Income Inequality and Socioeconomic Gradients in Mortality

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The nature of the association between income distribution and population health is of crucial importance to public health. The United States has wider income differences and a lower life expectancy than other developed countries, which appears to fit the international correlation between the 2.[1] Likewise, life expectancy among the 50 states also appears to be correlated with state income distribution.[2] However, despite a growing body of research and supportive findings from a large majority of published papers, disagreement remains about whether income inequality is a determinant of population health,[3,4] the nature of the processes through which it might influence population health, and how those processes might be related to the causes of health inequalities. A deeper understanding of these issues may pave the way for policymakers to improve population health and reduce health inequalities.

An initially plausible hypothesis is that both the socioeconomic gradient in health and the association between health and income distribution reflect the effects of socioeconomic disadvantage on health; if narrower income differences reduce disadvantage, they might improve average health by reducing health disparities. However, it is also possible that any effects of income distribution could reflect quite separate causal processes from those responsible for the socioeconomic gradient in health. Although health disparities are sometimes attributed primarily to material and behavioral factors such as smoking, diet, bad housing, and lack of health care,[5–7] we and others have suggested that income inequality is more likely to influence health through processes of social comparison.[8–10] It is even possible that there are 2 completely separate domains: health inequalities may reflect the direct effects of material living standards, and income inequality may reflect the psychosocially mediated effects of social comparisons.

Determining whether income inequalities work through the same or different processes

Objectives. We investigated whether the processes underlying the association between income inequality and population health are related to those responsible for the socioeconomic gradient in health and whether health disparities are smaller when income differences are narrower.

Methods. We used multilevel models in a regression analysis of 10 age- and cause-specific US county mortality rates on county median household incomes and on state income inequality. We assessed whether mortality rates more closely related to county income were also more closely related to state income inequality. We also compared mortality gradients in more- and less-equal states.

Results. Mortality rates more strongly associated with county income were more strongly associated with state income inequality: across all mortality rates, $r=-0.81$; $P=.004$. The effect of state income inequality on the socioeconomic gradient in health varied by cause of death, but greater equality usually benefited both wealthier and poorer counties.

Conclusions. Although mortality rates with steep socioeconomic gradients were more sensitive to income distribution than were rates with flatter gradients, narrower income differences benefit people in both wealthy and poor areas and may, paradoxically, do little to reduce health disparities. (*Am J Public Health.* 2008;98:699–704. doi:10.2105/AJPH.2007.109637)

from those responsible for health disparities is complicated by our lack of precise knowledge of the causal processes for either. Therefore, it would be informative to examine whether mortality rates that have steep socioeconomic gradients are also those most strongly related to income inequality and whether mortality rates that have little or no socioeconomic gradient have little or no relation to income inequality. Are mortality rates that are sensitive to the causes of health disparities also sensitive to income inequality?

METHODS

We measured the strength of the relation between median county income and 10 different mortality rates across all 3139 counties in the United States. We used county-level data instead of individual-level data to measure socioeconomic gradients in health because individual-level data on mortality by income were not available by age and cause of death for each state. In multilevel models, we also measured the strength of the relationship between county mortality rates and state income inequality, conditional on county median incomes. We then compared

how strongly each mortality rate was related to county median income with how strongly related it was to state income inequality. Finally, we investigated how health inequalities, as measured by the gradients between the mortality rates and county median income, were affected by differences in state income inequality.

County- and State-Level Data

We took data on median household income for all 3139 US counties, in 1999 dollars, from the US Census 2000 Summary File 3.[11] Mortality was drawn from the Compressed Mortality File, a county-level national mortality and population database. For each county we extracted 10 mortality rates: infant mortality, all-cause working-age mortality (mortality among those of working age, 25–64 years), all-cause elderly mortality (among those aged ≥ 65 years), ischemic heart disease mortality, mortality from diseases of the respiratory system, and mortality from diabetes mellitus, breast cancer, prostate cancer, alcoholic liver disease (liver disease caused by alcohol consumption), and homicide. Except for breast and prostate cancer, all mortality rates were for both genders

TABLE 1—Associations of Mortality Rates With County-Level Median Household Income and State-Level Income Inequality: United States, 1999–2002

	Single-Level Analyses of County-Level Income		Multilevel Analyses of State-Level Income Inequality (Adjusted for County-Level Income)	
Mortality Rate	Rate per 100 000, Mean (SD)	Correlation (r) With County-Level Income	Standardized Parameter Estimate for State-Level Income Inequality	Significant Interaction Between Income and Income Inequality (P < .1)
Infant	730 (443)	0.204***	0.118**	No
All causes, working age[a]	390 (113)	0.533***	0.328***	Yes
All causes, elderly[b]	5298 (711)	0.198***	0.211*	No
Ischemic heart disease	180 (50)	0.263***	0.213**	Yes
Respiratory disease	90 (23)	0.203***	0.161**	Yes
Diabetes	27 (12)	0.231***	0.078	No
Breast cancer	25 (9.5)	0.006	0.059	No
Prostate cancer	12 (6)	0.116***	–0.014	No
Alcoholic liver disease	4 (4)	0.167***	0.024	Yes
Homicide	4 (5)	0.309***	0.255***	Yes

[a]Aged 25–64 years.
[b]Aged 65 years or older.
*$P < .05$; **$P < .01$; ***$P < .001$.

combined. All rates except that for infant mortality were age-adjusted rates per 100 000 population and were averaged over the 4-year period of 1999 to 2002.

We used published information[12,13] to select age- and cause-specific mortality rates that would include cause-specific mortality rates with contrasting strong and weak socioeconomic gradients as well as all-cause mortality rates for contrasting age groups covering a large majority of all deaths.

For each mortality rate, we excluded from analysis any county for which the mortality was zero and the population was not sufficiently large to expect at least 1 death during the 4-year period. We also excluded a few counties (usually fewer than 8) for which an implausibly high mortality, usually attributable to small numbers, made them extreme outliers. After these exclusions, county mortality rates were approximately normally distributed. Means and standard deviations are shown in Table 1.

Data on income inequality for the 50 US states were taken from the US Census Bureau.[14] Income inequality was measured as the Gini coefficient of family income for 1999. Gini coefficients vary between 0 (complete equality) and 1 (maximum inequality—all income to a single recipient).[15]

Statistical Analysis

Our statistical analyses were designed to answer 2 questions: Are causes of death with steeper socioeconomic gradients more closely associated with income inequality than those with flatter gradients? How does the socioeconomic gradient in mortality differ in more- and less-equal states?

Association of income inequality and causes of death. We first performed a single-level ecological analysis at the county level to assess the steepness of the socioeconomic gradient by estimating the Pearson correlation coefficient for each mortality rate in relation to county median household income. We then examined the contextual effect of state-level income inequality on county-level mortality, independent of county-level median income, in multilevel mixed-effects linear regression models, with a random effect of state. We used z scores of mortality rates (mean=0; SD=1) to compare the multilevel model coefficients for different causes of death. We also used z scores of state-level income inequality so that the standardized parameter estimates (B) for income inequality from these models could be interpreted as correlation coefficients.

Across all mortality, we compared the strength of the association between state-level income inequality with the strength of the mortality gradient with median county income. To do this we estimated the Pearson correlation coefficient between the correlations with county-level income from the single-level models and the correlation coefficients for state-level income inequality the B's from the multilevel models. The association between mortality and state income inequality was therefore a contextual effect of income inequality conditional on county median incomes.

Socioeconomic gradients in more- and less-equal states. We categorized states into 2 equal groups of high- and low-inequality states and tested for a crosslevel interaction between these categories of state-level income inequality and county-level income in relation to county mortality in multilevel models. In these models, we interpreted $P \le .10$ as indicating statistically significant interaction effects. For causes of death with statistically significant interactions, we graphed the socioeconomic gradients in mortality for more- and less-equal states. All analyses were conducted with Stata version 9 (StataCorp LP, College Station, TX).

RESULTS

Nine of the 10 mortality rates had statistically significant negative gradients by county-level median income (Table 1). There was no socioeconomic gradient in breast cancer mortality.

Multilevel regression analysis, accounting for the clustering of counties within states, showed that state-level income inequality was related to 6 of the 10 mortality rates independently of differences in county incomes in each state. These included infant mortality and all-cause mortality for the working-age population and the elderly, as well as cause-specific mortality for heart disease, respiratory disease, and homicides. Deaths caused by diabetes, breast and prostate cancers, and alcoholic liver disease—all with weak or nonexistent socioeconomic gradients—were unrelated to state income inequality in these models. We then held county-level median household income constant to obtain the contextual effect of income inequality only. We found that a 1-standard-deviation increase in state-level income inequality was associated with increased
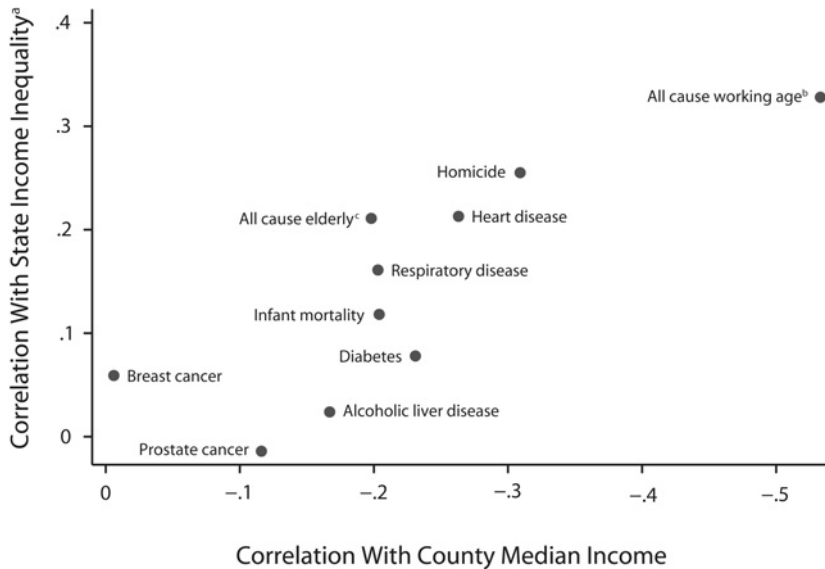
Note. r = –0.814; P = .004.
[a] Standardized parameter estimates (B) from multilevel model after county-level income was controlled.
[b] Aged 25–64 years.
[c] Aged ≥65 years.

FIGURE 1—The effect of county-level median household income in relation to contextual effect of state-level income inequality.

mortality per 100 000 of 38 deaths among the working-age population, 150 for deaths among the elderly, 52 for deaths among infants, 11 for deaths from ischemic heart disease, 4 for deaths from respiratory disease, and 1 for deaths from homicide.

Figure 1 shows that there was a clear tendency for the strength of the 10 mortality rates correlations with county-level median income to be related to the strength of their correlations with the contextual effect of state-level income inequality. The stronger the relation with county median income, the stronger the relation with state inequality (r=−.0814; P=.004).

Statistically significant interactions between county-level median income and state-level income inequality (showing that greater equality does not have the same effect on mortality in wealthier and poorer counties) were found for 5 of the 10 causes of death. For all-cause mortality among the working-age population, mortality from respiratory disease, and mortality from homicide, the socioeconomic gradient was flatter in more-equal states compared with less-equal states, and

more-equal states had lower mortality at any given level of county median income, as illustrated in Figure 2. For mortality from ischemic heart disease, the socioeconomic gradient was marginally steeper in more-equal states; people living in wealthier counties appeared to benefit slightly from greater state equality than did people living in poorer counties. For mortality from alcoholic liver disease, the socioeconomic gradients crossed over; compared with the socioeconomic gradients in more-equal states, greater inequality was associated with higher mortality from alcoholic liver disease in wealthier counties and lower mortality in poorer counties. There were no significant interaction effects for all-cause mortality among the elderly or for infant mortality, suggesting that greater state equality benefited wealthy and poor counties alike.

DISCUSSION

Causal Processes

Our findings show that mortality that was more strongly related to county median income was also more strongly associated with

state-level income inequality. This suggests that the factors responsible for the tendency for more-egalitarian societies to have better health may be closely related to those factors that account for the socioeconomic gradient in health. We believe this is the first demonstration of links between health inequalities and effects of income distribution.

Rather than suggesting compositional reasons for worse health in more-unequal states—resulting from lower incomes in less-equal compared to more-equal states—our results reveal strong contextual effects of inequality. A contextual effect of state income inequality means that even counties (or people) at the same level of income will have lower mortality if they are in more- rather than in less- equal states. After adjusting for differences in county median incomes, we found more-equal states had lower rates of infant mortality and both of the age-specific all-cause mortalities as well as of 3 cause-specific mortalities (homicide, heart disease, and respiratory disease) than did less-equal states.

For each mortality rate, the strength of its relation to these contextual effects of state inequality was related to the strength of its relationship to county median income (Figure 1). Only death from diabetes and the 3 mortalities most weakly related to county income (breast cancer, prostate cancer, and alcoholic liver disease) showed no contextual effect of state income inequality. The data in Figure 1 suggest that the contextual effects of inequality were proportional to the compositional effects of income differences.

Income Inequality and Health Disparities

If the processes responsible for health disparities are closely related to those that explain the association between income inequality and health, we might expect health disparities to be smaller when income differences are smaller. However, when we explored how the gradient in mortality by county income differed between more- and less-equal states, we found that mortality was reduced across a wide range of county median incomes in more-equal states.

Although compositional effects of greater equality would almost inevitably reduce the socioeconomic gradient in health, we found that the contextual effects of inequality on the
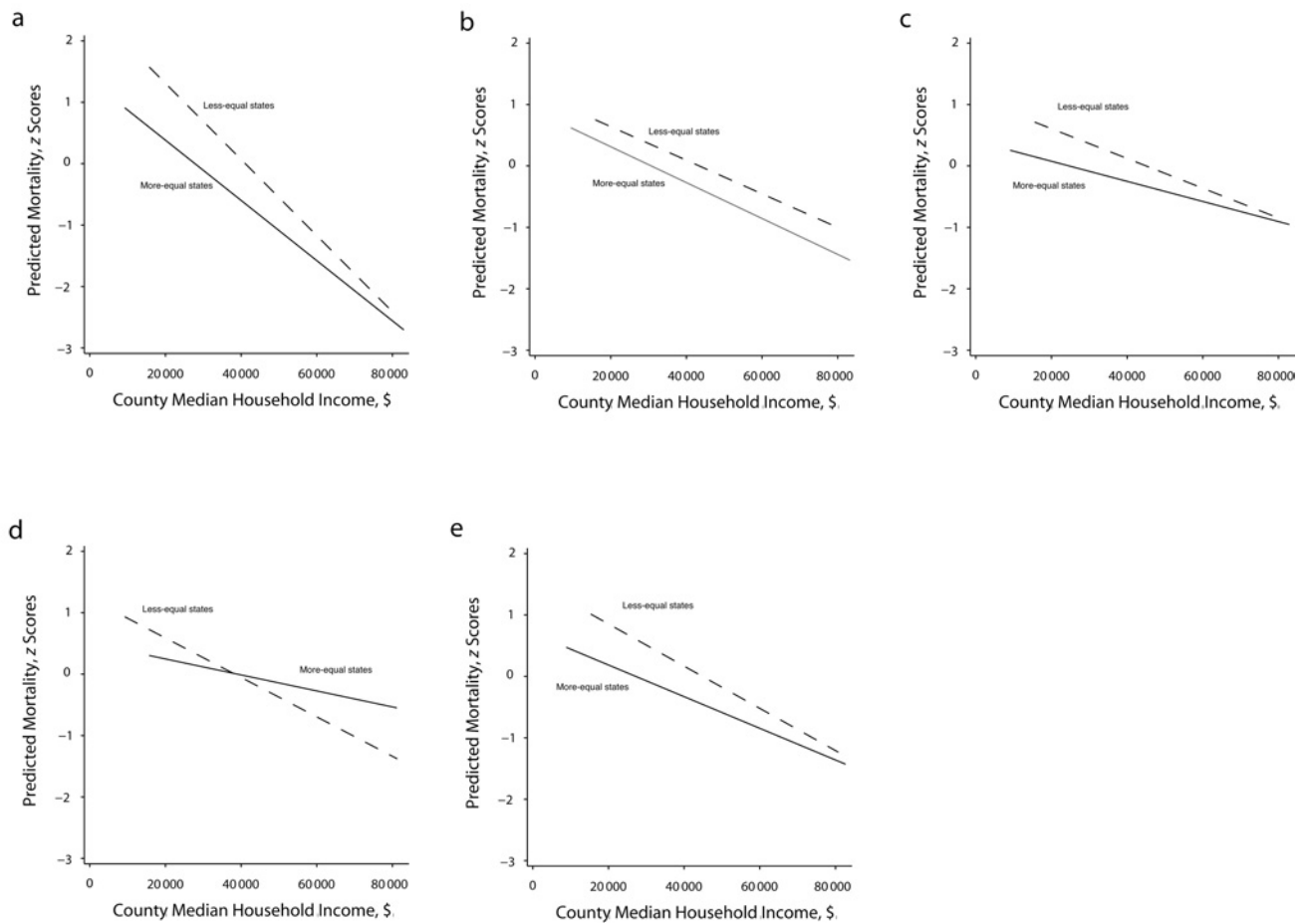
FIGURE 2—Mortality gradients, by mean county household income in 1999 dollars, in more- and less-equal states for all-cause mortality among those of working age (25–64 years) (a), ischemic heart disease (b), respiratory disease (c), alcoholic liver disease (d), and homicide (e).

slope of gradients varied from one mortality rate to another. For infant mortality and for all causes of death among the elderly, there were no interaction effects; reduced income inequality lowered mortality across all levels of county income without changing the slope of the socioeconomic gradients.

The gradients for all-cause working-age mortality showed that decreased inequality benefited the least well off the most, making the socioeconomic gradient less steep (Figure 2). The same was true of mortality from respiratory disease and homicide. For mortality from alcoholic liver disease, there was no overall effect of state inequality (Table 1), but a significant interaction effect suggested that a decrease in equality shifts the social distribution of the disease from wealthy to poor counties. Although statistically significant, the interaction

effect for ischemic heart disease was small. The benefits of greater equality were spread to all county income levels, but were, if anything, slightly greater in the more-wealthy counties (Figure 2). The remaining 5 mortality rates showed no significant interactions, indicating that there was no significant difference in the benefits of greater inequality in wealthy compared with poor counties.

The effect of inequality on the socioeconomic gradient in infant mortality and both all-cause mortality rates (among people of working age and the elderly) may be regarded as summarizing the effects of all their component cause-specific mortality rates. Our findings suggest that greater equality had contextual benefits that were widely shared across income groups: only among people of working age was there a contextual effect of smaller

income inequalities that reduced the socioeconomic gradient in health. For all 6 of the mortality rates that showed a main effect of state income inequality (including infant mortality and the 2 all-cause mortality rates), the benefits of greater equality extended to income groups covering the vast majority of the population. It is important to note that almost 98% of counties had a median household income between $20 000 and $65 500 (Figure 2).

Findings From Other Studies

Results of other studies that have tried to identify who benefits from greater equality are equivocal. In a review of multilevel studies of income inequality and health, Subramanian and Kawachi point out that "the question of who is most harmed by greater inequality has not been systematically addressed."[15] Four

multilevel studies have examined crosslevel interactions in relation to self-rated health, rather than to mortality.[2,16–18] All showed main effects of state-level income inequality, suggesting that the health of the population at large benefited from greater equality.

Two studies provided evidence suggesting that some income groups may not share in the benefits. Kahn et al. analyzed data from the National Maternal and Infant Health Survey. Their results suggest that although the effects of inequality on maternal depressive symptoms were widespread (considering effect estimates rather than *P* values), the association between greater equality and better self-rated health was confined to poor women.[16] Kennedy et al. used data from the Behavioral Risk Factor Surveillance System to examine the effect of individual income on self-rated health in analyses stratified by state income inequality. They found that odds ratios for worse self-rated health associated with greater state inequality were above 1 for all income groups—consistent with widespread health costs of greater inequality—but they were larger and only reached statistical significance among the poor.[2]

Subramanian et al., who studied data from the same sample in a multilevel interaction model that included state-level social capital, not only found benefits among the poor, but also discovered significant adverse effects of greater equality on self-rated health among high-income individuals.[18] In a later, more powerful analysis of self-reported health combining data from the 1970, 1980, and 1990 Current Population Surveys, Subramanian and Kawachi found no clear support for differential effects of state inequality across different population groups.[17] They concluded that their results suggested "an overall contextual effect of state income inequality."

The only study before ours to examine the effects of these crosslevel interactions on mortality did not use multilevel models. Lochner et al. used the National Health Interview Survey linked to the National Death Index.[19] They found that beneficial health effects of greater state equality were strongest among the "near poor" and disappeared among both the wealthier and the poorer income groups.

Lochner et al.'s study is the only one we know of suggesting that the poor do not share

the benefits of greater state-level equality. Otherwise, the picture from our own and other studies is consistent with widespread benefits, tending to be larger among the poor and becoming smaller or nonexistent (or possibly leading to adverse consequences) among the wealthy.

Relative Versus Absolute Gradients

If ill health is reduced in all income groups but is more reduced in poor than in wealthy groups, absolute health disparities will be smaller. However, relative differences—which express rates of ill health (or mortality) among the poor as a multiple of rates of ill health (or mortality) among the wealthy—may be undiminished.

Although more-egalitarian countries, similar to more-egalitarian US states, tend to have better health,[4] several attempts to compare the size of health inequalities internationally have reported that, despite lower overall mortality, some more-egalitarian countries, such as Sweden, may not have smaller relative mortality differentials between higher and lower social status groups.[20,21] Similar findings came from a recent comparison of health in the United States and in England.[22] Average health standards were better in England than in the United States (where income inequalities are larger). Although absolute health differences by income and education were smaller in England, they were not smaller when expressed in relative terms. These findings are consistent with our own and other results.

Discussing the contextual health effects of income inequality, which they found spread widely across income groups, Subramanian and Kawachi suggested that they implied a "pollution" model of the effects of inequality spreading throughout society.[17] Inequality has often been regarded as socially corrosive, and recent evidence on the relationship between inequality and levels of violence, trust, and social capital seems to corroborate this.[23,24] If the effects of greater inequality are not confined to the poor, but extend—like a pollutant—far up the income distribution, that may go some way to explaining why disparities in health may be smaller when expressed in absolute, but not in relative, terms in more-egalitarian countries.

Status, Status Competition, and Social Mobility

We have shown elsewhere that ill health may be just one of many social problems related to relative deprivation that are more common in more-unequal societies.[24] Others include adolescent births, violence, poor educational performance, mental illness, and imprisonment rates. This suggests that causal thinking should not be confined to factors likely to influence health alone.

If causes of death with strong socioeconomic gradients are most sensitive to the contextual effects of income inequality, this lends weight to suggestions that social relativities—such as social position, relative income, or relative deprivation—may be determinants of health. Recent interpretations of research findings on health inequalities suggest that social status differentiation may be close to the center of the problem.[23,25] If greater income inequality increases social status differences, it may also heighten status competition and status insecurities across low- and high-income groups. If the socioeconomic gradient in health—which runs right across society—is related to social status differences, then bigger income differences may worsen health across society by increasing status insecurities and competition.

However, an alternative, or perhaps additional, explanation of why income inequality appears to have rather little impact on relative health disparities might involve the role of social mobility. In an international comparison, we found that social mobility seemed to be greater in more-equal societies.[24] If social mobility is selective for health potential established in early life, then perhaps any tendency for greater income equality to reduce health disparities would be masked by contributions to the gradient resulting from increased social mobility.

Limitations

Our study had 2 main weaknesses. Because it was cross-sectional, we had no direct evidence of causal ordering. However, in the relationship between income inequality and health, it seems unlikely that health determined income inequality rather than the other way around. A weakness of the ecological nature of our data was that county mortality was influenced by the fact that most counties contained both wealthy and poor households. That we

used median county income rather than average county income reduced, but did not overcome, this problem. In addition, there may have been systematic differences, related to state inequality, in the material living standard that could be bought by any given level of median county income. However, using ecological rather than individual data allowed us to analyze data for the entire geographic population of the United States, rather than a sample, to include all deaths over a 4-year period, and to use age- and cause-specific mortality rates.

We are aware of no data sets large enough to have allowed us to analyze the relationship between individual income and deaths categorized by age and cause of death and how that relation was affected by state income inequality. As well as making our findings robust, using county data enabled us to look at age- and cause-specific mortality rates. Another advantage was that our data included a wider spread of income than did previous studies. County median household income in our study ranged from $9333 to $82929. The highest income categories in previous studies that used samples of individuals in crosslevel interactions were $50000 and greater in one study[19] and $35000 and greater in others.[2,16,18]

Conclusions

Although the compositional effects of narrower income differences may reduce health inequalities, the contextual benefits extend to a large majority of the population and therefore do little to reduce relative differences in mortality between income groups. This may explain the otherwise perplexing finding that, despite their higher overall health standards, health inequalities are sometimes no smaller in more-equal societies. Although the compositional effect of a narrower dispersion of income reduces health inequalities, this effect appears to be offset by contextual effects that spread far up the income range. If the strength of the contextual effects tends to be proportional to the strength of the compositional effects (Figure 1), relative measures of health inequalities may vary little between more- and less-equal societies.

However, our finding that mortality rates with stronger income gradients were also more sensitive to the contextual effects of income inequality implies the two were nevertheless linked. Such a picture could arise

if health inequalities resulted, among other influences, from social status differentiation. The effects of status differences might then be amplified or reduced right across society by bigger or smaller income differences. Observable symptoms of such a process might include increased status competition and status insecurity. ■

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Contributors

R.G. Wilkinson originated and designed the study and helped write the article. K.E. Pickett conducted the statistical analysis and helped write the article.

Human Participant Protection

No protocol approval was required for this ecological study.

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