# The Relationship Between Declining Mortality and Increasing Racial and Socioeconomic Disparities in Mortality

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Some years ago, it was noted with considerable alarm that in 1983 the disparity between black and white infant mortality rates was at its highest point in history. [1,2,3] That year, the ratio of the black infant mortality rate to the white infant mortality rate reached 1.98, up from 1.68 in 1940. [3] By 1990, in the face of continuing declines in overall infant mortality rates, the ratio had risen to 2.07. [4]

Recently, a study appearing in the *New England Journal of Medicine* found that the gap between black and white infant mortality rates persists even at higher socioeconomic levels. [5] Where both parents are college-educated, the disparity between black and white infant mortality rates for the 1983-1985 period examined in the study was only slightly lower than that found in the nation at large. [3] With respect to low birthweight, a critical factor in infant mortality, the study found that among the college-educated the black rate was almost 2.3 times the white rate, and the black rate for very low birthweight was 3.1 times the white rate. These are actually larger disparities than found in the nation at large, especially in the case of very low birthweight. In 1985, for the entire United States population, the black rate of low birth weight was 2.2 times the white rate and the black rate of very low birth weight was 2.8 times the white rate. [3]

That racial disparities in low and very low birth weights (particularly the latter) were greater among low risk groups than high risk groups was previously noted in a 1987 study specifically focusing on the issue. [6] That study also found that racial disparities in low and very low birthweight rates had been increasing.

Such findings have been cited as reason for continuing research into the effects of race on mortality. [6,7,8] Continuing research in this area may be warranted for a variety of reasons. But that research is unlikely to prove very useful unless pursued with an understanding that there is nothing remarkable about any of the findings just mentioned. They are, in fact, precisely what we ought to expect, and not necessarily something to be disturbed by. For, with respect to infant mortality and low birthweight, as well practically every other adverse circumstance disparately affecting black and white Americans, racial disparities can be expected almost invariably to increase as the conditions abate.

## Hypothetical Failure Rates

A simple hypothetical can illustrate why this is so. Imagine two demographic groups that differ in socioeconomic circumstances. With respect to a particular criterion or condition that is associated with socioeconomic status–say, test scores–let us divide Group A (the advantaged group) into three categories, with 30 percent in the High, 40 percent in the Middle, and 30 percent in the Low. Assuming that the test scores of both groups are more or less normally distributed and that Group D (the disadvantaged group) has substantially lower average test scores than Group A, we would expect to find members of Group D distributed among the three categories something like this: 10 percent in the High, 30 percent in the Middle, and 60 Percent in the low. To facilitate the discussion of these figures, I have set them out in Table 1 below.

[Table 1 goes here.]

Let us initially set the cutoff score at a point at which only the High Category passes. The failure

rate of Group D (90 percent) would be 1.29 times the failure rate of Group A (70 percent). Suppose we then lower the cutoff score to the point where only the Low Category fails. The failure rate for Group D would fall from 90 percent to 60 percent, a 33 percent reduction; and the failure rate of Group A would fall from 70 percent to 30 percent, a 57 percent reduction. Because the failure rate of Group D has fallen by a smaller proportion than the failure rate of Group A, the ratio of Group D's failure rate to that of Group A would rise, in this instance to 2.00.

On the other hand, if we raised the cutoff again to the point where only the High Category passed, the failure rate of Group A would have a larger proportionate increase (133 percent–i.e., from 30 to 70)–than the failure rate of Group D (50 percent–i.e., from 60 to 90), with the failure rate ratio falling to the original point.

The same increase in the ratio of failure rates observed when the cutoff was lowered would, of course, occur if instead of lowering cutoff scores, we were to improve education sufficiently that everyone originally scoring in the Middle Category is enabled to pass the test at the original cutoff point. An increase in the disparity between failure rates would even occur if Group D disproportionately benefited from the improvements in education in the sense that all members of Group D originally scoring in the Middle Category were enabled to pass the test while as few as three-fifths of the members of Group A originally scoring in the Middle Category were enabled to pass the test.

### Poverty Rates

The same tendency, as well as its universality, is reflected in census data on income and poverty. In 1990, 31.9 percent of blacks compared with 10.7 percent of whites fell below the poverty line, while 14.4 percent of blacks compared with 3.8 percent of whites fell below 50 percent of the poverty line. [9] Thus, had poverty fallen such that only persons previously below 50 percent of the poverty line remained in poverty, the black poverty rate would have fallen only 55 percent compared with a 74 percent reduction for whites; and the ratio of the black poverty rate to the white

poverty rate would rise from 3.0 to 3.8. On the other hand, 39.0 percent of blacks compared with 14.8 percent of whites fell below 125 percent of the poverty line. So if, instead of falling, poverty was to rise sufficiently to pull everyone into poverty who had previously been between the poverty line and 125 percent of the poverty line, the black rate would rise to 39.0 percent while the white rate would rise to 14.8 percent; this would reduce the black-white ratio to 2.6.

And, as with the hypothetical illustration of test scores, circumstances could also arise that would cause the ratio of the black poverty rate to the white poverty rate to increase even though blacks had benefited disproportionately from reductions in poverty. For example, if all blacks between the poverty line and 50 percent of the poverty line were lifted from poverty while only 90 percent of similarly situated whites were lifted from poverty, the ratio of the black poverty rate to the white poverty rates still would increase. Conversely, in the case of an increase in poverty, a higher proportion of blacks than whites with incomes between the poverty line and 125 percent of the poverty could be pulled into poverty with the black-white poverty ratio nevertheless declining.

These tendencies apply as well to racial differences in mortality, with the factors that are associated with susceptibility to mortality for both blacks and whites–like test scores and income and most other things–being more or less normally distributed for each racial group, though with the susceptibility for most conditions being somewhat greater for blacks. Thus, as advances in medical science and other factors related to improved health increasingly restrict mortality to the most susceptible segments of the population, the ratio of black to white mortality rates will tend to increase.

In 1983, when the ratio of black to white infant mortality reached its highest point in history, the infant mortality rates for both blacks and whites, at 19.2 and 9.7 deaths per thousand live births, [3] each reached its lowest point ever. This fact was overlooked, however. Also overlooked were the facts that both the black and white infant mortality rates had declined every year for the preceding two decades, and that in eight of the preceding ten

years those declines had been accompanied by an increase in the ratio of black to white infant mortality.

## Survival Rates

Another important aspect of changes like these is commonly overlooked as well. When a condition abates, the disparity between rates at which two groups manage to escape the condition tends to decline. Looking to the hypothetical testing data set out earlier, we observe that when the cutoff score was lowered, Group D's pass rate rose from 10 percent to 40 percent, a 300 percent increase, while Group A's pass rate rose from 30 percent to 70 percent, a 133 percent increase. Thus, the lowering of the cutoff would cause Group D's pass rate to rise from 37 percent of the pass rate for Group A (10 over 30) to 57 percent of the pass rate for Group A (40 over 70). This is why the lowering of cutoff scores is universally regarded as a way of moderating the discriminatory effect of tests that disadvantages minorities or women, [10] even though the lowering of a cutoff increases the disparity in failure rates.

Similarly, were poverty to decline such that only persons below 50 percent of the current poverty line remained in poverty, the rate at which blacks are able to avoid poverty as a percentage of the rate whites are able to avoid poverty would rise from 76 percent (68.1 over 89.3) to 89 percent (85.6 over 96.2). And, when black and white infant mortality rates reached their lowest points to that time in history, the disparity between the survival rates for black and white infants also reached its lowest point ever, with the black survival rate (98.1 percent) reaching 99.0 percent of the white survival rate (99.0 percent). By 1990, the survival ratio had reached 99.1 percent. [4]

## Odds Ratio

The lack of symmetry between disparities in success rates and failure rates, whether in test performance or susceptibility to an undesirable condition, has caused statisticians sometimes to present disparities in terms of odds ratios–i.e., the ratio of one group's success (or failure) rate divided by its failure (or success) rate to the other group's success (or failure) rate divided its failure (or success) rate. Odds ratios have the advantage of yielding the same proportionate disparity whether one examines success rates or failure rates. [11,12] That is, the ratio of Group D's odds of failing a test to Group A's odds of failing a test is the same as the ratio of Group A's odds of passing a test to Group D's odds of passing the test; or, alternatively, the ratio of Group D's odds of failing a test to Group A's odds of failing a test is the reciprocal of the ratio of Group A's odds of passing a test to Group D's odds of passing the test. Odds ratios are also attractive to researchers because the coefficient of the variable of principal interest yielded by a logistic regression analysis can be readily translated into an odds multiplier, of which the coefficient is the natural logarithm. [11,13,14] Another appealing feature of the odds ratio is that odds ratios will yield the same result for prospective and retrospective studies. [11,14]

It is not clear whether those who have favored the use of the odds ratio because of the lack of symmetry between disparities in success rates and failure rates have also appreciated that the two disparities vary inversely when cutoffs are raised or lowered (or when a condition abates or worsens). In any event, a recent example of the use of the odds ratios in contexts other than in appraising disparities in tests scores may be found in the National Research Council's extensive 1989 study of the status of black Americans, A Common Destiny: Blacks and American Society [15], where odds ratios were employed for measuring changing racial disparities in poverty rates, unemployment rates, and infant mortality rates.

At first sight, odds ratios might appear to offer a way of accounting for the fact that when a cutoff score is lowered (or a condition abates) disparities between success rates change in the opposite direction from disparities in failure rates. Yet, if odds ratios effectively dealt with such changes in the sense of being able to distinguish true changes in the relative status of two groups from across-the-board changes in the prevalence of the condition, we would expect odds ratios not to change when cutoffs are raised or lowered. Even

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when distributions are perfectly normal, however, this does not happen. For example, in the case of two normal distributions of tests scores where the means differ by one standard deviation, the ratio of the odds of passing tends to be very high when a cutoff is set very high, is reduced considerably when the cutoff is lowered toward the mean of the higher-scoring group, and grows high again when the cutoff is set very low. In the case of a reduction in poverty whereby all persons between the poverty line and 50 percent of the poverty line in 1990 are lifted from poverty, the ratio of the black odds of being in poverty to the white odds of being in poverty would rise from 3.9 to 4.2, despite the fact that there was no true change in the relative status of the blacks and whites.

Just how the relative odds will be affected by a particular modification of a passing score or change in the prevalence of a condition will also depend on the degree of difference between the distributions of the two groups being contrasted. For the hypothetical distributions in Table 1, lowering the cutoff from the point where only the High Category passed to the point where only the Low Category failed would cause the ratio of Group A's odds of passing to Group D's odds of passing to decline from 3.86 to 3.49; the same type of modification carried out with respect to the more similar distributions in Table 2 (which we shall turn to shortly) would cause that odds ratio to rise from 1.72 to 2.33.

In the case of epidemiological studies, where odds ratios are probably more commonly used than anywhere else, because different groups' chances of survival usually are both high are relatively close, odds ratios generally differ little from the simple ratios of mortality rates. [11,14,16] In fact, the odds ratio was originally proposed simply as a convenient way of approximating relative risks. [12,14] Thus, in epidemiological contexts, the use of odds ratios merely causes racial differences to appear slightly larger than they would seem using simple ratios of either pass rates or failure rates, though also causing the changes in the disparities that occur because of changes in the prevalence of the condition to be somewhat smaller. But odds ratios

are no more useful than simple ratios of rates for identifying whether seeming changes in racial disparities reflect anything other than the (mathematically) natural consequences of the abatement of the condition. And, in situations where chances that the studied event will occur are high enough that the odds ratio no longer approximates relative risk, odds ratios are even less interpretable, and hence less useful, than relative risk.

## Absolute Differences

For a variety of reasons, some commentators and researchers have avoided either ratios of rates or odds ratios, preferring absolute differences in rates, which are the same whether one focuses on success or failure. [17,18] But the same properties of normal distributions that can render the focus upon ratios of rates or odds ratios so misleading raise as serious problems in the case of absolute differences. Consider appraisals of disparities in test performance, for example, an area where a leading treatise on the use of statistics to prove discrimination has strongly argued for focusing upon absolute differences. [17]. As earlier suggested with regard to the scenario reflected in Table 1, a court might require the lowering of the cutoff in order to achieve what the law would regard as a reduction in the discriminatory effect of the test on Group D. Yet, by lowering the cutoff to the point where only the low category fails, the absolute difference in pass (or failure) rates would increase from 20 points to 30 points making the use of the lower cutoff more discriminatory according to that measure.

The focus upon absolute differences is especially problematic in situations where the cutoff point distinguishing success from failure may be anywhere in the overall distribution. Consider again a situation where there exists a difference of one standard deviation between the scores of two groups on a test. If the cutoff is set at a point where less than five percent of the higher-scoring group would pass the test, the lower-scoring group would be almost totally excluded; yet an absolute difference in pass (or failure) rates of under 5 points might be deemed trivial. But as the cutoff score is lowered, thereby

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diminishing the discriminatory effect from the traditional perspective, the absolute difference rises until it reaches a peak of about 37 points near the place where 70 percent of the higher-scoring group passes; the difference then starts to decline until it approaches zero at the point where almost all members of both groups pass.

In dealing with matters like poverty and mortality rates, we are generally concerned with areas of the two distributions where the absolute disparity would be expected to decline even when there has not been a true change in the relative status of two groups. For example, in the situation mentioned earlier whereby all blacks and whites between the poverty line and 50 percent of the poverty line are able to escape poverty, the absolute difference in poverty rates would decline from 21.2 percentage points to 10.6 percentage points, as the black rate falls 17.5 points (from 31.9 percent to 14.4 percent) while the white rate falls only 6.9 points (from 10.7 percent to 3.8 percent). It would make little sense, however, to maintain that blacks had improved their relative condition if, while the white rate fell 6.9 points, the black rate had dropped, say, 8 points.

Similarly, between 1970 and 1990 the black infant mortality rate declined by 15 deaths per thousand (from 32.6 to 17.6), while the white rate declined by 9.3 deaths per thousand (from 17.8 to 8.5), [3,4] with the black-white ratio increasing from 1.83 to 2.09. I have already explained why it is not possible to determine whether the increase in that ratio indicates a true decline in the relative health of black infants and that such increase is not necessarily inconsistent with an improvement in the relative health of black infants. But it seems very doubtful that if the black rate had declined by only 10 deaths per thousand live births, compared with a decline of 9.3 deaths for whites, this would provide a basis for inferring an improvement in the relative condition of blacks even though the focus upon the absolute difference would yield such a conclusion.

For essentially the same reasons, approaches to measuring difference, such as "relative absolute difference," [19,20] that blend absolute differences with other factors, while frequently useful for other purposes, do not provide an adequate basis for meaningfully evaluating the size of two disparities or determining whether changing disparities reflect true changes in the relative status of two groups.

## True Changes

In referring to "true changes" in the relative status of two groups, I have meant to indicate something other than the natural consequences of the modification of a cutoff point or a general decline in the prevalence of a condition. For example, when poverty declines such that all blacks and whites between the poverty line and 50 percent of the poverty line are raised from poverty, this would not, by my usage, be termed a true change in the relative poverty-proneness of blacks and whites even though the ratio of the black poverty rate to the white poverty rate would increase.

Some might argue that the increase in this ratio must be regarded as reflecting some true change in relative poverty status of blacks and whites, an argument that would apply as well in the case of increases in the black-white infant mortality ratio when there occurs an overall decline in infant mortality. Such arguments, of course, must somehow contend with the fact of the opposite change in disparities in rates of avoiding the condition. But my principal response is that the argument misses the importance of distinguishing between the changes just mentioned and those changes that I too would call true changes. Thus, whatever its merit in some abstract sense, the claim that the former changes constitute true changes in the relative well-being of two groups merely obstructs efforts both to understand the significance of changing disparities in the rates at which two groups are affected by a condition and to understand the meaning of differences between the disparities in the rates at which two groups (e.g., blacks and whites) or sub-groups (e.g., college-educated blacks and whites) are affected by a condition.

It is also important, however, to understand that in those contexts where we endeavor to evaluate that meaning of differences for the purpose of addressing their causes, the claim that there occur

true changes whenever ratios change lacks even abstract validity. Consider, for example, the situation where we are seeking to determine whether an employer intentionally discriminates against a group of applicants of a particular race that happens to have a lower average level of qualifications relevant to the job in question. In order to attempt to determine whether the difference in average qualifications is large enough to account for an observed difference in selection rates, it will be critical to understand that the same difference in qualifications will, in a completely nondiscriminatory selection process, lead to larger disparities in selection rates when one in a hundred applicants is selected than when one in ten applicants is selected. It is true that in circumstances where the difference in qualifications does account for the selection disparities whatever the applicant-to-hire ratio, it may be meaningful to point out that members of the less-qualified group have a greater relative chance of selection where the applicant-to-hire ratio is lower, for this is a matter that is of genuine significance to the well-being of the less-qualified group. But it nevertheless is a matter irrelevant to the appraisal of whether the employer is intentionally discriminating against the less-qualified group.

The same considerations apply when we endeavor to isolate the causes of group differences in medical treatments or outcomes and when we attempt to appraise the efficacy of efforts to address those causes.

### College-Educated Parents

Now let us consider the study of differences between the mortality rates of infants born to black and white college-educated parents. College-educated blacks and whites are much more alike than blacks and whites in general (though not completely alike) with respect to the circumstances that affect infant mortality. This tends toward narrowing the differences between both infant mortality rates and infant survival rates. At the same time, however, infant mortality is much less common where parents are college educated. This tends toward increasing disparities in mortality rates and reducing them in survival

rates.

Returning to the hypothetical data set out earlier, let us divide the college-educated members of Group A into three categories, again with 30 percent in the High, 40 percent in the Middle, and 30 percent in the Low. We might then expect the college-educated members of Group D to be divided among these three categories something like this: 20 percent in the High, 30 percent in the Middle, and 50 percent in the Low. These data are set out in Table 2 below.

[Table 2 goes here.]

Notice that if we set the cutoff so that only the High Category passes, the disparity between the failure rates is smaller for the college-educated groups than it was for the population at large when the cutoff for the larger population was also set at the point where only the High Category passed. Among the college-educated, Group D's failure rate (80 percent) would be 1.14 times the failure rate of Group A (70 percent), whereas that ratio was 1.29 for the larger population. Similarly, when we set the cutoff at the point where only the Low Category fails, the disparity between failure rates is smaller for the college-educated groups than it was for the population at large when the cutoff was set where only the Low Category of that population failed. Among the college-educated, Group D's failure rate (50 percent) would be 1.6 times the failure rate of Group A (30 percent), whereas that ratio was 2.00 for the larger population. Yet, when we grade both the larger population and the college-educated using a single cutoff, because a smaller proportion of the college-educated will fail the test, the disparity in failure rates among the college-educated could easily be greater than for the population at large. Such would be the case, for example, if only the Low Category of the college-educated failed the test while only the High Category of the population at large passed the test. In that event, the ratio of Group D's failure rate to the failure rate of Group A would be higher among the college-educated (1.66) than among the larger population (1.29).

The basic mathematical tendencies can again be illustrated by reference to income and poverty

data. Black and white married-couple families are much more alike than black and white female-headed families. In 1990, for married-couple families, the black median income was 84 percent of the white median income; for female-headed families, the black median income was only 62 percent of the white median income. [21] Nevertheless, because married-couple families are so much less likely to be poor than female-headed families–in 1990, 6.9 percent of married-couple families were poor compared with 37.2 percent of female-headed families–the racial disparity between poverty rates tends to be larger for married-couple families than for female-headed families. Among married couple families, the black poverty rate (14.3 percent) was 2.3 times the white rate (6.1 percent), while for female-headed families the black poverty rate (50.6 percent) was only 1.7 times the white rate (29.8 percent). [9]

In any event, in the case of racial differences in infant mortality, the combined effect of the countervailing tendencies just described is to cause the ratio of black to white infant mortality to be only fractionally lower for the college-educated than for the nation at large. For the 1983-1985 period examined in the study, the rates were 10.2 deaths per thousand for blacks and 5.4 for whites, a black-white ratio of 1.89 [4]; for the nation at large, the black rate was 18.2 compared with a white rate of 9.3, a black-white ratio of 1.96. [3] But if there is any reason for surprise, it is probably that the ratio is not larger for the college-educated than for the nation at large, as was the case with respect to rates of low birthweight. In fact, even as to mortality, the ratio was very likely higher among infants born to college-educated than among the rest of the population (i.e., exclusive of the college-educated).

## Avoidable Infant Mortality

There is another perspective warranting attention from which the racial disparity in infant mortality may actually be substantially greater among the college-educated than the nation at large. When we examine the way factors associated with race may affect infant mortality, our fundamental concern is with the impact of those factors on infant mortality that could

reasonably be avoided. It is likely that certain levels of infant mortality cannot reasonably be avoided at any socioeconomic level. Suppose the rate of unavoidable infant mortality is about 3 deaths per thousand live births. (I use the terms "unavoidable"/"avoidable" rather than "unpreventable"/"preventable" in order not to confuse my point with a different subject treated using the latter terms in the article on deaths of infants born to college-educated parents.) Study of racial differences ought then actually to be concerned with the deaths beyond 3 that could be avoided, but which whites are more able to avoid than blacks. Subtracting 3 from each of the rates presented in the preceding paragraph, the ratio of the black rate to the white rate of avoidable infant mortality is found to be much higher where parents are college-educated (3.2–i.e., 7.2 over 2.2) than for the nation at large (2.4–i.e., 15.2 over 6.3).

I make this point not merely to emphasize the predominating influence of the tendency for racial disparities to increase as conditions abate, but also to caution against an unwarranted readiness to interpret the absence of such increase as an indication of a true improvement in the relative health of black infants. For example, between 1983 and 1984, the black infant mortality rate declined from 19.2 to 18.4 while the white rate declined from 9.7 to 9.4, causing the black-white ratio to drop from 1.98 to 1.96. [3] Since in the case of a simple across-the-board decline in infant mortality we would expect the ratio to increase, there is some basis for reading the absence of an increase in the black-white ratio (and more so an actual decline in the ratio) as evidence of genuine improvement in the relative health of black infants. That reading might be warranted if we are principally concerned with racial disparities in gross infant mortality rates. Assuming that our greater concern is with disparities in avoidable infant mortality, however, the validity of the conclusion that the relative health of black infants had improved would depend on the rate of unavoidable infant mortality. The conclusion would hold if the rate of unavoidable infant mortality was as high as 4, but not if the figure

was as high as 5. In the latter case, we would be left with an increase in the ratio of black-to-white rates of avoidable infant mortality that is consistent both with improvement and decline in the relative health of black infants, but that would offer inadequate basis for inferring either.

It should, of course, also be borne in mind in attempting to interpret departures from the expected that the distributions that I have described as roughly normal are rarely completely normal, and irregularities near the tails of the distributions may greatly confound the process of interpretation even without regard to the avoidability issue.

## Disparities in Low Birth Weights

The tendencies described above reveal themselves in certain predictable patterns in more complex comparisons as well. Consider the 1987 study reported in the New England Journal of Medicine on racial disparities in low birthweights among various risk groups. [6] One of the more prominent tables in the article describing that study presented rates of very low and moderately low birthweights for blacks and whites among groups deemed, on the basis of maternal characteristics, to have high, moderate, or low risks of low birthweight. The table also presented racial disparities in terms of the ratio of the black rates to the white rates.

In light of the mathematical tendencies described above, there are two things that one might expect to find here. First, with respect both to moderately low birthweight and very low birthweight, the lower the maternal risk grouping, the greater should be the racial disparity. Second, given that very low birthweight was a condition more restricted to the most vulnerable elements of the risk groupings than moderately low birthweight, one would expect that for each maternal risk grouping, the racial disparity would be greater for very low birthweight than for moderately low birth rate. As shown below in Table 3, which is a slightly modified version of the referenced table from the article on birthweights, both expectations are borne out by the data. The black-white ratio of rates of moderately low birth weight was 1.6 for high risk,

2.0 for moderate risk, and 2.2 for low risk; the ratio of rates of very low birthweight was 1.7 for high risk, 2.7 for moderate risk, and 3.4 for low risk.

[Table 3 goes here.]

Once again, the universality of that tendency can be illustrated by 1990 income data, [9] in this instance by reference to three groups with high, moderate, and low risks of being near-poor or poor: female-headed families (overall poverty rate, 37.2 percent); unrelated individuals (overall poverty rate, 20.7 percent): and female-headed families (overall poverty rate, 13.5 percent). Consider the undesirable condition of falling below 125 percent of the poverty line and the somewhat severer undesirable condition of falling below the poverty line itself. As with moderately low and very low birthweights, we would expect the ratio of black to white rates of experiencing these conditions to be higher in each less susceptible group, and we would expect the ratio to be greater for each group with respect to the severer condition.

Table 4, which presents data on the rates at which blacks and whites fall into either of these income categories, shows that this is in fact the case. The ratio of the black to white rates of falling below 125 percent of the poverty line was 1.6 for persons in female-headed families; 1.7 for unrelated individuals, and 2.2 for persons in married-couple families; the ratio of rates of falling below the poverty line, was 1.7 for persons in female-headed families, 1.9 for unrelated individuals, and 2.3 for persons in married-couple families.

[Table 4 goes here.]

## Increasing Disparities Over Time

The study of low and moderately low birth rates also provided a variety of findings on changes in black and white rates between 1973 and 1983. It is difficult to generalize too much about these findings because they involve both changes in susceptibilities within risk groups and changes in the proportions of each race's total births falling within each risk group. For example, the white rate of moderately low birth weight dropped from 46.4 per thousand to 39.2, a decline

of 16 percent, while the black rate dropped from 101.6 to 95.4, a decline of 6 percent. For reasons already explained, it is to be expected that the white rate would drop at a greater rate than the black rate without necessarily indicating a true decline in the relative health of black and white infants. But at this point in the distribution, absent such true change, one would not expect the white rate to decrease more than the black rate in absolute terms as well. On the other hand, while it might seem that the fact that the black rate decreased less than the white rate in absolute terms suggests that blacks as a group were experiencing a decline in their relative health status with respect to the condition of moderately low birthweight, we must also take into account that between 1973 and 1983 a higher proportion of black births than white births had moved from low risk groups to high risk groups.

In this regard, it is worth noting that, other issues aside, any period-to-period comparisons of black and white mortality rates have little meaning if they do not take into account changes in the proportions of each groups found in different risk groups. The authors of the birthweight study recognized this and endeavored to separate out the effects of such changes from the relative changes in susceptibility within black and white risk groups. But the authors evaluated their results without taking into account the nature of the changes between blacks and whites in the same risk groupings that would be expected to occur in times of overall diminishing susceptibilities whether or not there occurred any true changes in relative health status.

The basic expectation is not only that racial disparities measured in terms of the ratios of rates of being affected by an undesirable condition will be greater for low risk groups than for high risk groups. The expectation is also that, as the condition abates, the racial disparities will increase more among low risk groups than high risk groups. Here, too, the expectation can be illustrated simply enough with income data on married-couple families (a group with low risk of economic distress) and female-headed families (a group with a high risk of economic distress). Let us create a category termed "economically distressed," and define it as including everyone with incomes below 125 percent of the poverty line. The ratio of the black to white rates of falling into this condition would be 2.15 for married-couple families and 1.62 for female-headed families. Suppose that the economy then improved such that all persons who previously fell between the poverty line and 125 percent of the poverty line were no longer economically distressed; the black-white ratio of being economically distressed would increase 8.8 percent (from 2.15 to 2.34) for married-couple families, but only 4.3 percent (1.62 to 1.70) for female-headed families. [9]

Table 5 shows the consistency of these patterns at a wide range of levels of economic distress, along with the corresponding (inverse) pattern with respect to disparities in rates of avoiding economic distress. The lower part of the table (in the first and second columns) shows the ratios of the black and white rates of falling into these circumstances both for married-couple and for female-headed families, and (in the third and fourth columns) the ratios of the black and white rates of avoiding these circumstances. Included in parentheses are the proportionate changes in those ratios in a situation where the economy is improving such as to serially alleviate the distress of each more poverty-prone segment of the population.

Reading down the first two columns in the lower part of the table we observe that as the economy improves, with a single exception, not only does the black-white ratio of being economically distressed increase both for married-couple families and female-headed families, but it increases at a greater rate for married-couple families, the higher socioeconomic groups. At the same time, however, as reflected in the third and fourth columns, not only does the disparity in rates at which blacks and whites both in married-couple families and female-headed families avoid economic distress decline in every case, but it usually declines more for female-headed families, the lower socioeconomic groups.

[Table 5 goes here.]

Of course, if the economy were instead declining such that each less poverty-prone group was being serially pulled into poverty, married-couple families would be generally experiencing a greater decrease in racial disparities in poverty rates, while female-headed families would be experiencing a greater increase in racial disparities in rates of avoiding poverty.

To be sure, these expectations will not be borne out in every case. In the last few examples, I have used 125 percent of the poverty line and the poverty line as reference points, rather than the poverty line and 50 percent of the poverty line, precisely because one of the few instances where the expectation is not in fact borne out involves the fact that the black-white ratio of rates at which persons in married-couple families fall below 50 percent of the poverty line is not larger than the ratio of rates of falling below the poverty line itself. A host of reasons may account for that departure from the expected. The varied findings in the study of changing racial disparities in low birthweights also do not invariably conform to the expectations I have outlined. Again, certainly a host of factors may be involved in the departures from the expectations. But it only with an understanding of these expectations and the mathematical principles that underlie them that one can effectively interpret any of the patterns observed in the data.

## Socioeconomic Differences

The tendencies describe above are not limited to racial comparisons. They apply, for example, in comparisons between more and less susceptible groups within a racial population. Table 6 presents in the first two columns the same information as presented in Table 5 on rates at which persons in black and white married-couple and female-headed families fall below various percentages of the poverty line. The third and fourth columns present the ratios of the rates at which persons in married-couple and female-headed families within each racial group fall below and above those percentages of the poverty line. For both blacks and whites (as reflected in the third columns), the ratios of the rates at which persons in female-headed families and married-

couple families within each population fall into various categories of economic distress increase with the severity of the economic distress, while (as reflected in the fourth column) the ratios of the rates of not falling into the category decrease. This means that as economic circumstances improve, within each race, socioeconomic disparities in economic distress rates increase. But it is also true that socioeconomic disparities in rates of avoiding economic distress diminish.

[Table 6 goes here.]

In the 1987 study on changes in patterns of low birth weights, the authors noted that for both blacks and whites, the rates of moderately low birth weight decreased more at higher educational levels thereby increasing socioeconomic differences within each race. But, as reflected in Table 6, this is entirely to be expected, as would a concomitant decrease in socioeconomic differences in rates of achieving normal birth weights

## An Illustration from England and Wales

In illustrating the implications of social class, two basic works on epidemiology [16,22] have cited infant mortality data from England and Wales for the periods 1930-1932 and 1949-1953, broken down by five socioeconomic classes. These data are set out in Table 7, along with an additional column showing the percentage decline in infant mortality rates experienced by each social class. Category I is the highest social class, while category V is the lowest.

[Table 7 goes here.]

The percentage declines shown in the third column provide a convenient method of determining the direction of changes in the ratios of mortality rates by social class. A class will improve its relative status, as expressed in ratios of mortality rates, over any class that experienced a lower percentage decline in its infant mortality rate. Among Classes II through IV, consistent with standard expectations during this period of dramatic decline in infant mortality, the ratio of the infant mortality rates of each increasingly lower class to that of each higher class increased. Notably, that tendency did not operate for the highest social class, with the disparity between its

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rate and those in each lower class decreasing. This suggests a true change in the relative health of infants in the four lower classes compared with the highest class during this period, possibly occasioned by the introduction of the National Health program in 1948. Quite possibly the same factor was causing a genuine change in the relative health of infants among the four lower classes as well, in terms of an improvement of lower relative to the higher, though not one of sufficient magnitude to overcome the statistical tendency that leads to increases in ratios of infant mortality rates of the lower socioeconomic groups to the higher socioeconomic groups as the rates generally decline.

## Further Applications

The same tendency must be taken into account in evaluating gender differences in infant mortality as well. Female infants have somewhat lower mortality rates than male infants. Demographers have puzzled over why this disparity is greater in developed than in undeveloped countries. [23] A possible answer is the simple fact that mortality rates for male and female infants are lower in developed countries. The tendencies that obtain in the case of infant mortality and low birth weight obtain with respect to all causes of mortality. Yet, efforts are made to appraise the changing relative health of black and white Americans in terms of changes in the ratio of mortality rates for different conditions. [24,25] In some cases, the data reveal genuine cause for concern, including situations where black rates are rising while white rates are declining. But unless the data are examined with the basic understanding that racial disparities in mortality rates will usually increase when mortality declines, the study of racial differences– or any other differences–in mortality is unlikely to be very fruitful.

At a time when not all adverse conditions are declining, it is just as important to keep in mind the expectation that disparities in the rates at which various populations experience an undesirable medical condition will decrease when the condition is increasing. Once again, however, we find it reported as if it were noteworthy that a particular condition is increasing at greater rates

among populations that previously were least susceptible to it. [26,27,28,29,30,31,32] Whether such changes are actually noteworthy, however, depends on whether they occur to a greater or lesser extent than what would be expected to occur in the usual course. This is why it is essential to understand what will occur in the usual course.

Epidemiology is hardly the only area where the failure to understand the properties of normal distributions wreaks such confusion. Despite the usefulness of poverty data to illustrate these properties, it is in the discussion of poverty that we find the most widespread confusion. The ratio of the black poverty rate to the white rate is at times considered a significant indicator of the relative well-being of black and white Americans [33,34] without an apparent appreciation either of the fact that the ratio will increase when poverty declines or of the inverse relationship between changes in the disparities between the rates which blacks and white fall into poverty and the rates at which they escape poverty.

Even more commonly misunderstood is the tendency for the proportion the poorer group comprises of the poor to increase when poverty declines. As shown in Table 1 (though the principle is implicit throughout the foregoing discussion) when the cutoff is lowered to the point where only persons in the Low Category fail, the proportion Group D makes up of those failing increases by 20 percent. That is, assuming the populations are of equal size the percentage members of Group D make up of those failing the test would rise from 56% to 67%, though the proportionate size of the increase would apply regardless of the relative size of the groups.

Nevertheless, that blacks are not making up a larger proportion of the poor has been seen as an encouraging sign that the black underclass is not increasing in size [34,35], when more than anything else it reflects the discouraging fact that poverty is not declining. When poverty was declining, as it did rather consistently between 1959 and the middle 1970's blacks were comprising an increasing proportion of the poor, as were other relatively poverty-prone groups such as female-headed families. [37] The increase in

the proportion of the poor made up of female-headed families–the "feminization of poverty" it was termed–was automatically regarded as an entirely negative trend without recognition of the degree to which it was a function of the overall decline in poverty. [38,39,40]

Similarly, when blacks have tended to comprise a high proportion of the persons failing to meet an educational requirement–for example, comprising 90 to 95 percent of persons disqualified by the National Collegiate Athletic Association's eligibility requirements–it has been almost universally regarded as evidence of the severe racial impact of the requirements. [41,42] But the high black representation among those failing to meet a requirement is more indicative of the fact that the requirement is relatively lenient and that the requirement would be deemed to have only a modest impact in terms of meeting the requirement, which is how the courts have typically analyzed such criteria. Recently-imposed, more stringent requirements are likely actually to decrease the black proportion of persons disqualified.

Very recently, one of the more publicized areas where racial disparities have been scrutinized is home-mortgage lending. Yet, the scrutiny has focused almost entirely on disparities in rejection rates. [43,44] The Comptroller General's Office has even indicated that it will carefully review the practices of lending institutions where the black rejection rate is double the white rate. That could be an unfortunate focus given the tendency for disparities in rejection rates to be highest in those institutions where the black chance of receiving a loan is closest to the white chance. [45]

## Problematic Applications

Theoretically at least, once one develops a basic understanding of the statistical tendencies I have sought to explain, it should be relatively easy to apply them to contexts like those just described. There are also a variety of contexts when the implications of these tendencies are much less obvious, yet where those implications may be of great importance in the interpretation of complex statistical models. Consider the following situations.

### *Male-Female Differential Longevity*

A seminal work on the question of whether there exists a genetic basis for the observed mortality differential between men and women is Francis Madigan's study of men (brothers) and women (sisters) in Catholic religious orders. [46] Brothers and sisters were chosen for the study because they were believed to be somewhat removed from the differences in life experiences that may affect male and female longevity among the population at large. One of the analyses Madigan considered crucial to supporting his thesis that the basis for the mortality differential was principally genetic involved comparing the mortality advantage that brothers enjoyed over the general male population with the advantage sisters enjoyed over the general female population. For reasons unnecessary to explore here, Madigan found support for the genetic thesis in the fact that the sisters in his study enjoyed a greater advantage over the female population–reflected in a lower ratio of the sister's mortality rate to that of the general female population, which is the same thing as a higher ratio of the mortality rate of the general female population to that of the sisters–than brothers enjoyed over the general male population. Suppose, however, that the ratio of general mortality rates to mortality rates in religious orders was higher for women than for men simply because (as was the case) the mortality rates were lower for women than for men. An important element of Madigan's thesis would seem to disappear.

### *Smoking Risks*

The relative mortality risk from smoking tends to decline with age. [47,48] This occurs even though older smokers will have been subjected to the harmful effects of smoking for greater lengths of time. Yet, ought we not to expect a tendency for the relative risk to be greater among the young simply because mortality, in general and with respect to the causes where smoking could make a difference, are less common among the young? Moreover, does this not suggest that whenever the association of smoking with a disease is measured in terms of relative risk (or relative odds), the strength of the association will be directly related

both to the extent to which smoking exacerbates susceptibility to the disease and the scarcity of the disease?

The relative risk that smokers, compared with nonsmokers, experience for bladder cancer is greater than the relative risk smokers experience for cardiovascular disease, [49] even though, at least intuitively, the mechanisms whereby smoking will exacerbate susceptibility are more obvious in the case of cardiovascular disease. But it seems quite possible that the relative risk is greater for bladder cancer simply because bladder cancer is far less common than cardiovascular disease. Because bladder cancer is more restricted to the tail of the overall distribution, the consequences of the fact that smokers have a somewhat different distribution from non-smokers with respect to risk of bladder cancer could be magnified sufficiently to yield a greater relative risk than in the case of cardiovascular diseases, notwithstanding that differences between the distributions of risk for smokers and nonsmokers are greater in the case of cardiovascular disease than bladder cancer.

The relative risk of smokers over nonsmokers is greater for chronic pulmonary obstructive lung disease than for lung cancer. [49] Since the mechanisms by which smoking can exacerbate susceptibilities are evident with regard to both conditions, there is no intuitive basis for questioning why the relative risk should be greater for chronic pulmonary obstructive lung disease. At the same time, one cannot be sure that the fact that the incidence of chronic obstructive lung disease is less than half that of lung cancer does not play a large role in yielding a greater relative risk with regard to the former condition.

Assuming that in fact the scarcity of the condition does tend to increase relative risk in the manner suggested above, one may ask what difference it makes. For one thing, it would seem important to understand this tendency in determining whether or how to explore the mechanisms that cause smoking to appear to exacerbate one condition more than another. We could find that there is sometimes little point in such inquiries, just as there is probably little point

in inquiring into why there exists a greater racial disparity in low birth weights among persons of high socioeconomic status than among persons of low socioeconomic status.

### *Gender Differences in Relative Risks*

Just as factors that increase the risk of mortality from certain diseases increase the risk less among older persons, in cases where mortality or morbidity is greater among men, factors or conditions that increase (or indicate) mortality and morbidity tend to do so less among men; and the more severe the factor or condition the less will be the gender disparity in its consequences.

(Keep in mind that the reference here to as more severe factor or condition with respect to consequences concerns something that defines a group that is more susceptible to some consequence and hence a group where gender (or other) disparities in rates of suffering the consequence will be smaller. This must be contrasted with the tendency that the more severe the factor or condition, the greater will be the disparities in experiencing the condition itself. For example, among the very poor, where low birth wrights would be relatively common, the racial disparity in low birth weights would be smaller than among the moderately poor; but the racial disparity in rates of being very poor would be greater than the racial disparity in being moderately poor. Once again, however, the more severe the condition, the greater will be the disparities in avoiding the consequences of the condition, but the smaller will be disparities avoiding the condition itself.)

The two tables that follow, drawn from articles on hypertension [50] and coronary artery disease, [51] are presented principally because they illustrate with such consistency the tendency for gender disparities in adverse consequences to decline depending on the severity of the factor defining the category. But they also illustrate the converse tendencies for disparities in survival (avoidance) to increase with the severity of the aggravating (indicating) factor, as well a point about the consistency in the latter tendency. Table 8 shows the impact of hypertension on male and female mortality from cardiovascular disease. The

stronger the symptoms of hypertension–and hence the greater the mortality risk–the smaller is the gender disparity. The converse tendency is not observed between the borderline and definite categories. But when the numbers are so close, as they frequently are in survival rates, any irregularity in the distributions easily may outweigh the statistical tendency.[Table 8 goes here.]

Table 9 shows the prevalence of coronary artery disease among men and women with three categories of angina symptoms. The more severe the symptoms–and hence the greater the disease prevalence–the smaller the gender disparity. Here, however, because the prevalence is high enough that there is room for substantial disparities in rates of not being diseased, we find equally consistent increasing gender disparities in rates of avoiding coronary artery disease. [Table 9 goes here.]

I assume that hypertension is principally a cause rather than a symptom of cardiovascular mortality, while I assume that angina is more a symptom than a cause of cardiovascular disease. But, whether either is a cause of symptom, by defining a category of persons where morbidity or mortality is more common, both conditions establish groups where gender disparities in mortality and morbidity will tend to be less pronounced regardless of whether the conditions in any "true" sense operate differently either to signify or exacerbate health problems of men and women.

### Gender Differences in Treatment

Last year there appeared in the New England Journal of Medicine two studies of differences between the treatment of men and women with coronary heart disease. One study examined the rates at which men and women hospitalized for coronary disease in Massachusetts and Maryland received coronary angiography and revascularization. [52] It found that, even taking into account certain factors that might explain gender differences, in both states women were substantially less likely to receive either angiography or revascularization, though the study left open the question of whether the difference indicated an overuse of the procedures in men or an underuse in women. The second study examined rates at which men and women in the United States and Canada enrolled in large postinfarction intervention experiment–the Survival and Ventricular Enlargement (SAVE) Study–underwent cardiac catheterization and bypass surgery. [53] This study, too, found that women underwent these procedures substantially less frequently than men even though the women in the study population appeared to be experiencing more severe symptoms than the men. The authors of this study also left open the question of whether the apparently less aggressive diagnostic and therapeutic approach for women was justified.

The studies were followed by a commentary by the Director of the National Institutes of Health calling for critical inquiry into apparent inequities in the medical care accorded to men and women. [54] The studies and commentary prompted correspondence both questioning the conclusions and providing evidence of similar disparities observed throughout the nation [55,56,57,58], as well as responses by the authors. [59,60]. Sorting out the causes for these disparities, including whether there exists subtle or unsubtle gender discrimination in the approaches physicians take to caring for male and female heart patients, is a formidable task. But it is likely to be even more difficult if not undertaken with an understanding of the ways various aspects of the observed disparities may be functions of the features of normal distributions described above. At any rate, the studies provide an opportunity both to explore the implications of the theory elaborated above and to appraise the validity of the theory.

### Angiography and Revascularization Study

The most obvious ways the data from the study on heart patients in Massachusetts and Maryland conform to these tendencies is reflected in comparisons between the gender disparities for angiography and for revascularization. Angiography, of course, is a much more common procedure than revascularization. As shown in Table 10, consistent with tendency for disparities

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to be greater when the condition is less common, in both states the relative risk of undergoing the procedure was greater for revascularization than for angiography.

[Table 10 goes here.]

The same tendencies hold for the odds ratios yielded by a logistic regression analysis that attempted to account for factors that might have a role in explaining the disparities. In Massachusetts, the odds ratio was 1.28 for angiography and 1.45 for revascularization; in Maryland, the odds ratio was 1.15 for angiography and 1.27 for revascularization.

Otherwise, the data presented in this study were as often inconsistent with my thesis as they were consistent with it, though usually there was such overlap in confidence intervals that one could not draw firm conclusions either way. For example, the study also carried out a logistic regression limited to patients whose principal diagnosis was myocardial infarction, since the authors believed that, because of the more explicit diagnostic criteria for myocardial infarction, the procedure rates were unlikely to be confounded by different thresholds for admission. In the results of that regression, the expectation of a greater disparity for revascularization than for angiography held for Maryland but not for Massachusetts, although there was great overlap of the confidence intervals.

Given that rates for both angiography and revascularization were substantially lower for myocardial infarction than the average for other serious conditions, there would be some basis for expecting the gender disparities in the procedure rates to be greater for patients diagnosed with myocardial infarction; on the other hand, men and women diagnosed with myocardial infarction would tend to be more alike with regard to their diagnostic and therapeutic needs than the entire population in the study, which should tend to diminish the gender disparities. In any case, for patients diagnosed with myocardial infarction, the gender disparity was larger than in the entire study population in three of the four comparisons, though again with considerable overlap of confidence intervals.

As to comparisons between the two states, the overall rates were too close to expect tendencies regularly to result in greater disparities in the state with the lower rates for the procedure.

One pattern that is worth noting involved comparisons of angiography and revascularization rates for insured and uninsured patients. As one would expect, the insured were much more likely to receive either procedure, which should lead to a greater gender disparity among the uninsured. Yet in both states, the gender disparities for each procedure were substantially greater for the insured than for the uninsured. One interpretation is that the observed disparities are in fact caused by discrimination on the part of physicians, with the greater disparities among the insured occurring because the institutional authorities that make decisions about these procedures for the uninsured do so more evenhandedly than personal physicians. On the other hand, the departure from the expected could suggest that the gender differences revealed in the study in fact reflect an overuse of the procedures by men, since overuse would seem more likely to occur among insured patients. I cannot here say either interpretation is more likely. But, if the basic theory I have asserted is valid, it is possible that there exists in this departure from the expected some clues as to the factor that is actually causing the disparities.

In any event, one way in which the tendencies I have described ought to figure significantly in interpreting the data concerns the authors' belief that the results of their study are generalizable throughout the United States, although the overall rates at which the procedures have been used have been lower in the Northeast that elsewhere in the country. The fact that the rates are lower in the Northeast, however, suggests that–if the phenomena producing the disparities operate throughout the country–the disparities should be greater in the Northeast than in other parts of the country.

Yet, data presented in a letter to the editor [56] from similar analyses throughout the nation do not follow such a pattern. A comparison of simple average of the odds ratios for Massachusetts and Maryland with the odds ratios produced by a

logistic regression for the entire nation shows that, while the Massachusetts-Maryland average odds ratio was slightly higher than the national figure for angiography (1.22 compared with 1.16), it was substantially lower for revascularization (1.36 compared with 1.76). For patients diagnosed with myocardial infarction, the Massachusetts-Maryland average was somewhat lower for angiography (1.34 compared with 1.48) and substantially lower for revascularization (1.36 compared with 1.74).

Viewed alone, the data would seem to suggest that "true" disparities are much greater in regions other than the Northeast, since the greater disparities in other regions occur notwithstanding the statistical tendencies that tend in the opposite direction. Further, the above-mentioned letter to the editor cited data broken down by region showing that gender disparities in the rate of angiography were almost 1.3 times as great in the South as in the Northeast. Given that the overall rates for angiography tend to be almost twice as high in the South as the Northeast, [61] this pattern seems to strongly suggest a "true" greater disparity in the South. Otherwise, the regional comparisons cited in the letter were generally consistent with the theory presented here. Disparities in revascularization rates were far higher in the Northeast than in the South and Midwest, where the procedures and used much more frequently. Yet, no similar trend was noted with regard to the West, despite the fact that the West has the highest revascularization rates of all.

Understanding regional differences in gender disparities in cardiac care may be a matter of some importance, since such differences may offer important evidence as to the underlying cause of the disparities. For example, it would seem more likely that physician attitudes vary by region than that the differences in the nature of male and female coronary problems would vary by region. The data described above do not provide an adequate basis for exploring this issue. It seems, however, that we cannot ultimately interpret the data on such issues without understanding the way the data may conform to or depart from the statistical tendencies that operate apart from "true"

differences.

The results of the Study on catheterization and bypass surgery were generally consistent with the central point made in this article. As shown in Table 11, the ratio of male to female rates for catheterization was higher for the less common procedure (coronary bypass surgery) than the more common procedure (catheterization).[Table 11 goes here.]

The SAVE Study also presented certain comparisons that the commentary following the study would interpret as supporting the view that it is physician attitudes that cause the gender disparities in the treatment of coronary artery disease. First, among persons who underwent catheterization, 46 percent of men compared with 38 percent of women subsequently underwent bypass surgery, a difference that was not statistically significant but that in any case was much smaller than the disparity in rates of undergoing catheterization. Second, for persons with a history of acute myocardial infarction, the male catheterization rate was 58 percent compared with a female rate of 44 percent, while for persons without such a history, the male rate was 9 percent compared with a female rate of 5 percent. The commentary would read the decreasing percentage of the gender disparities among persons evidencing more acute symptoms as demonstrating that it was only after a woman evidenced such symptoms that she would be treated like a man.

The inference that once patients were being examined more intensely, and with the aid or more objective bases for diagnosis, gender-related differences in physicians' approach to treatment had less of an impact appears plausible enough. Yet, the data must be interpreted in light of the statistical tendencies whereby smaller percentage disparities are to be expected where the treatment recommendations are more frequent.

Data in Table 5 provide a helpful perspective for evaluating the smaller gender disparities in bypass surgery rates for persons who have undergone catheterization (which I shall assume generally would be somewhere in the 46-versus-38-percent range shown in the study

though not in statistically significant terms). Persons in black married-couple families are more than twice as likely as white married-couple families to fall below 125 percent of the poverty line. Yet among persons in such families who fall below 125 of the poverty line, 72 percent of blacks compared with 66 percent of whites fall below the poverty line itself. It would make little sense, however, to infer from the smaller size of the latter disparity that the factors that influence black and white poverty have less effect in the subset of the population that is below 125 percent of the poverty line.

Similarly, whatever the factors may be that lead to the lower catheterization rates for women than for men, it is not possible to maintain that the data indicate, in any "true" sense, that those factors are operating to a lesser degree among persons with histories of infarction. Refer again to Table 8, where the disparities between the rates that men and women having non-specific heart pain would also have coronary artery disease was much greater than the disparities between the rates that men and women having definite angina would have coronary artery disease. It seems rather clear that such diminishing disparities were much a more function of the tendencies of normal distributions than of a greater readiness of physicians to equally consider the possibility that men and women have coronary artery disease only when they have manifested severe angina symptoms.

Thus, whatever the intuitive appeal of the argument advanced in the commentary, it is probably not possible to infer, on the basis of the diminishing disparities that it cited, the nature of the factors causing those disparities.

### Relative Risks from Peripheral Arterial Disease

A study that appeared in the New England Journal of Medicine in 1992 found mortality substantially greater for subjects with peripheral arterial disease with the difference due almost entirely to increased mortality from cardiovascular disease, especially coronary heart disease. [62]. Despite the fact that women had lower rates of cardiovascular disease and coronary heart disease

than men, the relative risk associated with peripheral arterial disease was slightly lower for women than for men with respect to both categories of disease.

The failure of the data to conform to the expected pattern may in this case suggest that peripheral arterial disease is in fact associated with greater consequences with respect to potential mortality from both types of disease for men than for women. On the other hand, given that the greater relative risk experienced by men was slight, and that there was considerable overlap of confidence intervals, these results may merely mean that the study was carried out on too few subjects to provide reliable information on potential differences in the consequences of peripheral arterial disease for men and women. Further study of this matter, however, must be carried out with an appreciation of the tendencies that are purely statistical.

### Racial Disparities in Effects of Social Roles

A recent study in the *Journal of Health and Social Behavior* examined the differences between the effect of social roles (e.g., whether married, employed, supporting persons other than spouses) on the health status of blacks and whites. [63] The study provides interesting data that illustrates how one might reach different conclusions with regard to the relative significance of certain factors on the health of each race unless one thinks very carefully about the issue being examined and does so with an understanding of the statistical tendencies described here.

Relying on results of multiple regression analyses that examined the effects of social role variables, the authors concluded that role configuration explained more of the variance in the health of blacks than of whites. While this could be characterized as the authors' main finding, they also presented tables showing the results of logistic regression exploring the impact of the same roles on mortality. The logistic regression showed that the same roles that had explained more of the variance in black than white health status had a greater impact upon whites than blacks with respect to the reduction in

mortality rates, a greater impact that I suspect is principally a reflection of lower white mortality rates. Thus, had mortality been the authors' principal focus, they might have reached very different conclusions as to racial differences in the effects of role configuration.

The differing interpretations of the data on the health consequences of role configuration depending on whether the focus is on continuous or dichotomous outcomes is akin to the contrasting interpretations one might give to differences in the impact of family structure on black and white economic well-being. The difference between the median incomes of married-couple families and female-headed families is much greater for blacks than for whites, and, in a standard regression analysis of factors affecting income, a suitable variable for family structure would likely yield a higher coefficient for blacks than for whites. As shown in Table 6, however, being in a female-headed family as opposed to a married-couple family increases the risk of poverty more for whites than for blacks, which would seem to justify a claim that being in female-headed family has greater impact on the economic well-being of whites than blacks. Yet, even apart from the fact that we would reach still a different conclusion if the focus were upon rates of avoiding poverty, where being in a married-couple family would appear more helpful to blacks than to whites, the focus upon the dichotomous outcome is far less informative, and far more likely to mislead, than the focus on continuous variables like income.

In epidemiology, unfortunately, dichotomous outcomes are frequently all that exists or at least all that exists in an observable form. There may be no fully satisfactory way of dealing with that problem. But a critical first step is to understand that the problem exists and the varied ways it that it may confound the interpretation of data.


–THE END–

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**Table 1.  Hypothetical Distribution of Test Scores of Two Groups by Percentage Falling Into Each of Three Categories.**

|  | Low Category | Middle Category | High Category | Total |
|---|---|---|---|---|
| Group A | 30 | 40 | 30 | 100 |
| Group D | 60 | 30 | 10 | 100 |

**Table 2.  Hypothetical Distribution of Test Scores of College-Educated Members of Two Groups by Percentage Falling Into Each of Three Categories.**

|  | Low Category | Middle Category | High Category | Total |
|---|---|---|---|---|
| Group A | 30 | 40 | 30 | 100 |
| Group D | 50 | 30 | 20 | 100 |

**Table 3.  Birth-Weight Components, According to Race and Maternal Risk–U.S., 1983.**

|  | Maternal Risk | | |
|---|---|---|---|
|  | High | Moderate | Low |
|  | (rate per 1000 live births) | | |
| **Black:** | | | |
| Moderately low birth weight | 117.2 | 90.7 | 60.0 |
| Very low birth weight | 25.1 | 21.2 | 17.2 |
| **White:** | | | |
| Moderately low birth weight | 74.3 | 44.4 | 26.8 |
| Very low birth weight | 15.1 | 7.8 | 5.0 |
| **Black-white rate ratio** | | | |
| Moderately low birth weight | 1.6 | 2.0 | 2.2 |
| Very low birth weight | 1.7 | 2.7 | 3.4 |

**Table 4.  Black and White Rates of Falling Into Two Levels of Economic Distress for Three Risk Groups.**

<u>Poverty Rates</u>

|  | Persons in Female-Headed Families (High Risk) | Persons in Unrelated Individuals (Moderate Risk) | Married-Couple Families (Low Risk) |
|---|---|---|---|
| **Black:** | | | |
| Below 125% of the poverty line | 59.1 | 43.1 | 19.8 |
| Below poverty line | 50.6 | 35.1 | 14.3 |
| **White:** | | | |
| Below 125% of the poverty line | 36.5 | 25.5 | 9.2 |
| Below poverty line | 29.8 | 18.6 | 6.1 |

<u>Black-white rate ratio</u>

|  | | | |
|---|---|---|---|
| Below 125% of the poverty line | 1.6 | 1.7 | 2.2 |
| Below poverty line | 1.7 | 1.9 | 2.3 |

**Table 5.  Rates of Falling Below Various Percentages of the Poverty Line for Black and White Married-Couple and Female-Headed Families, with Ratios of Rates at Which Blacks and Whites in Each Family Type Fall Below and Above the Percentage.**

|  | Married-Couple Family (low risk) | Female-Headed Family (high risk) |
|---|---|---|
| **Black:** | | |
| Below 200% of the poverty line | 36.7 | 74.5 |
| Below 175% of the poverty line | 31.6 | 69.7 |
| Below 150% of the poverty line | 25.6 | 64.2 |
| Below 125% of the poverty line | 19.8 | 59.1 |
| Below poverty line | 14.3 | 50.6 |
| Below 50% of the poverty line | 3.2 | 27.2 |
| **White:** | | |
| Below 200% of the poverty line | 21.8 | 53.8 |
| Below 175% of the poverty line | 17.6 | 48.3 |
| Below 150% of the poverty line | 12.9 | 42.3 |
| Below 125% of the poverty line | 9.2 | 36.5 |
| Below poverty line | 6.1 | 29.8 |
| Below 50% of the poverty line | 1.7 | 13.2 |

Table 5 (continued from previous page)

Ratios of Black to White
Rates of Being Below and
Above Various Income Levels
(with rates of change)

|  | Below | | Above | |
|---|---|---|---|---|
|  | Married-couple | Female-headed | Married-couple | Female-headed |
| 200% of the poverty line | 1.68 | 1.38 | 0.81 | 0.55 |
|  | (+13%) | (+4%) | (+3%) | (+7%) |
| 175% of the poverty line | 1.80 | 1.44 | 0.83 | 0.59 |
|  | (+10%) | (+6%) | (+2%) | (+5%) |
| 150% of the poverty line | 1.98 | 1.52 | 0.85 | 0.62 |
|  | (+9%) | (+7%) | (+4%) | (+3%) |
| 125% of the poverty line | 2.15 | 1.62 | 0.88 | 0.64 |
|  | (+9%) | (+5%) | (+3%) | (+9%) |
| Poverty line | 2.34 | 1.70 | 0.91 | 0.70 |
|  | (-20%) | (+21%) | (+8%) | (+6%) |
| 50% of the poverty line | 1.88 | 2.06 | 0.98 | 0.84 |

**Table 6. Rates of Falling Below Various Percentages of the Poverty Line for Persons in Black and White Female-Headed and Married-Couple Families, with the Ratios of Rates at Which Persons in Female-Headed Families Fall Below and Above the Percentage to the Rate at Which Persons in Married-Couple Families Fall Below and Above the Percentage.**

| | Female-Headed Family | Married-Couple Family | Ratios of Rates Below | Above |
|---|---|---|---|---|
| Black: | | | | |
| Below 200% of the poverty line | 74.5 | 36.7 | 2.03 | 0.40 |
| Below 175% of the poverty line | 69.7 | 31.6 | 2.21 | 0.44 |
| Below 150% of the poverty line | 64.2 | 25.6 | 2.51 | 0.48 |
| Below 125% of the poverty line | 59.1 | 19.8 | 2.98 | 0.51 |
| Below poverty line | 50.6 | 14.3 | 3.75 | 0.58 |
| Below 50% of the poverty line | 27.2 | 3.2 | 8.50 | 0.75 |
| White: | | | | |
| Below 200% of the poverty line | 53.8 | 21.8 | 2.47 | 0.59 |
| Below 175% of the poverty line | 48.3 | 17.6 | 2.74 | 0.63 |
| Below 150% of the poverty line | 42.3 | 12.9 | 3.28 | 0.66 |
| Below 125% of the poverty line | 36.5 | 9.2 | 3.97 | 0.70 |
| Below poverty line | 29.8 | 6.1 | 4.89 | 0.75 |
| Below 50% of the poverty line | 13.2 | 1.7 | 7.76 | 0.88 |

**Table 7. Infant Mortality Rates for England and Wales by Social Class During 1930-1932 and 1949-1953**.

| Social Class | Infant Mortality Rates 1930-32 | 1949-53 | Percentage Decline |
|---|---|---|---|
| I | 32.7 | 18.7 | 0.43 |
| II | 45.0 | 21.6 | 0.52 |
| III | 57.6 | 28.6 | 0.50 |
| IV | 66.8 | 33.8 | 0.49 |
| V | 77.1 | 40.8 | 0.47 |

**Table 8. Male and Female Mortality from Cardiovascular Disease According to Hypertensive Status (age 65-74), with Male-Female Ratios of Mortality and Survival–The Framingham Study, 20-Year Follow Up.**

| | Average Annual Mortality per 1000 Men | Women | Male-Female Mortality Ratio | Male-Female Survival Ratio |
|---|---|---|---|---|
| Normal | 9.6 | 3.8 | 2.53 | .995 |
| Borderline | 20.3 | 9.8 | 2.07 | .989 |
| Definite | 24.5 | 18.6 | 1.32 | .994 |

**Table 9. Angiographic Prevalence of High-risk Coronary Artery Disease Among Men and Women with According to Categories of Angina Symptoms, with Male-Female Ratio of Rates of Having and not Having Disease.**

| | Rate of Coronary Artery Disease Men | Women | Male-Female Ratio of Having Disease | Male-Female Ratio of Not Having Disease |
|---|---|---|---|---|
| Non-spec. Chest Pain | 14 | 6 | 2.33 | .913 |
| Probable Angina | 66 | 36 | 1.83 | .531 |
| Definite Angina | 93 | 72 | 1.29 | .250 |

**Table 10.  Male and Female Rates of Coronary Angiography and Coronary Revascularization in Massachusetts and Maryland, with Relative Risks.**

|  | Massachusetts | | | Maryland | | |
|---|---|---|---|---|---|---|
|  | Male Rate | Female Rate | M/F Ratio | Male Rate | Female Rate | M/F Ratio |
| Angiography | 27.5 | 16.1 | 1.7 | 28.7 | 17.7 | 1.6 |
| Revascularization | 15.5 | 7.4 | 2.1 | 14.1 | 6.5 | 2.2 |

**Table 11.  Male and Female Rates of Catheterization and Coronary Bypass Surgery from SAVE Study, with Relative Risks.**

|  | Male Rate | Female Rate | M/F Ratio |
|---|---|---|---|
| Catheterization | 27.3 | 15.4 | 1.77 |
| Bypass Surgery | 12.7 | 5.9 | 2.15 |