Demography (2018) 55:2045–2070
https://doi.org/10.1007/s13524-018-0718-z

Longevity and Lifespan Variation by Educational Attainment in Spain: 1960–2015

Iñaki Permanyer[1] · Jeroen Spijker[1] · Amand Blanes[1] · Elisenda Renteria[1]

Published online: 15 October 2018

Abstract
For a long time, studies of socioeconomic gradients in health have limited their attention to between-group comparisons. Yet, ignoring the differences that might exist within groups and focusing on group-specific life expectancy levels and trends alone, one might arrive at overly simplistic conclusions. Using data from the Spanish Encuesta Sociodemográfica and recently released mortality files by the Spanish Statistical Office (INE), this is the first study to simultaneously document (1) the gradient in life expectancy by educational attainment groups, and (2) the inequality in age-at-death distributions within and across those groups for the period between 1960 and 2015 in Spain. Our findings suggest that life expectancy has been increasing for all education groups but particularly among the highly educated. We observe diverging trends in life expectancy, with the differences between the low- and highly educated becoming increasingly large, particularly among men. Concomitantly with increasing disparities across groups, length-of-life inequality has decreased for the population as a whole and for most education groups, and the contribution of the between-group component of inequality to overall inequality has been extremely small. Even if between-group inequality has increased over time, its contribution has been too small to have sizable effects on overall inequality. In addition, our results suggest that education expansion and declining within-group variability might have been the main drivers of overall lifespan inequality reductions. Nevertheless, the diverging trends in longevity and lifespan inequality across education groups represent an important phenomenon whose underlying causes and potential implications should be investigated in detail.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s13524-018-0718-z) contains supplementary material, which is available to authorized users.

✉ Iñaki Permanyer
inaki.permanyer@uab.es

[1] Centre d'Estudis Demogràfics, Carrer de Ca n'Altayó, Edifici E-2, Campus de la UAB, 08193 Cerdanyola del Vallès, Spain

Keywords Life expectancy · Lifespan variation · Educational disparities in mortality · Gender disparities · Spain

Introduction

During the last decade or so, the study of individuals' lifespan variability has attracted a great deal of attention from demographers and other social scientists interested in studying inequalities in human populations. Living a long and healthy life is among the most highly valued and universal human goals. The existence of very unequal length-of-life distributions might therefore go beyond purely natural causes and could be indicative of an unfair state of affairs in which some population groups might be disadvantaged or discriminated against.

One of the key socioeconomic factors that can generate lifespan differences across and within groups is educational attainment. In the countries with available data, low-educated individuals tend to live shorter lives than their highly educated counterparts (Kitagawa and Hauser 1973; Mackenbach et al. 2003; Murtin et al. 2017), and the former can expect greater uncertainty in their age at death than the latter (Edwards and Tuljapurkar 2005; Sasson 2016b; Van Raalte et al. 2012). In this study, we extend previous research to discuss health differences across educational attainment groups in Spain from the 1960s to the present day. In doing so, we document not only the life expectancy differences across educational groups but also the inequality that might exist across the entire age-at-death distribution. Extending our attention beyond life expectancy—a "central longevity indicator," according to Cheung et al. (2005)—to embrace lifespan variation indicators can give a much more nuanced understanding of the health distribution across individuals, its evolution over time, and the underlying mechanisms behind it.

The interest in lifespan variability was boosted by the release of the World Health Report in 2000 (WHO 2000). The authors of that report suggested that it was necessary to go beyond the traditional comparison of group-based measures (e.g., comparing group-specific life expectancies) by quantifying the variation of health over all *individuals* in a population. They argued that by shifting the focus from groups to individuals, it would be possible to look at differences not only between predefined social groups but also within these groups. Because both approaches are interesting in their own right and because neither is clearly superior to the other, we aim in the present study to integrate them into a coherent whole by considering between-group differences as one component of total between-individual variation in a population.

Taking advantage of recently released mortality data by educational attainment from the Spanish National Institute of Statistics (INE, in its Spanish acronym) and reconstructing life tables for the 1960s, 1970s, and 1980s using the Spanish Sociodemographic Survey (Encuesta Sociodemográfica, henceforth ESD), this is the first study to document trends in life expectancy *and* lifespan variation by educational attainment in Spain during the last 50 years. Given the relative scarcity of countries and years for which individual mortality records can be broken down by educational attainment—mainly Western Europe and U.S. studies based on data since the mid-1990s, including Hendi (2017), Majer et al. (2011), Murtin et al. (2017), Sasson (2016b), and Van Raalte et al. (2012))—this study adds to the aforementioned ones in two respects. First, previous studies have barely included southern European countries in the analysis of lifespan variation by educational attainment.[1] Second, no previous research has analyzed trends in lifespan differences for such a long period.

Since the 1960s, Spain has undergone major socioeconomic, demographic, political, and cultural transformations. These transformations are reflected in the dramatic changes of the population structure during this period. Educational expansion has completely reversed the distribution that existed in the 1960s (i.e., from a large majority of individuals with no formal education and a small and highly selected minority of college-educated individuals to an overwhelming majority of the population with at least secondary school education). Furthermore, impressive longevity gains—in a few decades, Spain has escalated many positions in the international longevity rankings—have benefitted the entire population, but some groups have benefitted more. To gauge the effect that such structural changes have had on lifespan variability across and within education groups, we ran several counterfactual analyses. Our findings suggest that despite incipient divergences in life expectancy trends across education groups (with highly educated groups improving faster than the rest), overall lifespan inequality has decreased not only for Spain as a whole but also within most educational attainment groups. In addition, results indicate that declines in overall lifespan inequality are mainly driven by educational expansion and declining within-group variability rather than by generalized increases in longevity.

Adult Mortality by Educational Attainment

Differences in Longevity

The positive association between education and adult health and survival is well established: the least educated have, on average, worse health and a lower life expectancy, and the highest-educated have better health and the highest life expectancy (Davey Smith et al. 1994; KC and Lentzner 2010; Ross and Wu 1995). This association is, however, considered indirect through more specific (direct) determinants of disease. For instance, higher-educated individuals are (via their higher income) more able to afford food, clothing, and accommodation; have jobs that entail fewer health risks; are more engaged in healthy lifestyles; and are better informed about using health services and new medical treatments (Davey Smith et al. 1998; Hummer and Lariscy 2011; Kunst 1997; Pincus and Callahan 1994; Winkleby et al. 1992). All this implies that a rise in the educational level of a population is likely to favorably influence future mortality trends (Spijker 2004). In addition, using educational attainment as an indicator of socioeconomic status (SES) has several major advantages over others, such as employment status and income. Educational attainment remains constant after adulthood is reached, is usually available for all individuals and not only the economically active (important when studying women; Huisman et al. 2005a; Mackenbach et al. 2008; Smith 2004), tends to be more accurately reported than income or wealth, and is also less susceptible to missing data (Hummer and Lariscy 2011).

[1] One exception is the study by Majer et al. (2011), which included Spain. The countries Van Raalte et al. (2012) analyzed are Sweden, Norway, Finland, Belgium, Switzerland, France, Slovenia, the Czech Republic, Poland, Estonia, and Lithuania. Italy is the only southern European country Murtin et al. (2017) analyzed.

One of the general findings in the majority of studies on socioeconomic inequality in mortality in Europe and the United States is that relative differences have increased since the 1970s despite a general decreasing level of mortality (Duleep 1989; Elo and Preston 1996; Feldman et al. 1989; Kunst et al. 2004; Mackenbach et al. 2016; Marmot and McDowall 1986; Molla et al. 2004; Pappas et al. 1993; Rogot et al. 1992). This tendency goes against initial expectations, especially considering the move toward universal access to health systems in most industrialized countries (Davey Smith et al. 1990; Marmot and Shipley 1996; Marmot et al. 2012). This rise in inequality is sharper among adult men; among women, differences are much lower in the majority of studies.

Studies on socioeconomic differences in mortality in Spain have long struggled with the lack of death registry data linked to individual information at the national level. Researchers have overcome this challenge by conducting (small area) ecological studies (Borrell and Arias 1995; Borrell et al. 1997, 2010; Esnaola et al. 2006; Regidor et al. 1995) and by performing linkage studies in local areas, such as Barcelona, Madrid, and the Basque country (Borrell et al. 1999; Huisman et al. 2004, 2005a; Mackenbach et al. 2008; Puigpinós et al. 2009). More recently, based on the 2001 census, Reques et al. (2014) conducted a nationally representative follow-up study on individuals aged 25 and older during seven years and estimated mortality rates by education. Their results confirmed those from the earlier mentioned studies showing smaller educational mortality differences in Spain than in other countries in northern Europe.

Differences in Length-of-Life Inequality

As noted earlier, researchers have long focused their attention on the study of life expectancy gradients across socially salient groups (e.g., educational attainment groups). Yet, the debate sparked by the release of the World Health Report 2000 (WHO 2000) about whether lifespan inequality should be measured over groups or individuals gradually shifted scholars' attention toward the latter. In the last few years, the interest of demographers and other social scientists in the study of lifespan variability has grown spectacularly (e.g., Edwards 2013; Edwards and Tuljapurkar 2005; Engelman et al. 2010; Gillespie et al. 2014; Muszyńska and Janssen 2016; Nau and Firebaugh 2012; Sasson 2016b; Seligman et al. 2016; Smits and Monden 2009; Timonin et al. 2016; Van Raalte and Caswell 2013; Van Raalte et al. 2014; Vaupel et al. 2011; Wilmoth and Horiuchi 1999).

When investigating the extent of lifespan inequality across individuals, researchers are naturally interested in partitioning the population they are studying across socially relevant groups. The key idea is to investigate whether those groups—which can be defined along geographic, socioeconomic, religious, ethnic, labor-related, or other lines—are relevant when explaining the variability of length of life across the entire population. The paucity of additional information typically available in mortality records has hindered the possibility of generating length-of-life distributions across those groups. Yet, in recent times, a growing number of studies have linked mortality records to census data or administrative files. These studies include those by Van Raalte et al. (2014) on lifespan variation according to social class in Finland and Zarulli et al. (2012) on lifespan variation for educational categories in Sweden and Finland. Van Raalte et al. (2012) and Murtin et al. (2017) reported analogous results for, respectively, 11 and 23 high-income countries, although these studies also included countries with unlinked data. Other notable studies on lifespan inequality include those by Shkolnikov et al. (2003) on lifespan inequality by educational attainment in 1979 and in 1989 in Russia; Edwards and Tuljapurkar (2005), who did the same for income categories in the United States; and Brown et al. (2012), who used data from the U.S. Health and Retirement Study and the National Health Interview Survey Linked Mortality File to investigate mortality compression within educational groups. Using unlinked mortality records from the U.S. National Vital Statistics System, Sasson (2016b) reported analogous results for the U.S. during the period 1990–2010. Our study is the first to analyze length-of-life inequality by educational attainment in Spain for a period spanning more than 50 years.

Why Lifespan Variation Matters

Studying variations in age at death is important both for theoretical and practical reasons. From a theoretical perspective, the study of lifespan inequality is fundamental for a proper understanding of the present and future dynamics in human mortality. In an attempt to explain how social inequalities in mortality might evolve over time, numerous theories have been proposed (see Mackenbach 2012). The *mortality compression scenario* Fries (1980) suggested expects lifespan variation to decline as life expectancy approaches the biological limit of the human species. In light of empirical evidence against it, other scholars have advanced alternative scenarios, such as the *mortality translation model*, whereby life expectancy increases but lifespan variation stagnates (Bongaarts 2005; Bongaarts and Feeney 2003; Canudas-Romo 2008). Depending on whether these models are followed by subnational socioeconomic groups will determine whether, and to what extent, social inequalities in health are reproduced in the near future.

From a practical perspective, even if group differences in life expectancy constitute the primary and most commonly reported form of lifespan inequality, they do not explain the whole story because they fail to explain variations *within* groups. From a policy point of view, larger lifespan inequality might be indicative of a worsening state of affairs across or within socially relevant groups—a cause of legitimate ethical concern, especially when the social patterning in health is attributable to preventable causes. Several studies have demonstrated that looking at differences in group life expectancies alone (i.e., disregarding within-group inequalities) can lead to the elaboration of unfair or misinformed policies. For instance, based on longevity indicators alone, policy-makers would not be able to anticipate and act on the increasing health heterogeneity among oldest individuals already being observed in aging societies (Engelman et al. 2010). Analogously, Brønnum-Hansen (2017) proved that if the pension threshold age is moved uniformly for the entire population in Denmark, a disproportionately high number of individuals belonging to economically disadvantaged groups (which have larger lifespan variability) will die before attaining it, thus resulting in an unfair policy to address the problems of population aging, a problem that is likely to affect most advanced economies.

Data and Methods

Data

We use two sources of data: the Spanish ESD for the period 1960–1989 and the INE mortality files for the period 2012–2015. First, the ESD is a macro survey conducted in 1991 by INE on 158,264 individuals. These data contain detailed information on the survival status, birth year, and education level of 316,762 parents and thus contain children's retrospective reports of survival information about their parents. If the parent is dead, the ESD also includes the year in which the parent died. Second, we use the mortality microdata files by educational attainment (12 categories) for those who died after age 30, which the INE first made publicly available in 2016. INE used a matching algorithm linking registered deaths to population databases, such as censuses, municipal population registers, the ministry of education, and the public service of state employment (INE 2016), to obtain the deaths according educational attainment. The INE also provides the total population broken down by sex, age, and educational attainment, which are required for the denominators of our mortality indicators. Based on both data sources, we create four educational attainment categories: individuals with less than primary education ($<P$) and those with primary, secondary, and university education (P, S, and U respectively).

Methodology

Estimating Life Tables by Educational Attainment

To measure lifespan variability by educational attainment, we need to construct the corresponding life tables. We first describe how these tables are estimated when using ESD data for the 1960–1989 period and then explain how we proceed when using the more recent INE data for the 2012–2015 period. The former is based on indirect methods, and the latter simply takes advantage of the mortality microdata files by education generated by the INE.

When one has retrospective information on the child-reported survival status of a parent, the age of the reference individual is a proxy of the exposure time to the risk of mortality of that parent. This is the reasoning behind the well-known indirect method to estimate adult mortality that Brass (1971) and Brass and Hill (1973) proposed, which they called the *orphanhood method*. It was and still is a widely used method in regions without high-quality registry data on adult mortality (United Nations 1983). An expansion of the method has also been applied to European countries with no information on SES attached to mortality data (Luy 2012; Luy et al. 2011). More recently, other researchers have used the same retrospective information on the survival of parents or siblings but introduced simulation techniques into this type of indirect method (Masquelier 2013; Rentería and Turra 2009).

Because the information of census and surveys on survival information about parents is typically very limited, including only whether the parent is alive, different techniques (weights, in the case of the orphanhood method; stochastic probability imputations, in the case of microsimulation models) are needed to estimate the exact age and moment at death of the parent. This is not our case because the ESD gives exhaustive information about parental birth year as well as age and year of death if the parent died. We therefore have no need to impute any information regarding parental survival through the Brass orphanhood (or similar) method. Additionally, this detailed information avoids bias coming from unknown adopted children.[2] Finally, the information on educational attainment of the parents is attached to their survival, allowing mortality rates by age and level of education to be estimated. Before doing so, however, we eliminate those cases for which the existence of parents or their survival status is unknown, parent's age is considered improbable (too low) compared with the ages of the children, and the educational level of parents is missing. This represents 1.5 % of the original database. Finally, we also eliminate 3.6 % of parents with information missing for their birth year or age at death (for more detail, see Rentería and Spijker 2017).

To check the reliability of the mortality rates based on the ESD data set, we compare the rates for the total population with those published by the Human Mortality Database (HMD). Based on this comparative analysis (see Tables A1a and A1b in the online appendix), we consider the ESD data from the 1960s, 1970s, and 1980s fit for the purpose of our study. By grouping single ages and period decades, we also eliminate age and birth year heaping among the older cohorts.[3] Finally, we calculate the sex- and education-specific life expectancies using the following steps (see the online appendix for more detail on steps 2 and 3):

1. Based on the ESD data, we obtain five-year mortality rates from ages 35 to 89 for each decade by educational level and sex and calculate the corresponding abbreviated life tables.
2. To obtain the life tables by single and more advanced ages (until the exact age of 100), we apply a logit model using the HMD life table of the same sex and decade as reference.
3. We then readjust the probability of dying estimated in Step 2 for the different educational attainments so that the life table for the entire population fits the HMD life table for the corresponding sex and decade.
4. Finally, the resulting age-at-death distributions are smoothed using five-year age moving averages (a procedure that does not alter our findings).

Differences between the unadjusted and adjusted life expectancies at age 35 by educational level are shown in Table A2 in the online appendix. As shown there, differences are less for men than for women and decrease by decade to less than approximately one-half year for each educational level except university for women.

Last, regarding the estimation of life tables for the 2012–2015 period, we simply use the deaths by age, sex, and education tables generated by INE and the corresponding mean population sizes for that period (see INE 2016). In 1.5 % of the cases, INE could not impute the corresponding educational attainment.

[2] According to Luy (2012:611), adoption effects and wrong age reporting on parents by offspring are in any case "unlikely to bias orphanhood-based estimates in modern populations from developed countries. Moreover, the biases caused by multireporting and various kinds of selection are to some extent mutually offsetting and therefore considered to be small and rather unimportant, as demonstrated in detail by Palloni et al. (1984)."

[3] In the online appendix, Figs. A1 and A2 show the distribution of single-year birth years and age of alive and dead parents according to the ESD.

Assuming that lack of imputation is independent of educational attainment, these remaining cases are assigned according to the relative distributions of the different education categories for each sex and age. We subsequently use the annual population figures published by INE to estimate the mean population for the entire 2012–2015 period by sex, age, and educational attainment, which serves as our denominator. Like in the previous case, the resulting age-at-death distributions are smoothed using five-year age moving averages (a procedure that does not alter our findings). All our life tables start at age 35 and end at 100.

Measuring Lifespan Variability

Many indices are available for measuring lifespan variability (for a review of the most widely used measures, see Wrycza et al. 2015). Yet, only a few of them are amenable to the within- and between-group decomposition that we want to apply in our study. One of them is the Theil index, which is defined as

$$T = \frac{1}{l_a} \sum_{x=a}^{\omega} d_x \left(\frac{\alpha_x}{\mu_a} \right) \log \left(\frac{\alpha_x}{\mu_a} \right), \tag{1}$$

where a and ω are the youngest and oldest age intervals taken from the life table; l_a is the radix of the population (taken to be the initial subgroup population size); μ_a is the average age at death in the life table; and d_x and α_x are the life table number of deaths and the average age at death in the age interval x to $x + 1$, respectively. In this study, we set the minimal age (a) at 35 because (1) it is an age at which virtually all individuals have completed their education, and (2) it renders our findings more comparable to the ones reported in the cross-sectional study of Van Raalte et al. (2012). Assuming we have G educational attainment groups and setting $a = 35$, T can be rewritten as

$$T = \sum_{g=1}^{G} s_g \frac{\mu_{35}^g}{\mu_{35}} \ln \left(\frac{\mu_{35}^g}{\mu_{35}} \right) + \sum_{g=1}^{G} s_g \frac{\mu_{35}^g}{\mu_{35}} T_g, \tag{2}$$

where s_g, μ_{35}^g, and T_g, are the population share, life expectancy, and within-group inequality (respectively) of educational attainment group g. The first part in Eq. (2) is the between-group component (obtained assuming all individuals in each group die at the same age, so there is no within-group variation); the second part is the within-group component (a weighted sum of the within-group inequalities). In the online appendix, we present other additively decomposable measures used to check the robustness of our results (Tables A5–A10).

Lifespan Variation Counterfactuals

Observing that overall average age at death is equal to the weighted sum of group-specific average age at deaths for the different education groups, $\mu_{35} = \sum_g s_g \cdot \mu_{35}^g$, the additive decomposition of the Theil index (shown in Eq. (2)) for time t, can be rewritten as follows:

$$T_t = \sum_{g=1}^{G} s_{g,t} \frac{\mu_{35,t}^{g}}{\sum_{g=1}^{G} s_{g,t}\mu_{35,t}^{g}} \ln\left(\frac{\mu_{35,t}^{g}}{\mu_{35,t}}\right) + \sum_{g=1}^{G} s_{g,t} \frac{\mu_{35,t}^{g}}{\sum_{g=1}^{G} s_{g,t}\mu_{35,t}^{g}} T_{g,t}, \quad (3)$$

where the additional subscript indexes period t. As can be seen, overall lifespan inequality depends on three factors: (1) the population shares of the education groups (s_g), (2) the longevity of the groups (μ_{35}^{g}), and (3) the lifespan variability within groups (T_g). To simplify notation and explicitly indicate the dependency of lifespan inequality on these three factors, we rewrite Eq. (3) as

$$T_t = \phi\left(\{s_{g,t}\}, \left\{\mu_{35,t}^{g}\right\}, \{T_{g,t}\}\right). \quad (4)$$

Given the transformations undergone by these three components in Spain during the last decades, it is interesting to gauge their relative importance in assessing changes in overall lifespan inequality over time. To address this issue, we use a set of counterfactual analyses. We ask what would happen to total lifespan inequality in period 2 if we hold constant one of the three quantities that appear in the Theil index at its earlier (period 1) value and allow the other two to take their later (period 2) value. In this way, we generate a counterfactual level of lifespan inequality in period 2; and by comparing this with observed inequality in period 2, we can assess the impact of change in the quantity that we keep fixed at time 1 levels on inequality. In this way, we generate the following counterfactual inequalities:

$$C_1 = \phi\left(\{s_{g,1}\}, \left\{\mu_{35,2}^{g}\right\}, \{T_{g,2}\}\right) \quad (5)$$

$$C_2 = \phi\left(\{s_{g,2}\}, \left\{\mu_{35,1}^{g}\right\}, \{T_{g,2}\}\right) \quad (6)$$

$$C_3 = \phi\left(\{s_{g,2}\}, \left\{\mu_{35,2}^{g}\right\}, \{T_{g,1}\}\right). \quad (7)$$

Hence, C_1 indicates the level of lifespan inequality that we would observe in time 2 if the population share of each group had remained at its time 1 level (i.e., in case education expansion had not occurred). The other counterfactuals are defined analogously.

In the previous set of counterfactuals, we assume that two of the three factors were at their later (time 2) levels while the third one was kept at its earlier (time 1) level. For the sake of completeness, we explore what would happen if we keep two of the three factors at their earlier (time 1) levels and let the third one take its later (time 2) level. This way, we generate the following three counterfactual inequalities:

$$C_4 = \phi\left(\{s_{g,2}\}, \left\{\mu^g_{35,1}\right\}, \{T_{g,1}\}\right) \tag{8}$$

$$C_5 = \phi\left(\{s_{g,1}\}, \left\{\mu^g_{35,2}\right\}, \{T_{g,1}\}\right) \tag{9}$$

$$C_6 = \phi\left(\{s_{g,1}\}, \left\{\mu^g_{35,1}\right\}, \{T_{g,2}\}\right). \tag{10}$$

C_4 measures the amount of lifespan inequality that we would observe in time 2 if we changed only the population shares of the education groups. Analogously, C_5 and C_6 indicate the amount of lifespan inequality that we would observe in time 2 if we changed only longevity and within-group variability, respectively. Comparing the values of the counterfactuals $C_1, \ldots, C_6$ with the true inequality levels, we can assess which of the three factors has been more decisive in driving lifespan inequality changes over time. As a robustness check, in the online appendix, we also report the results of a well-known inequality decomposition technique suggested by Mookherjee and Shorrocks (1982).

Results

Education Expansion During the Last 50 Years

The distribution of the Spanish population aged 35+ across the four educational categories from the 1960s to 2015 is shown in Table 1. In the 1960s, most individuals had completed at most primary education (95 % of women and 89 % of men), and college-educated individuals represented a very small minority (4.5 % for men and 1.3 % for women). In the following decades (the 1970s and 1980s), the process of education expansion among the younger generations reduced the percentage of the population aged 35+ with less than primary education (to 66 % for women and 57 % for men, respectively, in the 1980s) and increased the share of the remaining groups. Yet, college-educated individuals continued to be a minority in the Spanish society (2.6 % of women and 6.7 % of men). By 2015, the distribution completely reversed: individuals with less than primary education were a minority (11 % of women and 8 % of men), and individuals with at least secondary education were the bulk of the population (70 % of women and 75 % of men).[4]

[4] As noted earlier, the 1960–1989 data come from children who reported their parental educational level (i.e., it excludes the childless population). A comparison of the ESD data with the 1991 census that included a question on parity shows that the proportion of women aged 35+ who at most finished primary school education was slightly higher for mothers than for childless women (see Table A3 in the online appendix). Other than that, the proportion of primary or less-, secondary, and tertiary educated ESD respondents' parents aged 35+ were between the proportions for the same age according to the 1981 and 1991 censuses.

Table 1 Distribution of education by sex and over time between 1960 and 2015 (percentage of population aged 35+ in each education category)

	Less Than Primary Education	Primary Education	Secondary Education	University Education
Female				
Period				
1960–1969	78.18	16.61	3.89	1.32
1970–1979	72.91	19.65	5.70	1.73
1980–1989	65.91	22.70	8.84	2.56
2012–2015	11.22	19.43	49.79	19.56
Male				
Period				
1960–1969	70.82	17.88	6.83	4.48
1970–1979	64.82	20.62	9.22	5.34
1980–1989	57.05	23.22	13.07	6.67
2012–2015	8.04	17.06	56.01	18.89

Source: Authors' elaboration using data from the ESD and INE.

Although more women than men were among the least educated in 2015, the gender gap was reduced to the extent that the educational distribution of both sexes was quite similar. Women aged 35+ were slightly overrepresented in the lowest education category and underrepresented in the higher ones with respect to men, but the results are entirely different if we focus on younger age groups (e.g., 25–29 or 30–34). Like in many other Western countries, Spanish young women were more highly educated than their male counterparts in 2015, a global trend that is expected to continue for some time to come (Esteve et al. 2012).

The dramatic change observed in the Spanish education distribution during the last 50 years suggests that educational expansion might be one of the key factors that could explain the trend in lifespan inequality over the period, an issue that we will investigate in detail in the Counterfactual Analysis subsection.

Life Expectancy Levels by Education

Over the 50 years we study, Spain has also undergone major changes in longevity. Figure 1 shows the sex-specific levels of life expectancy at age 35 for the four educational categories over time. (The corresponding Table A4 is shown in the online appendix.) Overall, life expectancy at 35 increased from 37.8 to 45.6 years for men and from 42.1 to 50.9 years for women during the entire period. The expected socioeconomic gradient of mortality is observed across most education group comparisons: in general, highly educated individuals tend to live longer than their less-educated counterparts.[5] In addition,

[5] Because of the small relative size of the population of highly educated individuals in the 1960s and 1970s, education-specific life expectancy levels might not always go in the expected direction when individuals with secondary education and those with college education are compared.

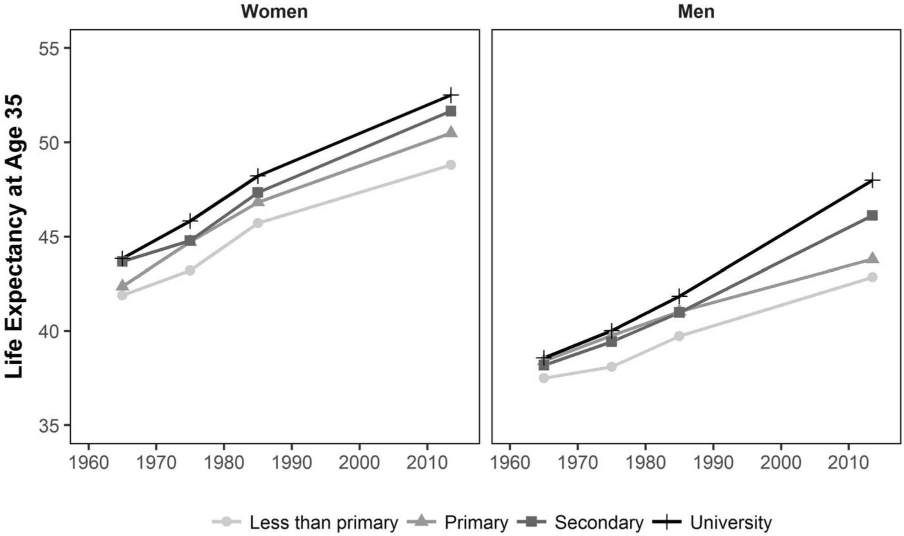

Fig. 1 Life expectancies at age 35 by gender and educational attainment for four periods: 1960–1969, 1970–1979, 1980–1989, and 2012–2015. *Source:* Authors' elaboration using data from the ESD and INE

this relationship is accentuated over time: although life expectancy at 35 increased for *all* education groups, it increased faster for the highly educated. Life expectancy at age 35 increased from 41.9 to 48.8 years (i.e., an increase of 6.9 years) among low-educated women and from 43.8 to 52.5 years (an increase of 8.7 years) among highly educated women. This pattern of widening differences across groups is particularly acute for men: increased life expectancy at age 35 increased from 37.5 to 42.8 years (an increase of 5.3 years) for low-educated men and from 38.6 to 48.0 years (a 9.4-year increase) for highly educated men.

Inspecting life expectancy trends alone, one might conclude that health disparities are increasing in Spain. Indeed, the dramatic improvements in life expectancy observed across the board suggest that increasing longevity might be another crucial factor in explaining the observed trends in lifespan variation. Yet, the comparison of group-specific life expectancies is equivalent to restrict our attention to the between-group component of overall inequality. In this regard, one might wonder how much extra inequality would be uncovered by going beyond comparisons of group means and taking into account the disparities within groups—an issue that we take up in the next subsection.

Length-of-Life Inequality: Levels and Decompositions

What do we find going beyond average values and looking at the entire age-at-death distribution? Figure 2 shows the life table death distributions for women and men across educational attainment groups in the 1960–1969 and 2012–2015 periods. The shape of these distributions suggests that although the dispersion in the ages at death was higher in the 1960s (the earlier distributions are more spread out than the later ones), the different education groups looked quite similar to one another, for both women and men. Even if it might not be obvious at first sight, the age-at-death distribution is more spread out among men than among women.

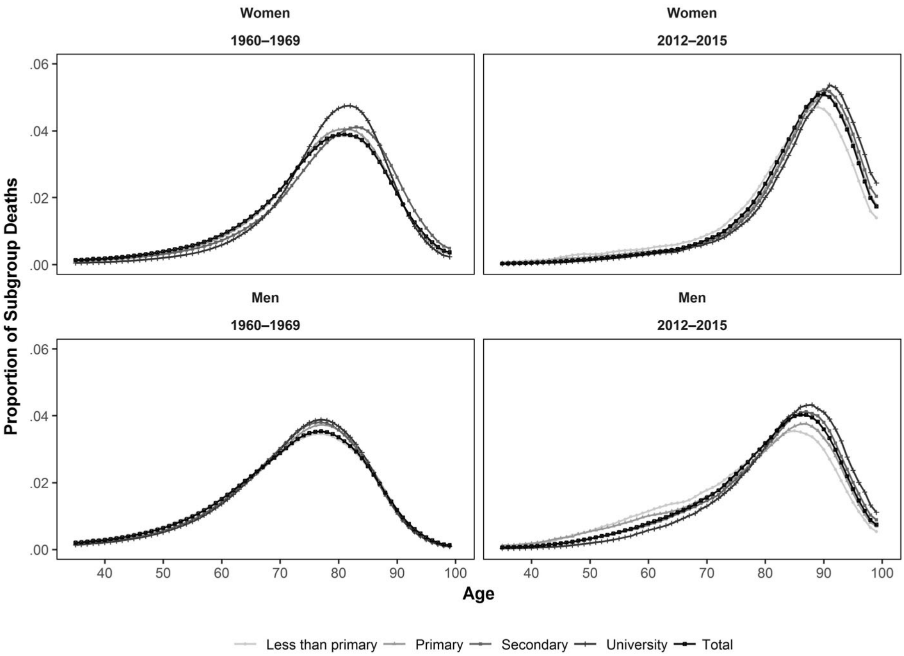

Fig. 2 Life table death distributions by educational attainment for women (upper panel) and men (lower panel) in the 1960–1969 period (left) and in 2012–2015 (right). *Source:* Authors' elaboration using data from the ESD and INE

Three major changes have occurred when moving from the 1960–1969 age-at-death distributions to the most recent ones. First, all distributions have clearly shifted to the right, thus indicating a lengthening of lifespan across all education groups. Second, the 2012–2015 distributions are much less spread out than the earlier ones: ages at death are more densely concentrated around the corresponding modal age at death. Third, a gradient in age-at-death distributions across education groups becomes clearly visible. As educational attainment increases, the distribution gradually shifts to the right and becomes more concentrated. This is in sharp contrast with the patterns of the 1960s, in which the different distributions were barely distinguishable. The emergence of an education gradient in age-at-death distributions is in line with the diverging trends in life expectancy at age 35 across education groups (online appendix, Table A2).

What is the extent of inequality (as measured by the Theil index) of the age-at-death distributions shown in Fig. 2? The results, presented in Table 2, show several noteworthy patterns. To start, overall lifespan inequality declined for both sexes. The Theil index substantially decreased from 1.25 to 0.82 for women and from 1.48 to 1.18 for men. In addition, for each period and educational attainment combination, lifespan inequality is systematically higher among men than among women. In general, we find the expected relationship between educational attainment and lifespan inequality: the higher the level of education, the less dispersed the age-at-death distribution.[6] When comparing lifespan

[6] Because of the relatively small size of the population of highly educated individuals in the 1960s and 1970s, we do not observe the expected relationships between some contiguous education categories.

Table 2 Theil index of lifespan inequality (×100) by sex and educational subgroup for four periods: 1960–1969, 1970–1979, 1980–1989, and 2012–2015

	Less Than Primary Education	Primary Education	Secondary Education	University Education	Total
Female					
Period					
1960–1969	1.28	1.16	1.14	0.83	1.25
1970–1979	1.19	1.01	0.90	0.99	1.13
1980–1989	1.06	0.91	1.02	0.87	1.01
2012–2015	1.14	1.00	0.81	0.74	0.82
Male					
Period					
1960–1969	1.55	1.35	1.31	1.26	1.48
1970–1979	1.53	1.35	1.28	1.26	1.45
1980–1989	1.60	1.29	1.19	1.34	1.44
2012–2015	1.50	1.53	1.18	0.93	1.18

Source: Authors' elaboration using data from the ESD and INE.

variation within each education group in the earliest (1960s) and latest (2010s) periods, we observe different trends according to gender. For women, we tend to observe declining trends for *all* education groups—particularly for those with secondary education, who are the bulk of the population. For men, we observe important declines for those with secondary and university education (who constitute approximately three-quarters of the population aged 35+ in 2015) in tandem with inequality *increases* for those with primary education. For this group—a nonnegligible sector of the population accounting for almost one-fifth of individuals aged 35+—the values of the Theil index increased from 1.35 to 1.53.

What do we observe when the values of the Theil index are decomposed into its within- and between-group components? The results, shown in Table 3, indicate that the size of the between-group component is extremely small, so its relative contribution to overall lifespan inequality is almost negligible: it changes from

Table 3 Decomposition of Theil's index of lifespan inequality in its within-group (WG) and between-group (BG) components by sex for four periods: 1960–1969, 1970–1979, 1980–1989, and 2012–2015

Period	Theil		BG Component		WG Component		% Contribution of BG	
	Female	Male	Female	Male	Female	Male	Female	Male
1960–1969	1.25	1.48	0.0002	0.0003	1.25	1.48	0.02	0.02
1970–1979	1.13	1.45	0.0008	0.0004	1.13	1.45	0.07	0.03
1980–1989	1.01	1.44	0.0013	0.0010	1.01	1.44	0.13	0.07
2012–2015	0.82	1.18	0.0020	0.0020	0.82	1.18	0.30	0.20

Source: Authors' elaboration using data from the ESD and INE.

0.02 % to 0.30 % for women and from 0.02 % to 0.20 % for men. Therefore, the observed declining trends in overall lifespan inequality are mostly driven by the shrinking within-group component. Even if the between-group component barely contributes to overall lifespan variation, it clearly increased over time: in relative terms, it experienced a manifold increase, a result that is in line with the diverging trends in group-specific life expectancies reported in Fig. 1. We investigate the robustness of our findings in the online appendix. There, we reproduce Tables 2 and 3 with the values obtained from other additively decomposable inequality measures. Summing up, declining overall lifespan inequality trends coexist with increasing inequality between groups, but the contribution of the latter is still too small to have a substantive effect on the values of the former.

Counterfactual Analysis

During the 50 years under study, Spain experienced major socioeconomic and demographic transformations. *Inter alia*, formal education expanded dramatically, and longevity achieved record levels. In this swiftly changing context, it is important to evaluate which explanatory factors were more decisive in driving changes to our variable of interest: overall length-of-life inequality. To investigate this point, we run several counterfactual analyses. Counterfactual analyses are based on the assumption that a change in one component does not affect the other two components, which is unlikely to be satisfied in practice. Even if their limitations are well known and they are not sufficient to assess causal association, counterfactual methods are nonetheless widely used to derive first-order approximations of complex phenomena like the ones analyzed in this article. In the previous subsections, we identify three factors that could potentially explain changes in lifespan variation over time: education expansion, increasing longevity, and decreasing within-group inequality. Because the three factors dramatically changed during the period we are studying, it is not *a priori* clear which of them could be more influential in determining the observed changes in lifespan variation.

In Table 4, we show the observed changes in the Theil index between the 1960s and 2012–2015 (it decreased from 1.25 to 0.82 for women and from 1.48 to 1.18 for men) and the different counterfactual inequality levels that would be observed under alternative scenarios (see Eqs. (5)–(10)). According to the first counterfactual, had there been no education expansion, overall inequality levels would have remained very similar to 1960s levels, particularly among men. Similarly, had there been no change in within-group inequality, overall lifespan inequality levels would not have changed very much (see the third counterfactual, C_3). Yet, even if group-specific life

Table 4 Counterfactual lifespan inequality that would be observed in 2012–2015 under alternative scenarios

	$T_{1960–1969}$	$T_{2012–2015}$	C_1	C_2	C_3	C_4	C_5	C_6
Men	1.48	1.18	1.44	1.23	1.33	1.34	1.47	1.46
Women	1.25	0.82	1.10	0.90	1.11	1.13	1.25	1.10

Source: Authors' elaboration using data from the ESD and INE.

expectancies had remained at their 1960s levels, overall lifespan inequality would have greatly decreased to 0.90 for women and 1.23 for men (see counterfactual C_2). This means that group-specific longevities do not seem to play an important role in determining lifespan inequality changes. What do we observe with the last three counterfactuals? If we allow only increases in group-specific longevity, overall inequality barely changes (see counterfactual C_5). However, when we change the population shares of each group according to education expansion (C_4) only, overall lifespan variation is substantially reduced. This suggests that among the three factors considered here, education expansion is the one that seems to be more influential in driving the changes in lifespan inequality, followed by the reductions in within-group inequalities. Group-specific life expectancies seem to have played a minor role in this process.[7] These conclusions hold when we use the inequality decomposition technique suggested by Mookherjee and Shorrocks (1982) (see the online appendix).

Discussion and Concluding Remarks

In this study, we investigate the evolution of life expectancy and lifespan variation levels for different education groups in Spain during the last 50 years. Our findings suggest that life expectancy has been increasing for all education groups but particularly among the highly educated. We observe diverging trends in life expectancy, with the differences between the low- and high-educated becoming increasingly large, particularly among men. In the 50-year period, life expectancy at age 35 increased by 6.9 years for the least-educated women but increased by 8.7 years for their highly educated counterparts; for men, these figures are 5.3 and 9.4 years, respectively. Looking at life expectancy differences across groups alone, one might be tempted to conclude that health inequalities have been increasing in Spain over the last decades. Yet, inspecting the trends in lifespan variability, we obtain a rather different picture. Concomitantly with increasing disparities across groups, length-of-life inequality decreased for the population as a whole and for the highly educated (but *not* for the least educated), and the contribution of the between-group component of inequality to overall inequality was extremely small. Even if between-group inequality increased over time, its contribution was too small to have sizable effects on overall inequality (<1 % of the total variation), which continues to be mainly explained by within-group variability.

Our results show how widening life expectancy differences together with converging and diverging within-group inequalities can coincide with overall mortality compression if there is substantial compositional change into groups experiencing compression. These findings, which could not be unraveled by inspecting life expectancy trends alone, pinpoint at least two sources of concern: health inequality is increasing across education groups *and* within the least-educated ones. Hence, the design of prospective public health or retirement age policies should avoid treating the least-

[7] To be sure, it is the interaction between these factors that actually drove the changes in lifespan inequality: without the emergence of group differences in education mortality, education expansion alone would not suffice to explain any of the observed changes. The counterfactual analysis shown here is helpful to indicate which factors might have been more influential in explaining the observed changes.

educated individuals (who represent approximately 30 % and 25 % of Spanish females and males aged 35+ in 2015) as if they were a homogeneous group. This naturally begs the question as to what drives the emergence of such health patterning and what should be done about it—an issue that is beyond the scope of this article and should be addressed in future research.

How do our findings relate to other studies on life expectancy and lifespan inequality differences by education or other socioeconomic characteristics across time? In recent times, several studies have investigated trends in life expectancy across social groups in high-income countries. Majer et al. (2011) investigated life expectancy at age 65 by education in 10 European countries for the period 1996–2001. Steingrímsdóttir et al. (2012) and Deboosere et al. (2009) explored longevity differences by educational attainment in, respectively, Norway (from 1961 to 2009) and Belgium (from 1991 to 2004). Analogously, Tarkiainen et al. (2012) and Bronnum-Hansen and Baadsgaard (2012) reported differences in life expectancy for different income quantiles in, respectively, Finland (from 1988 to 2007) and Denmark (from 1986 to 2014). Other studies from the United States have reported life expectancy differences across education (Case and Deaton 2015; Sasson 2016b) and income quantile groups (Chetty et al. 2016). Invariably, all these studies reported diverging trends in life expectancy across subpopulations, with the socially advantaged ones benefiting more than the rest. Although the studies carried out in European countries reported increases in longevity across all social groups, this is not the case for the United States (where the least-educated non-Hispanic white men and women experienced important declines). The findings presented in this article for Spain are in line with the aforementioned European studies: there are diverging trends in life expectancy across education groups, but none of them has experienced longevity declines.

Unfortunately, only a few studies have investigated lifespan inequality levels and trends across socioeconomic groups with which to compare our findings. In addition, great caution should be exercised when making comparisons among this kind of study. Typically, the lifespan inequality indicators are not exactly the same (and even if they are the same, the age range of the corresponding life tables might differ), the education or socioeconomic categories are not strictly comparable across countries, and the periods studied do not necessarily coincide. With these caveats in mind, we start comparing our results with other studies investigating lifespan inequality differences across education groups: Van Raalte et al.'s (2012) cross-sectional study of 11 European countries (henceforth referred to as VR) and those by Sasson (2016b) and Hendi (2017) of the United States.[8] When we compare the Spanish results with those reported in VR, several interesting patterns arise (see Fig. 3). To start, lifespan inequality levels in Spain seem to be among the lowest in Europe not only for the population aged 35+ as a whole but also for most education groups. The countries with lowest overall lifespan variability reported in VR are Sweden, Norway, Finland, Belgium, and

[8] The findings reported in Murtin et al. (2017) are particularly difficult to compare with ours because (1) the age ranges are different; (2) the analyzed years do not coincide; (3) they used three education categories rather than four; and more importantly, (4) they did not disaggregate their inequality results by sex as we do.

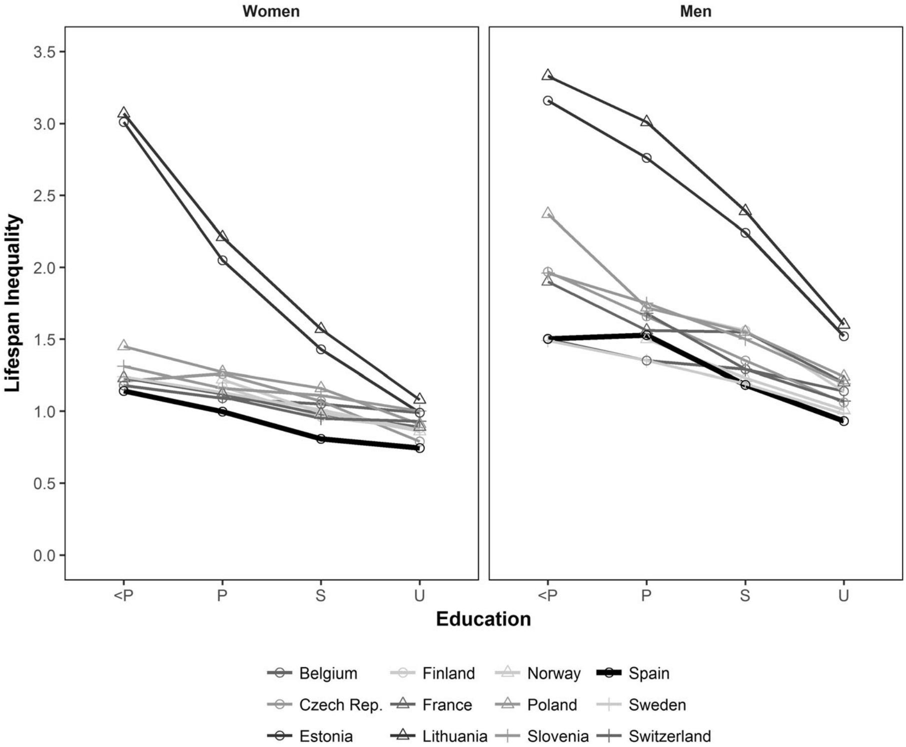

Fig. 3 Lifespan inequality gradient across education groups for women and for men (European countries around 2000, Spain in 1980–1989 and 2012–2015). *Note:* The same colors are used for countries belonging to the same geographic area. *Source:* VR and authors' elaboration using data from the ESD and INE

Switzerland, with Theil values of 1.08, 1.08, 1.07, 1.12, and 1.02, respectively, for females; corresponding figures for males are 1.28, 1.29, 1.58, 1.39, and 1.35, respectively (values estimated for the year 2000 approximately). Using data from the 2012–2015 period, the Theil values for the entire population (aged 35+) in Spain are 0.82 and 1.18 for women and men, respectively. Even if the time frames are different and therefore not strictly comparable, data from the HMD suggest that overall lifespan variation in Spain is indeed among the lowest in Europe. Looking at each education subgroup separately, we find again that lifespan variations in Spain tend to be among the lowest, particularly for women across *all* education groups and for highly educated men. Last, the small size of the between-group inequality component for Spain—in line with the findings reported for other high-income countries in VR and Murtin et al. (2017)—suggests that many other factors beyond education are responsible for the existing variability in lifespans.

So far, we have been comparing our results with respect to a cross-section of countries around year 2000. What can we say about the dynamics of lifespan inequality across education groups? How does the Spanish case relate to the experience of other countries? We compare our findings with the ones reported by Sasson (2016b) for the United States between 1990 and 2010. Yet, it should be borne in mind that the inequality measures are different (the latter uses S_{25}, the standard deviation of lifespan distributions above 25 years, and the KLD divergence measure),[9] and the education groups are not exactly the same. In addition, a replication study by Hendi (2017) reported conflicting results,[10] thus rendering comparisons with the Spanish case even more complicated. With regard to the evolution of overall lifespan inequality, the two countries seem to go in different directions. Although it has been monotonically decreasing in Spain from the 1960s to the 2010s for women and for men (see Table 3), both Sasson (2016b) and Hendi (2017) reported a U-shaped trend (decreasing from 1990 to 2000 and then increasing again in 2010) for all population groups except for non-Hispanic black women.

What do we observe when inspecting the gradient across education groups? Figure 4 shows the lifespan inequality levels across education categories for Spain (left panels) and the United States (right panels) using data from Sasson (2016b). For Spanish women, between 1980–1989 and 2012–2015, lifespan inequality declined among those who attained secondary education or more but increased among women with primary school education or less. This is similar to what took place between 1990 and 2010 among U.S. white women: lifespan variation increased among those with less than completed college, particularly among the least educated. Black women experienced small reductions in lifespan variability across most education categories. Regarding Spanish men, lifespan inequality decreased among all groups (particularly among the college-educated) except those with primary education. For white men in the United States, only the college-educated reduced lifespan variability; for black men, inequality reductions took place for the least educated and the college-educated. Overall, it seems that the evolution of lifespan variability across education groups in Spain is roughly similar to the one observed in the United States. Moreover, although there were increases in variability observed for both Spanish with primary school education (or less as in the case of men) and U.S. whites with less than college education during a similar time frame, in the case of the United States, the less than college educated constitute a larger proportion of the total population. Despite increases in lifespan variation among the least-educated white women both in the United States and Spain, the latter benefitted from longevity gains, whereas the former experienced losses in life expectancy (in spite of the fact that the former are still significantly more educated than the latter in absolute terms).

Last, Van Raalte et al. (2014) investigated trends in lifespan variability across occupational groups in Finland from 1971 to 2010 and Brønnum-Hansen (2017) across income quartiles in Denmark from 1986 to 2014. Despite research design differences, these two studies are also in line with the general trends that we find for Spain. In all cases, one observes stagnation or divergence in lifespan variation

[9] Even if the inequality indicators differ, it is still interesting to compare trends over time.

[10] Hendi (2017) argued that this was due to numerator-denominator bias because Sasson (2016b) used unlinked data sources (National Vital Statistics System and U.S. Census Bureau). However, in Sasson's (2017) reply, he stated that this discrepancy was within sampling variation. With regard to the two data sources used in our study, we would like to highlight that potential numerator-denominator bias is not relevant. As described earlier, the ESD pertains to a retrospective survey in which children reported on the survival status and educational attainment of their parents. Regarding the more recent INE mortality data, each mortality registry is linked to a population database that obtained the educational attainment of all individuals.

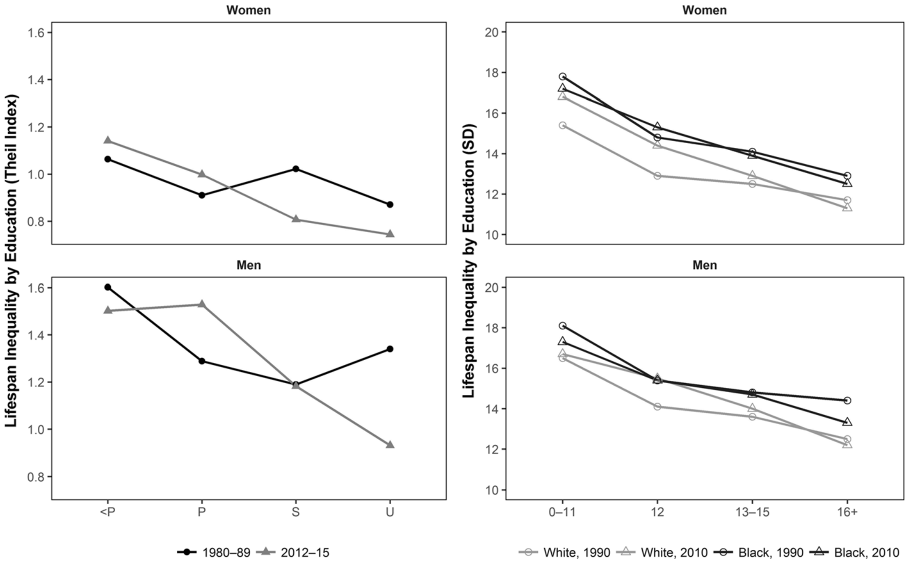

Fig. 4 Lifespan inequality gradient across education groups for women and for men over time for Spain (left panels) and the United States (right panels). *Note:* For Spain, *<P* refers to less than primary education; and *P*, *S*, *U* to primary, secondary, and university education, respectively; for the United States, we use the same education categories as Sasson (2016b). *Source:* Sasson (2016b) and authors' elaboration using data from the ESD and INE

among socially disadvantaged groups and mortality compression among the more advantaged ones.

Why is the overall lifespan inequality and between-group inequality relatively small in Spain? Kulhánová et al. (2014) associated the smaller inequality in mortality by educational level in Spain to a later modernization and educational expansion in Spain than in the north of Europe, which implies that educational attainment is less representative of the social status of individuals. This may have implied a later epidemiologic transition, in which cardiovascular diseases also started to rise later than in northern Europe, benefitting from advances in medical care before they peaked. As Kulhánová et al. noted, a Mediterranean diet is also one of the causes that could be behind lower mortality rates from ischemic heart diseases for individuals of lower SES. Finally, among women, they found a strong reverse relationship with education for cancer deaths that could also be an evidence of the later engagement of Spanish women in heavy smoking compared with the north.

For future research, studying causes of death may provide us with additional clues to lifespan variation differences between educational groups, over time and between countries. For example, we know from recent research that death rates among U.S. middle-aged white non-Hispanic men and women with less than a high school education actually increased since 1999 as result of very sharp increases in mortality by poisoning, suicide, chronic liver disease, and cirrhosis (Case and Deaton 2015; Sasson 2016a, b). Such causes of death tend to affect the lower-educated and younger adults more than the higher-educated and older population. Although drugs are far less of a problem in Spain than in the United

States, smoking prevalence in Spain among all men and younger women is one of the highest in western Europe (Huisman et al. 2005b). Moreover, among younger generations, women have overtaken men, and the lower-educated have overtaken the higher-educated (Huisman et al. 2005b; Schiaffino et al. 2003). Who is to say, therefore, that with healthy lifestyles being disproportionally adopted by the higher-educated (Wardle and Steptoe 2003) not just differences between the low- and high-educated will further increase but lifespan variation as well?

Despite our interesting findings, some limitations of our study should be highlighted. First, estimates generated from the ESD might be inaccurate approximations because they are based on information from offspring and they therefore refer only to those individuals who had children surviving until the adult age. These measurement errors might somewhat affect our estimates of longevity and lifespan inequality *levels*, but it is unlikely that they distort the overall *trends* reported in this article. The most important changes in longevity and lifespan variation have occurred between the period covered by the ESD (1960–1989) and the period covered by INE (2012–2015). The smaller measurement errors (i.e., better-quality estimates) of the ESD for the 1980–1989 period lends support to the idea that the overall changes reported in this article are not a spurious finding driven by measurement error problems.[11] To alleviate this potential problem, we satisfactorily compared and adjusted our results with respect to those found in the HMD for the entire population. Second, our counterfactual lifespan inequality analyses might look somewhat crude at first sight. Using *ceteris paribus*–like arguments, they simply assume that some of the three components in our Theil inequality index can be kept fixed while the others are allowed to change over time as they actually did, as if they were completely independent entities. Reality is far more complex than that, and intricate relationship patterns bind the different components with one another. Yet, these kinds of techniques—which have been widely used in demographic analysis (e.g., Breen and Andersen 2012; Breen and Salazar 2011; Permanyer et al. 2013)—are extremely useful to derive first-order approximations of complex phenomena that otherwise could only be approximated realistically with sophisticated models whose specifications depend on arbitrary decisions and that are prone to a wide range of conceptual and measurement errors.

Despite those limitations, the results presented in this article confirm that the study of health inequalities by education should not be limited to the analysis of average differences across groups. Ignoring the differences that might exist within groups and focusing on education-specific life expectancy trends alone, one might

[11] Attempts to model the potential effects of measurement error would need to specify how one would expect the measurement error to vary across education groups. Although one might *a priori* expect the less-educated to report the age at death and the educational attainment of their parents with lower accuracy than their highly educated counterparts, it is unclear what the direction of such error should be. Are the less-educated more likely to over- or underestimate the age at death of their parents? Might it be the case that the overestimation of some and the underestimation of others cancel each other? Because there does not seem to be a clear-cut answer to such questions, we consider that the benefits of performing a measurement error simulation exercise are not warranted. In this line, recent studies delving with related issues (i.e., estimating adult mortality indirectly based on data from close relatives) have concluded that it is unclear whether further attempts to account for the potential biases associated with indirect mortality estimation will result in more accurate estimates (Masquelier 2013).

arrive at the overly simplistic conclusion that health inequalities are increasing in Spain. Although it is true that life expectancy trends are starting to diverge across education groups, lifespan inequality has declined not only for the adult population as a whole but also for most education groups separately. Even if between-group inequalities have increased over time, their contribution to overall lifespan inequality is still extremely small. Nevertheless, the diverging trends in longevity and lifespan inequality across education groups is an important phenomenon whose underlying causes and potential implications should be investigated in detail. In future research, it will be necessary to investigate the mechanisms that lead one society to be more egalitarian in terms of health outcomes than others are, as well as whether and to what extent this equality can be maintained over time.

Acknowledgments The research leading to these results has received funding from the European Research Council (ERC-2014-StG-637768, EQUALIZE project); the Spanish Ministry of Economy and Competitiveness Ramón y Cajal and Juan de la Cierva Research Grant Programs (RYC-2013-14196, RYC-2013-14851 and JdlC-I-2014-21178); and the Spanish Ministry of Economy, Industry and Competitiveness, National R&D&I Plan CRISFAM (CSO2015-64713-R). Amand Blanes acknowledges support from the CSO2016-77449-R R+D project.

References

Bongaarts, J. (2005). Long-range trends in adult mortality: Models and projection methods. *Demography, 42,* 23–49.

Bongaarts, J., & Feeney, G. (2003). Estimating mean lifetime. *Proceedings of the National Academy of Sciences, 100,* 13127–13133.

Borrell, C., & Arias, A. (1995). Socioeconomic factors and mortality in urban settings: The case of Barcelona, Spain. *Journal of Epidemiology and Community Health, 49,* 460–465.

Borrell, C., Marí-Dell'Olmo, M., Serral, G., Martínez-Beneito, M., Gotsens, M., & MEDEA Members. (2010). *Inequalities in mortality in small areas of eleven Spanish cities (The multicenter MEDEA project). Health & Place, 16,* 703–711.

Borrell, C., Plasencia, A., Pasarin, I., & Ortún, V. (1997). Widening social inequalities in mortality: The case of Barcelona, a southern European city. *Journal of Epidemiology and Community Health, 51,* 659–667.

Borrell, C., Regidor, E., Arias, L.-C., Navarro, P., Puigpinós, R., Domínguez, V., & Plasencia, A. (1999). Inequalities in mortality according to educational level in two large Southern European cities. *International Journal of Epidemiology, 28,* 58–63.

Brass, W. (1971). On the scale of mortality. In W. Brass (Ed.), *Biological aspects of demography* (pp. 69–110). London, UK: Taylor & Francis.

Brass, W., & Hill, K. H. (1973, August). *Estimating adult mortality from orphanhood*. Paper presented at the International Population Conference IUSSP, Liège, Belgium.

Breen, R., & Andersen, S. H. (2012). Educational assortative mating and income inequality in Denmark. *Demography, 49,* 867–887.

Breen, R., & Salazar, L. (2011). Educational assortative mating and earnings inequality in the United States. *American Journal of Sociology, 117,* 808–843.

Brønnum-Hansen, H. (2017). Socially disparate trends in lifespan variation: A trend study on income and mortality based on nationwide Danish register data. *BMJ Open, 7*(5), e014489. https://doi.org/10.1136/bmjopen-2016-014489

Brønnum-Hansen, H., & Baadsgaard, M. (2012). Widening social inequality in life expectancy in Denmark. A register-based study on social composition and mortality trends for the Danish population. *BMC Public Health, 12,* 994. https://doi.org/10.1186/1471-2458-12-994

Brown, D. C., Hayward, M. D., Montez, J. K., Hummer, R. A., Chiu, C.-T., & Hidajat, M. M. (2012). The significance of education for mortality compression in the United States. *Demography, 49,* 819–840.

Canudas-Romo, V. (2008). The modal age at death and the shifting mortality hypothesis. *Demographic Research, 19*(article 30), 1179–1204. https://doi.org/10.4054/DemRes.2008.19.30

Case, A., & Deaton, A. (2015). Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proceedings of the National Academy of Sciences, 112,* 15078–15083.

Chetty, R., Stepner, M., Abraham, S., Lin, S., Scuderi, B., Turner, N., . . . Cutler, D. (2016). The association between income and life expectancy in the United States, 2001–2014. *JAMA, 315,* 1750–1766.

Cheung, S. L. K., Robine, J.-M., Tu, E. J.-C., & Caselli, G. (2005). Three dimensions of the survival curve: Horizontalization, verticalization, and longevity extension. *Demography, 42,* 243–258.

Davey Smith, G., Bartley, M., & Blane, D. (1990). The Black report on socioeconomic inequalities in health 10 years on. *BMJ, 301,* 373–377. https://doi.org/10.1136/bmj.301.6748.373

Davey Smith, G., Blane, D., & Bartley, M. (1994). Explanations for socio-economic differentials in mortality. *European Journal of Public Health, 4,* 131–144.

Davey Smith, G., Hart, C., Hole, D., MacKinnon, P., Gillis, C., Watt, G., . . . Hawthorne, V. (1998). Education and occupational social class: Which is the more important indicator of mortality risk? *Journal of Epidemiology and Community Health, 52,* 153–160.

Deboosere, P., Gadeyne, S., & Van Oyen, H. (2009). The 1991–2004 evolution in life expectancy by educational level in belgium based on linked census and population register data. *European Journal of Population, 25,* 175–196.

Duleep, H. O. (1989). Measuring socioeconomic mortality differentials over time. *Demography, 26,* 345–351.

Edwards, R. D. (2013). The cost of uncertain life span. *Journal of Population Economics, 26,* 1485–1522.

Edwards, R. D., & Tuljapurkar, S. (2005). Inequality in life spans and a new perspective on mortality convergence across industrialized countries. *Population and Development Review, 31,* 645–674.

Elo, I. T., & Preston, S. H. (1996). Educational differentials in mortality: United States, 1979–1985. *Social Science & Medicine, 42,* 47–57.

Engelman, M., Canudas-Romo, V., & Agree, E. M. (2010). The implications of increased survivorship for mortality variation in aging populations. *Population and Development Review, 36,* 511–539.

Esnaola, S., Aldasoro, E., Ruiz, R., Audicana, C., Pérez, Y., & Calvo, M. (2006). *Desigualdades socioeconómicas en la mortalidad en la Comunidad Autónoma del País Vasco* [Socioeconomic inequalities in mortality in the Basque Country (Spain)]. *Gaceta Sanitaria, 20,* 16–24.

Esteve, A., Spijker, J., Riffe, T., & García, J. (2012). Spousal and parental roles among female student populations in 55 low-and middle-income countries. *Vienna Yearbook of Population Research, 10,* 77–94.

Feldman, J. J., Makuc, D. M., Kleinman, J. C., & Cornoni-Huntley, J. (1989). National trends in educational differentials in mortality. *American Journal of Epidemiology, 129,* 919–933.

Fries, J. F. (1980). Aging, natural death, and the compression of morbidity. *New England Journal of Medicine, 303,* 130–135.

Gillespie, D. O., Trotter, M. V., & Tuljapurkar, S. D. (2014). Divergence in age patterns of mortality change drives international divergence in lifespan inequality. *Demography, 51,* 1003–1017.

Hendi, A. S. (2017). Trends in education-specific life expectancy, data quality, and shifting education distributions: A note on recent research. *Demography, 54,* 1203–1213.

Huisman, M., Kunst, A. E., Andersen, O., Bopp, M., Borgan, J.-K., Borrell, C., . . . Donkin, A. (2004). Socioeconomic inequalities in mortality among elderly people in 11 European populations. *Journal of Epidemiology and Community Health, 58,* 468–475.

Huisman, M., Kunst, A. E., Bopp, M., Borgan, J.-K., Borrell, C., Costa, G., . . . Marinacci, C. (2005a). Educational inequalities in cause-specific mortality in middle-aged and older men and women in eight western European populations. *Lancet, 365,* 493–500.

Huisman, M., Kunst, A. E., & Mackenbach, J. P. (2005b). Educational inequalities in smoking among men and women aged 16 years and older in 11 European countries. *Tobacco Control, 14,* 106–113.

Hummer, R. A., & Lariscy, J. T. (2011). Educational attainment and adult mortality. In R. G. Rogers & E. M. Crimmins (Eds.), *International handbook of adult mortality* (pp. 241–261). Dordrecht, the Netherlands: Springer.

INE. (2016). *Estadística de defunciones. Asignación de nivel educativo a ficheros de defunciones de 2015. Método de obtención y advertencias a usuarios* [Death statistics. Assignment of educational level to the 2015 death files. Obtaining method and warnings to users]. Madrid, Spain: INE (Instituto Nacional de Estadistica). Retrieved from http://www.ine.es/metodologia/t20/t2030306_niveduc.pdf

KC, S., & Lentzner, H. (2010). The effect of education on adult mortality and disability: A global perspective. *Vienna Yearbook of Population Research, 8,* 201–235.

Kitagawa, E. M., & Hauser, P. M. (1973). *Differential mortality in the United States: A study in socioeconomic epidemiology.* Cambridge, MA: Harvard University Press.

Kulhánová, I., Bacigalupe, A., Eikemo, T. A., Borrell, C., Regidor, E., Esnaola, S., & Mackenbach, J. P. (2014). Why does Spain have smaller inequalities in mortality? An exploration of potential explanations. *European Journal of Public Health, 24,* 370–377.

Kunst, A. E. (1997). *Cross-national comparisons of socio-economic differences in mortality* (Doctoral Dissertation). University Medical Center, Erasmus University Rotterdam, Rotterdam, the Netherlands.
Kunst, A. E., Bos, V., Andersen, O., Cardano, M., Costa, G., Harding, S., . . . Reid, A. (2004). Monitoring of trends in socioeconomic inequalities in mortality: Experiences from a European project. *Demographic Research, 2*(article 9), 229–254. https://doi.org/10.4054/DemRes.2004.S2.9
Luy, M. (2012). Estimating mortality differences in developed countries from survey information on maternal and paternal orphanhood. *Demography, 49,* 607–627.
Luy, M., Di Giulio, P., & Caselli, G. (2011). Differences in life expectancy by education and occupation in Italy, 1980–94: Indirect estimates from maternal and paternal orphanhood. *Population Studies, 65,* 137–155.
Mackenbach, J. P. (2012). The persistence of health inequalities in modern welfare states: The explanation of a paradox. *Social Science & Medicine, 75,* 761–769.
Mackenbach, J. P., Bos, V., Andersen, O., Cardano, M., Costa, G., Harding, S., . . . Kunst, A. (2003). Widening socioeconomic inequalities in mortality in six Western European countries. *International Journal of Epidemiology, 32,* 830–837.
Mackenbach, J. P., Kulhánová, I., Artnik, B., Bopp, M., Borrell, C., Clemens, T., . . . Lundberg, O. (2016). Changes in mortality inequalities over two decades: Register based study of European countries. *BMJ, 353,* i1732. https://doi.org/10.1136/bmj.i1732
Mackenbach, J. P., Stirbu, I., Roskam, A. J., Schaap, M. M., Menvielle, G., Leinsalu, M., & Kunst, A. E. (2008). Socioeconomic inequalities in health in 22 European countries. *New England Journal of Medicine, 358,* 2468–2481.
Majer, I. M., Nusselder, W., Mackenbach, J., & Kunst, A. (2011). Socioeconomic inequalities in life and health expectancies around official retirement age in 10 Western-European countries. *Journal of Epidemiology and Community Health, 65,* 972–979.
Marmot, M., Allen, J., Bell, R., & Goldblatt, P. (2012). Building of the global movement for health equity: From Santiago to Rio and beyond. *Lancet, 379,* 181–188.
Marmot, M. G., & McDowall, M. E. (1986). Mortality decline and widening social inequalities. *Lancet, 328,* 274–276.
Marmot, M. G., & Shipley, M. J. (1996). Do socioeconomic differences in mortality persist after retirement? 25 year follow up of civil servants from the first Whitehall study. *BMJ, 313,* 1177–1180.
Masquelier, B. (2013). Adult mortality from sibling survival data: A reappraisal of selection biases. *Demography, 50,* 207–228.
Molla, M. T., Madans, J. H., & Wagener, D. K. (2004). Differentials in adult mortality and activity limitation by years of education in the United States at the end of the 1990s. *Population and Development Review, 30,* 625–646.
Mookherjee, D., & Shorrocks, A. (1982). A decomposition analysis of the trend in UK income inequality. *Economic Journal, 92,* 886–902.
Murtin, F., Mackenbach, J., Jasilionis, D., & d'Ercole, M. M. (2017). *Inequalities in longevity by education in OECD countries (1815–2031)*. Paris, France: OECD. Retrieved from https://doi.org/10.1787/6b64d9cf-en
Muszyńska, M., & Janssen, F. (2016). The concept of the equivalent length of life for quantifying differences in age-at-death distributions across countries. *Genus, 72*(1), 6. https://doi.org/10.1186/s41118-016-0011-1
Nau, C., & Firebaugh, G. (2012). A new method for determining why length of life is more unequal in some populations than in others. *Demography, 49,* 1207–1230.
Palloni, A., Massagli, M., & Marcotte, J. (1984). Estimating adult mortality with maternal orphanhood data: Analysis of sensitivity of the techniques. *Population Studies, 38,* 255–279.
Pappas, G., Queen, S., Hadden, W., & Fisher, G. (1993). The increasing disparity in mortality between socioeconomic groups in the United States, 1960 and 1986. *New England Journal of Medicine, 329,* 103–109.
Permanyer, I., García, J., & Esteve, A. (2013). The impact of educational homogamy on isolated illiteracy levels. *Demography, 50,* 2209–2225.
Pincus, T., & Callahan, L. F. (1994). Associations of low formal education level and poor health status: Behavioral, in addition to demographic and medical, explanations? *Journal of Clinical Epidemiology, 47,* 355–361.
Puigpinós, R., Borrell, C., Antunes, J. L. F., Azlor, E., Pasarín, M. I., Serral, G., . . . Fernández, E. (2009). Trends in socioeconomic inequalities in cancer mortality in Barcelona: 1992–2003. *BMC Public Health, 9,* 35. https://doi.org/10.1186/1471-2458-9-35
Regidor, E., Gutiérrez-Fisac, J. L., & Rodríguez, C. (1995). Increased socioeconomic differences in mortality in eight Spanish provinces. *Social Science & Medicine, 41,* 801–807.
Rentería, E., & Spijker, J. (2017, April). *Half a century of education inequalities in adult mortality in Spain: An approach using survey data on parents' survivorship*. Poster presented at the Annual Meeting of the Population Association of America, Chicago, IL.

Rentería, E., & Turra, C. M. (2009, September–October). *Measuring educational differences in mortality among women living in highly unequal societies with defective data: The case of Brazil*. Paper presented at the International Population Conference IUSSP, Marrakesh, Morocco.
Reques, L., Giráldez-García, C., Miqueleiz, E., Belza, M. J., & Regidor, E. (2014). Educational differences in mortality and the relative importance of different causes of death: A 7-year follow-up study of Spanish adults. *Journal of Epidemiology and Community Health, 68,* 1151–1160.
Rogot, E., Sorlie, P. D., & Johnson, N. J. (1992). Life expectancy by employment status, income, and education in the National Longitudinal Mortality Study. *Public Health Reports, 107,* 457–461.
Ross, C. E., & Wu, C.-l. (1995). The links between education and health. *American Sociological Review, 60,* 719–745.
Sasson, I. (2016a). Diverging trends in cause-specific mortality and life years lost by educational attainment: Evidence from United States Vital Statistics Data, 1990–2010. *PLoS One, 11,* e0163412. https://doi.org/10.1371/journal.pone.0163412
Sasson, I. (2016b). Trends in life expectancy and lifespan variation by educational attainment: United States, 1990–2010. *Demography, 53,* 269–293.
Sasson, I. (2017). Reply to Trends in education-specific life expectancy, data quality, and shifting education distributions: A note on recent research. *Demography, 54,* 1215–1219.
Schiaffino, A., Fernandez, E., Borrell, C., Salto, E., Garcia, M., & Borras, J. M. (2003). Gender and educational differences in smoking initiation rates in Spain from 1948 to 1992. *European Journal of Public Health, 13,* 56–60.
Seligman, B., Greenberg, G., & Tuljapurkar, S. (2016). Equity and length of lifespan are not the same. *Proceedings of the National Academy of Sciences, 113,* 8420–8423.
Shkolnikov, V. M., Andreev, E. M., & Begun, A. (2003). Gini coefficient as a life table function: Computation from discrete data, decomposition of differences and empirical examples. *Demographic Research, 8*(article 11), 305–358. https://doi.org/10.4054/DemRes.2003.8.11
Smith, J. P. (2004). Unraveling the SES: Health connection. *Population and Development Review, 30,* 108–132.
Smits, J., & Monden, C. (2009). Length of life inequality around the globe. *Social Science & Medicine, 68,* 1114–1123.
Spijker, J. (2004). *Socioeconomic determinants of mortality differentials in Europe* (Unpublished Doctoral Disertation). Department of Spatial Sciences, University of Groningen, Groningen, the Netherlands.
Steingrímsdóttir, Ó. A., Næss, Ø., Moe, J. O., Grøholt, E.-K., Thelle, D. S., Strand, B. H., & Bævre, K. (2012). Trends in life expectancy by education in Norway 1961–2009. *European Journal of Epidemiology, 27,* 163–171.
Tarkiainen, L., Martikainen, P., Laaksonen, M., & Valkonen, T. (2012). Trends in life expectancy by income from 1988 to 2007: Decomposition by age and cause of death. *Journal of Epidemiology and Community Health, 66,* 573–578.
Timonin, S., Shkolnikov, V. M., Jasilionis, D., Grigoriev, P., Jdanov, D. A., & Leon, D. A. (2016). Disparities in length of life across developed countries: Measuring and decomposing changes over time within and between country groups. *Population Health Metrics, 14,* 29. https://doi.org/10.1186/s12963-016-0094-0
United Nations. (1983). *Manual X: Indirect techniques for demographic estimations*. New York, NY: United Nations Publications.
Van Raalte, A. A., & Caswell, H. (2013). Perturbation analysis of indices of lifespan variability. *Demography, 50,* 1615–1640.
Van Raalte, A. A., Kunst, A. E., Lundberg, O., Leinsalu, M., Martikainen, P., Artnik, B., . . . Mackenbach, J. P. (2012). The contribution of educational inequalities to lifespan variation. *Population Health Metrics, 10,* 3. https://doi.org/10.1186/1478-7954-10-3
Van Raalte, A. A., Martikainen, P., & Myrskylä, M. (2014). Lifespan variation by occupational class: Compression or stagnation over time? *Demography, 51,* 73–95.
Vaupel, J. W., Zhang, Z., & van Raalte, A. A. (2011). Life expectancy and disparity: An international comparison of life table data. *BMJ Open, 1,* e000128. https://doi.org/10.1136/bmjopen-2011-000128
Wardle, J., & Steptoe, A. (2003). Socioeconomic differences in attitudes and beliefs about healthy lifestyles. *Journal of Epidemiology & Community Health, 57,* 440–443.
WHO. (2000). *The world health report 2000—Health systems: Improving performance*. Geneva, Switzerland: World Health Organization.
Wilmoth, J. R., & Horiuchi, S. (1999). Rectangularization revisited: Variability of age at death within human populations. *Demography, 36,* 475–495.
Winkleby, M. A., Jatulis, D. E., Frank, E., & Fortmann, S. P. (1992). Socioeconomic status and health: How education, income, and occupation contribute to risk factors for cardiovascular disease. *American Journal of Public Health, 82,* 816–820.

Wrycza, T. F., Missov, T. I., & Baudisch, A. (2015). Quantifying the shape of aging. *PLoS One, 10,* e0119163. https://doi.org/10.1371/journal.pone.0119163

Zarulli, V., Jasilionis, D., & Jdanov, D. A. (2012). Changes in educational differentials in old-age mortality in Finland and Sweden between 1971–1975 and 1996–2000. *Demographic Research, 26*(article 19), 489–510. https://doi.org/10.4054/DemRes.2012.26.19