Income, inequality and mortality in 14 developed countries

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Abstract   The tendency for more egalitarian societies to have lower mortality rates has been identified in international data and subsequently confirmed in analyses of areas within countries, particularly within the USA. However, recent reports using data on OECD countries from the Luxembourg Income Study (LIS) suggest this relation no longer exists. We investigated whether the shift in relative poverty from elderly people (with high death rates) to young families (low death rates) may have affected the associations. Using age- and sex-specific mortality among 14 OECD countries in relation to income inequality, median income and absolute and relative poverty, we found that wider income distribution is related to higher premature mortality, and higher age-specific mortality rates below, but not above, age 65 years. Absolute income levels showed no consistent relation to mortality. The changing age distribution of relative poverty may have affected the way income inequality impacts on mortality measured across all ages.

Introduction

Associations between population mortality rates and income inequality have been reported in numerous papers comparing data from both developed and developing countries, from areas within countries, cross-sectionally and over time. The evidence shows a widespread tendency for population death rates to be lower in societies where income differences are smaller. Many of the key papers are reproduced in Kawachi *et al.* (1999) which also contains a detailed discussion of the interpretation of the data. The most recent international evidence comes from Hales *et al.* (1999). Although there are

different interpretations as to why such a relationship might exist (Lynch and Kaplan 1997, Kawachi *et al.* 1999, Wilkinson 1999), most start from the view that the scale of income inequality serves as a measure of the weight of the burden of relative deprivation on mortality: in short, the greater the gap between rich and poor, the greater the relative deprivation.

However, our concern here is not with the interpretation of the relationship so much as with anomalous reports of no relationship. It has been reported that more recent data for a group of developed countries show no association between income inequality and population mortality (Judge *et al.* 1998, McIsaac and Wilkinson 1997). Several reasons have been discussed for this lack of association, including the possible effects of high non-response rates in some national surveys of household income (McIsaac and Wilkinson 1997, Wilkinson 1998). But because such problems had not obscured the relation in earlier data we set out to discover whether there might be other reasons why it was no longer apparent.

As well as the changes in the extent of income inequality which have taken place in recent decades in a number of countries (Hills 1995), there have also been changes in the age distribution of the relatively poor: whereas the main burden of relative poverty used to fall on elderly people, it is now more common among families with children (Kangas *et al.* in press). Kangas *et al.* show that among three out of the four countries for which they had data from the 1960s and 1970s, rates of relative poverty were higher among those over 65 years than among families with children. In the 1990s the situation had reversed: among six of the eight countries they examined, rates of relative poverty were lower among elderly people than among families with children. Among the remaining two countries, rates were only very marginally higher among the older people. In each of the four countries where data could be compared between the two periods (Canada, Sweden, Finland and the USA), rates of relative poverty among the elderly population had decreased. Our central hypothesis was that the downward shift in the age distribution of relative poverty – from older people to the young families with children who now make up a large proportion of the relatively poor – might obscure an association between income distribution and mortality. A given percentage increase in the lower death rates of young people would make less difference to age-adjusted mortality rates across all ages than would a similar percentage increase in death rates among older people: percentage changes in the larger number of deaths at older ages have a disproportionate influence on the numbers of deaths contributed to age adjusted mortality rates.

We also wanted to compare the importance of absolute material standards with income inequality as predictors of mortality. To do this we tested the alternative hypothesis that, even among rich developed countries, the impact of absolute income on mortality would be substantial. We expected not to find such a relation between absolute income and mortality.

Data and methods

The Luxembourg Income Study (LIS) is widely regarded as providing the most internationally comparable data on income distribution (Atkinson *et al.* 1995). The LIS data provide access to selected years of data taken from official surveys of household income conducted in a number of countries. We decided to analyse income and mortality data for economically advanced and culturally similar OECD countries (all developed market democracies) in the most recent period for which data were available. LIS provides income data for a number of periods – or 'waves' – the most recent of which is wave 3 and includes countries for which LIS obtained data for a year during the period 1989–92. These included 15 countries which were members of OECD. After excluding Luxembourg because of its small size, we were left with data for the 14 countries: Australia, Belgium, Canada, Denmark, Finland, France, (former West) Germany, Italy, the Netherlands, Norway, Spain, Sweden, the United Kingdom, the United States.

For each of these countries the number of deaths by age and sex and their population denominators for 1990 were downloaded from WHO files available on the internet at: http://www.who.int/whosis/mort/download.htm# data-files. In an attempt to group age-specific death rates into socially meaningful categories, we calculated age- and sex-specific death rates for the following age groups: infants 0–1 year, preschool ages 1–4 years, children 5–14 years, early adulthood 15–29 years, middle-age 30-64 years and older people 65–84 years. Death rates from childhood to old age were age-standardised in five-year age-groups using the 'new' European Standard population (WHO 1993). We also calculated for each sex two summary measures of mortality: an age-adjusted death rate 0–84 years and, as a measure of premature mortality, age adjusted rate of Potential Years of Life Lost 0–65 years (PYLL). We computed PYLL using the formula given by Blane *et al.* (1990). As a measure of mortality below age 65, PYLL gives more weight to deaths at younger ages. Thus a death at 25 years is a loss of 40 years before age 65, and one of 45 represents 20 years of potential life lost.

Our choice of measures of income distribution was guided by papers using data from the United States which have compared the association between mortality and different measures of income distribution (Kawachi *et al.* 1997, Daly *et al.* 1998, Franzini *et al.* in press). Daly *et al.* (1998) and Franzini *et al.* (in press) showed that mortality was related most strongly to the ratio of income at the 50th to the 10th centiles. Following these findings from within the US we therefore chose the 50:10 centile ratio to analyse the international data. If the income at the 50th centile (the median income) was twice as high as at the 10th centile (the top of the bottom decile), the 50:10 centile ratio would equal 2.0.

We used 'personal disposable household income' which is income after the payment of taxes and benefits. Rather than measuring inequalities in

total household income or in household income per capita, we used 'equivalence scales' to adjust household income for the number of people living in each household. Each equivalence scale makes different assumptions as to the 'economies of scale' gained by people sharing facilities in larger households. Because most elderly people tend to live in one- or two-person households and many children in larger households, different equivalent scales have a major impact on assessments of the extent of poverty in these two income groups. We used two different scales, chosen because they make very different assumptions about the economies of scale enjoyed by larger households (Buhmann *et al.* 1988). According to the 'subjective' equivalence scale (so-called because it is based on asking people how much extra income they would need to maintain their living standard with an extra person in their household) the first adult counts as 1, and each additional adult or child as 0.2. In contrast, the 'OECD equivalence scale' counts the first adult as 1, each additional adult as 0.7, and each child under 18 years old as 0.5. This means that a household income for a family with (say) one adult and two children would be divided by 1.4 using the subjective scale, and by 2.0 using the OECD scale.

Households reporting negative or zero incomes (less than 1.4 per cent of all households) were excluded throughout because evidence suggests that their consumption levels might not differ substantially from the average (Hills 1995). Our own inspection of the limited international data allowing household income to be compared with expenditure showed that these negative or zero incomes were not indicative of living standards. Rather than being genuinely poor, these may be households with considerable resources in reserve.

After adjusting household income to take account of the number of people in each household, the dispersion of the equivalised household income can be measured using either people or households as the units across which income is distributed. Departing from some previous practice, we measured the distribution across proportions of the population rather than across proportions of households; it is after all people, not households, who are exposed to mortality risk.

We also calculated an age-specific measure of relative poverty in each age-group. This was the proportion of people in an age group with equivalised household incomes low enough to put them into the bottom decile of *their country's* income distribution. The data on the age of household members were inadequate to provide these age-specific measures of relative poverty for Sweden and Australia, so age-specific income measures were available for only 12 countries.

To compare with these measures of income inequality and relative poverty, we also calculated an index of absolute median income and a measure of age-specific absolute poverty in each country. When no better measure of material standards is available GNP per capita is often related to national mortality rates. However, as we had access to household income we

were able to use median income which provides a better indication of the material circumstances of the majority of the population. For both median income and age-specific absolute poverty, equivalised income in national currencies was converted at purchasing power parities taken from OECD National Accounts (1996) to reflect prices in each country rather than the vagaries of exchange rates. Our measure of *absolute* poverty was the proportion of people within each age-group and country whose equivalised incomes were low enough to put them among the poorest 10 per cent of the combined populations of all 14 countries in our data set. It differed from the measure of age-specific *relative* poverty in that the absolute poverty line was set at the same level of real income for all countries rather than being varied relative to living standards within each country.

All the income and mortality measures we used were chosen before starting the data analysis. Relationships between the income and mortality variables were analysed using correlations and visual inspection of scattergrams.

Results

Although all our analyses were carried out using income variables based on both the OECD and Subjective Equivalence Scales, the correlation between them was 0.92 and there was little difference in their relations with the mortality variables. For the sake of clarity and to avoid duplication, only the relations with the income variables using the OECD equivalence scales are shown here.

Among the 14 countries for which we had data, there was a close positive relation between income inequality and median income ($r = 0.72$). This relation is shown in Figure 1. It provides a fortuitous opportunity to examine an additional question: will a higher median income reduce mortality by more than greater inequality raises it? Can any effects of inequality survive the association with higher median income?

Because the USA, having higher and more unequal incomes, lies apart from the other OECD countries shown in Figure 1, its position can make or break relations. Therefore, it would be misleading to show levels of statistical significance for correlations as if the data were normally distributed.

How inequality and median income are related to our two summary measures of mortality is shown in Table 1. For PYLL (our measure of premature mortality), both higher median income and greater inequality are associated with *higher* premature mortality. However, relations with age-adjusted mortality 0–84 years are quite different: they are either non-existent or weakly inverse.

The contrast between the way the two summary measures of mortality are correlated with the income variables is surprising. There are, however, two differences between the mortality measures which might account for their contrasting relations to the income variables. While age-adjusted mortality
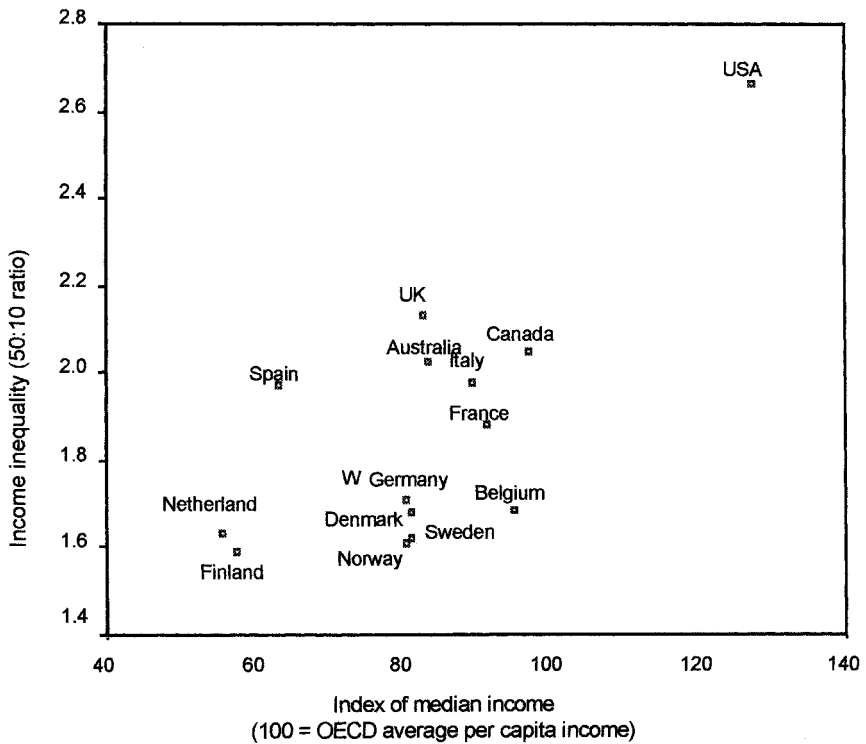
Figure 1: *Relation between median income and income inequality.*
(*14 OECD countries, 1990.*)

treats all deaths as of equal importance regardless of the age at which they occur, PYLL gives greater weight to deaths at younger than at older ages. In addition, our measure of age-adjusted mortality includes men and women aged 65–84 who are excluded from our measure of premature mortality. Looking at associations with age-specific mortality rates might therefore cast light on what underlies these rather odd results.

Table 1. *Correlations between median income, income inequality and two measures of mortality.*

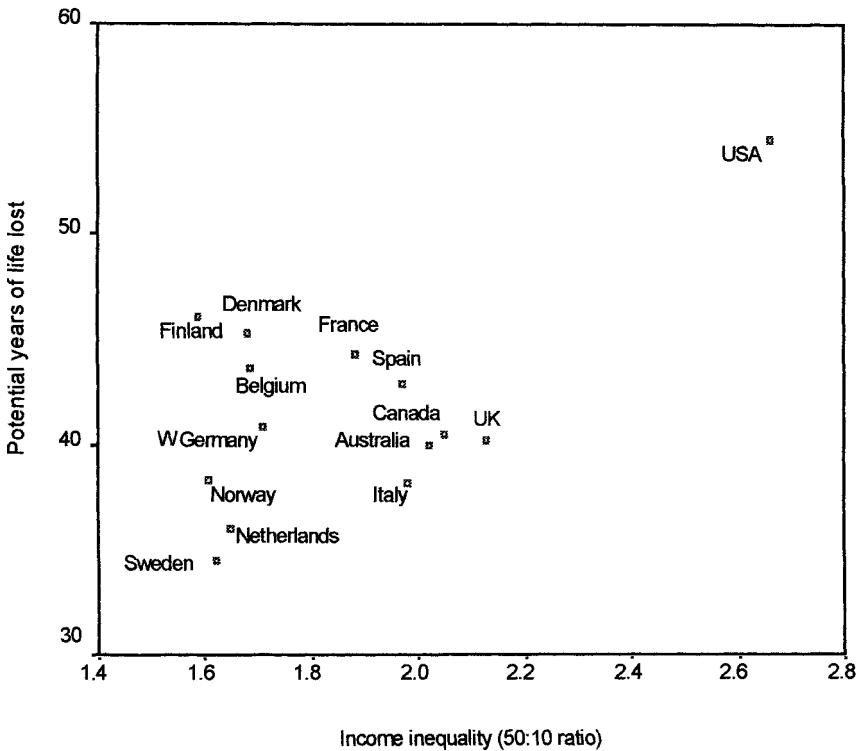|		*National Median income*	*Inequality. 50:10 centile ratio*
Potential years of life lost 0–64 yrs.	M	0.37	0.48
	F	0.61	0.57
Age-adjusted mortality 0–84 yrs.	M	−0.18	−0.16
	F	0.03	0.03

Figure 2: *Relation between potential years of life lost and income distribution. Males and females 0–65 years. (14 OECD countries, 1990.)*

Table 2 shows how death rates in seven age groups (M and F separately) are related to national median income, income inequality, age-specific absolute poverty and age-specific relative poverty. (For ease of reading we have shown, at the top of each column, the sign of the correlation coefficients to be expected *if* lower mortality rates were associated with higher absolute or relative incomes or with lower income inequality.)

At all ages below 65 years, higher mortality is *positively* associated both with higher median income (col. 1), and with greater income inequality (col. 3). After age 65 the signs of the relationships reverse so that higher mortality is weakly associated with both lower median income and lower income inequality. Relations with inequality appear to weaken at ages over 30 before reversing their sign among those over 65. The patterns found in the younger age groups tend to be strongest for infant mortality. The association between income inequality and infant mortality is shown in Figure 3. The different pattern in old age and the particularly strong associations at younger ages would seem to explain the contrasting relations

Table 2. *Correlations between age-specific mortality and income inequality, absolute median income and age-specific absolute and relative poverty.*

		National median income	‡Age-specific absolute poverty	Inequality. Ratio 50:10 centiles	‡Age-specific relative poverty
* Expected signs:		− ve	+ ve	+ ve	+ ve
Infant mortality	M	0.70	0.38	0.68	0.60
	F	0.64	0.30	0.87	0.21
Mortality 1–4 yrs	M	0.36	0.19	0.38	0.23
	F	0.25	0.32	0.45	0.45
Mortality 5–14 yrs	M	0.16	0.32	0.40	− 0.15
	F	0.23	0.11	0.21	− 0.03
Mortality 15–29 yrs	M	0.39	0.30	0.59	− 0.18
	F	0.40	0.14	0.53	− 0.04
Mortality 30–49 yrs	M	0.18	− 0.07	0.22	− 0.39
	F	0.47	− 0.41	0.18	− 0.60
Mortality 50–64 yrs	M	0.07	− 0.21	0.08	− 0.07
	F	0.34	− 0.15	0.28	− 0.64
Mortality 65–84 yrs	M	− 0.37	− 0.28	− 0.38	0.60
	F	− 0.21	− 0.08	− 0.16	0.53

* Sign of correlation expected on the assumption that death rates will be lower where absolute or relative incomes are higher and income inequalities are smaller.
‡ As age-specific income data were not available for Australia and Sweden, 'n' is reduced from 14 to 12 for these two columns.

of the income variables to the two summary measures of mortality shown in Table 1. Because most deaths occur in old age, the negative associations between income distribution and mortality in the 65–84 year age group (Table 2, bottom of col. 3) dominate the age-adjusted mortality rate 0–84 years (Table 1). But because PYLL 0–64 excludes the 65–84 age group and gives more weight to deaths at younger ages it reflects the positive correlations between income distribution and mortality in all the younger age groups.

To investigate the positive correlations between higher median income and higher mortality at all ages up to 64 years, we show the association between age-specific mortality rates and age-specific relative and absolute poverty (Table 2, cols. 2 and 4).

In the absence of other factors, one would expect a higher proportion of an age group in absolute or relative poverty to be positively associated with mortality in the same age group. Taking absolute poverty first (Table 2, col. 2), we find the expected positive relation in the youngest four age groups. This is despite the fact that in each of these age groups there is also a positive relation between mortality and increasing median income (col. 1). In these age groups mortality is higher both where more people in an age
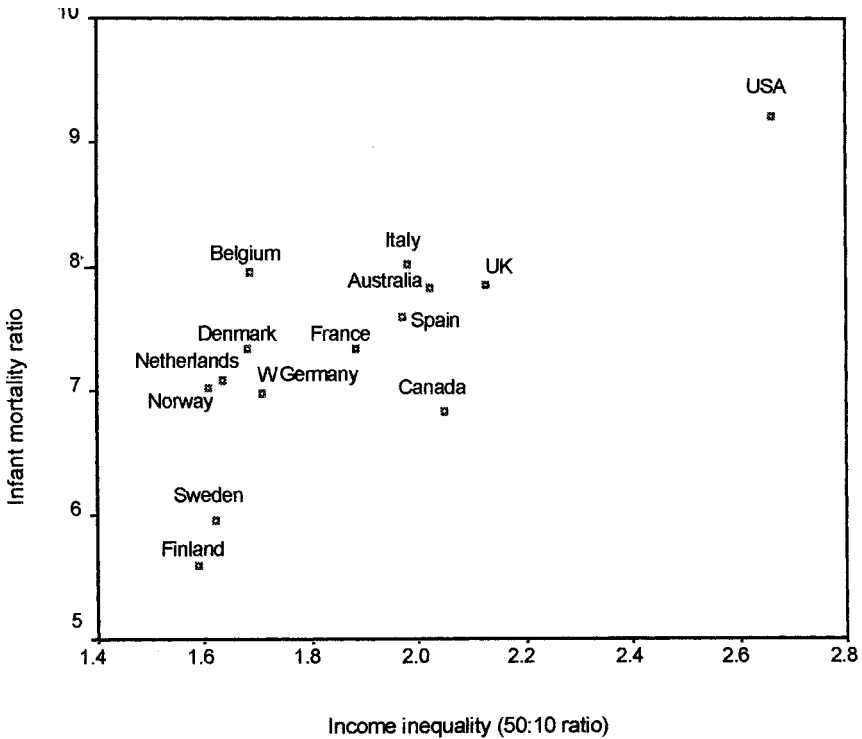
Figure 3: *Relation between infant mortality (M and F) and income distribution.* (*14 OECD countries, 1990.*)

group fall below an absolute poverty line and – paradoxically – where median income is higher. At the risk of over-interpreting, this comes close to saying that mortality rises with greater inequality – as is indeed suggested by the fairly strong correlations between mortality in these four age-groups and our inequality measure (col. 3).

For mortality in the next oldest two age-groups (30–49 years and 50–64 years), none of the signs for correlations with median income and absolute poverty are in the expected direction (Table 2, cols 1 and 2). But given the socio-economic gradient of health within societies it is unlikely that these correlations have any causal significance. As larger international data sets show either no correlation or a weakly negative – but never a strong positive – relation between mortality and median income, the positive relations in our data should not be regarded as an indication that a higher median income is bad for health. Given the relation shown in Figure 1 between median income and inequality, the positive correlations may instead reflect the conflicting effect of inequality on mortality.

Although for mortality in the oldest age group (65–84 years) there is – at least in this one age group – the expected negative correlation with median income (Table 2, col. 1), there is also, however, a negative correlation with absolute poverty (col. 2) (suggesting that countries in this data set with more old people in absolute poverty tend to have slightly lower death rates). But the correlations between the measures of absolute income and mortality in this age group are weak. In no age group did the data on median incomes and age-specific absolute poverty come together to attest to the likely influence of absolute living standards on health among this group of developed countries.

We shall now turn to see what sense can be made of the data on income distribution and on age-specific relative poverty shown in the last two columns of Table 2.

Age-specific relative poverty (col. 4) is positively related – as expected – to mortality rates in the oldest and in the two youngest age groups. But at other ages increased relative poverty is associated (at least weakly) with lower death rates – the reverse of what one would expect. However, these patterns of positive and negative associations do make some sense if mortality rates are primarily associated with societal inequality. The old and the very young are the age groups in which relative poverty occurs most frequently, and the signs in those age groups are in the expected direction. To a considerable extent, rising inequality is powered by the rising incomes of economically active middle-aged people who tend to have the more senior jobs and to be at the height of their earning power. Their incomes rise in relation both to junior – usually younger – people in the labour force, as well as in relation to those outside the labour force. The strongest of these negative associations with age-specific relative poverty appear in the 30–49 age group and among women in the 50–64 age group (Table 2, col. 4). So perhaps these inverse correlations reflect the contribution which rising relative incomes in these age groups make to increasing inequality. (The very weak negative correlations in the 5–14 year age group will wholly, and in the 15–29 age group will partly, reflect parental incomes.)

We have seen that greater income inequality is associated with higher death rates at all ages up to 65 years (Table 2, col. 3). But why does the association reverse in the oldest age group 65–84 years containing the bulk of deaths which dominate age-adjusted mortality 0–84 years? Given that the harmful effects of age-specific relative poverty are clearly shown in the strong positive correlations for both sexes in the oldest age group (col. 4), it seems particularly surprising that this age group's death rates appear to be lower where inequality is greater (col. 3). The explanation seems to be that greater societal inequality is strongly associated with *reduced* relative poverty in this age group. The correlation between them is -0.62 (not shown). So the strong connection between age-specific relative poverty and mortality among older people aged 65–84 seems (Table 2, col. 4, bottom lines) to have served to lower their death rates as inequality has risen.

The relationships between income inequality and both infant mortality and PYLL which are shown in Figures 2 and 3 suggest another reason why relationships may be weaker than in reports using earlier data (Wilkinson 1994). The countries which detract most from a relationship between income distribution and PYLL in Figure 2 are Finland and the United Kingdom. If wider income inequality were associated with higher mortality rates, then the UK appears to have fewer PYLL than its wide income differences might suggest. Finland is the other way round: it appears to have higher than expected PYLL given its narrow income differences. Both these countries have undergone major changes in income inequality. As the UK has become much less egalitarian, Finland has become more so (Kangas *et al*. in press). Interestingly, if we look at Figure 3 showing infant mortality in relation to income inequality, the infant mortality rates for Finland and the UK are now in their expected positions at opposite ends of the main cluster of countries. If infant mortality was primarily influenced by the current environment, but death rates at other ages were influenced also by early life and by cumulative exposure to adverse circumstances throughout life (McEwen 1998, Sapolsky 1998), then changes in income distribution would be reflected in infant mortality rates long before the effects were seen in mortality rates at other ages. Perhaps the close relationships between income distribution and mortality shown in some previous international analyses (and still shown among the US states), depended on sufficiently stable income distributions for lagged effects to have had time to work their way through.

Conclusion

Three possible explanations for the apparent disappearance of the relationship between income inequality and mortality in the LIS data have emerged. First, some of the burden of relative poverty has shifted from older people to young families with children, so changing the impact of income inequality on mortality rates standardised across all ages. Second, the strong positive correlation between income inequality and median income among the countries in this analysis means that the effects of income inequality may be partly confounded by higher median income. Third is the likelihood that there are lagged effects of changes in income distribution.

1. Greater income inequality appears, paradoxically, to be positively associated with increased PYLL 0–64 years but weakly and negatively associated with age-adjusted mortality 0–84 years (Table 1). We have shown that this may arise from an association between greater societal inequality and reduced relative poverty among people over retirement age. As deaths in old age dominate measures of age-adjusted mortality, they would mask the detrimental effects which inequality seems to have on mortality among all younger

age groups. These results may explain why, contrary to earlier impressions, there appears to be no relation between income distribution and summary measures of mortality across all ages among the countries covered by these data. In these countries, greater inequality is associated with increased relative poverty among young people and reduced relative poverty among elderly people. This downward shift in relative poverty, from older people to young families, may be the key to the changing relations between income inequality and all age mortality rates which we set out to explore.

Although only a minority of all deaths, influences on death rates under 65 years old are important. Not only do these age groups make up the majority of the population, but they account for all premature mortality. In addition, the cumulative impact of adverse circumstances on these cohorts at younger ages may also be expected to affect their health in later life (Davey Smith *et al.* 1998).

2. The correlation shown in Figure 1 between greater income inequality and higher absolute median income among these 14 countries might be expected to lead to opposite influences on mortality (higher income tending to reduce mortality while greater income inequality tends to increase it). It is notable however that at most ages mortality showed the expected correlation with income inequality but the reverse of what was expected with median income (Table 2). If median income was the more powerful influence on mortality, the relation between income inequality and infant mortality shown in Figure 3 would have been hidden. Our data (on both average median incomes and age-specific absolute poverty) show that higher *absolute* living standards among the population as a whole do not exert an overriding influence on mortality among developed countries. It is important to note that larger international data sets provide no support for the view that higher absolute income levels are associated with increasing mortality. Rather, the positive associations shown here between higher mortality and the measures of absolute income may be better interpreted as a function of its covariation with income inequality.

3. In periods when income distribution changes, the true effects of income distribution on population health may be made more difficult to detect (in all but the youngest age groups) by lagged health effects. The weakness of the relation between PYLL and income distribution among the other countries shown in Figure 2 may be partly a reflection of a time lag between changes in income distribution and mortality. The positions of the UK and Finland detract most from a relation between wider income differences and higher mortality. If there were lags we would expect the recent rapidly widening income differences in the UK to move the UK up in relation to the other countries in Figure 2, and the narrowing of income differences in Finland to move it down in relation to other countries. Such a lagged effect on PYLL might account for the sharp contrast between the positions of these two countries in Figures 2 and 3.

Lastly, we should stress the strong influence which data for the United States (an outlier in terms of absolute income and income inequality in this data) have on the relationships described. Given that the US income and mortality data are of a high standard and there are no extraneous reasons for treating them as an invalid data point, it would not be legitimate to exclude them from the analysis. We have therefore retained them while providing scattergrams which allow readers to assess their importance to the overall picture. That the US differs from other countries in degree rather than in kind has been shown by analyses of the 50 states (Kaplan *et al.* 1996, Kennedy *et al.* 1996). If the single observation for the USA were replaced by data for each of the 50 states, they would form part of a continuum with the more egalitarian states merging with the other countries shown in this analysis. This has recently been shown in a joint analysis of mortality in US states and Canadian provinces (Ross *et al.* 2000). We are therefore confident that the position of the USA is a function of the relationships under discussion.

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