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Global inequality in length of life, 1950–2015

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Abstract: This paper provides a broad picture of national, regional and global trends of inequality in length of life over the period 1950–2015. We use data on life tables from World Population Prospects to develop a comprehensive database of a battery of inequality measures for 201 countries at five-year intervals over the period under analysis. We estimate both absolute and relative inequality measures which have the property of being additively decomposable. This property makes the database remarkably flexible because overall inequality can be computed for any group of countries using only the information included in our database. The decomposition analysis reveals that differences in life expectancy *between* countries account for a very small portion of the observed changes in global inequality in length of life, evolution of which is large driven by *within*-country variation. Our estimates indicate that inequality in length of life has decreased sharply since 1950, a reduction that can be largely attributed to the substantial progress made in reducing child mortality worldwide. We also observe a degree of heterogeneity in the distributional patters of inequality in length of life across world regions.

Keywords: inequality, lifespan, mortality rates, life expectancy
JEL classification: D63, I01, I14

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1 Introduction

The unequal distribution of well-being among the members of societies is an enduring concern that has preoccupied economists and other social scientists for centuries. Although income has been until recent times the main indicator to measure well-being, there is a growing consensus that well-being also covers other dimensions that may be equally relevant (Alkire, 2002). Despite long-standing debates about its measurement, health is regarded as a fundamental aspect of well-being. For instance, the capabilities approach puts emphasis on the functional capabilities of individuals, such as fulfilling a long and healthy life, being educated, and enjoying a decent standard of living, as fundamental factors in enlarging people's freedoms (UNDP, 1990). Under this approach, income becomes just an instrumental factor to achieve more essential goals (Nussbaum and Sen, 1993), among which long life is crucial due to its irreversible nature: poor individuals might rise out of poverty, but there is no turning back from a premature death.

The recognition of long life as a catalystic human dimension for measuring well-being has prompted a renewed interest in the distribution of lifespan indicators, such as life expectancy and mortality rates. Most studies have focused on differences across social groups within societies (e.g. Wilkinson and Marmot, 2003), and those which investigate inequalities in length of life among individuals have generally restricted the analysis to one or, at most, a few countries (Peltzman, 2009; Tranvåg and Norheim, 2013). At the global level, while prior research does point towards considerable convergence in length of life over the last 50 years, such evidence is based, for the most part, on differences in life expectancy levels between countries (Becker et al., 2005; Ram, 2006). Hence, these findings should be treated with great caution because differences in average lifespan characterize only a marginal proportion of world inequality in length of life. Nevertheless, despite differences in lifespan within countries being the main drivers of global inequality, empirical research on within-country variation is surprisingly scarce, and the evidence available relates only to a few years (Smits and Monden, 2009; Edwards, 2011; Strømme and Norheim, 2016).

In this paper, we estimate the evolution of the global distribution of length of life between 1950 and 2015. To do so, we use data on life tables from World Population Prospects (the 2017 revision) to develop a comprehensive database of length of life inequality measures for 201 countries at five-year intervals over the period under analysis.[1] We focus on additively decomposable inequality measures, which allows

[1]Data on life expectancy and inequality measures for all years are available upon request.

us to assess the extent to which disparities are explained by within-country variation and differences in average lifespan between countries. Since between-country variation has been extensively analyzed, additively decomposable measures make our results partially comparable with most of the previous evidence. We provide a detailed analysis of the evolution of inequality in lifespan using both absolute and relative measures, to see whether different concepts of inequality present diverging trends over time. We also disaggregate inequality patterns by sex due to the fact that distributional patterns of length of life have been fairly different across gender. In line with previous analyses (Edwards and Tuljapurkar, 2005; Smits and Monden, 2009; Edwards, 2011), we opt for separating adult and infant mortality because the underlying factors which determine these two phenomena are etiologically different. Therefore, we show the estimates of different inequality measures for both total population and population aged over 15. We also provide some insights into the evolution of disparities in different world regions, which are expected to show fairly different paths.

The remainder of the paper is organized as follows: In Section 2, we review the literature on the estimation of global inequality in length of life. Section 3 presents the empirical strategy, including a discussion on the data, the methods used to construct length of life distributions and the estimators of national, regional and global inequality measures of length of life. In Section 4, we present the results of our analyses, before concluding in Section 5 with a discussion of the implications of our findings.

2 Inequality and length of life

To assess the health performance of countries, life expectancy is one of the most widely used indicators. Its popularity is mainly due to its availability for a large number of countries and the general agreement on the calculation methods, thus ensuring cross-country comparability. Life expectancy is defined as the number of years that an individual born today might live if the current mortality pattens remain. Hence, this indicator summarizes mortality risks at different ages into a single number, making it an intuitive proxy for the health conditions of countries.[2]

[2] Although life expectancy is a good indicator of the health performance of countries, it does not capture non-fatal health conditions and therefore remains a limited indicator to measure health performance. In order to assess the non-fatal dimension of health, indicators such as healthy life expectancy at birth or health-adjusted life expectancy at birth have been developed (see Mathers et al., 2003a; Mathers et al., 2003b). However, such indicators are highly data demanding and

However, life expectancy is just the mean of the distribution of length of life (in other words, the distribution of age at death), and even if a country shows average progress, this does not mean that every member of society is improving her health status. Therefore, our interest should reside not only in life expectancy, but also in the distributional patterns of length of life.

Previous research on health disparities can be categorized into two main types according to the methodology used. The bulk of the empirical work has focused on socioeconomic inequalities, i.e. differences in health status across regions or social groups (Kunst et al., 1998; Kunst et al., 2004; Elo, 2009). The fundamental limitation of this approach is its lack of robustness in the definition of socioeconomic status. Moreover, this kind of analysis is limited in measuring differences in lifespan among individuals of the same status, which, according to some of the existing evidence, might comprise a substantial proportion of overall health inequality (Wagstaff and Doorslaer, 2004). An alternative approach, which overcomes such limitations, focuses on measuring overall lifespan differences across individuals (Gakidou et al., 2000). The central advantage of this approach is that it allows for cross-country comparisons, a feature that, along with the public availability of data on life statistics for a large number of countries, has motivated the analysis of the world distributional patterns of length of life.

Most of the previous attempts to assess global inequality in length of life have focused on population-weighted inequality measures of summary statistics of the distribution, such as life expectancy or infant mortality.[3] This approach evaluates differences in lifespan between countries, but neglects disparities in length of life among the citizens of the countries. However, there is great variability in length of life among the citizens of the same country due to, for instance, genetic determinants and more importantly, the distribution of total resources in the society, especially those related to nutrition, security and health systems (Smits and Monden, 2009).

Although global inequality is only partially addressed using this approach, it is deemed to be useful, since these estimates represent a lower bound on global inequality. The results reported by Goesling and Firebaugh (2004) revealed a sharp

require survey information on several health states. This makes difficult it to publish these figures periodically and, more importantly, raises critical comparability issues between developed and developing countries (Salomon et al., 2013).

[3]Some papers have focused on convergence in life expectancy using non-weighted inequality measures (Mazumdar, 2003; Jordá and Sarabia, 2015), which is known as international inequality across countries. This kind of inequality might be problematic because big countries such as China and India count the same as Luxembourg, and hence it is relevant only for very specific analyses.

reduction of the differences in average lifespan between countries from 1980 to 1995. This result was confirmed by Moser et al. (2005), who found a long-term pattern of convergence in life expectancy from 1955 to the beginning of the 1990s. The study by Bourguignon and Morrisson (2002) also points towards a steady decrease in inequality in life expectancy since 1930 for a smaller sample of countries. From the second half of the 1990s, estimates of between-country variation in length of life present a diverging trend explained by the increase of adult mortality in sub-Saharan Africa (Ram, 2006) and some Eastern European countries (Goesling and Firebaugh, 2004). These observed trends in between-country inequality can be extrapolated to the global level if and only if the evolution of within-country disparities follows the same pattern. A priori, there is no reason to expect that these two components will follow the same trend. Looking at other dimensions of well-being, we observe disparate relations that give us no insight in this regard: for income, within- and between-country inequality presented opposite trends over the 80s and the 90s (Lakner and Milanovic, 2015), whereas for education, these two types of inequality show consonant patterns (Jordá and Alonso, 2017).

The uncertainty regarding the reliability of between-country variation as an indicator of global levels of inequality in length of life underlines the importance of exploring alternative approaches that can help us also consider within-country differences in lifespan. Drawing on more than 9000 life tables, Smits and Monden (2009) evaluated, for the first time, global inequality in length of life. Although overall inequality was decomposed into between- and within-country variation, their estimates referred to the year 2000 only, so no conclusion can be made about the temporal trend of these components. Edwards (2011), instead, presented several inequality measures in 1970 and 2000, thus allowing us to track the evolution of global inequality in lifespan over that period. His results depict a downward trend for the period 1970-2000, which is essentially driven by within-country mortality patterns. Indeed, the two analyses agree that between-country variation represents less than 10 per cent of overall inequality in length of life. Strømme and Norheim (2016) presented the most recent picture on the evolution of global inequality in lifespan, evaluated in 1990, 2000 and 2008. Their results confirm the decreasing trend observed by Edwards (2011) and suggest that this pattern might have continued until 2008.

Previous empirical evidence is based on evaluations of inequality at, at most, three points in time. Even though that is enough to give a rough picture of the evolution of disparities in length of life, it is necessary to analyze data over a longer time horizon to obtain more meaningful insights into these developments. Although the reviewed evidence is congruent across studies, their results are not strictly comparable because they are derived from different data sources. In this study, we aim to overcome the limitations in the existing scholarship on the estimation of the global distribution of length of life by systematically assessing world, regional and national inequality at five-year intervals over the period 1950-2015. We develop a comprehensive database with comparable observations over this period, which casts valuable light on the evolution of mortality patterns, both between and within countries.

3 Data and methodology

3.1 Data

To evaluate the level of inequality in length of life of a particular country in a given year, we need information about the death rate broken down by age and sex. Period life tables contain data on the number of deaths for every 5-year age group up to 95 for a synthetic cohort of 100000 individuals. Period life tables for a certain year are constructed using data on the number of deaths in that particular year. Hence, mortality rates do not refer to the actual mortality patterns of a real birth cohort over its lifetime, but to the current mortality patterns of a country. Due to the large decreases in mortality rates over time due to, for instance, medical advances, a person born today does not face the same probability of dying as a person born in 1900. Since we are interested in providing a snapshot of global inequality trends, we use period life tables to perform the analysis, as they provide an indication of the mortality situation at a particular point in time.

The data have been retrieved from World Population Prospects: The 2017 Revision, developed by the UN Population Division (UN DESA, 2017). Among all the available sources, this database is the most appealing because of its geographical and temporal coverage. Detailed demographic estimates and projections on fertility, mortality and migration are provided for every member state of the UN from 1950 onward. Hence, this publication provides us with a balanced panel of 201 countries from 1950 to 2010 for every 5-year interval.

Although the validity of the projections has been questioned (National Research Council, 2000; Lee, 2011), there is no doubt of the relevance and the utility of these long-term estimates (Wilson, 2001). However, the accuracy of the estimates strongly depends on the extent and the quality of the data used to construct mortality series. For many countries, especially developing ones, estimates provided by World Population Prospects are not constructed using official national data because official demographic statistics are not reported in the detail necessary for the preparation of cohort population projections. In the case of adult mortality, the lack of empirical data on age-specific mortality rates is problematic even for the most recent years. Regarding the period 2010-2015, reliable information was available for only 101 countries, which represented 54 per cent of global population (UN DESA, 2017). For the countries with no data of sufficient quality, the UN Population Division undertakes its estimation by using major surveys, such as the Demographic and Health Surveys or the Multiple-Indicator Cluster Surveys. When more than one source is available, the estimates are generated through expert-based opinion or using automated statistical methods such as local regression or cubic splines with analytical weights.[4]

Even though some data issues still remain and the procedures implemented to obtain the estimates might be debatable, the UN Population Division has managed to produce internally consistent and plausible estimates on fertility, mortality and migration. Series are periodically reevaluated to check their demographic plausibility and, if necessary, adjusted to be congruent over time and across age groups. An additional cross-check is undertaken to ensure the joint consistency of the three series by comparing a simulated birth cohort with the actual one. If there is a significant difference between the projected and the observed cohorts, the series are re-estimated to make them match. Life expectancy and other life statistics provided by the World Health Organization are computed from the same population prospects. Hence, even though we should be cautious when interpreting the results, it should be taken into account that these figures are widely accepted and used to make cross-country comparisons.

3.2 The world distribution of length of life

Let Y be a random variable representing the life time of an individual until death. Consider J realizations of that variable, $y_1, \ldots, y_J$, grouped in K age intervals, $[a_0, a_1], \ldots, [a_{K-1}, a_K]$. Period life tables provide information on the survivals (l_k) of a hypothetical birth cohort of a synthetic population of 100000 individuals. Hence, $l_0 = 100000$ because all newborns survived their birth. Then, dividing these figures by the size of this hypothetical population we obtain the proportion of survivals at the beginning of each interval x_{k-1}, which is known as the survival

[4]See https://esa.un.org/unpd/wpp/DataSources/ for a detailed description of the sources and UN DESA (2017) for the different procedures applied to construct the estimates on adult and child mortality.

function ($s_k = Pr[Y > x_{k-1}]$). The survival function relates to the cumulative distribution function (CDF) as follows:

$$F_k = 1 - s_k = Pr[Y \leq a_{k-1}].$$

The CDF therefore gives the probability of dying aged x_{k-1} or younger. We denote by f_k the proportion of observations in each interval, i.e. the proportion of people who died aged between a_{k-1} and a_k. This proportion essentially measures the mortality rate of the age interval k and can be derived straightforwardly from the CDF by first differencing it:

$$f_k = F_k - F_{k-1}.$$

Hence, mortality rates are points of the probability density function (PDF), which gives the probability of dying at the age interval k.

We can compute the distribution of length of life of any group of countries as a mixture of the national distributions, weighted by their population shares. Let $Y^{(i)}$ be the length of life in the county $i, i = 1, ..., N$, and $f_k^{(i)}$ be the mortality rate of the age group k in the country i. Then, the regional mortality rates are given by:

$$f_k^{(R)} = \sum_{i=1}^{N} \lambda_i f_k^{(i)}, k = 1, \ldots, K, \tag{1}$$

where λ_i stands for the population weights of the countries.

We have used Eq. (1) to compute the global distribution of length of life in four periods: 1950-1955, 1970-1975, 1990-1995 and 2010-2015 (Figure 1). The shape of the distribution of length of life is typically characterized by two peaks due to the two different underlying phenomena driving mortality patterns (see Peltzman, 2009; Edwards and Tuljapurkar, 2005; Edwards, 2011). The distribution presents a spike at the lower tail corresponding to infant mortality. The probability of dying decreases steadily until the age of 15, when the distribution becomes bell-shaped, representing adult mortality patterns.

The evolution of the distribution of length of life shows a sharp decrease in the height of the first peak over the period 1950-2015. The proportion of neonatal deaths, i.e. aged from 0 to 1 years, fell substantially from 0.14 to 0.04. The advances in the reduction of mortality are also observed for the next age intervals with similar growth rates. As a result, the last decades have seen an unprecedented decrease in infant mortality. The progress against mortality is also observed among the adult population. The second mode has moved from 65 to 80 years, thus reflecting great improvements in the distribution of adult mortality. However,

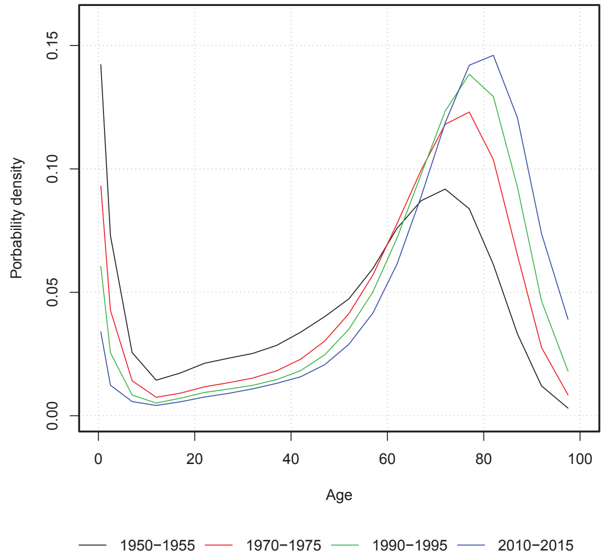


Figure 1: Evolution of the global distribution of length of life: 1950-2015
Source: Authors' calculations based on data from World Population Prospects

this evolution does not necessarily lead to a reduction in disparities in length of life among adults (Duncan et al., 2014). For the whole population, the observed reduction in infant mortality seems to be large enough to offset any potential increase in adult mortality, hence reducing global disparities in length of life.

The differing patterns observed for adult and infant mortality support the fact that the underlining factors behind both processes are etiologically different. The introduction of sanitary practices and the diffusion of effective medicine for pneumonia, diarrhoea and measles has dramatically reduced infant mortality (Liu et al., 2015). These factors have, however, almost no influence on adult mortality trends, which are affected by other kinds of factors, such as the HIV/AIDS spread in developing countries, or vascular diseases and cancer in developed ones (Lozano et al., 2012).

The distributional patterns observed in Figure 1 result from the combination of the mortality experiences of men and women, which have traditionally been affected by different mortality risks. Women's leading causes of mortality are HIV/AIDS, cardiovascular diseases and maternal disorders. The first two causes are also main drivers of men's mortality, although in a much smaller proportion for this group, which is hard-hit by road accidents (Lozano et al., 2012). The

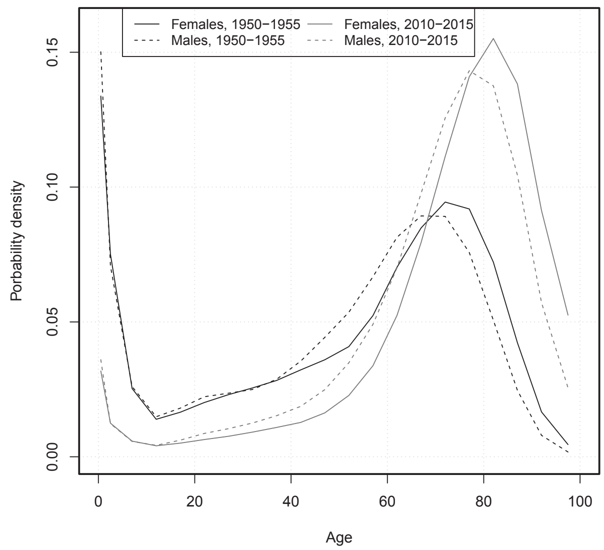


Figure 2: Evolution of the global distribution of length of life by sex
Source: Authors' calculations based on data from World Population Prospects

different factors affecting males' and females' mortality have traditionally led to a large gap in life expectancy between males and females. We expect, therefore, that the distribution of length of life shapes differently across sexes.

Figure 2 shows the evolution of the global distribution of lifespan for men and women in the periods 1950-1955 and 2010-2015. Although child mortality seems to present a similar pattern for both sexes, infant mortality remains higher for boys. There has been, however, a process of convergence in recent times. By contrast, we observe fairly similar distributional patterns for the adult population. Even though in both cases the distribution has shifted rightwards, the mode is in both periods higher for women, which rose from 72 to 82 years between 1950 and 2015. An increase of ten years is observed for men, from 67 years in 1950 to 77 years in 2015, but these are still below the female figures. Besides, the distribution seems to be more concentrated around the mode in the case of women, thus reflecting less variability among this group of the population.

3.3 Inequality measures

A whole range of inequality measures has been proposed to assess the level of disparities. A central consideration in the selection of the indicators is the manner in which differences in lifespan contribute to the level of inequality. In this regard, inequality measures can be classified into relative and absolute measures. To explain the difference between the two types of measures, consider the following example. Assume that we are interested in measuring inequality among just two individuals in each of two countries: in Country A, one citizen lived 5 years and the other 50 years; in Country B, one individual lived 6 years and the other 60 years. Relative inequality measures would show both countries as equally unequal, because the distribution of length of life in Country B can be obtained from Country A just by increasing both ages at death by 20 per cent, so that the relative difference between both individuals in these two countries equals to 1/10. By contrast, absolute measures would rank Country B as more unequal, since the absolute difference in lifespan between the two citizens is 54 years, whereas in Country A it is 45 years. Therefore, the choice between absolute and relative inequality is not neutral and might affect not only the levels, but also the trends in health inequality.

There is an open debate about which of the two approaches is more appropriate to evaluate disparities in health (Anand et al., 2001). Relative indicators seem to be an appealing choice for income variables, but for bounded variables, such as length of life, absolute changes might be the better alternative to measure health inequality (Atkinson, 2014). Therefore, demographers often prefer absolute measures, among which variance and standard deviation are the most widely used (Edwards, 2011; Edwards and Tuljapurkar, 2005).

For life tables, which present data in grouped form in K age intervals, the variance can be expressed as follows:

$$Var(Y) = \sum_{k=1}^{K} (y_k - \bar{y})^2 f_k,$$

where y_k is the average age of the age group $k, k = 1, ..., K,$ f_k is the dead rate of the age group k and $\bar{y}$ is life expectancy at birth. At global and regional levels, this measure can be easily decomposed by using the Law of Total Variance, whereby $Y_i, i = 1, ..., N$ denotes the length of life in county i. The variance can be decomposed by its within- and between-country inequality component as follows:

$$Var(Y) = \sum_{i=1}^{N} \lambda_i Var(Y_i) + \sum_{i=1}^{N} (\bar{y}_i)^2 \lambda_i - \bar{y}^2, \tag{2}$$

where λ_i stands for the population weights of the countries, $\bar{y}_i$ is the life expectancy of the country i and $\bar{y}$ denotes the regional life expectancy.

The decomposition of the variance is quite intuitive. The within-country component is given by the average of the variances of the countries weighted by their population size, whereas the between-country variance is the variance of the life expectancy of the countries.

Among the relative measures, the popularity of the the Gini index has spread to health variables (Shkolnikov et al., 2003; Smits and Monden, 2009; Edwards, 2011). Therefore, we also report estimates for this inequality measure, which can be computed as follows:

$$G(Y) = \frac{1}{2\bar{y}} \sum_{k=1}^{K} \sum_{j=1}^{K} |y_k - y_j| f_k f_j.$$

However, the Gini index is not additively decomposable in within- and between-country inequality. Moreover, this index is sensitive to the middle of the distribution, and it does not allow us to change the weight given to differences in specific parts of the distribution. Inequality measures can point to different results depending on their sensitivity to different parts of the distribution. For this reason, we compute an alternative set of inequality measures belonging to the Generalized Entropy (GE) family. This includes a sensitivity parameter (θ), which determines the importance given to the differences in length of life among the oldest. The mean log deviation (MLD) corresponds to the GE index when the parameter is set to 0, which is more sensitive to infant mortality. The Theil's entropy measure is equally sensitive to all parts of the distribution, being characterized by a parameter value equal to 1. We also compute the GE measure when the sensitivity parameter is set equal to 2, which is half the square of the coefficient of variation, to analyze the evolution of lifespan inequality when more importance is given to the differences in length of life among the oldest population.

The general expression of the GE measure is given by

$$GE(Y;\theta) = \frac{1}{\theta(\theta-1)} \left(\sum_{k=1}^{K} f_k \left(\frac{y_k}{\bar{y}} \right)^{\theta} - 1 \right), \theta \neq 0, 1, \tag{3}$$

where, for $\theta = 1$, we have the following limiting case:

$$T(Y) = \sum_{k=1}^{K} f_k \frac{y_k}{\bar{y}} \log \left(\frac{y_k}{\bar{y}} \right)$$

and for $\theta = 0$, the index tends to

$$L(Y) = \sum_{k=1}^{K} f_k \log \left(\frac{\bar{y}}{y_k} \right).$$

Global inequality estimates of the GE measures can also be derived by taking advantage of the decomposition of this family:

$$GE(Y;\theta) = \sum_{i=1}^{N} \lambda_i^{1-\theta} s_i^{\theta} I_i^{(\theta)} + \frac{1}{\theta(\theta-1)} \left(\sum_{i=1}^{N} \lambda_i \left(\frac{\bar{y}_i}{\bar{y}} \right)^{\theta} - 1 \right), \tag{4}$$

where the first component measures within-country inequality and the second one between-country inequality. λ_i is the population share and the GE measure of the country i, s_i stands for the proportion of mean income of country i in the national mean: $s_i = \frac{\lambda_i \mu_i}{\mu} = \frac{\lambda_i \mu_i}{\sum_{i=1}^{N} \lambda_i \mu_i}$ and I_i is the GE inequality measure of country i.

The special cases given by the Theil and the MLD can be decomposed as follows:

$$T_Y = \sum_{i=1}^{N} s_i T_i; T_B = \sum_{i=1}^{N} s_i log \left(\frac{\bar{y}_i}{\bar{y}} \right),$$

$$L_Y = \sum_{i=1}^{N} \lambda_i L_i; L_B = \sum_{i=1}^{N} \lambda_i log \left(\frac{\bar{y}}{\bar{y}_i} \right),$$

where T_i and L_i are, respectively, the Theil index and the MDL of country i.

We compute all of these measures at national level, for different groups of countries based on a geographic and an economic criterion, and for the whole world over the period 1950-2015. We use the national estimates to construct a database with a battery of inequality measures of length of life. The consideration of additively decomposable measures makes the database extremely useful, because overall inequality can be easily computed for any combination of countries. Such flexibility would not be achieved if we had focused solely on the Gini index, which involves, in addition to the between-country and the within-country components, an overlapping term that is specific to the particular group of countries under consideration.

4 Results

4.1 Global inequality in length of life

In this section, we present an analysis of the evolution of global inequality in length of life from 1950 to 2015. The estimates are computed from a sample of 201 countries for which there are available data on mortality patterns over the study period. Because of the different underlying causes of child and adult mortality, we first present inequality trends including the whole population, and then compare these with the evolution of inequalities of the population aged over 15. The choice of the age threshold for adult mortality might seem arbitrary. Our decision is driven by comparability issues, but also supported by the empirical evidence. First of all, Smits and Monden (2009) presented global inequality estimates for the population aged over 15, so this choice enables us to identify common patterns between the two analyses. More importantly though, we observe in Figure 1 that the first spike of the global distribution of length of life seems to end at the age of 15, when we observe a turning point, marking the beginning of the bell-shaped part of the distribution.

Table 1 presents the decomposition of global inequality in length of life over the period 1950-2015, while in Tables A1 and A2 in Appendix B we provide a more detailed decomposition by gender. To begin the discussion, we focus on the first row of Table 1, which summarizes the evolution of life expectancy for the whole population. Our estimates suggest that, on average, individuals across the globe live more years (die at older ages) with every passing decade. In 1950, the life expectancy was 49 years; by 2015, the expected lifespan had risen to 70.5 years, an increase of 44 per cent. To quantify the reduction in inequality, Table 1 also presents the variance, as an absolute measure of inequality, the Gini index and different GE measures that (i) are more sensitive to child mortality (the MLD, $\theta = 0$), (ii) give more importance to older mortality ($\theta = 2$) or (iii) weight equally all parts of the distribution (the Theil index, $\theta = 1$). Our estimates reveal a substantial decrease in global inequality since 1950, a result that seems to confirm the downward trends presented in previous studies (Edwards, 2011; Bourguignon and Morrisson, 2002).[5] Absolute inequality, measured by the variance, shows a decrease of 52 per cent since 1950. Relative inequality reports larger reductions for all of the measures presented in this analysis. The Gini index is the relative index with the lowest rate of decrease (about 57 per cent) going from 0.335 in 1950 to 0.144 in 2015. Generalized entropy measures present similar reductions, around 77 per cent. The levels, however, vary substantially across measures. The MLD decreased from 0.671 in 1950 to 0.162 in 2015, whereas the Theil index fell from 0.257 to 0.062, and finally the GE2 declined from 0.181 to 0.042.

We exploit the property of decomposability by population subgroups of the GE measures and the variance to break down overall inequality into differences in life expectancy between countries and disparities in length of life within countries. In line with previous studies, our estimates reveal that the within-country variation has played a predominant role in global inequality, while differences be-

[5] It is worth noting that in Edwards (2011) the Theil index refers to the GE measures with $\theta = 0$, which is defined as the MLD in this study.

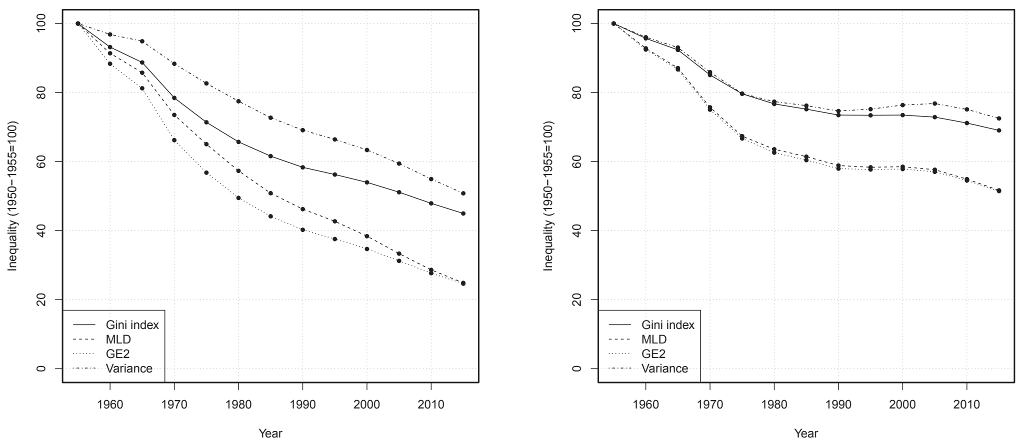
Table 1: Decomposition of global inequality in length of life - total population

	1950-1955	1960-1965	1970-1975	1980-1985	1990-1995	2000-2005	2010-2015
Life expectancy	49.088	53.043	59.216	62.987	65.270	67.705	70.486
Gini index	0.335	0.297	0.236	0.201	0.183	0.166	0.144
Theil index	0.257	0.215	0.154	0.118	0.100	0.081	0.062
Between	0.031	0.027	0.014	0.010	0.009	0.008	0.006
Within	0.226	0.188	0.139	0.108	0.091	0.073	0.056
MLD	0.671	0.578	0.434	0.337	0.283	0.221	0.162
Between	0.031	0.027	0.015	0.011	0.009	0.009	0.006
Within	0.640	0.551	0.419	0.326	0.274	0.212	0.156
GE2	0.181	0.148	0.102	0.078	0.066	0.055	0.042
Between	0.032	0.027	0.014	0.010	0.009	0.008	0.006
Within	0.149	0.121	0.088	0.068	0.057	0.047	0.037
Variance	928.601	883.335	759.807	660.628	601.241	533.909	445.938
Between	162.531	162.276	105.097	85.795	78.411	78.159	58.050
Within	766.070	721.058	654.711	574.833	522.830	455.750	387.888

Source: Authors' calculations based on data from World Population Prospects

tween countries have had a lesser role. Interestingly, the value of between-country inequality does not seem to vary substantially across GE measures. The share of this component in overall inequality has remained roughly constant over the last 65 years for the Theil and the MLD, whereas for the GE2 and the variance, its proportion fell from 17 per cent in 1950 to 12 per cent in 2015. The relatively small contribution of between-country inequality to global disparities in lifespan suggests that previous studies on the evolution of international inequality in life expectancy, while providing a lower bound on global inequality, addressed only a marginal proportion of global disparities.

To offer a clearer picture of the inequality patterns of length of life, the left panel of Figure 3 presents the evolution of the variance, the Gini index, the MLD and the GE2 measure since 1950. Our estimates point to a downward trend of disparities, with relative measures presenting larger rates of decrease than absolute indices in all years. The difference in growth rates is especially prominent for the case of the GE2 measure. Since the GE2 gives more importance to differences in lifespan among the oldest, this pattern might suggest that inequality at the top of the distribution might have been reduced notably or, conversely, that child mortality plays a major role in the evolution of inequality. Indeed, previous studies



Total population   Population aged over 15

Figure 3: Evolution of global inequality in length of life (1950-1955=100)
Source: Authors' calculations based on data from World Population Prospects

claimed that child mortality was one of the main factors of inequality reduction in lifespan [Seligman et al., 2016].

To investigate this point, we present the evolution of the previous inequality measures for the population aged over 15 in the right panel of Figure 3. The most striking feature of this graph is the stagnation of inequality from 1980 to 2000, which confirms that the trend in global inequality in lifespan was mainly driven by child mortality. In the case of absolute measures, adult inequality in length of life presents an ascending trend from 1985 to 2000. Another interesting pattern comes out from the comparison of the two GE measures, which show almost identical trends once child mortality is neglected. This result implies that the differences in trends observed for the whole population were due to child mortality rather than to differences in lifespan among the oldest.

To further investigate the effect of child mortality on global length of life inequality, Table 2 presents relative and absolute inequality measures of the global distribution of lifespan for the population aged over 15. Life expectancy for the adult population is obviously higher than for the whole population, but the effect is especially prominent during the first three decades (with differences in life expectancy of 12 years), becoming weaker during the 80s and the 90s due to the progress achieved in the reduction of child mortality. By the end the last decade, the difference in life expectancy at birth and life expectancy at 15 years is about 3 years. As we previously discussed, removing the child population has had a uni-

Table 2: Decomposition of global inequality in length of life - total population aged over 15

	1950-1955	1960-1965	1970-1975	1980-1985	1990-1995	2000-2005	2010-2015
Life expectancy	62.331	64.572	68.141	69.999	71.147	72.336	73.988
Gini index	0.165	0.153	0.132	0.124	0.121	0.120	0.114
Theil index	0.049	0.043	0.033	0.030	0.029	0.028	0.026
Between	0.006	0.005	0.002	0.002	0.002	0.003	0.002
Within	0.043	0.038	0.031	0.028	0.027	0.026	0.023
MLD	0.059	0.052	0.040	0.036	0.035	0.034	0.031
Between	0.006	0.005	0.002	0.002	0.002	0.003	0.002
Within	0.053	0.047	0.038	0.035	0.033	0.031	0.029
GE2	0.044	0.038	0.029	0.027	0.025	0.025	0.023
Between	0.006	0.005	0.002	0.002	0.002	0.003	0.002
Within	0.038	0.033	0.027	0.025	0.023	0.022	0.021
Variance	341.011	317.297	271.813	259.892	256.404	261.968	247.303
Between	46.536	41.119	18.249	17.831	19.190	27.499	22.443
Within	294.475	276.178	253.565	242.062	237.215	234.469	224.860

Source: Authors' calculations based on data from World Population Prospects

versal consequence of reducing length of life inequality. However, the size of this effect varies depending on the inequality measure considered. Suppressing the child population has reduced the variance by about 63 per cent. For relative measures of inequality, we observe that the higher the weight given to the bottom tail, the greater the effect of removing the child population. As expected, the MLD presents the largest reduction in inequality (91 per cent), followed by the Theil index (80 per cent) and the GE2 (75 per cent). The Gini index, as explained above, is more sensitive to the middle of the distribution, so the progress in child mortality has a less prominent effect on this inequality measure, although it is still substantial, with a reduction of 50 per cent. As regards the decomposition of inequality, both between- and within-country inequality have been reduced. The rate of decrease seems to be larger for the case of within-country inequality, and hence the share of between-country inequality has increased.

Table 3 summarizes the main trends related to life expectancy and inequality for the population aged 15 years and over by sex. In 1950 males lived an average of 47.3 years and females 50.9 years; by 2015 the average had increased to 68.5 years for men and 72.6 years for women. These estimates reflect not only an upward trend in life expectancy, but also that the female average lifespan has increased relative to that of males during the last decades, leading to a gender divergence in absolute terms. However, the rate of increase is higher for males (44.8 per cent) than for females (42.6 per cent). These estimates indicate that, although there is still a significant gender gap in life expectancy, males are catching up with females in relative terms, which eventually, and if the growth rates keep constant, will reduce the gender gap.

As has been widely reported in the literature, there is a high negative correlation between life expectancy and length of life inequality, a correlation that is also observed using relative inequality measures. Lower levels of inequality are observed for women, who also live more years than men on average. However, using absolute measures such a relationship does not hold, since the variance of lifespan is lower for men than for women along the entire period except the last decade. Decomposable measures reveal another interesting pattern. Although overall relative inequality is lower for women, differences in life expectancy between countries seem to be higher. This pattern is counterbalanced by within-country inequality, which is substantially lower in the case of women.

4.2 Regional length of life inequality

Thus far, we have analyzed the global distribution of length of life, which is the result of a variety of mortality experiences in different countries. For the sake of space, we do not examine the differences in lifespan in each country. We focus instead on regional inequality, while providing a generic picture, reveal important geographic patterns. To define the regions, we have followed the criteria of the UN Population Division, which classifies countries of the world into seven regions: Africa, Asia, Europe, Latin America and the Caribbean, Northern America and Oceania. Some of these regions are heterogeneous in terms of mortality rates. Hence, we disaggregate Africa into Northern Africa and sub-Saharan Africa; Asia into Western Asia, South Asia, and Central and East Asia, whereas Eastern European countries are grouped separately from other european countries located to the West and South of the continent.[6]

Table 4 summarizes the main trends related to life expectancy and inequality in length of life for the ten regions. Although there seem to be some differences across regions, our estimates suggest that, on average, length of life is longer in

[6]See `https://esa.un.org/unpd/wpp/General/Files/Definition_of_Regions.pdf` and Appendix A for more details on the regional classification of the countries.

Table 3: Decomposition of global inequality in length of life broken down by sex

Year	1950-1955		1980-1985		2010-2015	
	Male	Female	Male	Female	Male	Female
Life expectancy	47.339	50.934	60.842	65.258	68.470	72.613
Gini index	0.348	0.332	0.217	0.200	0.160	0.144
Theil index	0.272	0.254	0.129	0.118	0.070	0.061
Between	0.026	0.031	0.008	0.010	0.005	0.006
Within	0.246	0.223	0.121	0.107	0.065	0.056
MLD	0.709	0.665	0.364	0.334	0.179	0.162
Between	0.026	0.031	0.009	0.011	0.005	0.006
Within	0.683	0.634	0.355	0.324	0.174	0.156
GE2	0.194	0.179	0.086	0.077	0.049	0.042
Between	0.027	0.032	0.008	0.010	0.005	0.006
Within	0.167	0.147	0.078	0.067	0.044	0.037
Variance	867.764	927.252	639.808	658.006	459.275	445.805
Between	120.549	163.720	58.743	86.328	45.802	58.602
Within	747.215	763.532	581.065	571.679	413.472	387.203

Note: Data computed for the beginning of each five-year period.

Source: Authors' calculations based on data from World Population Prospects

2015 than in 1950 in all cases. In Eastern Europe the progress has been rather slow, resulting in a limited increase in life expectancy of 19 per cent, rising from 60 years in 1950 to 71 years in 2015. This improvement, however, was achieved during the periods 1950-1960 and 2000-2015, whereas between 1960 and 2000, the average lifespan remained fairly constant. So, while Eastern Europe was among the regions with the highest life expectancy in 1950, the moderate advances during the subsequent 65 years positioned it as one of the territories where individuals live, on average, fewer years. Latin America and the Caribbean, in contrast, was characterized by a relatively low life expectancy of 51 years in 1950, but an increase of 44 per cent to 74 years as of 2015 defines this region as one of the best-performing in terms of average lifespan.

Table 4: Decomposition of regional inequality in length of life

Year	1950-1955					1980-1985					2010-2015				
Region	LE	Theil	% within	Variance	% within	LE	Theil	% within	Variance	% within	LE	Theil	% within	Variance	% within
Eastern Europe	60.003	0.159	99.61%	753.650	99.41%	68.246	0.058	99.60%	389.109	99.45%	71.483	0.038	97.82%	312.116	97.27%
Europe	66.272	0.089	98.72%	510.036	98.10%	73.645	0.035	99.43%	282.166	99.24%	80.441	0.019	98.81%	202.457	98.57%
Northern America	68.125	0.064	100.00%	416.151	100.00%	73.897	0.037	99.96%	311.674	99.94%	78.589	0.027	99.77%	263.362	99.71%
Latin America	51.499	0.243	97.37%	892.325	96.19%	64.734	0.107	97.84%	601.693	96.83%	74.087	0.051	98.78%	406.780	98.34%
Oceania	63.273	0.107	80.21%	586.336	74.88%	70.359	0.058	89.11%	410.740	85.58%	76.689	0.040	85.64%	341.742	81.18%
Southern Asia	36.646	0.411	99.73%	865.256	99.66%	54.368	0.208	99.72%	832.535	99.61%	67.355	0.084	99.37%	511.938	99.05%
Central and Eastern Asia	46.040	0.275	96.66%	839.155	95.08%	66.484	0.088	97.68%	514.993	96.54%	73.855	0.039	96.32%	304.886	94.95%
Western Asia	44.936	0.344	94.32%	999.654	91.60%	62.231	0.135	97.65%	698.663	96.46%	72.108	0.052	96.61%	375.140	95.23%
Northern Africa	42.147	0.409	99.67%	1076.116	99.55%	59.402	0.166	99.41%	772.160	99.12%	70.287	0.062	97.60%	418.018	96.56%
sub-Saharan Africa	36.319	0.428	97.95%	894.050	97.38%	48.398	0.269	97.54%	904.677	96.49%	57.256	0.157	98.00%	727.968	97.17%

Note: Data computed for the middle of each five-year period.

Source: Authors' calculations based on data from World Population Prospects

As regards the African regions, Northern Africa has seen a steady increase in life expectancy, which rose by 67 per cent, from 42 years in 1950 to 70 years in 2015. Sub-Saharan Africa has also achieved notable improvements in life expectancy, although not as large. In 1950, the average lifespan was only 36 years; by 2015, individuals of the region lived on average 57 years, which means an increase of 58 per cent. Interestingly, sub-Saharan Africa and Southern Asia presented similar levels of life expectancy in 1950, but the latter's remarkable economic performance over the past four decades, largely driven by China, has increased the length of life, on average, to 67 years. The other two Asian regions have both seen an increase of 60 per cent. As regards the two industrialized regions, Europe (West and South) has improved, on average, more than Northern America (21 per cent and 14 per cent, respectively). As a result, people living in Europe are now expected to live more years than people living in Northern America, a relationship that has reversed since 1950.

Turning our attention now to inequality, we observe a decrease in disparities in all regions for both relative and absolute measures. In 1950, the two African regions presented the highest level of relative inequality, with both Theil indices taken as reference points. In 2015, sub-Saharan Africa was still the region with the largest disparities, reporting a Theil index of 0.157, while Northern Africa had seen major reductions in length of life inequality. Interestingly, Eastern European countries present a substantial decrease in inequality, with the Theil index falling from 0.159 in 1950 to 0.038 in 2015. This result contrasts with the evolution of life expectancy, which barely improved during the period under study. Hence, it seems that the substantial reductions in inequality observed in this region might be the result of two factors: first, a substantial progress in reducing child mortality, which would increase life expectancy, while decreasing inequality; and second, an increase in the probability of dying among the elderly, which would offset the former effect on life expectancy, while contributing to a decline in inequality of length of life.

Comparing the previous figures of relative inequality with the picture provided by the variance, a measure of absolute inequality, we find some contrasting results. Our estimates show that Northern Africa and Western Asia were the regions with the highest levels of absolute inequality in 1950, presenting variances in the range of 1000-1100. Hence, sub-Saharan Africa is not the region with greatest disparities if we evaluate them in absolute terms. Latin America and the Caribbean, Southern Asia and Central and Eastern Asia show similar levels of absolute inequality to sub-Saharan Africa. As observed for the Theil index, the more developed regions are the ones with lowest levels of disparities in lifespan.

We have also decomposed regional inequality in the differences in life expectancy between countries and the disparities in lifespan within the countries. The pattern dominance of the within-country component observed at the global level is even more patent at the regional level. In 1950, within-country variation represented over 95 per cent of the Theil index, except in Oceania, where this proportion was as low as 80 per cent. Disparities within the countries are also the main driver of the regional absolute inequality, although its weight is slightly lower than for the relative measures. The proportion of within-country inequality has been rather constant over the period under study in five regions: Europe, Northern America, Central and Eastern Asia, Southern Asia and sub-Saharan Africa. In Eastern Europe and Northern Africa, the weight of this component has declined since 1950, whereas in Latin America and the Caribbean, Western Asia and Oceania it has increased.

To provide a more detailed picture of the trends of absolute and relative inequality in the ten regions, Figure 4 shows the evolution of the Theil index and the variance for both total and adult population. The Theil index for the whole population shows a steady decrease over the whole period in all regions except Eastern Europe, where inequality remains constant from 1975 to 2000. During that period, adult inequality of length of life in this region increased, suggesting that the stagnation phase is driven by the offsetting effect of child mortality reduction. Adult inequality in length of life also increased in sub-Saharan Africa during the 1990s mainly due to the rapid expansion of the HIV/AIDS pandemic (Becker et al., 2005), although in this case the decrease in child mortality counterbalanced the upward trend in adult disparities. Hence, length of life inequality for the whole population steadily decreased over the period 1950-2015.

The highest rates of decrease in relative inequality, over 80 per cent, are observed in Central and Eastern Asia, Western Asia and Northern Africa, driven by a large decline in both adult and child mortality. Although Southern Asia shows similar growth rates of adult inequality in length of life as the other two Asian regions, the Theil index of the whole population presents lower rates of decrease than its neighbouring regions. This result suggests that this region has achieved less progress in child mortality. Indeed, before 1980, the rates of decrease of inequality in lifespan among adults were higher than those observed for the whole population, suggesting that the decline in length of life inequality was mainly due to the progress achieved among the population aged 15 and over. The progress in reducing adult mortality decelerated in the next decades and infant and child mortality became key to understanding the reduction in lifespan inequalities in

Southern Asia.

Northern America and Oceania show the lowest, although still substantial, rates of decrease of lifespan inequality. The downward trend, which resulted in a decrease in disparities of about 60 per cent, seems to be the result of the progress in both child and adult mortality in these regions. The poorer performance of these regions might be partially explained by the nature of the inequality measure itself, which has a lower bound at zero. This boundary makes it more difficult to achieve substantial progress in reducing disparities in those regions with already low levels of inequality. Moreover, improvements in mortality are more easily accomplished in developing countries, where the level of mortality is very high. The introduction of vaccines and antibiotics, imported from advanced nations in the 1950s, played a key role in the decline of mortality rates in developing countries (Deaton, 2004). However, mortality decline in rich countries depended on advances in knowledge and technology, especially in relation to noncommunicable diseases such as cancer, diabetes and cardiovascular diseases, for which new treatments require a long time to develop. There might also be other factors behind the reduction of mortality in developed countries which explain why, although Europe presented similar levels of relative inequality in 1950 as other developed regions, its inequality level decreased by 80 per cent over the period of study. In this regard, universal health coverage may be crucial because it generally leads to improved population health (Moreno-Serra and Smith, 2012), thus reducing the risk of a premature death.

Moving now to the evolution of the variance (bottom panels of Figure 4), for most regions our estimates show analogous trends to those observed for relative inequality, although with a less pronounced slope. Therefore, absolute inequality measures are characterized by smaller rates of decrease than relative indices. The rationale behind this finding is that an improvement of a given size in child mortality (say all children increase their length of life by one year) contributes more to the reduction of relative inequality than if such progress took place among the adult population. For absolute measures, on the other hand, both changes would have the same impact. As illustrated in the top panels of Figure 4, the decline in relative inequality is mainly due to improvements in child mortality, which would also promote the reduction of absolute inequality, although its impact would be comparatively less pronounced.

Two regions present quite different evolutions of relative and absolute inequality in length of life: Southern Asia and sub-Saharan Africa. The variance of lifespan in Southern Asia remains roughly constant from 1950 to 1980 because similar improvements have been achieved among the adult and child populations, resulting

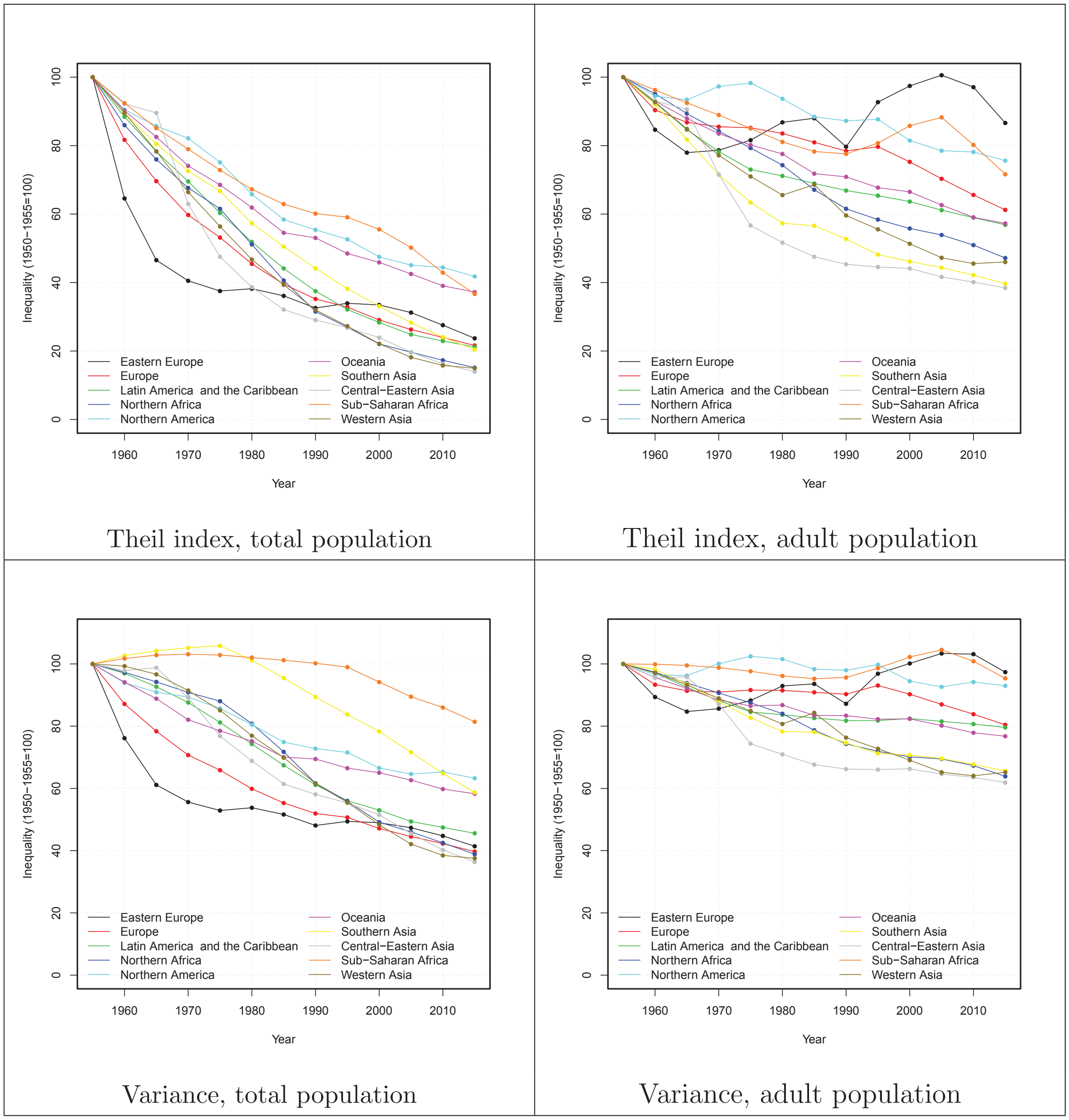


Figure 4: Evolution of regional inequality in length of life (1950-1955=100)
Source: Authors' calculations based on data from World Population Prospects

in no change in absolute inequality levels. In the case of sub-Saharan Africa, absolute inequality in length of life barely changes from 1950 to 1995, but this trend then becomes negative due to large improvements in child mortality promoted by the efforts to achieve progress towards the fourth Millenium Development Goal (Kinney et al., 2010).

5 Discussion and conclusions

To date, research on distributional issues of health has focused on the assessment of differences among social groups, an approach that is inherently sensitive to the subjective definition of socioeconomic status and, more importantly, neglects a vast proportion of inter-personal inequality. Despite the relevance of developing health inequality indicators which allow for cross-country comparisons (Gakidou et al., 2010), few studies provide a comprehensive analysis over a relatively long period. In this paper, we have analyzed the evolution of the global distribution of length of life over the period 1950-2015, thus providing a battery of inequality measures for virtually all countries in the world.

Using both absolute and relative inequality measures, our estimates indicate that there has been a substantial reduction in disparities in length of life. In line with previous studies, we find that there has also been an important increase in life expectancy. On average, world life expectancy increased by almost 43 per cent over the study period, whereas inequality shows rates of decrease between 60 and 80 per cent depending on the measure used to assess inequality levels. The decomposition analysis reveals that within-country variation represents over 90 per cent of global inequality in lifespan. Hence, the world distributional patterns of length of life are largely driven by the evolution of within-country disparities.

Due to the considerable weight of within-country variation on global inequality in length of life, we now turn our attention to the potential causes of its evolution. The fundamental factor behind the decrease of global inequality is the notable achievements in reducing infant mortality. The combating of diseases with cheap and easy-to-administer treatment, such as antibiotics and oral rehydration, has been fundamental in understanding this decrease. Indeed, the reduction in deaths by measles, pneumonia and diarrhoea is a major driving force behind the observed decrease in length of life inequality (Liu et al., 2012). Deaths due to HIV/AIDS and malaria have also decreased, but at slower rate because anti-retroviral drugs are not widely available in developing countries, and also because constraints in the accessibility and utilization of insecticide-impregnated bednets remain in countries where malaria is endemic. Progress in women's education seems to be another crucial factor in reducing child mortality because better education among girls and women in reproductive age facilitates the implementation of policies and practices that lead to advances in children's health and wellbeing (Cutler et al., 2006; Gakidou et al., 2010).

Among adults, within-country disparities in length of life are frequently associated with the existence of a socioeconomic gradient, along which citizens with higher income and education are better off in terms of health. There is plenty of evidence related to the differences in health across socioeconomic groups which suggests that the relation between income and health might be bi-directional. High income levels enable individuals to acquire good health care services, nutritive food and good quality clothing (Cutler et al., 2006). But for the poor, low income also means that they often cannot afford health care and a balanced diet. This phenomenon is prevalent especially in developing countries, but also among disadvantaged groups in developed countries. Cheap food is one of the central risk factors of obesity in the US, which makes poor individuals more likely to experience ill health (Cutler et al., 2003). In the absence of welfare institutions and well functioning insurance markets, poor health also leads to lower income, which is an even more plausible explanation of the correlation between these two dimensions (Adams et al., 2003). Education is another strong predictor of good health. Educated individuals tend to excersise more frequently, have healthier eating and drinking habits, are less likely to smoke and are more likely to use preventive health care.

Although differences in life expectancy between countries represent a marginal share of global inequality in length of life, it is relevant to mention the possible causes of its evolution. Our results suggest that, although inequality between countries has decreased over the study period (1950-2015), there was a period of divergence from 1980 to 2005. Several advances against mortality were introduced in developing countries after World War II, including antibiotics, vaccines and water supply improvements (Cutler et al., 2006), which led to considerable increases in life expectancy in those countries, thus favouring the process of convergence observed from 1950 to 1980.

The divergence phase, from 1980 to 2005, suggests that some countries were achieving greater progress in the expansion of life expectancy than others; reversals in mortality were even observed (Edwards, 2011; Moser et al., 2005). Our estimates show that virtually all the countries which experienced a decrease in life expectancy over the divergence period were African or Eastern European. The recurrent waves of violence associated with the social and economic upheaval in Eastern European countries at the end of the 1980s might be one of the central factors behind the reversal in mortality, along with cardiovascular diseases and the high levels of alcoholism in many of those countries (Timonin et al., 2016). The rapid spread of HIV/AIDS at the beginning of the 1980s might also be a key driver of the observed divergence in life expectancy across countries. Antiretroviral treatments were developed and introduced in industrial countries during the first half of the 1990s, but it was not until the early 2000s that the governments of Southern African countries implemented public health programmes to distribute antiretroviral therapy for HIV/AIDS (Bor et al., 2013).

Although length of life inequality is an essential dimension of health inequality, there are other relevant aspects that we have not covered in this study. First, the results that we present face the potential limitation of overlooking non-fatal events. Vos et al. 2015 and Murray et al. 2015 have emphasized the need to include morbidity indicators and construct composite measures such as disability-adjusted life years and healthy life expectancy, which would permit international comparisons, including both epidemiological and mortality patterns. Unfortunately, sufficiently detailed epidemiological data are not available to develop broader health inequality measures.

A second concern is that measuring inequality in length of life captures both *fair* and *unfair* types of inequality. Fleurbaey and Schokkaert (2009) assert that our interest should be in unfair inequalities, i.e. those driven by causal variables that do not belong to individuals' decisions. According to this approach, we should not consider the premature death by lung cancer of smokers because it was a direct consequence of their own unhealthy behaviour. Health equality would therefore be accomplished by providing all individuals with the same opportunities to enjoy good health. This approach requires us to distinguish between having the opportunity to achieve good health and the achievement of good health itself. Even if we agreed with the underlying propositions of this theory, there are no detailed cause-specific data to deploy this kind of analysis. This might not be a major limitation because, as asserted by Sen (2002), the achievement of health tends to be a good proxy for the underlying possibilities.

Finally, the measurement of health differences through inequality of length of life confronts us with a levelling-down objection. Consider, for instance that the central objective of a health policy is to reduce health inequality. In that case, it would be legitimate to allocate all health-care resources to preventing and treating diseases that can lead to premature dead, while letting old people die, because that strategy would equalize the distribution of length of life. To avoid arriving to this kind of unethical conclusion, we should distinguish between health inequality and health equity (Braveman and Gruskin, 2003). Health inequality is just one aspect of health inequity, which also involves judgements about the how resources are distributed and other social agreements that lead to particular cases of health inequality. However, health inequity cannot be evaluated without monitoring health inequality, and hence its analysis is essential to understand the broader concept of health inequity (Sen, 2002).

In sum, this study offers a comprehensive picture of national, regional and global trends of inequality in length of life, which shows various distributional patterns behind the observed decrease in world inequality. In addition, we develop a database that might be useful in identifying the causes of these trends and, more importantly, in providing guidance about potential areas of intervention. Although there are still issues to address in order to improve the measurement of health inequality, the analysis of the distribution of lifespan allows us to ascertain its evolution in the long run, which is a fundamental step towards a better understanding of health differences within and between nations.

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Appendices

Appendix A: Regional classification of countries

Central-Eastern Asia

Brunei Darussalam, Cambodia, China, China Hong Kong SAR, China Macao SAR, Dem. People's Republic of Korea, Indonesia, Japan, Kazakhstan, Kyrgyzstan, Lao People's Democratic Republic, Macao SAR, Malaysia, Mongolia, Myanmar, Philippines, Republic of Korea, Singapore, Tajikistan, Thailand, Timor-Leste, Turkmenistan, Uzbekistan., Viet Nam.

Eastern Europe

Belarus, Bulgaria, Czech Republic, Hungary, Poland, Romania.

Europe

Albania, Austria, Belgium, Bosnia and Herzegovina, Channel Islands, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, Norway, Portugal, Serbia, Slovenia, Spain, Sweden, Switzerland, TFYR Macedonia, United Kingdom.

Latin America and the Caribbean

Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, United States Virgin Islands, Uruguay, Venezuela (Bolivarian Republic of).

Northern Africa

Algeria, Libya, Morocco, Sudan, Tunisia, Western Sahara.

Northern America

Canada, United States of America.

Oceania

Australia, Fiji, French Polynesia, Guam, Kiribati, Micronesia (Fed. States of), New Caledonia, New Zealand, Papua New Guinea, Tonga, Samoa, Solomon Islands, Vanuatu.

Southern Asia

Afghanistan, Bangladesh, Bhutan, India, Iran (Islamic Republic of), Maldives, Nepal, Pakistan, Sri Lanka.

Sub-Saharan Africa

Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Mozambique, Namibia, Niger, Nigeria, Réunion, Rwanda, São Tomé and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.

Western Asia

Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, State of Palestine, Syrian Arab Republic, Turkey, United Arab Emirates, Yemen.

Appendix B: Gender decompositions

Table B1: Decomposition of global inequality in length of life - male population aged over 15

	1950 1955	1965 1970	1980 1985	1990 1995	2000 2005	2005 2010	2010 2015
Gini index	0.166	0.154	0.134	0.128	0.126	0.125	0.119
Theil index	0.049	0.043	0.034	0.032	0.030	0.030	0.028
Between	0.005	0.004	0.001	0.002	0.002	0.003	0.002
Within	0.044	0.039	0.032	0.030	0.029	0.027	0.026
MLD	0.059	0.052	0.040	0.038	0.036	0.036	0.033
Between	0.005	0.004	0.001	0.002	0.002	0.003	0.002
Within	0.054	0.048	0.039	0.036	0.035	0.033	0.031
GE2	0.044	0.038	0.030	0.028	0.027	0.027	0.024
Between	0.005	0.004	0.001	0.002	0.002	0.002	0.002
Within	0.039	0.034	0.029	0.026	0.025	0.024	0.022
Variance	325.690	302.329	262.790	257.077	255.478	263.319	253.459
Between	36.914	30.892	12.217	15.553	16.111	24.690	20.340
Within	288.776	271.437	250.573	241.524	239.366	238.629	233.119

Source: Authors' calculations based on data from World Population Prospects

Table B2: Decomposition of global inequality in length of life - female population aged over 15

	1950 - 1955	1960 - 1965	1970 - 1975	1980 - 1985	1990 - 1995	2000 - 2005	2010 - 2015
Gini index	0.162	0.149	0.127	0.117	0.114	0.113	0.106
Theil index	0.049	0.042	0.032	0.027	0.026	0.026	0.023
Between	0.007	0.006	0.003	0.002	0.002	0.003	0.002
Within	0.042	0.036	0.029	0.025	0.024	0.023	0.020
MLD	0.059	0.051	0.038	0.033	0.032	0.031	0.027
Between	0.007	0.006	0.003	0.002	0.002	0.003	0.002
Within	0.052	0.045	0.035	0.031	0.029	0.028	0.025
GE2	0.043	0.037	0.028	0.024	0.023	0.023	0.020
Between	0.007	0.006	0.003	0.002	0.002	0.003	0.002
Within	0.036	0.031	0.025	0.022	0.020	0.020	0.018
Variance	351.656	325.718	272.192	250.938	245.790	250.317	231.311
Between	57.360	53.312	27.873	23.854	25.311	33.241	26.664
Within	294.296	272.405	244.320	227.084	220.479	217.076	204.646

Source: Authors' calculations based on data from World Population Prospects