This is the submitted version of a paper that is published as:
Rigby, J.E. and Dorling, D. (2007) Mortality in relation to sex in the affluent world, *Journal of Epidemiology and Community Health* **61**(2)

# Mortality in relation to sex in the affluent world.

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**Abstract**

Objective: This paper explores newly available data for 22 countries with reliably recorded mortality data. The last century saw dramatic falls in mortality rates for both males and females in the most affluent countries of the world. However, these falls are not consistent for both men and women, and the inequalities in the male:female mortality ratios are not well-understood.

Design: By aggregating mortality at each year of life for the 22 countries for those years for which reliable data were recorded (during the period 1850 to 1999), distinct patterns emerge.

Main results: In the richer countries of the world, the male:female mortality ratio has been widening, for all years of age particularly for those born from 1942 onwards. Specific cohort effects are clearly identifiable.

Conclusion: Analysis of the emergent trends suggests that economic activity, status and position possibly provide a better overall explanatory model than a purely biomedical approach.

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## Introduction

"*Gender differences have been consumed by social change. We are in the midst of an ascent of women matched with an equivalent descent of men*".[1]

In the richest fifth of the world, the rate ratio of young men dying per year to young women is 3:1.[2] Amongst these richest of nations, in recent decades, the mortality rates of younger women have been falling much more quickly than for men.[3][4][5][6] The demographic and social antecedents of this trend, its historical uniqueness, and its potential implications for the future population structure of the rich minority of the world are not well understood, and not widely recognised, although many studies have been made of specific aspects of the trends.[7][8][9][10][11] A new international database [12], accessible to all researchers, makes the study of 22 countries now possible (see footnote 1), and the degree of accuracy achieved from amalgamating the data produces new trends for exploration and explanation. The aim of this paper is to investigate changes in the male:female mortality ratio over time, specifically to identify when the trend towards high rates of male/female inequality in mortality began.

## Methods

The Human Mortality Database project began in 2000, and is jointly maintained by the Department of Demography at UC Berkeley and the Max Planck Institute for Demographic Research. Countries are included if there is a "well found belief that coverage of census and vital registration statistics is relatively high" [12]. Different countries enter the dataset on different dates depending on when their data became reliable: the data have been stringently validated following a strict methods protocol [13] before being accepted for this database. The datasets contain some caveats in terms of data quality, which informed the time period extracted for this work i.e. from

1850 to 1999. Thus the geographical area being considered changes in size over time – but at each point in time the area corresponds to those nations of the world that could record reliable mortality data – in effect to the most economically advantaged nations of the world (countries identified as "relatively wealthy" [12]). Clearly these findings are unlikely to reflect conditions in much of the remaining four-fifths of the world, where so much mortality remains attributable to infectious disease and conflict. [14]

| | Data available at time of access | Population 1999 (millions) |
|---|---|---|
| Sweden | 1751-2002 | 8.9 |
| England and Wales | 1841-1998 | 52.6 (1998) |
| Norway | 1846-2002 | 4.5 |
| Italy | 1872-2000 | 57.6 |
| Switzerland | 1876-2002 | 7.1 |
| Finland | 1878-2002 | 5.2 |
| France* | 1899-2001 | 58.5 |
| Spain | 1908-2001 | 40.3 |
| Canada | 1921-1996 | 29.8 (1996) |
| Denmark | 1921-2000 | 5.3 |
| Bulgaria | 1947-1997 | 8.3 (1997) |
| Austria | 1948-1999 | 8.1 |
| Czech Republic | 1948-2001 | 10.3 |
| Hungary | 1950-1999 | 10.1 |
| Japan | 1950-1999 | 125.3 |
| Netherlands | 1950-1999 | 15.8 |
| E Germany | 1956-1999 | 15.3 |
| W. Germany | 1956-1999 | 66.8 |
| Latvia | 1959-1999 | 2.4 |
| USA | 1959-1999 | 272.5 |
| Lithuania | 1960-2001 | 3.5 |
| Russia | 1970-1999 | 146.3 |

*territorial changes during World Wars I and II

**Table 1 - Data forming the "affluent world"**

The full data set used here includes some 1.4 billion people, 702 million women and 695 million men living between 1850 and 1999 in the 22 countries shown in Table 1 above. Of these, almost 1 billion are alive now. People of 101 years of age or more are not included here. Data held include annual live birth counts, annual death counts

and population size on 1 January each year. Hence the data for each country were used to produce counts of deaths by age and sex for each year, and thus to calculate mortality rates for each year of life. The male : female mortality ratio was calculated by dividing the male mortality rates by the corresponding female mortality rates. The work did not require ethical approval.

It is extremely difficult to visualise changing rates, let alone rate ratios by age and cohort in one's imagination; a map of mortality trends is worth fifteen thousand numbers. Hence to assist with interpretation, Figures 1 and 2 are Lexis maps (see Footnote 2) of the ratio of male to female mortality by single year of age and year; and of the first derivative of change in that ratio (by age). The x-axis (or easting) represents time showing the years from 1850 to 2000. There are thus 150 columns of data. The y-axis (or northing) represents age, from under 1, to being aged between 99 and 100 years old. There are thus 100 rows of data and 15,000 cells in all. Each cell is coloured according to the mortality rates of women and men in each specific year of each particular age. Thus the top right hand cell refers to the mortality rates of people in their one hundredth year of life living in the calendar year 1999.

The cells in the Lexis map are coloured according to the ratio of female mortality rates to male mortality rates. For example the top right cell in Figure 1 is given a shade of orange that corresponds to a ratio of between 1.1 and 1.2 on the key to the right of the diagram. This means that for every 1000 men, between 10% and 20% more died in the year 2000, before their 100th birthday than did women of the same age group over the same time period. To distinguish between shades of colour locate the darkest red in the diagram. This refers to mortality ratios of less than 1.0 (where more women died than men). Note that the "ratio surface" on the Lexis map is quite

smooth. Areas of time and age where rates were less than 1.0 tend to be surrounded by areas where rates were between 1.0 and 1.1 and so on and up to the few cells in time and by age where more than 3.4 men died for every woman who died.

The quality of the data allows a single year of age first derivative (a measure of change) to be calculated for the first time. This shows the increase or decrease within any calendar year of mortality ratios comparing one cohort with that aged a year older (Figure 2). Here we are looking at the change in slope by age, so for each cell we divide its value by the value in the cells below it, relating to people aged 1 year younger. If there is a sudden increase or decrease in the smoothness of the Lexis map's surface it becomes evident by showing this first derivative. Note that we have smoothed the first derivate surface by taking a five-year moving average by age. The average is actually the geometric mean for two years younger, a year younger, the age group being considered, a year older and two years older. The geometric mean is calculated as the product of the five ratios (of ratios (of rates)) to the power of a fifth. We only smooth vertically (by age) and calculate the derivative by age, as we would expect some breaks of slope by time as new territories are introduced over time. Therefore we do not calculate the first derivative over time. We interpret the maps by looking for specific features e.g. diagonal lines of colour will show cohort effects, where vertical 'chimneys' will show a situation in a particular year: the World Wars are good illustrations of such period effects. In Figure 2, these chimneys appear strongly in blue, but much of the remainder of the diagram before 1950, for the ages between 20 and 70, is green – corresponding to around 1.0 on the legend, and indicating relatively stable change as males and females age by one year at a time. However, where we see diagonal lines of colour apparent, for example in dark blue

from 1970, the diagonal highlights a cohort of people as they age year by year, and the colour indicates the rate of change: so blue indicates that year on year, the rate of male mortality is worsening compared with that of women. This is explored in more depth following Figure 2 in the next section.

**Results**

Mortality rates have fallen rapidly over time in the rich world. In the first half of the 20th Century, much of this was attributable to continued public health interventions to supply clean water, sanitation, and improved housing quality. In addition, improved health care and nutrition were reflected in dramatic falls in maternal and infant mortality. [15]

Before turning to the relative mortality ratios of men to women, trends within each warrant consideration. These are summarised in Table 2 below, which shows the total male and female mortality rates for the data at approximately 10 year time intervals across the twentieth century.

| Year | Female mortality rate per 1000 | Male mortality rate per 1000 | Comment |
|---|---|---|---|
| 1910 | 16.76 | 18.28 | |
| 1919 | 16.44 | 18.76 | Influenza pandemic |
| 1930 | 12.44 | 13.84 | Beginning of Great Depression |
| 1940 | 12.65 | 15.17 | Early World War II in Europe |
| 1950 | 9.99 | 11.25 | Beginnings of regeneration |
| 1960 | 8.63 | 10.59 | Stability and prosperity |
| 1970 | 8.56 | 10.33 | Widespread contraception |
| 1980 | 8.81 | 10.18 | Periods of recession |
| 1990 | 9.01 | 9.83 | Onset of Japanese recession; AIDS |

Table 2 Overall female and male mortality rates at time intervals

From this summary information we can see how the rates for males and females fall over the twentieth century, but not at the same pace. For specific ages (see Figure 4, for example) the figures are particularly noticeable.

For ten year old girls, rates fell from just below five per thousand in 1850, to four in 1867, halving repeatedly to two in 1925, to one in 1947, 0.5 in 1955, 0.25 in 1975 and being approximately 0.125 per thousand now. For ten year old boys rates were similar in 1850 and the first milestone (less than four per thousand deaths per year) was reached in 1867, but subsequent milestones were attained later than for girls: 1926, 1949, 1961, 1996 respectively; mortality rates for 10 year old boys are currently approximately double those for girls of that age.

There has been only one outstanding worldwide single year period effect in the rich countries between 1850 and 1999. Those girls aged 10 in 1918 experienced a mortality rate equal to women aged 40 in the years either side of 1918. This shows the historic magnitude of the influenza pandemic of 1918.[16] For men, the First World War raised mortality rates in general from 1914 through to 1920, but rates in 1918 were still twice those of earlier and later years for all ages between 1 and 40.

More evident for men are the peaks in mortality. These occur at age 30 in 1853 at 10.6 per thousand, falling then rising again to 10.3 in 1871, falling then rising through the First World War to peak at 31.6 in 1918, then alternately falling and peaking at the times of the Wall Street Crash in 1929 (5.4), the depression in 1936 (5.2), reaching 9.8 in 1940 during the start of World War II, then falling rapidly to a low of 1.6 per thousand in 1967. These rates then rose and fell repeatedly with peaks coinciding with economic depressions [17] in 1970 (2.3), 1981 (2.1), 1994 (2.4) and ending with rates in 1999 of 1.9, higher than those in 1958, forty years earlier. Conversely mortality rates for women aged 30 halved from 1.3 per thousand in 1958 to 0.7 per thousand by 1999.

The Lexis maps show trends hinted at by studies before [4][5][6] but with a degree of accuracy only achievable when the sample size exceeds 1 billion, which has not been achieved before, and is only possible if this (albeit expanding) area of the globe is considered as a single areal unit of study.

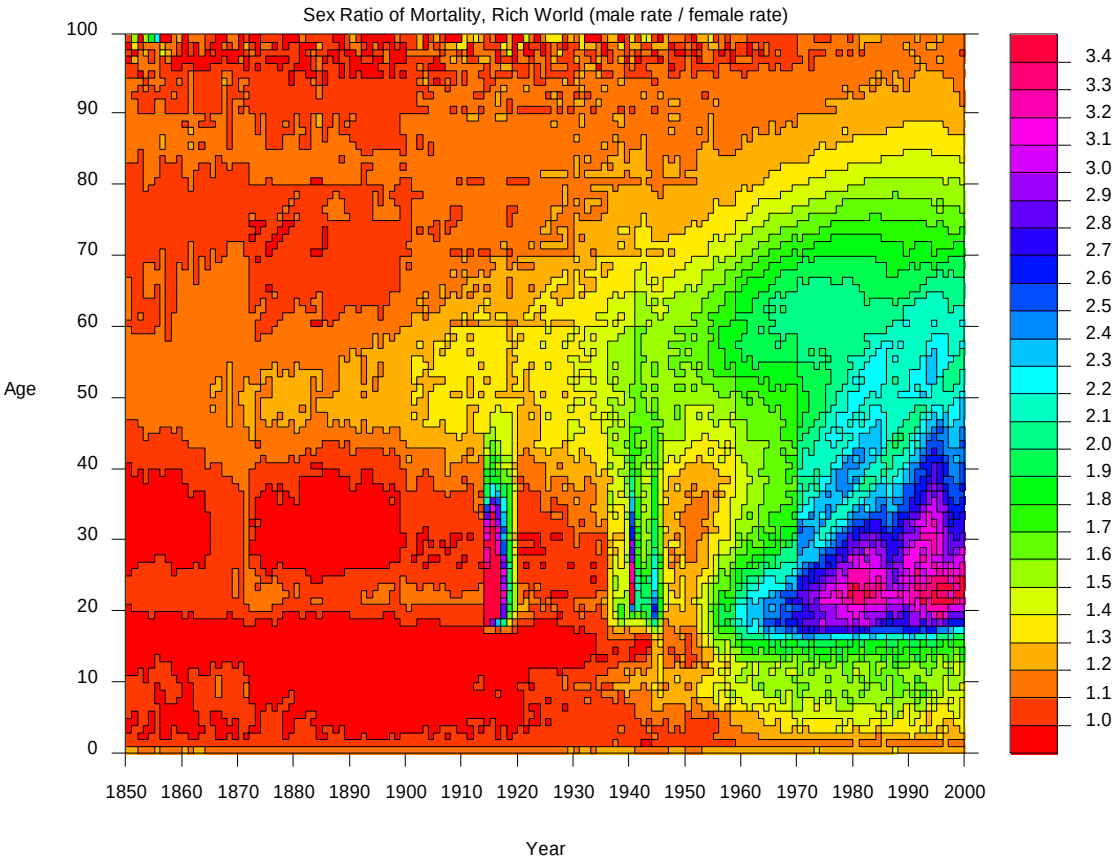


**Figure 1 - Sex ratio of mortality(male rate/female rate) for the richer countries**

Figure 1 shows the changing ratio of male to female mortality in these rich countries of the world by single year of age each year from 1850 to 1999. Hence the greater the scale value, the greater the proportion of men dying than women. Prior to 1940 at many ages slightly more women died per 1000 per year than did men. The main exceptions were for younger men during the First World War and for those aged 50 to 60 from the 1870s onwards, with maximum inequalities being recorded as mortality rates up to a third higher than for women in particular years at particular ages. For

men aged 21, mortality rates were 20% higher than women of the same ages in 1934, 31% higher in 1936, 60% higher in 1938 and 300% higher in 1940. Although falling again after the war, the ratio never fell back to its 1934 level and rose steadily again from 1950 to reach 113% in 1959, 216% in 1974, and peaking at 251% in 1995. By then, for every 100 women dying aged 21 some 351 men were dying at that age each year in the rich world.

As Figure 1 shows, the recent fortunes of 21 year old men were part of a general trend which began around 1950 for men aged around 20, included all those aged 20-30 by 1960, extending to age 40 by 1970, 50 by 1980, 70 by 1990 and covering ages 20-80 by 2000, for whom it became normal to die at almost twice the rate of women per year. Although this triangle has been identified before [4] it has not been mapped in as much detail as here and that detail provides more clues as to its possible origins. At the heart of this triangle, for men in their twenties in particular years in the 1980s and 1990s, rates of mortality three times those of women became normal. This is an unprecedented level of inequality in the richest countries of the world. Whilst deaths attributable to AIDS in younger men might contribute to this phenomenon, the contribution is relatively small, particularly for the youngest ages most affected (early twenties) and in the period at which inequalities became highest (1990s), before anti-retroviral therapy became effective.

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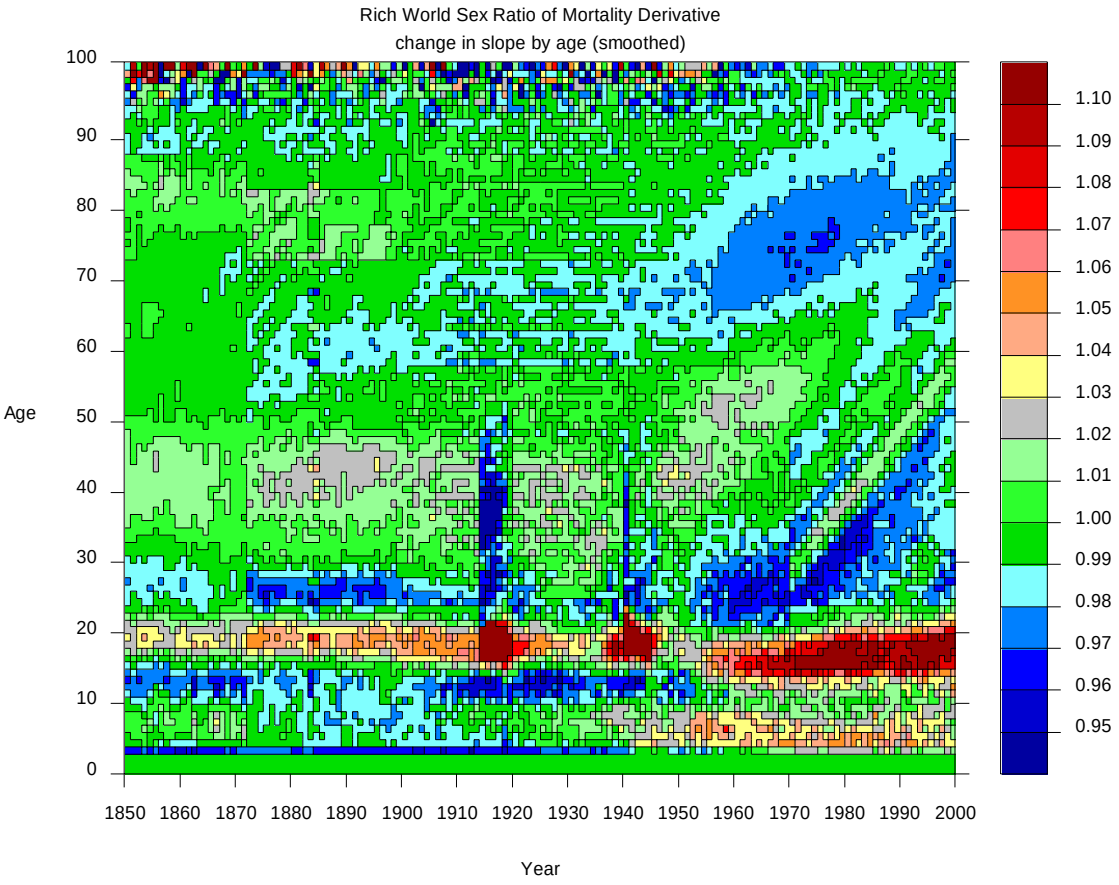


**Figure 2 - First derivative of sex ratio of mortality, showing change**

Figure 2 shows the first derivative of change in Figure 1 by age. It is clear that the increases in the ratios which have occurred over time are cohort-led. That is, from around 1950 onwards diagonal trends appear in the change in rate ratios. The first of these trends is for men aged around 80 in 2000 who would have entered the labour market in the 1930s; the second is for men aged 68 in 2000 who were 15 in 1947; the third for men aged 58 in 2000 (aged 15 in 1957); the fourth for men aged 37 in 2000 (entered labour market in late 1970s or early 1980s), the fifth for men aged 24 in 2000 (entry in early 1990s) and the sixth is for men entering the labour market around 2000. Each of these cohorts is of men who had to compete for work more than was normal (as compared to men born slightly earlier or later), both as a product of when they were born and of subsequent economic circumstances. For later cohorts that competition has also been increased as women have entered competing (rather than

separate) labour markets in increasing numbers.[18] Figure 1 also shows how, in terms of changes to the ratios, the worse years of the two world wars are similar in impact to social change since 1960.

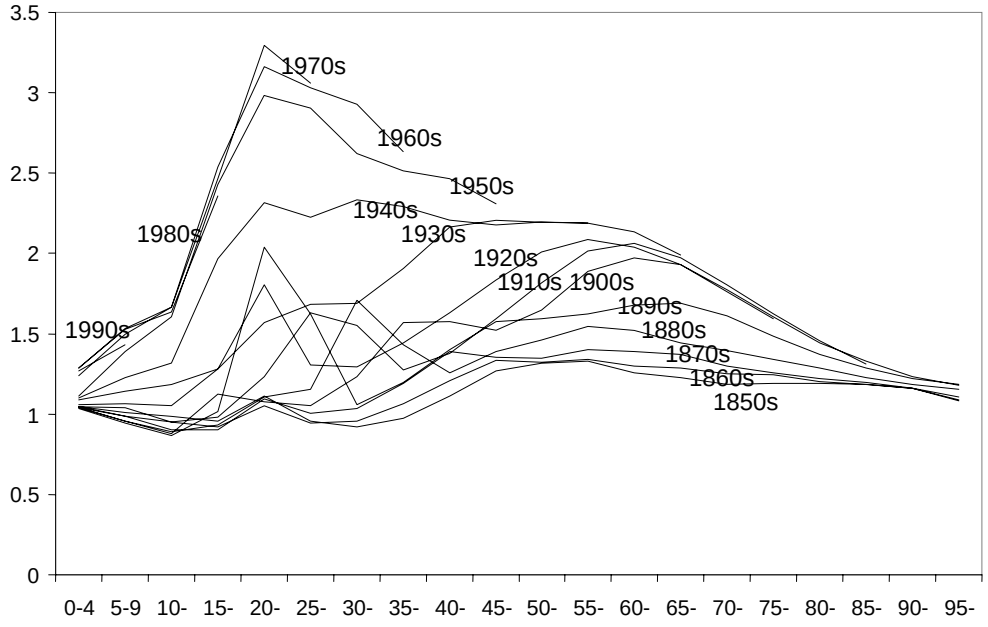


**Figure 3 - Male/Female mortality ratio by age in the Rich World by 10 year cohort 1850-1990**

To explore the trends over time Figure 3 shows male:female mortality ratios by age for successive ten year cohorts from 1850. The lowest line in the figure and first cohort is of all people born between 1850 and 1859. For that first cohort, ratios at all ages were near 1, and the same proportion of men and women died each year as they aged. For successive cohorts the flat lines of risk rise slowly and then more rapidly until, for men born in the 1930s their chances of dying between ages 40 and 65 were twice those of women born in that decade. This rise in male mortality in middle age coincides with the rise of smoking (originally more amongst men).[10] For men born before the turn of the century – the 1880s and 1890s cohorts - ratios rise at the age they would have been during the first world war. There are shallow peaks for those

born in the 1910s and 1920s at the ages they would have been most likely to have been fighting in the Second World War.

From the 1940s born cohort onwards, the peak age of inequality quickly becomes the early twenties and there is little subsequent rise in inequalities at older ages. By the time the 1970s born cohort reached their early twenties, male:female mortality inequalities had exceeded 3:1 and both the 1980s and 1990s born cohorts are following similar trajectories. From analysing Figure 2 it is possible to discern that the date at which the trend changed the fastest was for those children born in 1942. Men born in this year in the rich world were the first to be twice as likely to die as women, each year, from the age of 18 onwards.

**Discussion**

"*Manhood tells a social tale as much as one written in nucleic acids. It must, with all that it implies be constructed, and once its foundations are laid, what rises from them has little to do with DNA.*" [19]

For those born since 1942, by the age of 18 men have been twice as likely to die per year than women. Their relative chances then exceed this until they reach their 50s when again they are twice as likely to die per year. Below age 20 and above age 50 inequalities between men and women have been stable over the course of more than the last four decades. Between ages 20 and 50 subsequent cohorts of men have experienced successively poorer relative mortality as compared to women. At times male mortality rises in absolute terms for men of these ages whereas for women it relentlessly falls. What has changed since 1942 to create these new trends?

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In 1942 the rich world was in turmoil. The United States had joined the war a few weeks prior to the start of the year. Stalingrad was held, with huge losses, by the Russians, and at El Alemein the course of the war changed in the autumn of that year. But for those born during the height of this war it was the social changes that came later that most influenced their lives. When they turned 18 in 1960 the contraceptive pill was first marketed in the United States, coming a year later to Germany.[20] Women born in rich countries around 1942 were amongst the first in the world to have substantial control over both their bodies and social destinies. As Jones succinctly phrases it, the changing social relationships between men and women were what led to the current descent of men. [19]

No single medical, biological or "lifestyle" explanation can account for why young men's mortality is improving so much more slowly than young women's across all the richer nations of the world. Unlike the early rise in inequalities at older ages, there is no obvious agent such as the introduction of mass produced cigarette sales being clearly biased towards men and no small group of causes accounting for the majority of inequality.[7] The work of Gjonça and colleagues makes a very useful contribution to identifying social and biological factors when comparing England and Wales with France, but does not explore the crucial history of their economic contexts.[8] Given the history of epidemiology and public health it is not surprising to find the predominance of biological explanations frequently suggested [4][5], and indeed we may be witnessing the outcomes of some evolutionary processes which are only just emerging. However, any mechanical explanation has to encompass the whole growth in relative inequalities from ages 10 to 80 from the middle of the last century to the start of this one. No single biological explanation can account for why a 10 year old boy is half as likely again to die as a girl of that age in any given recent year, likewise

for an 80 year old man as compared with an 80 year old woman.[21][22] In 1912 their chances were almost equal. Whilst aspects of high risk behaviours (reflected in road-accidents, suicides and lethal drug abuse statistics) feature in explanations of higher male mortality for young adults [5], we argue that such explanations are hardly applicable for boys aged 10.

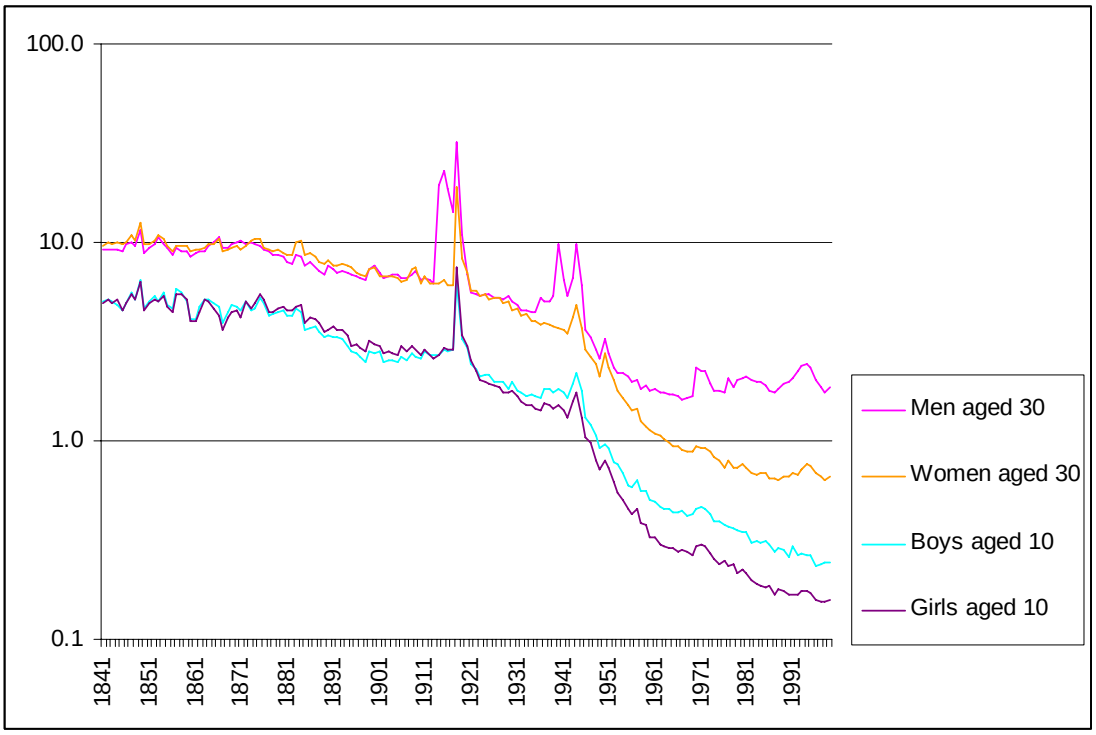


Figure 4 Mortality rate per thousand per year (logarithm scale): affluent countries of the world, selected single years of ages 10 and 30, male and female, 1841-2000

Figure 4 shows mortality rates separately for males and females, for the single ages of 10 and 30. The influenza pandemic, and for males the first and second world wars, and post-war economic depressions, are all evident. It is also clear to see that the male/female rates for 10 ten year olds begin to diverge at the same time as the rates for 30 year olds, from the mid 1940s.

The recent collection of reliable, validated historical mortality data from around the world allows both the patterns at large to be studied and individual countries'

trajectories to be compared. There may well be clues in the fluctuations to the general trend that point to its origins and likely future. Ratios improved slightly more slowly for women under the rule of Mussolini in Italy and Franco in Spain for instance. Between ages 5 and 14 many more girls died in 1918, for all years studied, than did boys. Perhaps fascist regimes held back women's emancipation enough to slightly influence relative mortality rates? Perhaps boys were valued so much more than girls that in times of stark deprivation (during war and pandemic in 1918) more brothers were kept alive than their sisters? The variations between the fortunes of men joining the increasingly global labour market at dates determined by their birth (listed above) provide more clues, through the coincidence of events, of the underlying processes at play. It may just be coincidence that men suffer more biological effects during recessions, benefit from recessive regimes, and die less in childhood in one unique year. Alternatively, perhaps all these signs point to the growing importance of social context in terms of gender equality and most importantly female emancipation in the rich world [23].

If women's emancipation is the driving force of this global trend then the prospects for men's future are not good, as in almost all rich countries the economic and social position of women still has a long way to improve to reach that of men. Four and five fold mortality inequalities are not hard to imagine at particular ages in the near future especially in particular countries (the ratio already exceeded 3.5 in 1995 for men aged 21). Just as the causes of these inequalities are not medical nor will the solutions be.

Clearly this study is limited to the findings from the data available i.e. those countries who had the infrastructure to supply the Human Mortality Database with population

and mortality data which met its stringent requirements. All available countries were included at the time this paper was written. There are other, affluent countries who are not in the database, but whose populations are unlikely to be large enough to affect the trends discussed. The authors also acknowledge that the historical events incorporated in the discussion are, whilst persuasive, clearly subjective and influenced by our UK perspective.

In the richer nations of the world the lives and social roles of young men and women only vaguely resemble those of their grandparents. If the same order of change were to occur in the next two generations then perhaps the relative descent of men could decelerate. As yet there is no strong evidence for that. It can, however, be seen that the step changes in Figure 1 start to shift direction in the upper age ranges (over 70) from about 1990: this convergence might reflect the ‘rounding off’ of the middle-aged bubble. This study suggests that international socioeconomic factors need to be carefully studied to better understand the recent history of mortality amongst the most affluent billion people of the world.

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## Footnotes

1. In Spring 2005 a 23rd country, Belgium, was added to the database which is omitted from the study here. It almost certainly had no effect.
2. The software used to draw the Lexis maps was Lexis 1.1 written by Kirill Andreev and named after the German demographer Wilhelm Lexis. Available from www.demogr.mpg.de
(software at http://www.demogr.mpg.de/books/odense/9/cd/default.htm)

## Acknowledgements

The authors would like to thank Charles Pattie and Eilidh Garrett, and four referees, for their helpful comments on an earlier version of this manuscript.

**Competing Interests**: there are no competing interests.



**Summary box:**
It is already widely known that in rich nations young male mortality rates are now several times higher than female rates and that these relative differences have widened as absolute rates have fallen rapidly for both women and most groups of men. However almost all studies focus on single nation states or compare a small number of nations. Few studies group nation-states to dramatically increase sample size and allow more subtle trends to be identified within what is already known. Those subtle trends may produce clues as to why relative inequalities are increasing as they are.

This study adds the most detailed description of this trend to date in terms of volumes of data involved and hence the clarity of the patterns which result. This allows the second derivative of the trend to be taken – the trend in the trend – and allows key dates to be identified where it appears that increases in the relative ratios of male to female mortality coincide with cohorts entering world labour markets during more economically depressed times. This study suggests international socioeconomic factors need to be carefully studied to better understand the recent history of mortality amongst the most affluent billion people of the world.

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