European
Historical
Economics
Society

EHES Working Paper | No. 238 | August 2023

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Abstract

This paper analyses social inequality in adult mortality over the last 500 years in rural Aragon (Spain). It uses individual-level microdata corresponding to more than 20,000 individuals whose socioeconomic status, age at death and other family, cultural and environmental variables are known. Using advanced statistical techniques (mainly event history analysis), it follows all individuals who died after the age of seven years in 17 villages throughout their lives. This study is focused on observing the evolution of inequality in mortality by SES over a period of 500 years, deepening and relating it to the debates present in the historiography. As it is a pioneer study in connecting adult mortality with SES for almost five centuries, it enables us to verify the persistence of social inequality in death in rural Spain, which contrasts with the results obtained in northern European countries where these differences only emerged from the late nineteenth or early twentieth century onwards.

JEL Codes: I14, N33, J11

Keywords: Adult mortality, socioeconomic differences, inequality, Spain

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* This article forms part of the framework of the research projects of the Ministry of Science, Innovation and Universities of the Spanish Government PID2022-138886NB-I00 and PID2022.137302NB-C32, and the Consolidated Research Group S55_23R of the Government of Aragon. A preliminary version of the study was presented in Iberometrics (Lisbon, 2023) and in the workshop "New Perspectives on Inequality and Human Capital in Southern Europe in the Long Term" (Zaragoza, 2023).

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1. Introduction

The debate on the historical evolution of social differences in mortality and its determinants is a central and hot topic in economic history and demography (Bengtsson et al., 2020; Deaton, 2015). We can identify two main theories or hypotheses: the fundamental cause hypothesis and the divergence-convergence hypothesis. Broadly speaking and with an oversimplification, according to the fundamental cause hypothesis, social differences in mortality have always existed, derived from the differential control that individuals of different social classes have over a set of resources such as money, knowledge, prestige, power, and social connections (Berkman & Kawachi, 2000; Freese & Lutfey, 2011; Link & Phelan, 1995, 1996, 2002; Lutfey & Freese, 2005; Phelan et al., 2010). According to the divergence-convergence hypothesis, in the West, in a first stage, the differences were small, since the ease of contagion of diseases and their high virulence, mainly due to the absence of adequate treatment, meant that mortality was not substantially related to the level of nutrition. In a second stage, a gap appeared in the most advanced countries between the mortality levels of one class and another. Finally, in a third stage, the differences narrowed again, thanks to the spread of medical, health and economic progress (Antonovsky, 1967; Deaton, 2015, pp. 104–108; Pressat, 1985, pp. 53–58; Smith, 1983, p. 754).

During the twentieth century and the first decades of the twenty-first century, there was an increase in social differences in mortality in practically all the cases analysed, which has led some authors to rename it as the divergence-convergence-divergence hypothesis (Bengtsson & Van Poppel, 2011). Another alternative version of this theory has been put forward by Jacques Vallin and France Meslé (Vallin & Meslé, 2005, p. 117), who argue that social differences in mortality may have varied over time depending on the ability to take advantage of the different stages of the health transition. In this sense, there would not have been a single phase of divergence followed by another of convergence, but rather "a succession of divergence-convergence movements that take place at different times from population to population" (Vallin, 2013, p. 158). This succession of phases would be caused by the emergence of new advances or factors that made it possible to improve life expectancy.

The existing studies do not offer a univocal view of the historical evolution of adult mortality by social class. The behaviour of inequality has not been homogeneous in the various development processes. Some articles show a sort of alternation between periods of convergence and divergence (Breschi et al., 2011; Haines, 2001). In other cases, there is evidence of a social gradient in mortality in the early stages of the demographic transition (Ferrie, 2003; Fornasin et al., 2016; Schumacher, 2011) or even in earlier periods (Perrenoud, 1975, 1981). However, other studies show that socioeconomic differences in mortality were not observable until the end of the nineteenth century (Molitoris & Dribe, 2016; Razzell & Spence, 2006), the early twentieth century (Edvinsson & Broström, 2017; Edvinsson & Lindkvist, 2011) or even up to the second half of the twentieth century (Bengtsson et al., 2020; Bengtsson & Dribe, 2011; Debiasi & Dribe, 2019).

Another element that seems to emerge from the analysis of the results of the various case studies up to the middle of the twentieth century is the presence of a regional pattern: 1) The evidence presented on the countries of southern Europe - Italy (Breschi et al., 2011; Fornasin et al., 2016), Spain (Luque de Haro et al., 2021; F. J. Marco-Gracia & Puche, 2021) and France (Kesztenbaum & Rosenthal, 2016)– shows considerable social differences in mortality in periods before the major transformations described by the demographic and epidemiological transition took place; 2) the results for the countries of north-west Europe (Razzell & Spence, 2006; Schenk & Van Poppel, 2011), and various overseas economies –the U.S. (Smith, 1983; Steckel, 1988), Canada (Gagnon et al., 2011) and New Zeland (Wilson et al., 2018)– show a diversity of results, with studies in which a certain social gradient in mortality is observed alternating with others in which no significant differences are observed; 3) the case of Sweden, in which the studies are more abundant and where practically all of them do not find significant evidence of the existence of a social gradient in mortality (Bengtsson et al., 2020; Bengtsson & Dribe, 2011; Edvinsson & Broström, 2017).

The existing evidence reveals that the social inequalities in health depend on the singularities of the different societies, their development processes and the state of medical science and the predominant epidemiological pattern. The importance of the various determinants of social inequality in mortality has changed over time. This fact, together with the different growth rates experienced by different economies, the way in which production and wealth have been distributed, the higher or lower level of education of the population and the role played by public administrations, has conditioned the evolution of social inequalities in mortality in each of the development processes. In a first phase, some resources that would ensure adequate nutritional intake, in addition to other material elements, would be sufficient for the population with a lower SES to position itself close to the *full health potential* of the time[3]. However, advances in knowledge and technology have made some of the causes of mortality avoidable. This has led to an increase in the importance of educational attainment, as well as an increase in the material resources needed to achieve full health potential, particularly in countries without universal health coverage (Luque De Haro, 2023; Mackenbach, 2020).

Traditionally, most of the research on social differences in mortality has been carried out from a transversal or moment perspective (e.g., Chapin, 1924; Marang-van De Mheen et al., 1998; Razzell, 2006; Van Reek, 1993; Woods, 2000)[4]. However, in recent years, the number of studies that, based on microdata, analyse inequality from a longitudinal

[3]The concept of Full Health Potential (FHP) implies a dynamic element and is included in recent World Health Organization publications (Whitehead & Dahlgren, 2006; World Health Organization, 2022). It has increased throughout development, as evidenced by the huge gains in life expectancy in the most advanced countries (Deaton, 2015). According to Whitehead and Dahlgren (2006, p. 5), "equity in health implies that, ideally, everyone could attain their full health potential and that no one should be disadvantaged from achieving this potential because of their social position or other socially determined circumstance".

[4]This method offers less certainty in its conclusions, as the results can be biased by the age effect, generation effect or selection effect (Bengtsson and Van Poppel, 2011; Bengtsson, Dribe and Helgertz, 2020; Luque de Haro and Sánchez-Picón, 2021). For more details on the advantages and limitations of macro and micro analysis, see, for example, Johansson (2000).

perspective has increased considerably. The reasons that explain the increase in the number of publications include the renewed interest in issues related to inequality, the development of demographic databases with longitudinal microdata and the greater computer facilities to carry out advanced calculations (Hall, McCaa and Thorvaldsen, 2002; Bengtsson, Campbell and Lee, 2004; Bengtsson and Van Poppel, 2011; Ramiro Fariñas and Oris, 2016; Ruggles, Fitch and Roberts, 2018). Despite the increase in the number of publications, there is a clear overrepresentation of analyses on northern and central European populations, with Sweden standing out in this regard (Bengtsson et al., 2020; Bengtsson & Dribe, 2011; Debiasi & Dribe, 2020). However, analyses of social differences in mortality in southern European populations are much scarcer. In fact, if we look exclusively at long-term studies, we can observe that only in the case of the aforementioned Nordic country are there studies that analyse more than 100 years from a longitudinal perspective. Thus, this study will be the first to make a long-term analysis for populations in southern Europe and the only one to date in which almost five centuries of evolution in social differences in mortality are continuously analysed. For this reason, by contributing new evidence related to this "knowledge gap", this study can enhance the knowledge of the evolution of social inequalities on a historical level.

2. Area and data

2.1. Rural Aragon as a case study

The area of study consists of 17 rural localities situated in the inland region of Aragón in northeastern Spain (see Figure 1). These localities are Alfamén, Aylés, Botorrita Cadrete, Codos, Cosuenda, Cuarte de Huerva, Jaulín, Longares, María de Huerva, Mezalocha, Mozota, Muel, Torrecilla de Valmadrid, Tosos, Valmadrid, and Villanueva de Huerva. The study area is located on the margins of the Ebro Valley, at the foothills of the Sierra de Algairén, combining plains with low mountain landscapes. It is located within 20-45 km of Zaragoza, the provincial capital, and covers an area of approximately 500 km^2. The population of the area has varied from approximately 5,000 in 1600 to more than 9,300 inhabitants in 1787, to 12,500 inhabitants in 1940 and to 8,200 inhabitants in about 1980 due to rural-urban migrations. The study is limited to these municipalities because of the availability of data and the methodology's cost and time consumption. The population lived primarily in nuclear households (Marco-Gracia, 2018). Table 1 shows the evolution of the resident population in each of the villages in the study area from the seventeenth to the twenty-first century and for the period for which we have demographic data in each case. We must bear in mind that, when the parish archives began after the Council of Trent (1545-1563), some of the localities studied were populated by Moriscos: Alfamén, Aylés, Botorrita, Cadrete, Cuarte de Huerva, María de Huerva, Mezalocha, Mozota and Muel (Marco-Gracia, 2020). In that case, due to the small temporal sample available (in most villages not even the archives for the Moriscos have been preserved), the study for these localities starts from 1610. This is the year when the Moriscos were expelled from Aragon and the process of repopulation with Christians began.

Figure 1. Location of the study area.

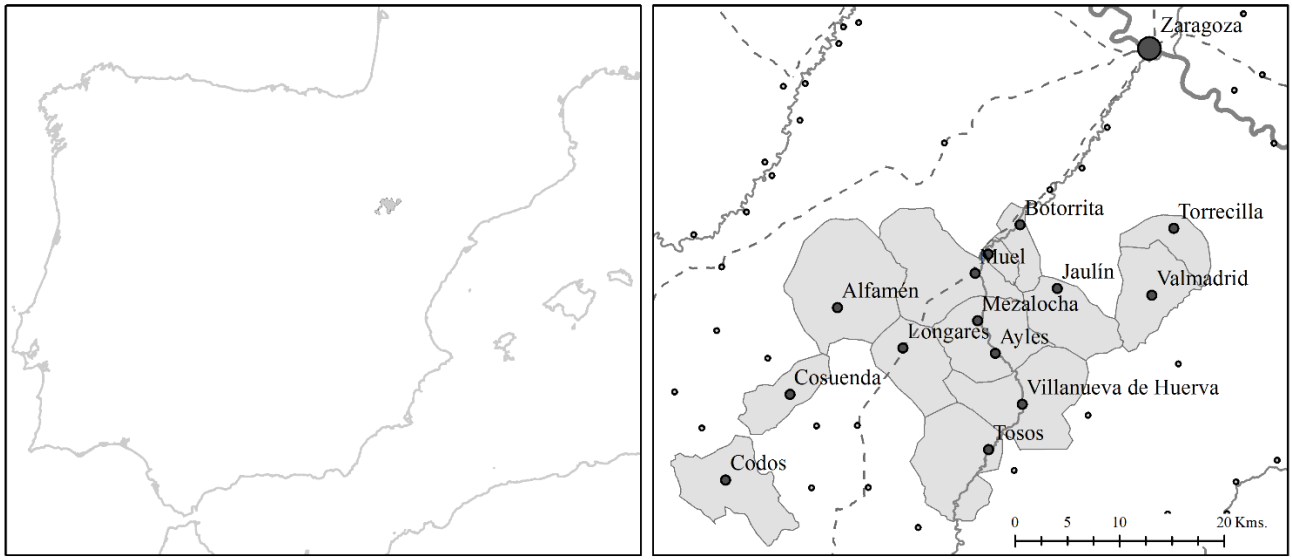


Table 1. Period of birth records and population of the villages in the sample 1860-1981

	Parish registers		Population						
	Start	End	1495	1646	1787	1860	1900	1940	1981
Alfamén	1716	1950	171	36	356	604	639	1,347	1,283
Aylés	1608	1950	5	-	23	45	26	47	0
Botorrita	1642	1950	90	185	147	294	350	557	382
Cadrete	1603	1827	360	351	637	599	647	767	680
Codos	1699	1950	99	338	772	1,232	1,195	938	355
Cosuenda	1551	1950	185	320	1,212	1,451	1,270	929	482
Cuarte de Huerva	1610	1937	369	243	356	342	275	322	1,148
Jaulín	1560	1950	32	225	561	390	348	528	334
Longares	1473	1950	527	693	1,206	1,120	1,329	1,385	959
María de Huerva	1612	1901	310	180	544	604	581	826	734
Mezalocha	1610	1950	158	203	429	544	482	660	357
Mozota	1610	1950	171	117	260	292	372	404	158
Muel	1610	1950	446	522	1,116	1,223	1,206	1,605	1,330
Torrecilla de V.	1586	1950	54	108	159	164	77	94	32
Tosos	1547	1950	171	234	578	682	865	801	297
Valmadrid	1852	1950	90	158	250	203	210	219	89
Villanueva de H.	1573	1950	378	644	802	690	970	1,158	771
TOTAL			3,616	4,557	9,408	9,471	9,699	12,587	8,194

Note: We have estimated the population of the 1495 and 1646 neighborhoods considering 4.5 residents per *fuego* (household). Where data is not available in the 1787 census, we have used the 1768 census as an approximation (this is the case of Codos, Cosuenda and Mozota).

Source: Spanish Statistical Institute (www.ine.es/)

The studied villages had a traditional manorial system, which meant that they were used to paying higher taxes than freeholds (Colás, 1993). According to the available eighteenth-century data, including the census of Aranda (1768) and the census of Floridablanca (1785–1787), the economic and social distribution was typical of small agrarian communities. The primary sources of income for the inhabitants were sheep farming and agriculture, including growing cereal crops, fruits, and vegetables along the banks of the Huerva River. Although the quality of the land was similar, the areas without access to water, such as Alfamén or Jaulín, were primarily used for grazing and were repopulated at a slower pace due to their relatively unattractive nature. Some inhabitants also worked in trade and the transportation of goods. During the eighteenth century, two out of the five glass production furnaces in Aragon were located in Alfamén and Jaulín, while the ceramics produced in Muel have been famous since medieval times (Marco-Gracia, 2017b). These villages lived under the traditional economic regime until economic modernisation. During the initial wave of globalisation in the end of the nineteenth century, Aragon experienced a surge in modernisation and economic growth that persisted for a significant part of the twentieth century. However, the progress was not uniform throughout the region, with Zaragoza leading the way while rural areas lagged behind (Germán, 2000). Unfortunately, the Civil War (1936-1939) dealt a significant blow to the economic modernisation of Aragon, causing growth to stagnate until the 1960s (Germán, 2012).

At the demographic level, prior to the demographic transition, the majority of the population in these villages practiced natural fertility, which meant that married couples had children without any significant use of fertility control methods (as defined by Henry, 1961). This resulted in high fertility rates and no restriction on the timing of childbirth within marriage. Consequently, families had many children, with births continuing until the mother reached menopause. Although this led to high child-mortality rates, it balanced family size (Marco-Gracia, 2017b). The average fertility rate of Aragonese families was around seven children until the early twentieth century. However, the large number of births and the increased number of surviving children eventually led to population growth, increasing demographic pressure over time. Unfortunately, infant and child mortality rates remained high, with only half of infants surviving beyond the age of five. However, similar to the rest of the country, mortality rates started to decline towards the end of the nineteenth century due to lower occurrences of epidemic crises and infectious diseases transmitted through water and food. Following the fertility transition, the fertility rate began to decrease to ratios of less than two children per family in subsequent decades (Marco-Gracia, 2017b). At standard of living level, the average height of Aragonese men during this time was around 160 centimetres, according to century-old measurements. These measurements indicate that biological well-being was low, as the

height was considerably below the European average and even other regions of Spain (Hatton & Bray, 2010; Martínez Carrión et al., 2016; Quintana-Domeque et al., 2012).

2.2.Data

This work is based on the database elaborated from the reconstruction of the demographic events of the rural population of 17 localities of the Ebro valley (Spain) following the family reconstitution method (Fleury & Henry, 1956). This database is the largest Spanish database with life-course longitudinal data since it has information for five centuries. In addition to the immense period covered by this database, another of its advantages is that it includes numerous variables related to family structure, hygienic-sanitary characteristics, and the socioeconomic status of the subjects. These characteristics enable us to analyse possible changes in the relationship between socioeconomic status and population health between the sixteenth and twenty-first centuries.

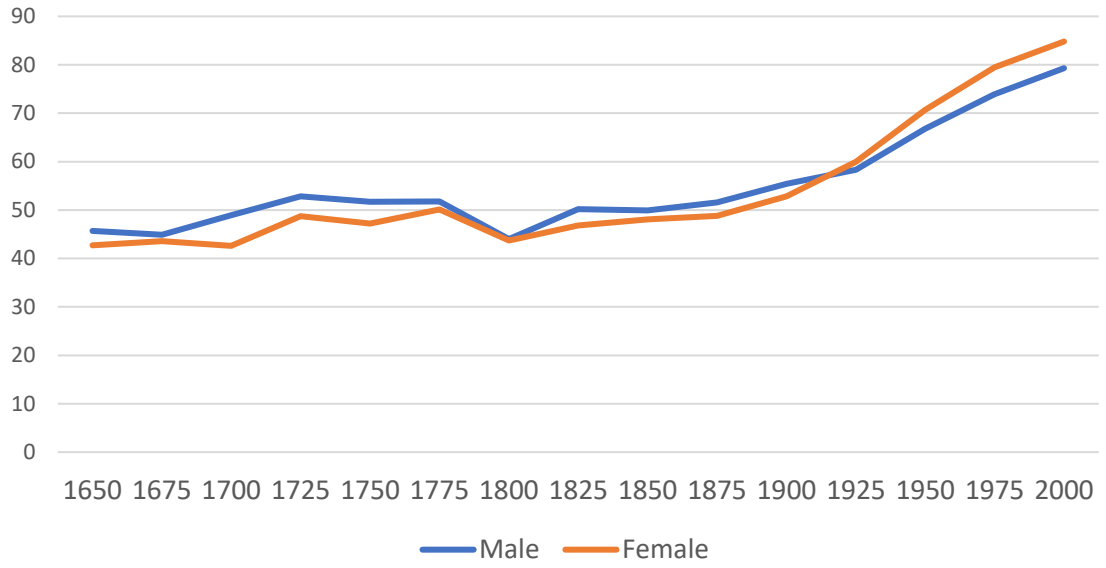
The familial and demographic data have been drawn from the complete church registers of the villages. These records provide high-quality information on all baptisms, marriages and deaths that occurred between the sixteenth century and the mid-twentieth century. It includes all individuals who were born and baptised in the reference parishes or who migrated to them and were registered. We have information on approximately 125,000 individuals, which has allowed us to reconstitute the life history of these individuals and their families. It should be borne in mind that this study is only concerned with adult mortality, so we have taken individuals who died at the age of 7 years or older whose age at death is known. In some cases, we know the date of birth and death and therefore know their exact age (in days, months, and years) of death. In other cases, we do not know their date of birth but in the parish archives there is a declared age of death. We used the declared age at death in 28.4% of the cases. Thanks to the individuals for whom we have the exact age and declared age at death, we know that on average there is a deviation of -0.71 years, with a standard deviation of 0.189.

As previously mentioned, the data have been obtained from the parish archives of these localities (baptisms, marriages and deaths) for the period prior to 1950. This is due to the existence of a data protection law. From 1950 onwards, similar data (dates of birth, marriage, death, educational level and male occupation) have been obtained from interviews with the majority of the resident population in these localities and from open cemetery sources. All of this has enabled us to connect the population data from the Council of Trent to the twenty-first century.

In Figure 2 we can see the evolution of lifespan by sex and period (every 25 years) of death between 1650 and 2020 for individuals older than 7 years. It can be clearly seen that the lifespan remained almost stable until the end of the nineteenth century. A strongly negative shock is only observed among those who died at the beginning of the nineteenth century. This is the result of the combination of the bad agricultural and disease years in

around 1804-1805, the Napoleonic wars (1808-1814) and the subsistence crises of the last years of these wars (1812-1813). From the end of the nineteenth century onwards, there was an upward trend in lifespan, especially for women, who outnumbered men, which increasingly widened the gender gap. By the beginning of the twenty-first century, the average lifespan had clearly exceeded 80 years for women and would have done so for men as well were it not for the excess mortality produced by covid which reduced the average age to slightly below 80 for men in the study area.

Figure 2. Evolution of average lifespan in the study area of people over 7 years by year of death and sex.



Source: Alfamén and Middle Huerva Database (AMHDB).

Note: We have not included the period before 1650 because of the small sample size by sex that generates results with high standard deviation.

For the study of socio-economic inequality up to 1800, given the limited availability of sources, we have used what we have called "funeral wills" (see Marco-Gracia, 2020). These wills were intended strictly for funeral expenses. Few wills in this area were notarised, and most were dictated to the parish priest when those who did not die suddenly received the extreme unction. Such wills did not indicate how to distribute the person's wealth but only what to spend on their funeral and how, which the priest was required to record in death certificates reviewed by his superiors. Not everyone drew up a will, although the priest asked all dying people of sound mind to do so, as he crucially depended on the funeral bequest for a part of his earnings. Over 90% of adults made a funeral will (i.e., all those who did not die suddenly), and if the priest found that the dying person had undeclared resources yet bequeathed insufficient funds for the funeral, he would try to increase the declared amount. This source (as all our analyses will show later) is very useful since they reveal economic differences at the time of death. While a high percentage of deceased individuals could leave nothing for their funeral (in almost

all decades above 25% of individuals), others could make large stipends with multiple priests at the funeral, continuous sung masses or special burial clothes. In funeral wills, the priest usually noted the amount of money that the deceased would cost in the margin or, with the data for each item from other funerals, we are able to calculate this. Moreover, they are in the currency of account (the basic funeral is 10 *escudos*), enabling us to compare one period with another.

We have classified the funeral wills into three categories: 1. The richest, those who assigned 50 *escudos* or more; 2. Those who are in an intermediate category can be described as individuals who have been able to afford their basic funeral expenses (10 *escudos*), and in some cases, even some extras (such as sung masses, multiple priests at their burial, or being buried in a special habit). However, they did not make large expenditures like those in the higher category. This group represented the majority of the population, as they had saved enough to cover the costs of their funeral and avoided being a burden to their descendants or facing the humiliation of being buried as charity cases. Nevertheless, they could not afford eye-catching events as their standard of living was close to subsistence levels; 3. The poorest who could not afford their funeral and who were given a full or mostly charity funeral (below 10 *escudos*). From this variable we have calculated the family burial will. The family category of each individual was assigned on the basis of the amount testified by the spouse or, secondarily, by the father. In most of the models we used the family burial will (and not the individual will) in order to avoid errors that could arise from the relationship between age and the amount bequeathed for the funeral[5]. We will explain in more detail how we use this variable in the next section.

From 1800 onwards, as funeral will data in parish archives disappear in most cases, we have approximated socio-economic differences through professions (see the example of Bengtsson and Dribe, 2020). The occupational data have been extracted from individual population lists (1824, 1857 and 1860), electoral censuses (we have taken a sample every five years from 1890 to 1955), and the parish registers for the intermediate period between 1860 and 1890, linking them to population records for every individual. In the case of women, given that a high percentage have no recorded occupation, we have used the occupation of the spouse in a subsidiary manner[6]. The Historical International Standard Classification of Occupations (HISCO) has been used to codify individual occupations[7]. Based on the HISCO codes assigned to each individual, we have used the

[5] In the under-30 age group, the average legacy is significantly lower than in the older age groups (see Table A.1 in the appendix). This could be explained both by cultural factors, i.e. it was not customary for younger people to have a more extravagant funeral, and/or by the fact that people who die at an older age had had more time to save and can afford a more sumptuous funeral.

[6] Unfortunately, as widely demonstrated, female occupational records suffer from significant underreporting throughout the nineteenth century and much of the twentieth century (e.g., Humphries & Sarasúa, 2012). The available records of women tend to concentrate on widows and non-single adult women, preferably in non-manual jobs (such as widows managing their deceased husband's estate or female teachers). Only in the latter third of the twentieth century do female occupation records begin to improve, coinciding with the changing attitudes towards women's work. To mitigate these strong biases, we have used the husband's occupation as a subsidiary measure.

[7] See Van Leeuwen, Maas and Miles (2002) and Pujadas-Mora, Romero Marín and Villar Garruta (2014).

HISCLASS scheme to classify occupations into socio-economic groups. The 12 HISCLASS categories have been grouped from the most widely used HISCLASS 5 scheme. Among other reasons, we have chosen this classification scheme because of its proven usefulness and because it facilitates the international comparability of results[8]. This grouping categorises occupations into five social classes: (1) Elite (senior managers and higher professionals), (2) lower middle class (junior managers, professionals, sales personnel, and foremen), (3) self-employed farmers and fishermen, (4) medium-skilled and lower skilled workers, and (5) unskilled workers and farm workers. In addition, we have added a sixth category, which includes healthcare or lower clerical occupations. The aim is to control for the possible effect on mortality of an increased exposure to infectious diseases associated with these occupations. This mode of classification is justified by the need to better adapt to the productive structure of rural Aragon at the time, since the range of occupations was limited and relatively concentrated in certain jobs. Therefore, the grouping of individuals into broader socio-economic categories allowed us to obtain more robust results than we would have obtained if we had analysed each occupation or HISCLASS category separately.

The available sources for occupation from the mid-nineteenth century to the end of the twentieth century also provide data on literacy[9]. Information on literacy helps us understand the effect of knowledge on health behaviour and it could be a good approximation of the economic investments made by parents. The Spanish literacy rate increased from 27 to 73 percent between 1860 and 1930 (Núñez, 2005). In fact, in our area of analysis, the inhabitants born in the 1930s were the first generation to reach full literacy (Marco-Gracia, 2018).

3. Method of analysis

Because of its advantages over other methods of analysis we will use COX PH, using age as the time scale instead of the observation time of the individual and adjusting for left truncation at a0. Among the reasons for this choice is the fact that using a model based on age at the time of the event rather than one based on the observation time of the individuals may be preferable if age is a stronger determinant of the event of interest (in our case death) than observation time (Kleinbaum & Klein, 2012, p. 137; Korn et al., 1997) .

$$h(a, X) = h_0(a|a_0)\exp[\sum \beta_i X_i]$$

where $h(a, X)$ is the hazard of death; $h_0(a|a_0)$ is the baseline hazard—that is, the hazard function for an individual having on all covariates the value 0.

[8] Most recent studies on social differences in mortality in the past use this classification for grouping individuals. See for example Schenk and Van Poppel (2011); Bengtsson, Dribe and Helgertz (2020) and Edvinsson and Broström (2020), as well as other studies analysing differential effects or behaviour by SES (Sánchez-Alonso & Santiago-Caballero, 2022)

[9] Already in the population census of December 31, 1860, we have literacy data for all individuals, including those who were born before that date and were alive.

i = [SES, birth date, village of residence, ... n], with n being the number of variables

$X_i = \begin{bmatrix} X_{SES} \\ X_{birth} \\ \vdots \\ X_n \end{bmatrix}$, where X_i corresponds to the value of variable i.

$\beta_i = [\beta_{SES} \quad \beta_{birth} \quad \dots \quad \beta_n]$, where β_i corresponds to the value "beta" of variable i.

For the elaboration of the database, we have used the counting process format as it allows multiple lines of data for the same person. In this way, each individual's total at-risk-follow-up time is sub-divided into smaller time intervals. The use of this format is recommended when using the age-at-follow-up time as the outcome variable instead of time of follow-up and, in addition, allows the inclusion of time dependent variables such as marital status (Kleinbaum & Klein, 2012).

We have included the year of birth as a control variable to consider the possible impact of economic improvements and advances in health and medical knowledge on survival probabilities. The reason is that, although we have run models for different sub-periods, the intervals are wide enough for substantial changes in material conditions to occur. In addition, especially in the last two periods, the pace of scientific progress and the expansion of medical and health knowledge was considerable, as well as the possibilities of its application by families, professionals and institutions. Other control variables included in the different models relate to the nature of the individuals, literacy, marital status, percentage of children over 5 years of age and the village of residence[10].

The different models were checked for compliance with the PH assumption using Formal tests, based on the scaled Schoenfeldt residuals (cox.zph in R), and, in general, no significant issues were identified. Regarding the SES, limitations are restricted to the #N/A category (Not Available observations). New models were attempted without this category, and the results were very similar. In the aggregate models, the variable sex does not meet the assumption due to the differences in risk between men and women. Therefore, we have chosen to include models differentiating by sex. Civil status is another variable that fails to meet the assumptions in some periods. We conducted tests stratifying data by age, i.e., 7 to 55 years and those above 55, in which the assumption is met. The variable's effect direction remains the same, but the penalty is more severe amongst single and widowed individuals in younger cohorts. Apart from this, there are no significant violations of the proportional hazards' assumption, and the model estimates can be interpreted as the average differences over the entire period. Due to the significant number of tables already included in the article, some of these models are not displayed in the appendix 1.

[10] The use of infant mortality per household as a proxy for sanitation has been used in previous research (Woods, 2000).

4. Descriptive Statistics

Table 2 shows a descriptive analysis of the sample. We have divided the table between men and women and included the values for each of the five periods analysed. We only have information on quantities tested up to 1800. The first quadrants on the left show the distribution of the population according to individual wills and family wills. The order of relative importance of the categories is the same for both variables: the category with the greatest relative weight is that relating to funerals costing between 10 and 50 escudos, followed by those costing less than 10 escudos and finally those costing more than 50 escudos. For the reasons given above, in most of the models we will use the variable relating to the will of the relative rather than that of the individual.

The percentages of men and women are quite similar in all of the categories. During the period 1500 - 1700 the group comprising the largest number of individuals is the one including family burial wills between 10 and 50 *escudos* with about 54% of women and 56.1% of men. This outcome is to be expected since this group includes those whose relatives have been able to afford their funeral by knowing throughout their lives that it was set at 10 escudos. In other words, even while living with modest means, they have saved this basic amount to ensure a regular funeral on the day of their passing. This is followed by the 3rd category (the poorest) with 13.9% of females and 15.2% of males. This group includes all individuals whose close family members could not even afford the minimum required and had to be buried through charity. Being aware of the efforts made by the priest to ensure that those who could not pay for their funeral genuinely had nothing, these figures indicate that a significant portion of society (more than 10%) lived in extremely impoverished conditions. During the period 1700 to 1800 the percentages were very similar to the previous ones, with a slight increase in the percentage of the poorest individuals and a reduction in the weight of category 1 and 2.

The percentage of individuals classified according to their occupation is shown on the right side of the table 2. As mentioned above, this variable –Individual Class– is only available in generalised form for men from 1800 onwards. The occupations of the bulk of the men are classified in groups 3 - *Self-employed farmers* and 5 - *unskilled and farmworkers*. The category that includes the occupations with the highest SES (1- *Elite*) concentrates slightly less than 2% of all men in the last three periods. Also noteworthy is the increase in the relative importance of category 2 - *lower middle class* and category 4 - *skilled workers* between 1800-1870 and 1945-2100 (from 1.3 to 3.6 and from 7.5 to 8.6 respectively).

As we have explained, estimates of social differences in female mortality have used the occupation of the head of the household - family class - as a proxy. On the basis of this variable, as expected, the groups with the highest number of women are, again, the third and the fifth. For both men and women, the proportion of people in category 6 (lower clergy and health professionals) is less than 1% in all periods. The small change in the occupational structure from one period to the next is explained by the fact that we are analysing a rural area where agriculture is still the dominant sector.

Table 2. Descriptive analysis of the sample

	A. Women		B. Men			A. Women			B. Men		
	1500 - 1700	1700 - 1800	1500 - 1700	1700 - 1800		1800 - 1870	1870-1945	1945-2010	1800 - 1870	1870-1945	1945-2010
Individual Burial Wills (%)					**Individual CLASS (%)**						
1	8,34	6,44	7,09	6,1	1 - Elite	5,06	0,45	0,56	1,88	1,90	1,88
2	67,61	46,2	67,61	49,41	2 - Lower middle class	0,12	0,48	4,25	1,30	1,93	3,60
3	21,51	34,75	21,63	31,58	3 - Self employed farmers	2,17	0,64	0,57	31,40	33,00	32,88
#N/A	2,54	12,62	3,67	12,91	4 - Skilled workers	0,57	0,52	3,82	7,54	5,97	8,59
					5 (ref) - Unskilled and farmworkers	2,10	3,61	2,81	33,53	45,72	45,84
					6 - Clergy and sanitary	0,00	0,05	0,03	0,88	0,36	0,27
					#N/A	89,99	94,26	87,95	23,46	11,11	6,94
Family Burial Wills (%)					**Family Class (%)**						
1	10,65	7,99	11,2	7,71	1 - Elite	7,17	2,72	2,41			
2	54,01	45,82	56,12	47,16	2 - Lower middle class	1,62	2,34	7,21			
3	13,92	20,15	15,28	20,44	3 - Self employed farmers	30,60	28,01	27,46			
#N/A	21,42	26,03	17,39	24,69	4 - Skilled workers	7,34	6,74	9,85			
					5 (ref) - Unskilled and farmworkers	34,23	44,53	39,13			
					6 - Clergy and sanitary	0,30	0,40	0,22			
					#N/A	18,74	15,26	13,73			
Birth Date (mean)	1634	1716	1634	1714	**Birth Date (mean)**	1812,9	1876,2	1921,8	1813	1877	1921,4
Civil Status (%)					**Civil Status (%)**						
Single	30,79	24,59	39,59	29,68	Single	32,45	23,76	12,51	40,94	35,18	32,84
Currently Married	25,77	31,88	30,41	31,57	Currently Married	34,42	31,19	24,49	35,11	29,26	21,30
Widow	7,65	8,55	7,57	8,93	Widow	6,93	9,80	18,21	6,45	10,03	18,74
N/A	35,78	34,99	22,43	29,82	N/A	26,20	35,26	44,78	17,50	25,53	27,12
Literacy (%)	0,09	0,04	1,96	2,51	**Literacy (%)**	1,86	27,16	61,82	17,91	51,33	74,16
Village (%)					**Village (%)**						
1-Alfamén	0	0,55	0,00	0,91	1-Alfamén	5,43	11,29	21,03	6,54	13,17	22,50
2-Aylés	0,10	0,05	0,06	0,02	2-Aylés	0,14	0,05	11,00	0,19	0,96	0,16
3-Botorrita	1,85	2,83	1,61	2,65	3-Botorrita	2,07	4,20	4,23	2,51	4,02	4,18
4-Jaulín	15,24	10,01	16,36	8,33	4-Jaulín	4,97	5,01	6,00	4,89	4,85	4,90
5-Longares	25,84	14,46	23,99	17,04	5-Longares	25,10	19,66	16,79	26,97	19,71	16,11
6-Mezalocha	12,11	7,50	8,14	7,00	6-Mezalocha	6,51	4,65	5,19	6,32	4,99	4,79
7-Mozota	2,05	4,34	2,59	3,46	7-Mozota	2,83	4,17	2,60	2,80	3,41	2,09
8-Muel	10,12	14,37	6,25	11,12	8-Muel	14,42	16,96	17,69	14,65	17,23	16,18
9-Tosos	0,86	0,19	0,16	0,40	9-Tosos	8,30	9,53	6,28	7,64	8,32	5,65
10-Villanueva de Huerva	0,00	1,03	0,00	0,68	10-Villanueva de Huerva	11,43	13,76	12,72	10,98	12,71	12,53
11-Valmadrid	0,00	0,00	0,00	0,00	11-Valmadrid	0,00	0,07	0,10	0,00	0,07	0,17
12-Torrecilla de Valmadrid	0,09	2,27	0,08	1,60	12-Torrecilla de Valmadrid	0,00	0,09	0,10	0,00	0,02	0,04
14-Cosuenda	23,64	26,89	23,99	21,42	14-Cosuenda	13,87	9,07	6,35	12,25	8,61	6,13
15-Codos	0,00	0,00	0,00	0,00	15-Codos	0,00	0,45	4,56	0,00	1,15	4,56
16-Cadrete	2,84	4,47	7,93	11,58	16-Cadrete	0,52	0,00	0,00	0,03	0,00	0,00
17-Cuarte de Huerva	2,50	5,07	5,41	6,73	17-Cuarte de Huerva	0,00	0,02	0,00	0,15	0,07	0,00
18-María de Huerva	2,76	5,95	3,44	7,06	18-María de Huerva	4,40	1,01	0,00	4,10	0,66	0,00
Person-years	29.285	60.285	38.020	76.931	**Person-years**	81.024	161.434	106.247	79.965	162.122	106.776
Number of deaths	616	1.713	737	2.071	**Number of deaths**	1.040	2.615	1.924	1.024	2.847	2.369

Source: See in the text.

Information on literacy is generally available from the early nineteenth century. Before that date, we only have information on a few isolated cases, which does not allow us to approximate the distribution by socioeconomic category or analyse its impact on health. For both men and women, there is a marked increase in the percentage of literates from 1800. This increase has been particularly pronounced for women, leading to a significant reduction in the gender gap in literacy. In the second table in the appendix 1, we can see that the percentage of literacy shows a clear relationship with the socio-economic status of individuals. In the case of men, although there is a general increase from one period to the next, the order of the socio-economic categories in terms of the percentage of

literates does not change significantly. The largest increase in literacy is in the lowest socio-economic status groups, favouring convergence between SES categories. However, the category that includes the majority of men (unskilled and agricultural workers) remains the one with the lowest percentage of literate population throughout the period. In the case of women, if we look at the classification performed using the husband's occupation, we can see that category 6 (among the clergy and health workers) is the one with the highest percentage of literate women. This is followed by categories 1 and 2 for the periods 1870-1945 and 1945-2010. Finally, the group with the lowest percentage of literate women is category 5.

5. Results

The preliminary results indicate the existence of social differences in mortality in the five subperiods analysed so far: 1) Before 1700; 2) 1700-1800; 3) 1800-1870; 4) 1870-1945 and 5) 1945-2010. The results are not perfectly comparable because, as explained above, the models for the first two periods analyse social differences in mortality based on the amount of the will of the deceased's relatives, whereas in the more recent periods (since 1800) the models do so based on socio-economic status, which is derived from the occupation of the individual or the head of the household.

The third table shows evidence of a social gradient in mortality during the period 1500 to 1700 and between 1700 and 1800 using the amount tested by relatives for SES classification. In both periods, a lower risk of death was observed for those in the highest and the middle SES category compared with those in the lowest category[11]. It should also be borne in mind that the first period is the period prior to the expulsion of the *Moriscos* in 1610 and, therefore, the beginning of the repopulation. Possibly the socio-economic differences of origin were more accentuated between the individuals who came to repopulate these villages (being of very poor origins) and the individuals residing in the Christian localities with a less unequal distribution of income (Marco-Gracia, 2020).

With regard to the effect of marital status on survival probability, in line with most of the literature on the subject, we find that single people have a significantly higher risk of death than married people (Crinela Holom et al., 2021; Edvinsson & Broström, 2012). Widowers also have a higher risk, although less than single people. The effect of this variable is relatively similar in the two periods analysed. This confirms that civil status is important. The reasons, however, are not clear. On the one hand, it could be that individuals with poorer health and socio-economic conditions find it more difficult to find a partner. On the other hand, the reciprocal care of spouses and children could favour

[11] See the results using the individual testcat variable in the appendix 1 (those that are calculated with the population over the age of seven are somewhat better than those of the population over the age of 30). As a robustness check, we calculated social differences in mortality from the age of 30 for the period 1500-1800 using the individual funeral will. The results are summarised in Table 3 in the appendix 1. As we can see, during the first period (1500-1700), a social gradient in mortality is observed. In the period 1700-1800, people in the highest social class have a significantly lower risk than the reference category. The second category, however, has a significantly higher risk.

a longer lifespan. In addition, we should keep in mind that previous studies for the same study area have found that single people tended to die at a higher rate than married people up to about age 50. Singles who reached that age had a life expectancy similar to that of the population as a whole (Marco-Gracia, 2017a).

The sex variable reflects a higher risk of death for women. We have seen this clearly in Figure 2 up to the twentieth century. Among the possible explanatory reasons, we highlight a dominant heteropatriarchal system, especially in rural areas, which favoured better nutrition and care for men to sustain the household. In addition, women were exposed to more causes of death such as those related to multiple births and the contagion of diseases because they were the ones in charge of caring for the sick. The graph of survival rates of males and females calculated from the Kaplan-Meier model (Figure A.4 in the appendix 1) seems to confirm this explanation. In the early periods, the risk of death is higher for women of childbearing age. In fact, Figure A.4 in the appendix 1 shows very clearly that the excess of adult female mortality is concentrated in the fertile ages, which would be associated with an excess of mortality during childbirth itself, but also in the following weeks, due to the limited means and medical knowledge for the management of postpartum complications and those resulting from hygiene problems (for example, it was not customary for doctors to wash their hands until the end of the nineteenth century) (Loudon, 2000). The disadvantage faced by women at these ages has diminished over time, reflecting the decline in maternal mortality.

Table 3. Cox regression estimates of mortality (1500 – 1800)

	1500-1700	1700-1800
TESTFAMILIACAT (3)		
SES-1 (>50)	**0,793·**	**0,767*** **
SES-2 (>=10 y <=50)	**0,788****	**0,901***
SES-3 (<10)	1	1
BirthDate	**1,002·**	**1,011*** **
Sex	**0,771*** **	**0,812*** **
Civil Status		
Single	**2,234*** **	**1,969*** **
Widow	**1,538*** **	**1,644*** **
Nativo	0,911	1,084
Village fixed	Yes	Yes
Person Years	67.174	136.932
Events	1.223	3.504

Note: Individuals older than 7 Years. Both sexes. Models are statistically significant below the 1 % level based on a chi-square test.

Source: See in the text.

Finally, it should be noted that the coefficient of the beta exponent associated with the variable year of birth has a value greater than one, in particular in the period from 1700 to 1800. This could be reflecting a deterioration in living conditions towards the end of the eighteenth century and a lower level of progress in health knowledge during the centuries under consideration. These results for the eighteenth century are compatible

with other studies for the same study area (Marco-Gracia, 2017a). In addition, we must take into account that throughout the eighteenth century there was a strong population increase in the area of study, which may have increased the competition for the available resources.

Social differences in mortality remain evident during the third (1800-1870), fourth (1870-1945) and fifth (1945-2010) periods. Between 1800 and 1945, the differences are significant when comparing category 3 - farmers - with the reference category 5 - unskilled and farmworkers. It should be remembered that, as shown in Table 2, these two categories concentrate the majority of individuals in our database during these periods. Meanwhile, the coefficients associated with the categories 1-Elite and 2-Lower middle class are also less than one, suggesting an advantage in terms of survival. However, these differences are only statistically significant in the case of the elite during the period 1870-1945. A slightly higher risk is also observed for the category that includes the lower clergy and health workers, reflecting their greater exposure to certain infectious diseases.

Between 1945 and 2010, social inequalities in mortality are slightly less pronounced and are only significant when comparing the population of the lower middle class to the reference group. We must take into account that throughout the twentieth century, but especially in the early second half, there was a significant migratory phenomenon from rural to urban areas. In this process, due to the mechanisation of rural areas and, above all, the higher urban wages, there was a mass exodus of the lower-income population from rural areas to the cities. Our study area was no exception to this trend. On the contrary, being so close to Zaragoza, the opportunity cost of moving to the city to seek higher incomes was low. Additionally, income from agriculture lost its significance compared to the industrial and service sectors. The workers from the new factories that were established in these villages or nearby municipalities were often offered better wages and working conditions than those in the countryside. The increasing availability of private cars for commuting to jobs outside the village, along with the establishment of bus routes facilitating travel to Zaragoza or other towns, further contributed to the socioeconomic homogenisation of rural areas. Moreover, the development of healthcare, education, sports, and cultural services in each village, accessible to all individuals regardless of their socioeconomic status, helped break down previous social barriers (Collantes & Pinilla, 2011).

The reduction in inequality levels during the last period compared to those observed in the nineteenth and early twentieth century is striking. Most studies show an increase in social inequality in mortality during the second half of the twentieth century (Bengtsson et al., 2020; Bengtsson & Dribe, 2011; Edvinsson & Broström, 2020). In our case, we believe that this can be explained by the smaller socioeconomic differences that existed in our study area during this period. The process of economic modernisation, the partial deagrarianisation of rural economies (at least those close to the cities) and the strong rural-to-urban migrations of the mid-twentieth century may have facilitated a trend towards the reduction of socioeconomic differences at the rural locality level (Collantes

& Pinilla, 2011). In fact, in the burial process we can observe greater similarities (all occupying similar spaces and with similar ceremonies) than in all previous centuries. This contrasts with the most dynamic urban areas where we can find a much wider range of occupations and probably greater differences in income and wealth. This could also be a consequence of a small sample size, and we hope to improve our knowledge in the near future.

Table 4. Cox regression estimates of mortality (1800 – 2010).

	1800 - 1870	1870-1945	1945-2010
SES (HISCLASS5)			
1 - Elite	0,892	**0,783****	1,029
2 - Lower middle class	0,736	0,909	**0,807***
3 - Self employed farmers	**0,826****	**0,874*****	1,029
4 - Skilled workers	1,092	0,966	0,919
5 (ref) - Unskilled and farmworkers	1	1	1
6 - Clergy and sanitary	1,301	1,249	1,189
BirthDate	1,001	**0,989*****	**0,99*****
Civil Status			
Single	1,04	**1,344*****	1,429
Widow	1,123	**1,278*****	1,196
Married	1	1	1
Sex	0,996	**1,172*****	**1,43*****
Controls	Yes	Yes	Yes
Village fixed	Yes	Yes	Yes
Person Years	160.904	323.340	212.878
Events	1.986	5.255	4.149

Note: Individuals older than 7 Years. Both sexes. Models are statistically significant below the 1 % level based on a chi-square test.

Source: See in the text.

Regarding the behaviour of the control variables, the reduction of the effect associated with civil status stands out. There is still a survival disadvantage for the single and formerly married compared to the married. However, the value of the coefficients is significantly reduced if we compare the first two periods (1500-1700 and 1700-1800) with the most recent one. Therefore, and following our previous argument, this could be the consequence of several reasons. Throughout the twentieth century, a process of economic and social modernisation took place, resulting in changes at various levels. There were improvements in biological well-being, leading to fewer single people with serious physical or socio-economic problems. Additionally, a social transformation occurred, known as the second demographic transition (Lesthaeghe & Van de Kaa, 1986), which stopped penalising singleness, causing the percentage of singles at the age of 45 in the study area to increase significantly from less than 10% to surpassing 25% (Marco-Gracia, 2017b). This also leads us to consider a transformation in the profile of single individuals, shifting from being primarily those who were not able to find a partner in the marriage market to becoming a voluntary choice within the context of social

transformation. Furthermore, with the advent of the welfare state and the democratising drive in Spain in the late twentieth century, the singles in the study area were able to replace the family as the caregiver with other institutions and services designed for the elderly. To sum up, the process of economic and social modernisation has brought about a transformation in how we interpret the significance of marital status and how and by whom care is provided in old age.

The results obtained in the models stratified by sex for the periods before 1800 are summarised in Table 5. During both periods, both men and women with a higher socioeconomic status had a lower risk of death than those of a lower status. The social gradient in mortality is more pronounced for men in the period 1500-1700 and for women in the following period. The social differences for women in the 1500-1700 period are only significant when comparing the second category with the third, while those for men in the second period are only significant when comparing the first category with the third. In any case, the remaining coefficients are also less than one, suggesting a lower mortality risk than the lowest SES category.

Table 5. Cox regression estimates of mortality by sex (1500 – 1800).

	1500 - 1700		1700 - 1800	
	Female	Male	Female	Male
TESTFAMILIACAT (3)				
SES-1 (>50)	0,888	**0,675***	**0,729****	**0,807***
SES-2 (>=10 y <=50)	**0,785·**	**0,797·**	**0,866***	0,935
SES-3 (<10)	1	1	1	1
BirthDate	1,002	**1,003·**	**1,01*****	**1,011*****
Civil Status				
Single	**2,233*****	**2,236*****	**1,887*****	**2,078*****
Widow	1,108	**1,944*****	**1,421*****	**1,782*****
Nativo	0,956	0,829	1,093	0,816
Village fixed	Yes	Yes	Yes	Yes
Person Years	29.252	37.922	60.195	76.737
Events	583	640	1.623	1.881

Note: Individuals older than 7 Years. Models are statistically significant below the 1 % level based on a chi-square test.

Source: See in the text.

Table 6 shows the results of the survival analyses for the periods from 1800 to 1870, from 1870 to 1945 and from 1945 to 2010, distinguishing between men and women. The pattern is similar between 1800 and 1945. For women, the lowest risk of death is particularly marked when we compare the highest SES category *–elite–* with the reference category *–unskilled and farm workers–*. In the case of men, the inequality is most pronounced when the self-employed farmers category is compared with the reference one. In the most recent period, the evidence of social differences in mortality is weaker and only the coefficient associated with lower middle class women in relation to the reference category is significant. In the case of men, the coefficients of the higher

socio-economic categories are less than one, but the significance is low.

As argued above, the smaller differences observed in the last subperiod could be explained by the minor socioeconomic disparities that characterise our study area compared to other areas with greater polarisation in the distribution of wealth and income, or by the greater occupational and socioeconomic heterogeneity of the cities. Another factor that could explain these phenomena is the influence of certain factors associated with harmful behaviour, which were more prevalent among people of higher socioeconomic status in certain periods[12].

Table 6. Cox regression estimates of mortality by sex (1800 – 2010).

	1800 - 1870		1870 - 1945		1945 - 2010	
	Female	Male	Female	Male	Female	Male
SES (HISCLASS5)						
1 - Elite	**0,452*** **	1,134	**0,826·**	**0,746·**	1,051	0,999
2 - Lower middle class	0,707	0,863	0,837	1,015	**0,759·**	0,879
3 - Self employed farmers	0,912	**0,687*** **	1,006	**0,772*** **	1,093	0,99
4 - Skilled workers	1,148	1,051	0,96	0,979	0,93	0,919
5 (ref) - Unskilled and farmworkers	1	1	1	1	1	1
6 - Clergy and sanitary	1,825	1,074	1,119	1,514	0,867	1,526
BirthDate	1,001	**1,007*** **	**0,987*** **	**0,992*** **	**0,988*** **	**0,992*** **
Civil Status						
Single	0,988	1,183	**1,207***	**1,741*** **	**1,327***	**1,392*** **
Widow	1,061	**1,312****	**1,163***	**1,428*** **	**1,235****	**1,132·**
Married	1	1	1	1	1	1
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Village fixed	Yes	Yes	Yes	Yes	Yes	Yes
Person Years	81.012	79.892	161.402	161.937	106.223	106.655
Events	1.028	958	2.588	2.666	1.900	2.249

Note: Individuals older than 7 Years. Models are statistically significant below the 1 % level based on a chi-square test.

Source: See in the text.

As mentioned above, the criterion used to classify people by socio-economic group was different for each sex. In the case of men, we have used their occupation; in the case of women, because of the small percentage who have a registered occupation, we have chosen to use the occupation of the husband as a secondary criterion. In any case, we have included the results of the survival analysis using women's occupations in the fourth

[12] We have an example of this kind of health-damaging behaviour in the case of tobacco. In most societies, men from the upper classes were the first to start smoking, usually followed in the following decades by people from the lower classes. For women, although their inclusion came later, the socio-economic pattern is similar (Joossens et al., 1999). However, it was during the second half of the twentieth century that the evidence of the damage caused by this practice became more widely known. Since then, men and women from the highest socio-economic classes have been the first to stop smoking (Graham, 1996; M. Huisman et al., 2005). Another example of a countervailing factor is the more sedentary lifestyle that characterises most of the occupations in the higher socio-economic status categories compared to the reference category.

table in the appendix 1 (these reinforce the findings presented in this section). The differences are only significant when compared with the reference category, the groups that, as observed in Table 2, concentrate at least 1% of women in each period. Thus, in the period 1800-1870, the risk of death is significantly lower for women in category 1 - Elite, while in the period 1945-2010, the most significant differences are observed in groups 2 - Lower middle class and 4 - Skilled workers. Contrary to what we saw in the calculations with the SES variable derived from the husband's occupation, the differences appear to be more pronounced in the most recent period when only the wife's occupation is used. This could reflect an improvement in the living standards of women who entered the labour market in skilled occupations in the second half of the twentieth century. We must bear in mind that the comparison that has been made in these models has the limitation that we are comparing only a small percentage of women with high SES with a small group of women day labourers. Despite the limitations of the analysis for the above reasons, we again find social inequality in death in the very long term for women in the study area.

As far as the effect of marital status on mortality is concerned, we find that it is stronger for men in all the periods analysed. Taking married people as the reference category, we can observe that single people of both sexes face a higher risk of dying. In the case of widows, the risk of death is significantly higher for men in both periods. For women, however, the coefficient is slightly lower and is only statistically significant for the period 1700-1800 and from 1870 onwards. This could be a consequence of women's specialisation in cooking and care. Men may have been more dependent on their spouse to improve their lifespan than vice versa.

The effect of literacy on survival is studied in the Table 7. We have only included the latest earlier periods since, as can be seen in the descriptive table, data on literacy in the periods before 1800 were very scarce (fundamentally, because no population list or parish register includes this information). The models included are basically similar to those discussed above but incorporating literacy and its interaction with Birth Date as an explanatory variable. By adding the interaction, the value of the coefficient of the Literacy variable alone represents the effect of this variable at the beginning of each of the periods: 1800, 1870 and 1945 respectively. As expected, the literate population presents a lower risk of death on the three dates. The effect seems to be greater for women. However, we must bear in mind that the percentage of literate women is much lower, so in this case we would be making a more extreme comparison between an elite female group and the rest of the non-literate women.

The value of the coefficient of the interaction between date of birth and literacy is particularly significant after 1870. This indicates that the health advantage associated with literacy has been increasing over the last two centuries. The explanation for this phenomenon should be related to the remarkable increase in the rate of progress in medical and health knowledge that has been taking place since the mid-nineteenth century (Preston and Haines, 1991, pp. 6–11; Mokyr, 2002, pp. 179–187; Nathanson,

2007, pp. 25–46). The fewer advantages for health that being literate implied at the beginning of the nineteenth century must be related to the fact that the medical and sanitary knowledge of the time was less useful (Easterlin, 1999, p. 269; Luque De Haro, 2023; Omran, 1998, p. 101). During the first half of the nineteenth century, there was still no clear knowledge about the causes of disease, little was known about the transmission mechanisms and even less about the most effective treatments once the disease had been contracted (Haines, 2001). These improvements in knowledge facilitated the adoption of preventive public policies and changes in the individual behaviour, encouraging the practice of healthier lifestyle habits and the abandonment of other harmful behaviours. Individuals with a higher level of education tend to have access to improvements in knowledge more easily and more quickly, which is an advantage for adapting their lifestyle to the prescriptions associated with the new advances (Johansson, 2010; Link & Phelan, 2002; Mokyr, 2002, pp. 187–198; Zimmer & House, 2003). In other words, literacy is providing us with interesting information not only on basic knowledge but also on the dissemination of ideas associated with hygiene, food preservation and health prevention.

Table 7. Cox regression estimates of mortality for both sexes controlling by the interaction between Literacy and BirthDate

	1800 - 1870			1870 - 1945			1945 - 2010		
	All	Female	Male	All	Female	Male	All	Female	Male
Literacy	**0,508*** **	**0,262***	**0,635****	**0,405*** **	**0,25*** **	**0,525*** **	**0,547*** **	**0,667*** **	**0,436*** **
Birth*Lit	0,991	1,032	**0,986***	**0,984*** **	**0,975*** **	**0,987*** **	**0,99*** **	**0,993***	**0,986*** **
BirthDate	**1,003·**	1,001	**1,009*** **	**0,996*** **	**0,994*** **	**0,998·**	**0,994*** **	**0,991*** **	1,002
HISCLASS-5									
1 - Elite	0,903	**0,453*** **	1,231	0,934	0,963	0,887	1,044	1,061	1,023
2 - Lower middle class	0,825	0,765	1,023	1,115	0,94	1,279	**0,82·**	**0,765·**	0,9
3 - Self employed farmers	**0,879·**	0,923	**0,752****	0,979	**1,118***	**0,848****	1,043	**1,104·**	1,006
4 - Skilled workers	1,16	1,157	1,164	1,081	1,037	1,089	0,947	0,943	0,963
5 (ref) - Unskilled and farmworkers	1	1	1	1	1	1	1	1	1
6 - Clergy and sanitary	1,472	1,948	1,172	**1,599***	1,669	**1,746·**	1,208	0,859	1,545
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person Years	160.904	81.012	79.892	323.340	161.402	161.937	212.878	106.223	106.655
Events	1.986	1.028	958	5.255	2.588	2.666	4.149	1.900	2.249

Note: Individuals older than 7 Years. Models are statistically significant below the 1 % level based on a chi-square test. Additional controls: Native or foreigner and number of siblings alive.

Source: See in the text.

Another remarkable element of these models is the partial reduction of the effect on mortality associated with SES, especially after 1870. This should not surprise us since higher educational level is something associated with higher SES groups and therefore, by including it as a separate element, we are detracting from the explanatory capacity of SES as a determinant of mortality or survival. As for the effect of literacy on the survival

probabilities of men and women, we found that it seems to be more intense in the case of women. In fact, when literacy is included in the female models from the third half of the nineteenth century, the differences associated with SES are reversed in the case of the third category, and the penalty in terms of life expectancy associated with the clergy and health workers categories becomes greater.

Finally, we have analysed the role of socio-economic status in different mortality crises[13]. We have chosen longer periods because in some of the sub-periods the number of mortality crises was very low. In Table 5 of the appendix 1, we have included the results of the models analysing the interaction of SES with the years of excess mortality due to famine. The results for the period 1500-1800 reflect a significantly lower risk for individuals of the highest socio-economic status compared to the reference category. The coefficients associated with the interaction show how this survival advantage increases in the famine years and beyond. Table 6 in the appendix 1 shows the calculations of the models analysing the interaction between SES and infectious epidemics. In these models we can see that in non-epidemic years there are significant differences in mortality risk according to SES. However, if we look at the value of the coefficients associated with the interaction with the epidemic, we see that, contrary to what we have observed in the case of mortality crises due to famine, there is no increase in the risk of the lowest classes compared with individuals of higher socio-economic status. Although the coefficients are not statistically significant, most have values greater than one. This would reflect a degree of equalisation between social classes in the years of epidemic mortality crises.

A more complex issue is the possible presence of selection effects that could derive from a higher level of child mortality or morbidity among the categories of lower SES (Elwert & Winship, 2014; Inwood & Maxwell-Stewart, 2020; Schneider, 2020). On the one hand, during most of the study period, there could be culling effects, if the weaker individuals of the lower classes are dying to a greater extent. On the other hand, there may be scarring effects if the survivors have been marked by the circumstances they lived through. Nor can we ignore the potential selective effect that may have occurred in occupations requiring greater physical effort. Individuals with better physical fitness would have a higher likelihood of performing jobs with high physical demands. Consequently, it is likely that some individuals from lower social classes who were sick or in poorer physical condition may not have been considered since they did not appear as laborers in records. Conversely, in the other segment of the population, the absence of adequate health conditions would not prevent individuals from being recorded (Jaadla et al., 2017; Livi Bacci, 1993, pp. 184–191). We are aware that these effects could have had some impact on the results, but we cannot quantify the effect for each period. In any case, this remains an avenue for future research.

[13] For more information regarding the selection of mortality crisis years (and their causes), please refer to the appendix 2.

6. Conclusions

The results obtained from the different survival analyses have allowed us to verify the persistence of social inequalities in terms of death in rural Spain throughout the more than 500 years analysed. This contrasts with results obtained in other articles about northern European countries, where these inequalities do not appear in the nineteenth century (Bengtsson et al., 2020; Bengtsson & Dribe, 2011; Debiasi & Dribe, 2019). This could be the consequence of the use of different sources of socio-economic levels before the nineteenth century or, in our opinion, because of the persistently low living standards in rural Spain.

In relation to the sources of socio-economic levels, the availability of information has forced us to use a different way of inferring the SES of individuals in the periods before 1800 compared to those after that date. This circumstance prevents us from making comparisons between them. However, if we look at the evolution of the coefficients associated with SES in the periods before 1800, we can observe a reduction in inequality between the first and second subperiods. In fact, between 1700 and 1800, inequality between women seems to have been reversed in some socio-economic segments. If we compare the last three periods (1800-2010), we can see that the social differences remain, but also seem to be partially reduced. In any case, we find the persistence over almost 500 years of social differences in death in rural Spain using longitudinal microdata. In the Tables and appendix 1, we have included multiple controls that reinforce our results. Therefore, we do not believe that we are facing a casual effect but possibly a pattern of differences in adult mortality common in southern Europe for centuries (Luque De Haro, 2023). This could possibly be the cause of even lower living standards among the working classes in Southern Europe than in other regions. Or, perhaps, warmer environments could have facilitated a greater spread of diseases that were especially deadly for people with near subsistence living standards.

Our results do not fit perfectly with either the fundamental cause or the divergence-convergence theory. In any case, they seem more closely related to the Link and Phelan postulates. Thus, in line with the fundamental cause theory, we have verified how, throughout the 500 years analysed, socioeconomic status appears to be a determinant of survival chances, which would reflect the differential control that individuals of different social classes have over a set of resources that have given them an advantage in terms of health, despite the fact that the profile of diseases has changed. Contrary to what Antonovsky (1967) stated, in our case the results show that in the first periods analysed, despite the lack of adequate treatment for most diseases, social differences in mortality were not minor. It is probable that this phenomenon is related to the scarce resources with which a large part of the population of the municipalities we studied lived, very close to the subsistence level, which explains why the mortality rate of the most disadvantaged increased during the famine years. On the other hand, we believe that the convergence observed in our results in the last period is due, besides the diffusion of economic and medical progress, to the reduction of socio-economic differences in our area of study.

However, we must be aware that our availability of longitudinal data over 500 years does not allow us to have a sufficiently large sample to work with short periods. To summarise, we cannot consider that our area of study fits perfectly into a particular theory, but neither can we claim that with a sample with more data and shorter periods this would be possible. Therefore, further research and data are needed to be able to categorically state whether we are dealing with a situation predicted by the theoretical models or trying to elucidate the casuistry of rural Spain.

We have tested the robustness of our estimates by means of different sensitivity analyses and we have further explored the possible interactions between the variables included. Based on the results obtained, we have highlighted the importance of how the different determinants of social inequality in mortality have changed over time. Since the middle of the nineteenth century, the increasing importance of educational attainment for survival is reflected in the rate of progress in health and medical knowledge. Therefore, the changes over time may reflect the processes of modernisation, but social differences in adult mortality have not disappeared.

We hope that this study - unique to date for a Southern European society because of the long period of time and the number of individuals studied - will contribute to improving our understanding of the standard of living in past societies and how economic, social and knowledge transformations have affected the health of different segments of society. This study contributes to reopening the debate on whether, unlike in northern Europe, differences in adult mortality by socio-economic status may have persisted in southern Europe since at least the sixteenth century and possibly earlier. This is possible to study through the use of individual life trajectories in the very long term. There is not yet abundant material in scientific studies of Mediterranean Europe.

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Appendix 1

A.1. Mean of funeral wills by sex an age

	Females	Males
7 to 14	6,9	5,5
15 to 19	11,8	8,4
20 to 24	12,7	11
25 to 29	15,4	13,4
30 to 34	19,5	17,3
35 to 39	17,4	16,5
40 to 44	17,8	17,1
45 to 49	21,6	17,4
50 to 54	21,8	18,7
55 to 59	19	18,9
60 to 64	20,7	18,8
65 to 69	22,4	21,4
70 to 74	22,9	28,4
75 to 79	21,6	24,6
80 or more	24,6	25,7

Source: See in the text.

A.2. Literacy percentage by socioeconomic categories

	A. Women			B. Men		
	1800-1870	1870-1945	1945-2010	1800-1870	1870-1945	1945-2010
HISCLASS5 (individual)						
1 - Elite	0,81	20,14	91,93	30,69	84,48	89,75
2 - Lower middle class	61,7	64,94	87,43	42,42	84,19	83,71
3 - Self employed farmers	2,79	51,78	85,89	31,95	67,08	80,55
4 - Skilled workers	0	53,83	75,27	34,67	71,62	89,32
5 - Unskilled and farmworkers	0,35	12,75	77,73	8,99	44,94	74,71
6 - Clergy and sanitary	100	100	100	32,72	71,92	76,41
N/A	1,86	27,2	59,12	3,55	7,9	12,3
HISCLASS5 (familiar)						
1 - Elite	1,53	36,83	71,8			
2 - Lower middle class	13,39	42,49	76,12			
3 - Self employed farmers	2,67	36,08	65,75			
4 - Skilled workers	2,67	32,33	67,76			
5 - Unskilled and farmworkers	0,36	21,28	58,2			
6 - Clergy and sanitary	21,57	62,27	85,47			
N/A	1,75	20,67	50,34			

Source: See in the text.

A.3 Cox regression estimates of mortality for the period before 1800

	1500 - 1700			1700 - 1800		
	All	Female	Male	All	Female	Male
INDIVIDUALWILLCAT (3)						
SES-1 (>50)	**0,598****	0,777	**0,47*****	**0,814***	0,891	**0,752***
SES-2 (>=10 y <=50)	0,875	1,28	**0,661*****	**1,311*****	**1,449*****	**1,195****
SES-3 (<10)	1	1	1	1	1	1
BirthDate	1,001	1,004	1	**1,013*****	**1,015*****	**1,012*****
Sex	1,002	-	-	**0,893****	-	-
Civil Status						
Single	**1,531*****	**1,541***	**1,593****	**1,664*****	**1,393***	**1,807*****
Widow	**1,448*****	1,112	**1,707*****	**1,606*****	**1,547*****	**1,619*****
Nativo	0,956	0,877	1,103	1,086	1,113	0,957
Village fixed	Yes	Yes	Yes	Yes	Yes	Yes
Person Years	26.248	11.549	14.699	70.252	29.928	40.324
Events	791	355	436	2.729	1.205	1.524

Note: Individuals older than 30 y.o. SES inferred from the amount tested for the funeral by each individual.

A.4. Cox regression estimates of mortality for females according to their occupation.

	Female (Individual Class)	Female (Individual Class)	Female (Individual Class)
	1800-1870	1870-1945	1945-2010
BirthDate	1,003	**0,987*****	**0,988*****
SES (HISCLASS5)			
1 - Elite	**0,393****	0,952	0,84
2 - Lower middle class	0,937	0,739	**0,412****
3 - Self employed farmers	0,812	1,068	0,903
4 - Skilled workers	1,029	0,931	**0,406****
5 (ref) - Unskilled and farmworkers	1	1	1
6 - Clergy and sanitary	0,00029	0,00000146	0,435
Poor and N/A	1,253	**1,366***	0,84
Civil Status			
Single	1,192	**1,913*****	**1,569*****
Widow	1,166	**1,186****	**1,203***
Married	1	1	1
N/A	**0,859·**	0,987	**1,178***
Nativo	0,982	1,042	0,9
SiblingAlive	**0,962****	**0,974*****	0,993
Village fixed	Yes	Yes	Yes
Person Years	81.012	161.381	106.094
Events	1.028	2.588	1.899

Note: females older than 7. SES inferred from occupation of each individual.

A.5. Cox regression estimates of mortality by SES interacting with famine years.

	1500-1800		
	All	Female	Male
TESTFAMCAT (3)			
SES-1 (>50)	**0,817****	**0,833**·	**0,797***
SES-2 (>=10 y <=50)	**0,84*****	**0,837****	**0,848****
SES-3 (<10)	1	1	1
BirthDate	**1,003*****	**1,004*****	**1,003*****
Sex	**0,812*****	-	-
Civil Status			
Single	**2,028*****	**1,984*****	**2,125*****
Widow	**1,654*****	**1,365*****	**1.876*****
Famine and next	**1,606*****	**1,668*****	**1,559*****
Famine and next * SES			
1	**0,676****	**0,611***	0,744
2	0,906	0,834	0,965
Nativo	1,037	1,077	**0,774***
Village fixed	Yes	Yes	Yes
Person Years	204.082	89.442	114.640
Events	4.723	2.204	2.519

	1800-1870		
HISCLASS5	All	Female	Male
1	0,894	**0,431*****	1,188
2	0,79	0,748	0,94
3	**0,839****	0,898	**0,736****
4	1,076	1,081	1,078
5	1	1	1
6	1,083	1,613	0,888
BirthDate	1,002	1,001	**1,008*****
Sex	0,997	-	-
Civil Status			
Single	1,041	0,991	1,18
Widow	**1,123**·	1,067	**1,322****
Famine and next	1,179	0,779	**2,141****
Famine and next * SES			
1	0,976	2,177	0,576
2	0,00006	3,185	0,00008
3	0,821	1,262	**0,403***
4	1,184	2,046	0,75
5	1	1	1
6	**2,99***	2,512	**2,9**·
Nativo	0,99	0,879	1,274
Village fixed	Yes	Yes	Yes
Person Years	160.904	81.012	79.892
Events	1.986	1.028	958

Source: See in the text.

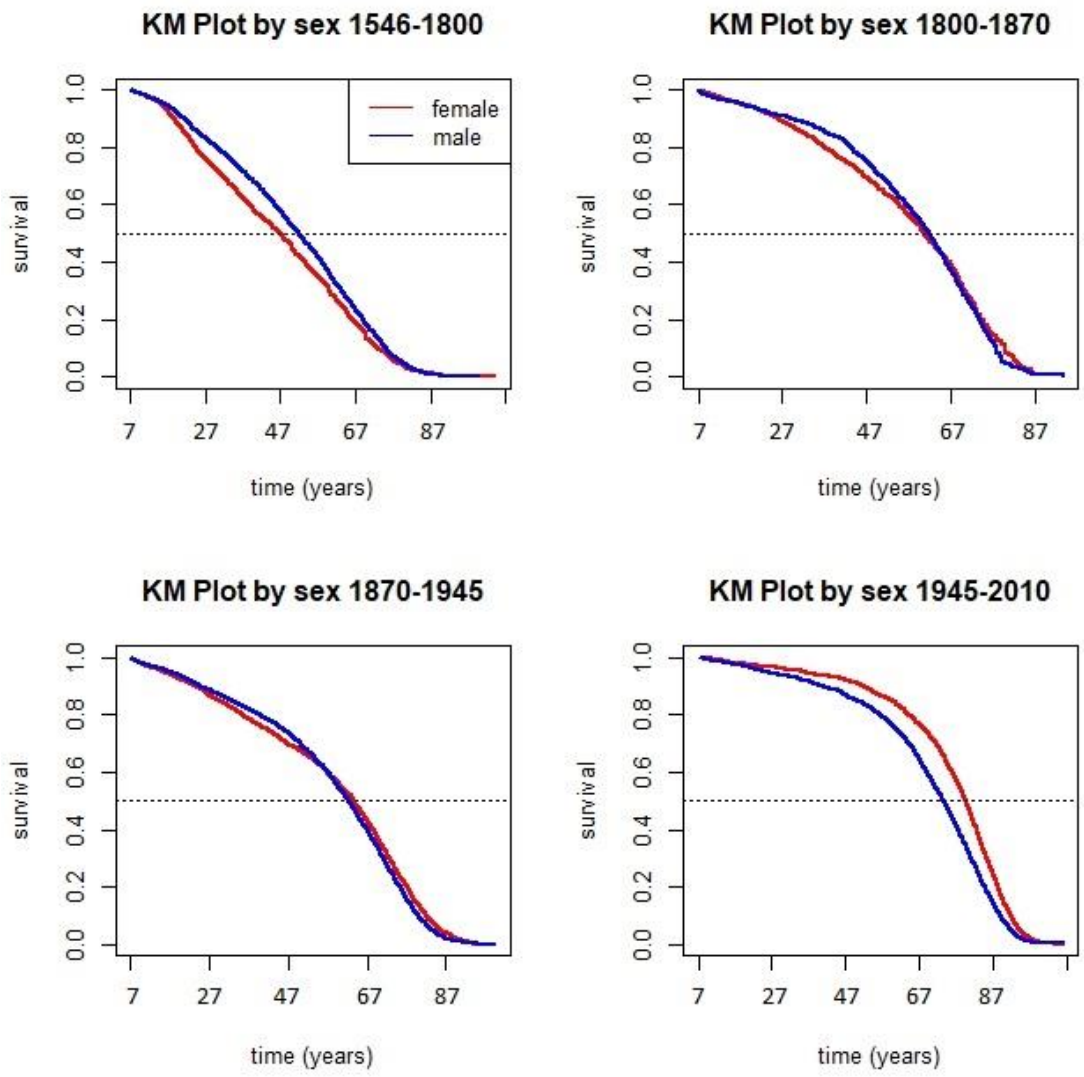
A.6. Cox regression estimates of mortality by SES interacting with epidemic years.

	1500-1800		
	All	Female	Male
TESTFAMILIACAT (3)			
SES-1 (>50)	**0,741*** **	**0,737** **	**0,74*** **
SES-2 (>=10 y <=50)	**0,821*** **	**0,786*** **	**0,86** **
SES-3 (<10)	1	1	1
BirthDate	**1,003*** **	**1,003*** **	**1,003*** **
Sex	**0,813*** **	-	-
Civil Status			
Single	**2,037*** **	**1,997*** **	**2,13*** **
Widow	**1,666*** **	**1,377*** **	**1.888*** **
Epidemic	1,094	1,167	1,285
Epidemic * SES			
1	1,261	1,448	1,155
2	1,035	1,481	0,796
Nativo	1,036	1,073	**0,782·**
Village fixed	Yes	Yes	Yes
Person Years	204.082	89.442	114.640
Events	4.723	2.204	2.519

	1800-1945		
HISCLASS5	All	Female	Male
1	0,785***	**0,708*** **	**0,789·**
2	0,858	0,798	0,968
3	**0,871*** **	1,007	**0,755*** **
4	0,999	1,026	0,987
5	1	1	1
6	1,245	1,441	1,065
BirthDate	**0,997*** **	0,996***	1
Sex	1,113***	-	-
Civil Status			
Single	1,251***	1,123·	**1,579*** **
Widow	1,237***	1,127*	**1,401*** **
Epidemic	**2,351*** **	**3,184*** **	**1,627*** **
Epidemic * SES			
1	1,332	0,631	1,627
2	1,393	1,296	1,574
3	0,952	0,812	0,994
4	1,045	1,036	1,017
5	1	1	1
6	0,232	0,,00000 1	0,455
Additional controls	Yes	Yes	Yes
Village fixed	Yes	Yes	Yes
Person Years	484.243	242.393	241.850
Events	7.240	3.616	3.624

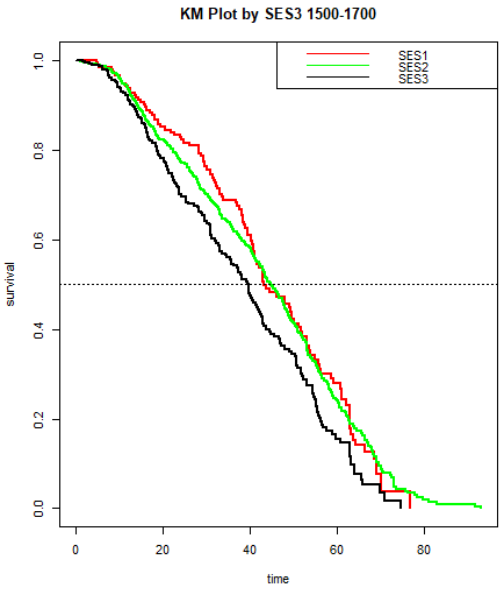
Source: See in the text.

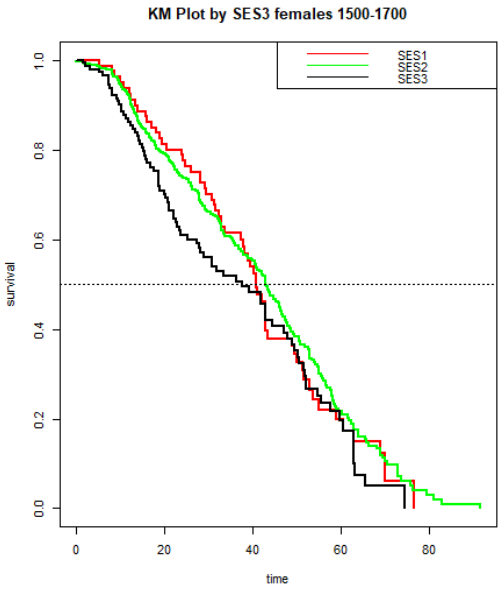
A.4. Kaplan Meier by sex for different periods

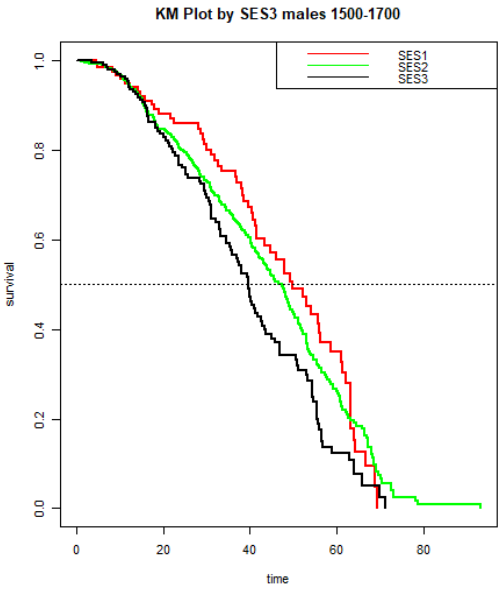


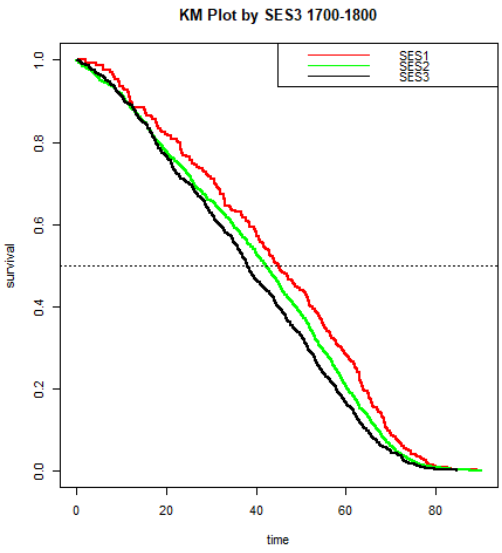
Source: See in the text.

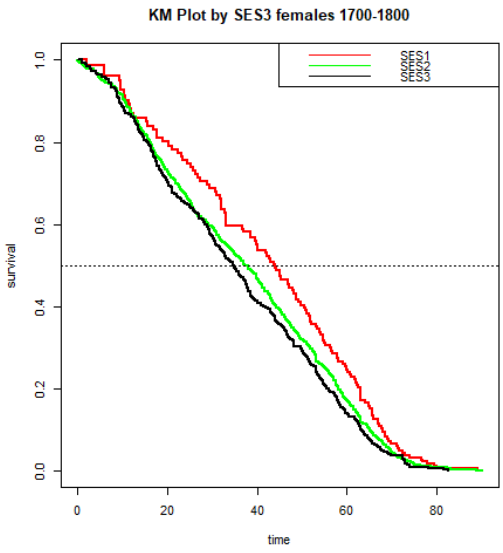
A.5. Kaplan Meier by SES for different periods

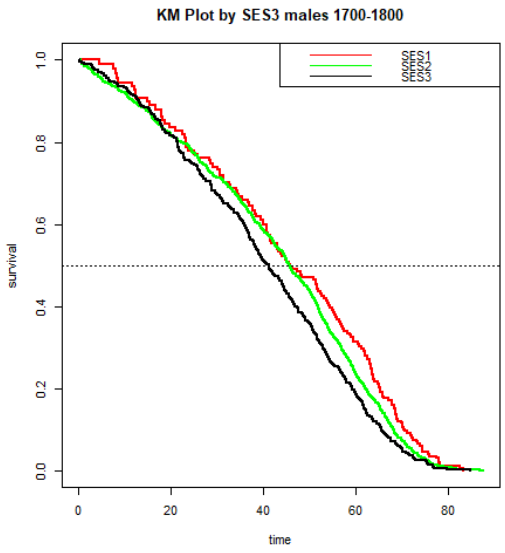


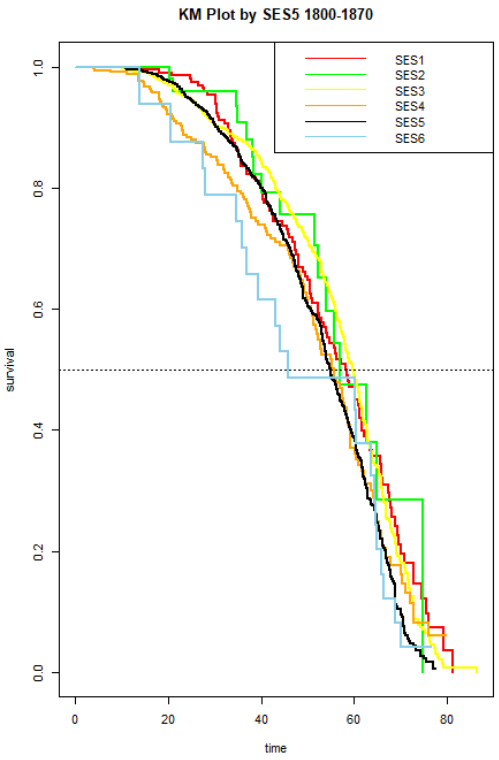











KM Plot by SES5 1800-1870
SES1
SES2
SES3
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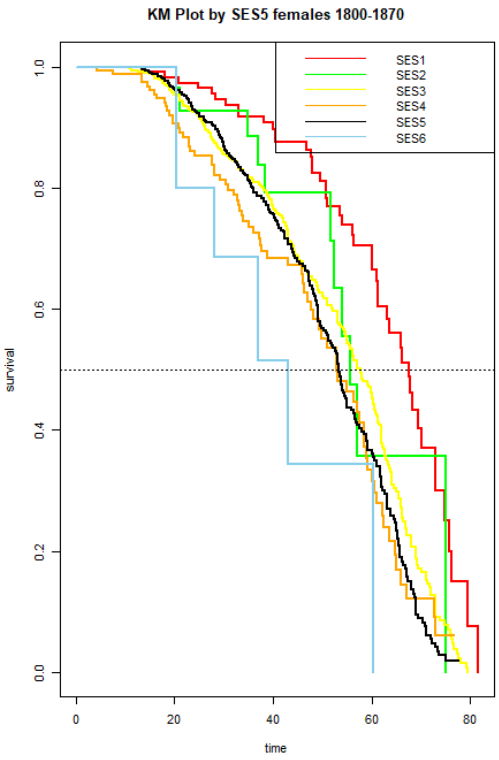
SES5
SES6
survival
time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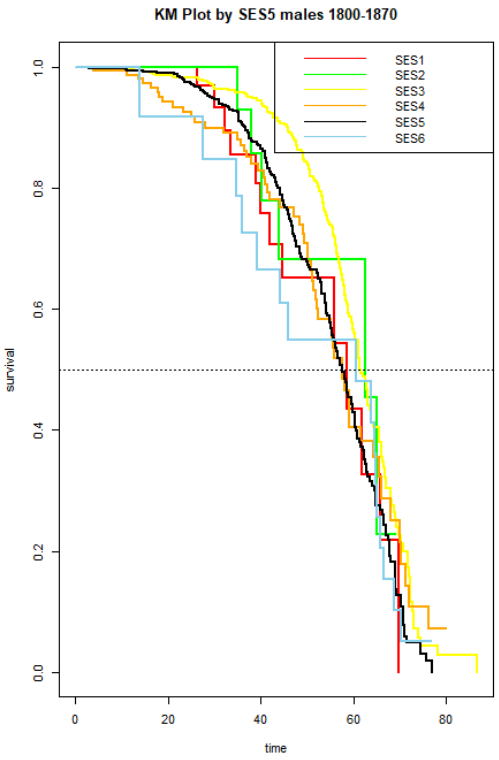
SES5
SES6
survival
time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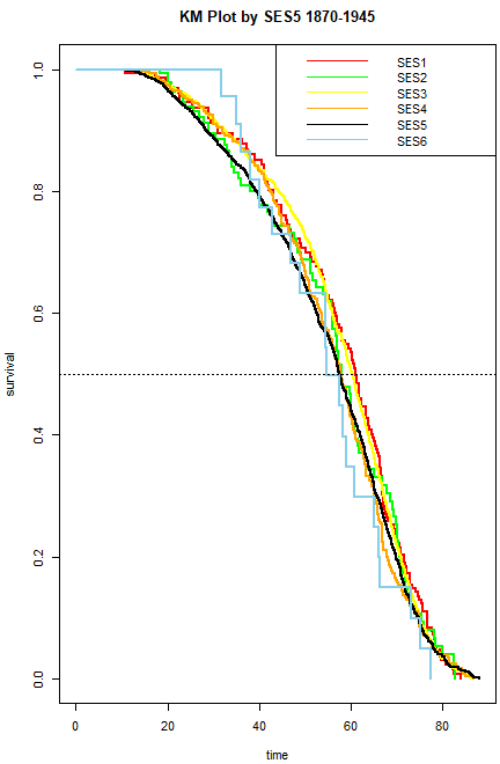
SES5
SES6
survival
time


KM Plot by SES5 1870-1945
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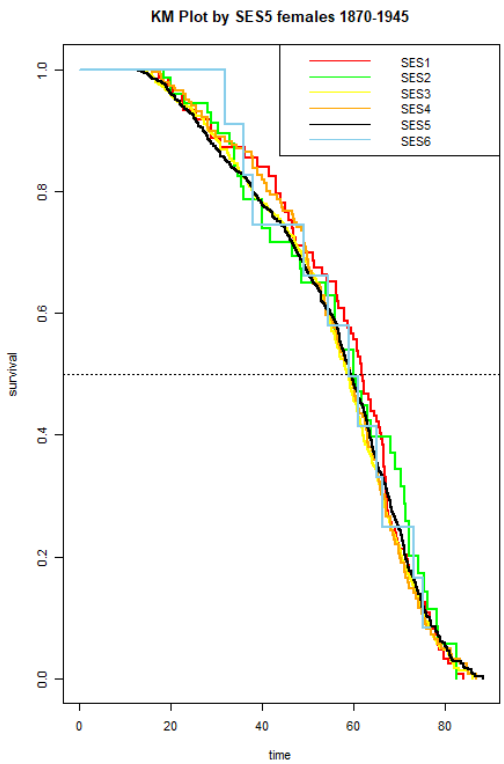
survival
time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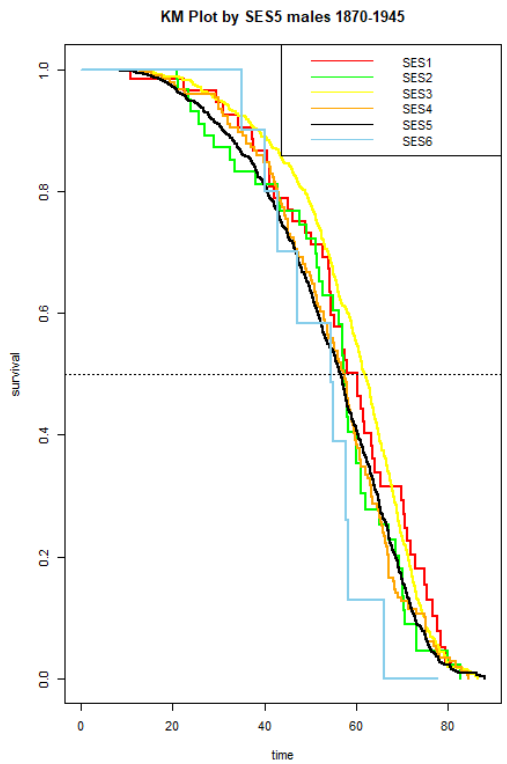
SES5
SES6
survival
time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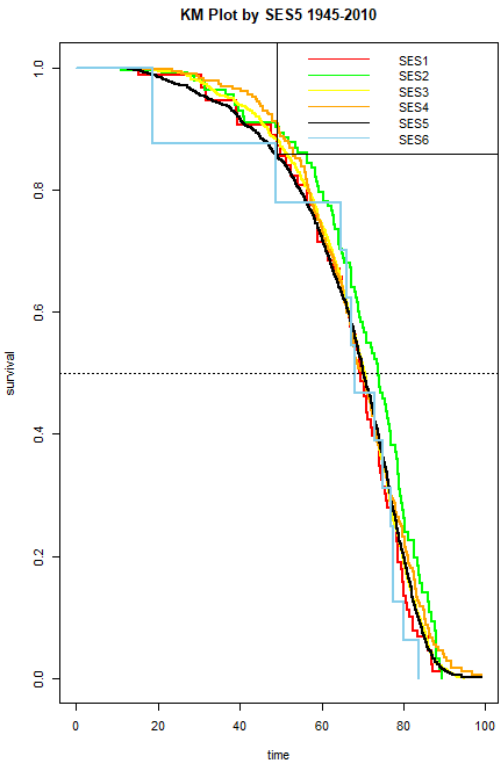
SES6
survival
time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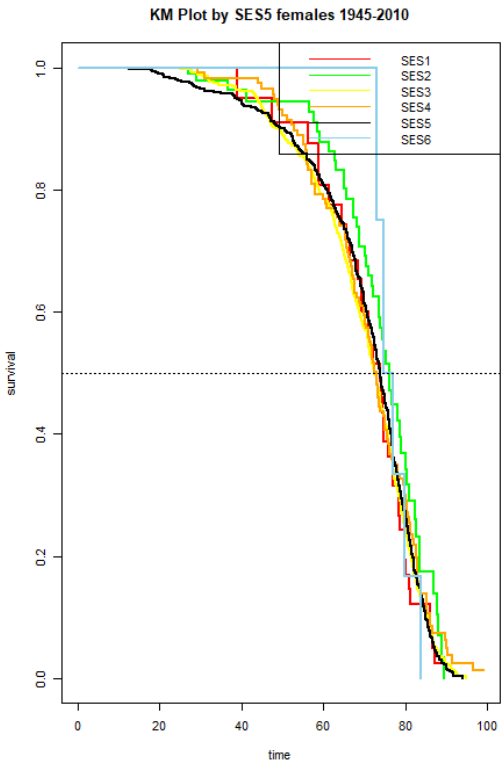
SES3
SES4
SES5
SES6
survival
time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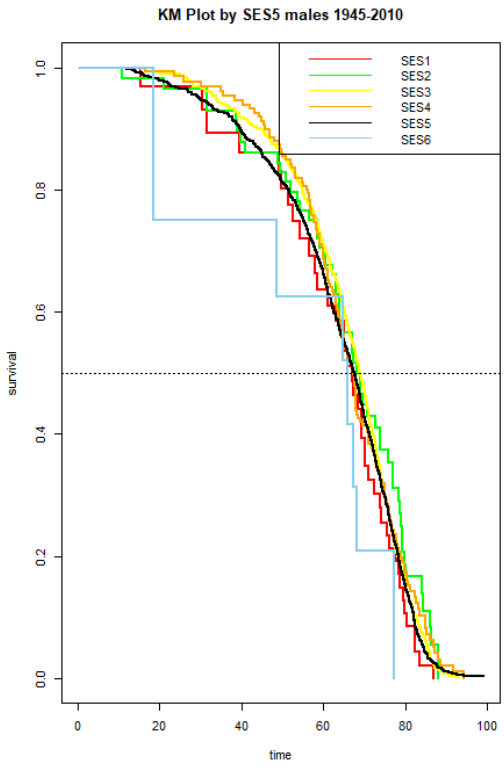
survival
time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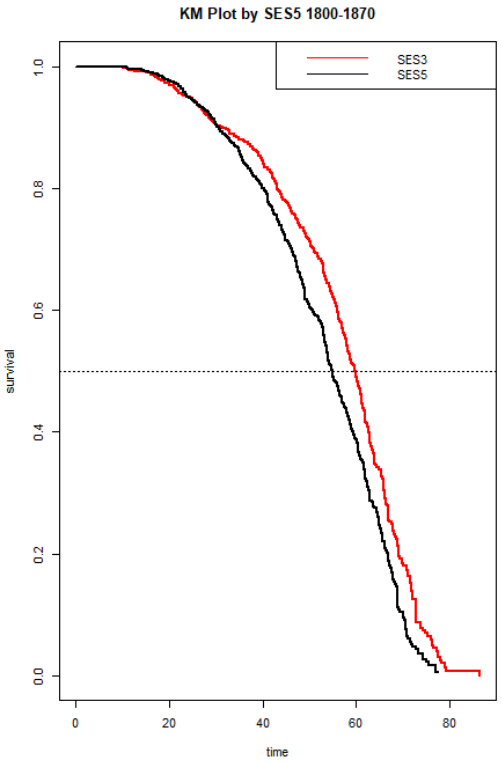
SES6
survival
time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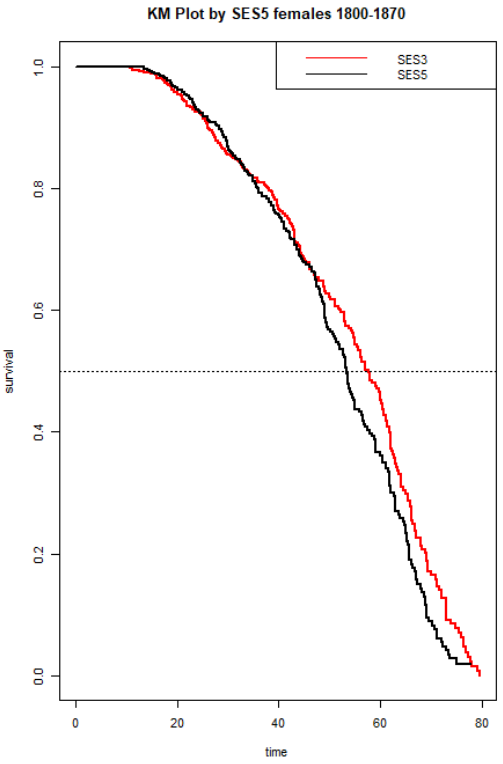
SES3
SES5
survival
time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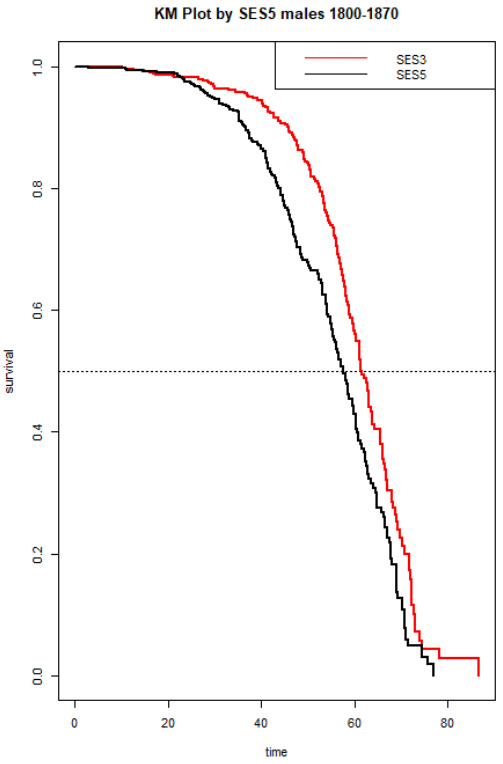
SES3
SES5
survival
time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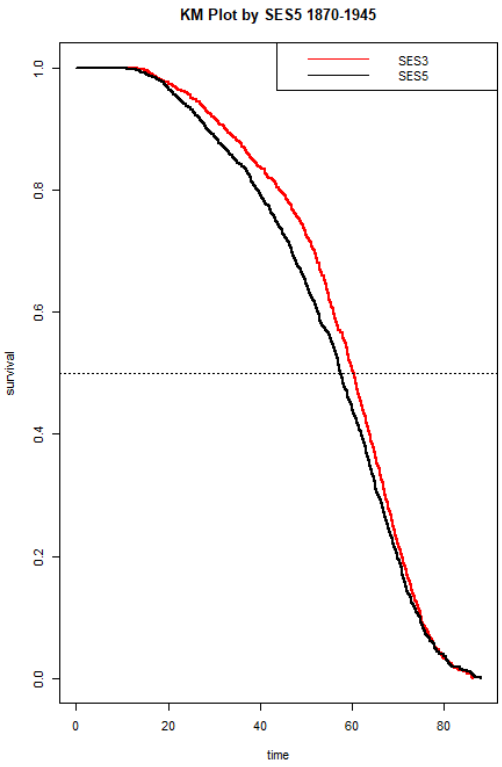
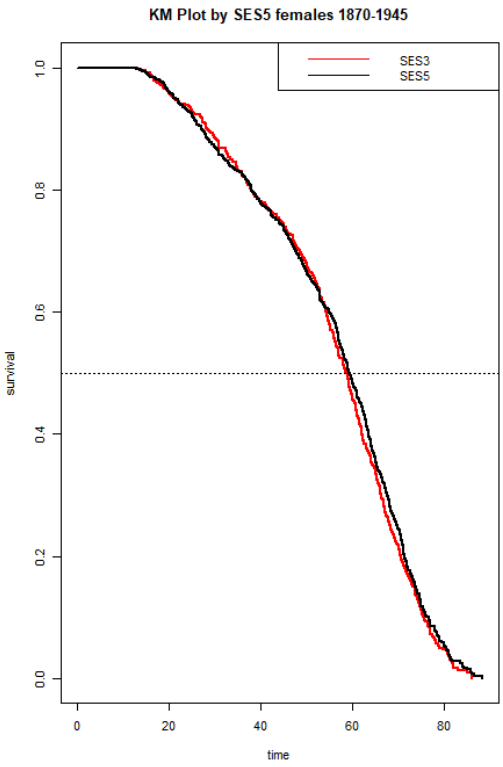
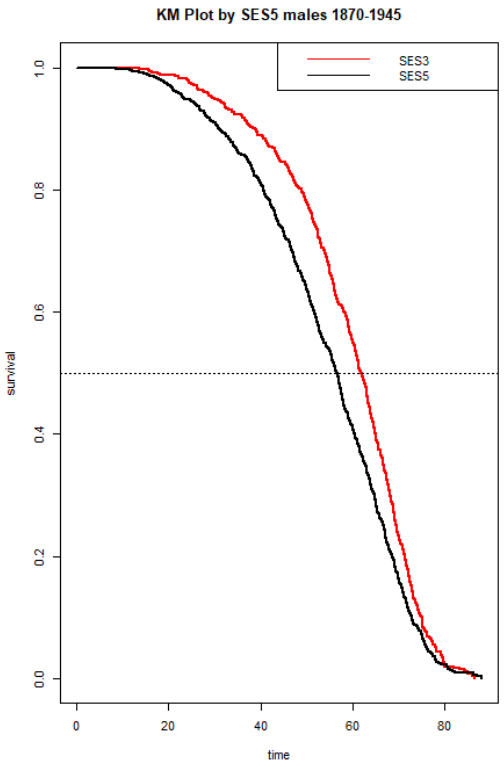
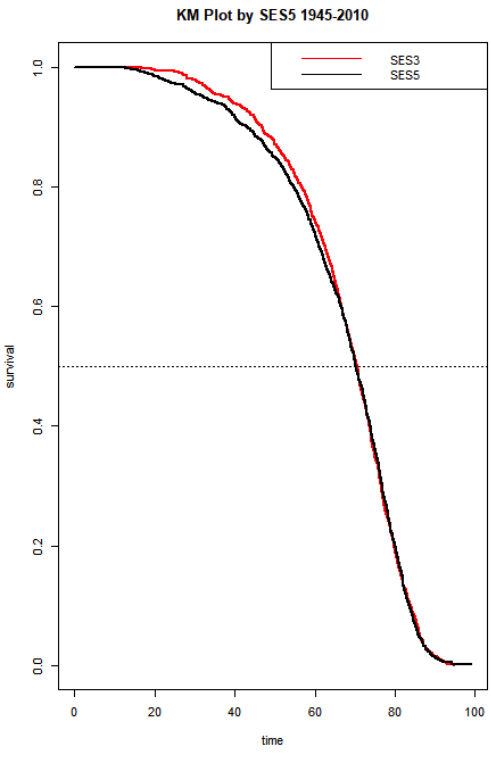
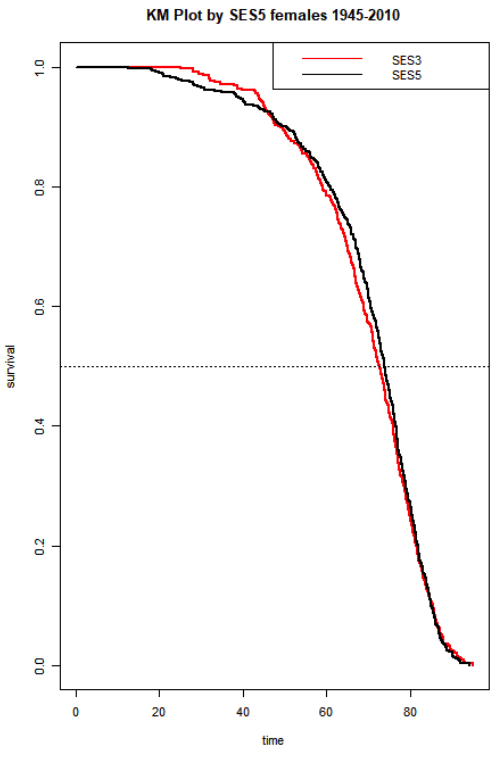
SES3
SES5
survival
time

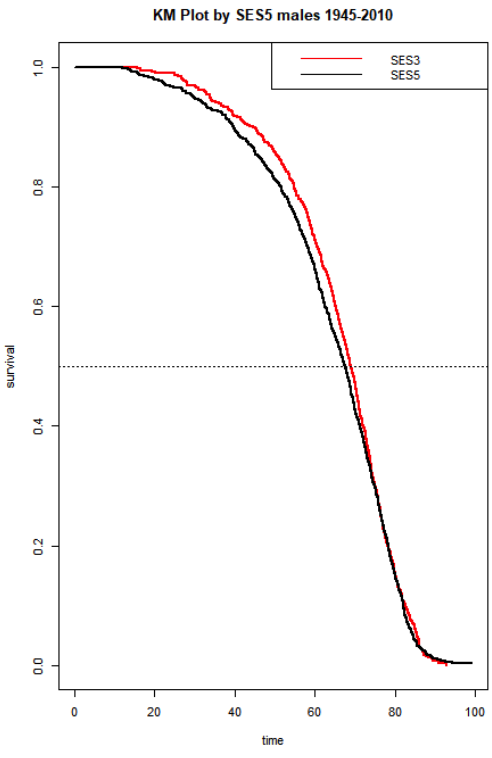












Source: See in the text.

Appendix 2

We have identified years of adult mortality crisis as those in which mortality for individuals aged 7 and above was at least 25% higher than the average mortality experienced in the 5 years preceding and 5 years following the same study area. This 25% threshold concerning preceding and subsequent years is a classic approach in Historical Demography for identifying mortality crises (Ferrer Alòs, 2021). Once these years were identified, we consulted the archival sources used themselves (which sometimes identify epidemics) or other secondary sources specific to the Aragon region (José Francisco, 2020; Pérez Moreda, 1980; Salas Auséns, 1988, 1989).

Following the explained criteria, we have identified the following years as high epidemic mortality years: 1570 (Plague), 1578 (Plague), 1579 (Plague), 1580 (Plague), 1585 (Plague), 1588 (Plague), 1602 (Plague), 1630 (Plague), 1631 (Plague), 1652 (Plague), 1661 ("Fevers," only this common symptom has been identified, not the primary cause), 1678 (Plague), 1684 (Plague), 1729 (Measles, although there are doubts about its actual cause), 1747 (Smallpox), 1760 (again, "fevers" without specific details), 1771 (Smallpox), 1782 (Smallpox), 1786 (Malaria), 1834 (Cholera, marking the transition from airborne diseases to waterborne diseases during the nineteenth century), 1855 (Cholera), 1864 (Cholera), 1885 (Cholera), and 1918-1920 (Spanish flu).

Furthermore, we have also identified the following years of adult mortality crisis (according to the stated criteria) that coincided with periods of famine: 1592, 1595, 1609, 1615, 1621, 1622, 1627, 1637, 1642, 1643, 1645, 1665, 1666, 1689, 1699, 1700, 1701, 1706, 1710, 1711, 1738, 1739, 1754, 1767, 1786, 1798, 1803, 1804, 1809, 1812, 1818, 1828, and 1874. These famines mostly correspond to years of poor harvests or plagues (such as the locust plague of the years 1665 and 1666). However, exceptionally, they can also be associated with political conflicts and food requisitions (as we believe happened in the years 1706, 1710, and 1711 in relation to the War of the Spanish Succession) or with inadequate policies that could have affected agricultural production (such as the Spanish Grain Laws of 1765).

Once the crisis years and their causes were identified, we incorporated them into the analysis presented in the article, categorized by causes of death (epidemics vs. famines). We were unable to conduct a more differentiated analysis by causes of death (such as airborne diseases vs. waterborne diseases) due to a lack of a sufficient sample of observations for the same sub-period. This limitation arises because waterborne diseases predominate in the last two-thirds of the nineteenth century when airborne diseases have diminished in significance. Nevertheless, the aim of the analysis is to examine social inequality in adult mortality concerning mortality crises, which has been achieved in Table 7.

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