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INCOME INEQUALITY AND HEALTH: What Does the Literature Tell Us?

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■ **Abstract** This paper reviews the large and growing body of literature on the apparently negative effects of income inequality on population health. Various hypotheses are identified and described that explain the empirically observed association between measures of income inequality and population health. We have concluded that data from aggregate-level studies of the effect of income inequality on health, i.e. studies at the population and community (e.g. state) levels, are largely insufficient to discriminate between competing hypotheses. Only individual-level studies have the potential to discriminate between most of the advanced hypotheses. The relevant individual-level studies to date, all on U.S. population data, provide strong support for the "absolute-income hypothesis," no support for the "relative-income hypothesis," and little or no support for the "income-inequality hypothesis." Results that provide some support for the income-inequality hypothesis suggest that income inequality at the state level affects mainly the health of the poor. There is only indirect evidence for the "deprivation hypothesis," and no evidence supports the "relative-position hypothesis." Overall, the absolute-income hypothesis, although >20 years old, is still the most likely to explain the frequently observed strong association between population health and income inequality levels.

INTRODUCTION

There is a large and growing body of literature exploring the apparently negative effects of income inequality on health. As long ago as the 1970s, researchers reported associations, at the population level, between measures of health, such as life expectancy and infant mortality, and income inequality, as measured by indices such as the Gini coefficient. These researchers emphasized that such a relationship might simply reflect a nonlinear association between health and income at the individual level (cf 25); that is, rising income allows people to purchase more and/or better-quality goods and services that are beneficial to health, but the opportunities to do so diminish as incomes increase.

More recently, however, it has been suggested that the population-level relationship between health and income inequality may reflect other causes. Income inequality may reflect social cohesion or social capital, and health at the individual level may not respond simply to absolute income but also to relativities in society, such as relative deprivation, relative income, and relative social status. Income inequality at the population level may be important because it accentuates these relativities and hence has a negative impact on health at the individual level.

A great deal of effort is now being directed at exploring the relationship between income inequality and health. Our focus is principally on literature that brings empirical evidence to bear on this thesis. Some of this work involves a reinterpretation of the population-level evidence on income inequality and health outcomes, which sometimes involves linking that evidence to other evidence at the population or individual level. Much of it, however, has involved the production of new results, at the individual level or at some intermediate level between individual and population that we somewhat loosely call the community level. "Community" can refer to a county, a state, a region, or, in principle, an area even smaller than a county.

Our aim is to provide a critical assessment of the empirical literature in this field. The review is not critical of the thesis itself, which seems perfectly plausible, nor is it simply a summary of existing studies, nor is it comprehensive, although we do hope that we have achieved a reasonable balance across the contributory academic disciplines. We also do not review all technical aspects of these empirical studies, such as the extent to which they deal with econometric problems arising from omitted-variable bias, simultaneity bias, or unobserved heterogeneity in the income-health relationship. Rather, this is an interpretative essay to critically assess what can be concluded from studies to date about the effects of income inequality on health and how these effects work. If some lines of inquiry appear fruitless, it is as well to try to agree on this. If some seem especially fruitful but currently under exploited, this too is worth knowing.

We have attempted to clarify the various hypotheses that have been advanced to explain the apparently negative effect of income inequality on health at the population level. Terminology is a problem in this literature. It is not always clear whether terms that, in the social sciences have distinct meanings—such as relative income, deprivation, and social position—have been used in this literature with their precise meaning in mind or more loosely, in a sometimes interchangeable way. We may have over-interpreted the literature in what follows and erred on the side of over-classifying the literature into different hypotheses, rather than lumping all relativity theories under one heading. It turns out that, at the population level as well as—albeit to a lesser extent—at the community level, it is hard if not impossible to distinguish one variant from another.

We also establish what in principle can be concluded, from studies undertaken at different levels of aggregation, about the effects of income inequality and relativities on health at the individual level. We assess the empirical literature to date, beginning with population-level studies, moving through community-level studies, and ending with individual-level studies, and then we state our conclusions.

THE HYPOTHESES

As indicated above, several studies show an association between measures of population health and income inequality. Figure 1 gives an example of such an observation. What can we conclude from such a relationship? In this section we consider various hypotheses that appear to have been advanced as being consistent with this relationship. Later we discuss the issue of discriminating between them, and then we discuss the empirical evidence.

The simplest of all of the explanations is that the association in Figure 1 reflects the influence of an individual's absolute level of income on his or her health. This was pointed out long ago by Preston (23) and Rodgers (25) and recently reemphasized by Gravelle (8). The key point in Rodgers' argument is that the relationship between health and income is concave—each additional dollar of income raises a person's health, but by ever smaller amounts (Figure 2). At the individual level, we could write this relationship as follows:

$$h_i = f_I(y_i), \quad \text{with } f_I' > 0; \quad f_I'' < 0 \qquad 1.$$

where h_i is the health of individual i, y_i is that individual's income, and f_I is a concave function by which income is transformed, at the individual level, into health, as in Figure 2. Let us suppose that income is the only factor that influences a person's health.

What does Equation 1 imply about the determinants of health at the community and population levels? From Figure 2, we can see that the health of both a

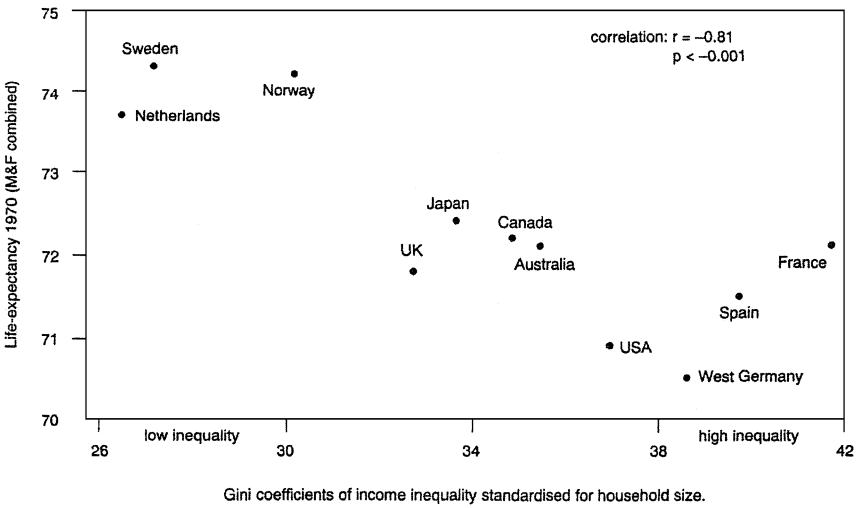

Figure 1 Life expectancy vs income inequality (from reference 30, p. 84). Data exemplify the absolute income hypothesis (AIH).

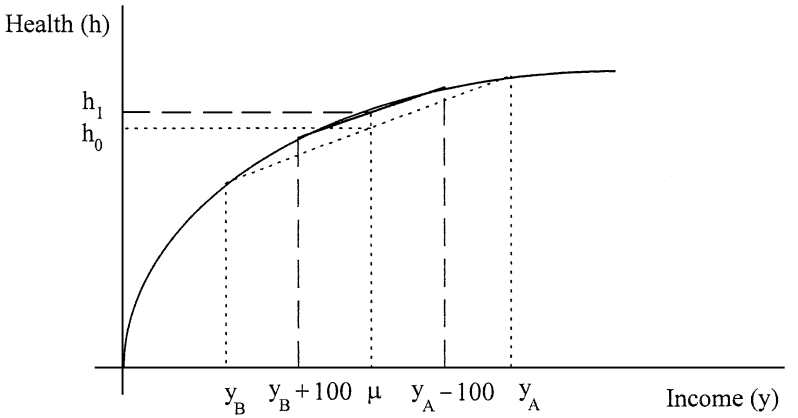

Figure 2 Implications of the concavity of the health-income relationship.

community and a population depends not only on the average income of the community or population, but also on the inequality in income within the community or population. The intuition is straightforward. Each additional dollar of income at the individual level raises individual health by ever smaller amounts. Starting from an equal distribution, taking $100 away from person A and giving it to person B reduces A's health and raises B's, but, because of the diminishing returns to income in the production of health, A's health falls by more than B's rises. The average income of this two-person population has not, of course, changed—it is still μ in Figure 1. Thus, if all that matters to health at the individual level is absolute income and the health-income relationship is nonlinear as in Figure 2, average health in the society will improve as the average income increases and the inequality of income decreases. This is called the absolute-income hypothesis (AIH). So, if I is income inequality, we can write:

$$h_c = f_C(y_c, I_c) \qquad 2.$$

and

$$h_P = f_P(y_P, I_P) \qquad 3.$$

where h_c and h_P are the average health levels of community c and the population p as a whole; y_c and y_P are their average income levels, respectively; I_c and I_P are measures of their income inequality, respectively,[1] and f_c and f_P are

[1] As indicated by J Hammer (personal communication), precisely which measure of income inequality is relevant at the aggregate level depends on the exact functional form (i.e. quadratic, log-linear, etc) of the individual nonlinear relationship between income and health.

functions that are increasing and nonlinear in income and decreasing in income inequality.

The Relative-Income Hypothesis

An alternative hypothesis is the relative-income hypothesis (RIH), which indicates that an individual's relative—rather than absolute—income affects his or her health. Thus Wilkinson (33) writes, "... poor people in the United States often have death rates comparable with people in Bangladesh. Their high death rates are not so much a product of their absolute living standards but reflect their low relative incomes and social status. ... Mortality is associated with relative income. ... Someone with an absolute income that equals half the US average income might do better to be moderately well off in Greece or Spain than poor in the US" (33, p. 1611).

The simplest version of this hypothesis is that, at the individual level, health depends on the deviation of the individual's income from the population mean income. Thus,

$$h_i = f_{\mathrm{I}}(y_i - y_P) \qquad 4.$$

So if everyone apart from individual *i* sees their income rising, Equation 4 implies that individual *i*'s health will worsen. At the community level, we have

$$h_c = f_{\mathrm{C}}(y_c, y_P, I_c) \qquad 5.$$

so that the community's health varies directly with the mean income of the community and inversely with that of the population as a whole. At the population level, by contrast, we have the same general relationship as before, that is, as in Equation 3.

An alternative version of the RIH would be that it is the individual's income relative to the community's average income that matters. Thus, at the individual level, we have

$$h_i = f_{\mathrm{I}}(y_i - y_c) \qquad 6.$$

so that, if everyone other than individual *i* in person *i*'s community sees their income rise, individual *i*'s health will worsen. At the community level, we have the same general relationship as in the AIH, namely Equation 2, because individuals identify with other people in their community, not with the population at large. At the population level, we also have the same general relationship as before, namely Equation 3.

The Deprivation Hypothesis

The terms "deprivation" and "poverty" appear in several studies in this literature (e.g. see 31). However, the underlying hypotheses in studies that use these terms

are not always fully articulated. Indeed, it is often unclear whether the authors have in mind anything different from the RIH.

In the social sciences, deprivation is typically the circumstance in which a person's income or living standards fall below some critical level, often referred to as the poverty line. The latter can be thought of in absolute terms—a person living below $1.00/day, for example, or in relative terms—a person's income being below, say, one half of the community's median income. If z is the poverty line, person i's income gap is defined as the shortfall from the poverty line ($z - y_i$), if the person is living below the poverty line, and zero otherwise. We might interpret the deprivation hypothesis (DH) to mean that it is not absolute income that matters for individual health but rather the extent of deprivation as measured by the income gap. Thus, if g_i is person i's income gap, rather than Equation 1, our individual-level equation takes the form:

$$h_i = f_{\mathrm{I}}(g_i, z) \qquad 7.$$

where presumably the function f_{I} decreases once g_i becomes positive and does so at an increasing rate. The graph of Equation 7 in $h - y$ space thus would look like that in Figure 2, except that, after the poverty line has been reached, the health-income relationship would be flat. At the community and population levels, the corresponding equations are:

$$h_c = f_{\mathrm{C}}(y_{c,poor}, I_{c,poor}, z, H_c) \qquad 8.$$

and

$$h_P = f_{\mathrm{P}}(y_{P,poor}, I_{P,poor}, z, H_P) \qquad 9.$$

where $y_{c,poor}$ and $y_{P,poor}$ are the average incomes of the poor in community c and the population p at large, $I_{c,poor}$ and $I_{P,poor}$ measure the inequality among the poor at these two levels, and H_c and H_P are, respectively, the proportions of the community and the population who are poor (known as the headcount ratios).

The Relative-Position Hypothesis

Yet another hypothesis, the relative-position hypothesis (RPH), holds that it is not just income that matters, but also one's position in the income distribution. Thus, Wilkinson (30) suggests that "... what matters within societies is not so much the direct effects of absolute material living standards so much as the effects of social relativities. Health is powerfully affected by social position. ..." (30, p. 3).

For a person's relative position in the income distribution, there are, it would seem, three possible variants of this hypothesis. The first is that what matters is a person's position in the national income distribution. If R_i is person i's relative

rank (e.g. the person in the middle of the distribution has a relative rank of 0.5), the individual-level equation becomes[2]:

$$h_i = f_1(y_i, R_i) \quad 10.$$

What does Equation 10 imply about the determinants of health at the community and population levels? The analog of Equation 2 is

$$h_c = f_C(y_c, I_c, R_c) \quad 11.$$

where R_c is the relative rank of community c in the population as a whole. The population-level relationship is simply Equation 3. The second variant of the relative-position hypothesis is that it is the person's rank in the community that matters. Thus, instead of Equation 10, we have

$$h_i = f_1(y_i, R_{i \in N_c}) \quad 12.$$

where the second term is shorthand for person i's relative rank in community c. However, when we aggregate up to the community and population levels, we obtain the same equations as before, namely Equations 11 and 3, respectively. The third hypothesis is that what matters to the individual is the community's ranking in the population. Thus, instead of Equation 10, we have

$$h_i = f_1(y_i, R_c) \quad 13.$$

As with the second variant, when we aggregate up to the community and population levels, we obtain the same two equations as we obtained in the first variant—Equations 11 and 3.

The Income Inequality Hypothesis

The final hypothesis worth considering is that an individual's health is directly affected by income inequality [i.e. the income-inequality hypothesis (IHH)]. Thus Wilkinson (30) argues that "health is powerfully affected by . . . the scale of social and economic differences among the population" (30, p. 3). He goes on to suggest that it is not inequality per se that matters, but rather that what makes egalitarian societies healthy is their degree of social cohesion or "social capital."

There are two possibilities here. One is that the degree of inequality in the individual's community influences his or her health, in addition to the absolute-income level.[3] Thus, at the individual level, we have

$$h_i = f_1(y_i, I_c) \quad 14.$$

[2]In fact, an even stronger proposition would be that only relative position matters and that absolute income has no effect at the individual level. We find this an extreme position that seems untenable in view of the overwhelming evidence that income does matter for individual-level health. Deleting absolute income from Equation 10 would obviously substantially alter the aggregate-level relationships.

[3]The same remark applies here as in footnote 1.

and at the community and population levels we have Equations 2 and 3. The second possibility is that it is not the community's inequality that matters but rather the level of inequality nationally. At the individual level, we have

$$h_i = f_{\mathrm{I}}(y_i, I_P) \qquad 15.$$

and at the community level we have

$$h_c = f_{\mathrm{C}}(y_c, I_P) \qquad 16.$$

By contrast, population health depends, as before, on population income and inequality at the population level, as in Equation 3.

DISCRIMINATING BETWEEN THE HYPOTHESES: THEORY

The foregoing discussion sheds a good deal of light on the usefulness of different kinds of evidence to discriminate between the competing hypotheses. The equations we have developed are reproduced in Table 1 for quick reference.

Population-level data emerge as the least useful. No fewer than eight hypotheses or variants thereof predict that, at the population level, average health will be associated with income inequality. The observation of such an association at the population level does not therefore provide a means of discriminating between these four hypotheses. Thus, the often observed association at the population level

TABLE 1 Comparisons of relationships implied by the various hypotheses[a]

Hypothesis	Variant[b]	Individual level	Community level	Population level
Absolute income hypothesis (AIH)		(1) $h_i = f_{\mathrm{I}}(y_i)$; $(f'_1 > 0, f_{\mathrm{I}}'' < 0)$	(2) $h_c = f_{\mathrm{C}}(y_c, I_c)$	(3) $h_P = f_{\mathrm{P}}(y_P, I_P)$
Relative income hypothesis (RIH)	[a]	(4) $h_i = f_{\mathrm{I}}(y_i - y_P)$	(5) $h_c = f_{\mathrm{C}}(y_c, y_P, I_c)$	(3) $h_P = f_{\mathrm{P}}(y_P, I_P)$
	[b]	(6) $h_i = f_{\mathrm{I}}(y_i - y_c)$	(2) $h_c = f_{\mathrm{C}}(y_c, I_c)$	(3) $h_P = f_{\mathrm{P}}(y_P, I_P)$
Deprivation hypothesis (DH)		(7) $h_i = f_{\mathrm{I}}(g_i, z)$	(8) $h_c = f_{\mathrm{C}}(y_{c,poor}, I_{c,poor}, z, H_c)$	(9) $h_P = f_{\mathrm{P}}(y_{P,poor}, I_{P,poor}, z, H_P)$
Relative position hypothesis (RPH)	[a]	(10) $h_i = f_{\mathrm{I}}(y_i, R_i)$	(11) $h_c = f_{\mathrm{C}}(y_c, I_c, R_c)$	(3) $h_P = f_{\mathrm{P}}(y_P, I_P)$
	[b]	(12) $h_i = f_{\mathrm{I}}(y_i, R_{i \in N_c})$	(11) $h_c = f_{\mathrm{C}}(y_c, I_c, R_c)$	(3) $h_P = f_{\mathrm{P}}(y_P, I_P)$
	[c]	(13) $h_i = f_{\mathrm{I}}(y_i, R_c)$	(11) $h_c = f_{\mathrm{C}}(y_c, I_c, R_c)$	(3) $h_P = f_{\mathrm{P}}(y_P, I_P)$
Income inequality hypothesis (IIH)	[a]	(14) $h_i = f_{\mathrm{I}}(y_i, I_c)$	(2) $h_c = f_{\mathrm{C}}(y_c, I_c)$	(3) $h_P = f_{\mathrm{P}}(y_P, I_P)$
	[b]	(15) $h_i = f_{\mathrm{I}}(y_i, I_P)$	(16) $h_c = f_{\mathrm{C}}(y_c, I_P)$	(3) $h_P = f_{\mathrm{P}}(y_P, I_P)$

[a]Numbers in parentheses preceding each equation correspond to equation numbers in text. For definitions of variables, see text.

[b]Bracketed letters correspond to different (or various) variants of the relevant hypothesis.

between health and income inequality could simply reflect the importance of absolute income and its diminishing impact on health. It might reflect some other mechanism at work, but we cannot be sure. Population data are even less useful in this context than this might suggest. It is not just that all but one of the nine hypotheses predict a relationship at the population level between health and income inequality. What also emerges is that the same eight hypotheses also predict that population health will depend on, and only on, the same two variables—average income and income inequality. Thus, there is no scope at the population level for discriminating between these four hypotheses by testing to see what else influences health other than income inequality. (We are abstracting here, of course, from the effects of influences on health other than income and income inequality. The important point is that these hypotheses do not differ about what additional variables affect health.)

These points do not apply to the DH. Population data can allow one to test this hypothesis against any of the other theories, because it leads to a different set of determinants of community and population health. What matters in the DH are the average incomes and income inequality among the poor, not the overall average income and overall income inequality. Furthermore, according to the DH, the health of a population (or community) ought also to depend on the proportion in poverty (the headcount). Obviously, as *H* gets closer to 100%, Equations 8 and 9 become increasingly like Equations 2 and 3. As nearly all of the group becomes poor, its average income becomes closer to that of the group as a whole, and the inequality among the poor is then close to that of the group as a whole. This means that discriminating between the DH and other hypotheses may be more difficult in low-income countries.

With community-level data, the scope for discriminating between competing hypotheses is somewhat greater, but it is not unlimited. Of the nine hypotheses, seven predict that, at the community level, there will be a relationship between average health and income inequality. Furthermore, three hypotheses predict that, at the community level, average health depends on, and only on, average income and income inequality. This is a distinct improvement over what can be achieved with population-level data. But the fact remains that one cannot distinguish, using community-level data, between the AIH, variant b (Table 1) of the RIH, or variant a of the IIH (Table 1).

The best opportunity for discriminating between the various hypotheses lies with individual-level data. At the individual level, the variables that matter for health vary from one hypothesis to the next. In the AIH, an individual's health is related, in a concave fashion, to the individual's own income; nothing else matters. In the RIH, the individual's health is, as in the AIH, a concave function of his or her own income, but is also inversely related to the average income of either the community or the population at large, when holding the individual's income constant. In the DH, the individual's health ought to rise with income, presumably in a concave fashion, but only up to the poverty line; any further increases in income will leave the person's health unaffected. Under the RPH, the

individual's health depends, in a concave fashion, on his or her income, but also on that individual's rank in the overall income distribution or in the community's income distribution, or in their community's ranking in the national income distribution. In the IIH, by contrast, the individual's health depends, in a concave way, on his or her income, but also on the income inequality in either the community or the population. As the various hypotheses predict such different determinants of health at the individual level, the scope for discriminating between them is inevitably much larger, at least in principle, with individual data than it is with aggregated data.

DISCRIMINATING BETWEEN THE HYPOTHESES: THE EVIDENCE

The empirical literature on the relationship between income inequality and health has grown very rapidly over the last decade. The intention of this review is not to be exhaustive but rather to highlight the trends that have occurred and the insights that have emerged from empirical tests of the above hypotheses. Two trends seem to stand out: (*a*) a shift in emphasis from aggregate-level studies to analyses of individual-level data and (*b*) a shift from mortality-based health measures to measures of (self-reported) morbidity. In our discussion of the empirical work, we have subdivided the studies by their levels of aggregation, that is, population, community, or individual level. Some of the more recent studies, which have looked at various levels of aggregation simultaneously, have been included in the section on individual-level studies.

Population-Level Studies

A large number of cross-national comparative studies have now shown that the relationship between income and mortality-based indicators of population health is nonlinear at the aggregate level [see e.g. Pritchett & Summers (24) and Kakwani (12)]. Insofar as these results reflect nonlinearity at the individual level, they are consistent with the AIH, but are also consistent with the various alternative hypotheses. Also consistent with the AIH and the other hypotheses are the numerous population-level associations between health and income inequality. Rodgers (25) was the first to draw attention to the strikingly consistent relationship between three mortality-based population health measures (life expectancy at birth, life expectancy at fifth birthday, and infant mortality) and income inequality, as measured by the Gini coefficient. These results were observed in a sample of 56 countries, while controlling for income by using a regression model that allowed income to influence health in a nonlinear fashion. The results held true both for all countries and for the subsample of less-developed countries, as confirmed by Flegg (7), who used various measures of income inequality while controlling for income, illiteracy, and medical-care availability. Waldmann (27), using a slightly

different approach, also showed that income inequality mattered; he found that, while controlling for the real income levels of the poor, indicators of the amount of health care available to the poor, and some other variables, a greater share of income going to the rich is correlated with higher infant mortality. In several papers, Wilkinson, either alone or with coauthors, has reported associations between population health outcomes and income inequality, in some cases controlling for income levels and other influences (see e.g. 21, 28, 29). Wilkinson and various others have also reported correlations between income inequality and measures of social cohesion or social capital. Coupling these two sets of correlations (income inequality to population health and income inequality to social cohesion or capital), they infer that income inequality influences health via its effect on social cohesion.[4] In various places, Wilkinson (e.g. 30, 32) has argued that, although the associations noted above may not be compelling in isolation, they are compelling when coupled with other evidence. Specifically, he has noted that the correlation between population health measures and average income is low compared with (*a*) the correlation between population health measures and income inequality and (*b*) the correlation between individual health and individual income (or social status). These two comparisons have led him to conclude that it is not the AIH that accounts for scatter plots of the type shown in Figure 1 but something else. Commenting on point *b* above, he argues that "... if health is related to differences in living standards within societies, but not to differences between them, we surely have to conclude that these differences mean something quite different within and between societies" (30, p. 3). As it happens, both of these findings are, in fact, perfectly consistent with the belief that individual health is determined along the lines of the AIH. It is easy to produce a numerical example in which the health status of individuals in different countries is constructed as a nonlinear function of income and to show that this is sufficient to generate the correlation patterns noted by Wilkinson.

The right-hand column of Table 1 suggests that it may be possible to shed some light by using population-level data on the validity of the deprivation hypothesis. In practice, however, there is relatively little evidence that we can bring to bear on the subject. Wilkinson (28) has reported a high correlation between the annual rate of change in life expectancy and the annual rate of change in the proportion of people living in relative poverty (i.e. $<50\%$ of the national average disposable income) in 12 European Community countries for the period 1975–1985. Anand & Ravallion (1), for a sample of 22 developing countries, showed that the

[4]Wilkinson's population-level studies of the link between health and income inequality are controversial. Critics question their validity on technical grounds (cf 10, 11). For our purposes, however, the issue of whether the associations are sound is something of a red herring—even if they are, and even if all the other aggregate correlations and partial effects are valid, the problem is that, as the right-hand column of Table 1 makes clear, we cannot be sure whether they simply reflect the AIH at work and nothing else or whether something else is going on.

effect of average income became insignificant after inclusion of a poverty measure (the proportion of the population consuming <$1.00/day), which did have a significant impact on their population health measures, along with public health spending. Similarly, Carrin & Polti (4), using an expanded data set for 1990 for 57 countries, found confirmation of this significant effect of the poverty headcount ratio. But neither of these two studies included the other two variables of interest in Equation 9, namely the income level of the poor and the degree of income inequality among the poor. The study by Bidani & Ravallion (3)—although designed with a different purpose in mind—is of interest, because it includes, in addition to a headcount, the average income of the poor, although not a measure of inequality among the poor. For a sample of developing countries, Bidani & Ravallion regressed life expectancy and infant and perinatal mortality on, inter alia, the proportion of the population in poverty and the average incomes of the poor and nonpoor (weighted by the proportions affected). They found that the poverty headcount has a significant effect on life expectancy and infant and perinatal mortality, but the average income among the poor (and that among the nonpoor) does not. The evidence on the DH is clearly far from conclusive. The limited evidence that does exist, however, suggests that deprivation may, at least in developing countries, play a part in shaping health outcomes. It is striking that, in contrast to what one would expect if absolute income were the whole story, poverty headcounts do seem to matter—more so, apparently, in some cases than absolute incomes.

Community-Level Studies

A second phase in the literature investigating the income inequality-health relationship is characterized by studies focusing on the within-country association at various levels of regional aggregation, using variants of Equation 2. Basically, all of these studies test whether, at some regional level, income inequality, measured in very different ways, exerts an influence on mortality after controlling for income level. Virtually all studies conclude that this is the case. The variations across studies lie in (*a*) the level of regional aggregation, (*b*) the measure(s) of mortality used, (*c*) the measure(s) of income inequality used, and (*d*) what, if anything, is controlled for when examining these relationships. Several studies have examined the variation across 50 US states (13, 14, 17), one has looked at the variation across 283 US metropolitan areas (20), and one has considered the variation across 369 local authorities in England (2). The latter study is somewhat different from the others in that it measured within-community income variation not by inter-individual income variation but by inter-ward variation in some deprivation index.

The first point to emerge from these studies is that they all confirm that income inequality is strongly associated with mortality, even after controlling for the average level of community income. Kaplan et al (13) found a significant correlation between the percentage of total household income received by the less well-off 50%

in each state and mortality from all causes, which was unaffected by adjustment for state median incomes. Moreover, states with higher initial income inequality (in 1980) had smaller declines in mortality by 1990, but the changes in income inequality between 1980 and 1990 themselves were not significantly associated with the mortality changes by state. Kennedy et al (17) found a strong association of income inequality, as measured by the Robin Hood Index[5] on all-cause and cause-specific mortality by state. Kawachi & Kennedy (14) later examined the sensitivity of the association to six different income inequality measures and found that they were all strongly correlated with each other and with overall mortality, even after adjustment for median income. Where does this evidence take us? The answer, unfortunately, is not very far. As is clear from Table 1, these correlations and partial correlations are consistent with no less than four of the five hypotheses considered above, namely the AIH, the RIH, the RPH, and the IIH. These results do not, therefore, get us any further than before in discriminating between the various hypotheses.

The second notable point is that some of these studies also shed some light—albeit only indirectly—on the plausibility of the DH, because they included a poverty measure among the covariates. Unfortunately, none of these studies report the partial effect of poverty. They report only the high bivariate correlations (positively with income inequality and negatively with income) and examine the influence of its inclusion among the covariates. Kawachi & Kennedy (14) find that the association between nine different measures of income mortality remained highly significant after adjustment for poverty, despite the fact that the poverty rate and all of these inequality measures are highly correlated. Lynch et al (20) examined essentially the same relationships but for 283 US metropolitan areas, using seven different income inequality measures. They controlled for per-capita income, median household size, and the proportion of the population with incomes $<200\%$ of the federal poverty level. Regardless of which measure was used and the type of covariate that was included in the regression models, income inequality was significantly associated with age-adjusted total mortality. The fact that income inequality remains significant when poverty is included clearly casts doubt on the hypothesis that it is solely the extent of deprivation that matters. If, on the other hand, the poverty rate shows an independently significant effect on mortality over and above income inequality, this is consistent with the DH, but a fuller test of its implication would require the inclusion of the other measures in Equation 8. None of the studies to date has done so.

[5]The Robin Hood Index is the maximum vertical distance between the Lorenz curve and the diagonal (18). It is also known as the Schutz coefficient. It measures the share of income that has to be taken from those above the mean and transferred to those below the mean to achieve an equal income distribution (for a proof, see 19, p. 43). The Schutz coefficient, which is also equal to twice the relative mean deviation, is unaffected by transfers not across the mean and therefore does not satisfy the Principle of Transfers (pp. 45 and 117).

A third point is that Lynch et al (20) also report that higher per-capita income was still significantly associated with lower mortality, but that this association was weaker than the effects of income inequality. As we argued in the previous subsection, this is perfectly consistent with the AIH hypothesis.

Fourth, several studies have examined potential pathways and mechanisms that may be mediating the association between income inequality and health, probably with some variant of the IIH in mind. Kawachi et al (15) examine the possibility that the degree of income inequality is related to indicators of (dis)investment in social capital like per-capita group membership and lack of social mistrust. They measure social capital by weighted responses to two items from the General Social Survey: per-capita density of membership in voluntary groups in each state and the proportion of residents in each state who believe that people can be trusted. After they controlled in their path analysis for disinvestment in social capital, they found little residual association between income inequality and mortality, suggesting that the primary effect of income inequality on mortality is mediated by social capital. Such evidence is clearly inconsistent with the AIH. If the non-linear relationship between health and income at the individual level is generating the effect of income inequality at the community level, then controlling for community-level social capital levels should not remove this effect.

Finally, none of the community-level studies has, to our knowledge, attempted to address the relative position hypothesis addressed in Equation 11, that the relative rank of the community within a country has an effect on mortality. It is therefore not possible to conclude anything about the RPH.

Individual-Level Studies

Table 2 summarizes the details of what we have termed the individual-level studies in this field. In some respects, they are not individual level—they all relate, for example, an individual's health to intrinsically ecological attributes of populations, like the income inequality in the individual's community. What makes them individual is that the focus is on the health of the individual rather than that of a community or population. [An exception is the study by Wolfson et al (34), which—despite the availability and use of individual-level data—draws its conclusion based on reaggregated relationships at the state level.] For at least two reasons, these studies are by far the most interesting of the field. First, as we have seen, it is only at the individual level that one can really discriminate cleanly between the various hypotheses. Second, the studies are generally more adequate than most of the studies done at higher levels of aggregation—they rely not on simple correlations but on regression analyses in which the confounding effects of influences other than income can be controlled.

Only four studies explicitly provide a proper test of the AIH, by allowing individual income to influence individual health in a non-linear fashion. Mellor & Milyo (22) include income and income squared and find clear evidence of

a concave relationship for self-reported health, whereas Wolfson et al (34) find a convex relationship for mortality risk. Kennedy et al (16) report odds ratios for six income categories, and Soobader & LeClere (26) do so for four income quartiles. Although the unequal income widths of these classes make the exact income-health relationship more difficult to assess, in both cases the increase in odds ratios increases with decreasing income. Fiscella & Franks (6) allow only for linear income effects, whereas Daly et al (5) do not report the estimates of their income effects. In all cases, the strong positive (but decreasing with rising income) effects are overwhelmingly consistent with the AIH. This is scarcely surprising given the multitude of other studies—including several published recently—that suggest a concave relationship at the individual level between health and income. [Two recent examples showing the concave relationship between income and self-perceived health include work by Ettner (5b) for US data and by Ecob & Smith (5a) for UK data. Others have found similarly that the mortality reduction resulting from increased income diminishes as income increases (1a, 20a).] In contrast to all other studies, Wolfson et al (34) do not aim at estimating the effect of income inequality on individual mortality risk while controlling for potential confounders. Instead they use the estimated convex relation between individual income and mortality risk to generate the state-level mortality rates that would have been generated if this were the only reason for state mortality differences. In this way, they show that the AIH can account for only a minor part of the actually observed state level association between income inequality and mortality.

Four studies include average community income in their regressions and hence provide—at least in principle—evidence on the RIH. In practice, however, the evidence is more limited, because only two (22, 26) report the regression coefficients on community income. If the RIH is true, holding individual income constant, community income should be inversely related to health; rises in everyone else's income without any change in one's own are bad for one's health. In this event, both studies report a positive relationship between individual health and average community income, although in most cases this is not significant when other variables are included in the equation. There is absolutely no evidence whatsoever, therefore, in these studies to support the RIH—if anything, the evidence that exists actually contradicts the RIH.

Most studies listed in Table 2 shed light on the IIH. The evidence here is mixed. Two of the mortality-based studies find no general evidence to support the IIH (5, 6), and the third (34) does not test it directly. This is somewhat surprising given the emphasis on mortality in the studies at community and population levels. The lack of any effects in the study by Fiscella & Franks (6) may be due to weaknesses in the study design: individual income is entered linearly even though the AIH predicts a concave relationship; the county-level income inequality data are estimated from the sample rather than taken from the census estimates and are hence subject to small numbers and imprecise estimation problems; the authors examine inequality effects only at one level (the county); the study makes only a limited attempt to control for other observed influences on health and

TABLE 2 Summary of individual-level studies[a]

Study (reference) survey, sample, & sample size	Health variable	Income measures & specification	Income inequality measure	Other covariates	Main findings	Comments
Fiscella & Franks (6) National Health and Nutrition Examination Survey 1971–1975 US adults 25–74; $N = 14{,}407$	Survival probability during follow-up	Annual family income (mean value of 12 categories). Income entered linearly. Mean community income	Share of income of poorest 50% of PSU	Family size, sex, age	Hazard ratio on family income <1 and significant. Consistent with AIH, but no full test owing to linearity assumption. Hazard ratio of median community income not reported. So cannot establish consistency with RIH. Hazard ratio of income inequality <1 but not significant—except when family income excluded. IIH rejected.	Data on income inequality obtained from survey and hence problematic because some PSUs have few observations.
Kennedy et al (16) Behavioral Risk Factor Surveillance Study 1993–1994 US residents 18+; $N = 205{,}245$	Probability of reporting fair or poor health	Annual household income in seven categories. Dummies allow for nonlinear income effects	Gini coefficient at state level, grouped into four categories (from 1990–1992); Current Population Survey	Age, sex, race, smoker, obesity, health insurance, health checkup, education, household composition	Income effects significant and >1; pattern implies impact of income falls as income rises. So consistent with AIH. Odds ratios on Gini dummies >1 and significant. Consistent with IIH.	

As above, but separate analyses for three different income categories	As above	Not controlled for	As above	As above	Odds ratios on Gini dummies largest for low-income sample; insignificant for highest-income sample. Only top categories have significant odds ratios for middle-income sample.	Household income level not controlled for
Daly et al (5) Panel Study of Income Dynamics; 1980 and 1990 cohorts Adults aged 25+; N = not reported (about 6,500?)	5-year mortality risk	Family income adjusted for family size. Median state income	Several, using percentile ratios at state level (all measures taken from Kaplan et al (13)	Age, race, sex	No significant effect of any inequality measure on mortality risk for total sample. IIH rejected. Household income effects and state income effects not reported.	
As above, but separate analyses for different age and income groups	As above	As above	As above	As above	Surprisingly, separate analyses for one subgroup only (middle income nonelderly) and for 1990 only showed some significant inequality effect, which was largest for the poverty-sensitive inequality measures [ratios of 50% (top) to 10% or 20% (bottom group)].	

(*continued*)

TABLE 2 (*Continued*)

Study (reference) survey, sample, & sample size	Health variable	Income measures & specification	Income inequality measure	Other covariates	Main findings	Comments
Soobader & LeClere (26) National Health Interview Survey 1989–1991 US white males 25–64; $N = 9{,}637$	Probability of reporting fair or poor health	Family income (category midpoint divided by household size). Median community income	Quartiles of Gini coefficients at the US tract and census level (Census data tape)	Age, education, occupational status, quartiles of proportion below poverty level	Dominant nonlinear family income effect. Consistent with AIH. Odds ratios rise with income inequality quartiles, but significant income inequality effect only for top two quartiles at census level, and only for top quartile at tract level. Consistent with IIH. No clear gradients in odds ratios and little or no significant effects of median income or poverty. RIH and DH rejected.	Community income and poverty not simultaneously included because of collinearity.
Mellor & Milyo (22) Current Population Survey 1995–1997 US adults 25–74; $N = 186{,}776$	Probability of reporting fair or poor health	Household income and its square. Mean state income	Coefficient of variation and two percentile ratios (90/10 and 50/20) of real household	Age, age squared, race, ethnicity, sex, marital status, health insurance	Effects of household income and its square are significant and imply concave relationship. Consistent with AIH.	Analysis at other levels of aggregation confirms robustness of main finding.

			income per census division, state, MSA, and county (computed from CPS 95–97)	coverage, urbanization, education. Year and state fixed effects	Income inequality effect positive but not significant for any inequality variable. Rejects IIH. Mean state income effect negative but not significant. Rejects RIH.	
As above, but separate analyses for the poor (below federal poverty level) $N = 19{,}675$	As above	As above	As above	As above	State-level income inequality has significant positive effect for one measure (CV) but not others. Some weak support for IIH.	Income inequality of total community population used, not inequality among the poor.
Wolfson et al (34) US National Longitudinal Mortality Study, 1990 US Census $N = 7.6$ million person years of follow up	Survival during follow-up (mortality data from National Death Index matched with CPS data)	Pretax household income	Share of income of poorest 50% of state (the median share)	Age, sex, household size	Convex relationship between individual level income and mortality risk confirms diminishing returns to income. Linear association between state-level expected mortality (predicted by convex individual-level relationship) and income inequality weaker than actually observed association.	Individual mortality risk was not directly related to income inequality measure. Individual level data aggregated to state level to show that non-linearity of income-health relationship at individual level alone cannot explain association.

[a]Abbreviations: MSA, Metropolitan Statistical Area; PSU, Primary Sampling Unit; CPS, Current Population Survey.

is unable, given the data, to control for unobserved fixed effects; finally, the study reports no subgroup analyses (e.g. by the income level of the individual). The design of the study by Daly et al (5) is somewhat better; it too enters individual income linearly; the income inequality data, however, are taken from the census; this study also examines income inequality effects at just one level (this time the state); the study is marginally more successful in controlling for other influences on health; and some subgroup analyses are undertaken (although not all results are reported in full). Despite the differences, neither study finds any general effect of income inequality on individual health.[6] It is a shame that the study with the greatest power (34) does not fully exploit the potential of the individual-level mortality data; they show that the AIH cannot explain most of the state-level association, but they do not further explore whether other individual or state characteristics (or fixed effects) might do so. Unless data linkage limitations prevented them from doing so, this return to aggregate-level analysis seems like a missed opportunity to further unravel the mechanisms underlying the association (cf 9).

The three studies with self-assessed health appear, on the face of it, to give rather different results from one another, with one finding effects of income inequality on individual health among the general population (16), another finding some effects on white working-age males (26), and a third finding no general effects (22). These differences are probably due to the fact that the model estimated by Mellor & Milyo includes fixed state and year effects (they pool data from 1995, 1996, and 1997). In their study, they thus control for variables that cannot easily be observed but vary across states or over time. The inclusion of these fixed effects, along with household income, produces a dramatic fall in both the estimated regression coefficient of income inequality and its significance. By contrast, the inclusion of individual covariates other than household income—given the presence of the state and year fixed effects—has very little effect on the effect of income inequality. The implication is that, in the studies of Kennedy et al (16) and Soobader & LeClere (26), income inequality is probably capturing, at least in part, other state characteristics.

Interestingly, although Mellor & Milyo find no general evidence of an effect of income inequality on individual health when household income is controlled for, some of their results are not that far from those reported by Kennedy et al (16) and Soobader & LeClere. Furthermore, although the authors of the latter two studies claim to find general evidence in support of the IIH, it would be more accurate to say they find mixed evidence.

The study by Kennedy et al (16) finds an effect of income inequality at the state level on individual health. But in subsample analysis, they find that the effects of income inequality depend on income level: among the richest subsample, there are no significant health effects; among the middle-income group, it is only when the Gini rises >0.332 that any significant effect appears; among the poorest income

[6]Daly et al do find an effect among one group—middle-income individuals aged 26–64—but the effect is present in only 1 of the 2 years that they studied (1990) and for only two of the five inequality measures used.

group, there are large and significant effects of income inequality on health, and the effect is larger the higher the level of income inequality. It is more honest to say, therefore, that the evidence from the study by Kennedy et al is mixed—there is strong evidence that income inequality at the state level is inversely associated with an individual's health; but the further one goes up the income distribution, the less evidence there is; at the top, there is no evidence at all. A not dissimilar picture emerges in the study by Mellor & Milyo (22). In contrast to Kennedy et al, they find, as indicated above, no evidence in support of the IIH for the population as a whole. They do find some—albeit rather fragile—evidence, however, of an effect of state level income inequality on the health of those living below the federal poverty line. In this sense, the results of these two studies are thus not that far apart.

Furthermore, the results of Mellor & Milyo (22) are not completely at odds with those of Soobader & LeClere (26). They compare the sensitivity of the estimated health effects of income inequality to the level at which income inequality is measured. As indicated above, they find some evidence of state-level income inequality having a significant effect on the health of those living below the federal poverty line. However, they fail to find any significant effects when income inequality is measured at any other level. The relative magnitudes of the various income inequality effects also vary. Inequality at the census region level has only one half of the effect of inequality at the state level. What is more surprising is that inequality at the metropolitan area level has only 20% of the effect of inequality at the state level, whereas inequality at the county level has only 10% of the effect of state level inequality. These results are more extreme than—but are not dissimilar to—those reported by Soobader & LeClere, who find that income inequality has a larger impact on individual health when measured at the county level than when measured at the lower census tract level. These results are thus consistent with the Mellor & Milyo (22) result that income inequality has the greatest effect when measured at the state level.

As far as the self-assessed health studies of the IIH are concerned, therefore, we have three findings. First, the estimated effects of income inequality are highly sensitive to the inclusion of fixed state and year effects that take into account unmeasured differences between states and years in variables that affect individual health. When these are taken into account, income inequality does not appear to have any effect on individual health. Second, there does appear to be some evidence to suggest that income inequality adversely affects the health of the poor. Third, it appears to be state-level income inequality that has the effect on health rather than income inequality at any other level. This last finding is, as Mellor & Milyo point out, rather odd—it seems more plausible that, if income inequality is capturing the effects of social capital and the adverse effects of social division associated with income inequality, the effect of measured income inequality ought to be stronger when measured closer to home than when measured at a level involving as many people as a state. The stronger effect of state-level inequality, coupled with the stronger effect among the poor, raises the question, as Mellor & Milyo note (22), whether income inequality in these studies is perhaps not capturing social capital or psychosocial factors at all, but rather the effects of public policies toward the poor,

for example, in welfare and Medicaid. Given where different policy decisions are taken in the United States, it seems more likely that the geographical unit across which variations in such policies are observed is the state rather than the census region or the metropolitan area (both of which are statistical constructs) or the county (which has a very limited role in shaping welfare policies). Furthermore, the policies that states adopt may well be correlated with their income inequality. If this is the case, the results reported in the Mellor & Milyo study for one of their income inequality measures, as well as those reported in the studies by Kennedy et al (16) and Soobader & LeClere (26), could quite simply be due to the effects not of state-level income inequality on the health of the poor, but rather the effects of state-level public policies towards the poor on the health of the poor. This clearly requires further empirical work.

CONCLUSIONS

We began with the observation that, at the population level, health and income inequality are often found to be inversely related. We then spelled out a number of hypotheses that have been advanced to explain this association and went on to argue that empirical studies at both the community and population levels—however carefully executed—cannot appropriately discriminate between them. It seems to us that one cannot, for example, despite what has been written and despite the sheer volume of them, conclude very much about the effects of income inequality on individual health from population-level studies. What seems to be required to discriminate between the various hypotheses are individual-level studies, because it is only at this level of aggregation that one can observe relationships that are consistent with one hypothesis and not with another.

Our survey of such studies produced the following conclusions. Extensive evidence strongly supports the AIH—the notion that individual health is a concave function of individual income. By contrast, no evidence whatsoever is consistent with the RIH—the notion that, holding constant one's own income, one's own health is a decreasing function of everyone else's income. Some evidence is consistent with the IIH—the notion that an individual's health is a decreasing function of income inequality in his or her area, but that the strength of the effect depends crucially on how well one controls for other influences on health, especially the individual's income and those that are hard to measure but vary systematically from state to state and from one year to the next. When such influences are controlled for by use of fixed-effect methods, the evidence at the population level appears to disappear. Some weak evidence remains, however, for the poorest section of the population, but only for income inequality measured at the state level—the effects at lower and higher levels are much smaller and are not statistically significant. This suggests that income inequality may not be capturing the hypothesised effects of social capital or psychosocial factors but rather the effects of state-level policies toward the poor that are correlated with income inequality.

In terms of what the literature to date tells us, then, we thus reach two rather negative conclusions. First, a large number of studies have been undertaken that, by their very nature, appear to be incapable of shedding any light on the effects of relative income and income inequality on individual health. This has been argued by other commentators and now seems accepted by most—but not apparently all—researchers in the field. Our second conclusion, which is new, is that the evidence emerging from the studies that can, in principle, shed light on these effects is rather negative—there is strong support for the AIH, no evidence for the RIH, no evidence for the RPH (because it has not been tested), and evidence relating to the IIH that suggests that, in the relatively few cases where income inequality appears to be associated with health at the individual level, this hypothesis may well not be picking up the psychosocial effects associated with social capital and social cohesion. This is not to say that this is definitely the case—rather that the evidence is far from compelling.

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CONTENTS