where there are \( n \) and \( m \) observations below and above the mean, respectively:

\[
E(Y) = \sum_{i=1}^{n} f(x_i) + \sum_{j=1}^{m} f(x_j)
\]

Let there be a number of infinitesimal changes, such that \( E(X) \) is unchanged, but that \( \Sigma x_i \) is increased and \( \Sigma x_j \) reduced (i.e. the mean deviation is reduced).

\[
E'(Y) = \sum_{i=1}^{n} f(x_i + \epsilon_i) + \sum_{j=1}^{m} f(x_j + \epsilon_j)
\]

where \( \Sigma \epsilon_i > 0; \Sigma \epsilon_j < 0; \Sigma (\epsilon_i + \epsilon_j) = 0 \)

Now

\[
\Sigma f(x_i + \epsilon_i) = \Sigma f(x_i) + \Sigma \epsilon_i f(x_i)
\]

\[
\Sigma f(x_j + \epsilon_j) = \Sigma f(x_j) + \Sigma \epsilon_j f(x_j)
\]

So

\[
E'(Y) = E(Y) + \Sigma \epsilon_i f(x_i) + \Sigma \epsilon_j f(x_j)
\]

By the definition of downward concavity, \( f(x_i) > f(x_j) \) for all \( i, j \), since \( x_i < x_j \) therefore \( \Sigma \epsilon_i f(x_i) + \Sigma \epsilon_j f(x_j) > 0 \)

since \( \Sigma \epsilon_i = -\Sigma \epsilon_j \)

Whence

\[ E'(Y) > E(Y) \]

i.e. a reduction in the dispersion of \( X \) raises the expected value of \( Y \).

Note that this result only applies to the mean deviation. For other measures of dispersion it is usually possible to find counter-examples. However, in general such counter-examples are rather extreme and, in practice, in socio-economic systems different measures of dispersion are usually monotonically related with each other.

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**Commentary: Liberty, fraternity, equality**

Richard Wilkinson

The relationship between income inequality and health has been independently discovered several times by people who appeared not to know of each other's work.\(^1,2\) When I first published on the subject\(^3\) I too was unaware of Rodgers' paper\(^4\) until George Davey Smith pointed it out to me.

Rodgers introduced an income distribution term into his regressions simply to take account of the well-known curvature of the international relation between gross national product (GNP) per capita and life expectancy as countries go through the so-called epidemiological transition. In contrast, I came to the subject through an interest in health inequalities within the so-called epidemiological transition. In contrast, I came to the subject through an interest in health inequalities within Britain. While using occupational incomes and death rates to discover whether death rates were responsive to changes in incomes for which people were not self-selected,\(^3,5\) I also wanted to know whether the shape of the individual relation between income and mortality within Britain was linear or curvilinear. My interest in this point was explicitly to find out whether, if income was redistributed from the rich to the poor, the health of the poor would benefit: I wanted to know if average health would be improved by redistribution.

Having been convinced by my results both that mortality was responsive to changes in income and that the health of the poor was more sensitive to changes in income than that of the rich, I thought I might be worth looking to see whether national mortality rates were lower in countries with a narrower income distribution. Mildred Blaxter had mentioned to me that she thought there was such a relationship though she had not looked at it herself.

My first three papers on income distribution\(^3,5,6\) were all accompanied by evidence that the individual relation between income and health or mortality was curved: that not only did the evidence then available suggest it was a substantial proportion and could not be accounted for by improvements to the poorest alone. At around this time I became increasingly interested in the fact that the curvature of the individual relation between income distribution and life expectancy

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was not the same as the social gradient in health within the developed countries. Indeed if you looked at the position of the US on graphs showing the relation between GNP per capita and life expectancy internationally, it was clear that even Americans on half the average US income (a commonly used definition of poverty) were still on the relatively flat part of the international curve. So it seemed as if the health inequalities were about something purely internal to a society.

Michael Marmot had been exploring psychosocial explanations of the social gradient for some time and indeed had set up Whitehall II to advance that process. Later Clyde Hertzman made us aware of the animal models of the relationship between health and social status.9–11 The great advantage of the monkey studies was not only that social status could be experimentally manipulated among captive animals, so increasing our confidence in the direction of causality in the health and social status relation but, for the first time, it was possible to make an unambiguous separation of material living standards and social status. Although among humans higher social status almost always goes with better material conditions (indeed the connection between social dominance among animals and social stratification in humans is that both are about gaining privileged access to resources) among captive monkeys it was possible to ensure that they all had the same diets and lived in the same compounds.11

While these studies demonstrated that low social status could have implications for health among monkeys even when material conditions were held constant, the biological effects of chronic exposure to stress were also becoming clearer and better known. Because their health consequences seemed so widespread, involving the endocrine, cardiovascular and immune systems—and more, psychosocial risk factors began to look like the generalized vulnerability factor capable of explaining why so many different diseases were more common lower down the social scale which had been proposed by Michael Marmot12 and seconded by Sally MacIntyre.13 The physiological processes consequent on chronic stress also seemed to meet other theoretical demands: they were compatible with a period of special sensitivity in early life, with cumulative effects throughout life, and with an impact of current circumstances—just what the epidemiology of health inequalities needed.

The impression that population health was more closely related to income distribution than to average income (which initially seemed true of developed countries and still seems true of US states and cities) added to the reasons for thinking that the social gradient in health was, as the animal studies had suggested, principally about social status rather than levels of material consumption. But we needed some new thinking to understand why. We needed to theorize social status as a psychosocial risk factor, and the biology tells us that this means theorizing it as a source of chronic stress.

Some years earlier the most obvious way of doing that would simply have been to list all the ways in which low social status was associated with sources of anxiety like debt, job and housing insecurity, and the many other difficulties of life on a low income. But two factors seemed to be pointing to something rather more fundamental. The first was that the health and income distribution relationship had led to a recognition, new at least to epidemiologists, that places with bigger income differences seemed to be less socially cohesive. While writing my book Unhealthy Societies8 I had surprised myself when I decided that before discussing the individual psychosocial risk factors which might explain why more egalitarian societies tended to be healthier, I would have a chapter looking at whether there were broader sociological characteristics which distinguished healthier more egalitarian societies from others. Surprised, because the impressionistic qualitative evidence was much stronger than I had expected. Admittedly, the examples I took—Britain in the two world wars, Roseto14 and Japan—were highly selected.

Soon the hypothesis that the quality of social relations was better in more egalitarian societies was supported by data from a number of other sources. Ichiro Kawachi and Bruce Kennedy,15 used a measure of trust as an indicator of the quality of social relations and found that ‘social trust’ seemed to mediate between income inequality and mortality in the 50 states of the US. Finding that there was a substantial literature showing that homicide rates were higher in more unequal societies came as another impressive confirmation of this picture—a novel post-diction’ as philosophers of science used to say. There are over 40 papers on the subject and the relationship seems robust, both within and between countries.16 We found that among the 50 states homicide rates (used as an indicator of the quality of social relations) also mediated statistically between inequality and death rates from all non-violent causes of death17—i.e. the states with social environments which produced high homicide rates also produced high death rates from other causes. Homicide seemed to be related to inequality because it was so frequently triggered by disrespect—being ‘dissed’—particularly when sensitivities were increased by relative deprivation.18,19 Bruce Kennedy20 also showed that racial prejudice was associated with greater inequality. Finally, Robert Putnam emphasized the strong links between his measures of ‘social capital’ and an egalitarian social ethos—cross-sectionally in his Italian study, and both cross-sectionally and over time in his study of involvement in community life in the US (ref. 21, pp. 102–05 and note 52 p. 224; ref. 22, p. 359).

On their own these links seemed more of a clue to, than an explanation of, the inequality relationship: going to meetings of community groups, not getting murdered, and trusting others, are not in themselves normally regarded as sufficient conditions to ensure good health. The second pointer comes from the main psychosocial risk factors for population health. In terms of population attributable risks, the three most powerful of these must be low social status itself, all the various measures of social affiliation, networks, support, etc, and stress in early life (probably pre-natal as well as in early childhood).3,23–26 Having control over one’s work27 may function partly as the fine grain of social status, in that if you do not have control of your work it usually means you are subordinate to someone else: a close synonym for having control in this context might be autonomy and its opposite would be subordination.

If we think of these intensely social risk factors as telling us about the most powerful sources of chronic stress in our society, then we can see that they may be different clues to the same inner source.26 The personal insecurities which come from early childhood are not unlike the insecurities and fears of inadequacy which come from low social status. Both are associated with higher basal cortisol levels, and early childhood insecurities must make us more vulnerable to the insecurities of low social
status. Friendship fits easily into this picture: friends provide positive feedback and reassurance of one’s acceptability and attractiveness, whereas not having friends, or feeling rejected, does the opposite and fills us with self-doubt. We worry about being unattractive, fat, boring, stupid, or gauche, and fear negative social comparisons. As reflexive beings we know ourselves—and actually experience ourselves—partly through each other’s eyes. We monitor how others react to us. How we imagine they see us can fill anyone with overwhelming embarrassment, pride, shame, or whatever.

These social anxieties are almost inescapably part of negotiating our way through social space, indeed they guide our behaviour and we cannot avoid monitoring how others respond to us. But some social environments make these processes more anxiety laden than others. While being among friends is clearly reassuring, finding ourselves in a society where people appear to be ranked according to ability and attractiveness, from the most able and successful at the top, to the most unattractive failures at the bottom, inevitably generates anxiety about ranking. Where some people appear to count for everything and others for nothing, and processes of class prejudice and discrimination mean that we take people’s status as a reflection of their abilities, few can avoid worrying about where they come.

We can now start to see how this inner angst about how we negotiate social space is affected by hierarchy, by friendship and, through its impact on our emotional resilience, by early childhood experience. In this context, one of the most interesting graphs Robert Putnam provides in his Bowling Alone shows that in the more unequal parts of the US, where participation in community life is lower, it is particularly the poorer people who have ceased to participate (Fig. 93 p. 361, note 16 p. 497). Where there is more income inequality, poorer people are more likely to feel out of place participating in community groups, more likely to feel ill at ease and to think that they will make fools of themselves and be looked down on. We know that there is more racial prejudice in those areas and it would be surprising if there was not also more class prejudice and stigma.

We now have the theoretical basis on which to integrate the personal psychological world into the broader social structure. It is a perspective which allows us to understand not just the impact of social structure in the broadest societal terms, but presumably also the effect of how institutions work, of how junior staff are treated, whether they feel valued or used, whether institutions are more egalitarian and inclusive, or more divisive and authoritarian.

We can take another important step in understanding what is going on if we ask why hierarchy and the quality of social relations have a double link between them: first, as they are powerful health risks factors (low social status and weaker social affiliations are both strongly associated with worse health) and second, as they vary inversely in societies (more inequality being associated with less trust, more violence and less community participation). On the face of it these two links seem quite independent of each other. But the reason why they move inversely in societies and are both related to health is surely because they are the opposite sides of the same coin. Social stratification, dominance hierarchies or ‘pecking orders’ are (among humans as among animals) principally about privileged access to resources based on coercion and superior power, regardless of the needs of others: that is why the ‘high’ are also the ‘mighty’ and get the lion’s share. Friendship on the other hand is exactly the opposite of that: It is about sharing, mutuality, reciprocity, social obligations, and a recognition of each others needs. The gift is a mark of friendship because, between giver and receiver, it symbolizes a renunciation of conflict for access to scarce resources.

We are dealing then with the fundamental elements of human social relationships: with whether we are threats to each other, or sources of help and support. Human beings can associate either on the basis of strength and superior power or on the basis of co-operation. Which we do has important implications for whether other people are a source of anxiety and stress, or whether they provide a sense of security and relaxation. Relations of one kind are damaging to health, and of the other, are beneficial. But how relationships are structured is not of course simply a matter for individual decisions: we find ourselves in a particular society with a set of institutions which already structure relationships into patterns of dominance and subordination, superiority and inferiority within which we have definite class positions.

Social status, friendship and equality impact so strongly on the quality of our lives that they have long been recognized as important political issues. Indeed, they translate directly into the revolutionary demand for liberty, fraternity, and equality—the slogan still reproduced on some of the French versions of the Euro coins. At the time of the French revolution, liberty meant not being subjected to the arbitrary power of the aristocracy and feudal nobility, not being subordinate or beholden to anyone. It expressed the desire to avoid the invidiousness of low social status, loss of autonomy, and subordination. Fraternity, or at least some less sexist term such as friendship, comradeship or solidarity, is just that—it expresses the human need for congenial and supportive social relations that we know are associated with better health. Finally, equality is substantially a precondition for the other two: for liberty because only in the more egalitarian and less hierarchical societies can the burden of social inferiority and subordination be reduced; and for fraternity, because we tend to choose our friends among our equals and find it difficult to negotiate the social distance created by differences in wealth and power.

Here we have a politics of health that is substantially a politics of human social relations, relating our psychological needs as human beings to the social structure in which we live. But it is a politics that also has important implications for the position of women. Not only are more unequal societies more violent, they are also more male dominated. More unequal societies seem not only to have more class and racial discrimination, but also more discrimination against women. Indeed, the position of women is unlikely to improve until social relations in the public space become more sociable: women’s status tends to be better in societies where income differences among men are smaller. The well-known tendency for health to be better in societies where women’s status is better may be a reflection of the fact that women’s status is likely to serve as an indicator of the nature of the social environment more generally. It is not just women’s health, or even women’s and infant health, which is better in such societies, but men’s health as well.

Given that among animals access to females was one of the most important resources which dominant males tried to monopolize, and that females in dominance hierarchies tend to prefer...
the higher status males, dominance relationships are likely to have profound implications for relations between the sexes. Ng and Bond\textsuperscript{33} have recently found that, as influences on mate selection, considerations of economic status become more important and other bases for attraction less important in more unequal societies. In such a context we should not be surprised by the violence that comes when young men feel they are being devalued and disrespected.\textsuperscript{17}

However, just when the theoretical picture seems to be coming together, its empirical underpinnings look as if they are starting to unravel. Part of the problem is that some researchers are redefining the effects of income distribution as only the residual effects left after controlling for individual income. This approach has attracted primarily those who assume that individual income distinguishes ‘compositional’ material effects of income from more peculiar ‘contextual’ effects of psychosocial relativities. But given that one of the most plausible interpretations of the social gradient in health is that it partly reflects the impact of individual social position (i.e. contextual social relativities) on health, this is misguided. Social class, social status, relative poverty are relational, or social system, variables. Rather than being context-free individual variables, they are about position in a wider social context.

In policy terms, it is also dangerously misleading to suggest that, insofar as inequality effects are mediated by people’s individual positions within the wider social context, inequality does not matter: if narrower income distribution is related to health, it makes little difference to policy makers which route does not matter: if narrower income distribution is related to health, it makes little difference to policy makers which route

The impact of individual social position (i.e. contextual social relativities) on health, this is misguided. Social class, social status, relative poverty are relational, or social system, variables. Rather than being context-free individual variables, they are about position in a wider social context.

In policy terms, it is also dangerously misleading to suggest that, insofar as inequality effects are mediated by people’s individual positions within the wider social context, inequality does not matter: if narrower income distribution is related to health, it makes little difference to policy makers which route it works through.\textsuperscript{34} However, for what it is worth and despite mixed results from other studies,\textsuperscript{35} the study which uses much the most reliable data suggests that more than half of the income distribution relationship exists even after controlling for the relation between individual income and health.\textsuperscript{36}

But that is not the only difficulty. Although income distribution has now been shown to be related to mortality or morbidity in many different settings, there is now more than a sprinkling of reports that do not confirm such a relationship. But over the last 20 years relationships have been reported in the US among all states,\textsuperscript{37} counties\textsuperscript{38} and cities,\textsuperscript{39} among counties in Texas,\textsuperscript{40} and North Carolina,\textsuperscript{41} among census tracts and zip code areas in New York,\textsuperscript{42,43} within Brazil,\textsuperscript{44} among the 88 regions of the Russian Federation,\textsuperscript{45} among the regions of Taiwan\textsuperscript{46} and local authorities in England,\textsuperscript{47,48} as well as nine times in international studies using different data sets\textsuperscript{2,4,6,9-53} and excluding Sen’s indicative findings.\textsuperscript{54} Attempts to explain away the relationship are rarely relevant to more than one of the many contexts in which it occurs. However, taking developed countries alone, the international relation between income distribution and mortality now appears to be limited to a few age groups and does not exist among the elderly who account for the bulk of mortality.\textsuperscript{55,56} In addition, although Canadian mortality rates are much as we might expect given Canada’s income distribution, there is no evidence of a relation within Canada.\textsuperscript{57}

Several studies using US data have found that in areas as small as census tracts or zip code areas relations are very weak or non-existent.\textsuperscript{42,58} Part of the problem is that if you use the two variables—income inequality within an area and the median income of the area—and you then move to larger or smaller units of analysis, some of the differences in the income inequality of larger areas will get converted to differences in median income between the smaller areas. This means that variance, which would be income inequality in larger areas, becomes median income in smaller areas, and is treated unthinkingly as if it only affected health as absolute income. You can convert either way. This is why associations between income inequality and health tend to be strongest in larger areas and weakest in smaller areas, while exactly the opposite is true of associations between median income and health.\textsuperscript{40-50,58-60} If we take single household areas as the extreme case of small areas, we are of course back to individual income. At that level, all the income variance that would be income distribution in larger areas appears as absolute individual income—although many would argue that it is actually individual income relative to others.

So where should research go from here? What view might we take of negative findings? Clearly no variable can be expected to show relationships to health every time, before any other factors have been taken into account. It seems likely that the shift in the distribution of relative poverty from the elderly (where death rates are high) to young families with children (where they are low) may have important consequences for associations with population mortality rates.\textsuperscript{55} But an important additional factor may be that, with the exception of the US, differences in income distribution among developed countries are fairly small. If income is only a crude proxy for how hierarchical the social status hierarchy is, then perhaps we need to find better measures. The evidence already mentioned makes it clear that social capital variables often seem to mediate between income distribution and health, but social capital has not been theorized or understood in terms of vertical power relations versus horizontal affiliative relations. A start might be to substitute something more like the Social Dominance Orientation Scale as a measure of the hostility of the social environment. Its originators, Jim Sidanius and Felicia Pratto\textsuperscript{61} suggest that it measures a ‘basic grammar of social power’ which operates in all societies. Extensive tests have shown that the scale is related to racism, classism and patriarchy, and that, as a predictor of attitudes, it performs better than scales measuring the ‘authoritarian personality’.\textsuperscript{62} Although previously used as an individual measure rather than as a measure of the social environment, it might provide a way of integrating rather nebulous ideas of social capital with a more theorized view of power and inequality. As for individual measures, a moment’s thought shows that as well as measures of social status, we also need to find measures of people’s social anxiety and sensitivity to status issues.

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Commentary: Theory in the fabric of evidence on the health effects of inequalities in income distribution

Miquel Porta, Carme Borrell and José L. Copete

Theory comes first. Thus, Rodgers' second paragraph begins: ‘Theory: Let us suppose that at the individual level there is a relationship between income and life expectancy.’ Then Rodgers expresses his seemingly simple idea in a (slightly less) simple diagram. By drawing the graph, the scholar has left the pier of ‘pure’ concepts; but he is not yet sailing the open sea of quantitative analysis (where theoretical concepts are the guiding stars, of course). He further notes: ‘the relationship in Diagram 1 is defined for an individual.’ What about the empirical data? That is a bit like the breeze you need to fill the sails, isn’t it ... Well, the author realizes that ‘in practice, data—once carefully, not gratuitously thought out—gives shape to a new dimension of the theory, which is then empirically tested. At the end of the paper Rodgers seems to conceal his amazement when concluding: ‘The most striking result is only by ‘thinking the diagram’? Surely, from his diagram ‘it is clear that there will be a tendency for greater dispersion of income to be associated with lower mean life expectancy’, The diagram is not semi-theoretical and semi-quantitative, but both theoretical and quantitative—yet, it is still untested.

By the way, what would have happened if data at the individual level had been available to Rodgers? Such is often the case, nowadays. So, theory comes first, then the data; and the nature of available data—once carefully, not gratuitously thought out—gives shape to a new dimension of the theory, which is then empirically tested. At the end of the paper Rodgers seems to conceal his amazement when concluding: ‘The most striking result is the consistent significance of the income distribution variable’. This is the ‘very robust conclusion’ that holds across a variety of statistical models: greater income inequality is associated with higher mortality. We comment on this immediately below. Also most appealing to us today, is the inner structure of Rodgers’ paper; in particular, the way theory, hypothesis formulation, model specification, statistical analyses, and conclusions are intertwined in a coherent fabric. Theory does not clothe the data: it weaves in with the data. Hence the unique texture of the evidence knitted by Rodgers.

How many public health journals would publish Rodgers’ article today? We fear many would not. We do not think it is a trivial question. The structure of the paper and its format faithfully reflect the process of inquiry and thinking, and the

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