Trends in World Inequality in Life Span Since 1970

Ryan D. Edwards*

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Abstract

Variance in length of human life represents a fundamental inequality in well-being. Like shorter average life expectancy, higher variance is also a considerable economic cost. Previous research has revealed much about worldwide trends in average length of life and in infant mortality, but trends in the variance of length of life, especially the length of adult life in particular, are less well understood. In this paper, I explore patterns in life-span variance in a broad panel of 180 rich and poor countries between 1970 and 2000. Widely remarked patterns of convergence in infant mortality has reduced overall or unconditional world variance in length of life, but world inequality in length of adult life has remained stagnant. Although inequality in length of life has been and still is primarily due to within-country inequality, increases in between-country inequality in length of adult life have roughly offset decreases in within-country iequality since 1970.

*Assistant Professor of Economics, Queens College and the Graduate Center, City University of New York, and NBER. Mailing address: 300-S Powdermaker Hall, 65-30 Kissena Blvd, Flushing, NY 10069. `redwards@qc.cuny.edu`. An earlier version of this paper was presented at the 2008 annual meeting of the Population Association of America in New Orleans, LA. This work is supported by PSC-CUNY grant 60104 37 38. I am grateful to Henry (Ayodeji) Fola-Owolabi for excellent research assistance, to Michel Guillot for an electronic dataset of the life tables used in Murray et al. (2003) and for helpful advice, and to Shripad Tuljapurkar for many helpful comments. All errors and opinions are mine alone and do not reflect the views of the City University of New York, the Professional Staff Congress, or the National Bureau of Economic Research.

The past 50 years have brought an enormous amount of global convergence in life expectancy at birth, e_0, which is the average length of human life (Wilson, 2001; Goesling and Firebaugh, 2004). To be sure, there have been exceptions to the general rule of monotonic gains against mortality. As remarked by Moser, Shkolnikov and Leon (2005), the impact of HIV/AIDS in Africa and the collapse of the Soviet Union in the 1990s contributed to evidence of some divergence in e_0 after 1980, even while convergence in infant mortality continued apace. But viewed over longer periods of time, the picture is much rosier. During a time when life expectancy has grown very rapidly among rich countries, at a rate of about 0.2 year of life each year since 1955 (White, 2002), life expectancy in developing countries has grown even faster. The gap in average life span between the richest and poorest nations has declined from about 35 years in 1950 to 23 years today (Wilson, 2001), accounting for an additional 0.24 year of life each calendar year, or more than a doubling of the rate among advanced countries. In a widely remarked study, Becker, Philipson and Soares (2005) report that accounting for the economic value of gains in life expectancy produces more worldwide convergence in "full income." Viewed this way, global health inequality largely appears to be declining.

But trends in the average length of human life only speak to a single component of overall world inequality in length of life, namely between-country variation. Edwards and Tuljapurkar (2005) reveal that trends in within-country variation in length of life, which they measure with S_{10}, the standard deviation in length of life past age 10 based on period rates, are equally interesting. They show that among advanced countries in the Human Mortality Database (2009), the variance in adult length of life, which had been falling in all countries prior to 1960 but which has been stagnant since, is increasingly responsible for lingering divergence in mortality. Similarly, Wilmoth and Horiuchi (1999) reveal that within-country variation, as measured by an array of measures including the interquartile range (IQR), plateaued after 1950 in Sweden, Japan, and the U.S. Bongaarts (2005) proposes a forecasting model for industrialized countries that effectively shifts out the mean length of life holding the variance fixed (Tuljapurkar and Edwards, 2008). But Cheung et al. (2005) find evidence of increasing compression of the variance around the mode since 1976 in high-quality data from Hong Kong.

What can we say about trends in total world inequality in length of life, and about the within-country component in particular? Data limitations have largely dissuaded earlier researchers from attempting to answer this question directly. An exception is Smits and Monden (2009), who examine trends in life-span inequality in an unbalanced panel of over 200 countries and decompose inequality in a modern cross section, revealing most variation is within-country but remaining largely silent on the trends in the composition. Contemporary mortality statistics in developing countries are rare and often of questionable quality, and historical statistics are even worse. But recent efforts by Lopez et al. (2002) have improved the quality of current estimates, and several papers in historical demography, such as Banister and Hill (2004), can fill in important gaps where previously only model life tables existed. Problems with data quality in developing countries persist, and they must temper our inferences. But there is no particular reason to judge historical estimates of higher moments of the distribution of life span much harsher than estimates of the mean or of infant mortality that are based on the same low-quality data. My strategy will be to examine what these data reveal and check robustness across quality tiers.

In this paper, I examine variation in length of life using a new balanced panel of 180 countries measured around 1970 and in 2000. I find that temporal trends in overall inequality in length of life and in the within and between-country components depend on the subject of interest, namely all or adult mortality, and also on the nature of the inequality measure. Metrics that are invariant over additive change in adult length of life, like S_{10} and the IQR, reveal that world inequality in adult length of life has been stagnant since 1970, owing to offsetting changes in contributions from within-country inequality, which has decreased, and from between-country inequality, which has increased. Metrics that are invariant over proportional change in length of life, like the Theil and Gini indexes, reveal narrowing overall inequality in adult life span because S_{10} has remained the same while e_0 has increased. Demographers traditionally prefer to measure inequality as additive differences in length of life, and there are several theoretical reasons to prefer such a measure.

A rising importance of between-country variation in adult length of life over time bears different implications than the standard finding in the cross section, which is that within-country variation in health is the larger component of global health inequality (Pradhan, Sahn and Younger, 2003; Smits and Monden, 2009). While the latter is still definitely true, and the variance in length of life faced by an individual is indeed large and costly, this new result suggests a new priority for health surveillance and policy. Much progress has been made in reducing infant mortality worldwide, and there are also signs of convergence in adult variance, as is consistent with the demographic and epidemiologic transition. But we may now be increasingly facing a new challenge during an era of considerable socioeconomic uncertainty and new contagious diseases: facilitating the international diffusion of healthy practices and medical technologies that extend average adult life.

Data sources

Appendix Table A-1 lists the 180 countries in the dataset, their World Bank region, the years of coverage, which sometimes differ from 1970 and 2000, and the data sources. Each country-year observation consists of a period life table for both sexes combined. More than 80 percent of the life tables in 2000 come from the World Health Organization Life Table Database (2009), which are based on techniques pioneered by Lopez et al. (2002); the remaining 34 are drawn from the Human Mortality Database (2009). In 1970, the life tables of 102 countries are from sources 1–9, which are all either high-quality or derived from age-specific mortality rates in the World Health Organization Mortality Database (2009). For the remaining 78 countries in 1970, we only have model life tables, mostly of the variety specified by Coale and Demeny (1983).

I matched model life tables to the 1970 period life expectancies at birth, e_0, reported by the United Nations Population Division (2006), using their published assumptions about each country in their Analytical Report. It is unclear why full estimates of these life tables are not included alongside estimates of e_0 in broadly available databases like the UN World Population Prospects or the World Bank's World Development Indicators. They derive from the same low-quality data. While it is important to be circumspect regarding any conclusions based on higher moments of these model life tables, I argue that issues of data quality are not much worse than with e_0 alone, which many researchers have examined.[1]

Asterisks denote observations where I have rescaled the country's life table from around 1970 to match period life expectancy at birth, e_0, for both sexes combined as reported by the United Nations Population Division (2006) for 1970. The rescaling method is effectively one of additive translation of the length of life distribution, recentering life expectancies to official estimates while leaving

[1]One reason e_0 may have less measurement error than the rest of the model life table is because model life tables are sometimes constructed based on infant mortality, which strongly affects e_0, and which is much easier to observe in developing countries. While this is true, adult mortality clearly also affects e_0. Measurement error stemming from unobserved patterns in adult mortality will therefore affect both e_0 and higher moments, although the latter more greatly. My view is that one should neither throw the baby nor the adult out with the bath water, even if the adult has sat in it longer; rather, one should check and be clear about the robustness of results based on incomplete data.

unaffected S_{10} and other inequality measures that are invariant to additive change.[2] It effectively transplants the shape of adult mortality from a different year to 1970. Of the 41 observations that fall into this category, 14 are life tables in 1990 from the World Health Organization Life Table Database (2009), 17 are life tables in the early 1980s from Murray et al. (2003) or from the World Health Organization Mortality Database (2009), and 10 are life tables in the early 1970s constructed using data from the WHO Mortality Database that had indicated a different e_0 than official estimates.

While they are broadly available and increasingly used by researchers, life tables for 2000 from the WHO Life Table Database are not necessarily of uniformly high quality. Inference techniques pioneered by Lopez et al. (2002) and others have produced recent estimates for practically all countries, but they are subject to a considerable amount of error. Here again, my strategy is to examine trends in these data but check for robustness with respect to data quality.

Population totals for each country-year observation are taken from the UN Population Prospects database. When life tables for both sexes combined are unavailable, I construct them from sex-specific life tables weighting by population. Similarly, life table aggregates for regions and for the world as a whole are population-weighted averages of life-table survivorship probabilities.

Inequality measures

Like Edwards and Tuljapurkar (2005), I argue that treating infant and adult mortality separately leads to new insights concerning the nature of inequality. The two are etiologically quite distinct, and we know that patterns of cross-country convergence in infant mortality and e_0 have not always agreed during recent decades (Moser, Shkolnikov and Leon, 2005). Because infant mortality is always fixed in a particular age range, including it in measures of inequality of length of life draws attention away from important trends in the spread of adult life span. In order to isolate trends in adult mortality, I truncate distributions of ages at death at age 10, a relatively arbitrary but perfectly reasonable cutoff also used by Edwards and Tuljapurkar. I also present results for total

[2] I perform the rescaling using one of two equivalent methods based on whether the underlying data include mortality rates or not. When they do, I raise or lower all mortality rates by the same proportion, a process that changes life expectancies but leaves the Gompertz slope and thus the variance in length of life unchanged (Tuljapurkar and Edwards, 2008). When the data only include survivorship, I reduce all ℓ_x above age 0 by the same additive amount, producing an additive vertical, or equivalently an additive horizontal, translation in survivorship.

inequality across the entire age range and reveal how they differ substantially.

My preferred measure of adult life-span inequality is S_{10}, the standard deviation of life-table ages at death above age 10, as introduced and discussed by Edwards and Tuljapurkar. Its unconditional analogue is S_0, the standard deviation at birth. Convenient properties of the standard deviation are that it is measured in years of life and that its square, the variance, is additively decomposable into within and between-group variance respectively:

$$Var[T^w] = E[Var[T_i]] + Var[E[T_i]], \tag{1}$$

where T is length of life, T^w is the world distribution of length of life, and the moments are weighted by the populations of the i countries. For comparability, I also calculate the interquartile range, the preferred measure of Wilmoth and Horiuchi (1999), and a statistic proposed by Vaupel and Canudas-Romo (2003): the average life years lost due to death, $e^\dagger$, which is closely related to the measure of entropy defined by Keyfitz (1985). These measures are all invariant over additive translations in the distribution of human length of life.

I also compute two other widely-used measures of inequality. Shkolnikov, Andreev and Begun (2003) discuss the construction of the Gini coefficient using life-table deaths. I also examine the Theil entropy measure, which Pradhan, Sahn and Younger (2003) use to examine distributions of children's heights and Smits and Monden (2009) prefer in their study of human length of life. Like the standard deviation and variance, the Theil, given for country i by

$$\tau_i = E[\log(E[T_i]/T_i)], \tag{2}$$

is additively decomposable into within and between-country inequality:

$$\tau^w = E[\tau_i] + E[\log(E[T^w]/T_i)]. \tag{3}$$

Both the Gini and the Theil are widely employed in studies of income inequality. In a tradition dating back at least to Lorenz (1905), this literature regards invariance over proportional change in money as a centrally desirable characteristic.

But when the good in question is length of life rather than income, there are several reasons to prefer measures of inequality that are invariant to additive change, like S_{10}. Edwards (2008) discusses this issue in greater detail; here I briefly outline some of the key points. Demographers typically prefer to measure additive inequality in length of life, for example the difference between male and female life expectancy. This is partly due to convention but also because proportional differences in age-specific mortality rates roughly translate into additive change in life expectancy Vaupel and Canudas-Romo (2003). Edwards (2008) also describes how a social welfare perspective suggests that additive differences in length of life are preferable indicators of inequality. At a basic level, there is no reason to view a given level of uncertainty in length of life, say a standard deviation equal to 15 years, as less meaningful or costly if the average length of life happens to be increasing, as a measure like the coefficient of variation would suggest.

To some extent, the choice of proportional versus additive measures of inequality in length of life can be unimportant provided our underlying interpretation is correct. In this regard, it is helpful to remark that proportional inequality is like additive inequality divided by the average. Because average length of human life has increased considerably over time across world regions, we would expect that proportional inequality in length of life must have declined faster than additive inequality. The question is what has happened to additive inequality in length of life.

Results

World length of life

The world distribution of length of life in 1970 and 2000 is depicted graphically in Figure 1. The eye is drawn to the rightward and upward shifts in the distribution around the adult mode, two dynamics that reflect increases in life expectancy. Rightward translation derives from increases in the mean length of life above age 10, M_{10}, which rose from 67.5 in 1970 to 71.3 by 2000. Upward translation could be the result either of a reduction in adult variance, S_{10}, which would increase just the mode, or a reduction in infant mortality, which would effectively redistribute densities equally across all older ages. In fact, S_{10} remained virtually unchanged during the interval, falling only 0.2 year from 17.0 to 16.8, while infant mortality declined considerably. As measured by the density before first birthday, it fell by more than a third to just over 0.04. Gains against infant mortality and in adult life span combined to produce an increase in world life expectancy at birth rose of 8.1

years, from 58.8 in 1970 to 66.9 by 2000, at an average rate of 0.27 year per calendar year.[3] This is faster than the rate of 0.208 reported by White (2002) for 21 OECD countries since 1955 and reflects patterns of global convergence in e_0 (Wilson, 2001; Becker, Philipson and Soares, 2005). But equally remarkable is the stagnation in world S_{10}.

Based on this picture alone, we can draw several inferences about global inequality in human length of life. One is that convergence in infant mortality is a clear source of reductions. The second is that inequality in adult mortality is more complicated. On an absolute basis, adult inequality has hardly changed at all. But because M_{10} has risen, we can posit that relative inequality among adults, which is roughly the ratio of S_{10} to M_{10}, must have fallen.

These points are made more clearly in Table 1, which depicts a variety of statistical characteristics of the full sample in 1970 and 2000 and also of a subsample of countries in the Human Mortality Database (2009) that have high-quality data.[4] The upper half of the table shows that when measured over the entire age range, the average, e_0, is strongly increasing while all measures of inequality are strongly decreasing. This is true of both samples, and it reflects the powerful influence of trends in infant mortality on unconditional moments. A starkly different picture emerges in the bottom half of Table 1, the table, which presents statistics conditional on survival to age 10. While the mean, here M_{10}, is still increasing, trends in inequality depend on the choice of measure and sample. Among all countries, inequality is at best stagnant when measured by any of the three additive measures, the IQR, S_{10}, and $e^{\dagger}$, and declining when measured by the Gini or the Theil. When we restrict our attention to the HMD countries, we find even less evidence of any universal trends at all. Additive measures like S_{10} actually indicate increases in adult inequality while proportional measures show very small declines.

World regions

Differences in mortality convergence between the world as a whole and the subset of high-income countries in the HMD suggest that patterns between world regions may also be interesting. Figure

[3]By comparison, the World Bank's World Development Indicators database lists world e_0 at 59.1 in 1970 and 67.3 in 2000. Statistics in official databases differ slightly because my dataset includes several observations from adjacent years. See the section on data sources and Appendix Table A-1 for details.

[4]As shown in the first several rows, the high-quality HMD subsample is far from representative; those 34 countries represent only around 20 percent of world population but have incomes that are three times higher. They also have higher life expectancy, lower infant mortality, and lower adult variance.

2 depicts two scatterplots that show regional standard deviations in length of life against regional means in each year. Region definitions are based on the level of development and specified by the World Bank. The “High income” group roughly overlaps with the HMD but excludes the emerging market economies in Eastern Europe and Russia and adds several oil producing states and island nations.

The top panel in Figure 2 shows S_0 versus e_0, or the unconditional variance against the unconditional mean. A relatively tight linear relationship emerges, reflecting the strong influence of infant mortality on both e_0 and S_0. All world regions achieved gains in life expectancy and made progress against variance during the period, which appears as movement toward the lower left corner of the panel. Because S_0 declined while e_0 increased, we can also infer that proportional inequality in length of life must also have increased uniformly during this period.

But a different picture emerges in the bottom panel, which plots S_{10} versus M_{10}, the first two moments of the adult life span distribution. Sub-Saharan Africa experienced only a moderate drop in S_{10} paired with a very slight decrease in M_{10}. Europe and Central Asia actually lost ground along both dimensions during the interval. Latin America and the Caribbean gained only in terms of M_{10}, retaining roughly the same level of $S_{10} = 16.8$. Overall, there is less evidence of convergence in adult mortality across world regions, and the linear relationship between S_{10} and M_{10} is weaker than that between S_0 and e_0. Another notable characteristic of the data is that the spread in M_{10} across regions, which is the between-country variation, seems to have increased since 1970. The same is not true of e_0.

Within and between countries

Using equations (1) and (3), I can decompose total variation in world length of life into within and between-country inequality. Table 2 presents four different decompositions for the world and then for the subsample of HMD countries. The top two decompositions are based off of total life-span inequality, while the bottom two examine inequality above age 10. Within each I calculate the Theil and the standard deviation; for the latter, I report components as standard deviations, whose squares are additive.

The main result is that in seven of the eight decompositions depicted in Table 2, the between-country share of inequality has grown since 1970. Although the within-country piece always remains significantly larger, never less than 80 percent of the total, growth in between-country inequality was often very large. This is particularly true in the HMD subsample, which consists of relatively rich countries that had already completed their demographic and epidemiologic transitions by 1970. In the bottom three decompositions, the between-country share of inequality grew by more than 7 percentage points. We would certainly expect these advanced countries to have relatively lower levels of within-country inequality, as they indeed do, and we see some decreases over time in the level of that component depending on the measure. But across all measures, between-country inequality among the HMD countries has increased in terms of both level and share.[5]

In the full sample, growth in between-country inequality is strongest when measured with S_{10}. Although its share of inequality across all ages also increases according to both the Theil and S_0, in each of those cases the level of between-country inequality is actually falling, but not as fast as within-country inequality. Such is also the case with the Theil measured above age 10, which is probably because M_{10} is increasing while S_{10} has remained constant.

For another look at within and between-country sources of variation, we can examine the components of equation (1) graphically. Figure 3 depicts histograms of country S_{10} in the two sample years, which is the within-country component of world S_{10} shown along the bottom of Table 2. The weighted mean of the S_{10}'s fell from 16.6 to 16.0 due to reductions at the high end of the distribution, which was bimodal in 1970. This reflects the lingering but reduced prevalence of high-variance countries in developing regions. Although the mean S_{10} did not decrease by a lot, a case for convergence in within-country inequality seems visually apparent.

By contrast, Figure 4 reveals very different dynamics in the distribution of country M_{10}, the between-country component of total S_{10}. While the weighted mean of the M_{10}'s rose from 67.1 to 71.0, the standard deviation also increased. The left tail had lengthened considerably by 2000, probably due to lost ground among countries heaped at the left side of the distribution in 1970. Visual evidence of convergence is practically nonexistent here; rather, it appears that some countries benefited greatly from increases in adult survivorship while others did not.

[5] Among the 27 countries in the HMD that are also in the High income group defined by the World Bank, the rise in between-country inequality is still present but somewhat smaller than depicted in Table 2.

Discussion

It is clear that the primary motive force behind global convergence in human length of life has been broad-based reductions in infant mortality Moser, Shkolnikov and Leon (2005). Infant mortality strongly affects life expectancy at birth, e_0, and measures of total inequality over length of life alike. To a certain extent, reductions in the variance in adult life span, most notably among developing countries experiencing their demographic transitions, has also contributed to convergence in length of life. But the noteworthy result revealed by this paper is that between-country inequality in adult length of life, or the spread across countries in life expectancy above age 10, has widened since 1970.

The widening of the gap between countries in adult life expectancy has not been large enough to offset the positive influences of declining infant mortality and declining within-country inequality that have led to overall reductions in global inequality in length of life. The basic convergence results of Wilson (2001) and Becker, Philipson and Soares (2005), who primarily examine life expectancy at birth, are still true, as discussed by Edwards (2009). But the widening in between-country inequality in adult life span is a significant cause for concern for two reasons. First, given that reductions in infant mortality are necessarily bounded and must eventually cease, they cannot continue to preserve global convergence without limit. While this might not be a problem if divergent forces were nonexistent, the inverse is unfortunately true. Second, the widening is rather mysterious, with causes that remain unclear. This is particularly problematic for specifying policy implications beyond the need for further research and surveillance.

We know that growth in between-country inequality in length of life has not been attributable to poor performance among developing countries. If anything, patterns of divergence were sharper among countries in the Human Mortality Database (2009), with group S_{10} and other measures actually rising over time. Part of this could in principle reflect the negative effects on health of socioeconomic upheaval in Eastern Europe and the former Soviet Union following the collapse of communism. But I found that restricting the HMD subsample further to only high-income countries did not change the basic result that between-country variation had risen.

Furthermore, if socioeconomic sources were important for the spread in M_{10}, one would expect them also to affect S_{10}, which seems not to have happened. Increased alcoholism, crime, or poverty should lower the mean but also raise the variance. But what we have found, namely reductions in within-country inequality concomitant with increases in between-country inequality, is not consistent with this story.

For the same reasons, the spread of HIV/AIDS in the 1990s also seems like an unlikely culprit. Communicable infectious diseases typically lower the mean and raise the variance within a country. Sixty countries including much of Sub-Saharan Africa, China, and the U.S. are identified by the United Nations Population Division (2006) as hardest-hit by HIV/AIDS. Together they comprise about 60 percent of the world's population. Removing them lowers both the within and between-group inequality components of S_{10} across the remaining 120 countries, and the time trend in the share attributable to between-group inequality becomes negative. But removing countries hard-hit by HIV/AIDS from the HMD subset hardly changes the original results. While HIV/AIDS may be part of the story, it is apparently not the only force driving the rise in between-country inequality.

It would help to characterize the widening gap as one in which either some countries are increasingly lagging behind the pack or others are increasingly leaving the pack behind. Unfortunately, reality may be a mixture of both dynamics. The consistency of results across subsamples certainly suggests this might be the case. If increases in between-country inequality in adult life are due to the uneven diffusion of healthy practices and technology across political boundaries, one could readily imagine a world in which there are leaders, followers, and laggards. At least as regards within-country variation, a recent view in health economics is that knowledge and technology are simultaneously important for gains against mortality and also likely to produce inequality, at least in the short run (Cutler, Deaton and Lleras-Muney, 2006). If such conditions are indeed driving what we are seeing as regards between-country inequality, the clear challenge for policy is to promote the freer exchange and distribution of technology and healthy practices across borders.

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Table 1: Characteristics of the world distribution of length of life in 1970 and 2000

	All countries		**HMD only**	
	1970	**2000**	**1970**	**2000**
Countries	180	180	34	34
Total population in millions	3,712	6,099	966	1,149
GDP per capita in 2000 USD	$4,360	$7,505	$11,808	$22,767
Life expectancy at birth, e_0	58.8	66.9	70.7	75.8
Standard deviation at birth, S_0	27.4	23.5	18.9	17.0
Interquartile range (IQR)	22.4	20.6	18.0	18.5
Avg. years lost due to death, $e^{\dagger}$	20.6	17.7	14.7	13.8
Gini coefficient	0.247	0.180	0.135	0.116
Theil index	0.442	0.242	0.125	0.060
Survivorship to age 10, ℓ_{10}	0.867	0.937	0.972	0.990
Mean length of life above age 10, M_{10}	67.5	71.3	72.7	76.5
Standard deviation above age 10, S_{10}	17.0	16.8	15.1	15.4
IQR above age 10	20.6	20.0	17.8	18.4
Avg. years lost, $e^{\dagger}$, above age 10	14.5	14.3	13.1	13.2
Gini coefficient above age 10	0.137	0.127	0.111	0.108
Theil index above age 10	0.054	0.044	0.029	0.027

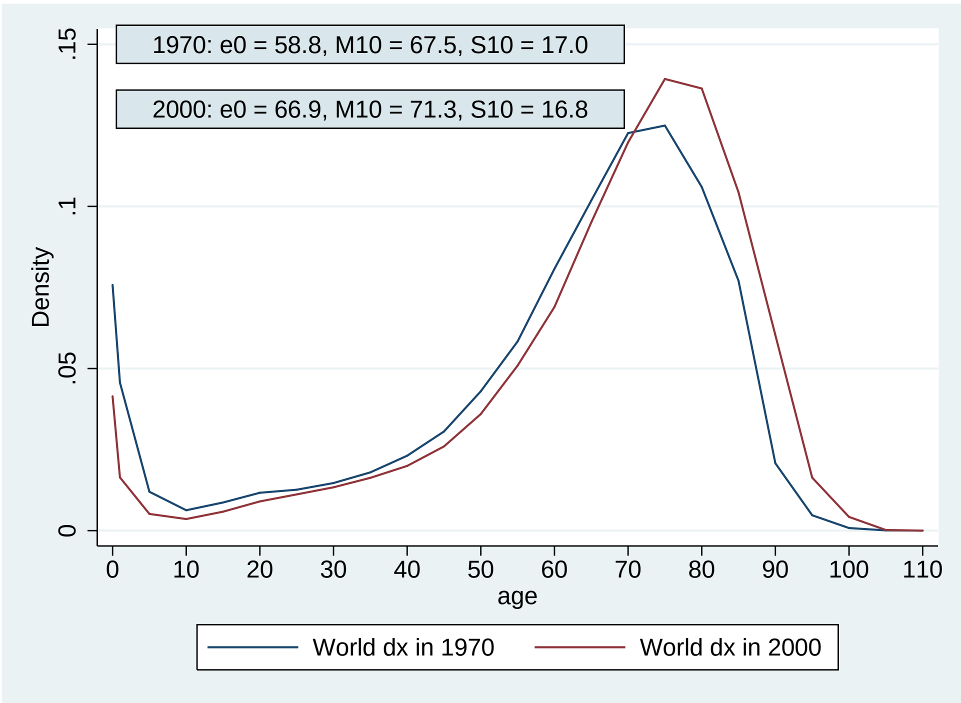
Notes: The source is author's calculations based on the data described in Appendix Table 1. HMD stands for Human Mortality Database (2009), the highest-quality source. Probability densities are the life-table deaths, ${}_nd_x$. Statistics measured above age 10 are calculated conditional on survival to age 10. The mean length of life above age 10, M_{10}, is equal to $e_{10} + 10$. The Gini coefficient is calculated per Shkolnikov, Andreev and Begun (2003). The Theil index is constructed per Pradhan, Sahn and Younger (2003). The interquartile range (IQR) is calculated using cubic splines on the original 5-year life tables taken to tenths of a year. Average life years lost due to death, $e^{\dagger}$, is calculated per Vaupel and Canudas-Romo (2003).

Table 2: Decomposing world variance in length of life in 1970 and 2000

	All countries		**HMD only**	
	1970	**2000**	**1970**	**2000**
Theil index	0.442	0.242	0.125	0.060
Within-country	0.428	0.233	0.125	0.059
Between-country	0.014	0.008	0.000	0.001
Share due to between-country	3.2%	3.3%	0.0%	1.7%
Standard deviation from age 0, S_0	27.4	23.5	18.9	17.0
Within-country	25.7	21.9	18.9	16.4
Between-country	9.5	8.4	1.7	4.8
Share due to between-country	12.0%	12.8%	0.8%	8.0%
Theil index above age 10	0.054	0.044	0.029	0.027
Within-country	0.045	0.037	0.029	0.026
Between-country	0.009	0.007	0.000	0.002
Share due to between-country	16.7%	15.9%	0.0%	7.4%
Standard deviation above age 10, S_{10}	17.0	16.8	15.1	15.4
Within-country	16.6	16.0	15.0	14.8
Between-country	4.6	5.5	1.5	4.5
Share due to between-country	7.3%	10.7%	1.0%	8.5%

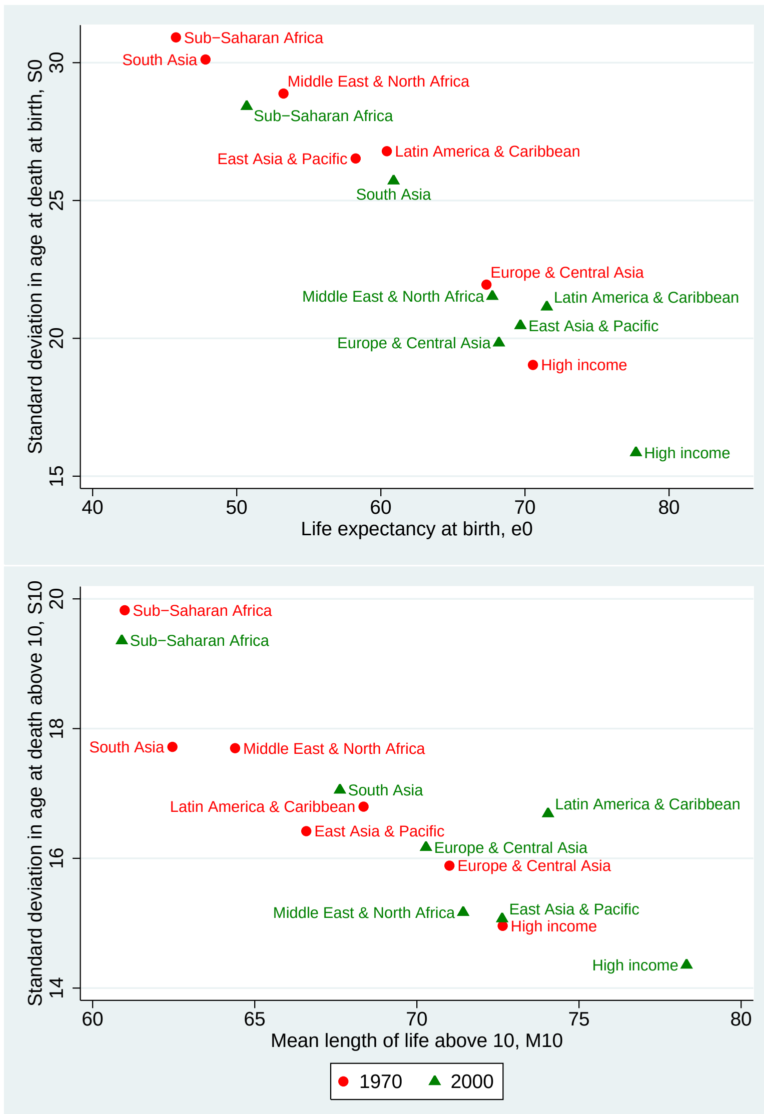
Notes: The source is author's calculations based on the data described in Appendix Table 1. HMD stands for Human Mortality Database (2009), the highest-quality source. Probability densities are the life-table deaths, ${}_nd_x$. Statistics measured above age 10 are calculated conditional on survival to age 10. The Theil index is constructed per Pradhan, Sahn and Younger (2003). The within and between-country components of the standard deviation are the square roots of the components of the variance. The share of the standard deviation attributable to between-country inequality is the analogous share of the variance.

Figure 1: World distributions of length of life in 1970 and 2000



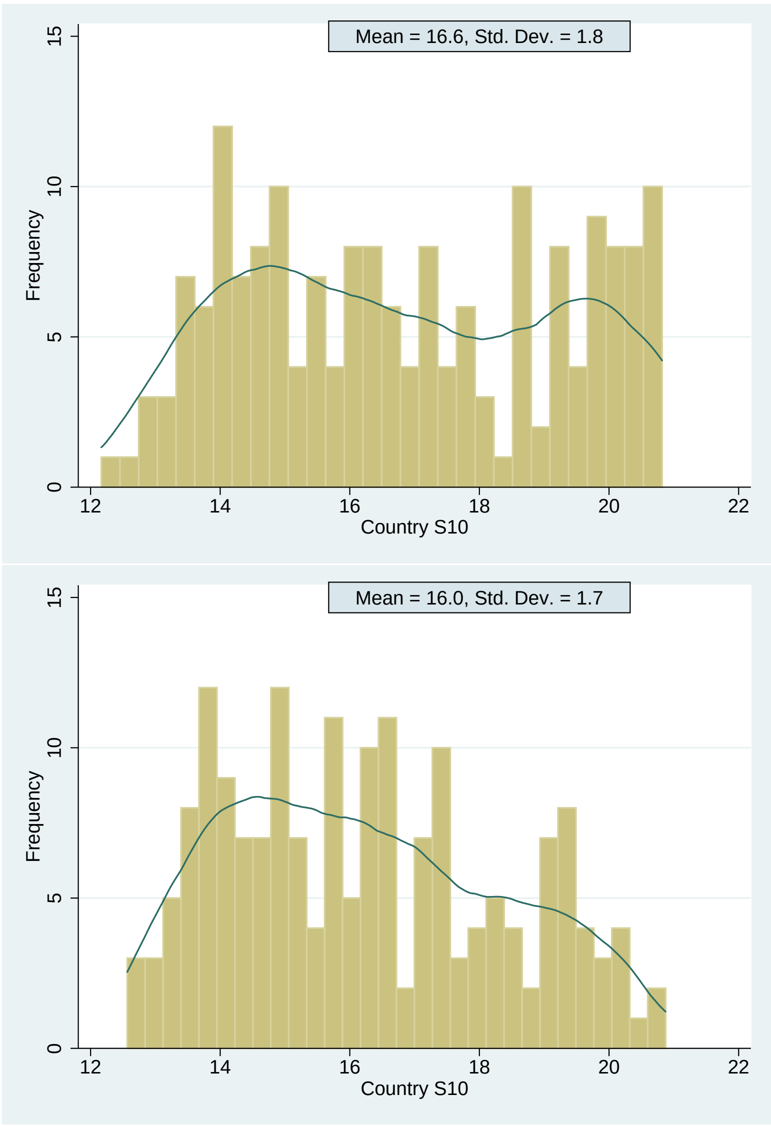
Notes: Individual data are life-table ${}_nd_x$'s for the world population around the year 1970 or in 1999 constructed from country-specific life tables and population totals as described in the text. The lines connect these data up until age 85, after which the author has distributed deaths at 85 and 90 in an ad hoc manner that is meant to be illustrative of the likely shape of the untruncated probability density functions. The countries included in this graph are all that are observed in both time periods, regardless of data quality. Countries with model life tables are included.

Figure 2: Trends across world regions in the mean and standard deviation in length of life since 1970



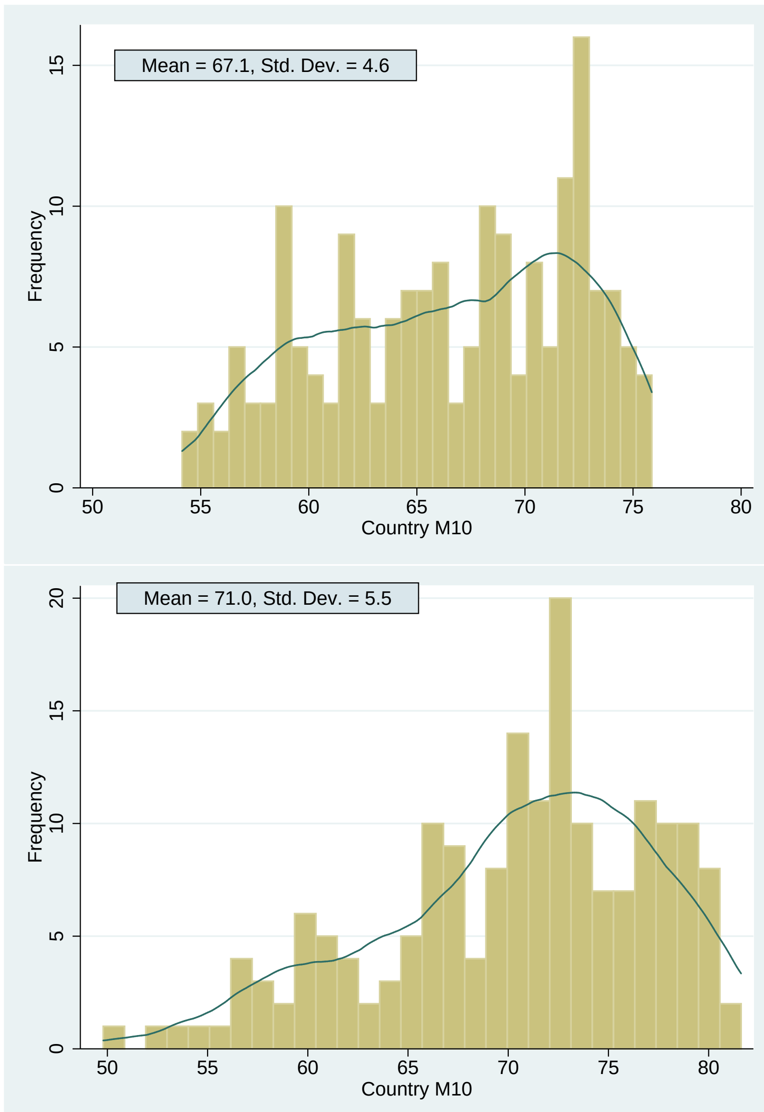
Notes: Data are means and standard deviations of length of life in world regions using life-table ${}_nd_x$'s as weights. Regions are defined on the basis of development and geography by the World Bank. The unconditional standard deviation of length of life at birth is S_0, while the standard deviation above age 10 is S_{10}. The mean length of life above age 10, M_{10}, is equal to $e_{10} + 10$.

Figure 3: Histograms of the standard deviation in length of life above age 10, S_{10}, in 1970 and 2000



Notes: Graphs are histograms of country-level observations of S_{10}, the standard deviation in length of life above age 10. Means and standard deviations of S_{10} are weighted based on population. The lines plot kernel density estimates.

Figure 4: Histograms of the mean length of life above age 10, M_{10}, in 2000



Notes: Graphs are histograms of country-level observations of M_{10}, the average length of life above age 10, which equals $e_{10} + 10$. Means and standard deviations of M_{10} are weighted based on population. The lines plot a kernel density estimates.

Appendix: Data sources

Table A-1: Dataset contents

Country	Code	World Bank Region	Year 1		Source	Year 2	Source
Afghanistan	AFG	South Asia	1970		10	2000	4
Albania	ALB	Europe & Central Asia	1990	*	4	2000	4
Algeria	DZA	Middle East & North Africa	1969-70		9	2000	4
Angola	AGO	Sub-Saharan Africa	1970		10	2000	4
Argentina	ARG	Latin America & Caribbean	1970		2	2000	4
Armenia	ARM	Europe & Central Asia	1981	*	5	2000	4
Australia	AUS	High income	1970		1	2000	1
Austria	AUT	High income	1970		1	2000	1
Azerbaijan	AZE	Europe & Central Asia	1981	*	5	2000	4
Bahamas, The	BHS	High income	1980	*	5	2000	4
Bahrain	BHR	High income	1990	*	4	2000	4
Bangladesh	BGD	South Asia	1970		10	2000	4
Barbados	BRB	High income	1970		10	2000	4
Belarus	BLR	Europe & Central Asia	1970		1	2000	1
Belgium	BEL	High income	1970		1	2000	1
Belize	BLZ	Latin America & Caribbean	1970		11	2000	4
Benin	BEN	Sub-Saharan Africa	1970		10	2000	4
Bhutan	BTN	South Asia	1970		10	2000	4
Bolivia	BOL	Latin America & Caribbean	1970		11	2000	4
Bosnia and Herzegovina	BIH	Europe & Central Asia	1982	*	2	2000	4
Botswana	BWA	Sub-Saharan Africa	1982		10	2000	4
Brazil	BRA	Latin America & Caribbean	1980	*	5	2000	4
Brunei Darussalam	BRN	High income	1990	*	4	2000	4
Bulgaria	BGR	Europe & Central Asia	1970		1	2000	1
Burkina Faso	BFA	Sub-Saharan Africa	1970		10	2000	4
Burundi	BDI	Sub-Saharan Africa	1970		10	2000	4
Cambodia	KHM	East Asia & Pacific	1970		10	2000	4
Cameroon	CMR	Sub-Saharan Africa	1970		10	2000	4
Canada	CAN	High income	1970		1	2000	1
Cape Verde	CPV	Sub-Saharan Africa	1970		10	2000	4
Central African Republic	CAF	Sub-Saharan Africa	1970		10	2000	4

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Table A-1 – continued from previous page

Country	Code	World Bank Region	Year 1		Source	Year 2	Source
Chad	TCD	Sub-Saharan Africa	1970		10	2000	4
Chile	CHL	Latin America & Caribbean	1970		2	2000	4
China	CHN	East Asia & Pacific	1964-82		7	2000	7
Colombia	COL	Latin America & Caribbean	1964		2	2000	4
Comoros	COM	Sub-Saharan Africa	1970		10	2000	4
Congo, Dem. Rep.	ZAR	Sub-Saharan Africa	1970		10	2000	4
Congo, Rep.	COG	Sub-Saharan Africa	1970		10	2000	4
Costa Rica	CRI	Latin America & Caribbean	1970		2	2000	4
Cte d'Ivoire	CIV	Sub-Saharan Africa	1970		10	2000	4
Croatia	HRV	Europe & Central Asia	1982	*	2	2000	4
Cuba	CUB	Latin America & Caribbean	1970		2	2000	4
Cyprus	CYP	High income	1990	*	4	2000	4
Czech Republic	CZE	High income	1970		1	2000	1
Denmark	DNK	High income	1970		1	2000	1
Djibouti	DJI	Middle East & North Africa	1970		10	2000	4
Dominica	DMA	Latin America & Caribbean	1969	*	5	2000	4
Dominican Republic	DOM	Latin America & Caribbean	1970	*	5	2000	4
Ecuador	ECU	Latin America & Caribbean	1970	*	5	2000	4
Egypt, Arab Rep.	EGY	Middle East & North Africa	1970		10	2000	4
El Salvador	SLV	Latin America & Caribbean	1971		2	2000	4
Equatorial Guinea	GNQ	High income	1970		10	2000	4
Eritrea	ERI	Sub-Saharan Africa	1970		11	2000	4
Estonia	EST	High income	1970		1	2000	1
Ethiopia	ETH	Sub-Saharan Africa	1970		10	2000	4
Fiji	FJI	East Asia & Pacific	1970		11	2000	4
Finland	FIN	High income	1970		1	2000	1
France	FRA	High income	1970		1	2000	1
Gabon	GAB	Sub-Saharan Africa	1970		10	2000	4
Gambia, The	GMB	Sub-Saharan Africa	1970		10	2000	4
Georgia	GEO	Europe & Central Asia	1981	*	5	2000	4
Germany	DEU	High income	1970		1	2000	1
Ghana	GHA	Sub-Saharan Africa	1970		10	2000	4
Greece	GRC	High income	1970		2	2000	4

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Table A-1 – continued from previous page

Country	Code	World Bank Region	Year 1		Source	Year 2	Source
Guatemala	GTM	Latin America & Caribbean	1964		2	2000	4
Guinea	GIN	Sub-Saharan Africa	1970		10	2000	4
Guinea-Bissau	GNB	Sub-Saharan Africa	1970		10	2000	4
Guyana	GUY	Latin America & Caribbean	1960		3	2000	4
Haiti	HTI	Latin America & Caribbean	1970-71		6	2000	4
Honduras	HND	Latin America & Caribbean	1974		2	2000	4
Hong Kong, China	HKG	High income	1971		8	2000	8
Hungary	HUN	High income	1970		1	2000	1
Iceland	ISL	High income	1970		1	2000	1
India	IND	South Asia	1971		2	2000	4
Indonesia	IDN	East Asia & Pacific	1970		10	2000	4
Iran, Islamic Rep.	IRN	Middle East & North Africa	1970		10	2000	4
Iraq	IRQ	Middle East & North Africa	1970		10	2000	4
Ireland	IRL	High income	1970		2	2000	4
Israel	ISR	High income	1975		2	2000	4
Italy	ITA	High income	1970		1	2000	1
Jamaica	JAM	Latin America & Caribbean	1981	*	5	2000	4
Japan	JPN	High income	1970		1	2000	1
Jordan	JOR	Middle East & North Africa	1990	*	4	2000	4
Kazakhstan	KAZ	Europe & Central Asia	1981	*	5	2000	4
Kenya	KEN	Sub-Saharan Africa	1970		10	2000	4
Korea, Dem. Rep.	PRK	East Asia & Pacific	1970		11	2000	4
Korea, Rep.	KOR	High income	1973		2	2000	4
Kuwait	KWT	High income	1975		3	2000	4
Kyrgyz Republic	KGZ	Europe & Central Asia	1981	*	5	2000	4
Lao PDR	LAO	East Asia & Pacific	1970		10	2000	4
Latvia	LVA	Europe & Central Asia	1970		1	2000	1
Lebanon	LBN	Middle East & North Africa	1970		10	2000	4
Lesotho	LSO	Sub-Saharan Africa	1970		10	2000	4
Liberia	LBR	Sub-Saharan Africa	1970		10	2000	4
Libya	LBY	Middle East & North Africa	1970		11	2000	4
Lithuania	LTU	Europe & Central Asia	1970		1	2000	1
Luxembourg	LUX	High income	1970		1	2000	1

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Country	Code	World Bank Region	Year 1		Source	Year 2	Source
Macedonia, FYR	MKD	Europe & Central Asia	1982	*	2	2000	4
Madagascar	MDG	Sub-Saharan Africa	1970		10	2000	4
Malawi	MWI	Sub-Saharan Africa	1970		10	2000	4
Malaysia	MYS	East Asia & Pacific	1990	*	4	2000	4
Maldives	MDV	South Asia	1990	*	4	2000	4
Mali	MLI	Sub-Saharan Africa	1970		10	2000	4
Malta	MLT	High income	1970	*	5	2000	4
Mauritania	MRT	Sub-Saharan Africa	1970		10	2000	4
Mauritius	MUS	Sub-Saharan Africa	1970	*	5	2000	4
Mexico	MEX	Latin America & Caribbean	1970		2	2000	4
Micronesia, Fed. Sts.	FSM	East Asia & Pacific	1970		10	2000	4
Moldova	MDA	Europe & Central Asia	1981	*	2	2000	4
Mongolia	MNG	East Asia & Pacific	1990	*	4	2000	4
Morocco	MAR	Middle East & North Africa	1970		10	2000	4
Mozambique	MOZ	Sub-Saharan Africa	1970		10	2000	4
Myanmar	MMR	East Asia & Pacific	1970		11	2000	4
Namibia	NAM	Sub-Saharan Africa	1970		10	2000	4
Nepal	NPL	South Asia	1970		10	2000	4
Netherlands	NLD	High income	1970		1	2000	1
New Zealand	NZL	High income	1970		1	2000	1
Nicaragua	NIC	Latin America & Caribbean	1990	*	4	2000	4
Niger	NER	Sub-Saharan Africa	1970		10	2000	4
Nigeria	NGA	Sub-Saharan Africa	1970		10	2000	4
Norway	NOR	High income	1970		1	2000	1
Oman	OMN	High income	1990	*	4	2000	4
Pakistan	PAK	South Asia	1970		11	2000	4
Panama	PAN	Latin America & Caribbean	1960		2	2000	4
Papua New Guinea	PNG	East Asia & Pacific	1970		11	2000	4
Paraguay	PRY	Latin America & Caribbean	1990	*	4	2000	4
Peru	PER	Latin America & Caribbean	1970		2	2000	4
Philippines	PHL	East Asia & Pacific	1970		2	2000	4
Poland	POL	Europe & Central Asia	1970		1	2000	1
Portugal	PRT	High income	1970		1	2000	1

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Country	Code	World Bank Region	Year 1		Source	Year 2	Source
Puerto Rico	PRI	High income	1970	*	5	2000	5
Qatar	QAT	High income	1990	*	4	2000	4
Romania	ROM	Europe & Central Asia	1970		2	2000	4
Russian Federation	RUS	Europe & Central Asia	1970		1	2000	1
Rwanda	RWA	Sub-Saharan Africa	1990	*	4	2000	4
Samoa	WSM	East Asia & Pacific	1970		11	2000	4
So Tom and Principe	STP	Sub-Saharan Africa	1970		10	2000	4
Saudi Arabia	SAU	High income	1970		10	2000	4
Senegal	SEN	Sub-Saharan Africa	1970		10	2000	4
Serbia and Montenegro	SCG	Europe & Central Asia	1982	*	2	2000	4
Sierra Leone	SLE	Sub-Saharan Africa	1970		10	2000	4
Singapore	SGP	High income	1970		2	2000	4
Slovak Republic	SVK	High income	1970		1	2000	1
Slovenia	SVN	High income	1982	*	2	2000	1
Solomon Islands	SLB	East Asia & Pacific	1970		11	2000	4
Somalia	SOM	Sub-Saharan Africa	1970		10	2000	4
South Africa	ZAF	Sub-Saharan Africa	1960		2	2000	4
Spain	ESP	High income	1970		1	2000	1
Sri Lanka	LKA	South Asia	1970		10	2000	4
St. Lucia	LCA	Latin America & Caribbean	1972	*	5	2000	4
St. Vincent and the Grenadines	VCT	Latin America & Caribbean	1970		10	2000	4
Sudan	SDN	Sub-Saharan Africa	1970		10	2000	4
Suriname	SUR	Latin America & Caribbean	1971	*	5	2000	4
Swaziland	SWZ	Sub-Saharan Africa	1970		10	2000	4
Sweden	SWE	High income	1970		1	2000	1
Switzerland	CHE	High income	1970		1	2000	1
Syrian Arab Republic	SYR	Middle East & North Africa	1970		10	2000	4
Taiwan	TWN	High income	1970		1	2000	1
Tajikistan	TJK	Europe & Central Asia	1981	*	5	2000	4
Tanzania	TZA	Sub-Saharan Africa	1970		10	2000	4
Thailand	THA	East Asia & Pacific	1970		2	2000	4
Togo	TGO	Sub-Saharan Africa	1970		10	2000	4

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Country	Code	World Bank Region	Year 1		Source	Year 2	Source
Tonga	TON	East Asia & Pacific	1970		11	2000	4
Trinidad and Tobago	TTO	High income	1960		3	2000	4
Tunisia	TUN	Middle East & North Africa	1970		10	2000	4
Turkey	TUR	Europe & Central Asia	1970		10	2000	4
Turkmenistan	TKM	Europe & Central Asia	1981	*	5	2000	4
Uganda	UGA	Sub-Saharan Africa	1970		10	2000	4
Ukraine	UKR	Europe & Central Asia	1970		1	2000	1
United Arab Emirates	ARE	High income	1970		10	2000	4
United Kingdom	GBR	High income	1970		1	2000	1
United States	USA	High income	1970		1	2000	1
Uruguay	URY	Latin America & Caribbean	1970	*	5	2000	4
Uzbekistan	UZB	Europe & Central Asia	1981	*	5	2000	4
Vanuatu	VUT	East Asia & Pacific	1970		11	2000	4
Venezuela, RB	VEN	Latin America & Caribbean	1970	*	5	2000	4
Vietnam	VNM	East Asia & Pacific	1990	*	4	2000	4
Yemen, Rep.	YEM	Middle East & North Africa	1970		10	2000	4
Zambia	ZMB	Sub-Saharan Africa	1970		10	2000	4
Zimbabwe	ZWE	Sub-Saharan Africa	1970		10	2000	4

Notes: An asterisk appears to the right of each life table that is rescaled so that it matches period life expectancy at birth for both sexes combined in 1970 as reported by the United Nations Population Division (2006). The variance in adult length of life remains essentially unchanged. See the text for details.

Sources: 1 Human Mortality Database (2009)

2 Murray et al. (2003)

3 United Nations Population Division (1982) UN Life Table Collection

4 World Health Organization Life Table Database (2009)

5 World Health Organization Mortality Database (2009)

6 Allman and May (1979)

7 Banister and Hill (2004)

8 Cheung et al. (2005)

9 Vallin (1975)

10 Coale and Demeny (1983) Model Life Tables

11 United Nations Population Division (1982) UN Model Life Tables