

Regional inequalities in life expectancy and lifespan variation by educational attainment in Spain, 2014-18

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Abstract:

Increases in longevity meant that a larger focus was put not only in efficiency (how long we live on average), but also in equity (how equally this longevity is distributed). Such concepts vary not only across space, but also across socioeconomic position. The relationship between life expectancy (an indicator of efficiency) and lifespan variation (a measure of equity) has been analyzed by socioeconomic position (measured in educational attainment) and spatial variation (considering a regional classification) separately, this was not done in a simultaneous fashion before. Therefore, this article intended to produce estimates of life expectancy and lifespan variation indicators (at age 35) by sex and educational attainment, considering data from contemporary Spain (2014-18 period). With these indicators, we also analyzed the relationship of said measures across the territory in a cross-sectional fashion, at a NUTS-2 classification (representing autonomous communities of Spain). With a combination of mortality data files and population exposures by educational attainment, given by the Spanish Institute of Statistics, we were able to produce such estimates.

In all autonomous communities, life expectancy at age 35 was higher (and lifespan variation was lower) for individuals with higher educational attainment. While we could identify a statistically significant association between having a lower life expectancy and a higher lifespan variation for individuals with a lower educational attainment across autonomous communities, it was not the case for individuals with higher educational attainment, where such relationship was not evident. These findings may suggest that across autonomous communities of Spain, the spatial conditions still matter as health determinants, but even more among individuals with a disadvantaged

socioeconomic position, not only in terms of life expectancy but also in terms of a larger lifespan variation.

Keywords: Life expectancy, lifespan inequality, educational attainment, spatial inequality.

1. Introduction:

Unprecedented increases in longevity in the 20th century could certainly be considered a success story (Riley, 2005, 2015). Given the almost universal desirability of living long lives, it is important to look not only at “efficiency”, that being how efficient societies are in generating and sustaining years of life (or how long do we live *on average*) but also at “equity”: how (un)equally distributed longevity (or any other health outcome) is. National level averages inevitably mask some degree of heterogeneity in the underlying distribution of health. In this paper, which focuses on contemporary Spain, we look at two sources of health inequality that, to the best of our knowledge, have never been investigated simultaneously with this particular focus: space (i.e., regional variation) and socio-economic differences (educational attainment). The study of these disparities brings on aggregate value for monitoring the health situation in a given population. On the one hand, regional differences in health are relevant because they reflect contextual factors that might vary within countries: differential provision or access to health, differences in infrastructure, different average living standards, and so on (Cutler et al., 2006). On the other hand, differences in mortality across socio-economic groups (SES) are important because they indicate how those contextual factors affect those individuals from different social standings, revealing the existence of social inequalities and their magnitude (Marmot, 2005).

Unfortunately, mortality differentials by SES are not easily measurable because of the difficulty of accurately linking mortality registers with SES indicators, and they have typically been investigated one population at a time and focusing more on the efficiency aspect rather than the equity aspect. When investigating differences across Spanish regions and SES groups, we look at two fundamental health outcomes: life expectancy and lifespan inequality. While the former is a well-known “health efficiency” indicator measuring the average number of years individuals are expected to live, the later informs us about the variability in the ages at which individuals die – thus being a key marker of health heterogeneity that, according to Van Raalte et al (2018), is

“the most fundamental of all inequalities”, since death is an irreversible state, longer lives are generally more desirable than shorter lives. Furthermore, modern societies tend to benefit individuals who have longer lives: the notion of retirement implies leaving the workforce (ideally, the notion of doing paid work to survive is not necessary anymore, because it is compensated with other monetary benefits). Exploring the relationship between life expectancy and lifespan inequality is important, among other things, to assess whether the normatively desirable goals of (i) living longer lives, and (ii) sharing them equitably (i.e., long lives are enjoyed by everyone), can be achieved simultaneously or not. In general, while these two health indicators tend to be negatively related (i.e., higher life expectancy tends to be associated with lower lifespan inequality (Aburto et al., 2020; Smits & Monden, 2009; Vaupel et al., 2011) very little is known about their relationship when we differentiate across SES groups and the analysis is performed at the regional level. A few studies have investigated the joint behavior of these measures either across SES groups (e.g., van Raalte et al 2014, Sasson 2016, Permanyer et al 2018) or at the regional level (Illsley & Le Grand, 1993; Wilson et al., 2020, Seaman et al 2019), but not combining both factors simultaneously – an issue we will address in this paper.

2. Background

Social and Spatial Differences in Mortality

In a way, mortality represents the final chapter of the biographies of individuals, and as a result, it is considered the ultimate indicator of the health of individuals (Rosero-Bixby & Dow, 2009). The existence of a positive relationship between health and socioeconomic status or position of individuals is not surprising and is something of common knowledge. But as Preston & Taubman (1994) point out, identifying the magnitude of such association is critical for the scientific dimension.

In health research, the socioeconomic position of individuals refers to their standing in a hierarchical social structure and is related to a series of social and economic factors that influence or determine such standing (Galobardes et al., 2006; Lynch et al., 2000). Those factors are usually associated with income, wealth, educational attainment, and other aspects relevant to the well-being of individuals (Brown et al., 2003). Since those aspects that indicate the social position are generally

correlated, they have been used alternatively for different studies in the matter as proxies. The social position of an individual does not work by itself as a mechanism that results in better health but could be related to the possibility of adopting certain technologies that are critical for ensuring their good health (Fogel & Costa, 1997). Furthermore, by being exposed to a certain accumulation of risks across the life course (e.g., working in physically demanding jobs, engaging in activities that may be detrimental for health like alcohol or drug consumption), individuals may present better or worse health outcomes that are socially mediated (Marmot, 2005).

It is also apparent from the latter that the aspects that are linked with poor health outcomes cannot be purely individual, but often the structural, material, and social conditions of the environment in which people live their lives must also be considered. Spatial inequalities in health, as their name suggests, are the result of unequal access to new technologies and distribution of resources (health provisions, medical care, sanitation, food rich in nutrients). From a population standpoint, those inequalities usually manifest in several negative health outcomes, including mortality (Chetty et al., 2016; Regidor et al., 2016; Reques et al., 2015; Vierboom et al., 2019). Even with similar deprivations at a household level or a similar individual socioeconomic position, individuals who have access to proper health facilities or even good paved roads could have a health advantage when compared to those lacking such access. Social relationships happen in space, and social inequalities occur at a spatial level as a result, in an existing material context (Lynch et al., 2000). In this approach, inequalities come from differential exposure to certain life-long experiences and situations that negatively impact the health of individuals. This exhibition is usually accompanied by a lack of resources of different kinds (social, physical, or health), both individually and at the general level, combining human, cultural and sociopolitical processes (Lynch et al., 2000). And many times, it is the presence and aptitude of health, technology, and social protection systems throughout the territory that have played a leading role in increasing not only the length but also the quality of life of individuals (Behrman, Sickles and Taubman, 1998). Henceforth, considering the spatial dimension is critical for identifying health inequalities.

Key Measures of health and mortality: the need to go beyond averages.

Traditionally, life expectancy at birth has been used as one of the key indicators to compare mortality levels across populations by demographers, actuaries, and other professionals and scientists. Life expectancy is a construct that is derived from an artifact known as a life table or mortality table (Preston et al., 2001). Life expectancy enjoys well-deserved popularity because it has some important properties that make it desirable for analysis. Not only it can deal with differential age-structure components and give a net measure of mortality (unlike crude death rates), but life expectancy also offers an easily interpretable indicator that is based on time (years, conventionally).

This measure, while undeniably powerful and useful to measure the mean level of mortality, also has some limitations. One of such limitations is based around the idea that life expectancy is an measure that gives an average value. Why this could be seen as a limitation? Because it assumes a given cohort would live a certain quantity of time on average, but it does not tell us about the dispersion of mortality (Van Raalte et al., 2018). Two populations can have the same life expectancy but very different patterns in terms of distribution of deaths in a life table: mortality can be expanded, with a larger proportion of deaths occurring at younger ages, or compressed, with a larger proportion of deaths population occurring at older ages (Kannisto, 2000)

While some individuals from a more disadvantaged socioeconomic position may outlive others from a more advantaged socioeconomic position (Vaupel et al., 2021), lower life expectancies are associated with higher variabilities in the time of death (Németh, 2017; Vaupel et al., 2011), resulting in a double burden: those who had higher mortality, also tended to have a higher age-of-death variability, which can be related with a higher number of premature deaths (Permanyer et al., 2018; Seaman et al., 2019)

The increase in heterogeneity (expressed in a larger group variation) also allows identifying worse health conditions for a particular group, usually associated with preventable causes. For instance, most pension systems are designed by considering average life expectancy, but in a high variability scenario with some strong inequalities in lifespan, such design may be unbalanced, favoring some individuals with better health and increasing social inequality, working regressively (Brønnum-Hansen, 2017). This implies that the study of variations in lifespan and health is not only theoretically important for understanding demographic dynamics in a given population, but also for very practical reasons. From a policymaker's point of view, it may allow a more efficient allocation of resources in health, to the design of pension systems that regard

equity as an important principle. From an individual standpoint, higher knowledge of how uncertainty in lifespan operates could provide insights into some critical decisions, such as applying for a mortgage or getting particular life insurance (Edwards, 2013).

Therefore, in the last years researchers focused on the importance of individual lifespans as a focal point for inequalities, and developed a series of indicators to consider lifespan variability in a population (Edwards & Tuljapurkar, 2005; van Raalte & Caswell, 2013; Vaupel et al., 2011 among others). However, it should be noted that lifespan inequality indicators do not seek to replace life expectancy, but to provide an additional dimension to the health situation of a particular population, with an emphasis on variability. After all, just like life expectancy, lifespan inequality measures are derived from a life table, so they are not entirely independent from each other (Aburto et al., 2019).

3. Previous contributions

Health inequalities across space and social class have been very well documented in the literature (Brønnum-Hansen, 2000; Gallo et al., 2012; J. P. Mackenbach et al., 1997; Regidor et al., 1995; Reques et al., 2015). Likewise, the literature on lifespan inequality has been expanding considerably since the turn of the 21st century, with many studies focusing on trends at a national level (Aburto & van Raalte, 2018; Le Grand, 1987; Permanyer & Scholl, 2019; Seaman et al., 2016; Vaupel et al., 2011, among others). However, studies investigating differences in life expectancy and lifespan inequality across sub-national regions or socioeconomic (SES) groups are much scarcer. On the one hand, studies by different proxies of SES (educational attainment, occupational class, disposable income) were done previously at a national level (Brønnum-Hansen, 2017; Permanyer et al., 2018; Sasson, 2016; van Raalte et al., 2014; Van Raalte et al., 2018). On the other hand, studies at subnational units were conducted without considering the SES component (Illsley & Le Grand, 1993; Wilson et al., 2020). Seaman et al. (2019) also analyzed lifespan variation at a subnational level, differentiating by deprivation-based areas as a proxy of the overall SES of those spatial units. However, it does not analyze within group variance, (which would be possible only by calculating measures for different SES groups by spatial units).

From a Spanish-based perspective, life expectancy increased rapidly in the country, after being considered somewhat of a laggard during the first half of the 20th century, according to the Human Mortality Database. However, previous studies indicate that, in spite of these accelerated improvement significant differences in mortality persist at a regional level (Gispert et al., 2007; Miqueléz et al., 2015; Regidor et al., 2011; Regidor et al., 1995; Reques et al., 2015), indicating that autonomous communities such as Andalusia or Extremadura (some of the poorest of Spain) had a higher mortality than the average of the country. These inequalities were also evident when considering differential educational attainment (Blanes & Trias-Llimós, 2021; Permanyer et al., 2018; Reques et al., 2015), with a higher mortality in lower educated individuals.

Studies on Spain that focus on socioeconomic differentials at an individual level have been scarce, given the difficulties to obtain individual level data on mortality at national level. This has meant that previous studies studying socioeconomic differences on mortality focused on some particular regions (Huisman et al., 2004; J. Mackenbach et al., 2008) and that were performed at an aggregate level data (Miqueleiz et al., 2015; Regidor et al., 2016; Reques et al., 2014, 2015). Some of these studies (Mackenbach et al., 2009; Reques et al., 2014) indicated that mortality differences by educational attainment in Spain seemed to be smaller when compared to other European countries. Furthermore, other studies indicate that there is a high level of correlation in death rates for the lower educated population across autonomous communities in Spain, but not for the higher educated (Miqueleiz et al., 2015; Reques et al., 2015). This would suggest that space is a stronger determinant of mortality for the lower educated people than the higher educated in Spain. However, the role of lifespan inequality and its relationship with life expectancy across regions remain unknown.

To our knowledge, the present paper is the only study so far that combines differential mortality by educational attainment and lifespan variation measures (within group variation) across subnational units (between group variation).

4. Materials and Methods:

For this analysis, we used a combination of data sources. We performed a cross-sectional type of analysis considering deaths and population exposures by sex and

educational attainment in each Autonomous Community (the first-level political and administrative units) of Spain.

Population exposures resulted from summing the reported population from 2014 to 2018 (having 1st of July of 2016 as the center point for population exposure) and deaths for the same period, both provided by the Spanish National Institute of Statistics (Instituto Nacional de Estadística or INE). The mortality file from INE provided death counts and population exposure by sex and educational attainment for each one of the autonomous communities in Spain, which are equivalent to the European standard NUTS-2 classification: Andalusia, Aragón, Asturias, Balearic Islands, Canary Islands, Cantabria, Castile and León, Castile – La Mancha, Catalonia, Valencian Community, Extremadura, Galicia, Madrid, Murcia, Navarra, Basque Country, La Rioja, Ceuta and Melilla (which, due to data constraints, were considered together for this analysis). Figure 1 presents the geographical distribution of those autonomous communities in the country. INE used a matching algorithm linking registered deaths to population databases, including censuses, municipal population registers, the ministry of education, and the Public State Employment Service, to obtain the deaths according to educational attainment, when possible. This mortality data was used successfully by Permanyer et al (2018) to measure both life expectancy and lifespan variability trends in Spain (at a national level). The INE also provided the total estimates of population by sex, age, and educational attainment in Spain. With these registers, we can determine, at an aggregate level and for each autonomous community, death counts and population exposures in the chosen period.

Figure 1: Map of Spain by Autonomous Communities.

Key:

1. Andalusia
2. Aragon
3. Asturias
4. Balearic Islands
5. Canary Islands
6. Cantabria
7. Castile & León
8. Castile-La Mancha
9. Catalonia
10. Valencian Community
11. Extremadura
12. Galicia
13. Madrid
14. Murcia
15. Navarra
16. Basque Country
17. La Rioja
18. Ceuta and Melilla



Source: Author's elaboration

The bottom truncation for the estimations was set at age 35, to give a reasonable amount of time for individuals to complete their educational attainment. To make comparisons as robust as possible we decided to establish two separate groups in terms of educational attainment as a proxy of socioeconomic position. As previously stated, education, income, and aspects that suggest individuals' social position are often strongly correlated. However, educational achievements are considered a more stable attribute, while income is often a more fluctuating feature throughout life (Smith, 2004). We opted to split between individuals with lower educational attainment (individuals who, at most, completed the first cycle of secondary education, which is equivalent to 8 years of mandatory schooling, or level 2 in the normalized ISCED-2011 classification) and individuals with higher educational attainment (who had more than 8 years of education, or ISCED-2011 level 3 and above). This is partly due to relative data scarcity in some autonomous communities, but also, due to strong compositional differences in regards to the value of education in terms of socioeconomic position: some years ago, having a university degree was less frequent, and earning a secondary degree was enough to relate to a strong socioeconomic position. That being said, and despite the rapid expansion of education in Spain, many adults still have not reached the 8 years of

education, making the cutoff point reasonable and robust enough for the analysis. From now on we will refer to these two groups as LEA (Lower Educational Attainment) and HEA (Higher Educational Attainment) respectively. Educational attainment could not be identified in less than 1% of the overall deaths. Therefore, a single mean proportional imputation was used to establish the educational attainment for those cases. We will be using the open-end interval for ages 100 and above as the closing value for the life table (top truncation).

Given that we are dealing with single age interval death counts and exposures, fluctuations may occur at a given age in regards to the distribution of deaths. Therefore, we opted for smoothing the death counts by considering the common in the literature assumption that mortality followed a Poisson probability distribution (Scott, 1981). We fitted death counts by performing a one-dimensional Poisson P-spline, specially tailored for mortality data, using the *MortalitySmooth* package (Camarda, 2012). Once deaths were smoothed, death rates by single age intervals were simply calculated as the quotient between the smoothed deaths and the given population by educational attainment.

In the analyzed period, a total of 1.626.092 deaths were reported: 806.057 for females and 820.035 for males. Additional details can be found in the appendix (see Table 1A), along with the population distribution in Spain by age (Figure 1A in the appendix), where it can be seen that as age increases the absolute number of individuals with a higher educational attainment decreases.

Longevity and lifespan variation indicators

We estimated life expectancy at age 35 (for a detailed explanation on how to compute life expectancies, see Preston et al., 2001).

As we mentioned, in the last years several ways to calculate measures of lifespan variability were developed, that express both absolute and relative values (for a good review of those indicators and methods, see van Raalte and Caswell, 2013). Those measures are strongly correlated to each other and offer similar results in terms of interpretation.. There is no clear consensus if absolute or relative measures are better for measuring those inequalities in health, and within those categories, which measures are better for capturing lifespan variability (although in the literature all have been used to a degree with success). Therefore, we opted to present a pair of measures, which are

perfectly dependent on each other: life disparity and the life table entropy index (an absolute and relative measure, respectively).

Life disparity (colloquially known as e-dagger or e^\dagger) is an absolute measure of inequality (i.e., its values are not affected when the same constant is added to all elements of the distribution) that expresses the number of life-years lost due to death (van Raalte & Caswell, 2013; Vaupel et al., 2011; Vaupel & Canudas-Romo, 2003). The smaller the value, the smaller the variation of the age at death in a given population. In the limit, if everyone died at the same age, e^\dagger would be zero. Life disparity is expressed as the result of the sum of deaths by the mean life expectancy (in this case life expectancy at age 35, which is the starting age):

$$e^\dagger(35) = \frac{1}{l_{35}} \sum_{y=x}^{\omega-1} d_y \bar{e}_y$$

being the l_{35} the quantity of survivors at age x , d_y the life table death distribution and \bar{e}_y the remaining life expectancy at a given age y .

The Life Table Entropy (also known as \bar{H} or Keyfitz-Leser entropy) was first derived by Leser (1955) but it was proposed as a lifetable function by Keyfitz (1977) and can be considered as the relative counterpart for life disparity. Life Table Entropy is a relative measure of inequality (i.e., its values remain unchanged when all elements of the distribution are re-scaled by the same constant) that is obtained simply by dividing the life disparity $e^\dagger(x)$ by the mean value of life expectancy \bar{e}_x in a given age (in this case, age 35). Just like life disparity, a higher value of \bar{H} indicate a larger inequality in the corresponding age at death distribution. This measure has the property to capture the dimensionless variation in length of life when compared to life expectancy at birth or at a given age (which means, its value is not dependent on the chosen initial age)

$$\bar{H}(35) = \frac{e^\dagger_{35}}{\bar{e}_{35}}$$

We also calculated the overall standard deviation (SD) across each of those indicators for autonomous communities. And we also looked for correlations between life

expectancy and lifespan variation indicators across autonomous communities separately by sex and educational attainment together with linear graphical associations.

Other relevant information such as the absolute distribution of deaths, death rates and the population exposures by educational attainment (LEA/HEA) and sex (M for Males and F for Females respectively) for Spain can be found in the appendix (Figures 1A to 3A in the appendix). As expected, death rates for males were higher than for females, independently of educational attainment, and the LEA group had a higher mortality than the HEA group (Figure 2A). It also can be seen that at younger ages, the majority of the population has a higher educational attainment, but near age 55, the group with the lower educational attainment outnumbers them (Figure 3A). This composition change is the result of the greater access to education that has occurred in Spain (and in many other societies around the world) in the last decades.

5. Results:

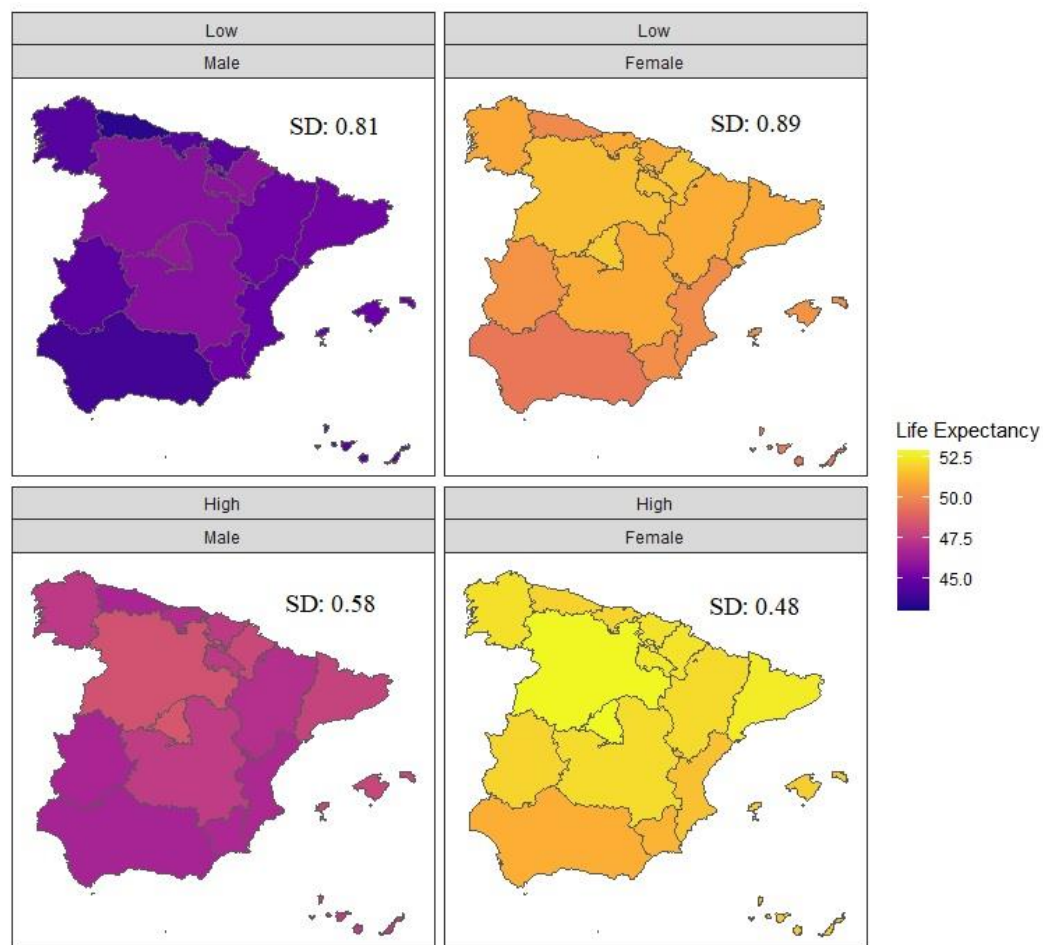
Analysis of life table functions and indicators:

Figure 2 presents the results of the estimates for life expectancy at age 35, separately by sex and educational attainment for each autonomous community and overall for Spain (Canary Islands were put at the bottom right end, below Balearic Islands). As we can observe, in all cases life expectancy at age 35 was higher for individuals with HEA in comparison to their LEA counterparts. Those differentials were larger for males than for females: differences were between almost 2 and 3.3 years for males, and between one and two years in the majority of cases for females. At the national level, the average difference in life expectancy by educational attainment was 2.6 years for males and 1.6 years for females. Additional details can be found in the appendix (tables 2A to 4A). The autonomous communities of Madrid, Castile & León, Basque Country, La Rioja and Navarra tended to present the largest life expectancies and Andalusia, Murcia, Extremadura and Asturias the lowest life expectancies.

When comparing males with females who have the same educational attainment, we can observe that differences in life expectancy at age 35 were larger in individuals who are part of the LEA group than those who are in the HEA group. The standard deviation of the life expectancy indicator across autonomous communities was larger for individuals in the LEA group when compared to their HEA counterparts. SD was larger for males

than for females in the HEA group (0.58 vs 0.48 SD respectively), and interestingly enough, the opposite occurs at the LEA group (0.81 SD for males and 0.89 SD for females). This seems to indicate that lower educated females have the highest heterogeneity for this indicator, and higher educated females are the more homogeneous of the four combinations.

Figure 2: Life expectancy at age 35 and above by sex and educational attainment in Spanish autonomous communities

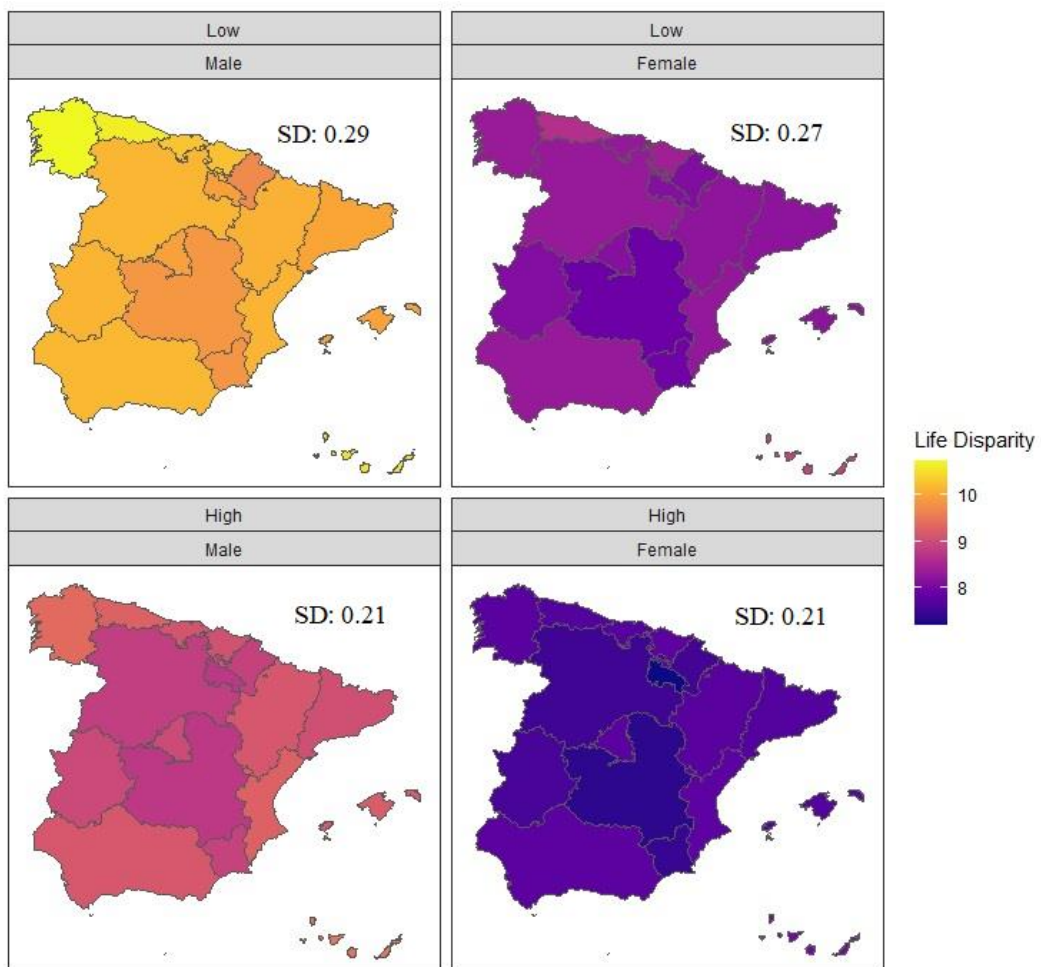


Source: Authors' Calculations based on INE

Figure 3 presents the results of the estimations for life disparity at age 35 and above across autonomous regions. In general terms, Murcia, Castile-La Mancha, La Rioja and Basque Country had the lower values of life disparity, and Galicia and Asturias the higher values. Individuals in the LEA group tended to present higher values (ranging from 9.7 and 10.7 years for males and 7.9 to 9 years for females) than their counterparts in the HEA group (with values between 8.8 to 9.5 years for males and 7.2

to 8.1 years for females). When considering the overall estimation for Spain, the gap in variability by educational attainment for males (slightly above one year) practically doubled the estimation made for females (0.5 years). As expected, the sex gaps at a national level, were wider for individuals belonging to the LEA group (with a nearly 1.9 years differential) than for the HEA group (the sex gap being 1.38 years in that case). In terms of variability across regions, SD was larger for males and females with LEA (0.29 and 0.27 SD respectively) when compared to their HEA counterparts (0.21 SD both for males and females), which may imply that the latter group have a greater homogeneity, independently of sex.

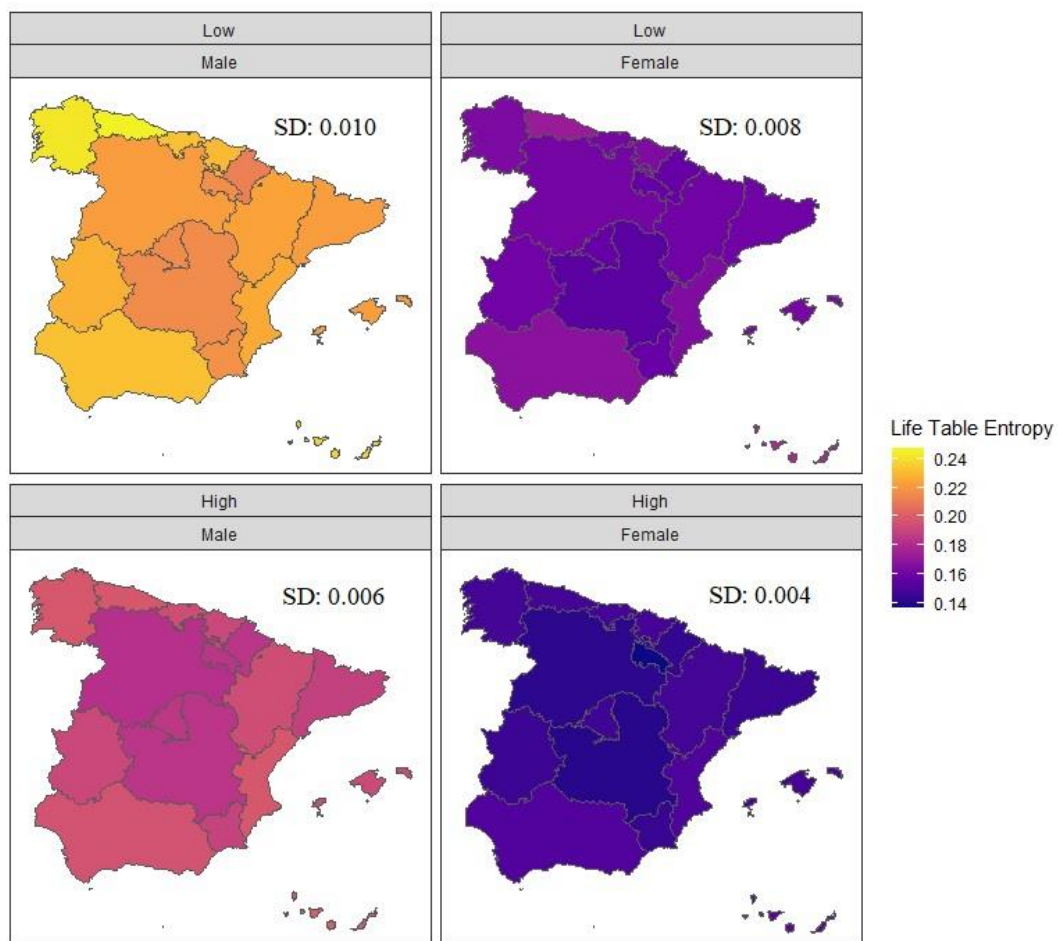
Figure 3: Life disparity at age 35 and above by sex and educational attainment in Spanish autonomous communities



Source: Authors' Calculations based on INE

Figure 4 presents the results of the life table entropy index, or H, at age 35 for the autonomous communities. Just like the previous case, the same autonomous regions are highlighted by their more extreme values. Results in figure 4 indicate that males are those who had a higher variability, and also that difference by educational attainment tended to be higher for males than for females. It also has to be noted that like the previous cases, differences by sex for the LEA group were larger than for the HEA group across regions. Standard deviation, as was the case for previous indicators, was larger for those with a lower educational attainment (0.010 SD for males and 0.008 for females) and smaller for those with a higher educational attainment (0.006 SD for males and 0.004 for females) across autonomous communities.

Figure 4: Life Table Entropy between ages 35 and above by sex and educational attainment in Spanish autonomous communities

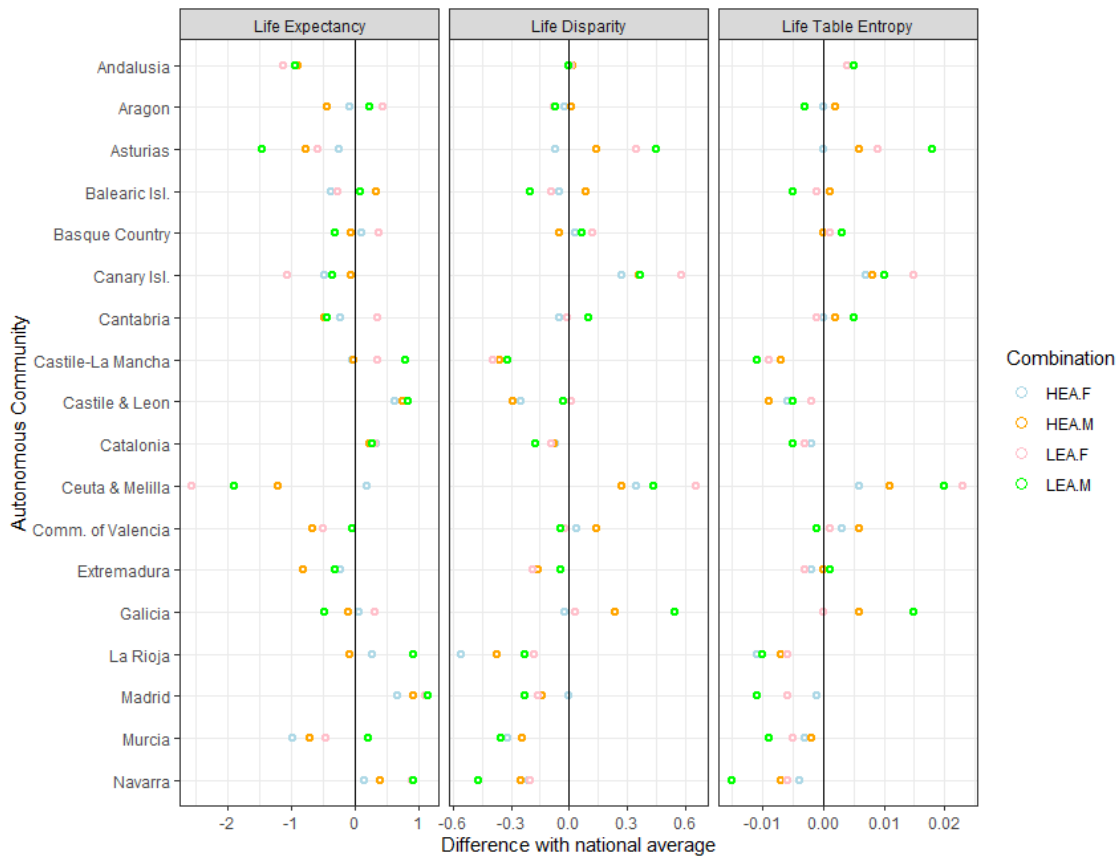


Source: Authors' Calculations based on INE

Comparison with national average and between indicators

To summarize the health situation of the autonomous communities individually, Figure 5 shows the difference of the values obtained for autonomous communities minus the value of the national average for the analyzed indicators. Positive differentials indicated a higher value than the national average (which is desirable for indicators like life expectancy) and negative values would be a lower value when compared to the overall country (which for life disparity or the life table entropy should mark a better performance than the average). This was done for all the four available combinations of sex and educational attainment. The Figure 5 indicates which autonomous communities consistently presented values below the mean (as is the case of Andalusia or the Canary Islands) and which ones tended to be above the mean (as is the case for Madrid, Castile & León or Navarra). The relationship between life expectancy and lifespan inequality is not that clear in some cases, given that in certain communities there was a degree of heterogeneity in the differentials: Extremadura or Murcia, for instance, have lower life expectancies than the national average but also a lower life disparity at age 35 when compared with the average. Another example of this could be seen in Basque Country and La Rioja, where females fared better when compared to the national average both in life expectancy and lifespan variation, but this was not the case for males. Finally, there are cases of autonomous communities where the opposite occurred, such as the Balearic Islands, Madrid, Navarra. Interestingly enough, in many autonomous communities, some indicators, like life expectancy, present positive differentials when compared to the national average for the LEA group, but negative for those in the HEA group, as it seems to be the case for Aragon, Canary Islands or the Valencian Community, to name a few examples of this trend. In other words, this acts as a remainder of the complexity of how health indicators fare for different combinations of sex and educational attainment when considering the spatial dimension.

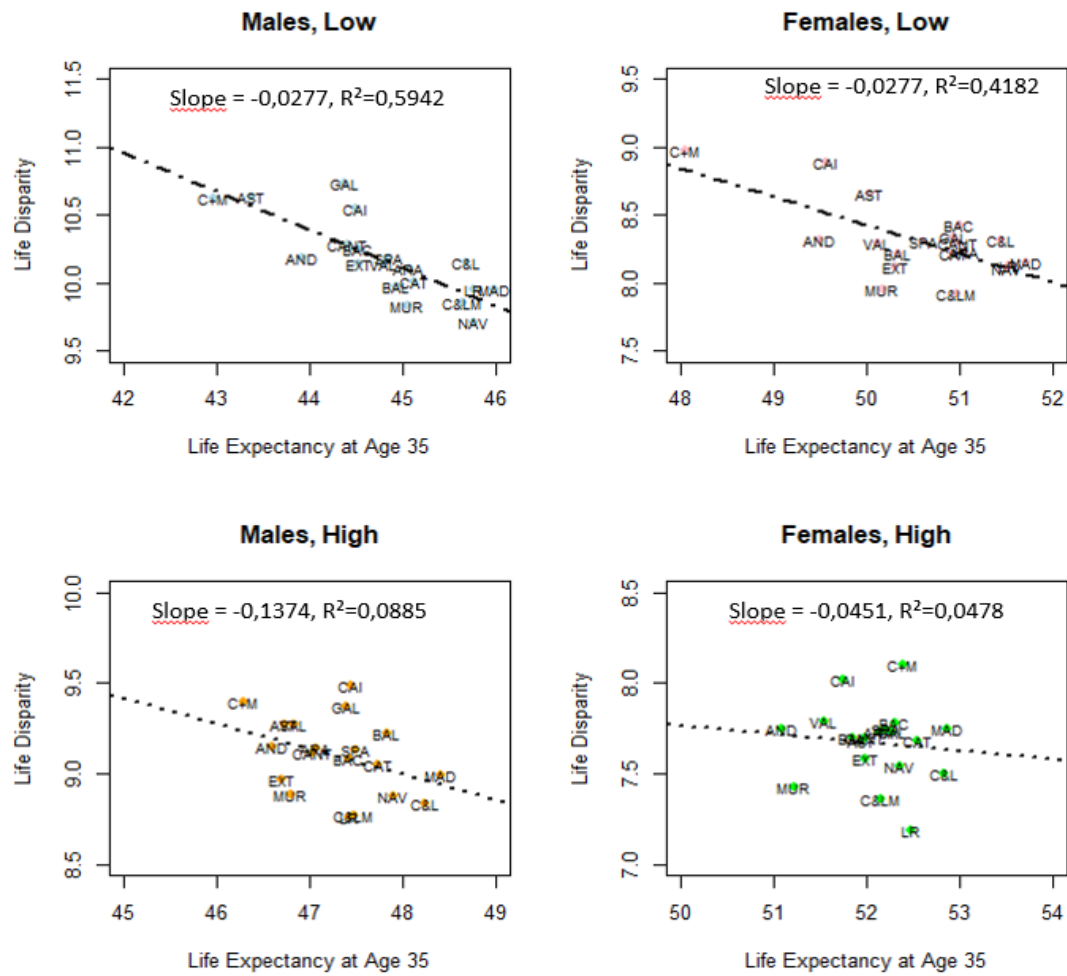
Figure 5: Difference between the autonomous communities and Spain for selected indicators at age 35.



Source: Authors' Calculations based on INE

To visualize the relationship between remaining life expectancy at age 35 and life disparity/life table entropy at age 35 and above, we did a simple series of cross-sectional scatterplots (separately by sex and educational attainment, given the scale disparities), as shown in Figure 6. Correspondingly, Figure 7 presents the relationship between life expectancy and life table entropy. This was done to explore the relationship between life expectancy and lifespan variation measures for each combination of sex and educational attainment and sex. The figures indicate that, at least at an ecological level, there does seem to be a significant association between Life Expectancy and Life Disparity in individuals with a lower educational attainment (with the slope of the line indicating that lower life expectancy correlates with higher life disparity), and considering the values of the adjusted R^2 , it is even stronger for the life table entropy, present in figure 7. However, this was not the case for individuals with higher educational attainment in both sexes and types of measures, where the relationship between life expectancy and lifespan variation measures was not evident.

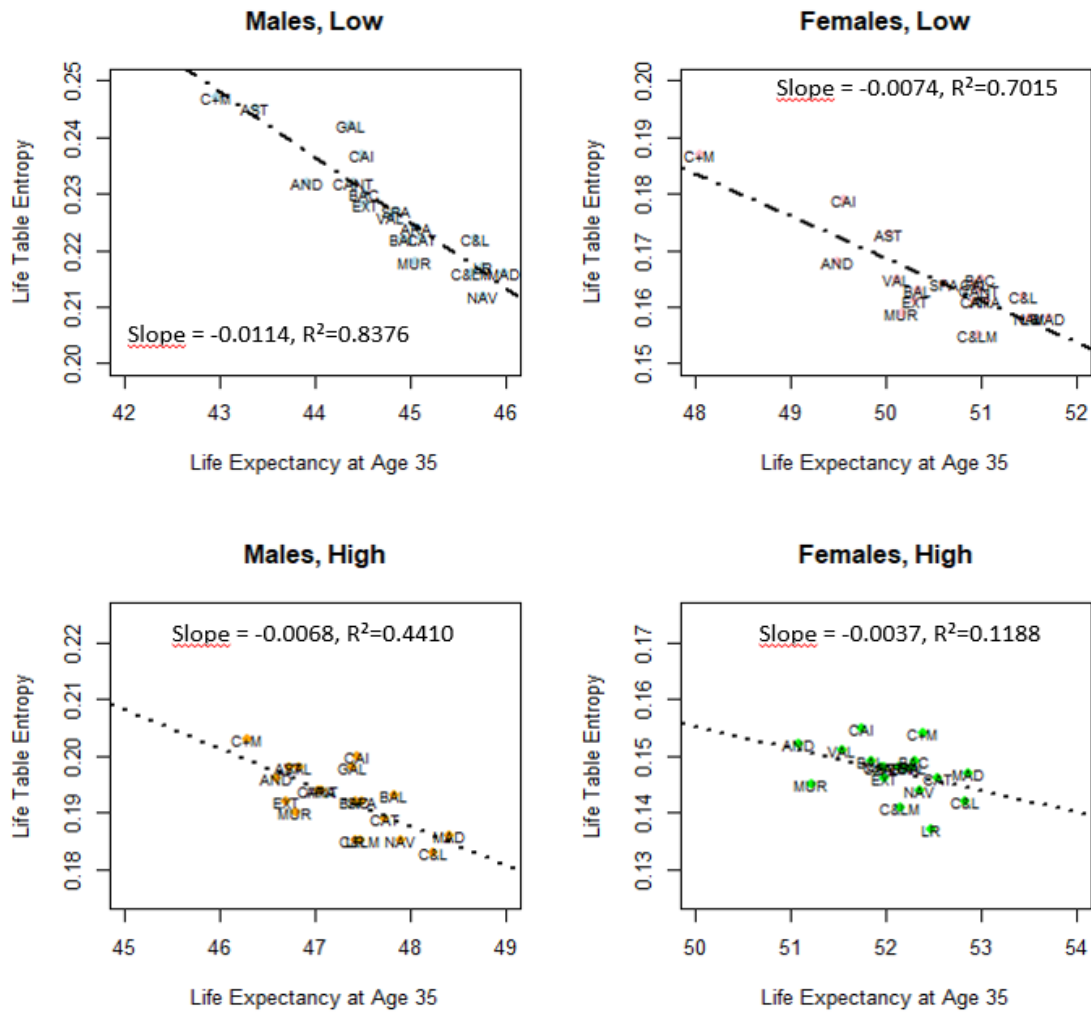
Figure 6. Scatterplot Between Life Expectancy and Life Disparity by sex and educational attainment across autonomous communities, Spain 2014-18.¹



Source: Authors' Calculations based on INE

Figure 7. Scatterplot Between Life Expectancy and Life Table Entropy by sex and educational attainment across autonomous communities, Spain 2014-18.

¹ Key: AND (Andalusia), ARA (Aragon), AST (Asturias), BAC (Basque Country), BAL (Balearic Islands), CAI (Canary Islands), CANT (Cantabria), CAT (Catalonia), C+M (Ceuta & Melilla), C&L (Castile and León), C&LM (Castile-La Mancha), EXT (Extremadura), GAL (Galicia), LR (La Rioja), MAD (Madrid), MUR (Murcia), NAV (Navarra), VAL (Valencian Community)



Source: Authors' Calculations based on INE

6. Discussion and Conclusions

General findings:

This article, on the one hand, presents some findings that are confirmatory: that in all autonomous communities of Spain, the remaining average life expectancy at age 35 was lower for those individuals with a lower educational attainment. The gap favoring those individuals with a higher educational attainment, on average, was 2.6 years for males and 1.6 years for females at a national level, but with differences between 1.65 and 3.3 years in some autonomous communities for the former and between 1 and 2 (with a clear outlier of 4 years in the small overseas territories of Ceuta and Melilla) for the latter. When comparing the sex gap in individuals with similar

educational attainment, we saw that differentials (females minus males) were larger for those with lower educational attainment, and narrower for those with higher educational attainment. This statement may be consistent with the notion that a better socioeconomic position may be more “protective” in general for males in terms of life expectancy gains (Gallo et al., 2012; Kitagawa & Hauser, 1973; Permanyer et al., 2018; Sasson, 2016; van Raalte et al., 2012). However, the difference of life expectancy and lifespan variability compared with the national average changed by sex and educational attainment across the different autonomous communities, reminding us the unique role that space has when interacting with other dimensions that give shape to a population.

On the other hand, for the first time, this paper has described inequalities in lifespan variability (using both absolute and relative measures) in Spain at a subnational level, considering sex and educational attainment. In a similar fashion as differences in life expectancy, the educational gap (HEA minus LEA) was wider for males than for females, and wider for males than females with a similar educational attainment. Seaman et al., (2019) suggested that variations in age-at-death were larger for the more deprived areas, and that for the least deprived areas the age-at-death distribution tended to be more equal, so we believe that our findings are in line with such claims. Another of the main findings in this article is that we identified a strong negative linear relationship between average remaining life expectancy at age 35 and remaining life disparity at age 35 and above for those individuals with a lower educational attainment (lower life expectancy tends to result in higher age-at-death variability) across autonomous communities, but such relationship was not evident for those who had a higher educational attainment, where a linear relationship is not apparent. While such relationship between life expectancy and lifespan variation measures was tested previously at a cross-national level (Vaupel et al., 2011; Aburto et al., 2020) or at a regional level (Wilson et al., 2020), the differential strength of such relationship by educational attainment was not evident before. It is noteworthy that the relationship between life expectancy and lifespan variation measures was stronger among the lower educated individuals independently of sex, even if females in the LEA group have a lower mortality than males in the HEA group.

These results seem to suggest that space matters, but even more so for individuals with a lower educational attainment when discussing, not only health and mortality on average, but also its variability. Or to consider the opposite, space may not be that relevant in terms of mortality and lifespan variation for those with a more

advantaged socioeconomic position, given the fact that the lack of a strong correlation between life expectancy and lifespan variability for those individuals. The figure of Education (and/or the mechanisms that is correlated to) could be associated with reducing lifespan variation at a spatial level. This could be because the higher educated individuals are part of a more homogeneous group than the lower educated. This has public policy implications, given that lifespan inequality is relevant to certain institutions: From a pension standpoint, this could imply that more equity on the system could be achieved with a dedicated focus on individuals with larger remaining lifespan variability (in this case, individuals with a lower educational attainment that live in particular autonomous regions). From a healthcare and public policy perspective, more resources for these particular groups could possibly reduce variability across regions.

We also have to remind that the particular constitution of groups chosen for this study has a great deal of heterogeneity, given the rather arbitrary merging of different educational groups. A different configuration could possibly present a different outcome: for instance, comparing only individuals with no education with those with post-university degrees will probably give a wider differential in life expectancy. Therefore, an average differential of 2.65 years in life expectancy (the average differential in life expectancy presented in males for the HEA minus LEA group) across two given groups may be hiding a greater degree of inequality in mortality, and the association between life expectancy and lifespan inequality may have a different strength if another educational categorization was presented instead.

This paper has some limitations. First of all, the role of educational attainment as a proxy for socioeconomic position, while reliable, is imperfect: since we are analyzing outcomes at an individual level (mortality by the educational attainment of individuals), we are not able to measure any effects related to the household composition, income, or any differential assets that they may have that might affect their socioeconomic positions, limiting the scope of the conclusions. There is also the nature of causation when considering the impact of educational attainment: is education just a proxy for socioeconomic position, or does it offer by itself some mechanisms that directly affect the probabilities of dying? More educated individuals may choose to avoid exposure to behaviors that may be detrimental for their own health (Cutler et al., 2006; Marmot, 2005; Smith, 2004; Soares, 2007), but this could explain only a part of all of the differential shown here. With the data at hand, we are not able to decipher which causal mechanisms are operating here.

We also would like to highlight the matter of age truncation used to produce the estimates. Spain is considered a low mortality country, therefore, choosing age 100 and above as the top truncation may produce slightly different estimates than if we tried to model the mortality curve for the centenarians with other statistical procedures (that could inevitably rely in strong and potentially unjustified assumptions) . But since the number of survivors after age 100 is relatively small (and that starting age is 35), we believe that the produced estimations are a very reasonable reflection of the overall mortality of each group and any potential differences with a different truncation would be minimal (and irrelevant to the trends and gradients presented in this paper).

Finally, there is also the question of temporal availability: unfortunately, the provided data were good enough to perform a single estimate in a given period, instead of a trend analysis, as is the case with other studies in Spain (Permanyer et al., 2018 the clearest example). However, unlike the Permanyer et al., study, we were available to provide estimates for each autonomous community in Spain and to verify the relationship between life expectancy and lifespan variation by educational attainment. Furthermore, we were able to explore how the relationship between life expectancy and lifespan variation measures changes its intensity for different levels of educational attainment, something that was not been documented before at the regional/subnational level. Future research should be focused on the mechanisms that result in such variation, and also considering the critical role of space as a health determinant (both in terms of average mortality and variability) for individuals with a lower socioeconomic position.

Acknowledgments:

Some of the results presented in this paper are part of the ongoing Doctoral Dissertation of Octavio Bramajo to obtain the degree of Doctor in Demography from the Autonomous University of Barcelona. Funding for this study was provided from the ERC Consolidator given to Iñaki Permanyer as a Principal Investigator (Grant Number 864616), project “Healthy Lifespan Inequality: Trends, Measurements and Determinants” (HEALIN) and by a FI-AGAUR 2021 doctoral grant, which Octavio Bramajo is recipient of.

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Appendix:

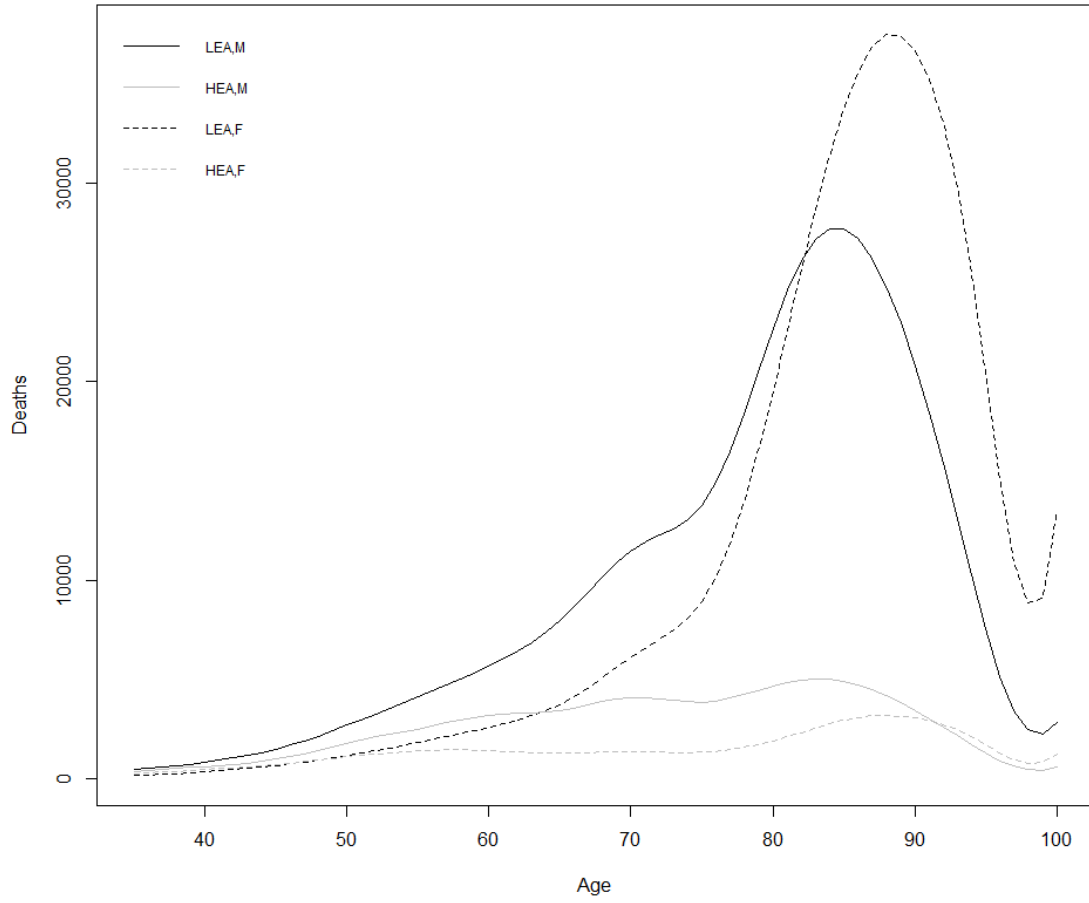
Table 1: Distribution of population exposures by sex and educational attainment in Spanish Autonomous Communities 2014-18

Autonomous Community	Sex	LEA	HEA	Autonomous Community	Sex	LEA	HEA
Andalusia	Female	6445472	3968366	Valencian Community	Female	3828733	2614802
	Male	5845334	3879646		Male	3553056	2487877
Aragón	Female	969632	798273	Extremadura	Female	921506	474049
	Male	855882	814719		Male	879383	445165
Asturias	Female	868292	713754	Galicia	Female	2418500	1545269
	Male	689646	688085		Male	2079526	1438246
Balearic Islands	Female	740665	652364	Madrid	Female	3777202	4743290
	Male	727641	633220		Male	2932183	4491890
Canary Islands	Female	1512654	1179128	Murcia	Female	1059735	675234
	Male	1478159	1132293		Male	1022953	666089
Cantabria	Female	426083	389916	Navarra	Female	419610	407107
	Male	364494	377865		Male	383265	403021
Castile and León	Female	1976932	1485780	Basque Country	Female	1487264	1569084
	Male	1837312	1425567		Male	1122746	1622858
Castile- La Mancha	Female	1651764	894128	La Rioja	Female	223429	191833
	Male	1609617	882271		Male	209509	184595
Catalonia	Female	5041236	4646264	Ceuta & Melilla	Female	53134	33372
	Male	4396655	4498358		Male	49693	39826

	Spain	Female	33873823	27011262
		Male	30037054	26111591

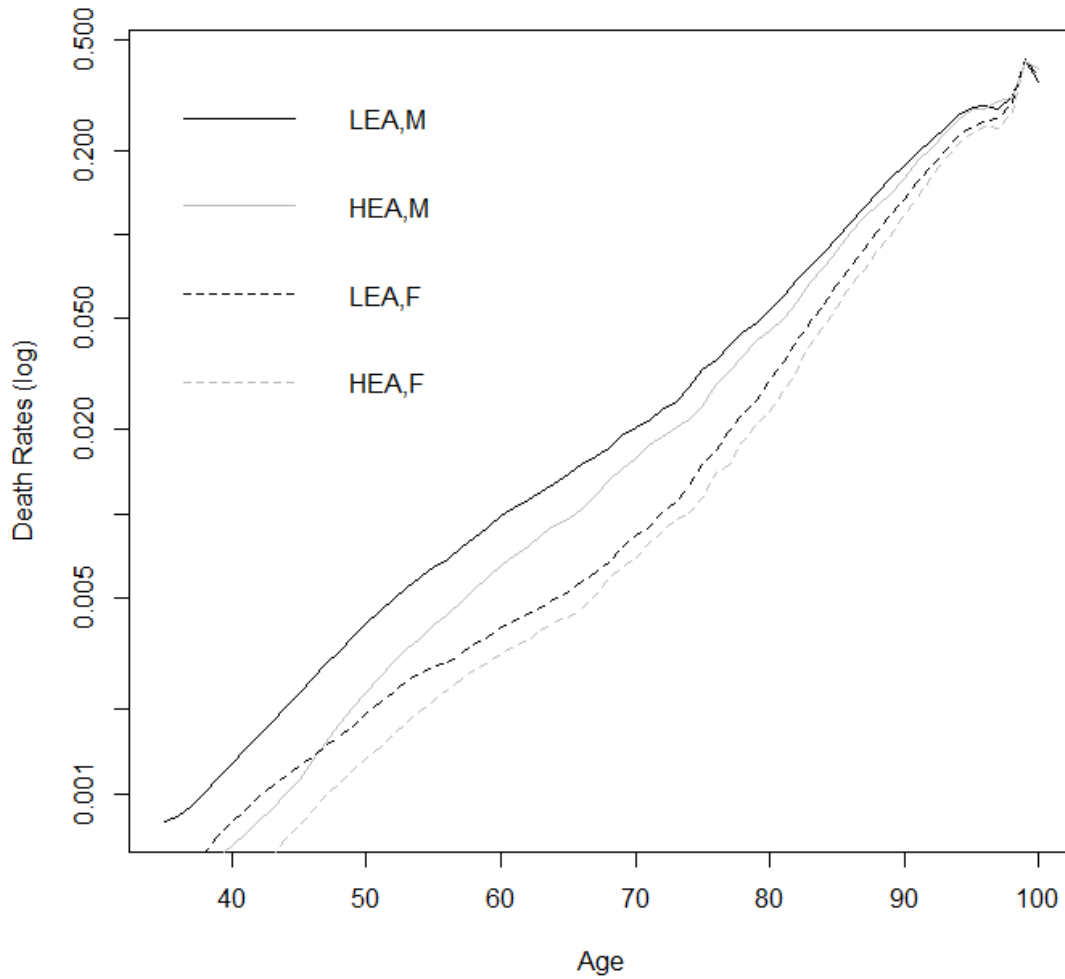
Source: Authors' Calculations based on INE

Figure 1A: Smoothed distribution of deaths by sex and educational attainment for Spain, 2014-18.



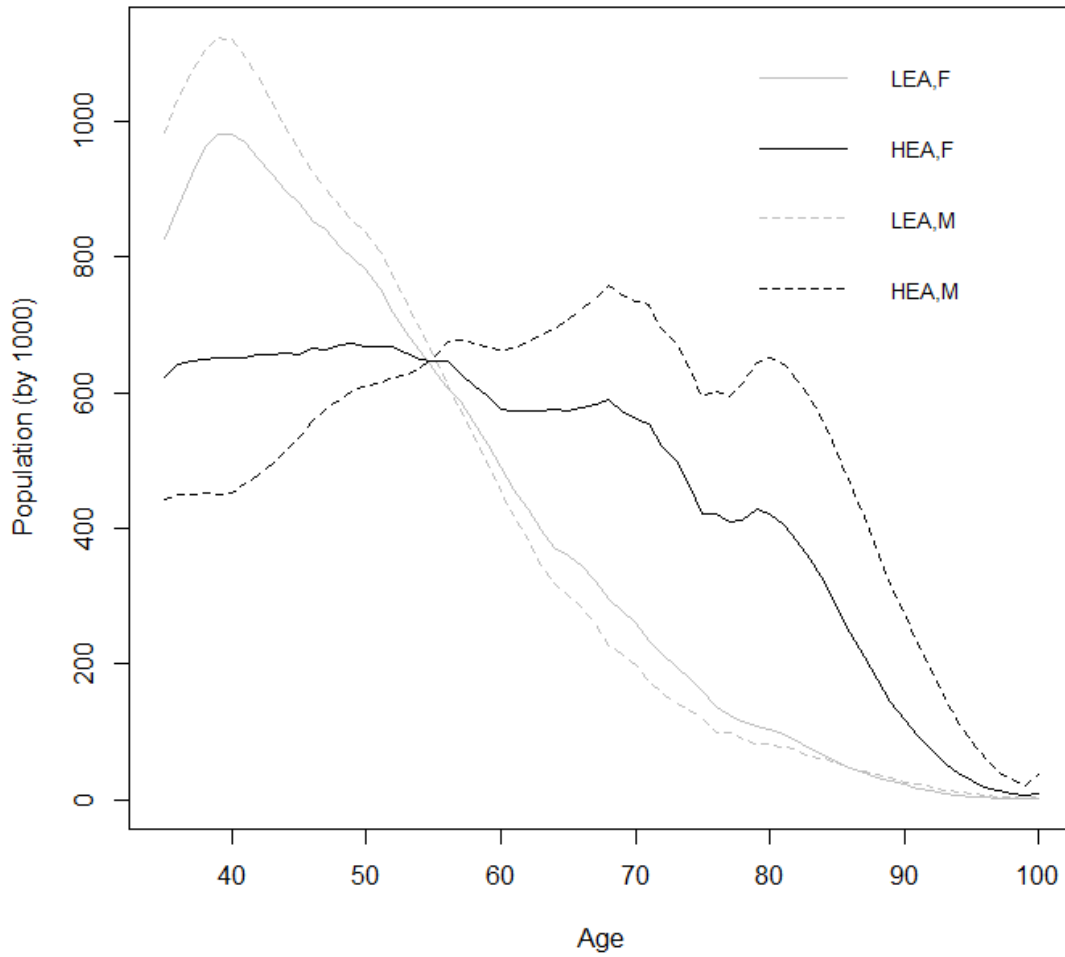
Source: Authors' Calculations based on INE

Figure 2A: Smoothed Death Rates by sex and educational attainment for Spain, 2014-18.



Source: Authors' Calculations based on INE

Figure 3A:
Population exposures (by thousands) by age, sex and educational attainment in Spain, 2014-18



Source: Authors' Calculations based on INE

Table 2A: Life expectancy at age 35 and above by sex and educational attainment in Spanish autonomous communities

Autonomous Community	Males		Dif	Females		Dif	Difference by Sex	
	LEA	HEA	HEA -LEA	LEA	HEA	HEA- LEA	LEA	HEA
Andalusia	43.92	46.60	2.68	49.49	51.08	1.59	5.57	4.48
Aragon	45.08	47.07	1.99	51.05	52.13	1.08	5.97	5.06
Asturias	43.38	46.73	3.35	50.03	51.95	1.92	6.65	5.22
Balearic Islands	44.94	47.84	2.90	50.34	51.84	1.50	5.40	4.00
Canary Islands	44.49	47.44	2.95	49.56	51.74	2.18	5.07	4.30
Cantabria	44.41	47.03	2.62	50.98	51.99	1.01	6.57	4.96
Castile and León	45.68	48.25	2.57	51.45	52.83	1.38	5.77	4.58
Castile-La Mancha	45.65	47.47	1.82	50.97	52.16	1.19	5.32	4.69
Catalonia	45.12	47.74	2.62	50.94	52.55	1.61	5.82	4.81
Valencia	44.80	46.83	2.03	50.12	51.54	1.42	5.32	4.71
Extremadura	44.53	46.69	2.16	50.30	51.98	1.68	5.77	5.29
Galicia	44.38	47.40	3.02	50.93	52.28	1.35	6.55	4.88
Madrid	45.99	48.42	2.43	51.72	52.87	1.15	5.73	4.45
Murcia	45.05	46.80	1.75	50.17	51.22	1.05	5.12	4.42
Navarra	45.77	47.90	2.13	51.51	52.36	0.85	5.74	4.46
Basque Country	44.53	47.43	2.90	51.00	52.31	1.31	6.47	4.88
La Rioja	45.77	47.42	1.65	51.53	52.48	0.95	5.76	5.06
Ceuta and Melilla	42.96	46.28	3.32	48.05	52.40	4.35	5.09	6.12
Spain	44.85	47.50	2.65	50.62	52.21	1.59	5.77	4.71
Standard Deviation	0.81	0.58	0.23	0.89	0.48	0.41	-0.08	0.10

Source: Authors' Calculations based on INE

Table 3A: Life disparity at age 35 and above by sex and educational attainment in Spanish autonomous communities

Autonomous Community	Males		Dif	Females		Dif	Difference by Sex	
	LEA	HEA	HEA -LEA	LEA	HEA	HEA -LEA	LEA	HEA
Andalusia	10.18	9.15	-1.03	8.32	7.75	-0.57	-1.86	-1.40
Aragon	10.11	9.14	-0.97	8.23	7.73	-0.50	-1.88	-1.41
Asturias	10.63	9.27	-1.36	8.66	7.68	-0.98	-1.97	-1.59
Balearic Islands	9.98	9.22	-0.76	8.22	7.70	-0.52	-1.76	-1.52
Canary Islands	10.55	9.49	-1.06	8.89	8.02	-0.87	-1.66	-1.47
Cantabria	10.28	9.12	-1.16	8.30	7.70	-0.60	-1.98	-1.42
Castile and León	10.15	8.84	-1.31	8.32	7.50	-0.82	-1.83	-1.34
Castile-La Mancha	9.86	8.77	-1.09	7.92	7.36	-0.56	-1.94	-1.41
Catalonia	10.01	9.05	-0.96	8.22	7.68	-0.54	-1.79	-1.37
Valencia	10.14	9.27	-0.87	8.29	7.79	-0.50	-1.85	-1.48
Extremadura	10.14	8.97	-1.17	8.12	7.58	-0.54	-2.02	-1.39
Galicia	10.73	9.37	-1.36	8.34	7.73	-0.61	-2.39	-1.64
Madrid	9.95	8.99	-0.96	8.15	7.75	-0.40	-1.80	-1.24
Murcia	9.83	8.89	-0.94	7.96	7.43	-0.53	-1.87	-1.46
Navarra	9.71	8.88	-0.83	8.11	7.54	-0.57	-1.60	-1.34
Basque Country	10.25	9.08	-1.17	8.43	7.78	-0.65	-1.82	-1.30
La Rioja	9.95	8.76	-1.19	8.13	7.19	-0.94	-1.82	-1.57
Ceuta and Melilla	10.62	9.40	-1.22	8.97	8.10	-0.87	-1.65	-1.30
Spain	10.18	9.13	-1.05	8.31	7.75	-0.56	-1.87	-1.38
Standard Deviation	0.29	0.21	-0.08	0.27	0.21	-0.06	-0.02	0.00

Source: Authors' Calculations based on INE

Table 4A: Life Table Entropy between ages 35 and above by sex and educational attainment in Spanish autonomous communities

Autonomous Community	Males		Dif	Females		Dif	Difference by Sex	
	LEA	HEA	HEA -LEA	LEA	HEA	HEA -LEA	LEA	HEA
Andalusia	0.232	0.196	-0.036	0.168	0.152	-0.016	-0.064	-0.044
Aragon	0.224	0.194	-0.030	0.161	0.148	-0.013	-0.063	-0.046
Asturias	0.245	0.198	-0.047	0.173	0.148	-0.025	-0.072	-0.050
Balearic Islands	0.222	0.193	-0.029	0.163	0.149	-0.014	-0.059	-0.044
Canary Islands	0.237	0.200	-0.037	0.179	0.155	-0.024	-0.058	-0.045
Cantabria	0.232	0.194	-0.038	0.163	0.148	-0.015	-0.069	-0.046
Castile and León	0.222	0.183	-0.039	0.162	0.142	-0.020	-0.060	-0.041
Castile-La Mancha	0.216	0.185	-0.031	0.155	0.141	-0.014	-0.061	-0.044
Catalonia	0.222	0.189	-0.033	0.161	0.146	-0.015	-0.061	-0.043
Valencia	0.226	0.198	-0.028	0.165	0.151	-0.014	-0.061	-0.047
Extremadura	0.228	0.192	-0.036	0.161	0.146	-0.015	-0.067	-0.046
Galicia	0.242	0.198	-0.044	0.164	0.148	-0.016	-0.078	-0.050
Madrid	0.216	0.186	-0.030	0.158	0.147	-0.011	-0.058	-0.039
Murcia	0.218	0.190	-0.028	0.159	0.145	-0.014	-0.059	-0.045
Navarra	0.212	0.185	-0.027	0.158	0.144	-0.014	-0.054	-0.041
Basque Country	0.230	0.192	-0.038	0.165	0.149	-0.016	-0.065	-0.043
La Rioja	0.217	0.185	-0.032	0.158	0.137	-0.021	-0.059	-0.048
Ceuta and Melilla	0.247	0.203	-0.044	0.187	0.154	-0.033	-0.060	-0.049
Spain	0.227	0.192	-0.035	0.164	0.148	-0.016	-0.063	-0.044
Standard Deviation	0.010	0.006	-0.004	0.008	0.004	-0.004	0.002	-0.002

Source: Authors' Calculations based on INE