THE MISINTERPRETATION OF HEALTH INEQUALITIES IN THE UNITED KINGDOM

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ABSTRACT: *For almost 30 years, researchers have been studying socioeconomic and geographic health inequalities in the United Kingdom. The consensus view, at least with respect to mortality, has been that those inequalities have increased since the institution of the National Health Service, and that they have continued to increase even after the current Labour government made elimination of the inequalities a priority. These inequalities have been found even in seemingly homogeneous segments of the population; and among one seemingly homogeneous segment few of whose members suffer from material deprivation (British civil servants), health inequalities have been found to be larger than those in the nation at large.*

With few exceptions, however, this research is suspect because not undertaken with a recognition of the way relationships between the rates at which different groups experience or avoid an outcome are affected by the overall prevalence of an outcome. Most notably, while health inequalities have generally been measured in terms of the ratio of the rate at which a disadvantaged group experiences an adverse outcome to the rate at which the advantaged group experiences that outcome, (i.e., the relative difference), researchers have failed to recognize the statistical tendency whereby the rarer an outcome, the greater the relative difference in experiencing it and the smaller the relative difference in avoiding it. Thus, in times of declining mortality researchers have failed to recognize that such declines will almost invariably be accompanied by increasing relative differences in mortality rates. Researchers have similarly failed to recognize that relative differences will tend to be greater among relatively advantaged segments of the population because overall mortality is lower among such groups.

But relative differences between rates of experiencing an outcome are not the only measures that are affected by overall changes in the prevalence of an outcome. All measures of differences between rates of experiencing binary outcomes, as well as all measures that are functions of binary outcomes, appear to change in one manner or another as there occurs a change in the prevalence of an outcome. Thus, it is unclear whether the sizes of health inequalities and whether they are increasing or decreasing can be measured in a meaningful way.

Introduction

For almost 30 years, researchers have been studying socioeconomic and geographic health inequalities in the United Kingdom. The consensus view, at least with respect to mortality, has been that those inequalities have increased since the institution of the National Health Service, and that they have continued to increase even after the current Labour government made elimination of the inequalities a priority (Shaw *et* *al.* 1999, Davey Smith *et al.* 2000, Davey Smith *et al.* 2002, Ferrie *et al.* 2002, Shaw *et al.* 2005). With little exception, however, this research is suspect because not undertaken with an appreciation of the ways relationships between the rates at which two groups experience or avoid some outcome are affected by the prevalence of the outcome. Most notably, the research has failed to recognize that declines in adverse outcomes like mortality tend almost invariably to increase relative differences in experiencing the outcome while reducing relative differences in avoiding the outcome.

Section A describes this tendency as well the way other standard measures of health inequalities tend to change solely as a result of changes in the prevalence of an outcome. Section B addresses the implications of the failure to recognize these tendencies in the study of health inequalities in the United Kingdom and elsewhere, with particular attention to interpretations of the Whitehall studies that have played such a large role in health inequalities research in the United Kingdom. Section C addresses possibilities for measuring health inequalities while attempting to take the described tendencies into account. Section D addresses certain issues peculiar to the study or morbidity.

A. Standard Patterns of Changes in Group Differences When the Prevalence of an Outcome Changes

The standard patterns of changes in relationships between the rates at which two groups experience (or avoid) some outcome can be found in virtually any data set that allows one to examine the rates at which two groups fall above or below various points on a continuum of factors associated with some outcome. Table 1 is based on the situation of two groups having normal distributions of some factor where the distributions have the same standard deviation and where the average of the advantaged group (AG) is half a standard deviation greater than that of the disadvantaged group (DG). Columns 1 and 2 show the proportion of each group that falls below each of 15 points defined on the basis of the proportion of AG falling below the point. The other columns will be described in due course.

For conceptual purposes, one might regard these data as reflecting performance on a paper-and-pencil test and regard the implications of moving down the table in terms of the lowering of the cutoff for passing the test. Thus, the proportion of each group falling below each point would be the group's failure rate at that point. It should be recognized, however, that the patterns illustrated with the data in the table would be observed in any set of data where two groups have different, more or less regularly-shaped, distributions of factors associated with experiencing or avoiding some outcome. For example, the patterns described below would also be found in income data showing the rates at which various groups fall below or above certain ratios of the poverty line (Scanlan 1991, 2000, 2006a). Moreover, the patterns would obtain even in situations where the underlying distributions cannot be directly observed, as in the case of the varied factors underlying distributions of risks of mortality. It should also be recognized that the changes effected by lowering a cutoff score from one point to another are the same as those that would occur if, rather than lowering a cutoff score, test performance were improved such that everyone scoring between the two points was enabled to achieve the higher score.

Relative Differences in Adverse Outcomes

The most notable problem in the analyses of health inequalities to date involves the failure to recognize the tendency whereby when two groups differ in their susceptibility to an outcome, the rarer the outcome the greater the relative difference in experiencing it and the smaller the relative difference in avoiding it (Scanlan 1991, 1994, 2000, 2006a). The former pattern is reflected in Column 3 of Table 1, which presents the ratio of DG's rate of falling below each point to AG's rate of falling below the point. The pattern is illustrated visually in Figure 1, which shows, moving from left to right, the way these ratios change as the lowering of the cutoff reduces the failure rate of each group. And we observe that the ratio increases as we move down the table or across the figure. For example, at Point J, DG's failure rate (49.2%) is 1.63 times AG's failure rate (30.0%); at Point K, DG's failure rate (36.7%) is 1.83 times AG's failure rate (20.0%). Thus, as cutoffs are lowered, and failure becomes rarer, the relative difference in failure rates increases. Further, viewing the matter in terms of improvement in test performance rather than lowering the cutoff, the failure ratio could increase even when a higher proportion of DG than AG scoring between two points was enabled to score above the higher point. For example, consider the situation where, with a cutoff at Point J, improvements in performance enabled 100% of DG but only 90% of AG previously scoring between Points J and K now to score above Point J. That would seem to reflect a genuine improvement in the situation of DG relative to that of AG. Yet such change would leave DG's failure rate at 36.7% and AG's failure rate at 21.0%. Thus, the ratio of DG's failure rate to AG's failure rate still would rise to 1.75 from the 1.63 it had been before the change.

The opposite, of course, would occur if a cutoff is raised rather than lowered. That is, the ratio would decline. And, viewing the matter in terms of a deterioration of test performance, the ratio could decline even when 100% of DG but some smaller percent of AG originally falling between two points moved from the pass category to the fail category. Thus, the ratio of DG's failure rate to AG's failure rate would decline even though the relative situation of DG had worsened.

Inferable from the table is a corollary to the increasing difference in failure rates effected by lowering a cutoff. As a result of lowering the cutoff, AG experiences a larger proportionate decline in its failure rate than DG does. For example, lowering the cutoff from Point J to Point K would reduce AG's failure rate by 33.3% (30% reduced to 20%), while it would reduce DG's failure rate by only 29.8% (49.2% reduced to 36.7%). Conversely, raising the cutoff back to Point J would increase AG's failure rate by 50.0% (20% increased to 30%), while it would increase DG's failure rate by only 33.9% (36.7% increased to 49.2%).

Another corollary to the increasing ratio of rates of falling below each increasingly lower point on the table is that DG comprises a higher proportion of the population falling below each point. For example, assuming groups of equal size, DG would comprise 62% of the population falling below Point J but 65% of the population falling below Point K. Recognizing this aspect of the matter is important to understanding why ratios of rates of experiencing some adverse outcome tend almost invariably to increase as the outcome declines. For progress in virtually every area of human well-being, including reductions in mortality, is generally a matter of serially restricting adverse outcomes to the points where only the most susceptible segments of the overall population continue to experience those outcomes – until, in an ideal world, the adverse outcomes disappear entirely. And disadvantaged groups comprise larger proportions of each increasingly more susceptible segment of the overall population. Thus, the closer a society comes to eliminating an adverse outcome, the more the outcome will be concentrated within disadvantaged groups, and the greater will be the differences between the rates at which advantaged and disadvantaged groups experience it.

Relative Differences in Favorable Outcomes

Now consider the other side of the picture – the relative differences in experiencing the favorable outcome. Columns 4 and 5 show the proportion of each group falling above each point, which proportions would be the pass rates on a test. Column 6 then shows the ratio of AG's rate of falling above the point to DG's rate of falling above the point (which is also shown visually in Figure 2). That ratio declines – *i.e.*, the difference grows smaller – as we move down the table.[1] Thus, we observe that the size of relative differences in experiencing an outcome and in avoiding the outcome tend to move systematically in opposite directions as the prevalence of the outcome changes.

It might initially seem counterintuitive that the same change in prevalence that causes relative differences in experiencing an outcome to increase also causes relative differences in avoiding the outcome to decline. In fact, however, the latter pattern is implied in the former, if, indeed, it is not exactly the same thing. For if declines in prevalence of an outcome lead to increasing differences in experiencing the outcome, it follows that increases in prevalence of the outcome will decrease differences in experiencing it. And if an adverse outcome is declining, it follows that the favorable (opposite) outcome is increasing, which means that differences in experiencing the favorable outcome will decline.

Further, just as DG comprises a higher proportion of those continuing to experience the adverse outcome when the cutoff is lowered than it did of those previously experiencing it, DG comprises a higher proportion of those newly-enabled to score above the cutoff than it comprised of those previously scoring above the cutoff. From this perspective, there is some appeal to perceiving the matter in terms of a meaningful improvement in the relative situation of DG. Yet, logically, there seems no more basis for regarding the matter in that way than in regarding the increase in the proportion DG comprises of those continuing to experience the adverse outcome as a meaningful worsening of its relative situation. And, of course, the reduction in the relative difference in pass rates could occur even when, for example, 100 percent of AG but less than 100 percent of DG initially scoring between the two points was enabled to achieve the higher cutoff.[2]

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[1] In a variety of publications I have generally presented the relative difference in experiencing the favorable outcome in terms of the ratio of the success rate of the disadvantaged group to that of the advantaged group (Scanlan 1991, 1994, 2000, 2006a). I have done so mainly because that is the ways relative success is usually examined in various American legal settings. Presented that way, a decrease in the relative difference would be reflected by an increase in the ratio. The manner of presentation, however, is irrelevant to the patterns of change in the size of the difference.

[2] To suggest a disproportionate improvement on the part of AG, I cast the example in terms of a 100 percent of AG but a lesser percent of DG, rather than simply in terms of a higher percentage of AG than DG being enabled to achieve the higher cutoff. For when less than the entire population falling between two contiguous points is enabled to reach the higher point, typically a higher proportion of AG than DG between the points will reach the higher cutoff. This occurs simply because between each of two points AG will tend to be disproportionately represented among the higher scoring part of the population. Only by positing that 100 percent of AG between the two points was enabled to achieve the higher cutoff can one

In any case, that increasing differences in experiencing an adverse outcome in times of declining prevalence of the outcome are attended by declining differences in avoiding the outcome has the following important implication with respect to the evaluation of changes in the size of inequalities. Some might be inclined to maintain that an increase in the difference between rates of experiencing an adverse outcome reflects some true worsening of the relative status of the disadvantaged group, even when the increase results solely from a general decline in the prevalence of the outcome. Even allowing the plausibility of the point for a moment, one would have to regard such a change as a much different occurrence – and a far less consequential occurrence – than a change that went beyond the usual consequences of the overall decline in the outcome. Indeed, one might say we have an interest only in the changes that are more than or less than the usual consequence of an overall decline in the outcome. But it becomes difficult even to maintain that an increase in the difference in adverse outcomes flowing solely from a decrease in prevalence reflects a true worsening of the relative situation of the disadvantaged group when one recognizes that, if one appraises the same matter in terms of the favorable outcome, one has to conclude that the inequality has declined.

As it happens, relative differences in many indicators have traditionally been measured in terms of the favorable outcome. In the United States, where laws limit the use of employment tests on which minorities or women do not perform as well as whites or men, relative differences in performance on tests has generally been examined in terms of pass rates. And because the lowering of cutoffs tends to reduce relative differences in pass rates, the lowering of cutoffs has been universally regarded as reducing the disproportionate impact of such tests on minorities or women, even though lowering cutoffs increases differences in failure rates.[3] Beneficial health procedures (*e.g.*, prenatal care, immunization, mammography) have traditionally been evaluated in terms of differences in rates of receiving the procedure. Thus, the increased availability of such procedures has led to a perception that inequalities are declining, even as that same increased availability, by reducing certain types of mortality, has led to the perception that racial differences in those types of mortality are increasing.

Odds Ratios

Now consider odds ratio, the ratio of one group's odds (*i.e.*, the rate of experiencing an outcome divided by the rate of avoiding it) divided by the odds of the other group. Some commentators favor the use of odds ratios because one gets the same result whether one focuses on the adverse or the favorable outcome (Cornfield 1951, Gastwirth 1998). And, given that odds ratios are functions of rates of both

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conclude that the fact that a lesser percentage of DG was enabled to achieve the higher cutoff would indicate that, in a meaningful way, among those scoring between the two points, DG did not proportionately share in the improvement.

[3] There is not perfect consistency in the way such issues have been addressed in comparable settings. For example, racial differences in mortgage lending patterns have been analyzed in terms of differences in rejection rates. This approach has persisted even though lenders have been encouraged to relax lending criteria that disadvantage minorities. Thus, the lenders that respond to such encouragement reduce racial differences in acceptance rates, but increase the racial differences in rejection rates that tend to make them targets for litigation (Scanlan 2000).

experiencing and avoiding an outcome, it warrants consideration whether the odds ratio might offer a useful means of identifying changes in the relative well-being of two groups vis-à-vis experiencing and avoiding some outcome that are not solely the result of chances in the prevalence of the outcome.

But in order to determine whether inequalities in outcomes like mortality (or survival) are changing in ways that are not solely functions of changes in the prevalence of the outcome, one needs a measure that does not change when there occurs a simple across-the-board change in prevalence – "across the board" meaning a change akin to lowering the cutoff from Point J to Point K in Table 1. As shown in Column 7 of Table 1 (and illustrated visually in Figure 3), however, the odds ratio is very large when the failure rate is very large, grows smaller as the failure rate declines towards the area where a majority of AG passes the test, then grows large again as failure becomes rare. (Ratios of the odds of avoiding the outcome, which are the reciprocals of the odds ratios shown in Column 7, would reflect the same patterns with respect to the size of the differences.) Thus, while the odds ratio of experiencing an adverse outcome behaves like the relative risk of experiencing the outcome when the outcome is rare (and like the relative risk of avoiding the outcome when the outcome is pervasive), it changes in less predictable ways when the outcome is relatively common. For example, serially lowering the cutoff from Point E would cause the odds ratio (2.53) to decline for a time, reaching a low of 2.19 at Point I, and then return to approximately the original level at Point K (2.50). In any event, the odds ratio does not provide a ready means of identifying changes that are not solely the function of changes in the prevalence of an outcome.

Absolute Differences

Some favor using absolute differences rather than relative differences to measure health inequalities. Reasons for this preference include (1) that the absolute difference is the same whether one examines the adverse or the favorable outcome and (2) that the absolute difference gives a better picture than the relative difference of the proportion of the disadvantaged group that is harmed by its greater susceptibility to an adverse outcome. But we see in Column 8 of Table 1 (and Figure 4) that, as with each of the other measures just described, absolute differences also change when there occurs an across-the-board change in the prevalence of an outcome. The absolute difference is small at the point where almost everyone from both groups experiences the adverse outcome, grows larger as the adverse outcome becomes less common, and then grows small again as the adverse outcomes becomes rare. And, as with the other measures, absolute differences can change in one direction, even when there is genuine change in the other direction. That is, for example, with a cutoff at Point J, if 100% of AG but a lesser percent of DG scoring between Points J and K was enabled to reach Point J, the absolute difference between failure (and pass) rates still could decline. Thus, absolute differences cannot provide an efficient and reliable means of identifying changes in the relative status of two groups with respect to some outcome that are not solely a function of changes in prevalence of the outcome. [See Addendum, item 1.]

Longevity Differences

Various studies have endeavored to measure changes in health inequalities in terms of longevity. Longevity, not being dichotomous (though it is a function of dichotomous outcomes), is more on the order of the measures that I have previously suggested might offer a useful means of appraising changes in the relative health status of two groups (Scanlan 1994) and that I discuss further below. If longevity could provide a benchmark for appraising such changes, however, it still would not be useful for evaluating changes in susceptibilities to particular types of mortality (which is the subject of much health disparities study) but only for evaluating changes in overall mortality differences. But it seems that longevity cannot even provide a means of appraising changes in overall mortality differences.

There are likely more realistic ways to model changes in relative longevity, while taking into account the tendencies described above, than the approach I set out in the next several paragraphs. But I believe the approach below satisfactorily illustrates the underlying issue.

Consider a society where people in good health live to age 80 and those in poor health live until age 70. There are no other alternatives. Thus, in this setting, the favorable outcome is living to age 80 and the adverse outcome is dying at age 70. Members of the advantaged group (AG) have a better chance of living until age 80 than do members of the disadvantaged group (DG); and hence AG has greater average longevity than DG. The distributions of the two group's chances of living to age 80 correspond to those underlying the patterns in Table 1. Based on these patterns, Table 2 shows the implications with respect to the average of the two groups of serially reducing the chances dying at age 70. The table also sets out the relative and absolute difference in longevity at each point.

We need not here address whether the size of the difference between two groups' average longevity is better captured by the relative or absolute difference (which, in any case, tend to show the same directions of change in this setting). It suffices to note that the table shows that, as there occurs a general decline in the prevalence of dying at age 70 – in other words, simply an across-the-board improvement in health that serially enables each segment of the overall population with the greatest chance of living to age 80 in fact to do so – the absolute and relative differences in longevity increase for a time and then decline. We would observe similar changes if we altered the ages of the alternative outcomes.

The point, however, lies not in particular patterns of changes of absolute and relative longevity differences, but in the fact that there is any change at all. For the underlying events do not reflect changes in the relative well-being of two groups that are not the natural consequences of the across-the-board improvement in the health of the two groups. Further, the underlying reality is comprised of a varied array of paired distributions with respect to particular risks of mortality, and progress in reducing each such risk can be contributing to either an increase or a decrease in overall longevity. Hence, neither relative nor absolute longevity differences provides a benchmark against which we can determine whether there have occurred any true changes in the relative well-being of the two groups.

Other Measures of Health Inequality

There exist varied other measures of health inequalities, such as the Gini coefficient, concentration index, relative index of inequality, slope index of inequality, which attempt to take into account the way the sizes of different groups change over time as well as the changes between outcome rates of the groups. (Mackenbach and Kunst 1997, Carr-Hill and Chalmers-Dixon 2005). One might in any case question the utility of any measure that attempts to take into account, and hence intermingle, different things such as changes in the size of various segments of the population and changes in differences among the health statuses of the various segments, since the different types of changes often implicate different concerns. For instant purposes, however, it suffices to say that, as with the measures previously discussed, all of these measures tend to change in some manner when there occurs an across-the-board change in the prevalence of an outcome. Hence, none offers a means of identifying changes in the relative health status of different demographic groups that are not solely the results of changes in prevalence.

B. Implications of Misunderstanding the Described Tendencies

It is important to recognize that the main tendency described in the preceding section – i.e., the tendency whereby the rarer an outcome the greater the relative difference in experiencing it and the smaller the relative difference in avoiding it – is merely a tendency. The prevalence of an outcome is not the only thing affecting the size of relative differences between rates of experiencing or avoiding an outcome. Both differences are also functions of the similarity of the risk distributions of two groups, and the similarity of those distributions will vary from setting to setting (with the greater similarity causing relative differences in experiencing an outcome and relative differences in avoiding the outcome, as well as odds ratios and absolute differences, to be smaller with respect to each point on Table 1).

One apparent departure from the expected pattern involves socioeconomic inequalities in mortality among men and among women. Since mortality is lower among women than among men, the described tendency suggests that relative socioeconomic inequalities would be greater among women than among men. Yet that seems not to be the case (Sacker *et al.* 2000, Martikainen *et al.* 2001, Huisman *et al.* 2005, Khang *et al.* 2005). But in industrialized societies, among others, it is understandable that the differences between the working conditions and physical strains associated with the occupations of the lower and higher social classes would have a greater impact with respect to men than to women. Such greater impact seems to be sufficient usually to outweigh the tendency for relative differences in mortality rates to be greater in settings where early mortality is less common.[4] Similarly, declines (or increases) in the prevalence of an outcome need not invariably yield the standard patterns of changes in relative differences described above simply because the distributions are becoming more or less similar during the period under examination. And of course, while distributions typically will tend toward the normal, they are unlikely always, or ever, to be perfectly normal. Thus irregularities in the distributions may occasionally have a role in the patterns one observes in different settings.

There may also be situations where there exist systematic countervailing factors. For example, because mortality is rarer among the young than the old, we expect relative differences in mortality to be greater among the young than the old. That is

[4] Other factors may be at work as well. To the extent that measures of social status are less exact for women than for men, such factor would tend to cause an underestimation of the social gradient among women. Further the apparent larger gradient among men may be dependent upon the type of occupation. Marmot (1995), discussed further *infra*, presents morbidity prevalence data separately for men and women in the Whitehall studies. In areas of where women tend to have lower prevalence rates, they tend to show (though do not always show) larger social gradients by grade than men (and vice-versa in the situations were men have lower prevalence rates). It is possible that, with respect to whether lower mortality rates of women would generally translate into a steeper social gradient, the office working environment in which the Whitehall group was mainly employed – lacking the physically arduous and relatively dangerous jobs in which lower SES men outside the civil service tend to be disproportionately concentrated – would show such a pattern.

generally found to be the case (Mackenbach *et al.* 2003, Huisman *et al.* 2005), as is discussed further below with regard to the Whitehall studies. Similarly, just as socioeconomic status increases mortality more (in relative terms) among the young than the old, factors other than socioeconomic status that increase mortality would tend to do so more among the young than the old, as, for example, is generally observed in the case of obesity.[5] A countervailing factor, however, would be that, whatever the mechanisms that are responsible for the difference in risk distributions between two groups, it would be expected to affect the distributions more among the old than the young, simply because the old have been subjected to those mechanisms longer than the young. Thus, while generally studies have found the relative difference between death rates of smokers and non-smokers to be greater among the young than the old, one study found the relative difference to be similar across age ranges and without a consistent pattern of decline with age (Smoking and Health 1964). Very likely the absence of a greater impact of smoking on the young than the old (in terms of relative increases in mortality rates) in this instance was a function of the greater cumulative effect of smoking on long-term smokers balanced against the tendency for relative differences in mortality generally to be greater among the young.

Despite these qualifiers, however, the tendency whereby the rarer an outcome the greater the relative difference experiencing it and the smaller the relative difference in avoiding it are sufficiently pervasive and powerful that it is not possible to meaningfully appraise the sizes of relative differences in different settings without recognizing the tendency. And because the tendency is generally unrecognized, we can see flaws in virtually all efforts to appraise the size of health inequalities, with respect both to evaluating change over time and to comparing inequalities in different populations. Most notably, the view that health inequalities have been increasing in the United Kingdom and elsewhere has generally been based on increasing relative differences in mortality during periods of overall declining mortality, and without recognition that increasing relative differences between the mortality rates of more and less advantaged groups are near inevitable consequences of declining mortality. Whether the observed increases in relative differences are greater than or less than

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5 The ways relative rates of experiencing (or avoiding) an outcome are affected by the prevalence of an outcome also have implications with respect to the interpretation of the impact of exacerbating (or ameliorative) factors on different groups, with the tendency being for exacerbating factors to increase mortality proportionately more for the group with lower mortality but reduce survival proportionately more for the group with higher mortality, and vice-versa for ameliorative factors (Scanlan 1994, 2000). Thus, studies find that obesity and high body mass index increase death rates where mortality is lower – i.e., more among the young than the old, more among whites than blacks, and more among non-smokers than smokers (Calle et al 1999, Calle *et al.* 2003, Visscher *et al.* 2004, Park 2006). Obesity has been shown to increase coronary heart disease mortality more for women than men (Kim *et al.* 2006), though the role of obesity with respect to men and women is somewhat mixed (compare Calle *et al.* 1999 with Calle *et al*. 2003). Increasing age raises the relative risk of coronary heart disease more among women than men; correspondingly male gender raises the relative risk of coronary heart disease more among the young than the old (Asian Pacific Cohort Studies Collaboration 2006). Prescott *et al.* (1998) showed that smoking increases the risk of death more for women than for men. Data presented in that study also showed, however, that, while the increased mortality risk for heavy smokers compared with non-smokers is greater among women than among men, decrease in survival rates is greater among men than among women. The data underlying the other studies, but not presented, might well also show contrasts between relative mortality increases and relative survival declines.

those that should be expected to occur solely as a result of declining mortality has gone unexamined.

Further, we observe a good deal of research expressing expectations that often are precisely the opposite of what one should expect as well as a variety of errors in the drawing of inferences based on the size of relative differences. As suggested above, we see it observed that, despite declining mortality, socioeconomic inequalities are increasing (Ferrie *et al.* 2002, CDC 2002); but it is precisely because of declining mortality that we should expect increases in relative differences in mortality. We see the expectation that welfare state would reduce the associations between cardiovascular disease and childhood socioeconomic status (Lawlor *et al.* 2006). But given the overall decline in cardiovascular disease (with the welfare state likely having a substantial role in that decline) the expectation that the association, when measured in terms of relative differences in experiencing cardiovascular disease, should be increasing is the more reasonable one.

Similarly, most measures that intuitively would be expected to reduce inequalities (like the National Health Service) are at least as likely to increase relative differences in mortality by increasingly restricting mortality to the most susceptible segments of the overall population. A study published last year in the *American Journal of Public Health* is illustrative. Pickett *et al.* (2005) examined changes in socioeconomic differences in rates of Sudden Infant Death Syndrome (SIDS) in the United States as a result of the Back to Sleep Program. The program, which was aimed at educating the public about the advantages of having infants sleep on their backs, was deemed by the authors as one expected to reduce health inequalities since there would be few barriers to universal implementation of the recommendations. Yet the study found that, while SIDS rates decreased substantially for all groups, socioeconomic differences in SIDS rates increased. In fact, however, the increase in those differences was just what one should expect as the result of a program like this that serially restricted avoidable SIDS mortality to the very most disadvantaged segments of the population – on the way, one would hope, to the complete elimination of SIDS. It of course is not impossible that a measure might be so much more relevant to the situations of the very disadvantaged that it could in fact yield a decline in the relative difference in adverse outcomes. But such measures are likely to be uncommon.

A good deal of the research into health inequalities in the United Kingdom has been based on the intensive examination of health outcomes among British civil servants (the Whitehall studies). The Whitehall studies found that, despite being a relatively homogeneous group few of whose members suffered from significant material deprivation, British civil servants showed larger relative inequalities in mortality rates than in the UK population at large (Marmot 1995, 2004). Though initially a source of puzzlement, the larger size of mortality differentials in a segment of the population where social status designation are relatively precise (by means of the civil service grade structure) was eventually interpreted as an indicator that the mortality differentials in the remainder of the population were underestimated due of imprecision in social class designations (Wilkinson 1996, Marmot 2004). The large mortality differentials among civil servants also appear to play a significant role in the increasing emphasis on the importance of factors other than material deprivation on variations in health across social classes (Wilkinson 1996, Marmot 2004). Yet, large relative inequalities in mortality health among British civil servants should be expected simply because mortality tends to be within that group. This has gone unrecognized.

Patterns of large relative differences in adverse outcomes among relatively healthy groups are commonly observed though rarely understood. Nine years ago, a landmark study in *The Lancet* surprised most observers by finding that, though more egalitarian than most western European countries, Sweden and Norway appeared to have among the largest socioeconomic inequalities in mortality – measured in relative terms – in western Europe (Mackenbach *et al.* 1997). But that large relative inequalities in mortality rates were to be expected in these countries because mortality is generally low there went unrecognized (Scanlan 2006a, 2006b). Similarly that in the United States large racial differences in infant mortality rates (in relative terms) among better-educated groups has been a source of puzzlement (Schoendorf *et al.* 1992, Singh *et al.* 1995) without recognition that such pattern is a consequence of the low infant mortality rates among the better educated (Scanlan 2000). The pattern of larger relative inequalities among the young than the old is simply another aspect of the same pattern.

Consistent with what other studies have observed in the general populations, the Whitehall studies also found that the relative difference in mortality rates between higher and lower graded civil servants declines with age, and this decline has been the subject of research and speculation. Marmot (1995) has argued that the absence of an increase in the gradient among older workers refutes the contention that poorer health leads to lower employment status rather than the reverse. Yet, given that, solely for statistical reasons, the social gradient would be expected to decline with age, the absence of an increase can not refute that contention. Similarly, however, that relative differences in survival rates increase with age would not support the contention, since that pattern, too, would be expected regardless of the validity of the contention.

Marang-van de Mheen *et al.* (2001) explored the impact of smoking, blood pressure, and plasma cholesterol in the decline in the relative risk of death at older ages in the Whitehall subjects, finding that only 20 percent of the decline was explained by these factors. But the study was undertaken without appreciation that the social gradient in mortality would be expected to be larger among the young (while the social gradient in survival rates would be expected to be greater among the old), simply because mortality was lower among the young. The Marang-van de Mheen article, however, did usefully set out the death rates by age group. Table 3 shows that, in fact, along with the declining relative difference in mortality rates with age, the relative difference in survival rates increase with age.

In any case, the small role of risk factors in explaining the decreasing relative difference in mortality rates with age is thus understandable. But the approach employed to determine that role is itself open to question for the failure to appreciate the tendencies described above. The study reached the conclusion regarding the 20 percent impact based on a comparison of the size of the adjustment for risk factors (*i.e.*, the degree to which risk factors reduced the relative difference) among the younger and older age groups. Yet it did so without appreciating that risk factors would be expected to increase mortality more among the young than the old (as discussed in note 5). Correspondingly, the adjustment effected by accounting for risk factors would be expected to be larger among the young than the old. The underlying data, however, would likely show that adjustments for risk factors would account for more of the relative difference in survival among the old than the young. [See Addendum, item 2.]

Van Rossum *et al.* (2000) studied the extent to which the social gradient in mortality observed in the Whitehall studies applied to most causes of death, finding that it did. In doing so, however, the authors drew a number of inferences that warrant rethinking when one appreciates the tendencies described above. The authors concluded that the social gradient could not be solely a function of risk factors, because relative differences in mortality were even greater among a group of low risk individuals. But given that mortality is lower among the low risk group, one would expect the social gradient in morality to be greater within the low risk group.[6]

The van Rossum study also found that the social gradient in mortality tended to be lower among the old than the young for most causes of mortality. Again, this is consistent with what one should expect, and it would be interesting to see differences in survival rates for the various causes. Failing to recognize near inevitability of the decline in the relative difference in mortality with age, however, the study offered three possible explanations for that decline. First, the authors suggested that the practical importance of employment grade might be diminished among retired employees. This is a plausible point and it is possible that risk distributions might therefore be closer among the retired employees than the active ones – thereby enhancing the effects of the tendency for relative mortality differences to be smaller among the older subjects (while mitigating the effects of the tendency for relative survival differences to be greater among the older subjects). It is also possible, however, that cumulative effect of the mechanisms underlying the gradient causes the distributions differ more among the retired than those still employed – though not enough to outweigh the statistical tendency for relative differences to be greater where mortality is lower.

Second, the authors suggested that selective removal of sick people would cause the older population to be relatively healthy. However, that the older population was a selectedly healthier group would, by reducing overall mortality, tend to increase the relative differences in mortality. Third, the authors suggested that the declining gradient may be related to the fact that inequalities are widening in recent decades and that in the future the future inequalities would increase among the old. Presumably the underlying thought was that the widening was being observed among the young and soon would be observed among the old. Yet, with declining mortality among both the old and the young, relative differences in mortality have increased among the old as well as the young. To the extent that the greater health enjoyed by the young (as reflecting in the decline in mortality among the young) leads to even greater decline in mortality in the future among the old, we should indeed see additional increases in relative differences in mortality (and declining differences in survival) among the old. But the mechanisms are not exactly what the authors envision.

In any case, even if some of the speculation as to ways certain factors might contribute to the decline might be entirely sound, it is unlikely the identified factors

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[6] Of course that a gradient was found among a group with no risk factors would be probative that risk factors do not alone account for the gradient. For example, a pattern found among persons who never smoked would be probative that smoking differences were not the sole cause of the social gradient in mortality in the total population. But the low risk group in the van Rossum study was defined by dichotomizing certain variables in a way that left the possibility that gradient within the low risk group was caused by unmeasured differences in risk factors within that group (which there were likely to be since there were differences in risk factors generally between higher-level and lower-level employees). The misunderstanding is akin to that observed in the study of mortgage rejection rate differences among black and white Americans. It has been observed that income differences (as opposed to discrimination) could not be the cause of relative differences in rejection rates since the relative differences were greatest among the highest income category. It was not appreciated that – whether caused by discrimination or differences in unmeasured factors – mortgage rejection rates would be expected to be greatest among the highest income group (where rejection rates were lowest) (Scanlan 2000). Differences in rates at which mortgages were granted, however, tended to be lower among such groups. Very likely the Whitehall data will show lower survival rate differences among the low risk Whitehall groups than among the entire study population.

are nearly as important as the overlooked factor – that the social gradient, as measured in relative differences in mortality, will almost invariably be greater where mortality is lower.

To date, no research on health inequalities in the United Kingdom appears to have recognized the tendency whereby the rarer an outcome, the greater the relative difference in experiencing it and the smaller the relative difference in avoiding it. However, last year the South East Public Health Observatory issued a handbook appearing to explicitly recognize the tendency (Carr-Hill and Chalmers-Dixon 2005). It failed, however, to explore all the implications of that recognition with respect to the varied measures discussed in the lengthy handbook. But the recognition is an important step in the right direction.[7]

C. Interpreting Changes in Light of Expected Patterns

So when, if ever, can we draw conclusions about the meaning of changes in relative susceptibility to mortality or survival, given that we cannot effectively observe the risk distributions of the groups being compared? When the rate of experiencing an adverse outcome is increasing for one group, while that rate is declining for another group, the discussion above, as well as common sense, suggests that such change would be a meaningful one. But such situations are likely to be relatively uncommon in any case and extremely uncommon when the change in either direction is substantial.

According to the tendencies described above, during a period when an outcome is generally declining the relative difference in rates of experiencing it should increase and the relative difference in rates of avoiding it should decline. Hence, in theory, if both the relative difference in the adverse outcome and the relative difference in the favorable outcome are increasing, that would suggest a true worsening of the status of the disadvantaged group (with the opposite interpretation when both differences are declining). Also, in circumstances where the absolute difference does not decline when a relatively rare outcome is declining, that would seem to suggest a true worsening of the status of the disadvantaged group. More broadly, we might interpret any departure from an expected pattern to reflect a meaningful change in the relative well-being of the disadvantaged group, either for better or for worse.

But there are difficulties with such interpretations. For example, the discussion above suggests that a decline in the relative difference in experiencing an adverse outcome during a period when an outcome was declining would tend to indicate a genuine improvement in the relative well-being of the disadvantaged group. But consider a relatively rare outcome like infant mortality. As infant mortality rates have continued to decline in recent decades in the developed world, racial and

[7] In the United States, last year the National Center for Health Statistics (NCHS) issued a major report on the measurement of health inequalities, in which it recognized that changes in health inequalities might be interpreted differently depending on whether one examines the adverse or the favorable outcome (Keppel *et al.* 2005). The report, however, merely recommended that all inequalities be measured in terms of adverse outcomes. It neither acknowledged nor attempted to address the implications of either the tendency for the sizes of inequalities in adverse and favorable outcomes to move systematically in opposite directions as the prevalence of an outcome changes or the crucial tendency for the size of the relative difference in experiencing an adverse outcome to increase as the outcome grows less prevalent. See also the further defense of the focus solely on adverse outcomes in Keppel and Pearcy (2005), my response in Scanlan (2006), and the authors' rejoinder in Keppel and Pearcy (2006).

socioeconomic inequalities have increased (CDC 2002, Frisbie *et al.* 2004, Gisselmann 2005). But in some cases, infant mortality rates among advantaged groups have approached a level where they may not be significantly lowered regardless of the quality of medical care and the favorableness of other conditions surrounding a birth. In Sweden, for example, a recent study showed that, following a continuing pattern of declines in mortality for infants born to mothers with both lower and higher education, the rate during the 1985-90 period examined had reached 6.3 deaths per thousand live births for mothers with lower education, while the rate for mothers with higher education had reached 3.9, and the relative risk had risen to 1.62 (Gisselmann 2005). The most recent Swedish data show the overall infant mortality rate to be just under 3 deaths per thousand live births. Suppose that regardless of the favorableness of conditions surrounding births, the rate cannot reasonably be reduced below 1 death per thousand live births. Suppose also that at the point where the infant mortality rate for the higher educated group reached 2.0, the rate for the lower educated group reached 3.0. The relative risk would be 1.5, down from the 1.62 in 1985-90. Yet underlying the relative risk of 1.5 would be a relative risk of reasonably avoidable mortality of 2.0 ((3.0 minus 1.0, or 2.0) over (2.0 minus 1.0, or 1.0)), while underlying the relative risk of 1.62 in 1985-90 would be a relative risk of reasonably avoidable mortality of 1.8 ((6.3 minus 1.0, or 5.2) over (3.9 minus 1.0, or 2.9)). Thus, it might be a mistake to regard the seeming reduction in relative risk as reflecting a meaningful improvement in the relative health of infants born to mothers with lower education.

It may initially seem that considerations regarding absolute minimums would be limited to situations like infant mortality where rates like the Swedish rate of 3 deaths per thousand facially seem extremely low. Yet among the older population, which is responsible for a substantial part of overall mortality, it would seem that a significant part of a 10% yearly mortality rate is not reasonably avoidable. Hence, considerations concerning irreducible minimums may have a role even in the interpretation of patterns in situations where the possibility of an irreducible minimum is less apparent. And whether or not the existence of irreducible minimums is the best way to conceptualize the matter, it is evident that mortality rates can decline to a point where it becomes increasingly difficult to achieve progress in additional reductions, allowing groups not yet to that level an opportunity to gain ground vis-à-vis relative mortality. The point is that such circumstances, like others described above, are simply the natural consequences of declining mortality and ought not to be mistaken for a change in the relative situation of two groups that is not such a consequence.

Further, the age standardized mortality rates we observe in studies are typically composites from subpopulations among which the overall mortality rates may vary substantially. At a minimum, the overall rates vary from quite low rates among young subpopulations to sometimes quite high rates among older subpopulations. Thus, for example, in times of declining mortality, among both the younger subpopulations and the older subpopulations, the patterns of changing inequalities may be exactly as would be expected; yet the composite age-standardized result may show a departure from those patterns.

An additional word is warranted on absolute differences. While Figure 4 might suggest that when relatively low mortality rates are declining further, an increase in the absolute difference, being contrary to the usual pattern, would suggest a genuine worsening of the relative situation of the disadvantaged group. In addition to the factor noted in the preceding paragraph, however, one needs to recognize that seemingly low overall mortality rates even among the relatively old are functions of the convention of reporting yearly rates. For example, a yearly mortality rate of 8%

for the 75-to-84 year-old group might seem in the range where we should expect that, in times of declining mortality in the age group, absolute differences would ordinarily behave in the manner we see around Points L and M in Table 1 and Figure 4. Yet the fact is that 80% of the age group will be dying during a ten-year period. Hence, the expectation of the types of changes we observe in the area of Points D to G may be more warranted. In sum, while one must understand the usual patterns of change of the various measures of inequalities in order not to be misled by them, it is also necessary to exercise considerable caution in order to avoid misinterpreting departures from the usual patterns.

D. Morbidity

Morbidity requires a few paragraphs of separate treatment. To the extent that the study of morbidity involves acute conditions, the observed patterns will be much the same as with mortality. And inasmuch as most, though not all, acute conditions have tended to decline in the same way that mortality has declined, the expectation would be that relative differences in acute morbidity rates will have been increasing.

But inequalities in morbidity are frequently studied in terms of self-assessments of general health and whether one has long-term limiting conditions. Such studies raise a number of additional issues. First, in contrast to the generally consistent decline in overall mortality rates, the overall rates of self-assessments of poor health and having long-term limiting conditions frequently have been stable or increasing. Such factor likely accounts for a significant part of the view that, in contrast to consistently increasing inequality in mortality, there has not been a consistent pattern of increasing inequalities in morbidity. Indeed, typically in the United Kingdom and elsewhere studies finding no increase in relative inequalities in health tend to be studies of self-assessed health (Ferrie *et al.* 2002, Dahl *et al.* 2001, Lissau *et al.* 2001, Lundberg *et al.* 2001, Manderbacka *et al.* 2001, Westert *et al.* 2005).[8] A recent study of morbidity in England and Wales found that in the situation where an outcome was generally declining – permanent sickness rates among men – inequalities had increased; but in the three situations where an outcome was generally increasing – permanent sickness among women and limiting long term illness among men and women –inequalities had decreased (Adams et al. 2006).

Second, studies of self assessments of general health usually examine responses to surveys that allow one to indicate whether his or her health falls into five categories (“very good,” “good,” “neither good nor bad,” “poor,” or “very poor”), with the results dichotomized such that the last three categories would be deemed “less than good” health (Dahl *et al.* 2001, Lissau *et al.* 2001, Manderbacka *et al.* 2001, Khang *et al.* 2004, Westert *et al.* 2005). But studies also use other approaches to phrasing, number of total categories, and number of categories deemed to reflect less than good health (Lundberg *et al.* 2001, Krokstad *et al.*, 2002, Ferrie *et al.* 2002). The different approaches will cause different proportions of the total population to be deemed to have less than good health, which would tend also to yield different relative (and absolute) inequalities for reasons unrelated to any actual differences in the nature of the inequalities.

Third, relative differences in morbidity seem almost invariably to be presented in terms of odds ratios. This is often the case for the presentation of inequalities in mortality rates as well. Mortality rates, however, tend to be presented in terms where

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[8] In the United States, dramatic increases in obesity have been accompanied by dramatic declines in socioeconomic differences in rates of obesity (Zhang and Wang 2004).

the rates are low enough that odds ratios approximate relative risks. Rates of less than good health, however, sometimes cover a substantial part of the population. In such circumstances, apart from the fact that odds ratios will often be considerably higher than relative risks, it is difficult even to know the expected direction of odds ratio changes solely as a consequence of increases or decreases in the prevalence of the outcome.[9] Thus, interpreting changing inequalities in self-assessed health is even more difficult than interpreting changing inequalities in mortality.

Ferrie *et al.* (2002) explored non-acute morbidity among the Whitehall study group, measuring changes over time in differences in factors like self-rated health less than good (measured in odds ratios) and systolic blood pressure (measured in rate differences). The study found the differences to be stable with some indication of a tendency to widen. Unfortunately the study presented prevalence rates only for the middle of the three points in time being examined, thus precluding the reader to determine whether prevalences were increasing or decreasing. Thus one cannot evaluate the implications of changes in prevalence.

But the approach employed by the authors for measuring changes in differences in factors like average blood pressure level does suggest possibilities for measuring changes in certain aspect of health inequality that might not be affected by changes in prevalence. It would seem, however, that such determination should be based on a comparison of the effects sizes of the difference at the points in time being compared (*i.e.*, the difference between averages divided by the pooled standard deviation) rather than the difference itself. Such an approach might also be applied to self-assessed health if the assessment were made using a continuous measure rather than the categorical measures typically employed.[10]

That is not to suggest that such approaches will prove to be entirely satisfactory or that devoting substantial resources to such studies will necessarily prove to be worthwhile. The key consideration, however, is that, in order to be of any real value, studies of the changing nature of health inequalities must be approached with an eye toward identifying changes that are not simply the consequences of a change in the prevalence of an outcome. The measures presently used seem ill-suited to that end. And, as matters now stand, substantial resources continue to be devoted to study of health inequalities without even consideration of the impact of changes in prevalence upon these measures.[11]

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[9] Kunst *et al.* (2005) studied changes between the 1980s and 1990s in socioeconomic differences in self-assessed health less than good in 10 European countries using odds ratios as the measure. It found education-related differences generally to remain stable and income-related differences to increase. The main aspect warranting note here is that for men in Great Britain, where the self-assessed health less than good was increasing for all income levels, in accordance with the described tendency, the relative difference between the rates of the lowest and highest income groups declined; but the odds ratio increased. Neither change was substantial, however.

[10] Among seemingly similar approaches that do not rely on self-assessment would be comparisons on scores on risk indexes, such as that used in Osler (2000). Yet, whether one smokes would seem a crucial element of any such index, and, as with other binary criteria, the difference in rates among groups would be affected by the prevalence, implicating the problematic issues addressed above.

[11] Some journals publish studies of health inequalities at least once month. Recent examples, where my on-line responses raised issues with the failure to consider the implications of changes in prevalence as they pertain to the particular setting, include: Ananth *et al.* 2005 (response at http://www.ajph.org/cgi/eletters/95/12/2213), Pickett *et al.* 2005 (response at http://www.ajph.org/cgi/eletters/95/11/1976), Satcher *et al.* 2005 (response at

ADDENDUM
(Sep. 5, 2007)

Below are several additional points regarding the paper "The Misinterpretation of Health Inequalities in the United Kingdom." The second is simply a correction of a conceptual error. Inasmuch as I circulated the paper fairly widely, it seemed a better course to leave the paper in its present form (save for references to points in this Addendum) rather than to correct the point in the paper itself.

1. The paper describes that way absolute differences between the rates at which two groups experience or avoid some outcome tend to be small when an outcome is rare, grow larger as the outcome becomes more common, then grow small again as the outcome becomes rare. It also describes the opposite pattern for differences measured in terms of odds ratios. But it fails to note an important point that can be derived from a close examination of Table 1 or figures 1 through 4. Such point is that, in the case of these normal distributions, the high point of the absolute difference and the low point of the difference measured in odds ratios both correspond with the intersection of (a) the ratio of the advantaged group's rate of experiencing the favorable outcome to the disadvantaged group's rate of experiencing that outcome and (b) the ratio of the disadvantaged group's rate of experiencing the opposite outcome to the advantaged group's rate of experiencing that outcome. Understanding this pattern is important to interpreting changes in absolute differences and odds ratios in different circumstances (though more so in the former case since the pattern tends to hold more strongly for absolute differences than for odds ratios when distributions depart from the normal.). This issue is the subject of a number of extensive on-line comments on journal articles, including:

a. Effects of choice measure on determination of whether health care disparities are increasing or decreasing. *Journal Review* May 1, 2007, responding to Trivedi AN, Zaslavsky AM, Schneider EC, Ayanian JZ. Trends in the quality of care and racial disparities in Medicare managed care. N Engl J Med 2005;353:692-700 (and several other articles in the same issue):

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http://content.healthaffairs.org/cgi/eletters/24/2/459#720), Shaw *et al.* 2005 (response at http://jech.bmjjournals.com/cgi/eletters/59/8/638?ck=nck#347), Geronimus 2006 (response at http://www.ajph.org/cgi/eletters/96/5/826), Regidor *et al.* 2006 (response at http://www.ajph.org/cgi/eletters/96/1/102), Low and Low 2006 (responses (two) at http://bmj.bmjjournals.com/cgi/eletters/332/7547/967), Adams *et al.* 2006 (response at http://jech.bmjjournals.com/cgi/eletters/60/3/218), Lynch *et al.* 2006 (response at http://jech.bmjjournals.com/cgi/eletters/60/5/436), Wilkinson and Pickett 2006 (response at http://www.thelancet.com/journals/lancet/article/PIIS0140673606684894/comments?action=view&totalComments=1), Edwards *et al.* 2006 (response at http://bmj.bmjjournals.com/cgi/eletters/333/7559/119), Ickes *et al.* 2006 (response at http://www.ajph.org/cgi/eletters/AJPH.2005.063339v1), Kaplan and Kronick 2006 (response at http://jech.bmjjournals.com/cgi/eletters/60/9/760). [See Addendum, item 3.]

http://www.journalreview.org/view_pubmed_article.php?pmid=16107620&webenv=00P_2r_lHBKZPkExnEkCR_j5-u8waNcJ-87aLnoSJWxvN_ljFKstOR3CAx%402B600907661FF950_0034SID&qkey=1&rescnt=2&retstart=0&q=%22vaccarino+v%22+%22rathore+ss%22

b. Understanding the ways improvements in quality affect different measures of disparities in healthcare outcomes regardless of meaningful changes in the relationships between two groups' distributions of factors associated with the outcome. Journal Review Aug. 30, 2007, responding to Sequist TD, Adams AS, Zhang F, Ross-Degnan D, Ayanian JZ. The effect of quality improvement on racial disparities in diabetes care. Arch Intern Med. 2006;166:675-681: http://www.journalreview.org/view_pubmed_article.php?pmid=16567608&specialty_id=

c. Understanding patterns of correlations between plan quality and different measures of healthcare disparities. *Journal Review* Aug. 30, 2007, responding to Trivedi AN, Zaslavsky AM, Schneider EC, Ayanian JZ. Relationship between quality of care and racial disparities in Medicare health plans. JAMA 2006;296:1998-2004: http://www.journalreview.org/view_pubmed_article.php?pmid=17062863&specialty_id=

2. At page 11, in discussing the treatment of Marang-van de Mheen et al. (2001) of the role of risk factors in explaining the seeming decline in the social gradient in health among the older Whitehall population, the paper points states that Marang-van de Mheen failed to appreciate that risk factors would be expected to increase mortality more among the young than the old. It then states:

> Correspondingly, the adjustment effected by accounting for risk factors would be expected to be larger ang the young than the old. The underlying data, however, would likely show that adjustments for risk factors would account for more of the relative difference in survival among the old than the young.

While it is correct that risk factors should increase mortality more among the young than the old, I do not presently see why the risk factors would effect a greater adjustment to social differences in mortality among the young than the old (or the greater adjustment to social differences in survival among the old than the young). I do not mean to say that the point is necessarily correct. I simply do not at this time understand what basis I may have had for making the point.

3. Note 15 lists and provides links to 14 on-line responses to articles in medical or health policy journals that implicated issues addressed in this paper. As of September 5, 2007, an additional 26 responses were posted.

Links to all on-line responses may be found in Section D of this web page: http://www.jpscanlan.com/homepage/measuringhlthdisp.html

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Tables and Figures

Table 1 *Illustration of Relationships of Rates of Falling Below and Above 15 Points for Two Groups with Normal Distributions with Half a Standard Deviation Difference between Means.*

Cut Point	(1)AG Fail%	(2)DG Fail%	(3)Ratio DGF%/ AGFail%	(4)AG Pass%	(5)DG Pass%	(6)Ratio AGP%/ DGP	(7)Odds Ratio	(8)Abs Diff
A	99.00	99.76	1.01	1.00	0.24	4.24	4.27	0.78
B	97.00	99.13	1.02	3.00	0.87	3.47	3.55	2.14
C	95.00	98.38	1.04	5.00	1.62	3.12	3.23	3.43
D	90.00	96.25	1.07	10.00	3.75	2.67	2.86	6.27
E	80.00	90.99	1.14	20.00	9.01	2.22	2.53	11.03
F	70.00	84.61	1.21	30.00	15.39	1.96	2.37	14.77
G	60.00	77.34	1.29	40.00	22.66	1.77	2.29	17.47
H	50.00	69.15	1.38	50.00	30.85	1.62	2.24	19.15
I	40.00	59.48	1.48	60.00	40.52	1.48	2.19	19.36
J	30.00	49.20	1.63	70.00	50.80	1.37	2.24	19.05
K	20.00	36.69	1.83	80.00	63.31	1.26	2.31	16.65
L	10.00	21.77	2.17	90.00	78.23	1.15	2.50	11.74
M	5.00	12.71	2.52	95.00	87.29	1.09	2.74	7.66
N	3.00	8.38	2.79	97.00	91.62	1.06	2.95	5.37
O	1.00	3.44	3.38	99.00	96.56	1.03	3.47	2.42

Table *2 Illustration of Changes in Longevity Differences Between Two Groups Where Falling Below Each Cutoff Represents Dying at 70 While Falling Above the Point Represents Dying at Age 80, Based on Patterns Reflected in Table 1..*

Cut Points	DG Longevity	AG Longevity	LongevityDiff	AG/DGLongevityRatio
A	60.03	60.20	0.17	1.00
B	60.10	60.60	0.50	1.01
C	60.19	61.00	0.81	1.01
D	60.48	62.00	1.52	1.03
E	61.24	64.00	2.76	1.05
F	62.22	66.00	3.78	1.06
G	63.42	68.00	4.58	1.07
I	66.60	72.00	5.40	1.08
J	68.65	74.00	5.35	1.08
K	71.11	76.00	4.89	1.07
L	74.38	78.00	3.62	1.05
M	76.53	79.00	2.47	1.03
N	77.62	79.40	1.78	1.02
O	78.95	79.80	0.85	1.01

Table 3 *Mortality Rates of Highest and Lowest Occupational Groups in Whitehall Study, Relative Differences in Mortality Rates and Survival Rates of Between Highest and Lowest Occupations Groups in Whitehall in Terms of Ratio of Mortality Rate of Lowest to Highest and Ratio of Survival Rates of Highest to Lowest.*

Age	HighestGroupMortRate	LowestGroupMortRate	Low/HighMortRatio	High/LowSurvRatio
55-59	6.80	13.90	2.05	1.007
60-64	11.30	19.90	1.76	1.009
65-69	17.50	28.10	1.61	1.011
70-74	30.90	47.50	1.54	1.017
75-79	50.60	70.00	1.38	1.021
80-84	78.30	107.60	1.38	1.033
85-89	144.30	181.60	1.26	1.046

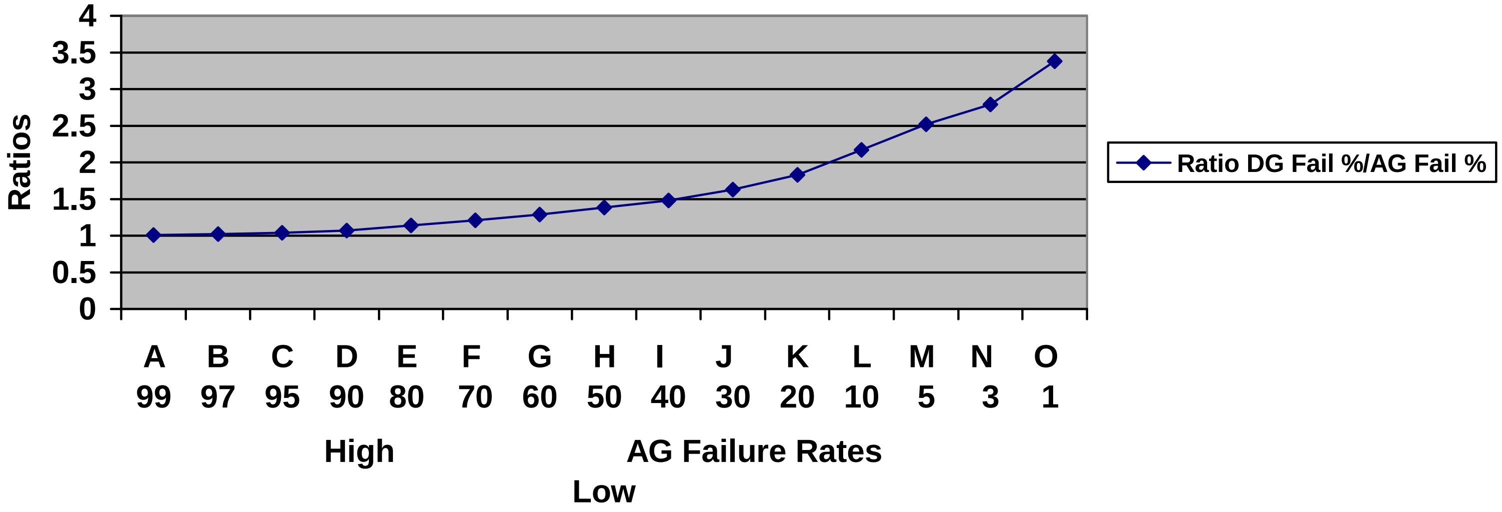

Figure 1 *Ratio of Disadvantaged Group (DG) Pass Rate to Advantaged Group (AG) at Various Cutoff Points (based on data in Table 1)*

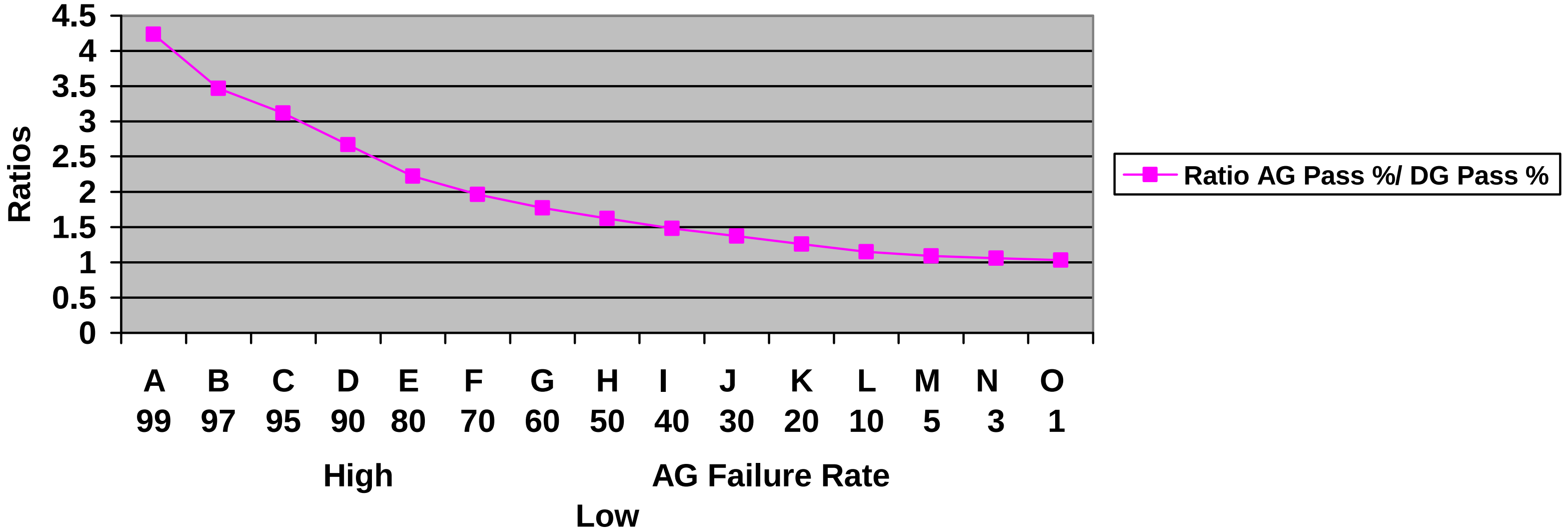

Figure 2 *Ratio of Advantaged Group (AG) Pass Rate to Disadvantaged Group (DG) Pass Rate at Various Cut Point (based on data in Table 1)*

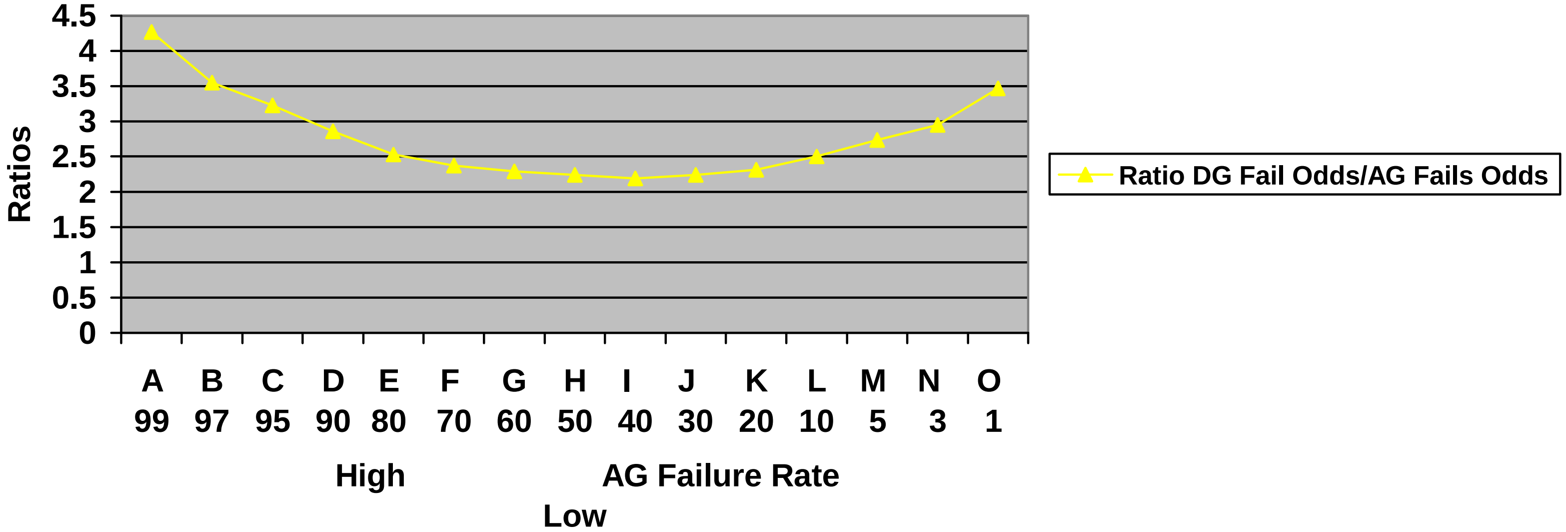

Figure 3 *Ratio of Disadvantaged Group (DG) Odds of Failure to Advantaged Group (AG) Odds of Failure ((based on data in Table 1)*

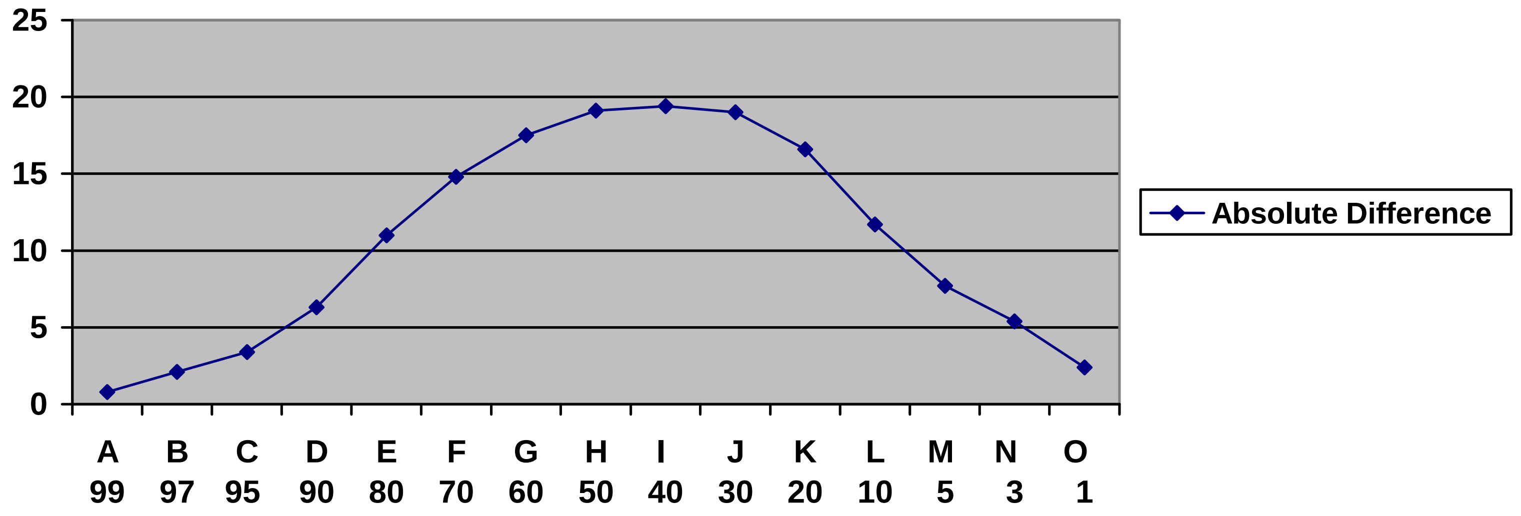

Figure 4 *Absolute Difference Between the Failure (and Pass) Rates of Advantaged Group (AG) and Disadvantaged Group (DG)(based on data in Table 1)*