Introduction

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

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

Methods

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

Measures of Absolute Disparity

Rate Difference (RD)

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

$$RD = r_1 - r_2 \qquad [1]$$

where r_1 and r_2 are indicators of health status in two social groups. In this case r_2 serves as the reference population and the RD is expressed in the same units as r_1 and r_2. A typical disparity measure that uses the absolute difference between two rates for an entire population is the range, in which case r_1 above corresponds to the least healthy group and r_2 the healthiest group. In the context of measuring health disparities the RD is often used to compare the health of less-advantaged social groups to more-advantaged. However, in this we use RD as a summary measure of the gap between the best rate and worst rate for a given outcome (i.e., the absolute range), regardless of which two social groups are being compared.

Between-Group Variance (BGV)

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

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

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

Absolute Concentration Index (ACI)

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

$$ACI = \mu RCI, \quad [3]$$

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

Slope Index of Inequality (SII)

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

$$\bar{y}_j = \beta_0 + \beta_1 \bar{R}_j \quad [4]$$

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

Measures of Relative Disparity

Rate Ratio (RR)

The RR is virtually identical to the RD described above, but is calculated by dividing r`1 by r2 rather than subtracting:

$$RR = r_1 / r_2 \quad [5]$$

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

Index of Disparity (IDisp)

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

$$ID_{isp} = \left(\sum_{j=1}^{J-1} \left| r_j - r_{ref} \right| / J \right) / r_{ref} \text{ x } 100, \quad [6]$$

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

Relative Concentration Index (RCI)

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

$$RCI = \frac{2}{\mu}\left(\sum_{j=1}^{J} p_j \mu_j R_j\right) - 1 \qquad [7]$$

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

$$R_j = \sum_{j=1}^{J} p_\gamma - \frac{1}{2} P_j \qquad [8]$$

where p_γ is the cumulative share of the population up to and including group j and p_j is the share of the population in group j. R_j essentially indicates the cumulative share of the population up to the midpoint of each group interval, similar to the categorization used for the Slope Index of Inequality above. In fact, the RCI has a specific mathematical relationship with the SII (6), such that,

$$RCI = 2\,\mathrm{var}(x)(\beta / \mu) \qquad [9]$$

where β is the slope parameter identified in the equation for the SII above. One of the reasons the RCI (and, by extension, the SII) is favored by some is that it "reflects the socioeconomic dimension to inequalities in health" (6, p.548). That is, a downward health gradient (such that health worsens with social group rank) results in a positive RCI, whereas an upward health gradient results in a negative RCI.

Relative Index of Inequality

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

$$RII = SII / \mu = \beta_1 / \mu \qquad [10]$$

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

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

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

$$T = \sum_{j=1}^{J} p_j r_j \, 1\mathrm{n} r_j$$
$$MLD = \sum_{j=1}^{J} p_j \left(-\,1\mathrm{n} r_j\right) \qquad [11]$$

where p_j is the proportion of the population in group j and r_j is the ratio of the prevalence or rate of health in group j relative to the total rate, i.e., $r_j = y_j / \mu$ where y_j is the prevalence of the outcomes in group j and μ is the total prevalence. Both measures are population-weighted, are more sensitive to health differences further from the average rate (by the use of the logarithm), and may be used for both ordered social groups (education) and unordered groups (gender, race).

Presentation of Results

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

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

Random Variation

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

Results

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

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

Males

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

Figure 1. Lung Cancer Incidence by Race among Males 45-74, 1990-2001