Income inequalities in longevity among Spanish retirement pensioners aged 65+: A comprehensive analysis from 2008 to 2021

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Abstract This paper examines disparities in longevity among Spanish retirement pensioners aged 65+, focusing on pension income and gender between 2008 and 2021. Using linked administrative records, we estimate life expectancy and complementary indicators (median, modal age at death, interquartile range). Results show persistent income-related gaps, especially for men, who face both shorter and less predictable lives, while female inequalities are smaller and tend to converge. Compared internationally, Spain displays

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distinctive narrowings for women but a widen-then-narrow pattern for men. Beyond documenting disparities, the article highlights how each longevity indicator offers distinct policy uses – for actuarial fairness, pension liabilities, and health and elderly care aimed at enhancing the well-being of disadvantaged groups.

Keywords actuarial, gender, life expectancy, pension scheme, pay as you go system, Spain

Introduction

Life expectancy is the most common metric of survival. It is the hypothetical average age at death given age-specific death rates in a given year. We are interested in examining the inequalities in life expectancy (LE) of retirement pensioners in Spain at ages 65 (LE_{65}) by pension income (PI) level.

The gender gap in pensions is more pronounced than the gender gap in wages in most countries within the European Union (Domínguez-Fabián et al., 2022). Both gaps have been extensively studied, yet there is a paucity of research focusing on income inequality in connection with old-age life expectancy, yet there is evidence that high-income countries experience substantial and potentially increasing inequality in late-life longevity (Fors, Wastesson and Morin, 2021). Studies using the amount of pension and/or pensionable earnings as a proxy for life expectancy are even scarcer, although some have been conducted in recent years for countries including Germany (Lampert, Hoebel and Kroll, 2019; Wenau, Grigoriev and Shkolnikov, 2019; Tetzlaff et al., 2020), the United States of America (Waldron, 2007; Goldman and Orszag, 2014; Bosley, Morris and Glenn, 2018, Italy (Ardito et al., 2022), Canada (Adam, 2012; Wen, Kleinow and Cairns, 2020; OSFIC, 2022), Chile (Edwards, Soto and Zurita, 2023), and Argentina (Bramajo and Grushka, 2019). For Spain, only two studies using the Continuous Sample of Working Lives (MCVL, also referred to as MCVL) have estimated life expectancy by pension amount (PI) – both restrict the analysis to male pensioners (Pérez-Salamero González, Regúlez-Castillo and Vidal-Meliá, 2021; Pérez-Salamero González et al., 2022).

This article focuses on Spain, a country for which little information about pensioners' life expectancy by PI level was known until recently. To the best of our knowledge, only two studies have examined this issue, and only for male pensioners (Pérez-Salamero González, Regúlez-Castillo and Vidal-Meliá, 2021;

Pérez-Salamero González et al., 2022). These authors found that individuals' PI levels contained information about their mortality experience and that this variable could be used as a proxy for socioeconomic status. They also found that disparities in LE_{65} and LE_{75} between pensioners in the lowest and highest income groups were relatively small and this gap in LE_{65} widened over time, from 1.49 years (2005–2009) to 2.54 years (2015–2018). These differences were statistically significant. The conclusions found by Pérez-Salamero González, Regúlez-Castillo and Vidal-Meliá (2021) and Pérez-Salamero González et al. (2022) were in line with previous findings for Spain involving older adults and using very different methodologies and/or databases (Regidor et al., 2012; Kulhánová et al., 2014; Permanyer et al., 2018; González and Rodríguez-González, 2021).

While the significance of the findings for the Spanish case is acknowledged, the two papers have a notable limitation in that they did not examine the case of females. They argued that this was because of lower labour force participation rates for female cohorts in Spain and the fact that women sometimes have shorter careers (in terms of years of employment) and may work less intensively than men due to family roles and commitments.

Another limitation of both papers is that longevity was measured solely in terms of life expectancy, without examining other indicators. To provide a more comprehensive analysis, it is important to complement life expectancy with additional metrics: the median can highlight robust central tendencies, the modal age at death captures shifts at older ages, and the interquartile range reveals lifespan variation and survival predictability (Canudas-Romo, 2008; Horiuchi et al., 2013; Aburto and van Raalte, 2018; Vidal-Meliá, Ventura-Marco and Garvey, 2024). Incorporating these measures allows a more nuanced understanding of longevity inequalities across pension-income and gender groups.

This article examines the disparities in longevity between males and females, focusing on key statistical measures such as life expectancy, mode, interquartile range (IQR), and median by pension income. To do this we use a large administrative data set (MCVL, the Continuous Work History Sample – *la Muestra Continua de Vidas Laborales* in Spanish) to estimate inequalities in longevity among male and female pensioners grouped according to their PI levels.[1] We study mortality trends among retirement pensioners aged 65 or older for the period 2008–2021.

The PI-longevity gradient is quantified in two ways. The first is by estimating the changes in total life expectancy by PI level at age 65 (LE_{65}) over time. The second is by introducing some additional longevity and life span variation indicators by PI level at age 65, these being the median age at death, the interquartile range and the modal age at death (Wilmoth and Horiuchi, 1999; Cheung et al., 2005). As a

1. Access the web portal of the Continuous Work History Sample.

supplementary approach, we also provide a comparison with the LE_{65} for the Spanish population as a whole.

This study is structured around several key research questions:

First, do differences in longevity exist between pension income (PI) groups for male and female pensioners, and if so, are these differences statistically significant? Second, do trends in life expectancy vary between PI groups, leading to a widening or narrowing of inequalities over time? Third, is the evolution of longevity by PI group consistent across genders? Fourth, are additional longevity indicators (median, modal age at death, interquartile range) aligned with, or do they reveal different patterns from, life expectancy within PI groups? Fifth, how has the longevity of the general population and the various PI-classified pensioner groups evolved over time? Finally, what distinct insights and policy applications can each indicator provide for understanding and addressing longevity disparities?

The remainder of the article is structured as follows: first, the data and methodology are described, together with the definition of variables and the classification of socioeconomic groups. The next section presents the empirical results, including complementary longevity indicators, comparisons with the general population, and the impact of the COVID-19 pandemic. This is followed by a comprehensive discussion that integrates the main findings, international contextualization, policy implications, and limitations. The article concludes with a summary of the key contributions.[2]

Data and methodology

This study utilizes the Continuous Work History Sample (MCVL), a comprehensive Spanish administrative dataset that offers several advantages over traditional survey data, including larger sample sizes, reduced costs, and decreased respondent burden. The MCVL dataset has been published annually since 2004, each edition containing social security records for a 4 per cent non-stratified random sample of individuals who, during that year, had any interaction with Spain's social security system. This includes those who were employed, receiving unemployment benefits, or drawing a pension. Individuals without any connection to the social security system in a given year are not included, and civil servants are similarly excluded from the dataset (Pérez-Salamero et al., 2021).

The MCVL compiles administrative data on individuals' working lives, drawing from anonymized microdata derived from social security records, which provide

2. This article is supplemented by an online Appendix, developed by the authors and made available to readers. See Supporting information for additional methodological details and supplementary analyses.

detailed personal information (Pérez-Salamero González, Regúlez-Castillo and Vidal-Meliá, 2017). The initial wave of the MCVL encompasses individuals who had any form of financial relationship with the social security system in 2004, including their entire working history. The sample is subsequently updated annually with data reflecting the variables tracked by the social security system since the start of computerized record-keeping, supplemented by information from other administrative sources that capture additional individual data. As of the time of this study, the available data spans from 2004 to 2021.

Our study focuses on a cohort comprising true retirement pensioners who retired at or after the statutory retirement age of 65, and who were classified under the general scheme, the primary segment of the Spanish social insurance system. Notably, until 31 December 2012, the statutory retirement age in Spain was age 65. However, a gradual transition is taking place between 2013 and 2027, culminating in two standard retirement ages from 2027 onwards: age 65 for individuals with at least 38.5 years of contributions and age 67 for those with a minimum of 37 years of contributions.

The Spanish public pension system is a mandatory, contributory, defined benefit scheme financed on a pay-as-you-go (PAYG) basis. Benefits are linked to contribution histories and statutory rules, with the statutory retirement age being gradually raised from age 65 to age 67 between 2013 and 2027. Although special regimes exist (self-employed workers under the *Regimen Éspecial de Trabajadores Autónomos* (*RETA*), civil servants under the *Régimen de Clases Pasivas*), over 90 per cent of pensioners belong to Spain's general scheme. What makes the Spanish case distinctive among Member countries of the Organisation for Economic Co-operation and Development (OECD) is that the public first pillar is virtually the only source of retirement income; occupational and private pensions cover only a small minority of the elderly. According to European Union (EU) microdata from the EU statistics on income and living conditions (EUSILC) and household budget survey data, more than 90 per cent of retired households' disposable income derives from these public pensions, with very limited weight from other sources.[3] These features make Spain's system one of the most public-centred and redistributive within the OECD, with relatively high replacement rates but limited diversification into other retirement income pillars (OECD, 2023). In this context, pension income provides a direct and robust measure of retirees' economic position.

Consistent with prior research that employed the MCVL to examine mortality and longevity among pensioners categorized by PI level Pérez-Salamero González, Regúlez-Castillo and Vidal-Meliá, (2021) and Pérez-Salamero González et al. (2022), we exclude from our analysis retirement pensioners covered under

3. See the Eurostat EUSILC web portal.

the special system for self-employed workers (RETA), individuals whose disability benefits were reclassified as retirement benefits, and early retirees who accessed benefits before reaching the statutory retirement age.

Coverage of our study population is approximately 91.7 per cent of Spanish retirement pensioners aged 65+ in 2008–2021. This share results from excluding civil-service (*Régimen de Clases Pasivas*) and non-contributory pensions from official beneficiary stocks. We do not impose a minimum contributory-history threshold; coverage refers to observed 65+ beneficiaries in the MCVL.

Variables and socioeconomic groups

We have divided the pensioners into specific income quartiles, in this case four equal-sized segments that each contain approximately a quarter (25 per cent) of the individuals. These segments are denoted G_1 – the PI group for pensioners with the lowest 25 per cent of retirement benefits ("lowest"); G_2 – for pensioners with retirement benefits between 26 per cent and 50 per cent (up to median, "second"); G_3 – in which the benefit amount is between 51 per cent to 75 per cent (above the median, "third"); and G_4 – which covers those pensioners with the highest 25 per cent of retirement benefits ("highest"). The people within each group do not represent exactly 25 per cent, since the number of deaths within each group varies over the six years of each window. The individuals (alive or deceased) assigned to each group according to their PI level represent exactly 25 per cent of the sample. Quartiles were calculated separately by sex and by rolling window.

We are mainly interested in the first (lowest) and fourth (highest) groups.

Focusing on the first (lowest) and fourth (highest) pension income (PI) groups is essential because these groups represent the most economically disadvantaged and advantaged segments of the population, respectively. Analysing these extremes captures the full range of socioeconomic disparities in longevity, providing clear insights into the extent of inequality. Differences in life expectancy and other longevity indicators are typically most pronounced between these two groups, making it easier to identify and quantify the impact of socioeconomic status on longevity.

Additionally, understanding the disparities between the lowest and highest PI groups is crucial for informing policy interventions aimed at reducing inequality and improving public health outcomes. These groups often represent the target populations for such policies. By focusing on these extremes, the study also facilitates comparison with other research and international contexts, allowing for broader generalizations about inequality trends.

Table 1. *Pensioners by PI level: exposures (Exp) in person-years, number of deaths (De) and crude death rates (%) for selected periods (W_1 2008–2013, W_5 2012–2017 and W_9 2016–2021)*

Periods	Items	Pension income quartile (females)				Pension income quartile (males)			
		G_1	G_2+G_3	G_4	Total	G_1	G_2+G_3	G_4	Total
W_1	Exp	25,758	48,971	26,009	100,737	31,763	75,601	35,850	143,213
	%	25.57	48.61	25.82	100	22.18	52.79	25.03	100
	De	1,144	1,000	522	2,666	1,692	2,611	699	5,002
	%	4.44	2.04	2.01	2.65	5.33	3.45	1.95	3.49
W_5	Exp	36,620	72,485	34,419	143,523	44,287	92,771	46,590	183,648
	%	25.52	50.50	23.98	100	24.12	50.52	25.37	100
	De	1,788	1,345	555	3,688	2,382	2,993	830	6,205
	%	4.88	1.86	1.61	2.57	5.38	3.23	1.78	3.38
W_9	Exp	41,006	85,660	41,212	167,877	43,765	100,655	51,823	196,242
	%	24.43	51.03	24.55	100	22.30	51.29	26.41	100
	De	2,148	1,519	599	4,266	2,328	3,684	1,064	7,076
	%	5.24	1.77	1.45	2.54	5.32	3.66	2.05	3.60

Note: Percentages of exposures refer to the share of each group in total exposures and therefore sum to 100%. Percentages of deaths are recalculated as deaths divided by exposures within each group (crude mortality rates), including the corresponding overall rate in the "Total" column. These do not sum to 100% across groups.
Source: Own work based on DGOSS (2008–2021).

Table 1 shows the exposures in person-years and number of deaths (percentages) for three of the periods studied (three of the nine rolling windows).

The percentages of deaths presented in Table 1 represent crude mortality rates (deaths over exposures) within each group and are therefore not additive to 100 per cent. This provides a clearer picture of the mortality risk of each pension income quartile and the total population.

Between the first rolling window and the last, the number of exposures in person-years increases by almost 50 per cent (from 243,950 to 364,119), with a 66 per cent increase for women and a 37 per cent increase for men. The share of women in the total number of exposed pensioners increases from 41.23 per cent to 46.10 per cent.

Methodology

The PI-longevity gradient is quantified in two ways. The first is by considering changes in total life expectancy by PI level at age 65 (LE_{65}) over time. We use the

Mort1Dsmooth function in the MortalitySmooth R package (Camarda, 2012) – which is tailored to smooth mortality rates across different ages with P-splines – to construct complete-period life tables from age 65 to age 105 and to calculate LE_{65} for each rolling window of six years. Data for ages above age 105 are unreliable because the exposures are small and, in addition, the reporting of deaths is questionable for very old ages.

A second method for quantifying the relationship between pension income (PI) and longevity involves estimating additional indicators of longevity and life span variation by PI level at age 65. While the mean age at death, or life expectancy, is commonly used as the preferred measure of longevity, other central tendency measures, such as the median and modal ages at death, also provide valuable insights into the distribution of deaths (Canudas-Romo, 2010). These measures complement one another by offering a more comprehensive understanding of the central tendencies in mortality (Vidal-Meliá, Ventura-Marco and Garvey, 2024).

The median age at death (Md) is defined as the age by which half of a hypothetical cohort has died. In our analysis, this cohort comprises individuals aged 65 or older. The adult modal age at death (M) is the age beyond infancy at which the highest number of deaths occur. This measure is frequently used to examine mortality differences at older ages and serves as a natural metric for assessing life span and its variation (Kannisto, 2001). Under a given mortality regime, M reflects the most common or "typical" life span among adults (Diaconu, van Raalte and Martikainen, 2022). Unlike conventional measures of old-age mortality, such as life expectancy, M has the advantage of not being influenced by an arbitrarily chosen threshold for "old" age and is determined solely by mortality at older ages. Despite its intuitive significance and beneficial properties, M has not been widely utilized to explore socioeconomic disparities in mortality.

Various measures are available for assessing life span variation, each with distinct properties (van Raalte and Caswell, 2013). These measures collectively aim to quantify the degree of heterogeneity in the ages at death within a population (Hiam, Minton and McKee, 2021; Seaman et al., 2019). The interquartile range (IQR), also known as the middle 50 per cent (Wilmoth and Horiuchi, 1999), represents the distance between the lower and upper quartiles of the age distribution of deaths in a life table. A decrease in IQR indicates a reduction in the variability of ages at death, making it an appealing single measure of variability due to its straightforward calculation and interpretation as the range encompassing the middle 50 per cent of deaths.

Indicators of life span variation have significant implications on both individual (micro) and population (macro) levels (van Raalte et al., 2018). At the micro level, life span variation highlights individual uncertainty concerning the timing of death. From this perspective, increasing life span variation among different PI groups suggests a growing dimension of social inequality in longevity. Specifically, pensioners from higher PI levels can plan their remaining years more effectively, while those from less advantaged groups face greater uncertainty about their survival. At the macro level, life span variation serves as an indicator of

Table 2. *LE_{65}. 95% confidence intervals by PI group*

Females		G_1			Whole			G_4	
Periods	2.5^{th}	50^{th}	97.5^{th}	2.5^{th}	50^{th}	97.5^{th}	2.5^{th}	50^{th}	97.5^{th}
2008-2013 (W_1)	23.13	**23.67**	24.20	24.94	25.20	25.46	24.98	25.59	26.19
2009-2014 (W_2)	22.74	23.29	23.85	25.15	**25.40**	25.64	25.08	**25.65**	26.21
2010-2015 (W_3)	22.98	**23.58**	24.18	25.24	**25.47**	25.71	25.12	**25.66**	26.20
2011-2016 (W_4)	23.43	**24.02**	24.61	25.41	**25.64**	25.87	25.48	**26.02**	26.56
2012-2017 (W_5)	23.35	**23.94**	24.52	25.52	**25.74**	25.95	25.60	**26.13**	26.66
2013-2018 (W_6)	23.84	**24.37**	24.89	25.66	**25.87**	26.08	25.77	**26.32**	26.86
2014-2019 (W_7)	24.24	$\boxed{24.77}$	25.29	25.82	$\boxed{26.03}$	26.24	26.07	**26.60**	27.13
2015-2020 (W_8)	23.87	**24.37**	24.87	25.63	**25.84**	26.04	26.45	**27.03**	27.61
2016-2021 (W_9)	23.94	**24.36**	24.78	25.70	**25.91**	26.11	26.46	$\boxed{27.03}$	27.61
Males		**G_1**			**Whole**			**G_4**	
Periods	**2.5^{th}**	**50^{th}**	**97.5^{th}**	**2.5^{th}**	**50^{th}**	**97.5^{th}**	**2.5^{th}**	**50^{th}**	**97.5^{th}**
W_1	19.75	**20.19**	20.64	21.50	21.71	21.92	22.20	22.86	23.53
W_2	19.65	**20.08**	20.50	21.68	**21.89**	22.09	22.74	**23.47**	24.20
W_3	19.26	**19.67**	20.09	21.63	**21.82**	22.02	22.49	**23.09**	23.70
W_4	19.11	19.49	19.88	21.70	**21.90**	22.09	22.92	**23.56**	24.19
W_5	19.35	**19.75**	20.15	21.92	**22.11**	22.30	22.99	**23.54**	24.10
W_6	19.33	**19.73**	20.14	21.95	$\boxed{22.14}$	22.32	23.21	$\boxed{23.74}$	24.28
W_7	19.45	**19.86**	20.28	21.92	**22.11**	22.30	22.98	**23.48**	23.97
W_8	19.65	**20.07**	20.49	21.79	**21.97**	22.16	22.73	**23.17**	23.62
W_9	19.83	$\boxed{20.25}$	20.66	21.71	**21.89**	22.08	22.65	**23.08**	23.51

Note: Minimum values are indicated by a circle, and maximum values are indicated by a box.
Source: Own work based on DGOSS (2008–2021).

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heterogeneity in population longevity. Within this study's context, a rise in life span variation among disadvantaged groups indicates that these pensioners are experiencing increasingly diverse life courses.

Results

Life expectancy at age 65 (LE_{65}) by pension income (PI) level and gender

The analysis confirms a positive relationship between life expectancy at age 65 (LE_{65}) and pension income (PI) levels for both genders across all periods studied (Table 2). Female pensioners consistently show higher LE_{65} than their male counterparts across all PI levels. However, the evolution of LE_{65} differs significantly between genders.

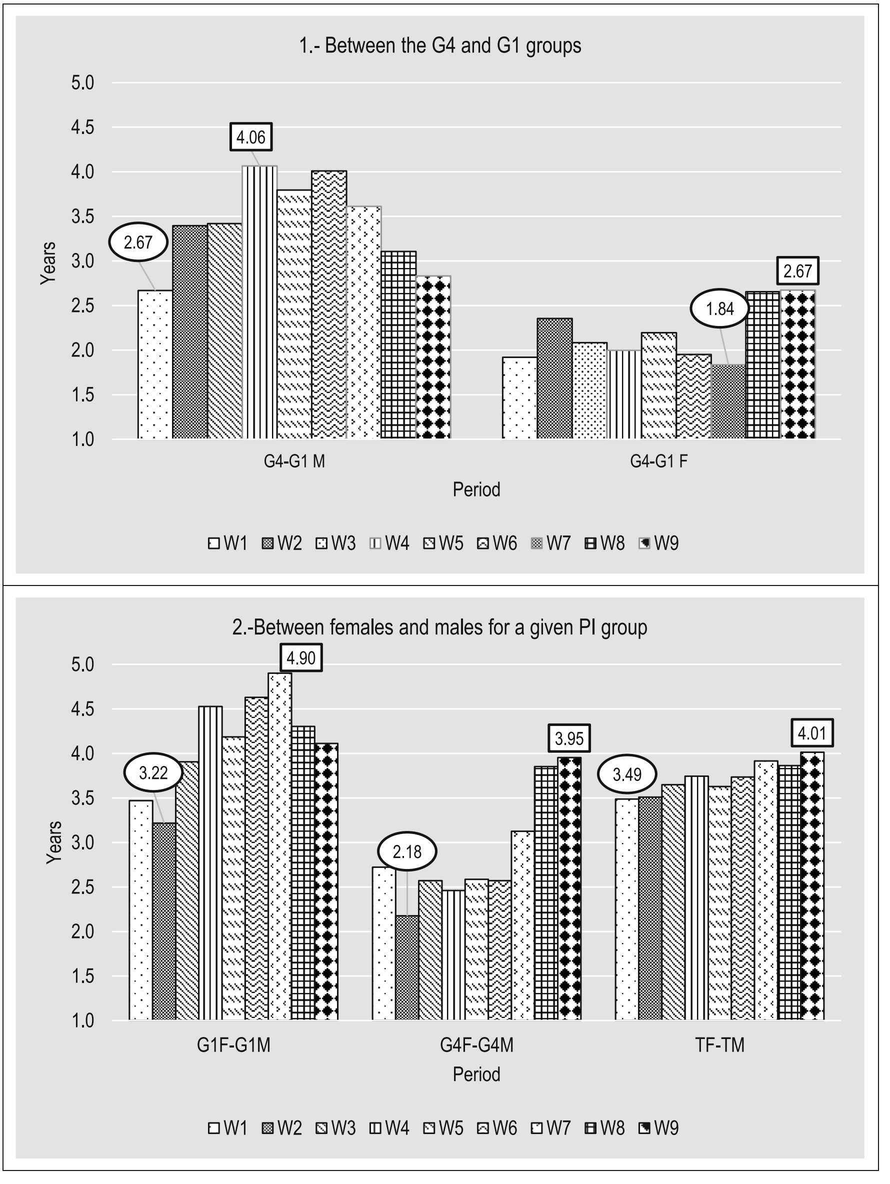
For males, the LE_{65} of the highest PI group (G_4) peaked during 2014–2018 (23.74 years) before declining to 23.08 years in 2016–2021. In contrast, the lowest PI group (G_1) saw an increase from 19.49 years in 2011–2016 to 20.25 years in 2016–2021, reducing the gap between these groups. For females, the G_1 group reached its highest LE_{65} in 2014–2019 (24.77 years) but dropped to 24.36 years in the following period, likely due to the COVID-19 pandemic, while the G_4 group's LE_{65} continued to rise, reaching 27.03 years by the final period.

These patterns suggest that the COVID-19 pandemic disproportionately affected certain groups. In particular, the G_1 female group experienced a decline in LE_{65} in the last period, while the G_4 female group showed a more modest impact, and the G_1 male group even saw a temporary increase. Overall, the trajectory of LE_{65} for all female pensioners broadly reflects the evolution of the G_1 group, whereas for males it aligns more closely with the G_4 group.

In the tables and figures, the minimum values are indicated by a circle and the maximum values by a box. It is important to note that the maximum and minimum values differ between the two groups of pensioners analysed.

These trends are further illustrated in Figure 1, which shows the absolute differences in LE_{65} between G_4 and G_1 groups. For males, the gap widened initially but then narrowed, while for females, the differences were smaller and more stable over time. The gender differences in LE_{65} also reveal that females in the most disadvantaged group (G_1) consistently outlive their male counterparts, with the absolute difference between genders within the same PI group increasing over time, particularly in G_1.

Figure 1. *Absolute differences in LE_{65} (PI groups and sexes)*



Source: Authors' elaboration.

Additional longevity indicators: Median age at death (Md_{65}), modal age at death (M_{65}) and interquartile range (IQR_{65})

In addition to LE_{65}, the study examines other indicators, including the median age at death (Md_{65}), modal age at death (M_{65}), and interquartile range (IQR_{65}).[4]

Median age at death (Md_{65}). The Md_{65} values are generally higher in the G_4 group than in the G_1 group for both genders, indicating longer lifespans among those with higher pension incomes. For females, the gap between G_1 and G_4 in Md_{65} has slightly narrowed over time, while for males, the gap has remained relatively stable, with G_4 consistently showing higher values.[5]

Modal age at death (M_{65}). The M_{65}, representing the most common age at death, follows a pattern similar to Md_{65}. For females, the M_{65} in the G_4 group is higher and more stable, while the G_1 group shows more variability. The proportion of pensioners surviving to M_{65} remains relatively constant over time for both G_1 and G_4 groups, with a slight decline observed during the COVID-19 pandemic-affected periods. For males, the G_4 group exhibits a higher and more stable M_{65} compared to the G_1 group, which shows more fluctuation and generally lower M_{65} values.[6]

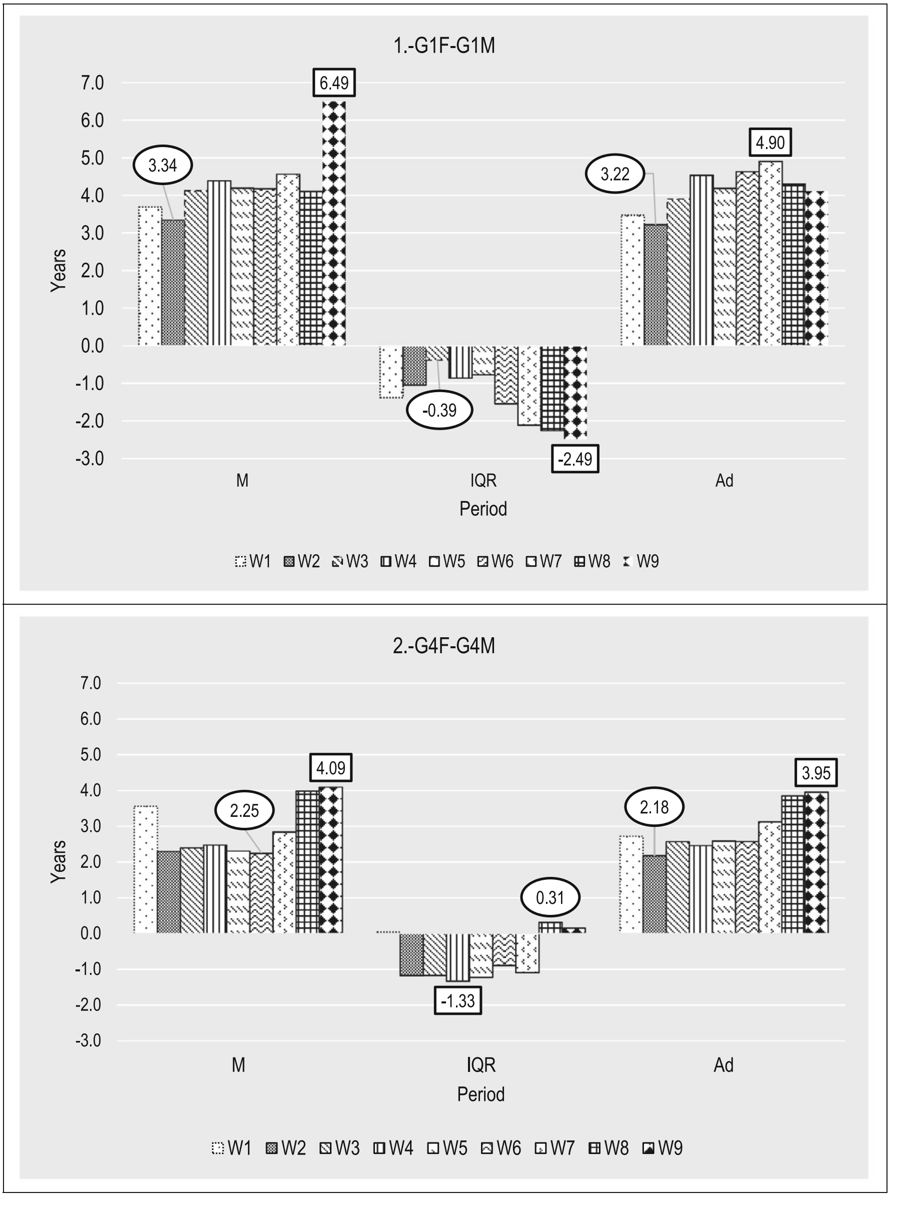
Interquartile range (IQR_{65}). The IQR_{65}, a measure of variability in age at death, shows divergent trends by gender.[7] For females, IQR_{65} values between the G_1 and G_4 groups have converged over time, indicating decreasing variability in lifespan. In contrast, for males, the IQR_{65} has diverged, with G_1 showing increasing variability compared to the more stable G_4 group. This suggests that socioeconomic inequality in longevity, as measured by lifespan variability, is more pronounced among disadvantaged males.

Absolute differences between G_4 and G_1 groups

The absolute differences in longevity indicators between the G_4 and G_1 groups offer deeper insights into the extent of socioeconomic inequality (Figure 2). For both males and females, the absolute differences in LE_{65}, Md_{65}, and M_{65} are consistently larger for males, indicating greater disparities in longevity among men. However, the absolute differences in IQR_{65} differ by gender, with females

4. See Supporting information, Tables OA.1 and OA.2 in the online Appendix A.2.
5. See Supporting information, Table OA.1 in the online Appendix A.2.
6. See Supporting information, Table OA.2 in the online Appendix A.2.
7. See Supporting information, Tables OA.1 and OA.2 in the online Appendix A.2.

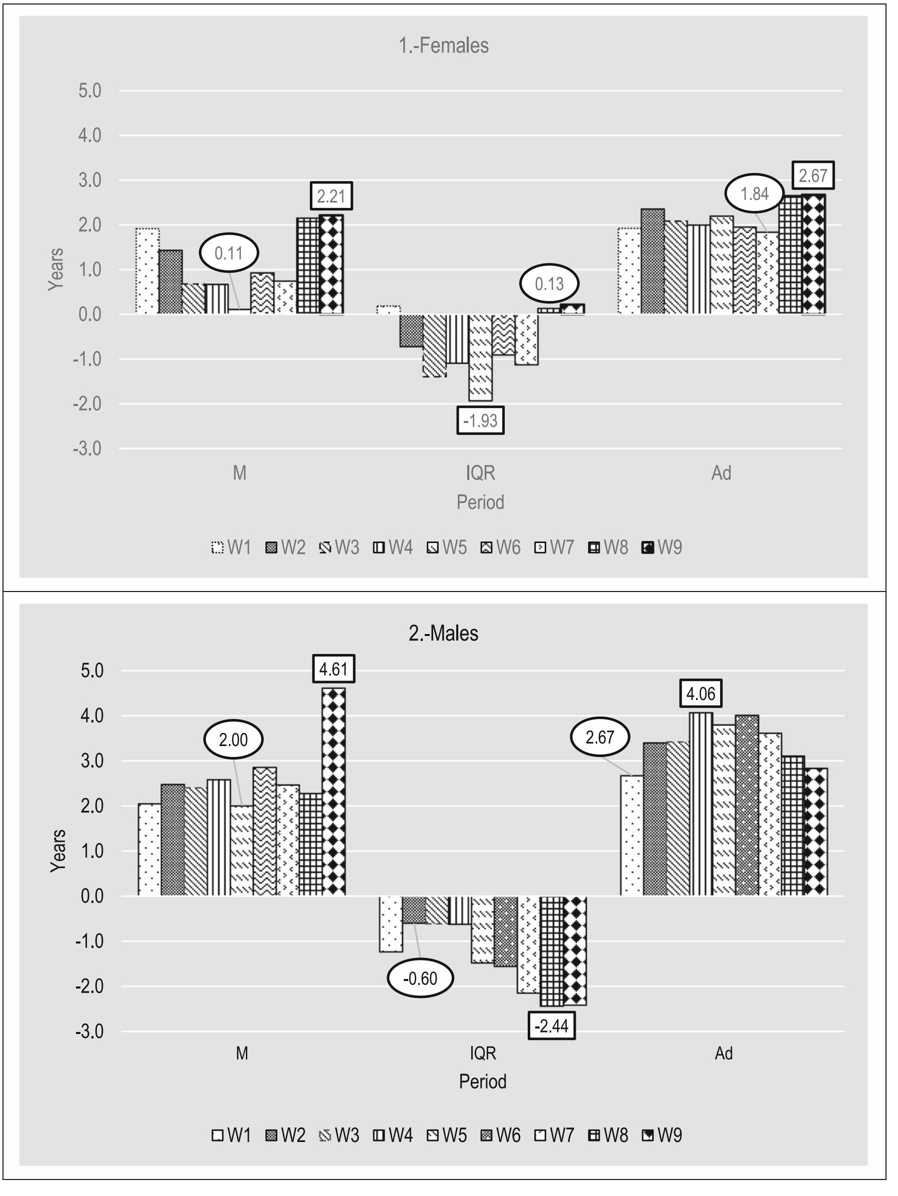
Figure 2. *Absolute differences between females and males for a given PI group in* IQR_{65}, Md_{65} *and* Ad_{65}



Source: Authors' elaboration.

showing a convergence between the G_1 and G_4 groups over time, while males exhibit increasing divergence.

Figure 3. *Absolute differences between the G_4 and G_1 groups in IQR_{65}, Md_{65} and Ad_{65}*



Source: Authors' elaboration.

The absolute differences in LE_{65} between the G_4 and G_1 groups fluctuate over time, with males showing the largest disparities in earlier periods (Figure 3). For females, these differences are smaller but increase slightly during the pandemic-affected periods. The patterns in Md_{65} and M_{65} largely mirror those of LE_{65}, with males consistently showing greater disparities. In contrast, the differences in IQR_{65} demonstrate a divergent trend for males and a convergent trend for females, highlighting different patterns of lifespan variability by gender.

In sum, the complementary measures nuance the evidence from LE_{65}. Md_{65} indicates a slight narrowing of female income inequalities but persistent male disparities. M_{65} shows that higher-income groups not only achieve higher ages but also concentrate around a common lifespan. IQR_{65} uncovers a double disadvantage for low-income males, who experience both shorter and more uncertain lives, whereas among females variability converges, indicating more predictable survival prospects.

Read together, the indicators answer complementary questions at age 65: LE_{65} shows the average remaining years, Md_{65} corroborates the central tendency, M_{65} locates the typical late-life age at death (driven by old-age mortality), and IQR_{65} captures lifespan variation (uncertainty). In Spain, females display small and converging IQR_{65} across PI groups, whereas low-PI males combine lower LE_{65} with a wider IQR_{65}; M_{65} is higher and more clustered in G_4, indicating compression at later ages (Canudas-Romo, 2008; Horiuchi et al., 2013; Aburto and van Raalte, 2018; Su et al., 2024).

Longevity comparisons with the general population

Comparing the LE65 of pensioners with that of the general population reveals that pensioners generally have a longevity advantage, likely reflecting the eligibility for and receipt of social security old-age pensions (Figure 4). For both genders, the absolute differences in LE_{65} between pensioners and the general population ($ADLE_{65}$) are positive across all PI groups and periods. However, the trends differ by gender and PI level.

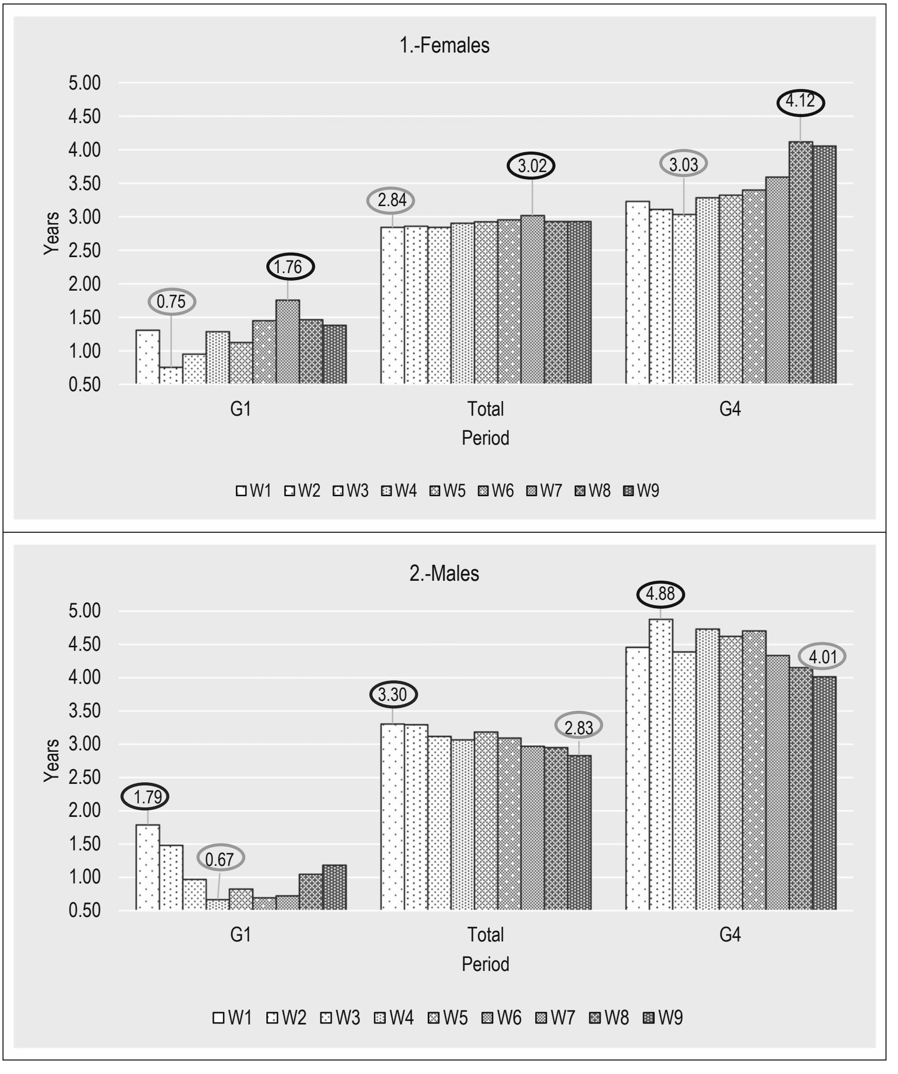
For females, the $ADLE_{65}$ shows a slight upward trend over time, particularly for the G_4 group, indicating increasing longevity advantages for higher-income pensioners. Conversely, for males, $ADLE_{65}$ exhibits a downward trend, particularly for the G_1 group, suggesting a relative decline in longevity compared to the general population. The convergence of $ADLE_{65}$ for G_4 males and females in the final period underscores the widening longevity gap between the most advantaged pensioners and the general population.

Impact of the COVID-19 pandemic

The COVID-19 pandemic had a significant impact on longevity indicators, particularly for the most disadvantaged groups. For females, the pandemic led to a decline in LE_{65} and an increase in IQR_{65} in the G_1 group, reflecting both reduced life expectancy and increased variability in age at death.[8] For males, the

8. See Supporting information, Tables OA.1 and OA.2 in the online Appendix A.2.

Figure 4. *$ADLE_{65}$. pensioners versus general population*



Source: Authors' elaboration.

pandemic exacerbated existing disparities, with the G_1 group experiencing a sharper decline in LE_{65} and a widening IQR_{65}.

Despite these pandemic-related impacts, the overall trend of increasing longevity inequality persists, particularly among males in the G_1 group. This highlights the vulnerability of disadvantaged pensioners to external shocks and underscores the need for targeted interventions to mitigate these effects.

It is also worth noting that annual changes in LE_{65} can partly reflect random fluctuations, particularly in smaller groups, which may explain apparent anomalies such as the temporary "benefit" observed for the least advantaged males and most advantaged females during the pandemic. Promising statistical methods to address this issue have been proposed recently (e.g. Navarro and Requena, 2023), but their application lies beyond the scope of this article.

Discussion

The discussion is organized into four parts. It first synthesizes the main findings of the study. The next subsection places the Spanish evidence in an international perspective. Building on this, we examine the policy implications for pension design, actuarial practice, and public health. Finally, the discussion addresses the study's limitations, providing a balanced interpretation of the results.

Findings

The data reveals several key differences in life expectancy, mode, IQR, and median age at death between males and females by pension income. These differences stress the complex interplay between gender, pension income level, and longevity.

- Life expectancy: Females consistently have higher life expectancy than males across all pension income levels. The positive correlation between pension income and life expectancy is evident for both genders, but the impact is more pronounced for men.
- Mode: The mode of age at death is higher for females and increases with higher pension income for both genders. The impact of pension income on the mode is more significant for males, reflecting greater economic disparities in male longevity.
- IQR: Females have a narrower IQR, indicating more consistent life spans. Higher pension income levels are associated with a narrower IQR for both genders, but the effect is more pronounced for males due to their greater initial variability.
- Median: The median age at death is higher for females and increases with higher pension income for both genders. The differences in median age at death between income quartiles are more pronounced for males, indicating greater socioeconomic inequality.

These findings demonstrate that socioeconomic inequalities in longevity cannot be fully understood through LE_{65} alone. While life expectancy provides a robust summary, the additional indicators reveal further complexity in the mortality gradient: disadvantaged males face both shorter and more uncertain survival, undermining their ability to plan retirement and well-being, whereas female inequalities remain more stable. Taken together – and strictly within our sex-PI-age-65 framework – movements in LE_{65} and Md_{65} across PI groups indicate broad shifts rather than tail effects; a higher and tighter M_{65} in high-PI points to late-life survival gains and compression (Canudas-Romo, 2008; Horiuchi et al., 2013); and the wider IQR_{65}

among low-PI males reveals greater uncertainty in remaining lifespan, supporting targeted prevention/outreach and risk-aware retirement guidance (Aburto and van Raalte, 2018; Su et al., 2024). These implications complement the LE-based gradient and connect directly to pension adequacy and health policy.

International comparisons

One question that immediately comes to mind is: are our results in line with those obtained in other countries using pension amounts and/or pensionable income?

When situating the Spanish findings within an international perspective, some caution is required, since the definitions of "lowest" and "highest" pension income groups differ across countries and methodologies, and thus direct comparability is limited.[9] Nevertheless, the international evidence reveals clear patterns that allow Spain's position to be contextualized.[10]

In Germany, results are broadly similar to those observed in Spain, with persistent but relatively stable differentials (Lampert, Hoebel and Kroll, 2019; Tetzlaff et al., 2020). By contrast, Canada, the United States of America, and Sweden display a clear widening of longevity gaps, particularly in recent decades (Reznik et al., 2021; Fors, Wastesson and Morin, 2021; OSFIC, 2022). Italy has been portrayed in prior studies as showing strong and persistent socioeconomic inequalities (Ardito et al., 2022), although the absolute gaps are more modest, reflecting definitional and period differences.[11] In the Netherlands, socioeconomic gradients in mortality have remained enduring despite overall gains in longevity (Kalwij, Alessie and Knoef, 2013). Beyond Europe and North America, Latin American evidence consistently points to large disparities, with Chile and Argentina reporting high levels of inequality in late-life survival linked to pension income and educational stratification (Edwards, Soto and Zurita, 2023; Bramajo and Grushka, 2019). Taken together, these comparisons indicate that, while Spain shares with Germany a relative stability of gradients, other countries reveal widening or persistently intense gaps, underscoring the heterogeneous trajectories of longevity inequality across contexts.

Finally, our comparison also highlights a significant gap in existing research: most previous international studies focused solely on life expectancy, without considering complementary measures such as median age at death, modal age at death, or lifespan variation. By incorporating these additional indicators, our study provides a more nuanced understanding of inequalities in old-age longevity and contributes novel evidence to the comparative literature.

9. See Supporting information, online Appendix A.1 for details.
10. International evidence is compiled in Supporting information, online Appendix A.2, Tables OA.6–OA.9.
11. See Supporting information, online Appendix A.2 for details.

Policy uses by indicator

Life tables by pension income (PI) quartiles are not only useful for documenting inequalities in longevity, but they also provide practical tools that can strengthen actuarial analysis and policy design in the Spanish pension system. The four indicators at age 65 considered in this study – life expectancy (LE_{65}), the median age at death (Md_{65}), the modal age at death (M_{65}) and the interquartile range of age at death (IQR_{65}) – each add complementary information that can directly improve standard actuarial uses and official reporting.

Actuarial fairness and distributional assessment (money's worth and internal rate of return). The first application is the routine publication of money's-worth ratios and internal rates of return (IRR) for representative workers and pensioners, stratified by sex and PI quartile. In the United States of America, the Office of the Chief Actuary of the Social Security Administration regularly produces such analyses for hypothetical workers (Rose, Burkhalter and Nickerson, 2024), and IRR is standard in the PAYG distributional literature (Knell, 2010). For Spain, the Bank of Spain has estimated IRRs for new retirees in 2017 (Moraga and Ramos, 2020), but these rely on general-population mortality. Substituting PI-specific life tables would align evaluations with the actual survival patterns of contributors. LE_{65} provides the baseline valuation; M_{65} and Md_{65} add information on whether survival gains are concentrated at later ages; and IQR_{65} highlights inequality and uncertainty across groups (Rose, Burkhalter and Nickerson, 2024; Knell, 2010; Moraga and Ramos, 2020).

Calibrating annuity and benefit factors in notional defined contribution-type settings. Another application concerns the calibration of annuity divisors and benefit conversion factors in notional defined contribution-type settings. When average population life expectancy is used for all, high-PI groups (who live longer) receive overstated pensions, while low-PI groups (who live shorter lives) receive understated ones – an implicit redistribution (Alonso-García et al., 2019; Bravo et al., 2021). Using PI-specific LE_{65} reduces this transfer by anchoring benefits to the longevity of each subgroup. Md_{65} and M_{65} help ensure factors are not driven by tail effects, while IQR_{65} highlights the groups that face particular uncertainty and may require risk-aware options in benefit design (Alonso-García et al., 2019; Bravo et al., 2021; Canudas-Romo, 2008; Horiuchi et al., 2013).

Risk-aware retirement guidance and targeted prevention. The IQR_{65} is also important as an "uncertainty flag". It identifies groups with shorter and less predictable lifespan – most notably low-PI men. Since means and dispersion can move independently, higher variation itself deserves policy recognition. A wider

IQR_{65} supports targeted health strategies (primary care and prevention) and financial guidance that incorporates risk (buffer savings, survivor protection, longevity hedges). M_{65} complements these insights by pointing to whether survival gains and compression are concentrated at older ages in higher-PI groups, information that can influence communication strategies and default options (Aburto and van Raalte, 2018; Su et al., 2024).

Valuing accrued-to-date pension liabilities (ADL — ESA2010 "Table 29"). A further use is in the valuation of accrued-to-date pension entitlements required under the European System of Accounts (more commonly known as ESA2010). Spain currently values liabilities using general-population mortality from INE (2022) and Eurostat projections,[12] but pensioners exhibit systematically higher LE_{65} than the general population, so existing practice understates the liability. Using PI-specific mortality aligns valuations with the covered population. In addition, M_{65} and IQR_{65} are informative for sensitivity checks, clarifying whether liabilities are sensitive to shifts in typical late-life survival or to dispersion at the bottom of the distribution (ECB and Eurostat, 2020; Garvey, Castañer and Vidal-Meliá, 2023).

Transparency and monitoring of inequality. PI-specific mortality tables can also strengthen the transparency of actuarial communication. Publishing not only average survival (LE_{65}) but also indicators of inequality (such as IQR_{65}, already applied here) would make visible the heterogeneity of lifespan prospects across income groups. This information helps stakeholders understand that not all contributors face the same longevity, reinforcing the fairness dimension of pension debates. In addition, while our study focuses on four core indicators, the broader mortality literature suggests complementary measures – such as life disparity ($e^\dagger$), the age threshold separating early from late deaths ($\alpha^\dagger$), or the Gini of longevity – that could be explored in future work as additional tools for monitoring dispersion and inequality (Zafeiris, 2024). Together, these extensions would allow Spanish institutions to improve regular reporting, increase public trust, and monitor inequality trends in retirement outcomes more systematically.

In sum, each indicator connects naturally to specific policy uses: LE_{65} sets the baseline for valuation and annuity factors; Md_{65} provides a robust centre that avoids distortions from extreme values; M_{65} reveals late-life concentration of gains and compression; and IQR_{65} captures survival variation and double disadvantage among low-PI groups. Together, they provide a richer actuarial toolkit for evaluating fairness, calibrating benefits, targeting risk-aware guidance, and valuing pension liabilities.

12. See footnote 3.

Limitations

Several limitations should be considered when interpreting our findings. First, while pension income (PI) serves as a robust proxy for socioeconomic status, particularly for lower-income pensioners, we acknowledge it may not fully capture total income, especially for higher-income groups with additional investments or private pensions. It is worth noting, however, that for 70 per cent of Spanish pensioners the state pension is their only source of income (Pérez-Salamero González et al., 2022), which makes PI a good indicator for the majority, especially in the lowest quartile (G_1), even if less accurate for the highest (G_4).

Second, our analysis excludes certain groups of pensioners, such as those with disability pensions, early retirees, and those covered by special schemes (e.g. self-employed workers), for whom applying our longevity indicators may not have been appropriate.

Third, we were unable to include pensioners under the *Régimen de Clases Pasivas* (civil servants), since they are not recorded in the MCVL database.

Fourth, although the sample does not permit nationwide extrapolation to all pensioners, it does cover a substantial share of this population. In 2021 there were 4,448,130 pensioners in the general scheme, representing 91.72 per cent of total retirement pensioners excluding the self-employed (MITES, 2023).

Fifth, our classification of PI into quartiles might omit heterogeneity within groups. If full individual-level records from the Spanish social security system, including supplementary income data, were available, the use of quintiles or deciles instead of quartiles could allow more precise estimates of mortality inequalities. These limitations, largely driven by data availability, have been explicitly acknowledged to provide a balanced interpretation of our results.

Conclusions

The study on gender and income inequalities in longevity among Spanish retirement pensioners aged 65+ reveals several key findings. First and foremost, life expectancy at age 65 (LE_{65}) follows a clear and consistent socioeconomic gradient: higher pension income (PI) groups live significantly longer than lower groups (RQ_1), and these differences remain statistically significant across the study period. The greatest disadvantage concerns men in the lowest PI group (G_1), who not only experience the shortest LE_{65} but also face the greatest uncertainty in the length of life.

Female pensioners consistently have higher LE_{65} than their male counterparts, regardless of PI level. However, the evolution of LE_{65} varies by gender, with males in the highest PI group (G_4) generally living longer than those in the lowest PI group (G_1). Trends in inequality evolved differently by gender (RQ_2–RQ_3): among men, disparities between G_1 and G_4 widened initially and then narrowed, while among women, inequalities were smaller and fluctuated more modestly but persisted throughout. Importantly, socioeconomic and gender disparities are most pronounced in the most disadvantaged group (G_1), where inequalities have deepened over time.

Additional longevity indicators provide complementary answers to our research questions (RQ_4–RQ_6). Median age at death (Md_{65}), modal age at death (M_{65}), and interquartile range (IQR_{65}) reveal distinct patterns compared to LE_{65}. While M_{65} attenuates measured inequalities relative to LE_{65}, lifespan variation indicators emphasize the heightened uncertainty among disadvantaged males in G_1. Together, these findings show that each indicator highlights a different dimension of inequality: LE_{65} best reflects the socioeconomic gradient; M_{65} captures the central tendency of survival; variation indicators inform about inequality in the distribution of lifespans – each with distinct policy implications.

In addition, the study places pensioners in the context of the general Spanish population (RQ_5). Longevity improvements have been observed across the entire society, but pensioners exhibit sharper socioeconomic gradients by income group, making PI a crucial stratifier of inequalities in older ages.

Comparatively, Spain exhibits distinctive trends in longevity inequalities. While many high-income countries such as the United States of America, Canada, and Italy show widening disparities in life expectancy by income level, Spain's trends are unique. The relative differences in LE_{65} for females are smaller and have slightly decreased, contrasting with countries such as Sweden and Germany. However, Spain shows increasing gender-based disparities in longevity among lower-income groups, especially among men in G_1, a pattern less common elsewhere. This makes the double disadvantage of low-income males in Spain particularly salient in international perspective.

These findings emphasize the need for targeted policies to address socioeconomic inequalities in longevity and improve the well-being of disadvantaged pensioners in Spain. Prior research on longevity inequalities has highlighted both structural factors beyond pension income and pioneering works within the pension system itself. On the one hand, cohort-level improvements in educational attainment (Solé-Auró and Lozano, 2019), together with persistent educational gradients in health and morbidity (Bramajo et al., 2024), underline the role of structural determinants. On the other hand, pioneering studies by Pérez-Salamero González, Regúlez-Castillo and Vidal-Meliá (2021) and Pérez-Salamero González et al. (2022) analysed mortality stratification by pension income, taking into account differences between contributory regimes (the self-employed workers scheme versus the general scheme). However, these studies focused exclusively on men, leaving aside women's trajectories. Our contribution builds on this line of research by extending the focus to both genders, covering the entire population of retirement pensioners, and applying a multidimensional set of indicators. LE_{65} serves as a benchmark for socioeconomic gradients; M_{65} and Md_{65} refine the measurement of central survival; and lifespan variation indicators highlight the uncertainty of the ageing process, especially among disadvantaged groups. Together, these findings reinforce the importance of adopting a multidimensional approach when designing equity-focused longevity policies in Spain.

Last but not least, reducing socioeconomic disparities in longevity can only be partially addressed through pension income policies alone, and ultimately requires a broader multidisciplinary perspective that goes beyond the demographic and actuarial focus of this study.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.