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Income inequality and population health: An analysis of panel data for 21 developed countries, 1975–2006

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The relative income–health hypothesis postulates that income distribution is an important determinant of population health, but the age and sex patterns of this association are not well known. We tested the relative income–health hypothesis using panel data collected for 21 developed countries over 30 years. Net of trends in gross domestic product per head and unobserved period and country factors, income inequality measured by the Gini index is positively associated with the mortality of males and females at ages 1–14 and 15–49, and with the mortality of females at ages 65–89 albeit less strongly than for the younger age groups. These findings suggest that policies to decrease income inequality may improve health, especially that of children and young-to-middle-aged men and women. The mechanisms behind the income inequality–mortality association remain unknown and should be the focus of future research.

Keywords: income inequality; population health; mortality rate; panel data; developed countries

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Introduction

The income inequality–health hypothesis postulates that population health and mortality are influenced by income distribution (Lynch et al. 2004). If supported by data, the hypothesis might help to explain why developed countries with high levels of income per head still show large differences in population health, and would also justify redistributive policies aimed at decreasing income inequality. Existing research, however, is inconclusive, possibly because the associations differ by population subgroup. The aim of the study reported in this paper was to investigate the income inequality–mortality association with a focus on sex and age differences in the association.

With some exceptions (Wagstaff and van Doorslaer 2000; Mellor and Milyo 2001; Gravelle et al. 2002; Beckfield 2004; Jen et al. 2009), most recent research has been supportive of the income inequality–health hypothesis (Shmueli 2004; De Vogli et al. 2005; Ram 2006; Dorling et al. 2007; Karlsson et al. 2009; Biggs et al. 2010; Idrovo et al. 2010). However, much of the research on income inequality and mortality has been at community and individual levels, as discussed in several review papers (Wagstaff and van Doorslaer 2000; Macinko et al. 2003; Lynch et al. 2004; Wilkinson and Pickett 2006). We chose to study the income inequality–mortality link at the population level because income inequality is by definition a property of the population and not of the individual (Kaplan et al. 1996); and because by studying the link at the population level we were able to take into account social and environmental factors behind the association (Kawachi and Kennedy 1999; Wilkinson 1999; Wolfson et al. 1999; Wagstaff and van Doorslaer 2000; Wilkinson and Pickett 2009).

We tested the income inequality–health hypothesis using a set of panel data collected over the years 1975–2006 for 21 developed countries (see the Appendix for a list of countries). We used mortality as the measure of population health and the high-quality Human Mortality Database (2010) as the data source. The source for the Gini index of income inequality, our income inequality measure, was the World Income Inequality Database (WIID) maintained by the United Nations University–World Institute for Development Economics Research (UNU-WIDER) (2008). In contrast to prior work that analysed the population-level association between income inequality and mortality (Mellor and Milyo 2001; Beckfield 2004; De Vogli et al. 2005; Babones 2008), we focused on developed countries only and distinguished between men and women and between age groups. Our analysis controlled for trends in gross domestic product (GDP) per head and unobserved period and country factors.

The main advantage of using a panel-data analysis was that it allowed us to control for all shared period factors and time-invariant country-specific factors. This has the important advantage over cross-sectional work that the results are not confounded by unobserved country heterogeneity. In addition, using our panel data, we were able to control for shared period factors, which otherwise could have been confounders, particularly in those analyses in which only a few time points were used. Although there may be yet other confounders beyond those we controlled for, such as unobserved time-varying processes not captured by trends in GDP per head, the panel-data procedure still presents an important step forward in addressing potential causality.

Our results suggest that an increase in income inequality increases the mortality of males and females at ages 1–14 and 15–49, and the mortality of women at ages 65–89. These age-specific mortality effects yield observable associations between income inequality and life expectancy at birth. The effects are strongest for children and young-to-middle-aged men, and suggest that redistributive policies intended to decrease income inequality could decrease mortality among these populations.

Previous research at the population level

Even though most recent research finds an association between income inequality and health measures, especially at the individual level, the nature, magnitude, and characteristics of the association at the population level between income inequality and health are not well understood (Wagstaff and van Doorslaer 2000; Macinko et al. 2003; Lynch et al. 2004; Kondo et al. 2009). We focus only on studies comparable to ours, and therefore only on those studies carried out at the population level. In an extensive review by Wilkinson and Pickett (2006), out of 45 cross-country studies, 30 are supportive of the income inequality–health hypothesis but 6 do not find any evidence for it. In another review of 26 cross-country studies, 15 studies support the income inequality–health hypothesis, 5 showed mixed results, and the remaining 6 provide no evidence for the hypothesis (Lynch et al. 2004). The results were most consistent for infant mortality, but less so for adult mortality.

Several studies have pooled together data from less developed and developed countries (Rodgers 1979; Waldmann 1992; Karlsson et al. 2009) or performed only a cross-sectional analysis that failed to control for country-specific characteristics such as welfare systems (Pampel and Zimmer 1989; Wilkinson 1992; Judge et al. 1998; Lynch et al. 2001; De Vogli et al. 2005; Ram 2006; Idrovo et al. 2010). Some of these studies found evidence for an association between income inequality and health (Rodgers 1979; Wilkinson 1992; McIsaac and Wilkinson 1997; Lynch et al. 2001). However, studies that focused on more homogeneous countries or that used panel-data methods to account for unobserved heterogeneity often did not find clear support for the income inequality–health hypothesis (Mellor and Milyo 2001; Beckfield 2004; Babones 2008). Moreover, early studies did not find the correlation between income inequality and health to differ between men and women (Kaplan et al. 1996; McIsaac and Wilkinson 1997). More recent studies find evidence that the association is stronger for women, which is at odds with findings that women's mortality is less sensitive to deprivation than that of men (Raleigh and Kiri 1997; Regidor et al. 2003; Hildebrand and Van Kerm 2005). Some of the heterogeneity in the findings may have been due to differences in the methods used, in the quality of the data, in the characteristics of the populations studied, or to combinations of these factors.

Among more recent studies, a cross-sectional study of 21 economically developed nations that controlled for income per head and educational achievement found the Gini index to be negatively associated with life expectancy at birth (De Vogli et al. 2005). A similar study using data on 126 countries found income inequality to be positively associated with mortality, especially among men aged 15–29 (Dorling et al. 2007). On the other hand, another cross-sectional study that focused on 75 countries did not find any associations (Gravelle et al. 2002). Many of these cross-sectional studies suffer from one or more of these three shortcomings: use of simple bivariate methods without appropriate controls; no consideration of the possibility of unobserved country heterogeneity; the use of measures of income distribution that are often not internationally comparable (Beckfield 2004). There are only a few population-level comparative studies that use panel data and account for heterogeneity across countries (Mellor and Milyo 2001; Beckfield 2004; Babones 2008; Shkolnikov et al. 2009). However, these studies have the limitation that either they pool together very different countries or do not distinguish systematically between age intervals and between men and women.

One of the first studies to make use of time series data was undertaken by Mellor and Milyo (2001), who analysed data from 30 countries and implemented a first-differences model to control for country-specific effects. Their results for the Organisation for Economic Co-operation and Development (OECD) countries, which comprised 12 of the 30 countries used for their analysis, did not suggest any association between income inequality and health. There could be two reasons why there was an effect but it was not revealed. Firstly, the study used a relatively small number of OECD countries, and was therefore limited in statistical power. Secondly, the study used a first-differences model, which could have had the effect of exacerbating the asymptotic bias in the estimation of the coefficients if there was measurement error in the explanatory variable, as can be the case for Gini time series. Beckfield (2004) analysed data spanning a 50-year period for 115 countries and used a fixed-effects model to take into account unobserved country heterogeneity, but found no evidence for the income inequality–health hypothesis. Babones (2008) analysed data for the period 1970–95 for 135 countries and found that changes in income distribution were not associated with changes in life expectancy and infant mortality when income per head was added as a control.

We expect that some of the inconsistencies in the results of previous research may be due to the pooling of a large set of heterogeneous countries and mixing of sexes and different age groups (McIsaac and Wilkinson 1997; Dorling et al. 2007; Kruger 2010). Mechanisms that explain the association might differ by sex and by age (Courtenay 2000; Pickett and Wilkinson 2007). To keep the country set homogenous we restricted our study to developed countries with high-quality data. Furthermore, we used methods that accounted for unobserved heterogeneity and stratified the analysis by age and sex in order to shed light on the mechanism behind the association.

Data and methods

For our study, we used absolute inequality measures to test the income inequality–health hypothesis. To analyse how mortality and life expectancy were associated with income inequality in developed nations we adopted a study design similar to that used by Shkolnikov et al. (2009). They used a country fixed-effects method and quinquinnial time series to analyse the association between income inequality and variation in age at death. We performed a panel-data analysis of age-specific mortality using fixed-effects models with data on 21 developed countries for an annual time series spanning more than 30 years, controlling for serial correlation. When selecting countries we were careful to avoid problems suspected of being the principal weaknesses of previous studies (Macinko et al. 2003; Moore 2006). Thus, we restricted the choice to economically developed countries and excluded countries that were part of the Soviet Bloc because of their idiosyncratic mortality trajectories following the collapse of the Soviet Union (Stuckler et al. 2009). For a list of countries included and length of the time series, please refer to the Appendix.

Response variables: life expectancy and mortality rates by age

We used data from the Human Mortality Database (HMD). The HMD provides internationally comparable data on mortality for national populations over long periods of time.

We used life expectancy at birth and age-specific mortality rates as our response variables. Life expectancy at birth summarizes the mortality experience of a synthetic cohort over the life course, thus being a concise measure of population health. The use of this measure also allows comparisons with existing research, because it has been used as the dependent variable in other comparable studies (Lynch et al. 2004). In order to gain understanding of how specific age groups respond to income inequality, we analysed age-specific mortality rates, using age groups 0, 1–14, 15–49, 50–64, and 65–89.

Independent variables: the Gini coefficient and gross domestic product (GDP) per head

As the key independent variable, income inequality, we used the Gini index of income inequality. Data for the Gini coefficient are taken from UNU-WIDER WIID (last available version: May 2008). The coefficient is a measure of how equally income is distributed across the population. It is derived from the Lorenz curve that marks the proportion of total income earned by a percentage of the population in the bottom category of income. The Gini coefficient is calculated as the ratio of the area that lies between the 45-degree line of perfect equality and the Lorenz curve to the total area under the line of perfect equality. It ranges between 0 and 1: the closer the coefficient is to 1, the higher the degree of inequality. The advantage of using the Gini coefficient is that data are relatively easily available. The literature suggests that the association between income inequality and mortality is robust to the choice of the income inequality measure (Kawachi and Kennedy 1997).

We used data on the Gini coefficient only for countries in which the income-sharing unit was the household, 'income' referred to disposable income, and the unit of analysis was the person. Of all OECD countries for which data were available from the UNU-WIDER database, we dropped Australia from the analysis because the data referred to a person instead of a household as the income-sharing unit. We also dropped Japan because the Gini data suggested surprising fluctuations and a falling trend over time, which was not consistent with published findings (Jones 2007). After these exclusions, we had time series data for 21 countries spanning the years 1975–2006.

Following Shkolnikov et al. (2009), we dealt with missing observations by simple linear interpolation. Because the Gini index evolves slowly over time, jumps and short-term fluctuations in the index are likely to be caused by measurement error rather than by changes in the true income inequality. We therefore applied a locally weighted (lowess) regression to smooth the time series that otherwise would have shown irregular variations across time (Solt 2009).

Our models controlled for income per head. Data for GDP per head in US dollars (at constant prices and parity purchasing power, reference year 2000) were collected from the OECD database, except for Taiwan (OECD 2008). For the latter, data were obtained in the same units from the International Monetary Fund (IMF) website (World Economic Outlook Database 2008).

Methods

The data set was a time series of observations with measurements made annually. The analysis was conducted using Stata version 10. We used fixed-effects regression methods with controls for both unobserved country heterogeneity and shared time trends to estimate the association between income inequality and the dependent variable (life expectancy or mortality rate). Before the regression analysis we took logs of the income inequality and the life expectancy/mortality variables to allow for an easier interpretation and comparison of the size of the estimated coefficients, and to control for heteroscedasticity and achieve linearity.

We used panel-data regression techniques to estimate the effect of income inequality on mortality. The regressions controlled for GDP per head, and fixed effects by country and time. The fixed effects by country controlled for unobserved factors that differed between countries but were constant over time for each country (e.g., welfare systems, geographic, and environmental differences). The time-fixed effects controlled for unobserved factors shared by all countries at a specific point in time that were not accounted for by GDP per head. In addition we adjusted the model to account for autocorrelation. The following equation shows the regression model:

$$\ln Y_{it} = \alpha + \beta_1 \ln \mathrm{GDP}_{it} + \beta_2 \ln \mathrm{Gini}_{it} + \tau_i + \gamma_t + \varepsilon_{it} \qquad \textit{with } \varepsilon_{it} = \rho\varepsilon_{it-1} + \eta_{it}$$

where Y denotes the dependent variable (life expectancy at birth or age-specific mortality rate) for country i at time t; GDP is the control variable for income per head of country i at time t; Gini is the index of income inequality for country i at time t and represents the main explanatory variable; τ_i is the country heterogeneity term that is constant over time; γ_t is a period dummy capturing time-fixed effects (5-year intervals starting from 1975 with the exception of 2000–06, for which the interval was 7 years long); and ε_{it} is the error term which we allowed to be serially correlated (AR(1) structure).

Controls for country differences may be implemented by differencing or by including fixed or random effects in the model. Initially, we compared a fixed-effects model with a first-difference one. We chose a fixed-effect rather than a first-difference model for two reasons. First, differencing reduces the sample size and decreases statistical power. Second, if both the error term and the regressors are serially correlated, and the latter correlation is stronger, the first-difference estimator will worsen the asymptotic bias caused by measurement error (Wooldridge 2001).

We also tried a random-effects model, with random rather than fixed country intercepts. This model may be more efficient in a small sample such as ours, and comparing the fixed-effects and random-effects models also provided a robustness check of the results. The results turned out to be similar for both the model specifications. Since the bias in the fixed-effects model is in standard cases lower than in the random-effects model, we opted for the fixed-effects model and added an indicator as a control for each country.

Because all our response variables were trending over time, we also included time dummies to control for shared time trends. Given the limited number of observations in our data set, we were not able to include annual time dummies since annual dummies combined with controls for country-fixed effects and GDP per head did not leave enough variation to produce estimates and standard errors for the income–inequality variable. For this reason we included dummies for 5-year intervals. The results from this specification were similar to those obtained using a simple linear time trend.

We checked for serial correlation of the residuals using the Baltagi–Wu Locally Best Invariant test (Baltagi and Wu 1999). Values for the test statistic were generally below 1.5, suggesting that there was serial correlation in the errors. We therefore controlled for autocorrelation in the model, correcting our model for first-order autoregressive residuals. Thus what we had was a panel model using corrected standard errors with country heterogeneity controlled by the use of fixed effects and time-fixed effects controlled by the use of 5-year dummies, with autocorrelation allowed in the residuals. Our regression model thus estimated whether increases in income inequality are associated with increases in mortality after controlling for country-specific factors that are fixed over time and for period factors that are shared across countries. We also estimated the models with lagged variables, with no significant change in the results.

Results

Descriptive results

Table 1 shows descriptive statistics for all the variables. The table shows that there is large variation in both the Gini coefficient and GDP per head. For example, the difference between the largest and smallest Gini coefficients is more than 100 per cent (46.5 per cent for the USA in year 2004 vs. 20.3 per cent for Sweden in year 1978). The mean is 29.8 per cent, a figure consistent with previous research, which has found the Gini coefficient to be an average of 30 per cent in member countries of the OECD (Förster and Mira d'Ercole 2005).

The average life expectancy of males at birth is 73.1 years, ranging from 65.1 (Portugal in 1975) to 79.5 years (Iceland in 2003). The average life expectancy of females at birth is 6 years higher than, and varies slightly less than, that of males. Mortality rates are higher among men than among women in all age groups, with the largest proportional difference in the age interval 15–49, where the

Table 1 Descriptive statistics for the Gini coefficient, GDP per head, life expectancy, and age-specific mortality, 21 developed countries 1975–2006

N = 551	Mean	Std dev.	Min.	Max.
Gini coefficient (%)	29.79	5.11	20.32	46.54
GDP per head	$19,048	$10,054	$3,071	$78,138
Male				
Life expectancy at birth	73.10	2.60	65.14	79.49
Mortality rate by age				
0	8.81	4.81	1.34	45.27
1–14	0.33	0.16	0.06	1.16
15–49	1.92	0.50	0.73	3.41
50–64	11.51	2.66	6.03	19.76
65–89	63.05	7.75	45.93	84.89
Female				
Life expectancy at birth	79.35	2.18	73.55	84.13
Mortality rate by age				
0	6.96	3.68	1.00	35.95
1–14	0.24	0.11	0.00	0.87
15–49	0.92	0.21	0.49	1.62
50–64	5.82	1.32	3.06	10.58
65–89	45.71	6.28	30.40	64.32

Note: Data on GDP per head are in US dollars, at constant prices and purchasing power parities (2000); mortality rates are in per 1,000 person-years.
Source: Data on GDP per head are from the OECD online database (with the exception of Taiwan, for which data are from the IMF website); data on Gini coefficients are from the WIID database; data on mortality rates and life expectancy at birth are from the Human Mortality Database.

Table 2 Bivariate correlations between the Gini coefficient, GDP per head, life expectancy, and age-specific mortality for 21 developed countries 1975–2006

N = 551	Males		Females	
Variables	Gini	GDP per head	Gini	GDP per head
Life expectancy at birth	−0.09**	0.75**	−0.06	0.71**
Mortality rates by age				
0	0.29**	−0.65**	0.31**	−0.64**
1–14	0.24**	−0.70**	0.25**	−0.69**
15–49	0.28**	−0.56**	0.23**	−0.59**
50–64	0.02	−0.70**	0.06	−0.55**
65–89	−0.14**	−0.71**	−0.09**	−0.70**

*$p < 0.05$; **$p < 0.01$.
Source: As for Table 1.

rates for males are approximately twice that of females.

Table 2 shows bivariate correlations for the main variables. The Gini coefficient is negatively correlated with life expectancy at birth (significant for men, not for women) and positively correlated with mortality rate for both men and women up to age 50. At ages 50–64, the correlation becomes insignificant and at ages 65–89 changes sign and is negatively correlated with mortality. Overall, the bivariate correlations suggest that a higher level of income inequality is linked to lower life expectancy at birth and higher mortality rates below age 50. For GDP per head, the results are similar for men and women, and suggest that higher average income is associated with increased life expectancy and decreased mortality in all age groups.

Regression results

Table 3 reports the results of the regressions of life expectancy and age-specific mortality on the Gini coefficient. All models control for GDP per head, and fixed effects for country and time, and allow for autocorrelation in the residuals. Figure 1 illustrates the key results shown in Table 3.

Table 3 presents the estimates for the twelve models used (six response variables, two sexes). Each row shows the estimates for one response variable, with results reported separately for men

Table 3 Regression of life expectancy and age-specific mortality on Gini index and GDP per head, for 21 developed countries, 1975–2006

Number of observations = 551	Males			Females		
Response variables	Gini coefficient	GDP per head	R^2	Gini coefficient	GDP per head	R^2
Life expectancy at birth	−0.0147*	0.0527**	0.65	−0.0191**	0.0445**	0.59
	(0.0063)	(0.0039)		(0.00597)	(0.00254)	
Mortality rate by age						
0	0.190	−0.658**	0.70	0.120	−0.633**	0.68
	(0.144)	(0.0643)		(0.124)	(0.0624)	
1–14	0.281**	−0.553**	0.75	0.331**	−0.543**	0.75
	(0.0901)	(0.0653)		(0.115)	(0.0716)	
15–49	0.252*	−0.279**	0.40	0.145*	−0.304**	0.45
	(0.0998)	(0.0375)		(0.0697)	(0.027)	
50–64	−0.021	−0.266**	0.57	0.052	−0.281**	0.33
	(0.0394)	(0.0314)		(0.0463)	(0.0212)	
65–89	0.023	−0.205**	0.58	0.149**	−0.216**	0.54
	(0.0283)	(0.0188)		(0.0338)	(0.0188)	

*$p < 0.05$; **$p < 0.01$. Standard errors in parentheses.
Note: Twelve models are estimated (six dependent variables, men and women separately) using a panel of 21 countries from 1975 to 2006. All variables are expressed in logarithmic scale. The models control for GDP per head, country-fixed effects and time-fixed effects (5-year intervals starting from 1975 with the exception of 2000–06, for which the interval is 7 years) and allow for autocorrelation in the residuals.
Source: As for Table 1.

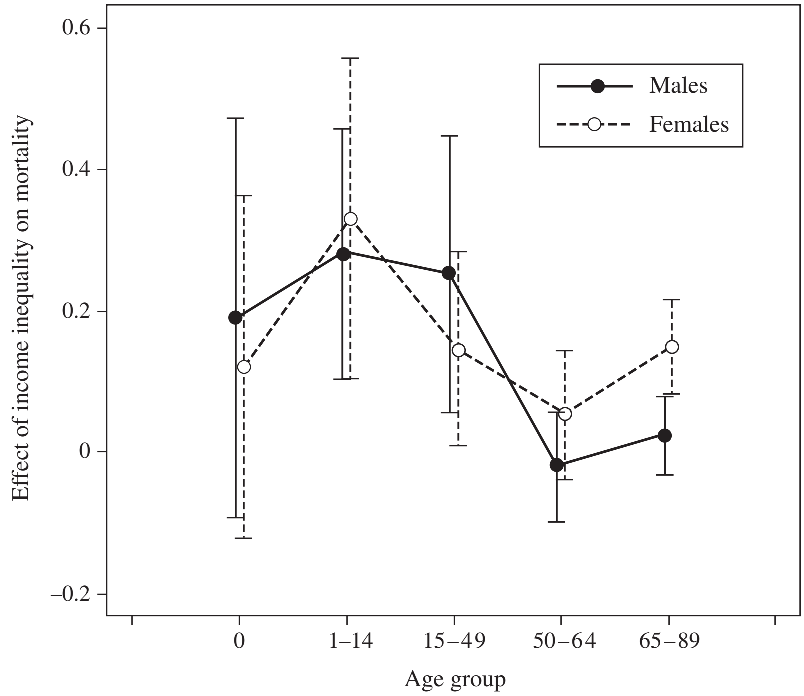

Figure 1 Regression of age-specific mortality on Gini index and GDP per head, for 21 developed countries, 1975–2006. Key results from Table 3

Note: The coefficients are shown in Table 3. The models are estimated with all variables in log scale and control for GDP per head, country-fixed effects and time-fixed effects, and allow for autocorrelation in the residuals

Source: As for Table 1

and for women. Each column shows the explanatory variables introduced in a model. The first row shows the association between life expectancy at birth, Gini coefficient, and GDP per head. For both men and women, the Gini coefficient has a negative sign and is statistically significant, suggesting that there is an inverse relation between income inequality and life expectancy. For example, for men the coefficient −0.015 for income inequality implies that net of country heterogeneity, shared time trends, and income per head, a 1 per cent increase in Gini coefficient is associated with a 0.015 per cent decrease in life expectancy, and a doubling of the Gini coefficient is associated with a 1 per cent decrease. For women, the coefficient −0.019 implies that a doubling of the Gini index is associated with a 1.3 per cent decrease in life expectancy, which, given the average life expectancy for women of 79.4 years, corresponds approximately to a 1-year decrease in life expectancy.

As expected, the control variable GDP per head is strongly associated with life expectancy, and the association is in the opposite direction to that of income inequality. The association is also markedly stronger than that of income inequality. For example, the coefficient 0.053 for men suggests that a 1 per cent increase in GDP per head leads to a 0.053 per cent increase in life expectancy, and a doubling of GDP per head—which happens every 25 years with 3 per cent growth rate—would increase life expectancy by 3.7 per cent. This would correspond to an increase in life expectancy at birth for males from 73.1 to 75.8. For females, the coefficient is of similar magnitude.

Other rows in Table 3 show results from regression models with age-specific mortality rates regressed on the Gini index and GDP per head. We do not observe a statistically significant association between income inequality and infant mortality for either men or women. For men, we observe positive and significant coefficients for the Gini index from age 1 up to age 49. Above this age, the coefficients are small, negative, and statistically insignificant. For women, the coefficients are positive at ages 1–49 and at old ages, 65–89. For the control variable GDP per head, we observe both among men and women a consistently negative and significant association with all age-specific mortality rates.

For mortality at ages 1–14, the coefficients are positive and significant and of similar magnitude for both sexes. For women, the absolute value of the coefficient is slightly larger, but because child mortality is higher for men than for women, the absolute effect is slightly smaller than that for men. The UK's experience is an illuminating example of the effect of an increase in the Gini index: a 43 per cent increase in income inequality, which was observed in the UK over the period 1975–2006, would correspond to a 10.6 per cent increase in child mortality for boys and a 12.6 per cent increase for girls. However, since mortality rate at ages 1–14 is lower for women than for men (in our data, on average 25 per cent lower), the absolute effect is greater for men.

At ages 15–49, the mortality coefficient for males for the Gini index is still positive (0.252) and significant ($p < 0.05$). For women aged 15–49 the coefficient is much smaller (0.145). Again, the UK's experience is a useful example: a 43 per cent increase in the Gini index would correspond to a 9.4 per cent increase in the mortality of males. For men, the average mortality rate in the data is 1.9/1,000 at ages 15–49, and a 9.4 per cent increase would take it to 2.1/1,000. Given the UK's population size and age structure (around 15 million men and women aged between 15 and 49 years), these mortality changes would correspond to approximately 2,700 excess deaths of males and 700 excess deaths of females at ages 15–49. Conversely, if the Gini coefficient declined from 30 per cent (the average in our data) to 20 per cent (the minimum in our data) for this population, a decrease of 33 per cent, with baseline mortality rates corresponding to the average in our sample, the number of lives saved in the age range 15–49 would be approximately 2,900 for men and 800 for women.

At old ages (65–89), the income inequality–mortality association is significant only for women. The coefficient 0.149 implies that an increase of 43 per cent in income inequality is associated with 5.5 per cent increase in mortality. While significant, this increase is markedly smaller than the increases observed at ages 1–14 for both sexes, or for men at ages 15–49.

Robustness checks

We confirmed that the results were robust to the exclusion of single countries (i.e., the exclusion from the model of each country in turn). By re-estimating the models without time controls, we also confirmed that the inclusion of time-fixed effects influenced the results only marginally. We tested an alternative, more parsimonious specification of the time control by using a linear shared trend, and found that the key results did not change. Finally, we estimated the models with income inequality lagged by 1 year. The results did not change in any significant manner.

Discussion

Rodgers (1979) and Wilkinson (1992) were among the first to provide evidence for the negative association between income inequality and population health, but the association has not been confirmed by some recent research that used longitudinal data (Mellor and Milyo 2001; Beckfield 2004). Recently, Shkolnikov et al. (2009) used longitudinal data to analyse the association between income inequality and variation in age at death and found that income inequality explained inter-country but not within-country differences. We used an analytical strategy similar to that used by Shkolnikov et al. (2009) to analyse the dependence of life expectancy and age-specific mortality on income inequality. We analysed the association between income inequality and mortality by sex in 21 developed countries for the period 1975–2006 and found income inequality to be an important predictor of the mortality of males and females at ages 1–14 and 15–49, and of mortality of females at ages 65–89.

These results shed new light on the income inequality–health hypothesis. They differ from several earlier results, possibly because we focused only on developed countries, excluded transition economies, used panel-data models which allow controlling for unobserved country effects, and measured the effects separately for males and females and for different age groups. Many previous studies combine rich and poor countries, use cross-sectional data, or do not estimate the associations separately for men and women or for different age groups (Judge 1995; Judge et al. 1998; Bobak et al. 2000; Mellor and Milyo 2001; Gravelle et al. 2002; Beckfield 2004).

The results for life expectancy at birth suggest that increasing income inequality is associated with decreased life expectancy for both men and women. Studying the age patterns of the association helps to shed light on possible drivers. Our results suggest that income inequality matters more at younger ages so that the association between income inequality and mortality is strongest for children aged 1–14 and young adults aged 15–49. We were unable to confirm a positive association between income inequality and infant mortality. While the coefficients suggest a positive association for both sexes, the results are not statistically significant. This finding differs from that of previous research (Wennemo 1993; Hales et al. 1999; Lynch et al. 2001; Babones 2008) but is in line with more recent and more similar studies (Mellor and Milyo 2001; Beckfield 2004). It is possible that the null finding is at least partially explained by the lack of statistical power resulting from the use of a method that accounts for unobserved confounders.

Our results show that the positive link between income inequality and mortality at ages 1–14 is similar for girls and boys, a finding consistent with that of other recent individual-level research (Collison et al. 2007; Pickett and Wilkinson 2007). At this stage of life, income inequality may influence health through its effects on parents' resources and their investment in the care of offspring. Plausible mediating factors are underinvestment in social services directed at mothers and their children and inadequate monetary support to families (Marmot 2003; Lundberg et al. 2008). It is also possible that in societies with more income inequality, parents have to struggle more in order to maintain or improve their status in the social hierarchy. In pursuit of this end, they may invest relatively more energy in work than in their children's well-being. As Macinko et al. (2003) suggest, higher inequality may have a number of malign social effects: higher levels of social stress; restricted access to resources; fewer investments in infrastructure and social security systems directed to the poorest; lower levels of social cohesion; less trust and less cooperation; and higher opportunity costs for the parents, especially the opportunity cost of time. With regard to the last of these issues, recent studies suggest that income inequality is associated with longer work hours and an increase in household debt (Bowles and Park 2005; Iacoviello 2008). If parents are forced to spend more time working than caring for their offspring, there may be adverse effects on the children's health and probability of surviving, especially among those disabled or ill who require more resources and parental investment than an average child.

We observe an important difference between the sexes in the association between income distribution and health when we focus on adults aged 15–49. For this age interval, there is a strong positive association between income inequality and mortality for men. For women, the association is significant, but weaker than for men. Backlund et al. (2007) found a similar sex difference in favour of women at ages 25–64 in an analysis of 50 US states. Dorling et al. (2007) also found a sex difference in favour of women using data for OECD countries. A plausible explanation for this difference comes from sex selection theory: among young adults, men have a higher incentive than women to compete and advance their position in the social hierarchy because higher status increases the prospects of success in finding a mate more for men than for women (Kruger 2010). If so, according to the theory, higher income inequality will mean that some men become relatively worse off than others, a situation that may intensify competition among men to establish and enhance their social status and prospects of securing a suitable mate. The result is likely to be a higher likelihood of risk-taking behaviours such as working for excessively long hours. The competition may also increase testosterone levels, thereby increasing the propensity to take potentially fatal risks such as driving at excessive speed and alcohol abuse (Ferrini and Barrett-Connor 1998; Wilson et al. 2002). Moreover, in societies where men are typically the breadwinners, income inequality may make them more exposed to the stress of maintaining or improving the family's socio-economic status, intensifying competition among them to be upwardly mobile. A step forward from our analysis would be a study of the mechanisms, including a cause-of-death analysis, by which income inequality influences excess mortality among males. One possibility is that deaths from accidents, violence, or risk-taking behaviours, which are more common at younger than at older ages, may also be more closely related to inequality.

With the exception of older women (aged 65–89), we do not find any association between mortality and income inequality at ages above 50. It is possible that at later stages of adulthood as well as in old age, most men have secured their position in the social hierarchy and are past the stage of mating and reproducing. Consequently, they have less incentive to adopt competitive and risk-taking behaviours that can have adverse effects on health. This hypothesis is consistent with the fact that men's testosterone levels, which are correlated with risk-taking behaviour, decrease with age (Ferrini and Barrett-Connor 1998). An alternative explanation could be selection: those who survived to age 50 either were never affected by the negative effects of income inequality or are selected by having been successful. A possible explanation for the association we observe for women aged 65–89 is that at these ages many of them are widows; losing the financial support of the spouse may have stronger effects on health and well-being in countries with high income inequality than in countries where there is less of it.

In summary, our results show that in developed countries income inequality has an important effect on child and adult mortality and that there are sex differences for adults. The importance of average income, however, is greater than that of income distribution. Our results suggest that recent scepticism (Gravelle et al. 2002; Lynch and Smith 2002) about the income inequality–health hypothesis needs to be reconsidered. While our population-level analysis cannot disentangle the factors underlying the concave association between income and individual health, it shows that mortality among children and young adults is lower in societies where income distribution is relatively equal than in those in which it is unequal. Moreover, income distribution is associated more closely with the mortality of young adult males than with that of females—an interesting sex difference worthy of further study. Given the importance of health for productivity as well as the sustainability of an ageing society, redistributive policies aimed at reducing income inequality might yield generally benign social effects in addition to improved population health.

Note

1. Roberta Torre was at the Max Planck Institute for Demographic Research when this paper was written and is now at the European Commission. E-mail: torre.roberta@gmail.com. Mikko Myrskylä was at the Max Planck Institute for Demographic Research when this paper was written and is now at the London School of Economics.

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Appendix: Developed countries and their Gini coefficients

Country	Gini coefficient
Australia	*No data by household*
Austria	1983–2006
Belarus	
Belgium	1979–2006
Bulgaria	
Canada	1975–2005
Czech Republic	
Denmark	1976–2006
UK	1975–2006
Estonia	
Finland	1976–2006
France	1975–2006
Germany	1992–2006
Germany East	
Germany West	1975–2004
Hungary	
Iceland	2003–06
Italy	1975–2006
Japan	*Poor data quality*
Latvia	
Lithuania	
Luxembourg	1985–2006
Netherlands	1977–2006
New Zealand	1975–2004
Norway	1979–2006
Portugal	1980–2006
Russia	
Slovak Republic	
Slovenia	
Spain	1980–2006
Sweden	1975–2006
Switzerland	1978–2002
Taiwan	1975–2003
Ukraine	
USA	1975–2004

Note: Countries excluded from the analysis are shown in italic.
Source: Human Mortality Database (2010); UNU-WIDER WIID, version 2008.