EXPLORING AND EXPLAINING INEQUALITY IN LENGTH OF LIFE AROUND THE WORLD

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Introduction

One of the central questions in social sciences concerns the unequal distributions of resources and rewards among the members of societies. In some societies, life chances – in the broadest sense – are distributed more equally than in other societies. Social scientists study socio-economic outcomes such as income, wealth, educational attainment and occupational status to gain insight in the nature and causes of social inequality. For instance, there is a long research tradition that examines income distributions across societies and time (Firebaugh ; UNDP). Another well-established literature studies cross-national differences in educational and occupational status attainment (Breen & Luijkx 2005; Hout & Diprete 2006). However, this research has largely neglected the ultimate expression of differences in life chances among individuals: differences in length of life. A long and healthy life is among the most highly valued and universal human goals. Several authors have argued that income is *instrumental*, whereas a long and healthy life is an ultimate goal (Sen, 1979, 1985; Pradhan, 2003; Goesling & Firebaugh, 2004). Therefore it is important to study how societies affect the variation in length of life among their population members.

Length of life is mostly known as life expectancy, which is one of the most widely used indicators of the performance of societies. Life expectancy for a given year is defined as the average age of death of a birth cohort that would face, at each age, the same age-specific mortality rates as observed in that year. In other words, life expectancy simply is the expected average length of life of a population given the contemporaneous age-specific mortality rates. Many studies have shown that life expectancy is distributed very unequally among countries (Goesling & Firebaugh, 2004; UNDP). However, these studies do not take into account that also within countries length of life can be unequally distributed. In fact, very little is known about how is length of life distributed within societies and how societies differ in this respect. Inequality in length of life (IL) within populations has remained largely a terra incognita.

There are studies that focus on variation in length of life within countries. Notable examples are the literatures on social class, education, income, racial and regional differences in length of life. This literature shows that there are substantial socio-economic and regional health and mortality differences within countries (Wilkinson & Marmot 2003; Mackenbach et al. 1999)**.** It has been estimated that about a quarter of the total inequality in health can be captured by differences among socioeconomic groups (Wagstaff & Van Doorslaer 2004). There have also been several attempts to construct indicators of overall health inequality (Pradhan et al., 2003; Gakidou & King, 2002), but they were focused on restricted aspects of inequality, like children's height or survival, which are only indirectly related to IL. A number of studies focus explicitly on IL (LeGrand, 1987; Wilmoth & Hiriuchi, 1999; Silber, 1988; Shkolnokov et al., 2003; Cheung et al., 2005; Edwards & Tuljapurkar, 2005). These studies show that there are substantial differences among developed countries in inequality of length of life (LeGrand, 1987; Shkolnokov et al., 2003; Edwards & Tuljapurkar, 2005). They also show that with increasing life expectancy of countries, inequality in length of life within the countries decreases. However this decrease is not unambiguous. Several studies indicate that the trends in LE and IL do not exactly mirror each other or that there is substantial variation in IL at the same level of LE (Shkolnikov et al 2003; Wilmoth & Hiriuchi, 1999). However, the number of populations examined in these studies was too small to reveal the complete pattern of IL differences among societies. This paper presents the most comprehensive picture of IL currently possible. We have build up a very large database, containing 8,904 life tables (LT) for almost all countries of the world covering a period of over a hundred years. In this paper we use this database to (a) study to what extent length of life is (un)equally distributed within and among societies, (b) the variation among countries in their distribution of length of life, and (c) to explain this variation on the basis of country characteristics.

In the following sections, we first discuss the relationship between LE and IL. We conclude that the variation in IL among countries at the same level of LE, which we will call relative inequality of length of life (RIL), might be the most relevant indicator of a societies IL. We then discuss why societies might differ in RIL and formulate hypotheses on effects of socio-economic and health-related country characteristics on RIL. In the method section, we discuss the database that will be used, the selection of LT and the way IL and RIL are measured in this paper. In our results section we start by showing how length of life is distributed among the total world population in the year 2000. We calculate total world LE and IL for this year and we decompose IL into within and between country and region components. Next we describe the male and female patterns of IL in relation to LE in detail on the basis of our complete database. This pattern is explored in more detail by computing the magnitude of the IL differences for specific LE-categories, by looking at the size of these differences for selected countries, by highlighting trajectories of individual countries through the IL-LE space, and by studying the variation in IL in situations of extreme calamities. After that we present the results of our explanatory analyses in which for 140 countries around the year 2000 the variation in RIL and LE is related to selected country characteristics. In the concluding section, the findings are discussed in light of their implications for the social inequality literature.

Theoretical background

Length of life at the individual level

What is meant by “inequality in length of life” is most easily illustrated by depicting the distribution of length of life for countries at different levels of development. In Figure 1 this is done for males in Niger, Brazil, and Japan in the year 2000. This figure shows that this distribution generally has two peaks. The first peak is in the youngest age categories and reflects the relatively high mortality at birth or directly thereafter. As we concentrate on adult mortality, this peak is not relevant for the present study. From an age of 5-10 onwards, the number of deaths shows a gradual increase until a peak is reached somewhere in the 65+ age group. After this peak, the number of deaths decreases rather quickly. We see that the variation of the distribution surrounding the old age peak is not the same in each country.

Another observation from Figure 1 is that the distribution of length of life is bounded at the right side; not bounded in a strict sense -- the proportion of people reaching a very high age increases gradually -- but bounded in a practical sense, because the proportion of people actually reaching a very high age is small. With increasing LE, length of life becomes more and more concentrated in small age band around the peak (see Fig. 1). This implies that the variation in length of life (or IL) becomes smaller if LE increase. Indeed, previous research has shown a strong negative correlations between LE and IL (Shkolnikov et al 2003; Wilmoth & Horiuchi, 1999; Cheung et al., 2005). However, these studies also showed that increases in LE do not necessarily lead to lower IL. Wilmoth & Horiuchi (1999) found that the trends in IL and LE for Sweden did not show the same patterns. Shkolnikov et al. (2003, p. 339) showed with data for 1996-1999 that, in spite of correlations of 0.69 (males) and 0.58 (females) between LE and IL, countries with similar LE had substantially different levels of IL. In this paper, we focus on this variation in IL among countries with the same level of LE, which we call relative IL (RIL). We do this because our major interest lies in country differences in inequality and not in country differences in the average length of life. If we would study crude IL, the country differences in IL would to a large extent be a result of the huge differences in LE, which are already well studied. We argue that studying the part of IL that is not determined by LE contributes to our understanding of inequality within societies. Much is already known about the causes of differences in LE among countries, but it remains an open question why countries with the same level of LE differ in overall inequality in length of life.

Our analyses are restricted to adult mortality (age 15 and over). The factors that influence infant and child mortality are to a large extent different from the factors affecting adult mortality (Marmot, 2005; Bloom et al., 2003; Houweling et al., 2001; Wolleswinkel et al 1998). The reduction of infectious diseases due to sanitary practices and the introduction and diffusion of effective medicine has drastically reduced infant and child mortality in most parts of the world. However, these developments had less influence on adult mortality patterns, which tend to change much more slowly and under influence of other mechanisms (Cutler & Meara, 2003). By focusing on adult IL, a clearer picture is obtained of the inequality caused by the unequal distribution of (un)healthy behavior and of resources, opportunities and rewards within societies.

< FIGURE 1 about here >

Studies on LE have shown that country-characteristics that refer to the general development level are contributed most to explaining cross-national differences in LE. Gross domestic product or health expenditures are strongly correlated with LE, although not in a linear way. At higher levels of development, the relationship between LE and GDP becomes smaller or even absent (refs). We want to understand why countries at the same level of LE differ in IL (RIL). We expect that LE and IL may partly be associated with the same factors, but that generally different mechanisms are at work. For instance, both LE and RIL may be affected by the how actively the government supports the most disadvantaged groups. Such support will increase LE and at the same time lower inequality as it primarily reduces premature mortality.

For other factors an effect on LE is more likely than one on RIL as well. Higher total health expenditures will in general improve LE but it is not obvious that higher all population members will benefit equally from the extra expenditure. Therefore, we do not expect an association with RIL. Some other indicators of development could be important for both LE and RIL. Throughout the world many health problems are caused by insufficient access to clean water. We expect that lower access to clean water lowers LE and is also negatively related to RIL. If access to clean water is a scarce good, the unequally access to this important health resource will lead to inequality. Furthermore, if more people are employed in the service sector we expect EL to be higher because of the greater overall wealth. On the other hand we expect lower RIL because a smaller proportion of the workforce is exposed to unhealthy and dangerous working environments if a lower proportion works in either industry or agriculture.

We expect that indicators of social, economic and region differences in a country are positively associated with IL. The larger the diversity in a country in social groups and regions, the more likely it is that there exist substantial differences in access to health resources. This will increase IL. Thus, we expect that countries with higher income inequality have higher levels of IL than would be expected given their level of LE. We expect similar patterns for indicators of gender inequality and social inequality with regard to ethnicity.

Data

The information needed to determine the degree of inequality of mortality for a given country in a certain year is contained in life tables. A life table is basically a table with information on the total population and number of deaths in the country in that year broken down according to age and sex.

We have brought together as many life tables as we could find. We searched for life tables on the level of nation states. Because China and India comprise more than a third of the world population and have some important institutional differences among their regions, we also collected life tables at the province and state level for China and India. In total, we managed to gather 18,576 tables, of which 14,992 are sex-specific. Tables referring to subpopulations (ethnically or geographically) are not used. Some tables only provided information up to age 75 and had to be removed. Furthermore, we removed over 300 corrupt tables. Corrupt tables were detected by comparing life expectancy at birth to annually highest life expectancies as reported by Oeppen & Vaupel (2003). Low values were checked manually. Tables with impossible values in any of the age categories were also removed and their source was checked to detect possible structural problems.

For some combinations of year, country and sex more than one source was available. We selected one life tables in these cases by using following hierarchy based on reliability: (1) life tables from national bureau of statistics or other official publication, (2) Human Mortality Database (data collected by teams at Berkely and Rostock), (3) Human Lifetable Database, (4) World Health Organization database on deaths and population, (5) International Database (IDB) of the US Bureau of the Census, (6) raw data on deaths and population from the UN and (7) WHO estimates for all countries for 2000.

After removing doubles (3,406), our database contains 9,373 tables. These life tables represent more than 200 countries. Most of the life tables are for the period 1950-2003, but for some countries they reach much farther back in time, as far as 1900 for the USA, 1846 for Norway, 1840 for the UK, 1806 for France and 1750 for Sweden. Finally, some life tables are left out of the analysis because they refer to exceptional years, namely war, famines and epidemic.

All LT used are abridged 85+ period LT, using 5-year age intervals. LT with more detail in our database were recalculated into this form to make them comparable to the others. Shkolnikov et al. (2003, p. 318-323) show that the Gini coefficient computed over abridged 85+ LT can be a reliable indicator of IL, if an adjustment is made for the value of the open ended interval (85+). We have followed their method and made this adjustment for all the LT in our final database. In a few cases, only LT with a lower open-end interval than 85+ were available. For 80+ life tables, we estimated the 85+ values by linear regression. For the states of India, part of the regional LT were 70+ tables. In these cases, the higher values were estimated using information from 85+ tables for other years. In Appendix A, we present further information about the LT and their sources.

Measurement of IL, RIL and LE

IL is measured by computing the Gini coefficient over the distribution of age at death from age 15 onwards. LE is calculated as the mean age of death from the same 15+ distribution. The distributions of age at death were obtained by applying the age and sex-specific mortality rates from the LT to a population of 100.000 individuals aged 15, thus standardizing for differences in adult population structure among countries and time periods.

The Gini coefficient is a widely used inequality measure (Cowell, 1995; Sen, 1973). It can be computed by taking the mean of the difference in age at death (length of life) between every possible pair of individuals in the population, divided by the mean age at death (Cowell, 1995). The Gini coefficient varies between zero and one, with zero indicating a situation of maximum equality --everybody has the same age at death -- and one indicating maximum inequality. The choice of the inequality measure for computing IL is not a critical one. The use of different inequality measures leads to similar results (Wilmoth & Hiriuchi, 1999). We use gini as it most sensitive to the complete distribution. In order to be able to decompose properly, we will also calculate Theil over the distribution of length of life when necessary.

In our explanatory analyses, we use relative IL (RIL). RIL is measured by standardizing IL scores within one-year ranges of LE. It represents the deviation from mean IL at a certain level of LE in units of one standard deviation. Measured in this way, RIL is not correlated with LE and is comparable across levels of LE.

Explanatory variables

For virtually all countries in the world, the World Health Organization has published characteristics of the health systems that will be used as explanatory variables. These characteristics are the total per capita expenditure on health in percentage of GDP, share of the governmental expenditure in total health expenditure (or the public-private mix), and the number of physicians per capita. We use the average values of these variables for the period 1995-1999. There is a time-lag between the moment that such factors exert their effect and the moment these effects become visible in the death rates. By taking the average for multiple years we minimize the influence of extreme years.

The World Development Indicators database of the World Bank contains a number of relevant indicators of general development and inequality that we suppose may affect both LE and IL. We use gross domestic product per capita, proportion of the population employed in service sector, HIV prevalence in the population aged 15-49, proportion of the population with access to improved water and the Gini coefficient for income inequality. Per capita GDP and per capita health expenditures are highly correlated. In multivariate analyses, we prefer to use the most direct measure of wealth that is directed to health by including per capita health expenditure. We test whether per capita GPD has an additional effect, but due to multicolinearity, this test is not always possible.

Next to income inequality, we employ two other indicators for potential within-country inequalities. First, we use an index for ethno-linguistic fractionalization from Professor Roeder political indicators database (University of California at San Diego; http://weber.ucsd.edu/~roeder). This index indicates how heterogeneous the population of a country is in terms of ethnicity and language. We assume that in more heterogeneous population all kinds of socio-economic inequalities along ethnic and linguistic lines are larger and potentially produces larger health inequality as well. We do not argue that diversity leads to more inequalities. Rather, we expect that in more heterogeneous countries there are simply more potential lines of division that can entail regional, social and cultural health differences. Second, we use the proportion of women in parliament as a measure for gender inequality.

Results

Total world average length of life and inequality

We start by describing total world life expectancy and inequality in length of life for the year 2000. For this year we can construct a set of life tables for virtually all countries in the world. It consists of real life tables for the countries for which they were available and estimated life tables for the WHO member countries for which the information needed for construction a life table was lacking. For many countries in the developing world, African countries in particular, no nation-wide registrations are available. However, the World Health Organization produced as set of life tables for these countries based on surveys and region-specific models. This is the most elaborate set of life tables available for a single point in time. It provides us with the possibility to calculate the overall life expectancy on earth for the year 2000. Moreover, it allows us to study the distribution of length of life for world as a whole. Note that we weight countries by their population size but that we do not take differences in age distribution into account.

Table 1 shows male and female LE and IL for the total world population and for the populations in a subdivision of the world in twelve geo-political regions. We see that in 2000 the world-wide life expectancy at birth for women was more than 4 years higher than for men. The difference is slightly higher for the life expectancy conditional on reaching age 15. The male life expectancy of 63.81 means that on average a male born in the year 2000 who for the rest of his life faces the age-specific mortality rates observed throughout the world (and weighted by population size) in the year 2000, will live almost 64 years. (Footnote: these figures are similar to Goesling & Firebaugh, who do not distinguish between men and women)

< Table 1 about here >

With regard to inequality, Table 1, shows length of life somewhat more unequally distributed among men than among women (gini of .128 and .115 respectively). Most of the inequality can be ascribed to within countries inequality. About 90% of the total inequality among men and 86% among women, is due to within countries differences in length of life. Because the populations of India and China are so much larger than those of other countries, we also analyze a set of life tables where we substitute the single tables for China and India with life tables at the province level for China (33 provinces) and state level for India (16 states). Differentiation within China and India does not influence the estimation of total world inequality very much, nor does it substantially increase the between country component (results in online supplement).

When we decompose total inequality by geo-political regions instead of individual countries, we obtain quite similar results to those in table 1. Using the regions listed in Table 2, we capture about 80% of the between country inequality. South Asia (notably Afghanistan, Pakistan, Bangladesh), India and sub-Saharan Africa stand out because in these regions inequality among women is equal to or even larger than inequality among men. Notice also that the difference between men and women is particularly large in Eastern Europe and Russia. The mortality crisis in this region has especially hit men in middle-aged and younger groups.

< Table 2 about here >

Next, we address the question of natural variation. Perfect equality would imply that all member of a population die at the exact same age. It is likely that even if all external causes of mortality were eliminated there would be some variation in length of life. This means there will always be a certain degree of within-country inequality. If we ignore this when decomposing, the between-country factor will be underestimated (Pradhan et al. 2003). Therefore we adjust our decomposition for a minimal level of within-country inequality which we assume to be similar across-countries. In doing so, we follow the approach by Pradhan et al. It is unknown what the genetic variation will be. We take as an estimate the level of inequality that is one-third lower than observed in the most equal country in our database. Table 1 shows that taking into account natural variation increase the between-country component by 25% for women and almost 40% for men.

Differences in IL among countries

The correlation between IL and LE, as discussed in theoretical section, can be clearly seen in Table 2. Regions with a higher LE tend to show lower levels of IL. If we plot LE and IL for all available country-year combinations, the relationship becomes even stronger. Figure 2 shows how adult IL varies across societies with different levels of LE. In spite of the high correlation, figure 2 clearly demonstrates that there are large differences in IL at all levels of LE.

< figure 2 about here >

Each dot in the two plots represents a male or female LT for a certain country in a certain year. Over 8,000 life tables 212 countries are used. Figure 2 is restricted to the basic pattern of IL and LE in more or less normal situations. Country-year combinations with extremely low LE due to severe calamities (wars, epidemics, famines) are excluded. Figures including severe calamities are presented and discussed in the appendix/online supplement.

For both males and females, the dots are concentrated in elongated cigar-like clouds running from the upper left to the lower right [endnote 2], thus reflecting the extremely strong negative correlation between LE and IL (over 0.9). However, this correlation is only one part of the story. At each level of life expectancy we observe considerable variation between societies with lower and societies with higher IL. For example, for populations with a LE of 65 (marked a in Figure 2), male IL varies roughly between 0.11 and 0.16 and for populations with a LE of 73 (marked c) between 0.08 and 0.12. Similar variation is observed for females. These results make clear that, besides the average number of years of life available in a society, also the way in which these years of life are distributed among the population members varies among societies and time periods.

Figure 2 also demonstrates that the absolute level of IL, as has been used in earlier studies (e.g. LeGrand, 1987; Silber, 1988; Edwards & Tuljapurkar, 2005) is a less informative measure, because whether a specific level of IL is high or low depends on the population's position on the LE axis. A male IL of 0.12 is relatively low in populations with a LE of 65, but it is high in populations with a LE of 73. Therefore the level of IL in a given population should be compared with IL in other populations at the same level of LE. This degree of IL in comparison with other populations at the same level of LE will henceforth be called *Relative Inequality in Length of Life* (RIL).[3]

Magnitude of differences in RIL

Before moving on to the analyses of cross-national differences in RIL, it is important to get an idea of the magnitude of the variation in RIL. What does it mean that in a population with a certain LE the Gini coefficient for IL is, for instance, 0.03 higher than in another population with a similar LE? Is this really a large disparity? To get an intuitively appealing idea of the magnitude of these RIL differences, we have translated them into numbers of deaths in the 15-50 age interval. A higher level of IL at the same LE implies that there are more persons reaching a high age, but also that there are more persons dying premature. Because premature mortality makes a more dramatic societal impact than longevity, we restrict our example to premature mortality. Note, however, that a high RIL can be the result of a more unequal distribution of length of life before and after the average. Figure 3 presents the number of premature deaths by RIL quintiles for males and females at the three arbitrary levels of LE, marked a, b, and c in Figure 2.

< Figure 3 about here >

We observe substantial differences in premature mortality. In populations with a male LE of 73 (72.5 - 73.5), the average number of males dying premature is 58 per 1000 in the 20% most equal societies. This number increases by each RIL quintile until it reaches a level of 92 per 1000 in the 20% most unequal societies. This means that at a LE of 73, premature mortality among males is as much as 34 per 1000 or 59% higher in the most unequal societies compared to the most equal ones. For societies with a LE of 69, the difference in premature mortality between the lowest and highest RIL quintiles is almost the same: 58%. At a LE of 65, the difference is somewhat lower, but with 37% still substantial. For females we find similar differences, ranging from 33% at a LE of 70 to 72% at a LE of 74. These huge differences in premature mortality (all significant at $p<0.001$) stress the importance of RIL as a meaningful indicator of mortality differences among populations.

We give another example to illustrate the magnitude of RIL differences in highly developed Western societies. Recent data for the US (2003) show a male LE of 75.56 and a IL of 0.102. When France reached the same level of LE (in 1999) its IL was quiet similar (0.099). However, when Sweden and England & Wales (E&W) reached that LE (in 1990 and 1997 respectively), IL was much lower, namely 0.089 and 0.088. Expressed in terms of premature mortality, the higher RIL in the US and France translates into about 70 premature deaths per 1,000, compared to about 49 in E&W and Sweden. Thus, while the average number of years of life available to the population members was the same in these four societies, the number of premature deaths was about 40% higher in the high RIL countries.

Trajectories through IL - LE space

An illuminating extension of the foregoing is obtained by highlighting the trajectories described by individual countries through the IL - LE space. Figure 4 shows such trajectories for males from E&W, France, the US and Sweden. This figure makes immediately clear that the country-specific trajectories are not steadily decreasing chronological lines, but that, depending on what happens in the country in a given year, the dots may jump forward and backward through the IL-LE space. For example, for three of the four countries, the first dot at the upper left corner is not for the first observed year (e.g. for Sweden it is 1790 instead of 1751). Other examples are the special position of the year 1919 (aftermath of the Spanish flu) in all four countries and the open spaces between 1939 and 1946 (due to jumps to the upper left) in the three countries that were actively involved in World War II.

The trajectories reveal interesting variations, both within and among countries, like changes into the direction of more or of less equality and periods of acceleration and deceleration. There are also huge differences in whether and when such changes take place and in which year a country reaches a certain level of LE or IL. For E&W, the dots are mostly located near the lower boundary, indicating that during most of the 160-year period, RIL among males in this country was low. The French observations, on the other hand, were located in the upper part of the cloud for a substantial part of time. Thus, over most of the period observed, male RIL was higher in France than in E&W. For the US, we see high levels of RIL in the 19th and early 20th century, followed by a period of moderate RIL until the 1970s, after which RIL rises to reach again a high level in the 1990s. Sweden shows much variation in the 18th and 19th century, followed by a period of high RIL in the first half of the 20th century. After World War II, Sweden moves towards lower RIL, reaching a level of relatively low inequality in 2002.

< Figure 4 & 5 about here >

In Figure 5 comparable trajectories are presented for females. The pictures do not differ very much from those for the males. Still there are some interesting differences. For example, since WWII, RIL for females in E&W was less favorable than for males, whereas in France it was more favorable than for males. Another example is the World War II period, which was clearly distinguishable as an open spot in the trajectories for males in E&W, US and France, the countries that participated in the war. In the female trajectories, this open spot is only present in the trajectory for France. This might be due to the fact that in France a land war was fought, whereas the (male) soldiers of E&W and the US were fighting oversees. In contrast with the relatively small effect of the wars on female mortality, the effect of the 1918 flu pandemic on female mortality was very strong. If we compare mortality in 1918 with that of 1919 (a year in which the flu was still making victims) it becomes clear how profound the effect of the pandemic has been. In all countries there was a very large jump back in LE and the effect on RIL was even stronger. In France, Sweden, and US, 1918 was the year of highest female RIL and also in E&W RIL in 1918 was extremely high.

On the basis of these (and other) trajectories it can be concluded that, although absolute IL decreases with rising LE in the vast majority of countries during most time periods, the level and trends in RIL are not related to LE in a predictable way. Highlighting the trajectories of individual countries is a powerful instrument for detecting variations in RIL among countries and time periods. By relating these variations to processes taking place within the countries, insight can be gained into the factors responsible for the (unequal) distribution of life within societies and thus into the deeper roots of inequality in our world, or into what has been called “the causes of the causes” (Marmot, 2005; Rose, 1992).

Explaining country-differences in RIL

To gain insight in the factors that determine the differences in LE and IL among countries, we use the values of these measures for 172 countries around the year 2000. Bi-variate correlations between LE and RIL on the one hand and our set of explanatory variables on the other hand are presented in Table 3.

< Table 3 about here >

All eleven explanatory variables are significantly correlated with LE for men and women.

Note that for nine country characteristics the correlation coefficients for LE are higher for women than for men. The correlation coefficient for the other two characteristics, per capita gross domestic product and proportion employed in the service sector, are similar for men and women. Apparently it matters more for women in which country they life than for men. This also seems to hold true for RIL. We find only two significant correlations for male RIL, whereas six country variables are significantly related to female RIL.

Two country-characteristics affect RIL among both men and women. The higher the share of the total per capita health expenditure that is managed by the state, the lower RIL. It is especially interesting to note that a larger public-share in health expenditure is, at least in a bi-variate model, associated with higher LE as well. The second country-characteristic that is associated with RIL is income inequality. As expected, we observe that in countries where income is more unequally distributed, the relative inequality in length of life is also higher. An additional test for a non-linear relationship was not significant. Also LE is correlated with income inequality, but negatively. The correlation between LE income inequality is stronger than that between IL and income inequality. Also with regard to LE an additional test showed that the relationship is linear. Because LE and RIL are a very low correlation (not completely zero, because the 129 life tables used in this analyses are a non-random selection all life tables used in the construction of RIL), we also can conclude that RIL and LE cover different aspects of what is measured by the Gini coefficient for income inequality.

For women, three other significant negative correlations are found. A higher GPD per capita is associated with lower IL as are higher health expenditures. Also a higher number of physicians per inhabitant is related to lower inequality among women. Finally, a marginally significant negative correlation with urbanization can be observed.

Next to income inequality, a second indicator of social inequality --or better: indicator for the potential of social inequalities—is positive related to IL: ethno-linguistic fractionalization.

High prevalence of HIV is related to lower levels of LE, but for men does not affect IL. Maybe HIV hits the male population quite evenly. For women, we observe a positive correlation with IL, although marginally significant. Perhaps, HIV is less equally spread among different groups of women. For instance, in as far as HIV is spread through prostitution we expect older women to be much less effected compared to younger women, whereas among men the older and younger will differ much less. As a result, HIV/Aids lowers LE for both sexes, but increase RIL only among women.

< Table 4 here >

Finally, we present multivariate models for the relationship between LE and LI on the one hand and country-characteristics on the other. In Table 4, we present models with significant covariates only. All variables from Table 3 were entered in the models and a procedure of manual repetitive forward and backward stepwise selection lead to this final models. No variable from Table 3 that is entered to the models shown in Table 4 has a significant effect, nor is the model fit improved.

In line with the observation of more and stronger bi-variate correlations in Table 3, we find more significant covariates and higher explained variance for women than for men. This holds true for LE as well as for IL.

With regard to LE, the results are quite well in line with previous findings. Countries with higher health expenditure and more access to clean water have higher LE. The negative effect of HIV prevalence is also easily understood. It is not that obvious, however, why ethno-linguistic fractionalization shows a negative relationship with LE. We expected that countries with more diversity are more likely to have larger regional and social differences in the distribution of and access to health resources. Ethno-linguistic fractionalization is higher in some of the poorer African and Asian countries. Maybe this is what is picked-up by the significant effects, even after controlling for health expenditure.

The most striking finding in Table 4 is that two factors that are important for RIL do not affect EL at all. The share of the total health expenditure managed by the state and the level of income inequality both affect RIL in the expected manner. In countries where the state distributes a larger share of the money spend on health, RIL is lower than in countries where the private sector has a larger share. The state has incentives (or obligations) to let everyone benefit equally or even give extra support to disadvantaged groups that the private market has not. Also in the multivariate model, countries with higher income inequality have higher levels of RIL.

Somewhat surprisingly there is a non-linear relationship for men between per capita health expenditure and RIL. When health expenditure as a percentage of GDP increases inequality first inclines, but it declines after more than six percent of GPD is spend on health (calculated from the unstandardized coefficients).

For women, we also find two significant covariates in addition to income inequality and government share of health expenditure. Both higher levels of ethno-linguistic fractionalization and employment in the service sector are related to higher inequality. For ethno-linguistic fractionalization this is in line with our expectations. The positive effect of employment in the service sector is more difficult to explain.

Conclusions

In this paper, we showed that countries with a similar level of life expectancy differ substantially in how equal or unequal length of life is distributed among the population. This relative inequality in length of life (RIL) can be viewed as one of the fundamental forms of inequality in the world. However, until now hardly anything was known about it. We compiled large database and reveal large difference in RIL among societies. At a given level of life expectancy, premature mortality may be 30 to 70% higher in the most unequal societies compared to the most equal ones.

We showed that a substantial part of cross-national differences in relative inequality in length of life can be explained by the level of health expenditure, the share of this expenditure managed by the state and socio-economic inequalities, income inequality in particular.

On basis of 191 countries for the year 2000, we estimated that about one-tenth and one-sixth of respectively male and female total world inequality in length of life can be attributed to between-countries variation. The largest share of total world health inequality in mortality thus seems to be due to within-country differences. We are aware of only one other study that assessed a somewhat similar decomposition of the total world distribution of health. Pradhan et al. (2003) used childhood stunting as a health outcome and estimated that about one-third of world health inequality can be explained by between-country differences.

Cross-national RIL differences are a general concern to scientists and policy makers. Why, for instance, was the risk of dying premature for males in France so much higher than in England & Wales, when life expectancy in both societies was similar? The fact that we find such large differences in RIL, even among highly developed countries, raises questions about the mechanisms responsible for them. As these countries differ little in technological development and genetic differences are probably too small to play a role of importance, it seems that behavioral differences and social distribution mechanisms may play a major role. There may for example be differences in the accessibility of the health care system, in redistribution systems, like social security and pension schemes, in violence, in environmental and traffic safety, or in eating, drinking and smoking habits. The difference between England and France might be due to a greater accessibility of the English health care system but just as well to the more exuberant lifestyle of the French men (which has for example been documented by Mesle & Vallin, 1998). It will be a challenge for future research to identify the factors that are responsible for these differences and to find out which social and behavioral changes might be associated with gains in RIL.

Our findings also make clear that monitoring RIL besides other performance measures of health care systems will become essential in the coming decades. RIL reflects generic inequality in length of life brought about by the impact of many social and behavioral determinants of health. It shows the overall performance of a country with regard to the distribution of resources needed for a long life and the creation of healthy life conditions, compared to other countries at the same level of LE. As advancements in biomedical sciences reduce mortality from diseases, non-medical factors, like unequal social distribution mechanisms, become increasingly important as obstacles to further gains in LE. When new possibilities to live longer are only available to selects groups in society, LE of these groups will rise, but the country's overall performance will not improve much. This might be exemplified by the performance of countries like France and the US, where the gain in male LE has been modest over the last decades and RIL has increased, in spite of the fact that per capita health expenditures have been high in both countries (in the US even highest of the world (WHO, 2005)). Is this because health resources have not been sufficiently redistributed among the entire population or are other mechanisms playing roles? Our results suggest that, at least on a world-wide scale, health resource are more equally distributed if the government manage a larger share of the health expenditure in a country. Moreover, the most direct measure of unequally distributed resources, income inequality, has a clear and robust positive association with inequality in length of life.

In line with the conclusion of the 2005 Human Development Report (UNDP, 2005) that "Distribution should be put at the centre of strategies for human development" (p. 71), we conclude that focusing on LE alone might not be sufficient to truly evaluate a society's overall performance with regard to mortality: RIL should be studied as a separate, meaningful and fundamental aspect of the mortality patterns of societies. Analyzing the relationship between a country's RIL and its health and social policies, as well as other social and economic factors will enhance our understanding of the social determinants of health, or the 'causes of the causes' that produce health differences within and among countries.

Endnotes

1. We are aware that data from the 18th and 19th century and of developing countries may be less accurate than more recent data from industrialized countries. However, our substantive conclusions do not change if we leave out the less reliable data.

2. The dots for females are spread out over a longer cloud, because on the one hand women on average live longer than men, but on the other hand there are some countries in which the social situation of women is so bad that their LE is lower than that of men (the missing-

women phenomenon (Sen, 1992).

3. RIL can be measured by standardizing IL scores within one-year ranges of LE. In that case, it represents the deviation from mean IL at a certain level of LE in units of one standard deviation. Measured in this way, RIL is not correlated with LE and is comparable across levels of LE.

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Table 1
Total world life expactancy and inequality in length of life for 191 countries in 2000

	Life expectancy		inequality in length of life				
	at birth	at age 15	gini	theil	decomposition (theil)		
					between	within	
Males	63.81	68.58	0.128	0.031	9.9%	90.1%	unadjusted
					13.8%	86.2%	adjusted
Females	68.03	73.03	0.115	0.028	13.8%	86.2%	unadjusted
					17.3%	82.7%	adjusted

Table 3

Correlations between life expectancy, inequality in length of life and country characteritics

	men		women	
	LE	**IL**	**LE**	**IL**
GDP per capita (log)	0.72 *	0.09	0.72 *	-0.16 *
Health experditure per capita	0.71 *	0.11	0.74 *	-0.19 *
Government share of health expenditure	0.24 *	-0.26 *	0.29 *	-0.27 *
Physicians per 100,000	0.57 *	-0.01	0.67 *	-0.30 *
Access to improved water sources	0.62 *	0.14	0.64 *	-0.13
Urban population (%)	0.61 *	0.05	0.64 *	-0.14 ~
HIV prevalence (% 15-49 population)	-0.68 *	0.08	-0.70 *	0.16 ~
Income inequality (gini)	-0.47 *	0.32 *	-0.49 *	0.38 *
Ethno-linguistic fractionalization	-0.48 *	-0.04	-0.49 *	0.32 *
Proportion of women in parlement	0.21 *	0.01	0.24 *	0.00
% employed in service sector	0.44 *	0.05	0.44 *	0.08

LE=life expectancy at age 15; IL=inequality in length of life measured by a gini coefficient

N=172, except for water (150), HIV (140), income inequality (129)

Ethno-linguistic fractionalization (158) and service sector (122)

~ $p<0.10$; * $p < 0.05$

Table 3

Correlations between life expectancy, inequality in length of life and country characteritics

	men		women	
	LE	**IL**	**LE**	**IL**
GDP per capita (log)	0.72 *	0.09	0.72 *	-0.16 *
Health experditure per capita	0.71 *	0.11	0.74 *	-0.19 *
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LE=life expectancy at age 15; IL=inequality in length of life measured by a gini coefficient

N=172, except for water (150), HIV (140), income inequality (129)

Ethno-linguistic fractionalization (158) and service sector (122)

~ $p<0.10$; * $p < 0.05$

Table 4
Standardized regression coefficients from models with significant variables regressed on LE and RIL

	men		women	
	LE	RIL	LE	RIL
Health expenditure	0.467 **	1.575 **	1.267 **	
Health expenditure squared		-1.332 *	-0.822 **	
Government share of total health expenditure		-0.278 **		-0.223 **
Physicians per 100,000 inhabitants			0.110 *	
Access to improved water (%)	0.205 *		0.156 ~	
Urban population (%)				
HIV prevalence (% 15-49 population)	-0.523 **		-0.523 **	
Income inequality (gini)		0.499 **		0.429 **
Ethno-linguistic fractionalization	-0.141 **		-0.110 **	0.265 **
Employed in service sector (%)				0.283 *
adjusted R squared	79.4%	18.3%	86.7%	19.6%

N=172, results from dummy imputation models; similar to multiple imputation results

*~ p<0.10; * p<0.05; ** p<0.01*

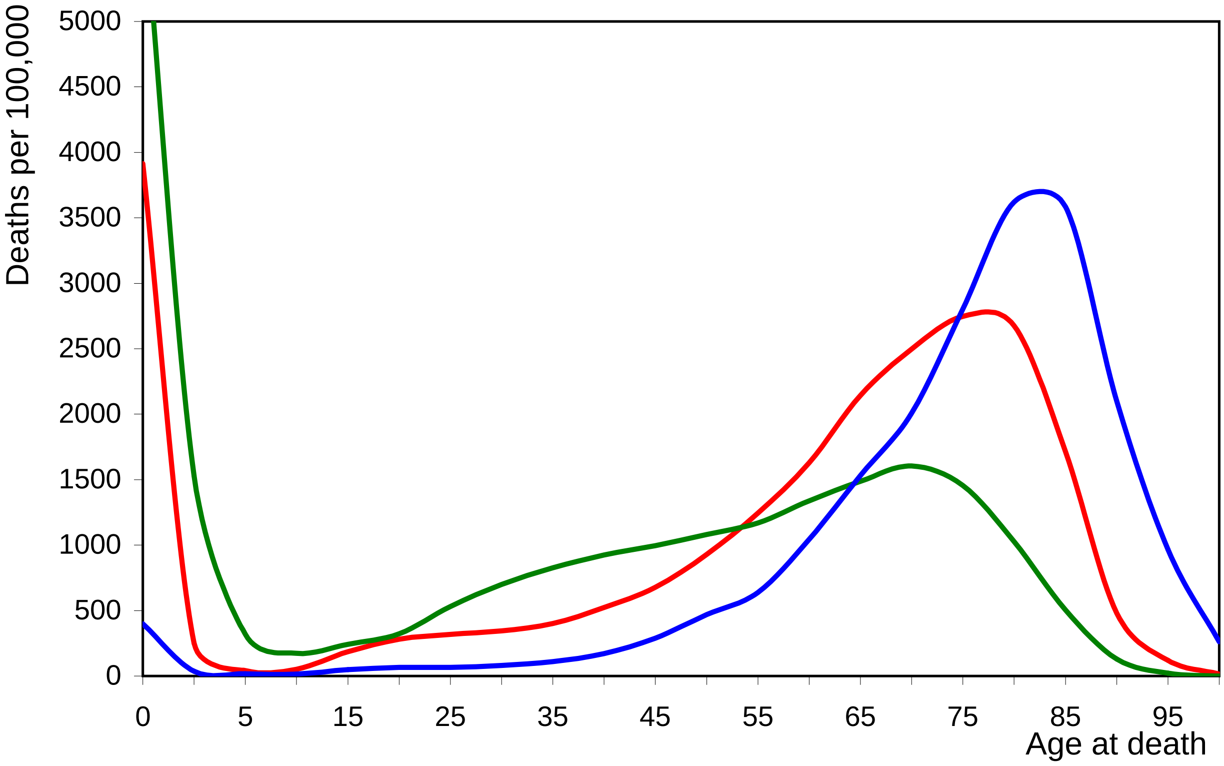

Fig. 1 Distribution of age at death for males in Niger, Brazil and Japan in 2000

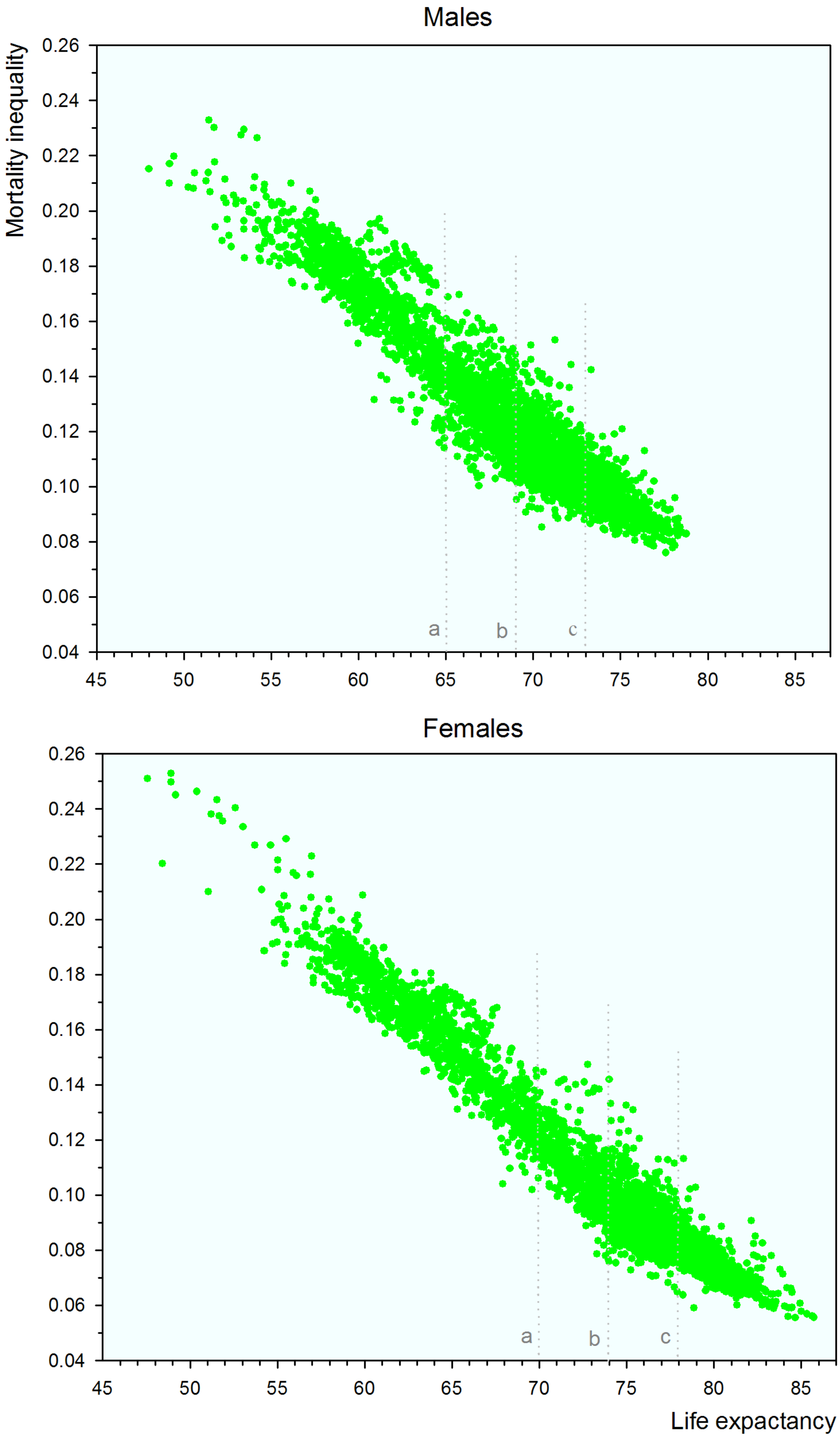

Fig. 2 Mortality inequality by life expectancy for adult (15+) males and females based on 8,712 life tables for 212 countries

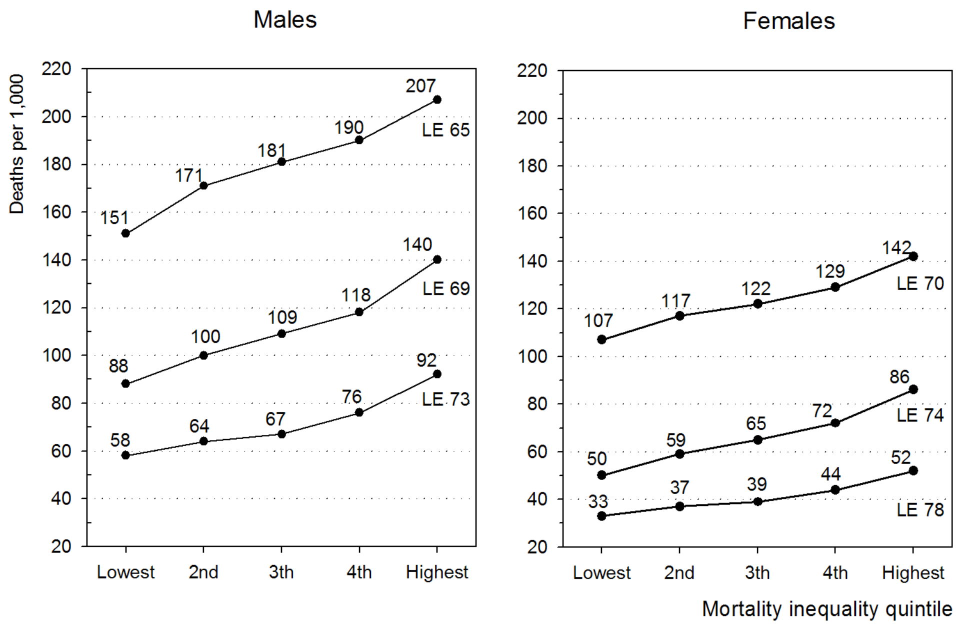

Fig. 3 Number of deaths per 1,000 males and females aged 15-50 for mortality inequality quintiles at different levels of life expectancy

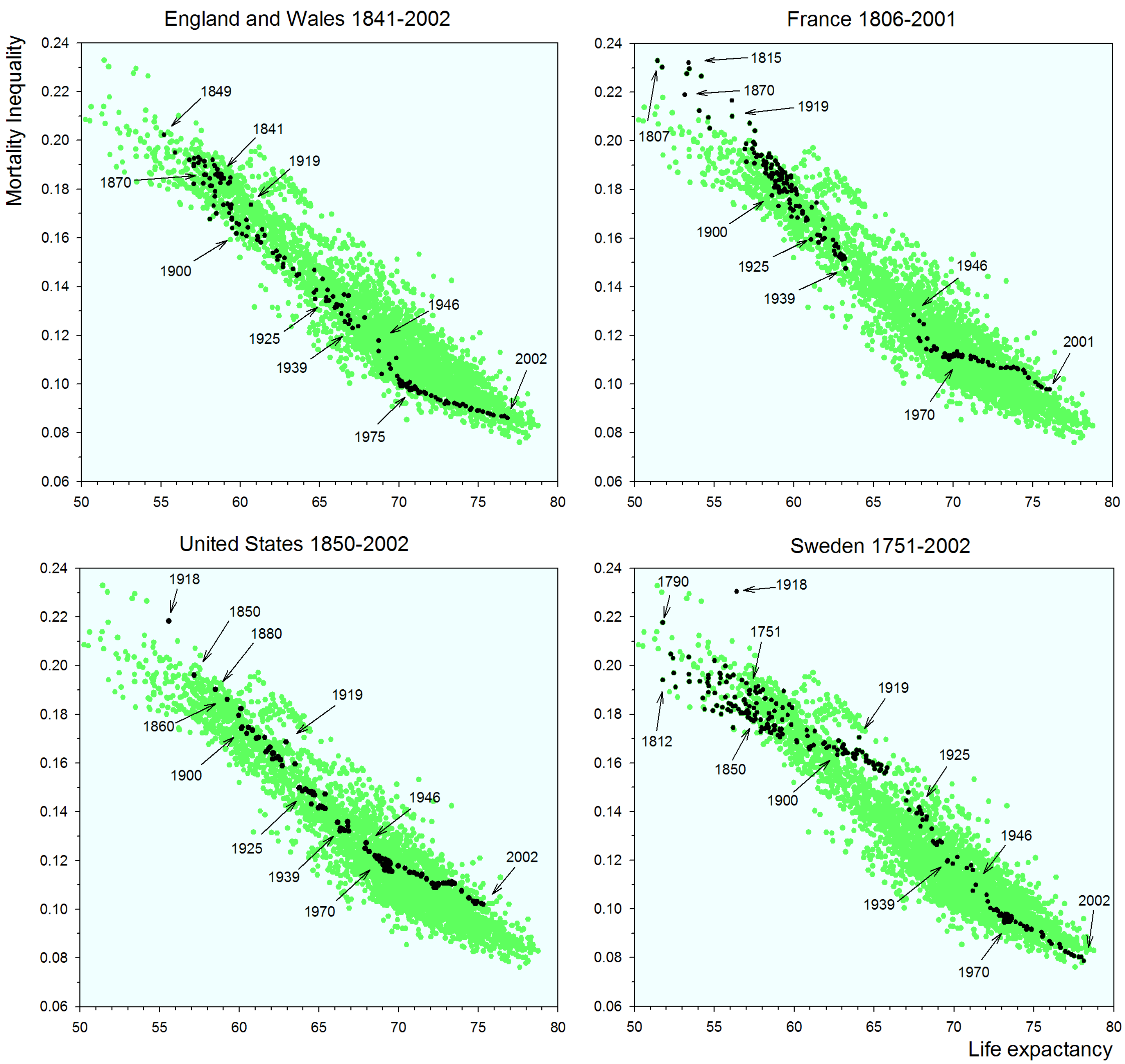

Fig. 4 Trajectories through the MI-LE space for males in the England & Wales, France, United States and Sweden

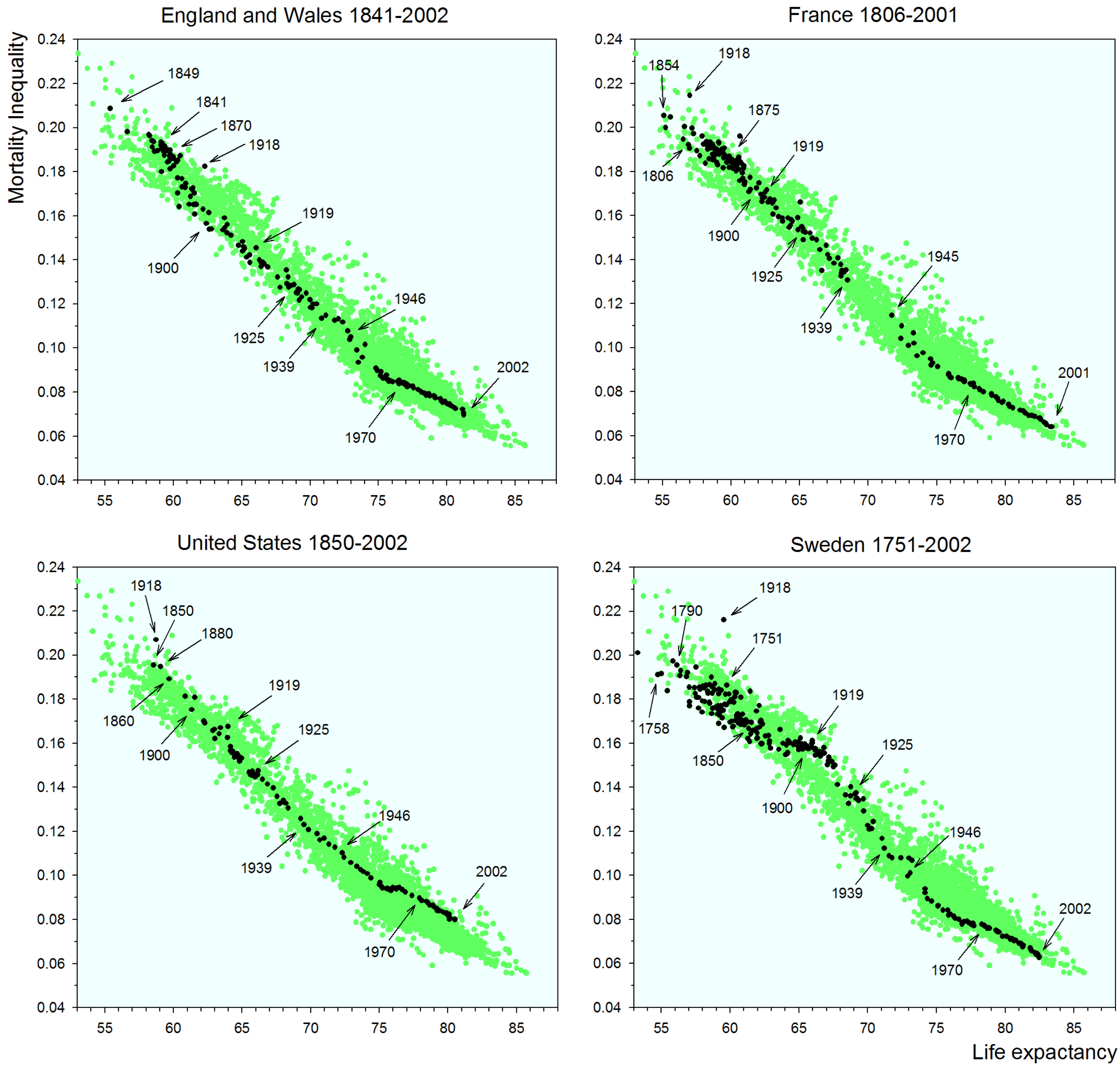

Fig. 5 Trajectories through the MI-LE space for females in the England & Wales, France, United States and Sweden