

## REPRINTS AND REFLECTIONS

# Income and inequality as determinants of mortality: an international cross-section analysis<sup>a</sup>

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## Introduction

The determinants of mortality change in less developed countries are not easy to unravel. Improvements in health technology and availability are evidently relevant; education certainly plays an important part; sanitation, clean water supply and a host of other environmental variables have undoubted effects. But empirically, the effects of these different factors are difficult to identify. The variables tend to be collinear with each other, and with many other aspects of development, making their isolation difficult. Moreover, there is a tendency for health programmes to be most intensive in the least healthy places, for obvious reasons, further confusing observed relationships.

Identifying the impact of factors such as these, which are directly associated with health, is well worth while for purposes of policy formulation; but it may not be critical for a description of mortality changes in the process of development. For behind these specific variables, the overall economic status of individuals is likely to dominate health changes—through nutrition and other aspects of consumption, and also because economic status is a close correlate and determinant of many of the more specific variables noted above. Higher incomes may be a precondition for healthier environments and better health services, given competing demands on resources—this is self-evident at the community or national level but is also likely to hold at the individual level. Thus, for a general empirical analysis, it is quite reasonable to propose a sequence of causation which goes from income to mortality via a number of intermediate variables with which we need not necessarily concern ourselves.

## Theory

Let us suppose that at the individual level there is a relationship between income and life expectancy. Observations in developed countries suggest that this relationship is asymptotic; that is, there is a maximum life expectancy beyond which increases in income have no further effect. It is even possible that at very high

incomes, diseconomies of excessive income might reduce life expectancy, but this we disregard for present purposes. The relationship between income and life expectancy is thus non-linear, and we can reasonably suppose that it will take the form suggested by  $FF_1$  in Diagram 1, with the slope of the curve declining (at a declining rate) with increasing income. This suggests the use of the reciprocal of income as a determinant of life expectancy. There is also some intuitive support for the proposition that a proportional change in income may be required for arithmetic changes in mortality, but the presumption here is weaker. If correct, this would suggest the use of the logarithm as the explanatory variable.

The relationship in Diagram 1 is defined for an individual. In practice, however, data for studying this type of relationship are available only at the aggregate level, if only because of the difficulty of generating appropriate, accurate micro-data. Thus, we need to formulate a relation between life expectancy at community or national level, and the incomes of the individuals composing the society concerned. With a linear relation between life expectancy and income, no problem arises; a corresponding linear relationship between mean life expectancy and mean income can be defined. However, our function is non-linear, and mean life expectancy is a function not only of the mean income level, but also of the distribution of income. Without defining the distribution function for income, no complete relation can be established. But it is clear that there will be a tendency for greater dispersion of income to be associated with lower mean life expectancy. This can be seen by taking two income observations in Diagram 1,  $x_1$  and  $x_4$ , with mean  $\bar{x}$ ; their mean life expectancy is  $\bar{y}_1$ . If dispersion is reduced, by raising  $x_1$  to  $x_2$  and reducing  $x_4$  to  $x_3$ , while holding  $\bar{x}$  constant, mean life expectancy is raised to  $\bar{y}_2$ . This relationship is discussed in more detail in an appendix.<sup>1</sup> In theory, it holds only for the mean deviation measure of dispersion; in practice, however, different measures of dispersion of income are highly correlated, so that under normal circumstances a similar negative relation may be expected between mean life expectancy and measures such as the variance or the Gini coefficient.

Our macro-model can therefore be specified as

$$Y = a + f(X) + bG + \epsilon$$

where  $Y$  is mortality or life expectancy  
 $f(X)$  is a function of mean income  
 $G$  is a measure of income distribution  
 $\epsilon$  is an error term

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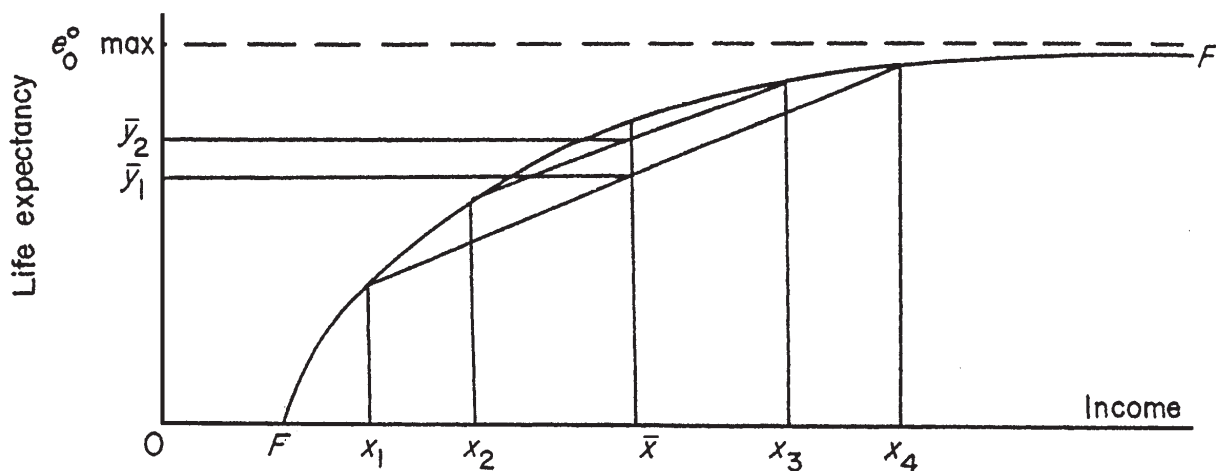


Diagram 1 Life expectancy as a function of income

The precise shape of this function depends on the joint relation between a number of other variables and income and mortality. General improvements in medical technology, for instance, will shift the asymptote upwards; this could be represented by introducing time explicitly into the function. More specific health improvements (e.g. eradication of malaria, exceptionally large health programmes, etc.) may also shift the function at lower income levels. It might, therefore, be possible to analyse the impact of such variables by looking at deviations from the trend relation with income. However, we do not treat these issues in the present paper.

## Data

The function described above has been estimated using international cross-sectional data from 56 countries. The basic criterion for the choice of countries was that income distribution data were available. The distribution of income data used are those of Paukert,<sup>2</sup> in some cases somewhat updated, with Thailand added and Lebanon deleted for lack of appropriate mortality information. Gini coefficients and quintile distributions were taken from this source.

Mortality data (life expectancy at ages 0 and 5, and infant mortality) were taken either from standard demographic sources<sup>3</sup> or from an ILO compilation.<sup>4</sup>

For the income variable, national income per head in US dollars was taken for a year approximating as closely as possible to the year for which life expectancy data were available.<sup>5</sup> Some cases where the income and life expectancy referred to very different dates have been dropped.

## Results

A variety of different model specifications were tried, using three different dependent variables—expectation of life at birth, at fifth birthday, and infant mortality. The income variable was tried in a number of different specifications, including reciprocal, reciprocal quadratic and reciprocal logarithm. The income distribution variable used was the Gini coefficient, except that in some runs the mean income of specified population groups

was used rather than mean overall income, to combine income and its distribution into a single measure.<sup>6</sup>

### (i) Life expectancy at birth

Results from three different specifications are given in Tables 1, 2 and 3. In general, it can be seen that both income and income distribution are highly significant, with  $R^2$  mostly over 0.75.

In Table 1 a sequence of specifications based on logarithms of income is presented, parameterizing on a coefficient ( $p$ ) multiplying income. Maximum explanation is achieved when this coefficient is 0.12. However, this gives an asymptotic life expectancy of about 95 years, which is unrealistic. On the other hand, if we select a value for the parameter  $p$  which gives us an asymptote of around 75 years,  $R^2$  diminishes rapidly. Thus, there are some practical reasons for doubting the applicability of the formulation using the reciprocal logarithm and the Gini coefficient as independent variables. However, these are both highly significant.

Table 2 gives the results of an alternative formulation, using the reciprocal of income and its square, together with the Gini coefficient. All three variables are significant and the asymptote is more or less in line with *a priori* expectations. This is, therefore, a rather more satisfactory result.

In Table 3 we present the results of a different approach, using mean income of the lowest 20, 40, 60 and 80 per cent of the population, respectively. Mean income for the population as a whole is also given for comparative purposes. The best results are achieved in the 60 per cent to 80 per cent levels in terms of the  $R^2$ s, and in the 20 per cent and 40 per cent levels in terms of the  $t$  values. When income in the population as a whole (the 100 per cent level) is used, the explanation is noticeably worse, thus further demonstrating the effect of income distribution on life expectancy. The asymptotes all fall within an acceptable range.

### (ii) Life expectancy at fifth birthday

Much of the international variation in life expectancy is due to infant mortality, and we may expect the factors affecting infant mortality to be somewhat different from those which influence adult and child mortality. Life expectancy at fifth birthday was,

**Table 1** Dependent variable: life expectancy at birth; whole sample.\* Regression coefficients and *t* values (*N* = 56). *p*: parameter multiplying income

<i>p</i>	Independent variables				<i>R</i> <sup>2</sup>
	$\frac{1}{\log(pY)}$	$\frac{1}{(\log Y)^2}$	Gini	Asymptote	
1.00	-136.2 (11.85)	-	-	113.4	0.722
1.00	-132.0 (12.27)	-	-27.46 (3.10)	114.9	0.765
1.00	-3.71 (0.56)	-183.5 (3.79)	-35.26 (3.55)	103.0	0.775
0.01	0.1889 (2.43)	-	-44.30 (2.70)	63.5	0.188
0.02	-3.323 (8.16)	-	-56.01 (4.82)	71.7	0.600
0.03	-11.74 (11.32)	-	-47.52 (5.09)	78.9	0.736
0.06	-28.15 (12.46)	-	-38.85 (4.47)	87.2	0.770
0.08	-35.98 (12.57)	-	-36.58 (4.23)	90.3	0.773
0.10	-42.49 (12.60)	-	-35.12 (4.07)	92.6	0.7740
0.12	-48.09 (12.60)	-	-34.09 (3.95)	94.5	0.7741
0.15	-55.30 (12.59)	-	-32.98 (3.81)	96.7	0.7738

\*Notes to tables are given after Table 6.

**Table 2** Dependent variable: life expectancy at birth, whole sample.\* Regression coefficients and *t* values (*N* = 56)

Independent variables				
$\frac{1}{Y}$	$\frac{1}{Y^2}$	Gini	Asymptote	<i>R</i> <sup>2</sup>
-4469 (6.40)	149 900 (3.38)	-	72.9	0.712
-2236 (12.11)	-	-43.87 (4.94)	73.7	0.760
-3389 (4.93)	76 880 (1.74)	-36.47 (3.76)	75.1	0.773

\*Notes to tables are given after Table 6.

therefore, used as a dependent variable, partly as a proxy for adult mortality. The best results are given in Table 4. For reasons similar to those in the case of life expectancy at birth, the non-logarithmic formulation is preferable, and the most acceptable result is the simplest, using only the reciprocal of income and the Gini coefficient as explanatory variables. The squared reciprocal of income was nowhere significant. The level of explanation, as measured by *R*<sup>2</sup>, is virtually as high as for life expectancy at birth.

**(iii) Infant mortality**

The best results with infant mortality as dependent variable are given in Table 5. *R*<sup>2</sup> is generally lower than for life expectancy

**Table 3** Dependent variable: life expectancy at birth; whole sample.\* Regression coefficients and *t* values (*N* = 56). *a*: population percentiles

<i>a</i>	Independent variables			
	$\frac{1}{Y_a}$	$\frac{1}{(Y_a)^2}$	Asymptote	<i>R</i> <sup>2</sup>
20	-1334 (8.26)	13 751 (4.82)	75.0	0.724
40	-1821 (8.83)	24 987 (5.00)	75.0	0.770
60	-2043 (7.41)	30 799 (3.56)	73.9	0.781
80	-2505 (7.17)	45 466 (3.30)	73.4	0.782
100	-4469 (6.40)	149 900 (3.38)	72.9	0.712

\*Notes to tables are given after Table 6.

at birth or birthday five; but otherwise the pattern is similar. The negative asymptote in the logarithmic form is unsatisfactory, and the best results are found when using income in the lowest 60 per cent of the population as the explanatory variable (with a squared term), and using overall income and the Gini coefficient.

**(iv) Less developed countries only**

In order to test the possibility that the results merely reflect the difference between two groups of countries, one developed, the

**Table 4** Dependent variable: life expectancy at fifth birthday; whole sample.\* Regression coefficients and *t* values (*N* = 43) (best results and results for comparative purposes)

<i>a</i>	<i>p</i>	Independent variables			Gini	Asymptote	<i>R</i> <sup>2</sup>
		$\frac{1}{Y_a}$	$\frac{1}{(Y_a)^2}$	$\frac{1}{\log(pY_a)}$			
100	-	-1587 (11.10)	-	-	-18.02 (2.49)	70.4	0.758
100	0.05	-	-	-16.40 (11.05)	-15.33 (2.12)	78.2	0.756
100	1	-	-	-89.58 (9.57)	-6.31 (0.79)	97.9	0.700
80	-	-1299 (4.42)	11 989 (1.05)	-	-	70.0	0.769
80	0.6	-	-	-31.24 (10.71)	-	82.3	0.737
60	0.8	-	-	-29.02 (10.81)	-	81.6	0.740

\*Notes to tables are given after Table 6.

**Table 5** Dependent variable: infant mortality; whole sample.\* Regression coefficients and *t* values (*N* = 51) (Best results and result for comparative purposes)

<i>a</i>	<i>p</i>	Independent variables			Gini	Asymptote	<i>R</i> <sup>2</sup>
		$\frac{1}{Y_a}$	$\frac{1}{(Y_a)^2}$	$\frac{1}{\log(pY_a)}$			
100	-	6275 (7.04)	-	-	112.5 (2.58)	21.1	0.543
100	0.05	-	-	66.61 (7.29)	103.9 (2.43)	-11.5	0.559
100	1	-	-	385.6 (7.58)	64.1 (1.51)	-90	0.577
60	-	7465 (5.45)	-147 433 (3.45)	-	-	14.0	0.581
80	1.6	-	-	229.1 (7.82)	-	-55.4	0.555

\*Notes to tables are given after Table 6.

other less developed, a series of runs was undertaken using only data for countries with incomes per head of less than \$1000. Some results are given in Table 6, where it can be seen that significance is somewhat reduced by comparison with runs using the whole sample, particularly for infant mortality. However, the results on expectation of life at birth (and also those at fifth birthday, not reported here), hold up quite well, with significance generally retained, and estimated coefficients not significantly different from those on all countries.

## Conclusion

The most striking result is the consistent significance of the income distribution variable. This is a very robust conclusion which holds across a variety of specifications and with each of the three dependent variables. Although a few specifications led to relatively low significance for income distribution, these were

usually unacceptable for other reasons (e.g. poor asymptote), and the sign of the income distribution terms was always as expected—greater inequality being associated with higher mortality. The results for life expectancy at birth suggest that the difference in average life expectancy between a relatively egalitarian and a relatively inegalitarian country is likely to be as much as five to ten years. The distribution of income may not be the only factor operating, of course—inequality in income distribution is likely to be associated with inequality in access to health and social services, in education, and in a number of other aspects of society relevant to mortality.

The highly significant income terms are much more predictable of course, but here too, the form of the function is of interest. Asymptotes near the predicted level of 75 years for life expectancy at birth, 70 years at fifth birthday, and 15–20 per 1000 for infant mortality are generated by functions using the reciprocal of income, or a quadratic expression in that variable,

**Table 6** Less developed countries only compared with all countries; selected regressions for comparative purposes

Dependent	Independent variables				Asymptote	R <sup>2</sup>
	$\frac{1}{Y}$	$\frac{1}{Y^2}$	$\frac{1}{\log Y}$	Gini		
<b>Life expectancy at birth</b>						
(i) less developed countries	-	-	-150.1 (8.47)	-37.96 (3.25)	124.6	0.646
(ii) all countries	-	-	-132.0 (12.27)	-27.46 (3.10)	114.9	0.765
(iii) less developed countries	-3041 (2.95)	56 682 (0.94)	-	-41.30 (3.34)	74.6	0.646
(iv) all countries	-3389 (4.93)	76 880 (1.74)	-	-36.47 (3.76)	75.1	0.773
<b>Infant mortality</b>						
(i) less developed countries	-	-	352.8 (4.09)	61.3 (1.05)	-84	0.324
(ii) all countries	-	-	385.6 (7.58)	64.07 (1.51)	-90	0.577
(iii) less developed countries	4801 (0.91)	12 751 (0.04)	-	78.67 (1.26)	38.1	0.333
(iv) all countries	10 547 (2.99)	-279 611 (1.25)	-	83.30 (1.69)	72	0.558

$Y$  = income per head in US dollars (not deflated for price differences and changes); 'Gini' is the Gini coefficient of income equality.

Figures in the tables are the estimated coefficients of the independent variables indicated, in a linear formulation, with  $t$  values in brackets. The asymptote is life expectancy (or mortality) as income tends to infinity, and equals the regression constant where only income variables are used. Where the Gini coefficient is included as an independent variable, it is assumed that it tends to 0.33 as income tends to infinity (see Paukert, *op.cit.* in footnote 2), and the overall asymptote reflects this.

The  $a$  coefficients refer to income in a certain proportion of the population. Thus for  $a = 60$  we would have  $Y_{60}$  as the mean income per head in the 60 per cent of the population with the lowest incomes.

The  $p$  coefficients are merely designed to improve the logarithmic form by making it a three rather than a two-parameter model. The values reproduced are those giving the best or most interesting results.

and these also tend to be among the best in terms of significance. These are functions which are sharply non-linear—in the last function in Table 2, for example, the rate of increase of life expectancy with income declines from 0.185 at \$100 per head to 0.003 at \$1000 per head. The downward concavity conforms to expectations,<sup>7</sup> and gives indirect support to the conclusions with respect to income distribution.

Finally, it is worth stressing again that the neglect of health, environmental and social variables does not imply that they are unimportant. Rather it is only after gaining an overall appreciation of the relations between mortality and economic status and inequality that their impact can be assessed.

## References

- <sup>1</sup> Cf. also S. H. Preston, 'The Changing Relation between Mortality and Level of Economic Development,' *Population Studies*, **29**, 2 (July, 1975), pp. 231–248.
- <sup>2</sup> F. Paukert, 'The Distribution of Income at Different Levels of Development', *International Labour Review*, **108**, 2–3 (August–September 1973).
- <sup>3</sup> E.g., UN, *Demographic Yearbooks* (New York, various dates).
- <sup>4</sup> Due to Richard Anker. Sources for this compilation are given in R. Anker, 'An Analysis of Fertility Differentials in Developing Countries', *Review of Economics and Statistics* **60**, 4 (February 1978).

<sup>5</sup> From UN, *Yearbooks of National Accounts Statistics* (New York, various dates).

<sup>6</sup> Certain other specifications were tried out and dropped. In particular, (a) the year of the life expectancy data proved not to be significant in explaining asymptotic life expectancy; (b) a series of runs using income per adult equivalent rather than income per head gave virtually identical results, and was eliminated by applying Occam's razor; (c) experiments with non-asymptotic specifications of the income variable explained significantly less of the variance of life expectancy.

<sup>7</sup> The quadratic forms have unpredictable shapes at incomes below the range of the observations, but are of the expected form from a certain income level—\$68 per head in the case of the last function of Table 2.

## Appendix

Take any function,  $Y = f(x)$ , concave downwards (of which our postulated relationship between life expectancy and income is a special case). Let  $X$  be a random variable with unknown distribution. Then we postulate that given  $E(X)$ ,  $E(Y)$  is a negative function of the dispersion of  $X$ .

The mean deviation of  $X$  is given by

$$\sum_{i=1}^n (\bar{x} - x_i) + \sum_{j=1}^m (x_j - \bar{x})$$

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

$$\begin{aligned}\Sigma f(x_i + \epsilon_i) &\approx \Sigma f(x_i) + \Sigma \epsilon_i f'(x_i) \\ \Sigma f(x_j + \epsilon_j) &\approx \Sigma f(x_j) + \Sigma \epsilon_j f'(x_j)\end{aligned}$$

So

$$E^*(Y) \approx E(Y) + \Sigma \epsilon_i f'(x_i) + \Sigma \epsilon_j f'(x_j)$$

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.

## 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.<sup>1,2</sup> When I first published on the subject<sup>3</sup> I too was unaware of Rodgers' paper<sup>4</sup> 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 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,<sup>3,5</sup> 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 by more than the health of the rich would suffer: 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 it 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<sup>3,5,6</sup> were all accompanied by evidence that the individual relation between income and health or mortality was curved: that not only seemed to lend plausibility to a causal interpretation of the cross-sectional relationships between income distribution and mortality in different countries, it was why I thought they existed. It was then a little annoying when, a few years later Gravelle<sup>7</sup> suggested, as if it were a new hypothesis, that the income distribution relationship might be explained by the curvature of the individual relation between income and health. He did so without reference to the evidence in my earlier papers, although I had pointed it out to him when he sent me a draft of his paper for comment.

It was George Davey Smith who originally suggested to me that income distribution might be associated with health for reasons unconnected with the curvature of the individual income health relation (ref. 8, p. 105). I had previously done some back-of-an-envelope calculations of how large a part of the health disadvantage associated with low socioeconomic status it would be necessary to remove to produce the improvement in average health that seemed to be associated with greater equality. The evidence then available suggested 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 international relationship between income distribution and life expectancy

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.<sup>9–11</sup> 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.<sup>11</sup>

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 Marmot<sup>12</sup> and seconded by Sally MacIntyre.<sup>13</sup> 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 Societies*<sup>8</sup> 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, Roseto<sup>14</sup> 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<sup>15</sup> 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.<sup>16</sup> 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 death<sup>17</sup>—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.<sup>18,19</sup> Bruce Kennedy<sup>20</sup> 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).<sup>9,23–26</sup> Having control over one’s work<sup>27</sup> 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.<sup>26</sup> 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*<sup>22</sup> 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<sup>20</sup> 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.<sup>28</sup> 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 *friendship*, 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.<sup>29</sup> 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.<sup>30</sup> 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.<sup>31,32</sup>

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<sup>33</sup> 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.<sup>17</sup>

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 it works through.<sup>34</sup> However, for what it is worth and despite mixed results from other studies,<sup>35</sup> 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.<sup>36</sup>

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,<sup>37</sup> counties<sup>38</sup> and cities,<sup>39</sup> among counties in Texas<sup>40</sup> and North Carolina,<sup>41</sup> among census tracts and zip code areas in New York,<sup>42,43</sup> within Brazil,<sup>44</sup> among the 88 regions of the Russian Federation,<sup>45</sup> among the regions of Taiwan<sup>46</sup> and local authorities in England,<sup>47,48</sup> as well as nine times in international studies using different data sets<sup>2,4,6,49-53</sup> and excluding Sen's indicative findings.<sup>54</sup> 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.<sup>55,56</sup> 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.<sup>57</sup>

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.<sup>42,58</sup> 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.<sup>40,58-60</sup> 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.<sup>55</sup> 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,<sup>61</sup> 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'.<sup>62</sup> 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

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Theory comes first. Thus, Rodgers' second paragraph<sup>1</sup> 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.'<sup>1</sup> 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 for studying this type of relationship are available only at the *aggregate level*'. This—we might call it—'minor practical problem' entails, he writes, 'the need to formulate a relation between life expectancy at community or national level, and the incomes of the individuals composing the society concerned'. It seems as if only then does a new hypothesis—radically new, it will turn out—occur to him: 'the mean life expectancy is a function not only of the mean income level, but also of the distribution of income.' This seminal idea—does it become apparent to him

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'.<sup>1</sup> 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 ...<sup>2</sup>

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.'<sup>1</sup> 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.<sup>1</sup>

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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careful dialogue between theory and data. So also does the parsimonious explanation of methods and results, the tables, the omission of many quantitative results, the interspersed comments ... It is all quite unconventional by today's editorial standards. Not only editorial standards, in fact: unconventional by many standards. It is at odds with most papers we write and read, with the predominant ways of working and thinking ... At odds, perhaps, with the place of theory in our current weaving of epidemiological evidence. By the way, how much thought do you feel the diagram deserves?

## The theories and mechanistic findings of Richard Wilkinson and others

Naturally, the most interesting aspect of Rodgers' paper is the main finding itself: greater inequality in income distribution is associated with higher mortality.<sup>1</sup> Through an intense, and at times difficult, process of inquiry developed over the past few decades, a diversity of theories and data have provided a rich body of evidence on the impact upon health indicators of the shape of the income distribution. Much of the evidence, but by no means all,<sup>2</sup> supports the idea that the level of population well-being depends not only on the absolute income of a society, but also on the distribution of income across society. At an aggregate level, among less developed nations, a relationship frequently exists between increase in GNP per capita and improvement in health. This relationship may not hold for developed societies, where the income distribution may matter more. The paper by Rodgers<sup>1</sup> was one of the earliest studies, if not the earliest, to empirically show that. (The history of political science would, no doubt, provide the ideological and social roots for Rodgers' work; unfortunately, the analysis of such historical foundations is beyond our expertise, as we further acknowledge later.) Subsequently, the work of Richard Wilkinson was fundamental in defending this *relative income hypothesis*.<sup>3-6</sup> Wilkinson's work is mainly based on studies showing a relationship between income inequality and life expectancy at the cross-national level. This evidence has expanded in the last 5-7 years with studies focusing on income inequalities within countries, mainly in the US (states and metropolitan areas).<sup>2,7-10</sup>

The importance of relative income on health has been found not only in ecological designs but also in multilevel studies, where individual data as well as aggregated data have been integrated. For example, in a cross-sectional multilevel study, Kennedy *et al.*<sup>11</sup> detected a relationship between income inequality and self-perceived health, after controlling for personal characteristics and absolute income. A relationship between health and income distribution has also been observed using different measures of income distribution.<sup>12</sup>

On the other hand, not all studies using individual and aggregate data found relationships between income inequality and health indicators.<sup>2</sup> For instance, a recent aggregate study using data from 16 countries did not find a relationship between income inequality and life expectancy, although it did find a relationship with infant mortality.<sup>13</sup> This study also found inconsistent associations between indicators of mortality and social capital. Other studies using both individual and aggregate data found different results: one found a relationship between income inequality and mortality,<sup>14</sup> while another did not observe this relationship.<sup>15</sup>

As in other branches of science (including public health and the social sciences),<sup>16</sup> research on health and social inequalities has increasingly dived into 'black boxes'; i.e. it has focused on causal processes and pathways, mediators, effect modifiers, and mechanisms of all sorts. As an example, Kawachi, Kennedy and Wilkinson<sup>17,18</sup> point out that the mechanisms by which the societal distribution of income could affect health can be conceptualized in three categories:

- (1) By influencing investment in human capital. As income inequality increases, the interests of the rich and the poor diverge. The greater the gap in income, the greater the disparity in interests. This often implies pressure from the upper social classes for lower taxes. It may then happen that social spending (education, health, infrastructure) diminishes, leading to diminished opportunities for the poor.
- (2) Through social processes, such as disruption of the social fabric. Societies with more income inequality may have less social cohesion and social capital. The diminution of the social fabric is then related to poor health through several possible mechanisms (e.g. social cohesion may influence health behaviours in a community, social capital may facilitate increasing access to local services and amenities).
- (3) Through psychosocial processes. The perceived widening of the gap leads to frustration, with possible health consequences. Other psychosocial processes that can be involved are hopelessness, sense of control over life, job insecurity, etc.

The focus on mechanisms in no way diminishes the importance of theory. Mackenbach, for instance, has questioned whether educational achievement should be treated as a confounder or as an intermediary between income inequality and mortality. He has also stressed the importance of coherent integration of theoretical concepts and empirical analyses.<sup>2</sup>

## Some criticisms: the 'whys', 'whats' and 'hows'

Muntaner and Lynch<sup>19,20</sup> have offered a critical appraisal of the income inequality and social cohesion model, which can be summarized as follows.

### 1. Income inequality

The theory is in practice restricted to developed countries. It thus neglects the impact of international economic relations on the level of income inequality. Yet, world income inequality affects within- and between-country income inequality. Another issue that the theory should address is the social mechanisms that generate income inequalities; theories of social stratification and class analysis try to explain how class positions in a society generate income inequalities. Usually high income is associated with capitalist classes. The model by Wilkinson *et al.* does not include the central issue of *what produces* economic inequality in the first place. Neo-Marxian models proffer social mechanisms that aim to explain why and how income inequality occurs.<sup>21,22</sup>

### 2. Social cohesion

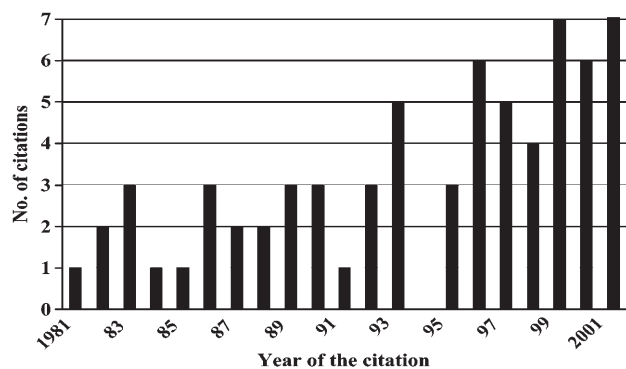
According to some critics,<sup>23-25</sup> this concept needs to be better defined. Social cohesion may have both good and bad consequences on health (e.g. in fascist societies, social cohesion has

been used as a mean of social control).<sup>19</sup> It is also necessary to analyse the relation between class and social cohesion, as well as the political aspects related to income inequality and social cohesion. For instance, whilst countries belonging to the former Soviet Union have suffered from a breakdown of social cohesion, to *understand* such breakdown the change from a socialist state to a capitalist one must be analysed.<sup>19,24</sup> Furthermore, models that emphasize social cohesion as a potential determinant of population health have implications for social and health policy. For ease, policy-makers will prefer the call to 'increase social cohesion' in order to reduce health inequalities, rather than proposals to reduce income inequalities through taxation and state transfers. Some views of the role of social cohesion make the community ultimately responsible for their health.<sup>19</sup> Thus, again, policy-makers as well as scholars choose specific threads of theory and data shreds to weave their policies and papers ...

### The trail left by Rodgers' paper in the academic literature

The influence of Rodgers' paper<sup>1</sup> appears to have been considerable. To assess it, there can be no substitute for scholarly reading—witness the contributions of our colleagues in these pages of the *International Journal of Epidemiology*, or the anthology edited by Ichiro Kawachi *et al.*, which Rodgers' paper opens.<sup>17</sup> Beyond the scholarly literature, the influence of Rodgers' work on social organizations and policies would be harder—though no less important—to assess (see below).

We also thought it might interest readers of this debate to know the papers that have used or otherwise mentioned Rodgers' article.<sup>1</sup> We thus searched for citations to it made by papers included in the Social Sciences Citation Index (SSCI) data base (1981–2001) and in the Science Citation Index (SCI) data base (1980–2001). We are aware of the limitations that this approach has, but it seemed useful, nonetheless ...<sup>26</sup> We found 70 such papers, including just one of his own (see Appendix on web-site <http://ije.oupjournals.org>). The vast majority appeared in journals included in the SSCI. Figure 1 shows the number of citations received by Rodgers' paper<sup>1</sup> since its publication. As can be seen, references have continued in recent years. *Social*



**Figure 1** Number of citations received by Rodgers' paper (*Population Studies* 1979;33:343–51) over the years

Sources: Institute of Scientific Information, Inc.: Web of Science, Social Science Citation Index (1981–2001) and Science Citation Index (1980–2001).

*Science and Medicine* is the journal that has published most papers citing Rodgers' (9 papers), followed by the *British Medical Journal* (6), the *American Journal of Public Health* (also 6) and *Social Indicators Research* (4). Authors citing Rodgers' article most frequently were: RG Wilkinson (7 papers), JB Williamson (4), JW Lynch (4) and, with 3 papers each, GA Kaplan, I Kawachi, BP Kennedy, JM Mellor and JD Milyo (some of them were co-authors of the same paper).

### Questions we cannot answer

The influence of Rodgers' work surely stemmed away from the scholarly literature and has expanded beyond it. Unfortunately, this is but one among several important issues that we are unable to address. However, they seem important enough to formulate, in the hope that they will be addressed by more knowledgeable colleagues in the near future. So, how were these and other findings by Rodgers received by the academic, political and economic communities? In particular, what influence did his research have on social policies in different countries and international organizations? Who was GB Rodgers, what did he do before and after leaving the International Labour Organization (ILO) World Employment Programme? Was the ILO interested in income inequalities as determinants of human mortality, or was this Rodgers' more personal endeavour? What was the political, economic and scientific context in which the analyses of Rodgers and others arose, and how were they mutually linked?

Answers to these and related questions would certainly help us today to understand the process through which theory, hypothesis formulation, model specification, statistical analysis and conclusions were intertwined to produce a unique fabric; a multi-layered tapestry of the relationships between health and income distribution.

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# Commentary: The convoluted story of international studies of inequality and health

Angus Deaton

## Content and context

Rodgers' paper on income inequality as a determinant of population health starts, like so much else, from Preston's paper on international patterns of income and health, published in the same journal four years previously.<sup>1,2</sup> Preston showed that life expectancy increased with income across countries, but at a rate that became progressively lower as income increased—there are diminishing health returns to income—and noted that, if similar relationships between income and health held within countries, a country with a more equal distribution of income would have higher life expectancy, other things being equal. Rodgers tested Preston's conjecture using a sample of 56 (unnamed) developed and developing countries, and found, indeed, that the Gini coefficient of income inequality had a significant negative effect in a (non-linear) relationship between average income and life expectancy (and infant mortality). In the life-expectancy regressions, the coefficient on the Gini coefficient

varied with the specification, but was around –40. This estimate would imply a difference in life expectancy of 12 years between two countries with identical mean income but with Ginis of 0.6 and 0.3, which are about the extremes that we observe.

The theoretical framework for Rodgers' analysis comes from the notion that there is a non-linear causal relationship running from income to health, and that the relationship is steeper at low income levels than at high income levels. According to this story, income inequality has no effect on *individual* health, and its effect on *population* health comes from the averaging of the individual, non-linear, relationships to obtain a societal relationship. More recently, this *aggregation effect* has been labelled a *statistical artefact*, to emphasize the fact that income inequality is not a risk factor for individual health.<sup>3</sup> Even so, it is important not to lose the important insight that, if income causes health, and if the effect is greater among poor than rich, then a costless redistribution of income from rich to poor will improve population health. Indeed, and as is sometimes overlooked in the health inequalities literature, it is *necessary* that the Preston curves be non-linear if such redistribution is to improve average

health. If life expectancy were linear in income, and there were no effect of income inequality on individual health, then no matter how extreme the inequality of income, and how wide the associated health inequalities, income redistribution will have no effect on population health. In looking for evidence of the effects of income inequality, Rodgers was tackling an extremely important policy issue.

The fame of Rodgers' work has been much enhanced by the later literature, particularly the work of Wilkinson, who developed the notion that income inequality is not simply a summary of the balance of income between rich and poor, but is an individual health risk in its own right.<sup>4,5</sup> Wilkinson, like Rodgers, found a relationship between life expectancy and income inequality among rich countries, both in levels and in differences over time, but assigned to income inequality a direct role in creating stress and harming individual health. Indeed, he saw the degree of income inequality as the crucial indicator of the extent to which the social and institutional environment is harmful to health.<sup>6</sup> The international evidence was supported by a relationship between income inequality and age-adjusted mortality rates across states and cities in the US.<sup>7-9</sup> Because the US possesses large-scale national survey data (from the National Longitudinal Mortality Study) that allow us to estimate the relationship between income and mortality at the *individual* level, it is possible to replace Rodgers' hypothetical calculation by an actual one, and to work out exactly how much of the relationship between inequality and mortality at the state or city level is accounted for by the curvature in the individual relationship.<sup>10</sup> The answer is not very much, so that something else must be going on, either because income inequality is a risk factor for individual health, as postulated by Wilkinson, or because some unaccounted third factor is at work.

### Data problems: are the results reliable?

Discussions of data quality are often tedious and it is easy to pay them insufficient attention. Even so, international comparisons of income inequality are especially difficult. Nor are comparisons of life expectancy much easier. Many, perhaps most, developing countries lack a complete vital registration system, so that *adult* mortality rates are poorly measured. For infant and child mortality, by contrast, household surveys, especially the system of Demographic and Health Surveys, often provide adequate measures of mortality rates. Estimates of life expectancy must therefore rely on the extrapolation of mortality among children to calculate life expectancy, using the 'model' life tables drawn up by demographers. In consequence, the life expectancy estimates for most poor countries are effectively functions of measured child mortality (at least until the AIDS pandemic forced a change in practice). Such extrapolations would be adequate if current health transitions in poor countries recapitulate the earlier health transitions from which the model tables were constructed. However, this is unlikely because current health environments in poor countries are quite different from those that once prevailed in now rich countries. The transmission from rich to poor countries of antibiotics, vaccines, and smoking habits makes it improbable that current health transitions will look much like those of the past.<sup>11</sup>

Measures of income inequality are derived from household surveys in which respondents are asked to provide information

on their incomes from various sources over a specified 'reference' or 'recall' period. In some countries, the surveys collect data on total household expenditures rather than income; the distinction is important because expenditures are more equally distributed across households than are incomes. Most household surveys are not designed to measure inequality; instead, most were originally set up to measure *means*, often the mean expenditures on various items to be used in the construction of consumer price indexes. Surveys that accurately measure means will often do a poor job of measuring dispersion. For example, people tend to forget events as time passes, so that short reference periods are desirable for accurate measures of mean income or expenditure. But because many people will spend or receive nothing over, for example, the last few days, short reference periods will overstate true dispersion. Accurate measurement of income or expenditure over longer periods, such as a year, which is desirable for good measurement of living standards, requires multiple visits, and is likely to be prohibitively expensive. Other issues of survey design matter too. Asking a single question about income or expenditure typically produces lower responses than asking detailed questions about components. Questionnaires sometimes ask people to report their income in a series of 'ranges' or 'intervals' and the choice of these matters, especially if there is an open-ended interval at the top. Yet there is no international standardization of these issues; every country's survey is different.

A dramatic example of what can go wrong is provided by recent measures of income inequality in the US where, between 1992 and 1993, there was a very large increase (of about 4 percentage points) in the Gini coefficient for family and household income. On this one jump hinges the question of whether there was *any* increase in income inequality in the US in the 1990s. (There is no similar question about the increase in the 1980s, though the questionable increase between 1992 and 1993 is as large as the total increase for that decade.) It is currently unknown (and probably unknowable) how much of the increase was real, and how much was due to changes in questionnaire design and the switch to computer-aided interviewing techniques.<sup>12</sup> This non-comparability occurred within a single country with one of the world's best statistical services and within an otherwise broadly comparable set of surveys. Non-comparability across countries is a great deal worse.

When Rodgers wrote, there were very few sources of international data on income inequality, and for many years, there were only two possibilities, Paukert's International Labor Organization (ILO) data (which Rodgers used) and a World Bank compilation by Jain.<sup>13,14</sup> These authors made no secret of the deficiencies of their data. In more recent years, matters have improved in two ways. The Luxembourg Income Study (LIS) provides access to unit record data for a number of years for a range of wealthy countries, so allowing researchers to construct measures of income inequality. Even though the surveys are far from fully comparable, they have been well-studied, and their strengths and weaknesses are well understood, so that the LIS now provides the best data on income inequality for the (25) countries that are included. The World Bank has also made available a much larger compilation of more than 2600 observations on Gini coefficients for more than 100 rich and poor countries.<sup>15</sup> These data have been widely and mostly uncritically used, mostly by economists for other purposes, but also

to examine international patterns of health and inequality. However, recent careful reworking has shown that the World Bank data suffer from many of the problems of the earlier data compilations, even for the more developed Organization for Economic Co-operation and Development (OECD) countries.<sup>16</sup> The non-comparability problems are almost certainly a good deal worse for developing countries.

The inadequacies of the inequality data are currently such as to prevent us from discovering the true cross-country relationship between health and income inequality. But we do know that the earlier results are not robust to use of the new data sets. The cross-country relationships for wealthy countries estimated by Rodgers and Wilkinson do not show up in the LIS data, nor can Rodgers' original regressions be replicated on the international data from the World Bank.<sup>17,18</sup> Although Wilkinson's original negative relationship is present in the LIS data for the countries he used, the correlation disappears when a few more countries are added.<sup>19</sup> The city and state relationship between inequality and mortality in the US also turns out to be a result of confounding and disappears once we control for racial composition.<sup>20</sup> Across states in 1990, the relationship also disappears once we control for education.<sup>21</sup> As of the time of writing, little appears to remain of the whole enterprise. For developing countries, this must be a tentative verdict that might well be reversed with better data on life expectancy and on income inequality. For the countries in the LIS, and for the states and cities of the US, the data are good enough and comparable enough (extremely good and fully comparable within the US) for us to be reasonably sure the relationship does not exist in any simple or clear form.

### Was Rodgers wrong? Where to from here?

In spite of all the negative results, Rodgers' (or rather Preston's) theoretical case is strong, and I would be very surprised if at least some part of the story were not to be eventually validated. Beyond that, I would argue that research on the health effects of inequality have been too narrowly focused on *income* inequalities.

There is a great deal of evidence that infant mortality in poor countries is associated with low incomes, that poorer couples are more likely to have children that die, and that increasing their incomes (as well as their level of education, and their access to remedial health services) will save children's lives. Redistribution of income in poor countries will therefore reduce child mortality among the poor by more than it raises it among the rich, so that even if we make an allowance for deadweight loss—that it costs something to transfer a rupee from a richer to a poorer person—greater income equality will improve the national rates of infant and child mortality. Which is, of course, precisely Preston's and Rodgers' argument. That the prediction is not transparently true I take to be a reflection of the poor quality of the data, especially on income inequality though, as we shall see below, there are other explanations. In the rich country data, using the LIS, some relationship between income inequality and child health often shows up.<sup>17,19</sup> Similar arguments for adult mortality are harder to make, if only because we know so much less about the shape of the relationship between income and adult mortality in developing countries.

On the broader issues of the social determinants of individual health, and the role of inequality in particular, the search needs

to look beyond *income* inequality. In the US, the relationship between income inequality and mortality is a mask for the effects of race; whites die younger in cities and states where there is a larger fraction of the population that is black.<sup>20</sup> While we do not understand the mechanisms, the plausible candidates all involve some kind of inequality. The stress and lack of trust mechanisms that are frequently cited as a consequence of *income* inequality apply with as much plausibility to racial inequalities in the US.<sup>22</sup> Empirical analysis across cities shows that trust is lower where income inequality is higher, and where the fraction of blacks in the population is high, but when both variables are added to the regression, only racial composition matters.<sup>23</sup> The quality of health care provision is also conditioned by race, so that another possible mechanism is that whites are more likely to die of heart disease if they are unfortunate enough to experience an acute myocardial infarction near a relatively under-equipped hospital in a predominantly black area.

In developing countries, other inequalities exert negative effects on health. The denial of education to girls relative to boys compromises women's health and that of their children.<sup>24</sup> Political inequalities, the *de facto* or *de jure* disenfranchisement of some groups relative to others, prevents collective action in the interests of the disenfranchised and may slow down or prevent the construction of public health projects, even when economic growth provides the resources to do so.<sup>25</sup> Income inequality is important, but other inequalities may play a larger role in population health.

One final suggestion is that the literature pay more attention to mechanisms that depend, not exclusively on income causing health, but on a fuller recognition of the mutual dependency between health and the ability to earn an income, especially but not exclusively in developing countries. In most of the world, where there is no earnings insurance for people who cannot work, poor health, by depriving some people of the ability to work, is an important cause of income inequality. Better health, better insurance against disability, or a fuller system of income insurance against disability would limit the effects of poor health on income, and limit its consequences for income (and health) inequalities. In this case, 'reverse' causality, from health to income, generates a mechanism through which a policy that improves health will reduce inequalities in income.<sup>26</sup>

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## Commentary: Income inequality and health: The end of the story?

John Lynch<sup>a</sup> and George Davey Smith<sup>b</sup>

Over the last 10 years, there are few issues that have captured the imagination of public health researchers and advocates, as has the question, whether income inequality drives population health. This was indeed a 'big idea'<sup>1</sup> that attracted contributions from scholars motivated by the humanitarian potential of showing how health could be improved through greater equity and social justice.<sup>2</sup> The question facing us now is whether this idea has had its 15 minutes of academic fame? Our own work<sup>3</sup> and several papers recently published in the *British Medical Journal* prompted an editorial comment by Johan Mackenbach that '... evidence for a correlation between income inequality and the health of the population is slowly dissipating'.<sup>4</sup>

It is therefore timely, that the *International Journal of Epidemiology* has revisited Rodgers' study<sup>5</sup> as it was the first to directly examine links between income distribution and health,

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although these issues had been raised in Preston's seminal paper 4 years earlier.<sup>6</sup> Rodgers' overall concern was to try to understand the determinants of mortality change, especially in regard to developing countries, and he presaged many of the issues which have since occupied researchers in this field. He recognized that specific factors like clean water, sanitation, food supply and health care—aspects of social infrastructure investment—were important but empirically difficult to disentangle because they tend to be highly collinear with each other and with income. That realization certainly remains salient today.<sup>7</sup> He noted that disentangling their specific contributions was important for policy formulation, but not 'critical for a description of mortality changes in the process of development' (p. 343). He thus set aside the messy issues of figuring out appropriate confounders and specifying causal pathways that might link aspects of development, income, inequality and population health. Rodgers also explicated what Gravelle later referred to as the 'artefact' explanation,<sup>8</sup> and showed how the curvilinear individual association between income and health will produce an apparent

effect of income inequality on health at the population level. However, he was unable to directly examine this because he only used aggregate data. The issue of control for individual income has been seen as crucial by several later researchers.<sup>9–11</sup>

Rodgers examined different characterizations of the income and inequality variables in regard to life expectancy and infant mortality. Throughout the paper, Rodgers presented the most robust formulations of his statistical models, as judged by *P*-values and the amount of variance explained ( $R^2$  value). He was thus primarily concerned with the efficient predictive statistical functioning of the models, not whether they were causal representations. Indeed, he considered it self-evident that ‘the overall economic status of individuals is likely to dominate health changes’<sup>5</sup> and that there is a ‘sequence of causation which goes from income to mortality via a number of intermediate variables with which we need not necessarily concern ourselves here’.<sup>5</sup> He also clearly left open the possibility that associations between income inequality and health could be due to confounding by health and social services, including provision of education.<sup>12</sup> Nevertheless, he argued that there was 5–10 years difference in life expectancy between relatively egalitarian and less egalitarian countries. And thus, the first empirical plank in the income inequality and health story was in place.

How should we interpret this in light of more recent studies about links between income inequality and health? Rodgers’ study attempted to show that income inequality differences between countries, net of absolute income differences, contributed to variation in average levels of health. For international comparisons of this sort, it is now clear that results are sensitive to country selection, time periods and sources of income data. Rodgers used 56 unnamed countries with income data from different time periods, the quality of which is likely to have varied considerably. So in hindsight it is hard to know what to conclude from his analysis. Given our experiences working in this area, we would not be surprised to find that under certain data selection criteria, associations may or may not be found. Even with contemporary income data from different sources, there are uncomfortably modest correlations between income inequality measures for the same countries and same time periods. Regarding international associations, it seems we are limited to using the best data available, and our recent analyses have shown no overall association between income inequality and life expectancy, but like Rodgers, did show consistent associations with child health outcomes.<sup>3</sup>

Is there an association between income inequality and health? The evidence that income inequality affects mortality differences across richer countries is not strong, except for infant health outcomes.<sup>7</sup> There is little evidence that the extent of income inequality, especially after adjustment for individual income, affects health within countries other than the US.<sup>4,13</sup> The unadjusted aggregate-level association within the US seems solid, but conceptual and empirical questions remain over what constitutes appropriate confounders and pathways, at both the aggregate and individual levels.<sup>11,12</sup> Finally, the appropriate reference group for social comparisons is unclear: if income inequality influences health through the psychological consequences of individuals perceiving themselves as being in inferior situations to other individuals, what are the groups—according to geographical proximity, age, sex, ethnicity, salience

of presence—to which people compare themselves? Intriguing preliminary data suggest that choice of comparison group can influence the statistical associations between income inequality and health that are observed.<sup>14</sup>

So, which way forward? We would urge readers to consider several intersecting issues, lest we throw the ‘social inequality baby’ out with the ‘income inequality bathwater’. First, several empirical issues—such as that of appropriate social comparison reference group—have yet to be fully explored and these may change the overall evaluation of the income inequality and health literature. Second, social inequality is multidimensional—it is not limited to income differences—and is expressed in education, occupation, housing, access to services and discrimination according to ethnicity, gender and age. The interconnections between these dimensions are intricate and difficult to disentangle with the relatively crude measures we employ. Third, ‘health’ is a multidimensional construct that is not captured by death statistics—something we have under-emphasized in our previous work. While the evidence for links between income inequality and disease-specific mortality is generally weak, that does not preclude an important role for income inequality in reducing quality of life, and adding to the misery and drudgery that characterize the existence of many people living in rich and poor countries. Despite recent findings from the US<sup>15</sup> and Japan<sup>16</sup> not being supportive of an easily detectable influence on self-rated health or symptoms of psychological distress, it is still plausible that while income inequality, *per se*, may not cause cancer or stroke, it does contribute to human suffering. Fourth, income distributions come from somewhere—they are the result of particular historical, cultural, economic and political processes,<sup>17</sup> and their influence on population health should be understood as markers of complex historical forces acting over the lifetimes of successive birth cohorts, which may not be expected to reveal themselves in cross-sectional (rather than time-lagged) correlations.<sup>18</sup> Would anyone seriously argue that the decades of greater general social (and income) equality of the Nordic countries has had nothing to do with generating better population health profiles? This does not deny that there are cause-specific factors that generate particular variations in health between those countries, or that there are other pathways to longer national life expectancy, such as in France or Japan. But it is hard to make the case that these historical patterns of equitable social investments, via both publicly and privately held resources, have had no impact on better population health in the Nordic countries, or conversely that the systematic lack of such broad-based historical investments in the UK and US has had no impact on population health in those countries.

Finally, even if as Mackenbach suggests,<sup>4</sup> all the research on income inequality and health has done is to help us rediscover the crucial role that individual income plays, then this remains a worthwhile lesson. Individual incomes are primarily the result of market-driven distributions and government-sponsored redistributions of income. Does income distribution affect health? Of course it does, because it affects individual incomes. For this reason alone it warrants the continuing attention of public health researchers and advocates. The fact that we can muster little evidence to show that the extent of income inequality, *per se*, affects population health through mechanisms other than what income inequality indexes in terms of material resources

acting over the life course of individuals within populations, is not an argument against income redistribution. Redistribution works, especially in those countries like the UK and US where income deprivation is a particularly salient component of the multiple deprivations that exist in those countries. Lets take up the challenge and see how well it really does work.<sup>19</sup>

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