

Macro-to-Micro Links in the Relation between Income Inequality and Mortality

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IT HAS LONG BEEN KNOWN THAT THE SOCIO-economic status (SES) of an individual is a pervasive and persistent correlate of that individual's health (Haan, Kaplan, and Syme 1989; Adler et al. 1993). Regardless of whether SES is measured by occupation (e.g., Fox, Goldblatt, and Jones 1985; Marmot et al. 1991; Moore and Hayward 1990; Mare 1990; Kotler and Wingard 1989); education (e.g., Feldman et al. 1989; Lahelma and Valkonen 1990), or household income (e.g., Kitagawa and Hauser 1973; Duleep 1986; Pappas et al. 1993), the correlation between SES and health is invariably positive and is often best described as a continuous but nonlinear "gradient": large improvements in health are associated with incremental gains in SES among populations at the lower end of the socioeconomic scale, whereas smaller health gains are associated with increments in SES among groups situated at higher levels of the scale.

Studies extending the level of SES measurement from the individual or household to the neighborhood often find powerful links to health as

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well. For example, Haan, Kaplan, and Camacho (1987), using data from the Alameda County Study, found that mortality risk is strongly predicted by an individual's residence in a neighborhood that has been designated by the federal government as a poverty area. The connection between neighborhood SES and individual health persisted even after the introduction of controls for both individual- and family-level SES.

Some of the most intriguing recent work on SES-health links measures SES at even higher levels of aggregation—political units, like states (Kaplan et al. 1996a; Kennedy et al. 1996a) or provinces, as well as countries themselves (LeGrand 1989; Wilkinson 1992b). In these cases, it is possible to examine the effect on health of both the unit's level of SES and the degree of dispersion in the distribution of SES within the unit.

Given the overwhelming evidence of a positive correlation between an individual's SES and health, it would seem obvious that such a correlation would apply to the average level of health in, say, a state and that state's *average level* of income. In fact, this correlation is at best weak (Preston 1975; Wilkinson 1992b), leading to expectations of even weaker associations between level of health and the *degree of inequality* in the distribution of SES. Yet some studies (reviewed below) have uncovered links between greater degrees of inequality and worse health outcomes in both states and countries. Furthermore, these health-inequality links persist, even after controlling for average level of SES.

Despite these empirical associations between income inequality and health at the aggregate level, there is no consensus on either the strength of the relations or the reasons why SES inequality affects individual health. In part, this lack of consensus is attributable both to the newness of the literature and to some fundamental, unresolved issues, the most important of which is how to define and interpret income inequality. Some research suggests that both the magnitude and significance of the inequality-health association are sensitive to the measure of inequality adopted (Wilkinson 1996), implying that inequality is not unidimensional.

In fact, as a voluminous social science literature has demonstrated, income inequality can increase in a number of ways and for a range of reasons, all of which could have unique effects on health and mortality (see Wolfson [1994] for a more detailed discussion of this literature). For example, it is possible that increases in inequality resulting from improvements in the middle and upper portion of the income distribu-

tion may produce different health and mortality outcomes than those associated with a deterioration of living standards in the lower tail of the income distribution. Thus, empirical work requires experimentation with a variety of inequality measures that distinguish among the kinds of inequality changes.

Another important, but seldom investigated, issue is the extent to which income inequality affects people who differ on their individual- or household-level SES. These are not tests of the "reality" of the ecological effect; they are elaborations of it. By identifying subgroups of the population differentially affected by income inequality, we enhance our understanding of how it works and what can be done about it.

We will begin to address these two issues here by applying a variety of inequality measures, including one that accounts separately for inequality in the top and bottom halves of the income distribution, and by using longitudinal data from the Panel Study of Income Dynamics covering the years 1978 to 1982 and 1988 to 1992, to relate state-level income inequality to the five-year, age-adjusted mortality risk of individuals. Our findings suggest that inequality is not a simple, unidimensional factor and that the significant links between inequality and mortality found at the aggregate level do not always carry over to the individual level.

The paper is organized as follows: First, we outline the theoretical links between inequality and health and review previous research on empirical links. We then summarize the major changes in inequality in the United States during the last two decades. Third, we describe the data and methods. Finally, we present our results and summarize our findings.

Background

Income Distribution and Inequality in the United States

No one disputes the fact that income inequality in the United States increased substantially during the 1980s (for recent evidence, see Karoly [1993] and Danziger and Gottschalk [1995]). Although the degree of income inequality that is tolerated in the United States has always exceeded that of most other industrialized nations, the acceleration of this rift during the 1980s reopened the debate over the costs and ben-

efits of allowing such an unequal income distribution to persist. This debate has resulted in a significant body of research that attempts to answer several basic questions:

1. Why has inequality increased in recent years?
2. Who has gained and who has lost during this period?
3. Can inequality be classified simply as a bad or a good for society? (See Levy and Murnane [1992] and Karoly [1993] for a review of this literature.)

The answers to these questions are controversial. Inequality in the distribution of income should be understood as reflecting certain factors: structural characteristics of the economy; political decisions regarding the generosity of government-based transfer of income sources like welfare and Social Security; and family demographic trends (Danziger and Gottschalk 1995; Iceland 1997). Macroeconomic forces, like technological change, increasing monetary rewards for the attainment of education and skills, economic returns to capital, and aggregate employment opportunities, all influence the distribution of income related to society's factors of production. Household income aggregates the labor-, capital-, and government-based transfer of income to household members and thus also reflects decisions that hinge on the nature and generosity of government-based transfer and tax policies, like those affecting the search for paid employment and the fertility and marriage/cohabitation arrangements that determine family composition. Some have argued that the recent growth in income inequality is a social negative because it has come at the expense of poor and middle-class families (Danziger and Gottschalk 1995). Others have suggested that much of the recent growth in inequality resulted from large and unprecedented gains in the middle and upper parts of the income distribution (Burkhauser et al. 1996). According to this latter view, the status of the poor has fallen in a relative, but not absolute, sense. These seemingly contradictory conclusions underscore the complicated nature of the inequality debate.

Theoretical Links between Inequality and Health

Why differing degrees of inequality in the distribution of a society's resources might affect health adversely is not at all certain, and there is

very little empirical evidence to inform a discussion of the topic (Wilkinson 1996; Lynch and Kaplan 1997; Kaplan and Lynch 1997). Our discussion of the theoretical issues is speculative, highlighting the need for more theoretical work to guide research.

Our expectations about the relation between income inequality and health are based on two related propositions: First, an inequitable income distribution may be associated with a set of economic, political, social, and institutional processes that reflect a systematic underinvestment in human, physical, health, and social infrastructure. This underinvestment has possible consequences for both poor and middle-class individuals and thus represents a material dimension to the inequality-health link.

Second, inequitable income distribution may directly affect people's perceptions of their social environment, which may in turn have an impact on their health. This constitutes a psychosocial dimension to the relation between inequality and health. The material and psychosocial strands are linked to the extent that perceptions of inequality are based on material conditions.

In thinking through how income inequality is related to health, it is helpful to inquire into the characteristics and conditions present in a country, state, or region that tolerates, and even generates through its own tax and transfer policies, high levels of inequality in the distribution of income. We believe one important answer to this question is that political units that tolerate a high degree of income inequality are less likely to support the human, physical, cultural, civic, and health resources needed to maximize the health of their populations. Furthermore, although health has an obvious relation with the absolute level of income-based resources of a country or state, much of the link between inequality and health may well be independent of income level.

What differences might exist between two geographic areas that have the same average absolute level of income but that differ in the allocation of total income to the poorest 50 percent of their populations? It may well be that the areas characterized by higher inequality also are less equitable in their support of education, affordable housing, good roads, and environmental protection, and by the many other disparities typical of such societies that directly, and indirectly, influence health status. In those cases, one would expect to find that areas of higher inequality typically share certain conditions: fewer immunization or tuberculosis control programs; fewer public health initiatives to educate

people about smoking, diet, or exercise; lower standards for environmental pollution; less support for cultural festivals, civic performances, and art shows; higher concentrations of cigarette and alcohol advertising; and greater tolerance of racial and gender discrimination.

It is also possible that a high level of income inequality creates an undesirable psychosocial climate that directly influences health by affecting the level of social cohesion and perceptions of fairness. Social capital refers to the stock of investments, resources, and networks that produce social cohesion, trust, and a willingness to engage in community activities (Kawachi et al. 1997). Social capital may be an important mediating variable in the relation between income inequality and mortality, but more research is needed to clarify the pathways by which social capital, or the lack of it, is related to health.

There are clearly many differences between areas of high and low income inequality. Assessment of the association between income inequality and health should build on conceptual models of disease causation that are based on the precursors and consequences of income inequality and their relation to health status. Researchers attempting to separate the spurious from the genuine pathways linking income inequality to mortality should bear in mind the following possibilities:

1. *An Omitted Third Variable.* Omitted-variable bias is a potential problem for every causal analysis. Scrutiny of the evidence on inequality and health in the United States, for example, leads to the question, What is it about high-inequality states like Mississippi and Louisiana that produces higher age-adjusted mortality than exists in low-inequality states like New Hampshire and Utah? If the omitted variable is caused by inequality and affects health, then it takes on the status of a mediator, helping to account for the effect of inequality on health.

Income level is an obvious omitted-variable candidate because there is generally a negative association between income level and income inequality and a positive association between income level and health. An obvious solution, followed in much of the literature, is to adjust the inequality-mortality associations for differences in income level. However, there are numerous, potentially important, omitted variables; many reflect spurious factors, and most cannot easily be measured.

The omitted-variable issue can be addressed by certain general strategies: (a) introduce the omitted measures explicitly into the analysis and gauge the adjusted degree of association between inequality and health; and (b) estimate "fixed effects" models, in which *changes* in inequality

within states or countries are related to *changes* in health within those states or countries. Fixed-effect models difference out effects of persistent characteristics (both measurable and not) of the political units of analysis. Kaplan et al. (1996) performed this kind of analysis by relating state-specific changes in inequality to state-specific changes in mortality between 1980 and 1990. They continue to find negative correlations, although these correlations are not as strong as those found in their analysis of level and are more sensitive to the measure of inequality. Empirical work presented here is based on both level and fixed-effects models.

2. *Nonlinear Effects of Individual SES and Health.* In the context of a constant level of macroeconomic activity, growing income inequality reflects the combination of a drop in the incomes of poor households and an increase in the incomes of wealthy households. If the causal association between income and health is nonlinear (Preston 1975; Rodgers 1976), whereby a given increase in income has a more positive impact on health at low than at high levels of income, then the inequality-induced declines in incomes at the bottom of the distribution should worsen the health of individuals in poor households more than the increases at the top improve the health of wealthy individuals. Micro-level data that match the health status of individuals with aggregate (e.g., state)-level information on inequality would be suitable for testing this hypothesis.

3. *Effect of Inequality on Perceptions of Equity and Levels of Stress.* The absolute level of income surely affects health, especially if that income level is very low. It is also possible that one's *relative* position in the income distribution matters. Wilkinson (1992a; 1996) argues that, in developed nations, levels of depression, isolation, insecurity, and anxiety are associated with relative position. Kawachi et al. (1994; 1997) argue that the effect of income inequality per se on health may be due to people's perception of societal fairness. Citing evidence that mortality can also increase during periods of rapid economic growth, they suggest that unfulfilled expectations can lead to frustration and stress.

Here again, microlevel observations on individuals' health would be invaluable in testing these kinds of hypotheses. With such data, we would expect to observe residents of political units with high levels of inequality to report the greatest number of mental health symptoms and to find that a person's relative position within the income distribution of such a unit predicts his or her health status, even in the face of adjustments for absolute income level.

4. *Shared Health Risks of Inequality-Induced Increases in Poverty.* An increase in the proportion of the population with few resources may lead to certain outcomes: an overburdened health-care system; an increase in unhealthy antisocial behavior (e.g., crime); a reduction in the effectiveness of preventive health care (e.g., campaigns to eradicate against tuberculosis); and other conditions that threaten the health of the entire population.

Considerable empirical evidence suggests strong correlations between inequality and some of these mediators. For example, Kaplan et al. (1996a) show striking negative income level-adjusted associations at the state level between inequality and rates of homicides (-.74), violent crimes (-.70) and per capita medical care expenditures (-.67).

An implication of this hypothesis is that it is important to distinguish the degree to which increases in inequality can be traced to a fall in the incomes of the poor rather than to a rise in the incomes of the rich. Only the former situation would be expected to produce the detrimental effects associated with this explanation. Furthermore, intervening variables, like health-care quality, crime, and successful preventive health care, might account for the bulk of the association between inequality and health.

5. *Shared Health Benefits of Inequality-Induced Increases in Affluence.* This represents the reverse of the previous possibility. An increase in the number of affluent families may have positive effects on a population's health through a number of hypothetical mechanisms: increases in the level of medical technology (e.g., magnetic resonance imaging) available to the population; increases in the quality of other public services (e.g., schooling, parks and recreational areas, crime prevention); and a more enlightened and efficient government sector. It is also quite possible that increases in the wealth of rich families may have negative effects on health if, for example, the economic isolation of the rich renders them insensitive to the needs of the poor and reduces their feelings of altruism.

All in all, it is important to distinguish the degree to which recent increases in inequality have come about because the poor have less income and the rich have more. It is unlikely that the health of the poor has benefited from a decrease in their absolute and/or relative incomes. However, increasing the affluence of the rich may have either detrimental or beneficial health consequences, and these consequences may differ for poor, middle-class, and affluent individuals. Our empirical work

examines the differential health effects of inequality by the income class of individuals. However we leave to future work an analysis of the extent to which intervening variables, like medical technology and the quality of public services, account for the association between inequality and health.

Empirical Links between Inequality and Health

The empirical associations between health and the extent of inequality in a political unit are best known from the work of Richard Wilkinson (e.g., 1992a,b; 1996), who relates income inequality to life expectancy across countries in the Organization for Economic Development and Cooperation (OECD) and finds strikingly negative associations, even after controlling for cross-country differences in income level. Kaplan et al. (1996a,b) and Kennedy, Kawachi, and Prothrow-Stith (1996) document similar associations across individual states in the United States. Lynch et al. (1998) further demonstrate that associations between income inequality and health in U.S. metropolitan areas are largely independent of differences in the size, population, average household size, per capita income, and proportion of low-income households. Overall, Wilkinson (1996) reports that significant negative associations between inequality and health have been found by at least eight difference research groups working from ten separate data sets.

Judge's (1995) replication and extension of two analyses found in Wilkinson's papers led him to question the strength of the inequality-health associations. He found that the international correlations are quite sensitive to the particular measure of inequality and income because seemingly innocuous changes (e.g., from income per household to income per person) affect the strength of the evidence. Wilkinson (1996) himself notes some of these kinds of sensitivities, although he characterizes the weight of the evidence on links between health and inequality as "overwhelming."

In the case of cross-state differences in inequality and health in the United States, it appears that the associations between income inequality and mortality are not sensitive to the measure of inequality that is used (Kawachi et al. 1997; Lynch et al. 1998) or to the specific measure of income (Kaplan and Lynch 1997; Kawachi and Kennedy 1997). In addition, Kaplan et al. (1996b) and Kennedy, Kawachi, and Prothrow-Stith (1996b) show that using equivalent incomes and distributions of

disposable income does not affect their results. Because measures of income inequality may have different influences on health, it is necessary to experiment with a wide variety of inequality measures in order to establish the nature and robustness of the links between inequality and health.

Although much of the work on inequality has focused on describing patterns and itemizing their causes, the mortality-inequality literature represents research designed to measure the effects of inequality on social outcomes. From a policy perspective, this type of research is critical. If inequality is shown to have a lasting impact on outcomes like health, then it may be beneficial and efficient to minimize inequality instead of designing policies to correct differences in outcomes. In contrast, if inequality has little or no impact on measurable outcomes, then it will be placed in the realm of a social or moral issue rather than an economic one. It is in this context that we proceed.

Data and Methods

Data

Two data sources are used for our original empirical analyses. The sources of our measures of state-level mortality, income level, and income inequality are identical to those used by Kaplan's group (1996a). State-level mortalities for 1980 and 1990 were based on the National Center for Health Statistics Compressed Mortality File and were adjusted for age by dividing the age distribution into 13 groups. Income level and inequality were measured according to state-specific data on the 10th, 20th, 50th (median), 80th, and 90th household income percentiles taken from the 1980 and 1990 decennial censuses.

The source of individual-level data was the Panel Study of Income Dynamics (PSID), an ongoing longitudinal study of a representative sample of individuals living in the United States and of the family units in which they reside. The PSID began in 1968, with mortality follow-up through 1994; its emphasis is on the dynamic aspects of economic and demographic behavior. Starting with a representative stratified national sample of U.S. households and individuals in 1968, the PSID has collected data on individuals from those households annually, with an initial response rate of 76 percent in 1968. Sample attrition was 11 percent between 1968 and 1969 and has remained stable between 2

percent and 3 percent each year since 1969. Approximately 55 percent of the still-living original sample of individuals continued to participate in the study in the interviewing year 1995.

The rules established for the PSID (e.g., children are tracked when they leave parental homes and form independent households; children born to original members of the sample become sample members themselves) provide (apart from immigration) a continuously representative sample of the U.S. population in years subsequent to 1968. The original PSID sample was selected to be representative of the nation and of the four major census regions. Geographic mobility of sample families since 1968 has led to sample residence in all U.S. states. Although its size prevents it from being representative within all states, the overall PSID sample still reflects both the United States as a whole and the major demographic dimensions that characterize states, including high-, medium-, or low-income inequality.

Probability-of-selection weights are available to adjust for differential nonresponse not related to mortality, as well as the design-driven, unequal selection probabilities of the original sample. Studies evaluating the national representativeness of the surviving PSID sample at various points (including 1980 and 1990) have found no significant problems (Moffitt, Gottschalk, and Fitzgerald 1995). Appendix table 1, which compares income data in the decennial census and the PSID in 1980 and 1990, also shows close agreement.

Death is recorded as a reason for attrition from the sample. In the majority of instances, deaths are reported in the next annual interview by surviving household members. For persons who were living alone when last interviewed, information about death comes from a variety of sources: a surviving contact person; the administrator of the deceased person's estate; or the post office via returned mail. Comparisons of the PSID and vital statistics mortality data from the National Center for Health Statistics (NCHS) show generally close agreement.

Our analyses of PSID data are based on two subsamples. The first consists of individuals aged 25 and older who were present in interviewed households in 1978 and whose possible mortality was tracked between 1978 and 1982. The mortality experiences of these individuals will be related to state-of-residence inequality in 1980. The second consists of individuals aged 25 and older who were present in interviewed households in 1988 and whose possible mortality was tracked between 1988 and 1992. The mortality experiences of these individuals

will be related to state-of-residence inequality in 1990. There were 341 deaths in the first period and 375 in the second. Data on household income, sex, and age of these individuals are drawn from the 1978 and 1988 interviews.

Measures

State-level inequality is measured in several ways. Our first measure (labeled "Kaplan") is from Kaplan et al. (1996a) and is the proportion of the total household income in each state that is received by the less affluent 50 percent of the population. This and all other inequality measures are calculated from both the 1980 and 1990 censuses.

Our second set of measures of inequality is more common in the social sciences literature: the ratio of the 90th to the 10th percentile and the ratio of the 80th to the 20th percentiles of the household income distribution for each state. The use of both 90th:10th and 80th:20th percentiles provides evidence on the robustness of our results.

Our third set of measures allows for asymmetry in the distribution of income. Specifically, the first set is the ratio of (a) the 90th percentile to the 50th percentile and (b) the 80th percentile to the 50th percentile. The second set is the ratio of (c) the 50th percentile to the 10th percentile and (d) the 50th percentile to the 20th percentile. The former pair of measures reflects dispersion at the high end of the income distribution; the latter pair measures dispersion at the low end.

Results

Trends in Inequality

Table 1 presents means, standard deviations, and correlations among our state-level inequality measures for 1980 and 1990. Increases in the extent of inequality are apparent in all the measures. Kaplan's measure of the share of income received by the lowest 50 percent of households fell from .22 to .21, a decline of about one standard deviation. The ratio of the income levels defining the top and bottom deciles of the income distribution increased from 9.16 to 9.86, which is more than half the 1980 standard deviation. The corresponding ratio of the income levels defining the top and bottom quintiles of the income distribution increased from 4.08 to 4.23, which is nearly half the 1980 standard deviation.

TABLE 1
Correlations between Measures of State-Level Income Inequality, 1980 and 1990

State-level measures of income inequality ^a	Means (SD)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Overall inequality															
1980 Kaplan	0.22 (0.012)	1.00													
1980 90:10	9.16 (1.030)	-0.93	1.00												
1980 80:20	4.08 (0.370)	-0.96	0.94	1.00											
1990 Kaplan	0.21 (0.014)	0.90	-0.83	-0.89	1.00										
1990 90:10	9.86 (1.610)	-0.87	0.87	0.90	-0.95	1.00									
1990 80:20	4.23 (0.463)	-0.86	0.83	0.92	-0.96	0.97	1.00								
Poverty sensitive															
1980 50:10	4.02 (0.306)	-0.76	0.93	0.83	-0.75	0.82	0.77	1.00							
1980 50:20	2.33 (0.134)	-0.85	0.91	0.95	-0.85	0.88	0.91	0.91	1.00						
1990 50:10	4.08 (0.435)	-0.80	0.85	0.86	-0.90	0.97	0.93	0.83	0.88	1.00					
1990 50:20	2.33 (0.157)	-0.77	0.77	0.87	-0.90	0.93	0.97	0.77	0.92	0.94	1.00				
Affluence sensitive															
1980 90:50	2.28 (0.113)	-0.92	0.82	0.83	-0.73	0.70	0.67	0.55	0.63	0.60	0.54	1.00			
1980 80:50	1.75 (0.068)	-0.94	0.82	0.88	-0.78	0.75	0.75	0.56	0.70	0.66	0.63	0.98	1.00		
1990 90:50	2.40 (0.133)	-0.91	0.81	0.85	-0.96	0.90	0.89	0.67	0.75	0.80	0.79	0.81	0.84	1.00	
1990 80:50	1.81 (0.081)	-0.91	0.83	0.90	-0.96	0.91	0.94	0.69	0.82	0.82	0.83	0.79	0.85	0.97	1.00

^aInequality measures are defined as follows: (1) Kaplan measure is the percent of income held by the bottom 50 percent of the population; (2) percentile measures are defined as income level at the first percentile divided by income level at the second percentile, e.g., the 90:10 measure is the income level at the 90th percentile divided by the income level at the 10th percentile.
Sources: Authors' calculations based on census data.

That inequality at the top increased more than inequality at the bottom is seen in a comparison of changes in the "poverty sensitive" and "affluence sensitive" measures listed in the table. At the high end of the distribution, the ratios of the 90th to the 50th and the 80th to the 50th percentiles both increased by nearly one standard deviation. In contrast, the ratio of the 50th to the 10th percentile increased by less than one-fifth of a standard deviation, and the ratio of the 50th to the 20th percentile did not change at all.

Not surprisingly, the cross-state correlations among the inequality measures in either 1980 or 1990 are quite high, often above .90. The measure of inequality at the bottom of the distribution, the 50:10 ratio, tends to have the weakest associations with the other measures. Interestingly, the .55 correlation in 1980 between inequality in the upper and lower halves of the distribution is among the weakest. This indicates that states with thick tails at the low end of their income distributions were only modestly more likely to have thick tails at the top. Correlations between the measures across the decade of the 1980s are generally in the .80 to .90 range.

State-Level Links between Inequality and Mortality

Table 2 presents state-level associations between inequality and mortality. The first two columns of the first row of the table reproduce the data from Kaplan et al. (1996a), which show strong ($-.45$ and $-.62$) and highly significant correlations between NCHS-based measures of state-level mortality and the "Kaplan" inequality measure in both 1980 and 1990. The next two columns of the first row show that these correlations change little in the presence of adjustments for state differences in median income level.

The second row in the table switches the inequality measure from Kaplan's to a more conventional one, based on the ratio of the 90th to the 10th percentiles of the state income distribution. In contrast with Kaplan's measure, higher values on this ratio indicate a greater degree of inequality, so the correlations with mortality are expected to be positive rather than negative. The magnitude of the correlations is slightly stronger with the 90:10 measure than with the "income received by the bottom 50%" measure used by Kaplan's group, and none of the measures is affected much by adjustments for differences in the state's level

TABLE 2
State-Level Zero Order and Adjusted Correlations between Income Inequality and Age-Adjusted Mortality
in the United States, 1980 and 1990

State-level inequality measures ^a	Zero order ^b		Adjusted for state median income ^b		Change in mortality and inequality, 1980-90 ^b	
	1980	1990	1980	1990	Zero order	Adjusted for state median income
Overall inequality						
Kaplan	-0.454 (0.0001)	-0.616 (0.0001)	-0.440 (0.002)	-0.581 (0.0001)	0.029 (0.838)	0.033 (0.823)
90:10	0.567 (0.0001)	0.690 (0.0001)	0.554 (0.0001)	0.663 (0.0001)	0.414 (0.0028)	0.415 (0.003)
80:20	0.524 (0.0001)	0.657 (0.0001)	0.518 (.0001)	0.635 (0.0001)	0.131 (0.3660)	0.134 (0.357)
Poverty sensitive						
50:10	0.607 (0.0001)	0.720 (0.0001)	0.605 (0.0001)	0.696 (0.0001)	0.474 (0.0005)	0.475 (0.0001)
50:20	0.564 (0.0001)	0.669 (0.0001)	0.554 (0.0001)	0.644 (0.0001)	0.167 (0.2471)	0.167 (0.253)
Affluence sensitive						
90:50	0.330 (0.019)	0.534 (0.0001)	0.300 (0.036)	0.484 (0.0004)	0.097 (0.5028)	0.100 (0.492)
80:50	0.356 (0.011)	0.558 (0.0001)	0.330 (0.020)	0.515 (0.0002)	0.001 (0.994)	0.003 (0.986)

^aSee table 1 for definition of inequality measures.

^bP values are in parentheses

Source: Authors' calculations based on census data.

of income. Similar patterns are observed when the measure of income inequality is based on the 80th and the 20th percentile cutpoints.

The bottom half of table 2 presents correlations separately for the two components of income inequality. Turning first to the poverty-sensitive measures of income dispersion (the ratio of the 50th to the 10th and the 50th to the 20th percentiles), it can be seen that state-level mortality has a strong association with inequality at the bottom end of the income distribution: the deeper the poverty of the poor, the higher the state level of mortality. These associations are considerably stronger than any revealed by the Kaplan measure and are consistently stronger than those found with the 90:10 and 80:20 ratio measures. The bottom panel of table 2 shows that dispersion in the upper half of the income distribution has considerably weaker associations with mortality, especially in 1980.

Estimates of changed correlations in inequality and health between 1980 and 1990 are listed in the fifth and sixth columns of table 2, and they offer a much stricter test of the inequality-mortality association (see Appendix 2, note 1). The pattern of correlations clearly shows that the only inequality measures that are strongly linked to mortality are those comparing the very bottom of the income distribution (10th percentile) with the rest. Thus, with regard to health consequences, table 2 correlations appear to support theories that emphasize spillover effects of increased poverty, such as an overburdened health care system or an increase in antisocial behavior that affects the general population.

Linked State and Individual Data

In tables 3 and 4 we use data from the PSID to move from the aggregate state level to the individual level. Our analysis is based on logistic regressions, in which individual mortality risk over the five-year period surrounding the 1980 and 1990 censuses is related to state-level income inequality in 1980 or 1990. All of our regressions control for age, race, sex, and median state income. (The addition of a control for family size, which effectively converts the family income measure into a size-adjusted poverty measure, had no effects on the results presented in these two tables.) For each inequality measure, we ran two logistic regressions, first excluding and then including the individual's own household income. Differences between these two models show the ex-

TABLE 3
 Individual-Level Logistic Regression Coefficients Showing the Relation between Inequality and Log Odds of Five-Year Mortality
 (1980 and 1990) for Individuals Aged 25 and Older

State-level inequality measures ^a	Not controlling for family income ^b		Controlling for family income ^b	
	1980	1990	1980	1990
Overall inequality				
Kaplan	-3.29 (7.49)	-7.79 (5.74)	-3.58 (7.46)	-6.80 (5.75)
90:10	0.054 (0.082)	0.054 (0.046)	0.052 (0.082)	0.046 (0.046)
80:20	-0.002 (0.244)	0.197 (0.164)	0.004 (0.244)	0.166 (0.165)
Poverty sensitive				
50:10	0.156 (0.265)	0.181 (0.160)	0.131 (0.265)	0.160 (0.160)
50:20	-0.099 (0.613)	0.525 (0.461)	-0.115 (0.613)	0.439 (0.463)
Affluence sensitive				
90:50	0.276 (0.682)	0.463 (0.508)	0.350 (0.681)	0.364 (0.510)
80:50	0.278 (1.28)	0.944 (0.943)	0.403 (1.27)	0.792 (0.946)

^aSee table 1 for definition of inequality measures.

^bStandard errors are in parentheses.

Sources: Authors' calculations based on census data and PSID data.

TABLE 4
Individual-Level Logistic Regression Coefficients Showing the Relation between Inequality and Log Odds
of Five-Year Mortality by Age Group and Income Status, 1980 and 1990 PSID Cohorts

State-level inequality measures ^a	Individuals aged 25 to 64 ^b						Individuals aged 65+ ^b						Individuals aged 25 to 64 with middle income ^b			
	Not controlling for family income		Controlling for family income		Not controlling for family income		Controlling for family income		Not controlling for family income		Controlling for family income		Not controlling for family income		Controlling for family income	
	1980	1990	1980	1990	1980	1990	1980	1990	1980	1990	1980	1990	1980	1990	1980	1990
Overall inequality																
Kaplan	3.84		2.64	-0.942	-7.32	-9.81	-7.16	-9.71	8.16	-20.72	10.98	-23.40				
	(12.23)		(12.17)	(9.47)	(10.29)	(7.59)	(10.26)	(7.60)	(17.03)	(14.86)	(16.91)	(15.06)				
90:10	0.085		0.096	0.028	0.040	0.060	0.033	0.060	0.017	0.170	-0.021	0.202				
	(0.138)		(0.136)	(0.077)	(0.111)	(0.060)	(0.111)	(0.060)	(0.182)	(0.115)	(0.181)	(0.117)				
80:20	0.240		0.281	0.140	-0.125	0.197	-0.134	0.197	-0.085	1.102	-0.153	1.187				
	(0.411)		(0.409)	(0.274)	(0.331)	(0.215)	(0.331)	(0.216)	(0.564)	(0.404)	(0.562)	(0.410)				
Poverty sensitive																
50:10	0.629		0.656	0.176	-0.057	0.192	-0.106	0.192	0.511	0.962	0.381	1.06				
	(0.440)		(0.435)	(0.280)	(0.361)	(0.205)	(0.362)	(0.205)	(0.561)	(0.415)	(0.562)	(0.423)				
50:20	1.293		1.390	0.437	-0.784	0.556	-0.852	0.562	0.987	4.213	0.849	4.402				
	(1.02)		(1.04)	(0.738)	(0.838)	(0.599)	(0.841)	(0.600)	(1.36)	(1.183)	(1.36)	(1.97)				
Affluence sensitive																
90:50	-0.912		-0.833	-0.252	0.935	0.625	0.999	0.616	-1.78	-0.370	-1.96	-0.132				
	(1.08)		(1.08)	(0.839)	(0.956)	(0.673)	(0.955)	(0.673)	(1.58)	(1.36)	(1.59)	(1.35)				
80:50	-1.54		-1.39	0.345	1.25	0.893	1.35	0.870	-4.07	2.35	-4.37	2.86				
	(2.04)		(2.03)	(1.58)	(1.78)	(1.24)	(1.77)	(1.24)	(2.96)	(2.40)	(2.97)	(2.44)				

^aSee table 1 for definition of inequality measures.

^bStandard errors are in parentheses.

Sources: Authors' calculations based on census data and PSID data.

tent to which the individual's own household income accounts for the relation between inequality and mortality.

Table 3 presents results for these regressions that were run on the full sample of PSID adults aged 25 and older. Table 4 presents results from PSID subsamples defined by age (25 to 64 and 65+) and income (at the federal poverty level [FPL] and at five times the FPL). Considerable experimentation across sample subgroups indicated that these selections produced the most interesting results on the links between inequality and mortality.

Surprising in the full sample results in table 3 is the absence of significant effects of inequality on mortality risk. The varying magnitudes of the coefficients and standard errors on the inequality measures reflect, in part, the very different methods of scaling these measures (see the standard deviations in column 1 of table 1 and note 2 of Appendix 2). Although increased mortality is always associated with greater inequality, the effect sizes are small, virtually all of the coefficients are less than their associated standard errors, and none attains conventional levels of statistical significance.

Subgroup results presented in table 4 show more interesting patterns. The division of the sample by age generally shows detrimental (i.e., higher mortality risks), but statistically insignificant effects of inequality on mortality risks for both the elderly and the nonelderly. Patterns between the age groups differ for the divided 90:10 measure. Inequality at the high end of the income distribution (captured by the 90:50 measure) has a negative association with mortality risk among the nonelderly; among the elderly, its association with mortality is positive. However, in none of these cases are the relevant coefficients statistically significant, so it is unwise to engage in much speculation about the differences.

Considerable experimentation with subgroups classified by household income showed that the middle-income nonelderly were the only group for whom inequality has a statistically significant (and, in this case, detrimental) effect on mortality risk. The inequality measures producing the most significant correlation with mortality were the poverty-sensitive ones: the ratio of household income of the 50th to the 10th and the 50th to the 20th percentiles, both of which emphasize the thickness of the tail at the low end of the income distribution. In this case, the effect sizes are noteworthy, are increased with adjustment for individual income, but are also quite sensitive to whether the model is fit to

1980 versus 1990 data (see note 3, Appendix 2). All in all, to the extent that inequality produces spillover effects, it appears that middle-income individuals aged 25 to 64 are most affected by increasing inequality at the low end of the income distribution.

Discussion

A growing literature suggests links between inequality and health. We argue that it is important, both theoretically and empirically, to distinguish between inequality increases resulting from (a) a higher concentration of poor families at the bottom end of the distribution and (b) a higher concentration of rich families at the top end of the distribution. Although most of the recent increase in inequality in the United States is due to increased income among the middle and upper levels of the income distribution, it can also be traced to the worsened situation of the poor. Empirically, the mortality correlations are stronger for measures that stress the depth of poverty rather than the height of affluence.

Our second contribution is to extend the empirical literature by relating state-level inequality measures to individual-level health. We use longitudinal (PSID) data for the years 1978 to 1982 and 1988 to 1992 to relate state-level income inequality to the five-year, age-adjusted mortality risk of individuals. We fail to find significant links between inequality and mortality, except in the case of those with middle incomes between the ages of 25 and 64. In this exceptional case, it was again the depth of relative poverty among the state's poor rather than the height of affluence of the state's rich that was critical.

The results of our analyses are not consistent with the analysis of the association between the Kaplan measure and mortality in another cohort that is representative of the United States (Fiscella and Franks 1997). In this latter study, a significant association between the Kaplan measure and mortality risk was no longer significant when it was adjusted for individual income. The PSID analyses revealed no significant overall association, and the impact of adjustment for individual income was inconsistent. These differences could be related to the larger sample size and longer time allotted to the epidemiological follow-up study of the first sample used by Fiscella and Franks from the National Health and Nutrition Examination Study (NHANES), or to the lower level of aggregation (county-like versus state primary sampling units). This

underscores the need to examine these relations in other data sets using a variety of measures of income inequality and differing levels of aggregation.

Overall, our findings indicate the importance of moving beyond single measures of income inequality to measures that reflect income differences between particular economic strata. They also point to the need for further studies of the impact of inequalities in income distribution on the health of individuals. Both kinds of activities will be critical to determining by what mechanisms, in what circumstances, and in what segments of the population income distribution influences health.

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Appendix 1: Table

Means and Standard Deviations of State Income Percentile Cutpoints in Data from the Decennial Census and the Panel Study of Income Dynamics, 1980 and 1990^a

State income percentile cutpoints	1980	1990
	Means (SD)	Means SD
Census data		
10th	6,891 (1,136)	7,563 (1,792)
20th	11,896 (2,036)	13,179 (3,036)
50th	27,504 (4,039)	30,351 (5,799)
80th	48,126 (6,518)	54,731 (9,408)
90th	62,441 (8,801)	72,625 (12,783)
PSID data		
10th	6,808 (949)	7,527 (1,604)
20th	11,861 (1,748)	13,291 (2,744)
50th	27,814 (3,400)	31,262 (5,302)
80th	48,813 (5,040)	56,980 (8,861)
90th	63,438 (6,652)	76,323 (12,279)

^aIn 1991 dollars.

Sources: Authors' calculations based on census data and PSID data.

Appendix 2

Note 1: Although the fixed-effects estimates of correlations shown in table 2 difference out the spurious effect of any persistent, health-related characteristic of states, they may induce a downward bias in the inequality–health relation if the process by which inequality affects health takes time to unfold. Suppose that mortality in, say, 1990 in state i ($M_{i,90}$) is causally affected by inequality but that the health effects of inequality are a gradual process, involving both current ($I_{i,90}$) and prior

(I_{i80r}) levels of inequality as well as persistent characteristics of the state (X_i). Thus:

$$(1) M_{i90} = a + b_1 I_{i90} + b_2 I_{i80r} + b_3 X_i.$$

If a comparable relation existed in 1980, then we have:

$$(2) M_{i80} = a + b_1 I_{i80} + b_2 I_{i70r} + b_3 X_i.$$

Differencing (1) and (2) and using " Δ " to denote change between 1980 and 1990 results in:

$$(3) \Delta M_i = b_1 \Delta I_i + b_2 (I_{i80r} - I_{i70r}).$$

The change formulation has indeed successfully eliminated the spurious effects of the X factors, but the estimate of b_1 is still biased by the product of correlations between (a) ΔM and ($I_{80r} - I_{70r}$) and (b) ΔI and ($I_{80r} - I_{70r}$).

Note 2: Using the coefficients in the fourth column of table 3 to illustrate, a standard deviation (i.e., -.014) increase in 1990 inequality as measured by the Kaplan measure is associated with a risk ratio of 1.10 ($= e^{-.014 \times -6.80}$), while a one standard deviation (i.e., 1.61) increase in the 90:10 inequality measure in 1990 is associated with a 1.08 ($= e^{1.61 \times 0.46}$) risk ratio.

Note 3: To illustrate effect sizes, consider the "1.06" coefficient on the 50:10 inequality measure in 1990 (twelfth column). A one standard deviation (.435) increase in inequality is associated with a 1.59 ($= e^{.435 \times 1.06}$) risk ratio. The corresponding risk ratio for the 50:20 measure is 2.00 ($= e^{.157 \times 4.402}$).