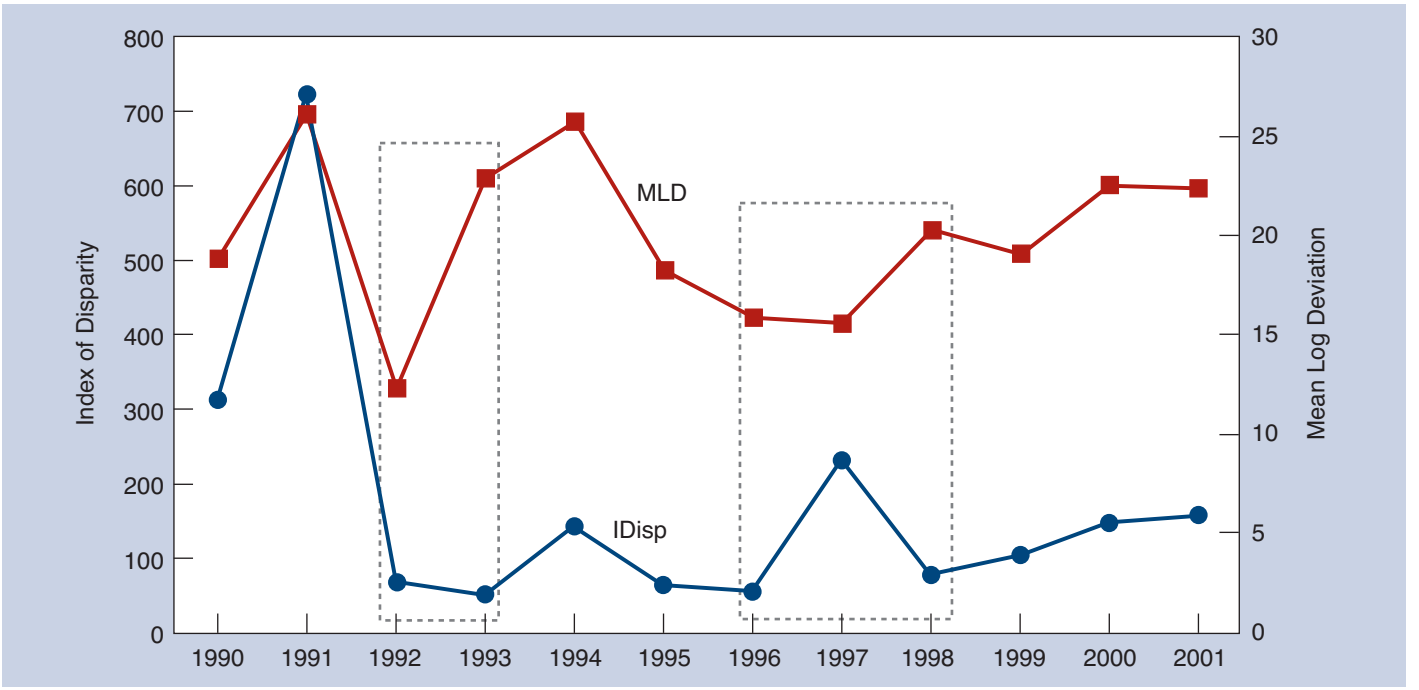
Changes in race / ethnic relative and absolute disparity are shown in **Table 28**. In contrast to the overall pattern of results for women 45-74, there is generally disagreement among both relative and absolute measures for the change in race / ethnic disparity from 1990-2001 (bottom row of **Table 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.

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.

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

Figure 25. Race and Ethnic Trends in Relative Disparity in Female Breast Cancer Incidence among Those 75 and Over, 1990-2001



(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

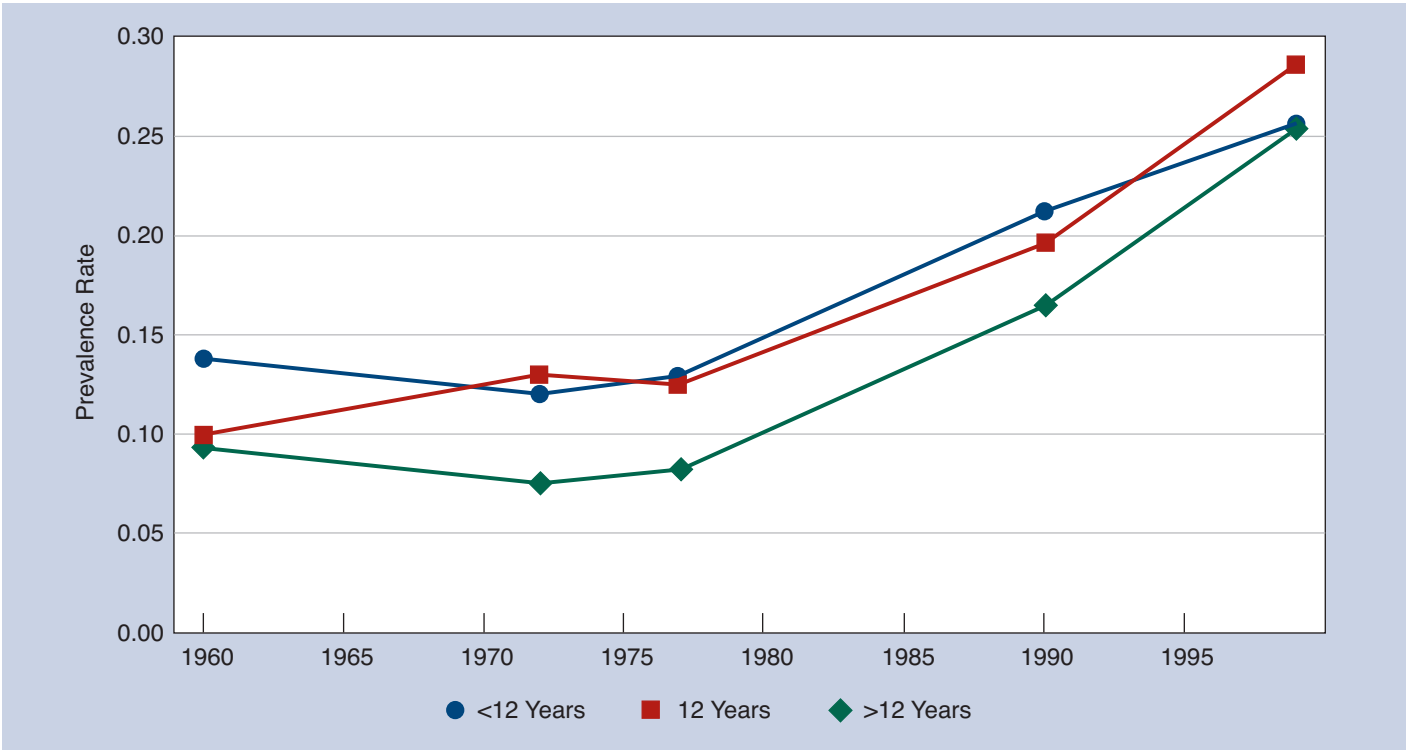


Table 29. Prevalence of Obesity and Population Distribution by Education among Males, 1960-2000

	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
Δ1961 to 2000	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%

Table 30. Changes in Educational Disparity in Obesity among Males, 1960-2000

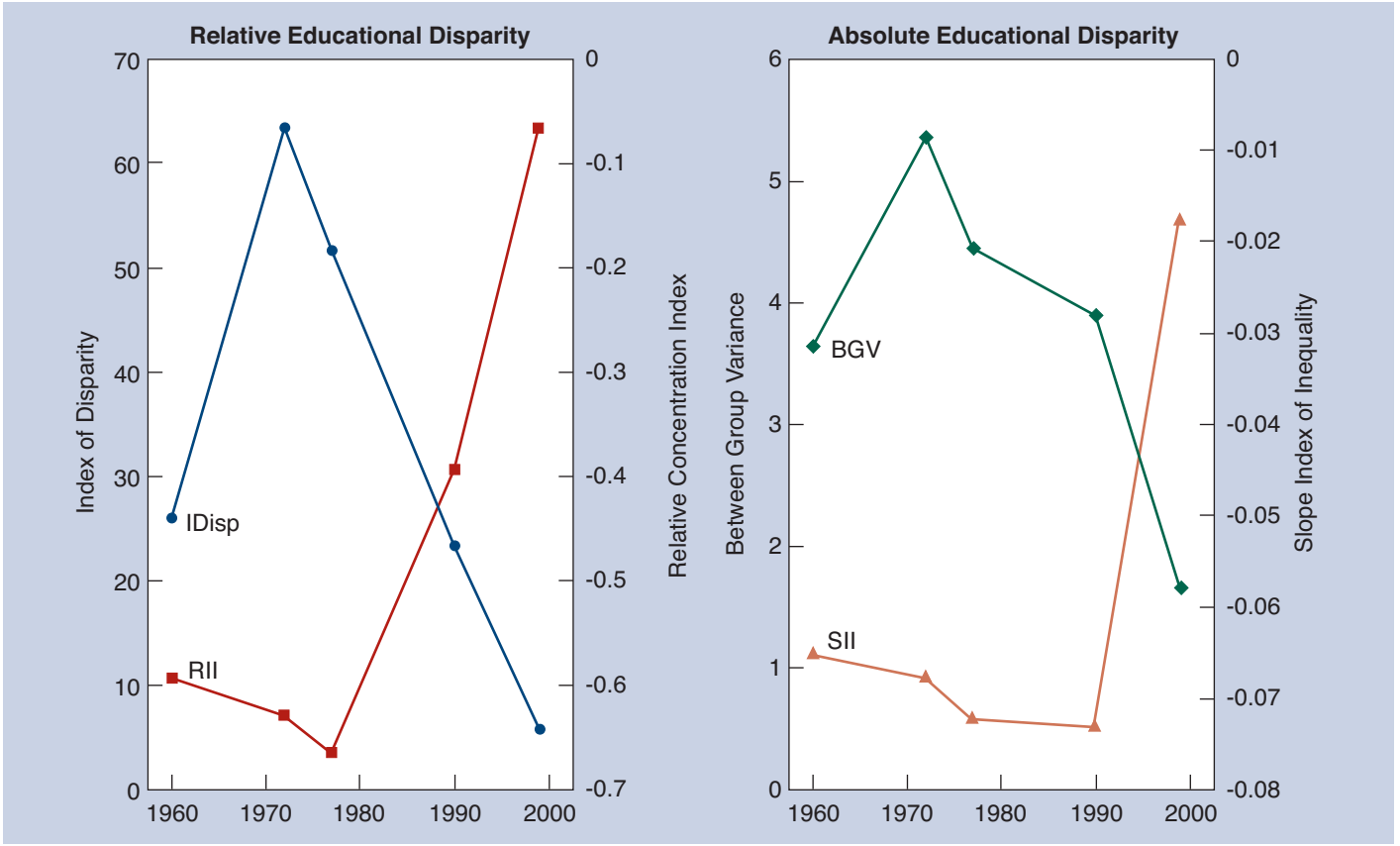
	Raw Data		Measures of Relative Disparity				Measures of Absolute Disparity			
Education	Rate	% Pop	RR*	IDisp	RCI	RII†	RD*	ACI	BGV	SII†
1960										
<12 years	0.138	0.311	1.47	23.6	-0.269		0.044	-0.0296	2.49	
12 years	0.099	0.473	1.05	2.5	0.040		0.005	0.0044	0.60	
>12 years	0.094	0.216	1.00	0.0	0.145		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**
Δ1960 to 2000	0.154		-0.36	-20.2	0.075	0.526	-0.015	0.007	-1.97	0.048
%Δ	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.

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.

Disparity trends are shown in **Figure 27**. For relative disparity both the IDisp and the RII show educational

Figure 27. Trends in Educational Disparity in Obesity among Males, 1960-2000



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.

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.

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%).

Figure 28. Trends in Obesity by Years of Education among Females, 1960-2000

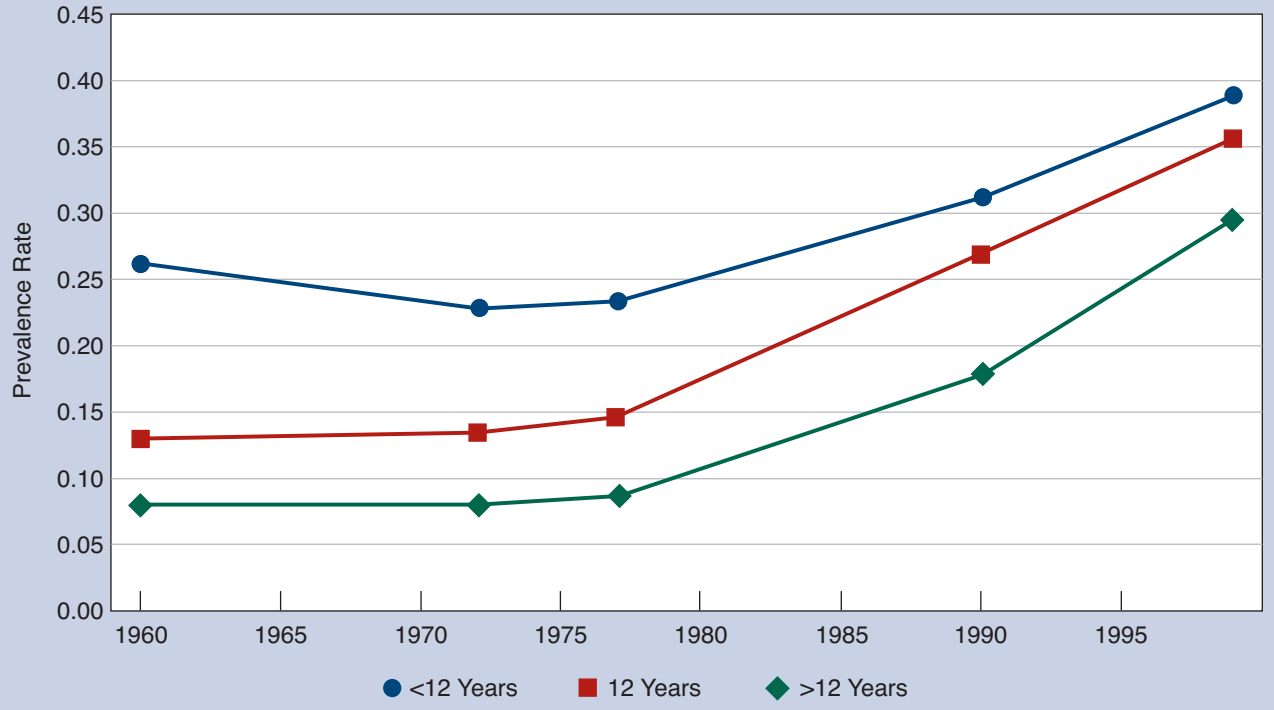


Table 31. Prevalence of Obesity and Population Distribution by Education among Females, 1960-2000

	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
Δ1961 to 2000	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%

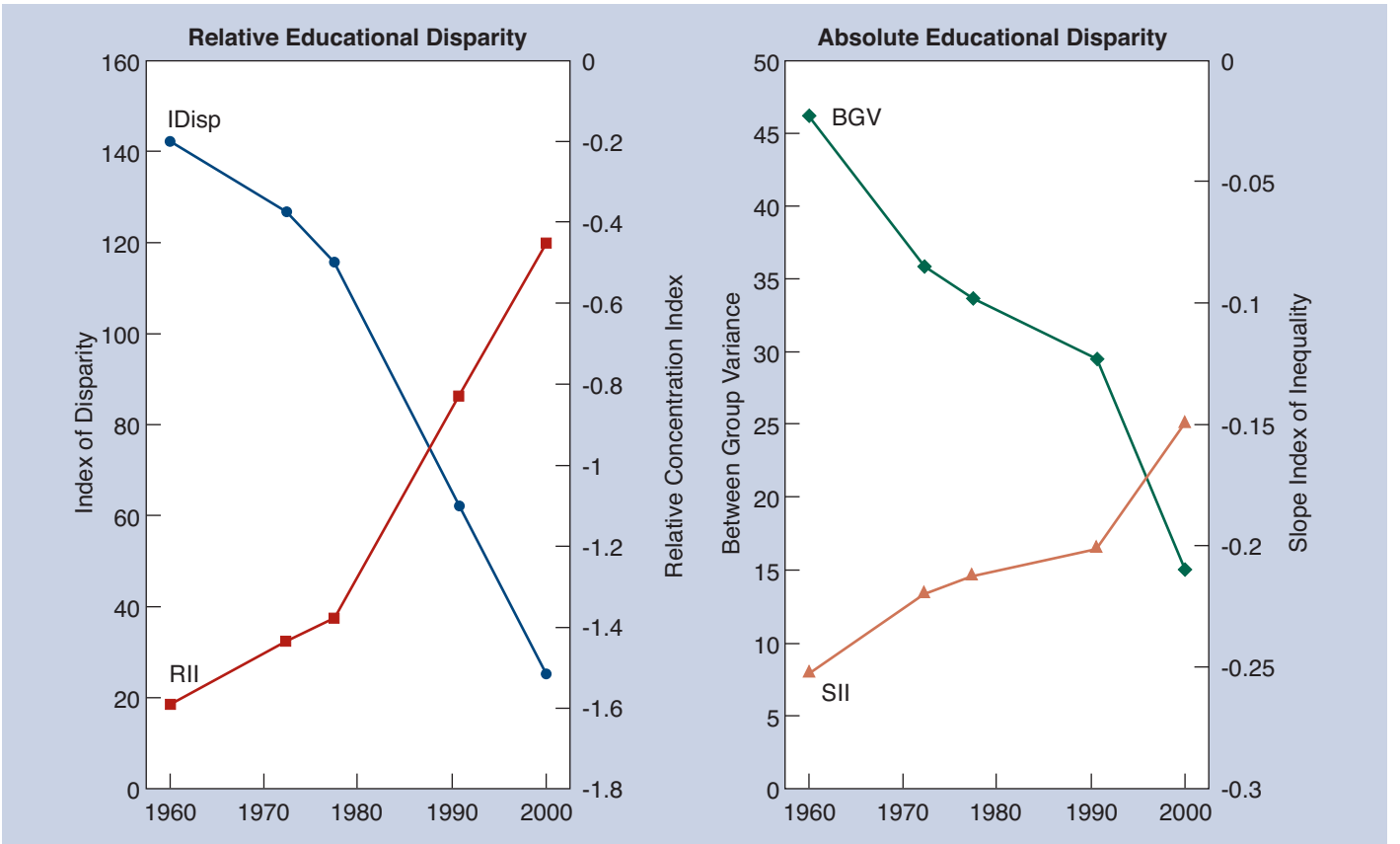
Table 32. Changes in Educational Disparity in Obesity among Females, 1960-2000

	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**
Δ1960 to 2000	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 and 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 and Ethnicity among Women <45 Years of Age, 1990-2001

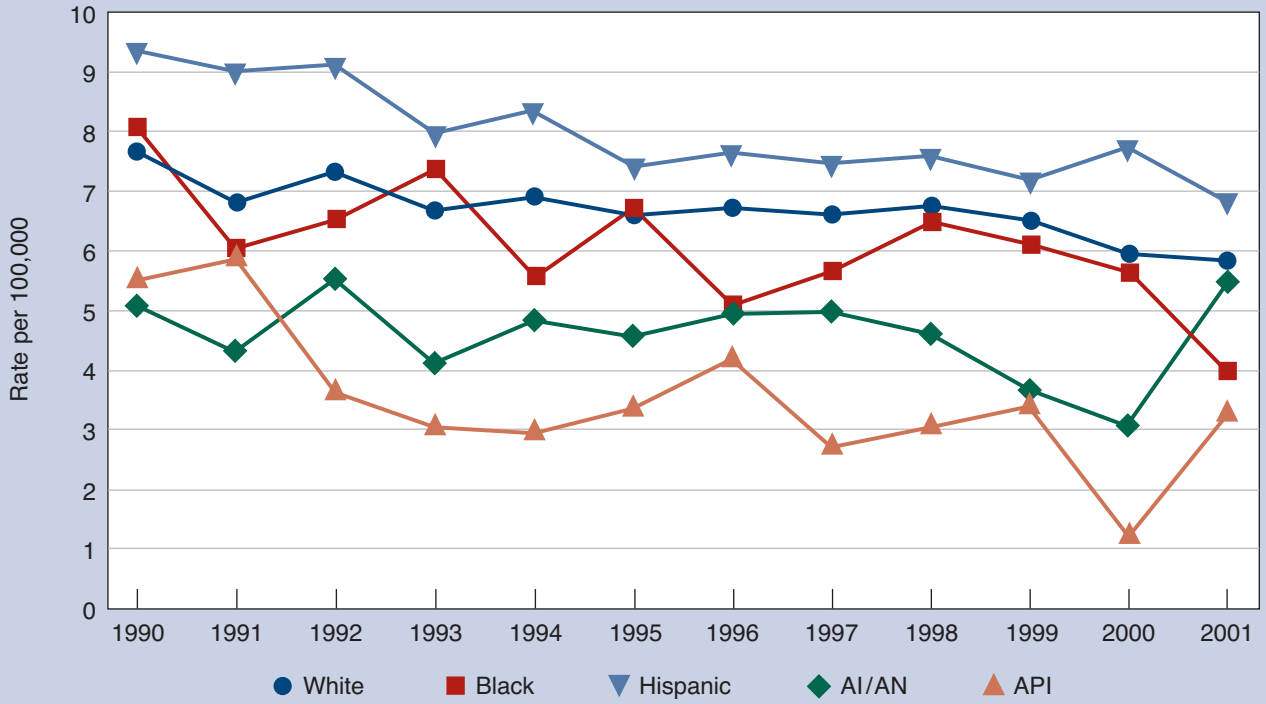


Table 33. Incidence of Cervical Cancer and Population Distribution among Females <45 Years of Age, by Race and Ethnicity, 1990-2001

	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	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
Δ1990 to 2001	-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 and Ethnic Disparity in Cervical Cancer Incidence among Females <45 Years of Age, 1990-2001

	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**
Δ1990 to 1995	-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**
Δ1995 to 2001	-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%
Δ1990 to 2001	-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 the set of relative measures and among the absolute measures, but there is disagreement between the absolute and relative measures. All of the relative measures indicate an increase in disparity whereas and both absolute measures show 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.

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.

Figure 31. Trends in Relative Race and Ethnic Disparity in Cervical Cancer Incidence among Women <45 Years of Age, 1990-2001

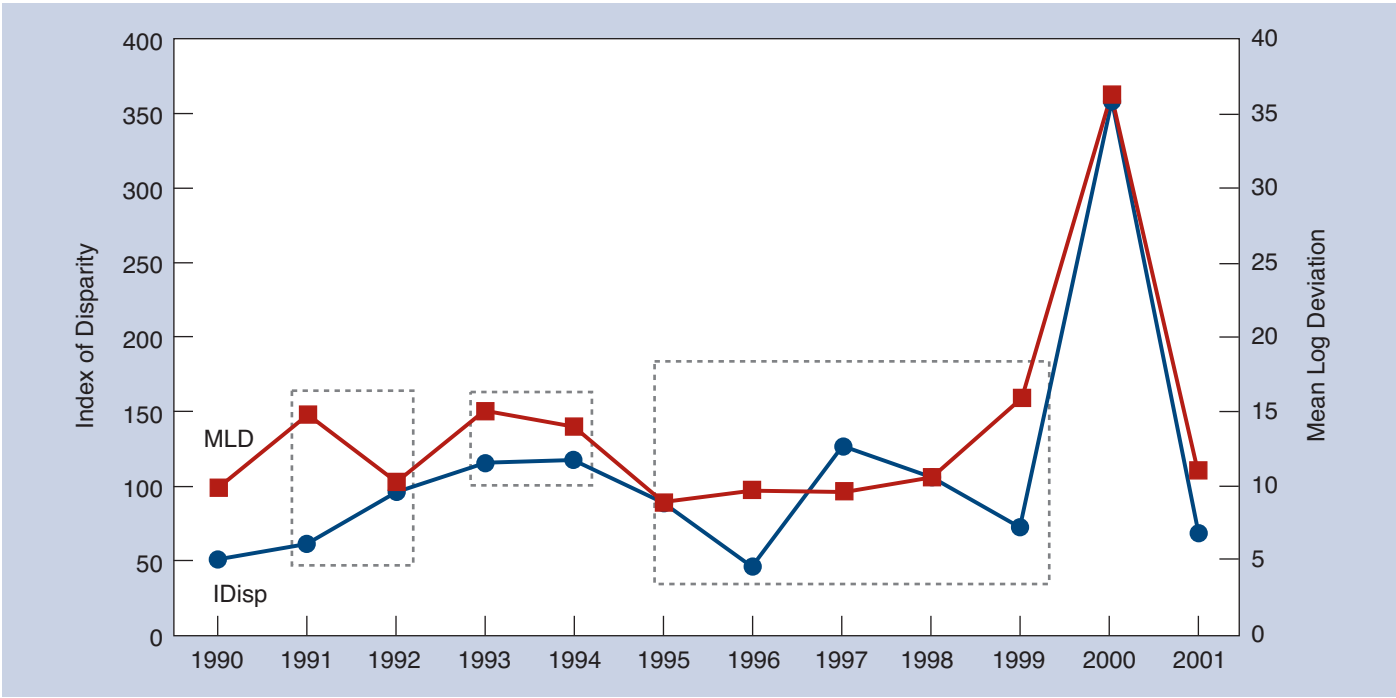
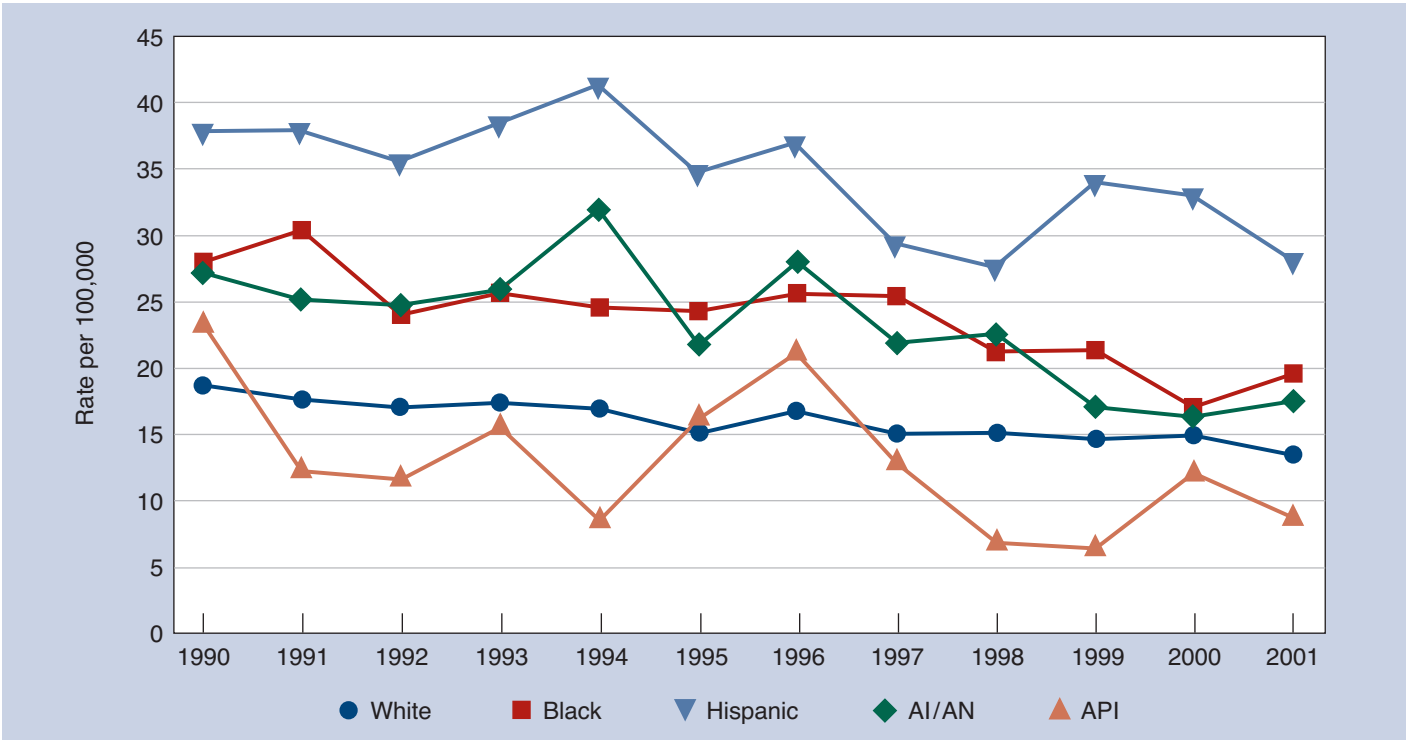


Figure 32. Trends in Cervical Cancer Incidence by Race and Ethnicity among Women 45-74, 1990-2001



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 in Table 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

Changes in race / ethnic disparity in cervical cancer incidence among those 45-74 are shown in **Table 36**. Overall, the measures of relative disparity generally agree with respect to the overall change in race / ethnic disparity: relative disparity has increased.

Table 35. Incidence of Cervical Cancer and Population Distribution among Females 45-74, by Race and 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
Δ1990 to 2001	-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%

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.

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

Table 36. Changes in Race and Ethnic Disparity in Cervical Cancer Incidence among Females 45-74, 1990-2001

	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**
Δ1990 to 1995	-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**
Δ1995 to 2001	-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%
Δ1990 to 2001	-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.

(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.

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 33. Trends in Relative Race and Ethnic Disparity in Cervical Cancer Incidence among Those 45-74, 1990-2001

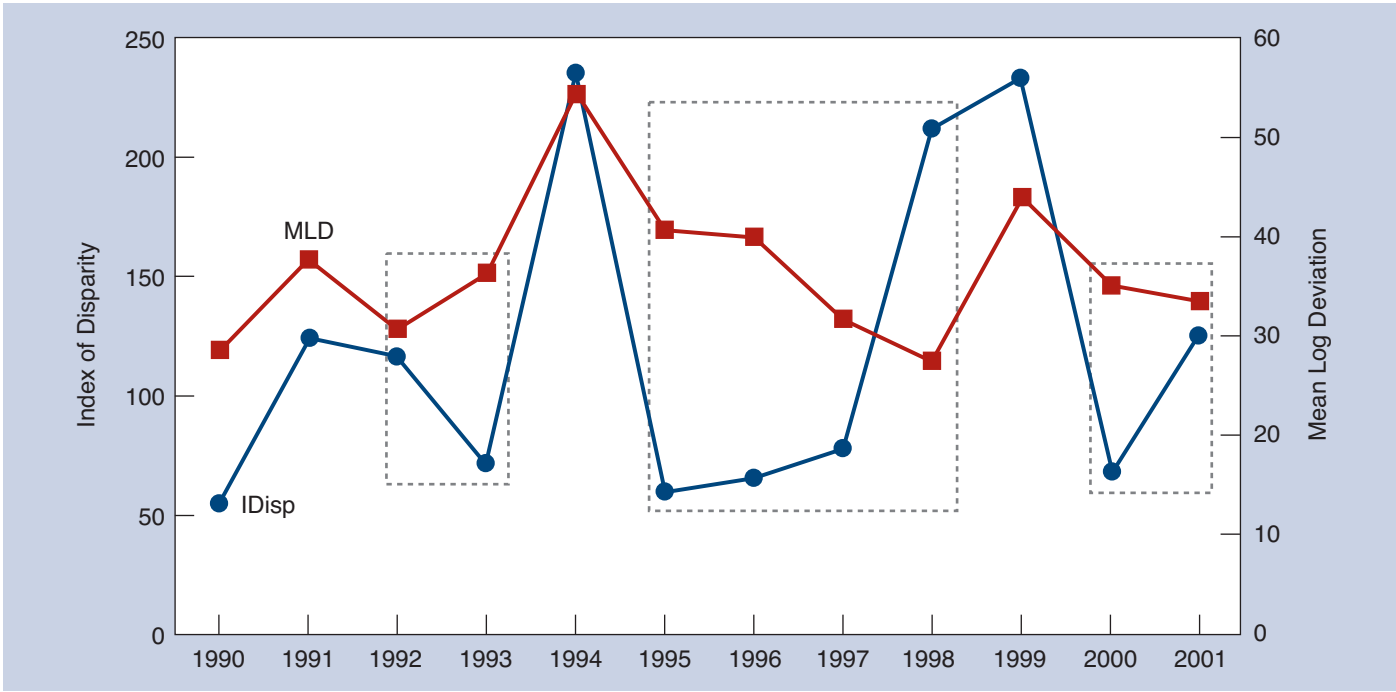
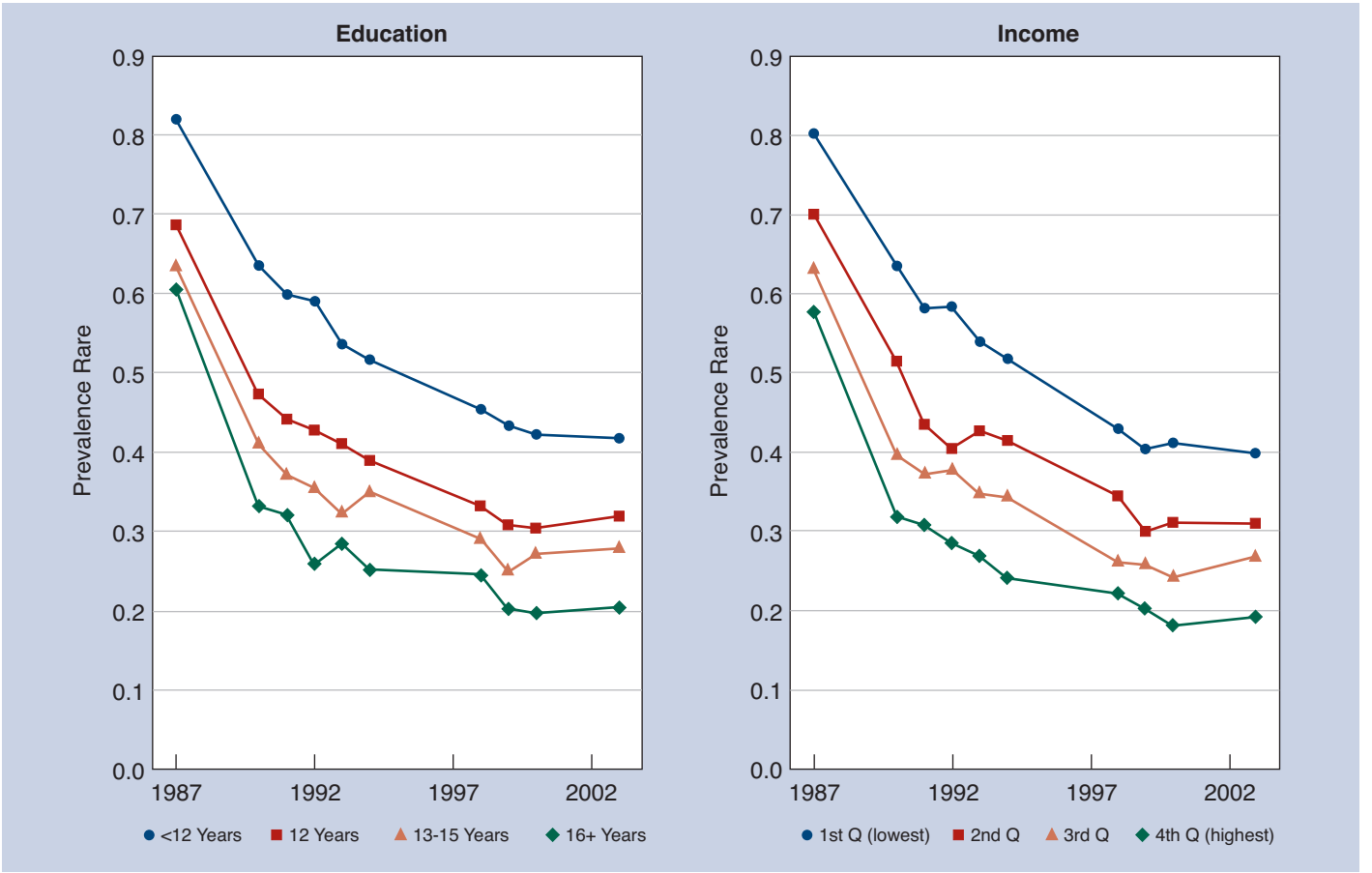
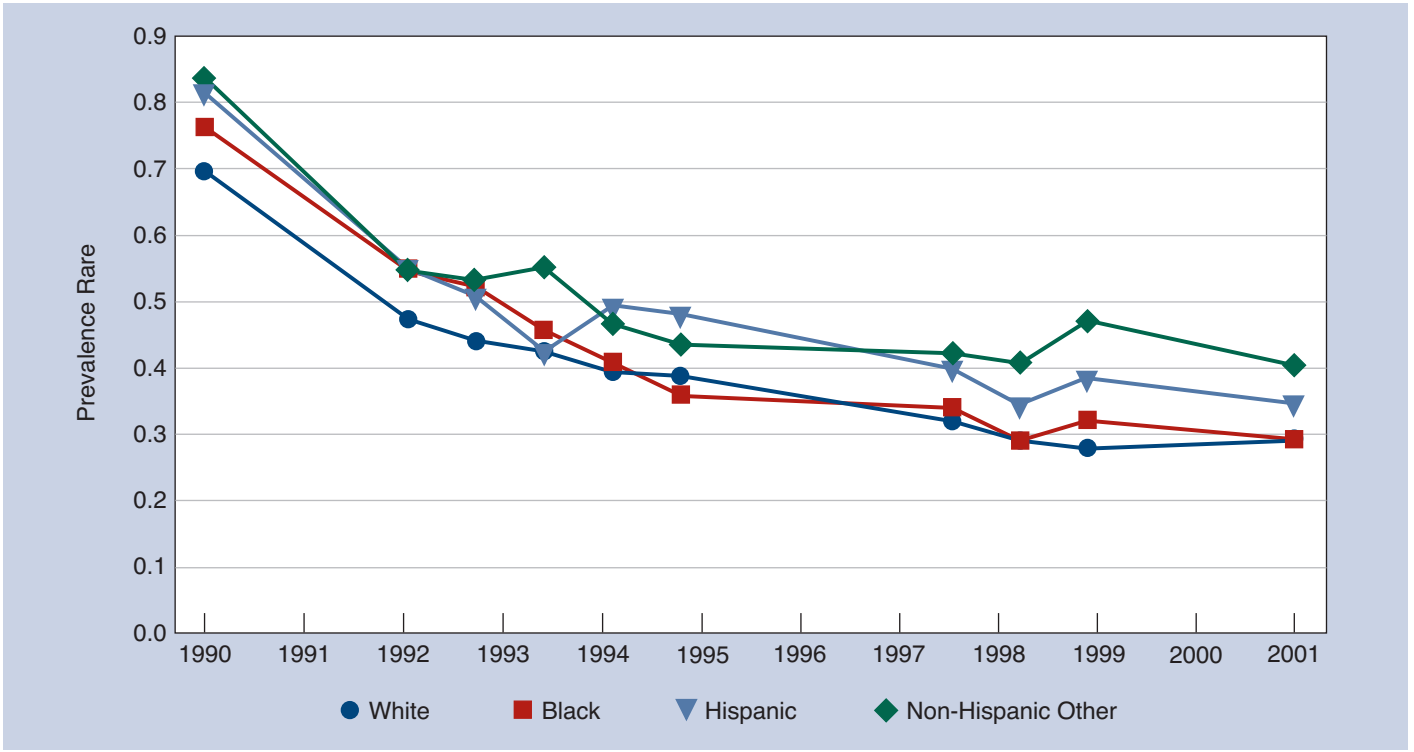


Figure 34. Trends in the Proportion of Women 40 and Over Not Receiving a Mammogram in the Past 2 Years, by Education and Income, 1987-2003 National Health Interview Surveys



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

Figure 35. Trends in the Proportion of Women 40 and Over Not Receiving a Mammogram in the Past 2 Years, by Race and Ethnicity, 1987-2003 National Health Interview Surveys



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 and 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
%Δ1987 to 2003							
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 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 determine 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

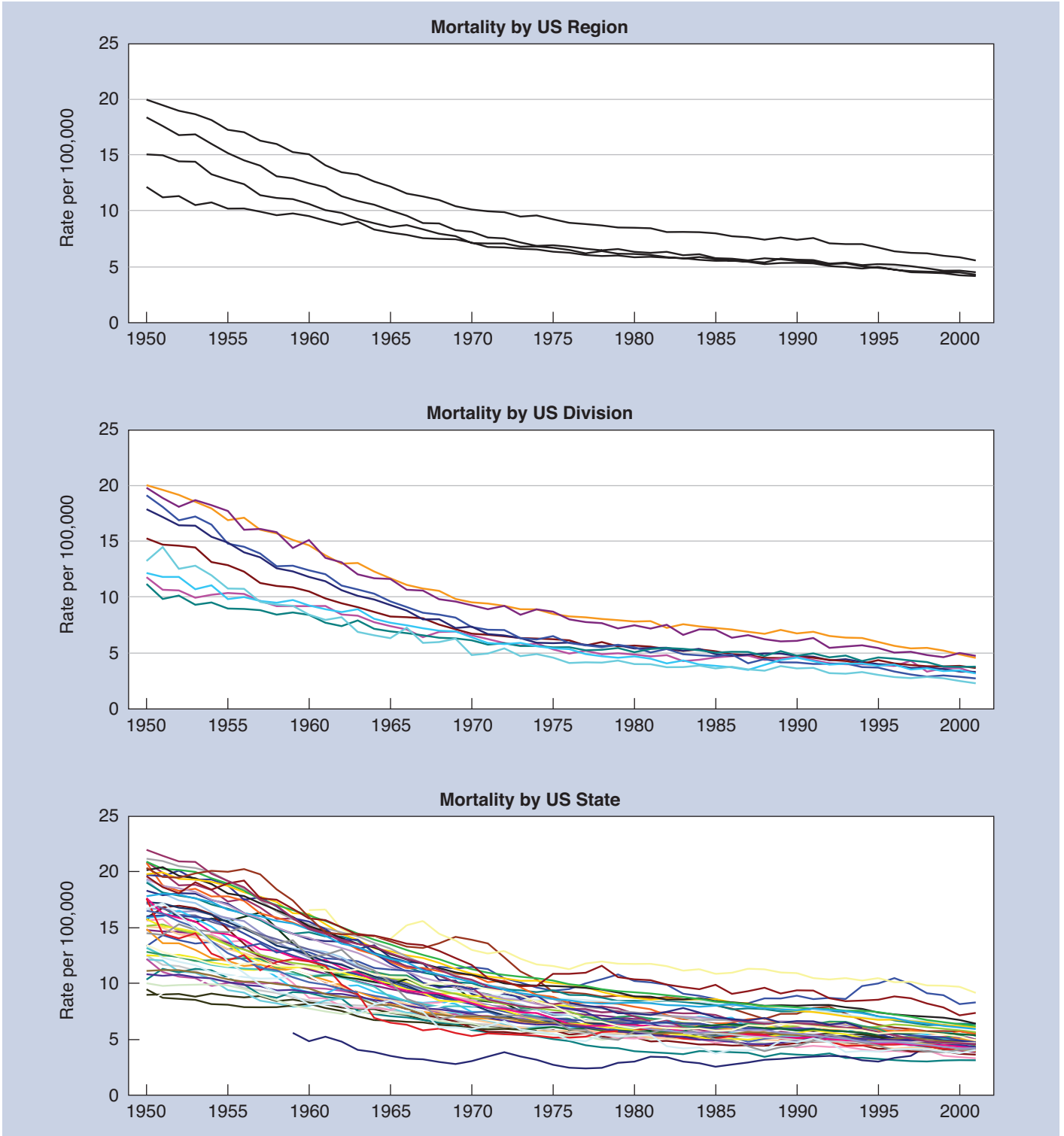


Table 38. Changes in Geographic Disparity in Stomach Cancer Mortality by Different Levels of Geographic Aggregation, 1950-2000

		Measures of Relative Disparity				Measures of Absolute Disparity	
Geographic Area	Year	RR	IDisp	T	MLD	RD	BGV
Region	1950	1.7	47.5	20.5	21.3	7.8	10.3
(n=4)	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 2000	-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	1950	1.7	40.7	21.0	21.8	8.3	10.5
(n=9)	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 2000	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	1950	2.8	102.6	28.0	29.9	14.2	13.9
(n=51)	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 2000	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%

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.

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.

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.

Figure 37. Geographic Disparities in Stomach Cancer Mortality among Those 60 and Over, 1950-2001 (3-Year Moving Average)