Appendix: Example Analyses

This appendix presents two examples of how to measure and monitor cancer-related disparity trends using the suite of indicators and measurement strategy outlined in the recommendations above. The examples are taken from the cancer-related objectives outlined in *Healthy People 2010* and are illustrative rather than substantive analyses. The first example assesses the trend in the prevalence of mammography screening among education groups and emphasizes disparity measures for ordered social groups. The second example assesses the trend in colorectal cancer mortality among racial groups and highlights the use of disparity measures for unordered social groups.

Example 1: Educational Disparity in Mammography Screening, 1990–2002

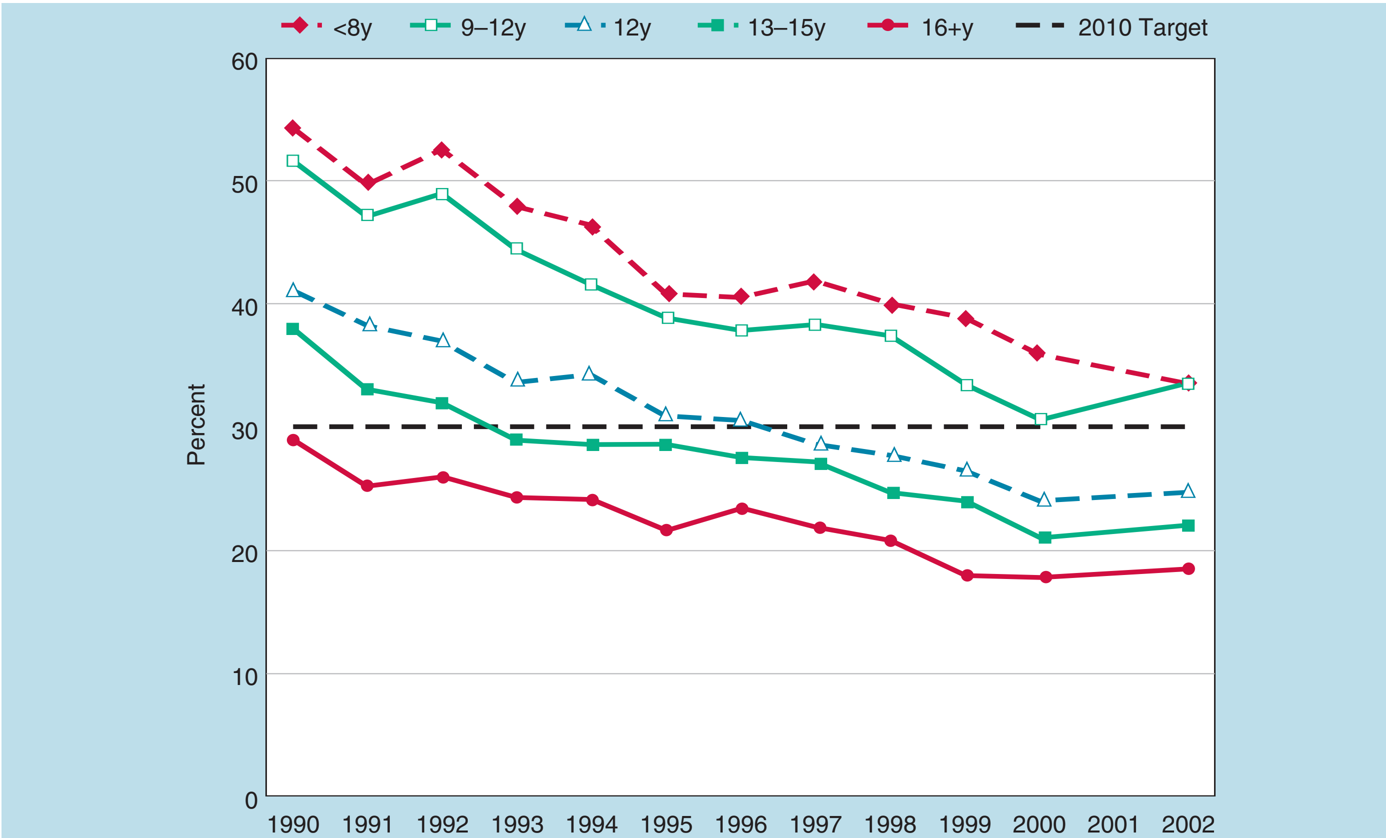
This example is based on self-reported data on the use of mammography screening from the Centers for Disease Control and Prevention's (CDC) Behavioral Risk Factor Surveillance Survey (BRFSS), an annual state-based telephone survey of adults. Although perhaps not the optimal source of data on routine cancer screening because of its high rate of nonresponse, the BRFSS may be used to approximate a nationally representative sample (99), and its annual administration and timely reporting of results make it useful for illustrating disparity trends.

Method

- *Step 1: Inspect the underlying subgroup data.* Figure A1 (page 66) shows the prevalence of women over age 40 who reported having not received a mammogram in the past 2 years for five education groups. From the chart, two things are immediately clear. First, all groups are improving over time (i.e., the proportion of women not having mammograms is declining), and some groups have actually achieved the *Healthy People 2010* target rate of 30%. Second, there is a graded relationship between the proportion of women not having a mammogram in the past 2 years and years of education—women with fewer years of education are less likely to have received a mammogram in the past 2 years.

- *Step 2: Determine the disparity question to be answered.* For this example, we are concerned about whether the extent of disparity in mammography screening across *all* education groups is increasing or decreasing. As a result, we will use a summary measure of health disparity. Suppose, however, that there had been a dedicated effort to increase the rate of screening among women with a high-school education. We then might be more interested in the question of whether the effort had narrowed the gap in screening between women with the highest

Figure A1. Proportion of Women Age 40 and Over Who Did Not Receive a Mammogram in the Past 2 Years by Educational Attainment, 1990–2002



Source: CDC, Behavioral Risk Factor Surveillance Surveys 1990–2002.

screening rates (college-educated) and high-school-educated women. In this case, a summary measure might mask an important change in this particular subgroup, so we would use a simple pairwise comparison of the absolute and relative difference in screening.

- *Step 3: Choose a summary measure of health disparity.* Having decided to use a summary measure, the choice of a measurement tool hinges on whether the social groups in question have a natural ordering. In the case of years of education, there clearly is a natural ordering, so we will choose the Relative Concentration Index (*RCI*) as a measure of relative disparity and the Absolute Concentration Index (*ACI*) as a measure of absolute disparity. Both measures are calculated for two levels of disparity aversion, $\nu = 2$, which gives the standard *RCI* and *ACI* (96), and $\nu = 4$, which gives additional weight to the health of the lower-educated groups.

Results

For the beginning and end of the period 1990–2002, Table A1 (page 68) shows the prevalence of not having a mammogram in the past 2 years (μ_j) and the population proportion

(p_j) for each group. The relative ranking of each interval (R_j), based on the midpoint of the cumulative population distribution, is derived by applying equation [23] above; thus, for the group with 9–11 years of education, the relative ranking is 0.09 + (0.5 × 0.14) = 0.17. This particular group's contribution to the *RCI*(2) is calculated using equation [26] above as $[2 \times 0.14 \times (1 - 0.17)^{(2-1)}] - [(2/41.0) \times 51.6 \times 0.14 \times (1 - 0.17)^{(2-1)}] = -0.0618$. Applying equation [26] across all education groups gives the overall *RCI*(2), which for 1990 = –0.1045. To give this value some perspective, Zhang and Wang, using income as a measure of socioeconomic position and using data from the National Health and Nutrition Examination Survey (NHANES III) (100), report a relative Concentration Index of –0.055 for obesity. Because in this case the outcome is the proportion of women *not* having a mammogram, the negative sign of *RCI*(2) indicates that the disparity favors better-educated women. A positive *RCI*(2) in this case would have indicated that disparity actually favors less-educated women. Additionally, the effect of increasing the aversion to disparity becomes readily apparent as the value of the *RCI* in 1990 increases (from –0.10 to –0.19) when the aversion to disparity increases twofold. Our preferred measure of absolute disparity for ordered social groups, the Absolute Concentration Index (*ACI*), also is displayed in Table A1 and is calculated from equation [27] above; for 1990 *ACI*(2) = 41.0 × (–0.1045) = –4.2.

Comparing 1990 and 2002 it appears that, as measured by the standard *ACI* (i.e., with $\nu = 2$), absolute disparity in mammography screening declined substantially over those 12 years—a 43.9% reduction. Relative disparity showed only slight improvement, with the *HCI*(2) declining only 2.6%. Note that, with an increased aversion to disparity ($\nu = 4$), relative disparity actually shows a slight increase (from –0.191 to –0.201), while absolute disparity still declines (from –7.8 to –4.7). Although this indicates virtually no change in relative disparity, Figure A2 (page 69) shows that, when calculated annually, relative disparity was not consistent over the entire period. As the prevalence of not having a mammogram fell faster for the less-educated groups in the first half of the 1990s, both absolute and relative disparity declined (i.e., the best possible scenario). As screening rates tapered off among the less-educated groups, however, relative disparity increased in the latter half of the 1990s, eventually returning to the 1990 level by 2002. Note also that two components of the *RCI* and *ACI* were changing over the period of observation: the prevalence rates and the population shares in each education group. Most notably, the share of the population with less than 12 years of education—the groups with the highest prevalence rates—declined from 24% (0.09 among those with <8 years plus 0.14 for those with 9–11 years) to 14% (0.06 + 0.08). Because the *RCI* is a population-weighted index, this change alone (i.e., in the absence of any change in prevalence rates) would serve to decrease the level of disparity. Thus, a logical next step in analyzing the disparity trend might be to decompose the change in disparity to determine how much of the change is due to declining prevalence rates and how much is due to upward shifting of the education distribution. We will not go through the decomposition steps here, but we would re-emphasize that such decomposition techniques are likely to be useful in understanding the sources of changes in health disparities.

Table A1. Example of Relative and Absolute Concentration Index Applied to the Change in Educational Disparity in Mammography, 1990 and 2002

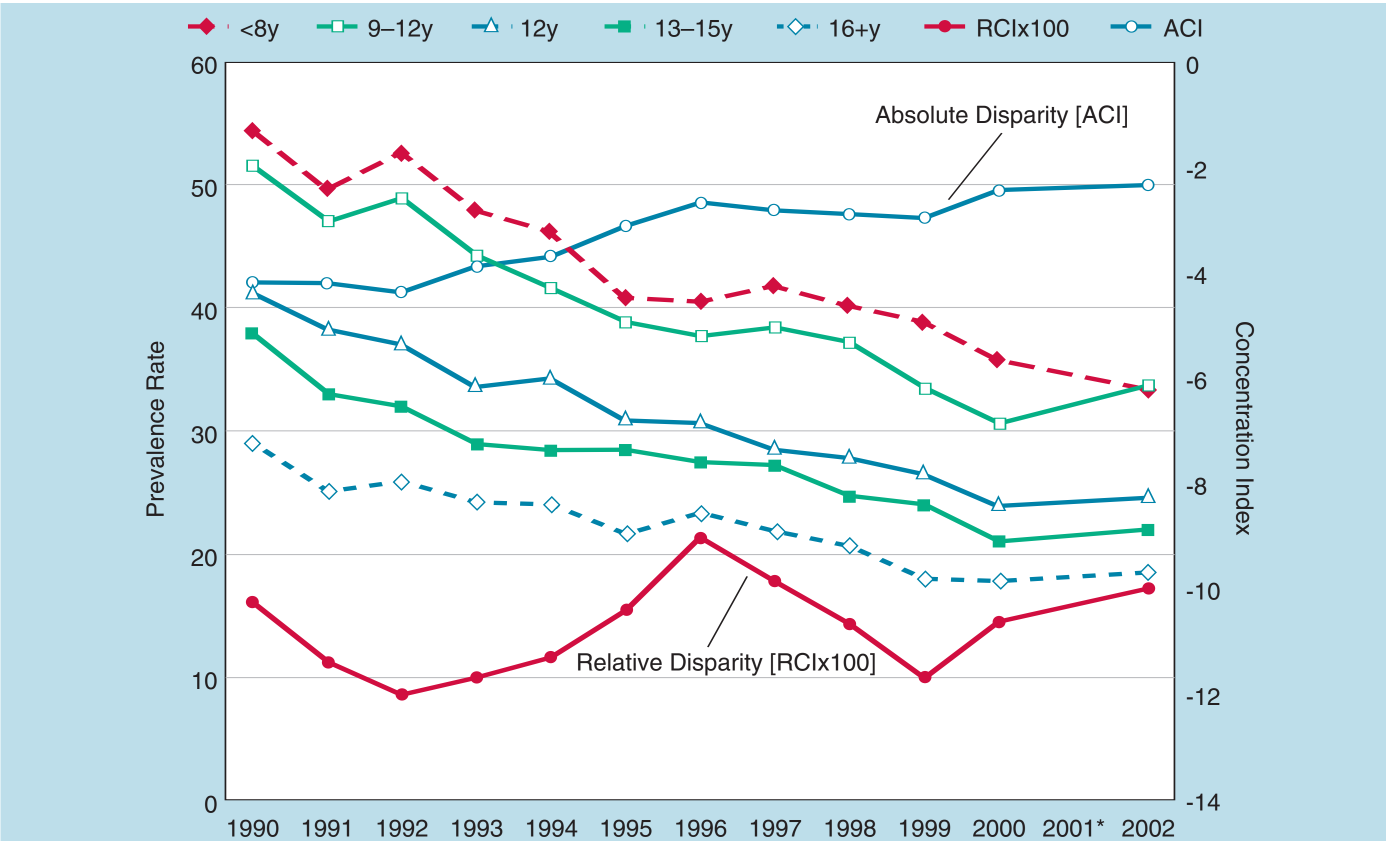
Years of Education	Rate $[\mu_j]$	Population Share $[p_j]$	Cumulative Share $[p_\gamma]$	Midpoint $[R_j]$	$RCI\ (\nu = 2)$ $(\nu)\sum [p_j(1- R_j)^{(\nu-1)}] -$	$RCI\ (\nu = 4)$ $(\nu/\mu)\sum [p_j\mu_j(1- R_j)^{(\nu-1)}]$
1990						
<8 years	54.2	0.09	0.09	0.05	–0.0583	–0.1059
9–11 years	51.6	0.14	0.24	0.17	–0.0618	–0.0860
12 years	41.1	0.36	0.60	0.42	–0.0012	–0.0008
13–15 years	38.0	0.22	0.82	0.71	0.0093	0.0016
16+ years	29.0	0.18	1.00	0.91	0.0095	0.0002
Total	41.0					
				Relative Concentration Index →	***–0.1025***	***–0.1910***
				Absolute Concentration Index →	***–4.1963***	***–7.8229***
2002						
<8 years	33.3	0.06	0.06	0.03	–0.0452	–0.0854
9–11 years	33.7	0.08	0.14	0.10	–0.0610	–0.0998
12 years	24.7	0.34	0.47	0.30	–0.0214	–0.0208
13–15 years	22.1	0.27	0.74	0.61	0.0134	0.0042
16+ years	18.6	0.26	1.00	0.87	0.0144	0.0005
Total	23.6					
				Relative Concentration Index →	***–0.0998***	***–0.2014***
				Absolute Concentration Index →	***–2.3549***	***–4.7493***

Note: Data is for the proportion of women over 40 who did not have a mammogram within the past 2 years and is drawn from the 1990–2002 Behavioral Risk Factor Surveillance System.

Thus, by using two summary measures of disparity, we can make some generalization about the trend in the education-related disparity in mammography screening. Between 1990 and 2002, the relative disparity between education groups remained essentially the same, but the absolute disparity declined because the prevalence of not having a mammogram declined in all education groups, with the largest absolute declines having occurred among the less-educated groups. Thus, we would argue that the population health burden associated with the education-related disparity in mammography screening has decreased. This, of course, is not the best possible scenario, but we would argue that the disparity situation is better in 2002 than it was in 1990.

Lastly, we would re-emphasize that our conclusion about the socioeconomic disparity trend in mammography reflects a population health perspective on health disparities. Because we were concerned about the disparity across all education groups, we chose two population-weighted summary disparity measures. The results obtained by the application of these measures may or may not be consistent with other disparity measures that reflect concern about a different dimension of disparity.

Figure A2. Trends in Education-Related Disparity and Prevalence for the Proportion of Women Age 40 and Over Who Did Not Receive a Mammogram in the Past 2 Years, 1990–2002



Source: CDC, Behavioral Risk Factor Surveillance Surveys 1990–2002.
*Note: Question not asked in 2001.

Example 2: Racial Disparity in Colorectal Cancer Mortality, 1990–2002

Our second example concerns rates of colorectal cancer mortality from 1990 to 2002 among four racial groups: American Indian/Alaska Natives, Asian/Pacific Islanders, blacks, and whites. The data for this example come from NCI's SEER Program (**www.seer.cancer.gov**). There are several limitations to this example that should be recognized. First, it is not possible with current data to analyze longer trends for mutually exclusive detailed racial/ethnic groups because many states did not have complete information on ethnicity in death certificate data. Second, there is great heterogeneity of cancer risk among subgroups of American Indian/Alaska Natives and Asian/Pacific Islanders that is not reflected in this simple example because we are forced to combine these groups. Similar issues of lack of homogeneity arise in comparing groups defined by ethnicity and by various social, economic, and geographic factors.

Method

- *Step 1: Inspect the underlying subgroup data.* Figure A3 (page 71) shows trends among those aged 45–64 years for colorectal cancer mortality for the four racial groups. Blacks have the highest rates of colorectal cancer mortality, followed by whites, and then by American Indian/Alaska Natives and Asian/Pacific Islanders, both of whom have similar mortality rates that actually are near the 2010 age-adjusted target rate. Both blacks and whites experienced relatively steady declines in colorectal cancer mortality rates during the 1990s (although the decline in black rates seems to slow down after the mid-1990s), but the rates among other groups remained somewhat steady, hovering near the 2010 target rate.

- *Step 2: Determine the disparity question to be answered.* Although a number of interesting pairwise comparisons could be made, in the spirit of the *Healthy People 2010* goals we are interested in the extent to which progress is being made toward the elimination of racial disparities in colon cancer mortality. This would be achieved when *all* groups have the same mortality rate, so we will use a summary measure of health disparity to determine if racial disparities in working-age colorectal cancer mortality are increasing or decreasing.

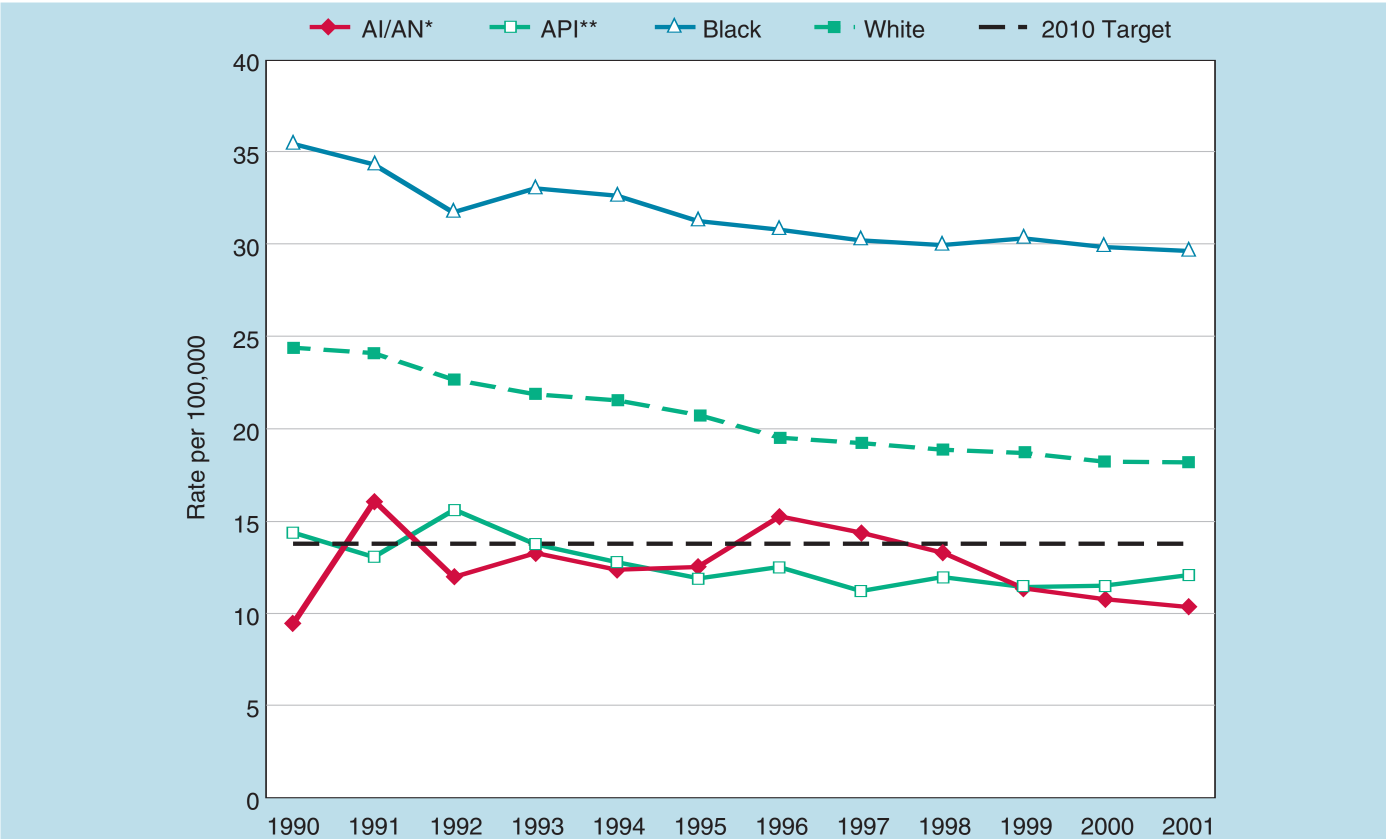
- *Step 3: Choose a summary measure of health disparity.* Clearly, there is no natural ordering among racial groups, so having decided to use a summary measure of health disparity, we will use the Between-Group Variance (*BGV*) to measure the absolute level of disparity and two entropy-based measures of relative disparity—the Theil index (*T*) and the Mean Log Deviation (*MLD*). Although it is not necessary to use both *T* and *MLD* to measure relative health disparity, it may be instructive to do so for reasons outlined below.

Results

Table A2 (page 72) shows the colorectal cancer mortality rate (μ_j), the rate relative to the population average rate (i.e., the mortality ratio r_j), and the population share (p_j) for each racial group in 1990 and 2001. Recall that both *T* and *MLD* are measures of average disproportionality—that is, they take the general form $\sum_j p_j f(r_j)$ and measure the extent to which shares of population and shares of health differ—but they use different disproportionality functions (i.e., different specifications of $f(r_j)$). The disproportionality function for *T* is $r_j \ln(r_j)$ and for *MLD* is $-\ln(r_j)$ or, equivalently, $\ln(1/r_j)$. It may not seem immediately clear why it might be helpful to use both measures, but it may be more clear if we use some simple algebra to rewrite the equations. First, note that when the denominator for the mortality ratio r_j is the total population rate, $r_j \times p_j = s_j$, where s_j is the *share* of mortality for racial group *j*. We can then rewrite the disproportionality function $f(r_j)$ for *T* as $\frac{s_j}{p_j} \ln\left(\frac{s_j}{p_j}\right)$ and *MLD* as $\ln\left(\frac{p_j}{s_j}\right)$. When we apply the general formula $\sum_j p_j f(r_j)$ for measures of average disproportionality, the formula for *T* becomes $\sum s_j \ln\left(\frac{s_j}{p_j}\right)$ and *MLD* becomes $\sum p_j \ln\left(\frac{p_j}{s_j}\right)$.

Expressed in this fashion, it is clear that both *T* and *MLD* measure the difference in (log) shares of health (or ill health) and population, but *T* is

Figure A3. Trends in Mortality from Colorectal Cancer by Race, Ages 45–64, 1990–2001



*AI/AN = American Indian/Alaska Native
**API = Asian/Pacific Islander
Source: Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database, National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released December 2003.

weighted by shares of health (or ill health, i.e., s_j), whereas *MLD* is weighted by population shares (p_j). Thus, in the context of our example *T* will be somewhat more influenced by groups with high mortality ratios, whereas *MLD* will be somewhat more influenced by groups with large population shares.

Applying the disproportionality functions for *T* and *MLD* listed in Table 2, in 1990 the American Indian/Alaska Native segment of *T* is calculated as $0.006 \times 0.375 \times \ln(0.375) = -0.0023$, and the segment of *MLD* is $0.006 \times [-\ln(0.375)] = 0.062$. The Between-Group Variance (*BGV*) is calculated using equation [17] above and, for the American Indian/Alaska Native segment in 1990, is calculated as $0.006\ (9.5 - 25.5)^2 = 1.607$. The racial disparity in 1990 as measured by the Theil index is 0.0124. We might then immediately ask whether this disparity is large or small. Because there has been little use of entropy-based measures in health disparities research, this is a difficult question to answer. We may get some leverage, perhaps, from the recent work by Goesling and Firebaugh (101), who used *T* and *MLD* to investigate trends in international health disparity in life expectancy among 169 countries. They report that in 2000 *T* for global disparity in life expectancy was 0.0099 and *MLD* was 0.0106. We find a *T* of 0.0198 and *MLD* of 0.0186 in 2002. Thus, it would appear that U.S. racial disparities in colorectal cancer among those 45–64 are similar in magnitude to cross-national disparities in life expectancy, but the extent to which the number of groups compared (4 race groups vs. 169 countries) and the health outcome (colorectal cancer mortality rates vs. life expectancy) may affect the level of disparity is an open question. As additional analyses applying entropy-based disparity measures within the United States are conducted (102), a clearer sense of how to interpret their magnitude should develop.

The results in Table A2 suggest that the absolute racial disparity (*BGV*) in colorectal cancer mortality rates remained approximately constant over the period in question, but the relative disparity increased and to a slightly greater extent when measured with *T* than with *MLD*. The slight difference between *T* and *MLD* results from the fact that *T* is somewhat more affected by high mortality ratios, and *MLD* is somewhat more affected by large population shares (88). Thus, in the case of colorectal cancer mortality, the Theil will be more sensitive to mortality change in blacks, and the *MLD* will be more sensitive to mortality change in whites. The black mortality ratio increased from 1.41 to 1.59 from 1990 to 2001, but the white ratio declined only slightly,

Table A2. Example of Theil Index and the Between-Group Variance Applied to the Change in Racial Disparity in Colorectal Cancer Mortality, 1990 and 2001

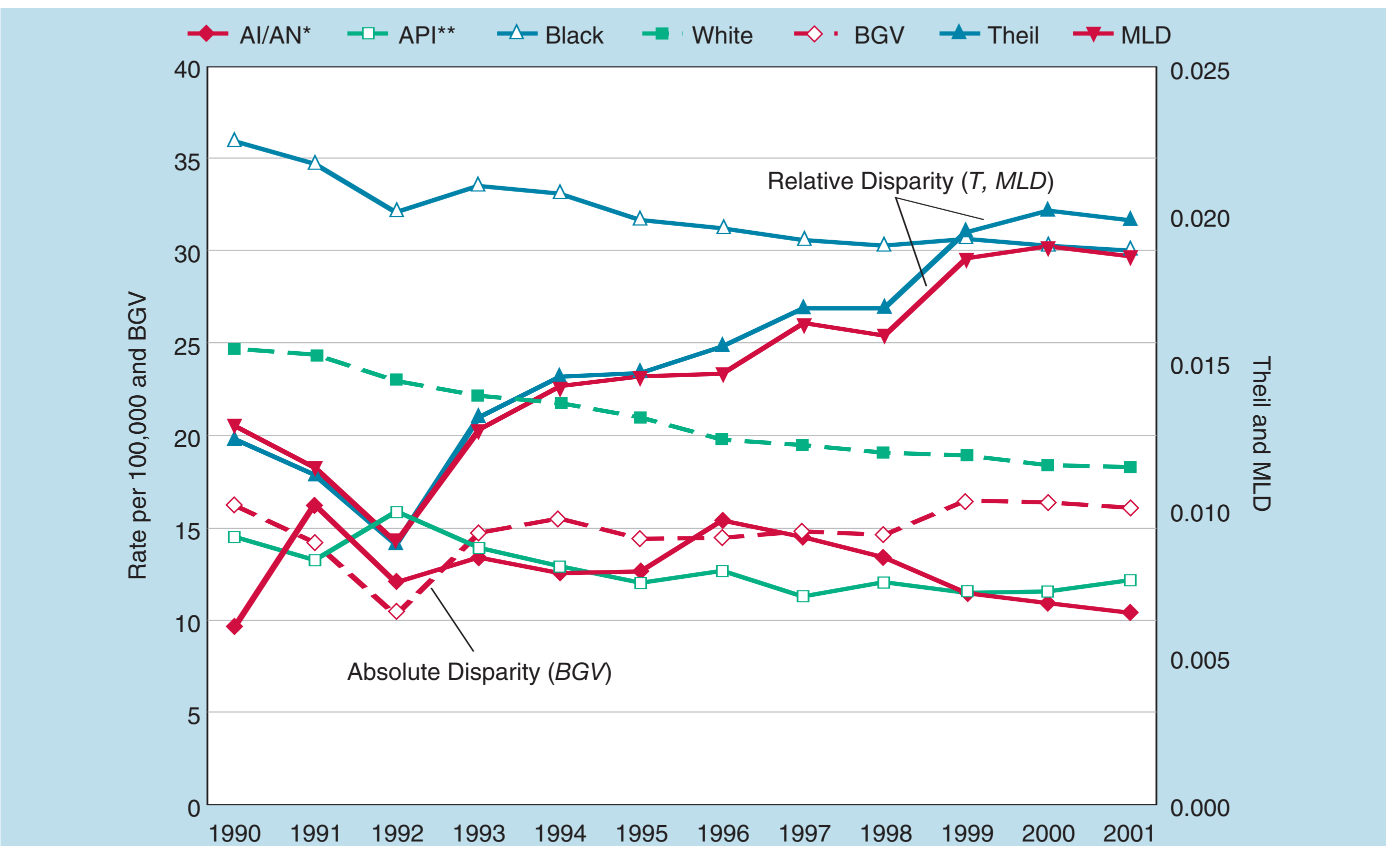
Race	Rate per 100,000 $[\mu_j]$	Population Share $[p_j]$	Rate Relative to Total $[r_j]$	*T* $[p_j \times r_j \times \ln(r_j)]$	*MLD* $[p_j \times -\ln(r_j)]$	*BGV* $p_j [(\mu_j - \Sigma\mu_j)^2]$
1990						
American Indian/ Alaska Native	9.5	0.006	0.375	–0.0023	0.0062	1.607
Asian/Pacific Islander	14.5	0.026	0.570	–0.0084	0.0147	3.130
Black	35.9	0.100	1.412	0.0486	–0.0344	10.979
White	24.7	0.868	0.970	–0.0255	0.0263	0.502
Total	25.5			0.0124	0.0128	16.219
2001						
American Indian/ Alaska Native	10.4	0.009	0.541	–0.0029	0.0053	0.672
Asian/Pacific Islander	12.1	0.040	0.629	–0.0116	0.0184	2.018
Black	30.0	0.109	1.559	0.0751	–0.0482	12.561
White	18.3	0.843	0.950	–0.0410	0.0431	0.776
Total	19.2			0.0198	0.0186	16.027

Note: Rates are age adjusted to the year 2000 population distribution and were generated by the National Cancer Institute's SEER*Stat software, version 5.2.2.

from 0.97 to 0.95, thus favoring a relatively larger increase in the Theil index.

Figure A4 shows the absolute and relative disparity trends across the entire 11-year period, which indicate that the change in racial disparity was not constant over time. Both absolute and relative disparity declined from 1990 to 1992, after which absolute disparity rose to remain at roughly its 1990 level for the rest of the period, while relative disparity continued to increase steadily as mortality rates declined for all racial groups. On the whole, then, we would take a less favorable view of the trend in racial disparities in colorectal cancer compared to that of education-related disparities in mammography. There virtually was no decline in absolute disparity, and relative disparity increased markedly from 1990 to 2002 despite an overall decline in the population mortality rate.

Figure A4. Racial Disparity Trends in Working Age (45–64) Mortality from Colorectal Cancer by Race, 1990–2001



*AI/AN = American Indian/Alaska Native
**API = Asian/Pacific Islander
Source: Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Mortality—All COD, Total U.S. for Expanded Races (1990–2001), National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released December 2003. Underlying mortality data provided by NCHS (www.cdc.gov/nchs).