1. MORTALITY AT ADVANCED AGES IN SPAIN

BY

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2. ABSTRACT

We have compiled national data for people over the age of 100 in Spain. We have faced several problems due to the inconsistency of data from the Spanish National Institute of Statistics (hereinafter the INE). For instance in 1996 the number of people over the age of 100 was forecasted to be 573, whilst in 1995, 1295 people over the age of 100 died.

In order to avoid this and other problems, we have collected data on those deceased from 1975 to 1995 and analyzed the number of people over the age of 100 over a period of 20 calendar years, paying special attention to sex, causes of death, month of death, location of death, Marital status and profession. We have also compared this data with the ten-year census (1981 and 1991) and its 5 year updates (1986 and 1996).

Spain has one of the highest life expectancies and the number of inhabitants over the age of 100 increased by 43.29% from 1981 to 1999, indicating an average growth rate of 2.41% per year. In the same period, the total Spanish population has increased by 6.68%, showing that the percentage of people over the age of 100 from the total population was approximately 34.32% more in 1999 than it was 19 years previously.

The death figures for people over the age of 100 during the 20 year period analyzed have sharply risen from 457 deaths in 1975 to 1195 in 1995: an increase of 161.49% or an average rise of 8% in the annual deaths of people over the age of 100. The reliability of these figures will be discussed further on in this paper.

We have also investigated a group of retired women over a period of 20 years and observed one woman over the age of 100, whilst 6% of them are currently over the age of 90. We have compared the evolution of this group with the evolution at a national level.

We have concluded from the analysis of available data that different possibilities include evidence of an increase in the probability of living until the age of 100.

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4. INTRODUCTION

The question is, why are there people who live over the age of 100? As time goes by, will more people survive the age of 100? Furthermore, what will be the quality of life for those over the age of 100 and will this quality of life improve with time?

Many questions can be asked about centenarians. There is clear evidence that centenarians have always existed throughout the ages, with one of the longest living persons documented being a pharaoh in ancient Egypt. Recent medical and biological innovations seem to indicate that the capacity to survive over the age of 100 is closely related to a gene, therefore, only those people with the right gene will live over the age of 100[2]. Regarding the quality of life of these elderly people, it appears that only two thirds of them have any kind of disability[3]. This data has been obtained in Spain, but also using research on centenarians carried out by Harvard University in the United States of America.

To answer all these questions we will require interdisciplinary teams; any help would be welcome. Here in Spain, the actuarial profession, with one of the largest fields of expertise in analyzing mortality, may be able to provide some statistics and results.

Our personal aim here was a less ambitious one: we have searched for information on centenarians (this has proven to be very hard work) and we have described and summarized the information we have obtained. We searched for indications of any kind of evolution through time, and the relationship of different kinds of variables.

Spain is undoubtedly a country with many centenarians. In 1999 there were approximately 11 people over the age of 100 to every 100,000 Spaniards. 8 of these 11 centenarians were women. Spanish women have the second largest life expectancy in the world[4]. From our experience with group annuity insurance we have often found centenarians who are insured. Therefore, it is not so surprising that we have found two centenarian women amongst a group of 261 nuns over the age of 65 during a period of 13 calendar years.

Moreover, the analysis of centenarians is not only of interest to insurers but also to the Spanish Government, which is the last provider of retirement pensions and healthcare for those over the age of 100.

Therefore, in trying to answer those questions we raised at the beginning of this introduction we will start reviewing the information on centenarians in Spain that we have obtained and worked out. Afterwards, we will proceed to analyze this information to extract any possible knowledge about Spanish centenarians and their evolution through time. In order to do this we have firstly worked with the national centenarian population, secondly with the group of women, thirdly a preliminary approach to mortality of centenarians as a group will be worked out and finally we worked with the national centenarian deaths observed over a period of 20 years, from 1975 to 1995. Again, it is important to stress that the main objective of this paper is an statistical description of available national centenarian data.

5. INFORMATION AND RELIABILITY

5.1. NATIONAL DATABASE

5.1.1. Survivors

The Spanish National Institute of Statistics (INE) has refused to provide frequencies by calendar year, age and sex for centenarians. Therefore, we have only been able to work with public data which is grouped by centenarians. Furthermore, the forecasts for centenarians based on the 1991 census contradict the public data of the 1996, 1997, 1998 and 1999 padron update. Forecasts methodology is explained in the survival table elaborated by INE, mainly moving averages are used to smooth exposures and occurrences, but no explanation has been given in view of the differences between forecasts and raw data.

The main sources of data are taken from the ten year census and its administrative update, the padron. In this case, data is based on the information provided by the population. Nevertheless, reliability has improved over the last decade as the database is used in conjunction with other databases and cross checked. However, for information on centenarians we are unaware of any analysis on the reliability of the data.

5.1.2. Deaths

The source used has been an INE micro database including all deaths in Spain from 1975 to 1995 with the following variables:

- Calendar year of the death
- Month of death
- Age at death
- Cause of death
- Regional location
- Marital Status

- Profession

These data are obtained from the registry of deaths, which is required to be completed upon death. Once again, the information is provided by other people, usually the family of the deceased. We do not know of any analysis on the reliability of the data regarding centenarians.

We have found the following errors or inexplicable data:

- Two men died at the age of 129 being married
- Two men died with their profession being stated as students
- There are 54 deceased people registered without profession
- There are 7 deceased people registered with no regional location

5.2. WOMEN GROUP DATABASE

This information has been provided by retired Spanish nuns from the north and east of Spain, some of whom have been missionaries, mainly in Africa. We have been able to follow this group of women from 1987 to 2000.

6. NATIONAL SURVIVORS

The INE website provides estimates from 1981 to 1991 based on the 1981 census and forecasts to 2005 based on the 1991 census. The most recent census in 2001 is now underway as per **Chart 1**. We have also graphed the data of the census and its updates during the corresponding year in order to compare both. It can be observed that the INE was expecting a decrease in centenarians, which was not as sharp if the most recent census update of 1999 is assumed to be correct.

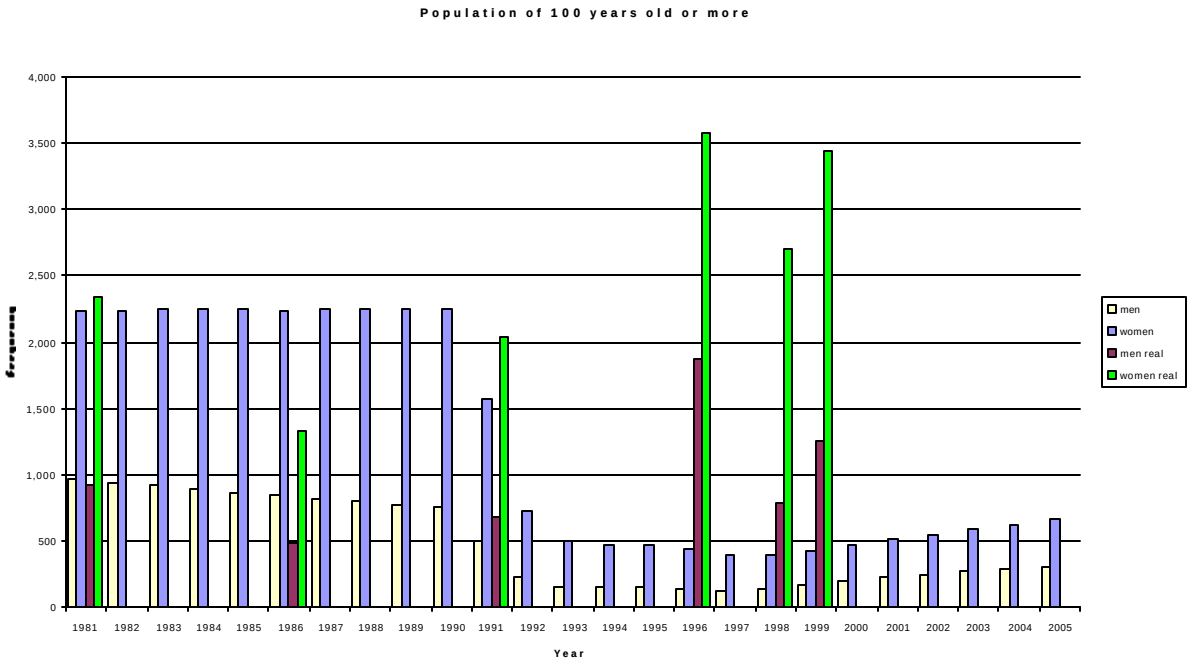

Chart 1: Comparison between published data of census and its updates with estimates and forecasts by INE for people 100 years of age and over

The weight of centenarians in the total population has increased from 8.66 to 11.64 centenarians for every 100,000 individuals. If we analyze this by sex it can be seen that the weight of female centenarians has increased over the total female population from 12.19 to 16.72 for every 100,000 females. Male centenarians have slightly improved their ratio over the total male population from 5 to 6 for every 100,000 males. Figures are shown in Table 1.

			more than	
total		all ages	100	95
	1981	37,683,360	3,266	14,328
	1986	38,473,332	1,815	14,741
	1991	38,872,268	2,727	18,040
	1996	39,669,392	5,443	34,175
	1998	39,852,650	3,488	39,154
	1999	40,202,158	4,680	30,378
men	1981	18,491,741	925	3,614
	1986	18,878,072	490	3,631
	1991	19,036,446	682	4,430
	1996	19,399,548	1,870	9,731
	1998	19,488,465	788	10,421
	1999	19,670,641	1,246	8,235
women	1981	19,191,617	2,340	10,714
	1986	19,595,259	1,325	11,110
	1991	19,835,822	2,045	13,610
	1996	20,269,844	3,573	24,444
	1998	20,364,186	2,700	28,731
	1999	20,531,517	3,434	22,143

Table 1: Spanish population over the age of 100 according to sex.

In this regard, the weight of females over the age of 100 shows a tendency to increase with respect to the total centenarian population, from 71.65% in 1981 to 73.38% in 1999. This seems to contradict the fact that the weight of females over the age of 95 had decreased

regarding the total population of 95 years of age and over from 74.78% to 72.89%. This means that although the female population of 95 years of age and over has increased by 106.67%, from 10,714 to 22,143, during the analyzed period, the corresponding male population has risen even more by a total of 127.86% over the 19 year period from 3,614 to 8,235. From these data it can be observed that it is still difficult to live beyond the age of 100, as the surge in the population of 95 years of age and over has little impact on centenarians: the male population of centenarians has increased over the period by 34.70% and the female centenarian population has grown by 46.75%.

Therefore, the evolution of the population of 95 years of age and over is not as closely related to the population of 100 years of age and over, as it may have been assumed. Furthermore, we have observed how the number of centenarians has increased at a higher rate than the growth of the total population.

Can we therefore expect an increase in centenarians in absolute and relative terms compared to the rest of the Spanish population in the near future? This question is difficult to answer, but it appears that we can expect a growth in centenarians in Spain, but at a higher rate than the total population, excluding the effect of immigration.

7. A FIRST APPROACH TO NATIONAL MORTALITY

As we have mentioned above, we have been unable to analyze mortality at ages over 100 because we do not have a disclosure of the exposures by sex, ages and calendar year as we have of the occurrences. In Table 2 we present the number of deaths of people of 100 years of age and over registered in Spain from 1975 to 1995 by sex.

calendar year	female	male	Total
1975	355	102	457
1976	321	105	426
1977	339	120	459
1978	411	119	530
1979	354	108	462
1980	382	104	486
1981	415	129	544
1982	455	158	613
1983	449	149	598
1984	459	160	619
1985	547	196	743
1986	545	138	683
1987	615	185	800
1988	652	191	843
1989	740	213	953
1990	828	273	1,101
1991	829	248	1,077
1992	803	240	1,043
1993	807	243	1,050
1994	892	247	1,139
1995	952	243	1,195
Total	12,150	3,671	15,821

Table 2: Number of deaths in Spain of centenarians according to sex and calendar year

Deaths of centenarians have increased significantly during this period of 20 years: 168% for women and 138% for men. This is difficult to interpret solely using this information, as two main causes, or a combination of both, could have taken place. Firstly, there could have been a corresponding increase in exposures, i.e. the centenarian population, without any effect on mortality patterns. Secondly, there could have been an increase in the mortality of centenarians, i.e. a deterioration in the mortality pattern at ages of 100 or more.

In order to distinguish between these two causes, we have tried to calculate a preliminary approach to centenarian mortality in Spain and its evolution. In Equation 1 we illustrate the formula used to calculate mortality ratios for 1981, 1986 and 1991. Due to the scarce data available for the last period we have applied another approach as per Equation 2.

$q_{100+} = \frac{\sum_{t=1979}^{t=1983} D_t}{5 * E_{1981}}$	$q_{100+} = \frac{\sum_{t=1994}^{t=1995} D_t}{2 * E_{1996}}$
Equation 1: average mortality ratio	**Equation 2: second approach to mortality ratio**

The results of this method are shown in Table 3, where it can be observed that there is a large disparity between 1981 and the remaining years in both sexes. Surprisingly enough, it seems that for all calendar years female mortality is greater than that for males. This can be explained by the low number of males of 100 years of age or more observed. At the same time, no clear trend appears from these scarce observations.

	men	women
1981	0.14010811	0.17564103
1986	0.35510204	0.42535849
1991	0.36686217	0.39188264
1996	0.131016043	0.25804646

Table 3: First approach to national mortality for centenarians from 1981 to 1996

As a result, we can summarize that no conclusion could be reached at this stage. Assuming the reliability of the database, a more detailed investigation of centenarians by age, sex and calendar year will have to be carried out, and this will be impossible without the cooperation of the INE supplying the available data for centenarian survival population.

8. GROUP DESCRIPTION AND EVOLUTION

It is normal that we found centenarians amongst the beneficiaries of private insurance annuities, when those annuities are paid during retirement and include widows. In this regard, we have been able to follow the evolution of a group of retired nuns over the age of 64 from 1987 to 2000. The group studied has an average of 261 nuns during the period and an average of 10 deaths every year. In accordance with the observations from the rest of the group, we have concluded that the deaths of these elderly nuns are closely related to extreme weather conditions (i.e. heat in summer or cold in winter). Nevertheless, any conclusion arising from the observation of a small group like this, will be of reduced reliability, however certain trends can be traced if there is no other data available.

Therefore, through the observation of this group we can see that the probability of a 93 year old surviving to the age of 100 is 14.29%, as observed from 1987 to 1993. From a total of 14 exposures, there were 2 nuns who lived over the age of 100, one died at the age of 103 and the other at the age of 101. A summary of the observation matrix is shown in Table 4, whilst the complete observations made are presented in Appendix I, Table 6.

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
77	7													
78	10	7												
79	13	9	7											
80	7	12	9	7										
81	8	7	12	9	6									
82	10	8	7	11	8	6								
83	8	9	8	7	10	8	6							
84	6	8	9	7	7	10	8	4						
85	3	5	7	9	6	7	9	7	4					
86	2	2	5	6	8	6	6	9	6	3				
87	4	2	2	5	6	8	5	6	7	6	3			
88	4	4	2	2	5	5	8	5	6	7	6	3		
89	1	4	4	2	2	5	5	7	5	4	7	4	3	
90	4	0	2	4	1	2	5	5	7	4	3	7	3	2
91	5	4	0	1	3	1	2	3	4	5	3	2	5	3
92	0	4	4	0	1	2	1	2	2	4	4	1	1	5
93	2	0	4	4	0	1	2	1	2	1	4	3	1	1
94	1	2	0	2	4	0	0	1	0	1	1	3	2	1
95		1	2	0	2	3	0	0	1	0	1	1	2	1
96			1	2	0	0	3	0	0	0	0	1	1	2
97				1	2	0	0	3	0	0	0		1	1
98					1	1	0	0	2	0	0			1
99							1	0	0	1	0			
100								1	0	0	1			
101									1	0				
102										1				

Table 4: Evolution of female group throughout the observation period

Although it is difficult to compare this group with national female survivorship of centenarians we can work out an easy comparison. We have observed 2 centenarian nuns from an average of 261 which will be equivalent to 766 out of 100,000 females centenarian of 65 years of age or more. In terms of 1998 national data, the equivalent ratio of centenarian females over the age 65 or more was of 72. Clearly this group of nuns show a different pattern of behavior.

9. STATISTICAL ANALYSIS ON NATIONAL DEATHS

We have obtain from the INE 15,821 observations of centenarian deaths of both sexes over a period of 20 years, from 1975 to 1995. A description of the variables has been provided previously in this paper and in Appendix II we present the attributes or values of the variables we will analyze. In this section we proceed with a descriptive analysis of the database in order to observe the behavior of centenarian mortality and their evolution through time or age.

A first approach towards this evolution by sex and calendar year was presented in Table 2. We have presented this information in Chart 2, where we can observe the increase in the number of deaths throughout the period that was previously mentioned. This graph shows that the number of female deaths is three times those observed for males. Although the population by sex is nearly 50% to 50% at all ages, mainly due to the higher life expectancy of Spanish women, the population of centenarians is 77% for females and 23% for males. The number of deaths by sex presents the same rate as an average throughout the period: 77% to 23%. Therefore, a different analysis by sex is required as is usual in mortality.

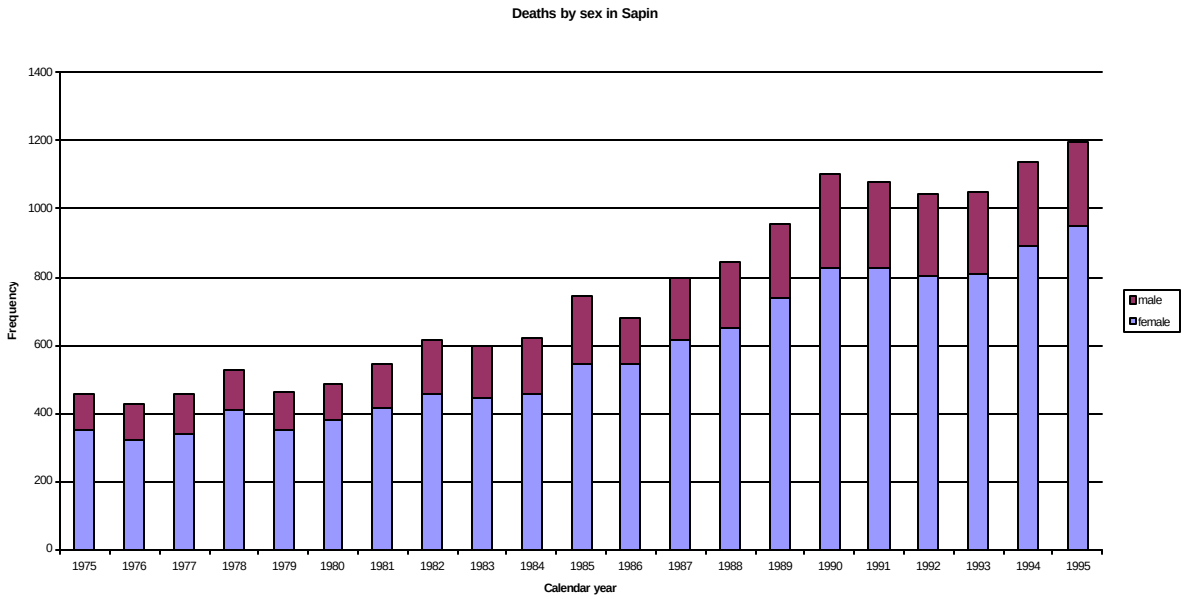

Chart 2: Number of deaths over 100 years old in Spain by sex, from 1975 to 1994

We will therefore analyze the deaths by sex, first males, and their females and finally comparing both sexes. In order to compile these analyses we will start with some descriptive statistics in order to summarize observations. Afterwards, we will present the corresponding box plot graph with comments thereon. We believe that box plot graphs are a very easy and visual way to present and compare distributive behavior through their quartiles and separation between them (the box) and the detection of outliers.

9.1. DESCRIPTIVE STATISTICS

In Table 5 we present the descriptive statistics for the three numerical variables analyzed: Calendar year, age and month of death by sex.

Variable Age has a right tail distribution very similar for both sexes and it is solely the maximum age reached, more for women, that gives rise to differences. The mean age is practically the same for both sexes: 101.6. 75% of observations are 102 or below, and each year after the age of 100 makes up 25% of the total deaths. It therefore seems that the difficult age to surpass is 104, as only approximately 10% of the deaths occur over this age. Only 1% of the observations are more than 116 for men or 108 for women.

Variable Calendar year presents three different subperiods for males:

- 1981-1980, with a very similar number of deaths and an average frequency ratio of 3%.
- 1981-1990, with an increase in the number of deaths per year and a frequency ratio which grows from 3.5% to 7.4%.
- 1991-1995, again a stable period with a similar number of deaths by year and an average frequency ratio of 6.6%.

Therefore, most of the increase in the number of deaths by years has been reached over a 10 year period from 1981 to 1990. This is opposite to female behavior where the observed increase in the number of deaths through the period has grown during the whole period from 1975 to 1995.

Seasonal effects have been approached based on the variable month of death. As expected, the first and last quarter of the year, corresponding to the coldest weather, present a higher number of deaths. In both sexes from April to October frequencies are lower than 8.5%. It seems that seasonality affects both sexes equally.

	men			women		
Descriptive Statistics	Calendar year	Age	month	Calendar year	Age	month
25 percentile	82	100	3	83	100	3
50 percentile	88	101	6	88	101	6
75 percentile	92	102	10	92	102	10
Mean	88.8	101.6	6.3	87.0	101.6	6.3
Mode	90	100	1	95	100	1
Maximum	-	129	-	-	134	-
Variancy	33.8	8.6	13.8	34.3	5.5	13.3

Table 5: Descriptive statistics in numerical variables.

9.2. MALE

9.2.1. Age by Calendar year

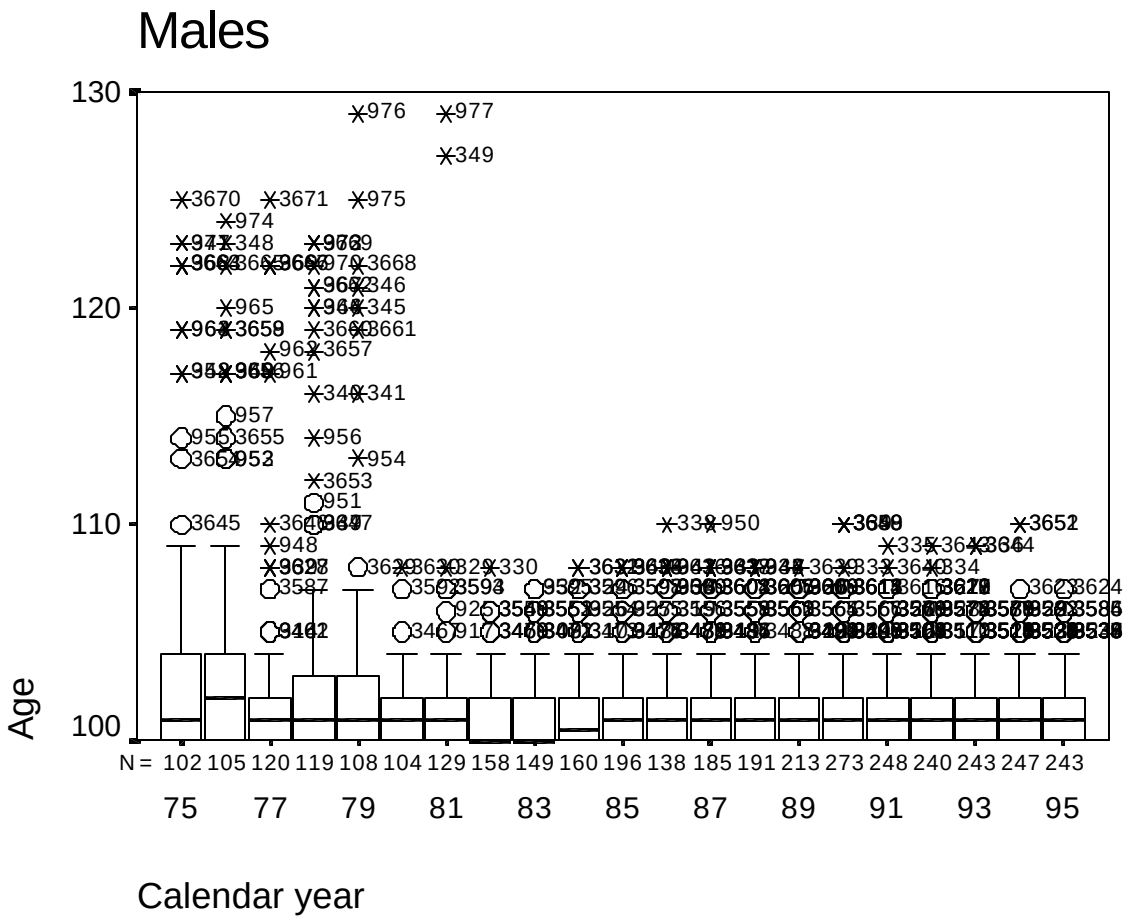

Chart 3: Males. Age by calendar year

Draft conclusions from Chart 2:

- The variability of the variable age by calendar year has decreased with years.
- The right tail of the distribution of age by calendar year has shortened with years.
- Outliers have diminished.
- There is a high level of consistency in the value of the quartiles (100, 101 and 102) and the end of the distribution (90% of the observations correspond to 104 and below).

9.2.2. Location

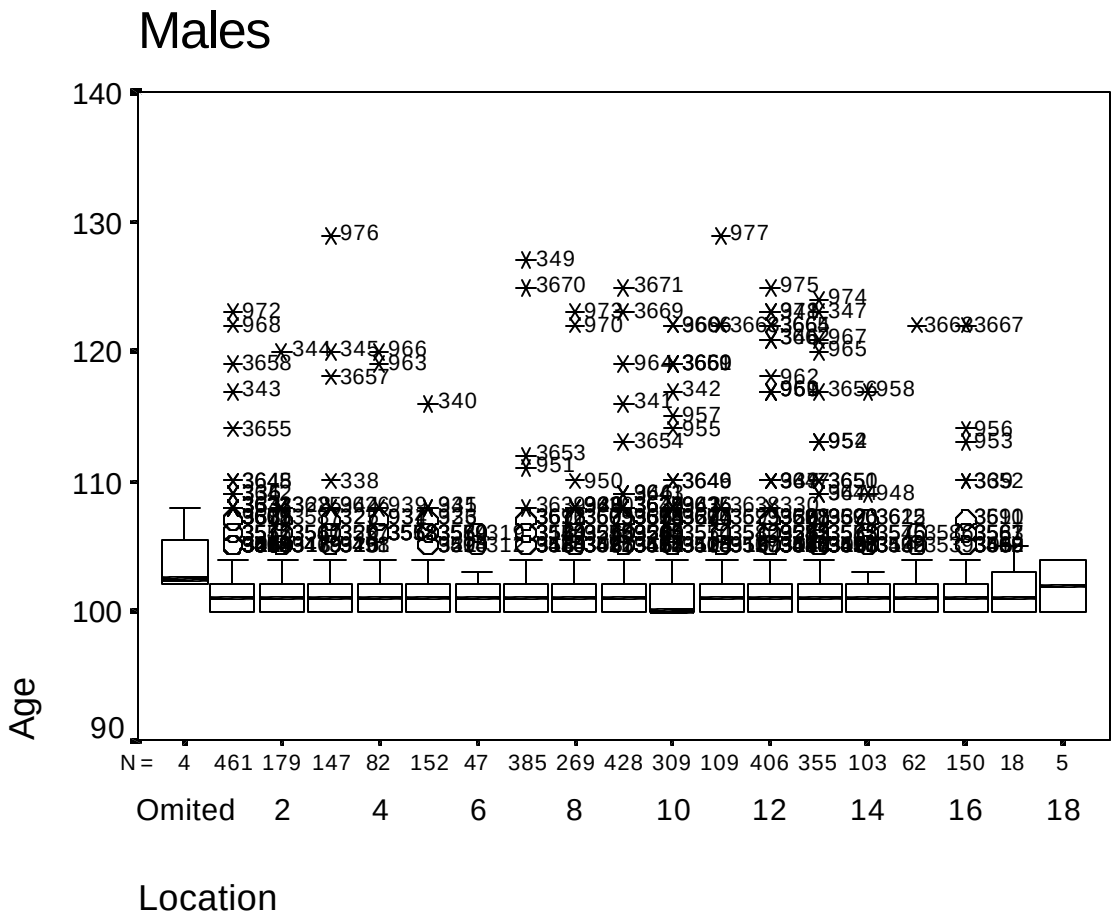

Chart 4: Males. Age by Location

A description of the regional location used in this paper can be found in Appendix II. The population of the regions is dissimilar, but there was no data available relating to centenarian population in regions for the whole period. Nevertheless, most of the distribution observed in regions with a number of deaths exceeding 50, is similar to the total age distribution pattern. However, the Region of Valencia is an exception. This region is in the east Mediterranean coast of Spain and presents an increased number of deaths at 100 years of age compared to the other regions. The Murcia Region, south of than Valencia, presents a shortness of the distribution.

Consequently, differences in the number of deaths by Location should be explained by differences in the centenarian population of each region, as the geographical situation does not appear to explain the number of deaths.

9.2.3. Marital Status

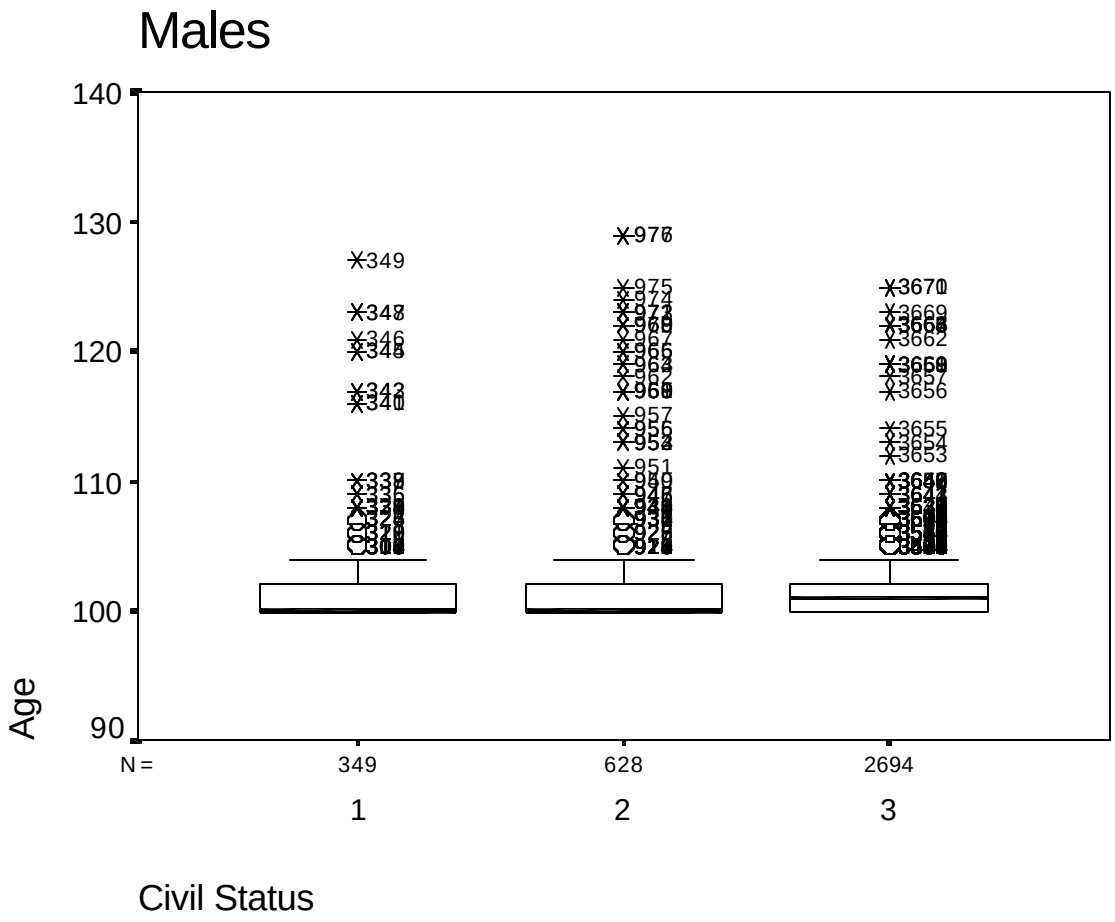

Chart 5: Male. Age by Marital status

No legally separated couples have been observed, but we must take into account that Spain has a long tradition of Catholicism where legal separations were rare in the past. However, changes in this situation may be possible in the future. Although 73.4% of centenarian deaths relate to widows, 17.1% were married and 9.5% were single.

Age distribution by marital status seems to follow the same pattern as total age distribution, except for single and married persons where the 2nd quartile coincides with the age of 100.

9.2.4. Causes of Death

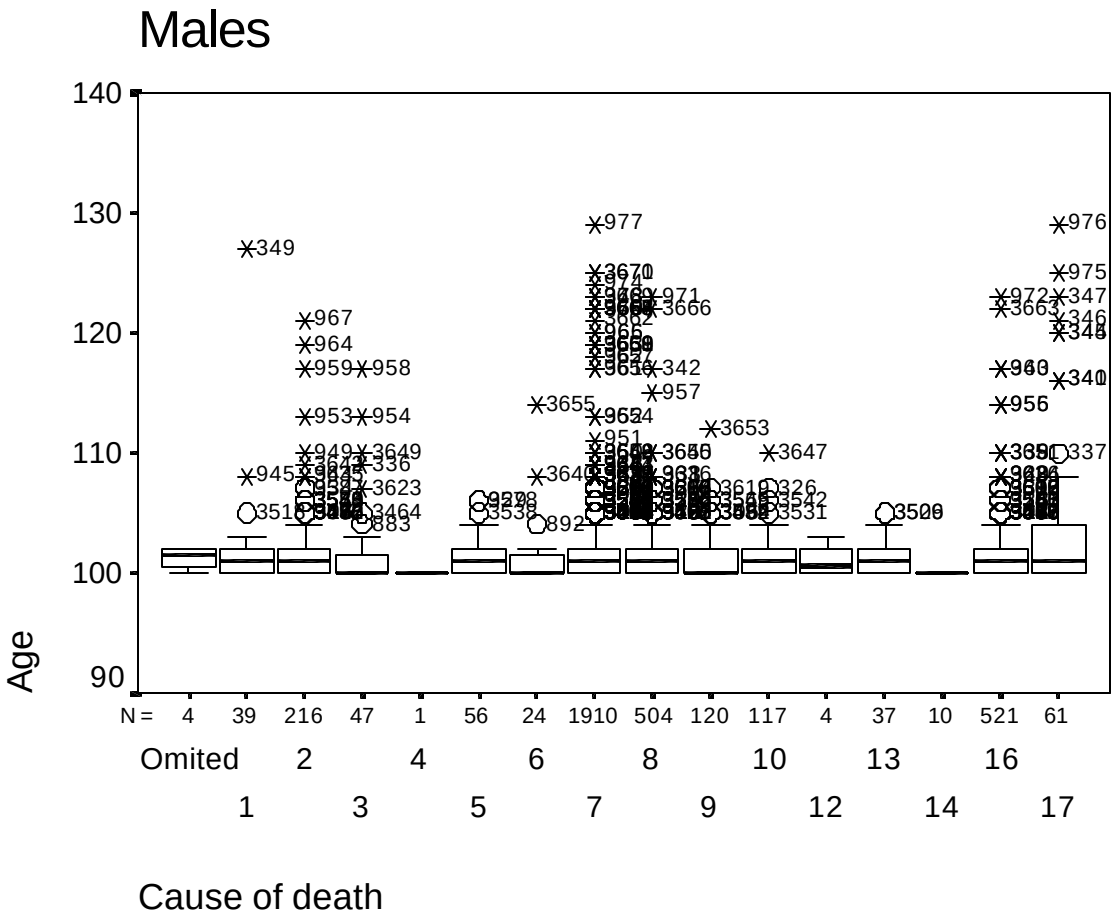

Chart 6: Males. Age by cause of death

A description of the classification into 17 groups of disease used in this paper can be found in Appendix II. 52% of deaths have been classified as circulatory diseases, mainly heart attacks. Second in importance are badly classified symptoms (14.2%); and thirdly with a relative frequency of 13.7% are respiratory diseases. These 3 groups account for 80% of observed deaths over the period, and present the same pattern for age distribution as the general pattern of this variable.

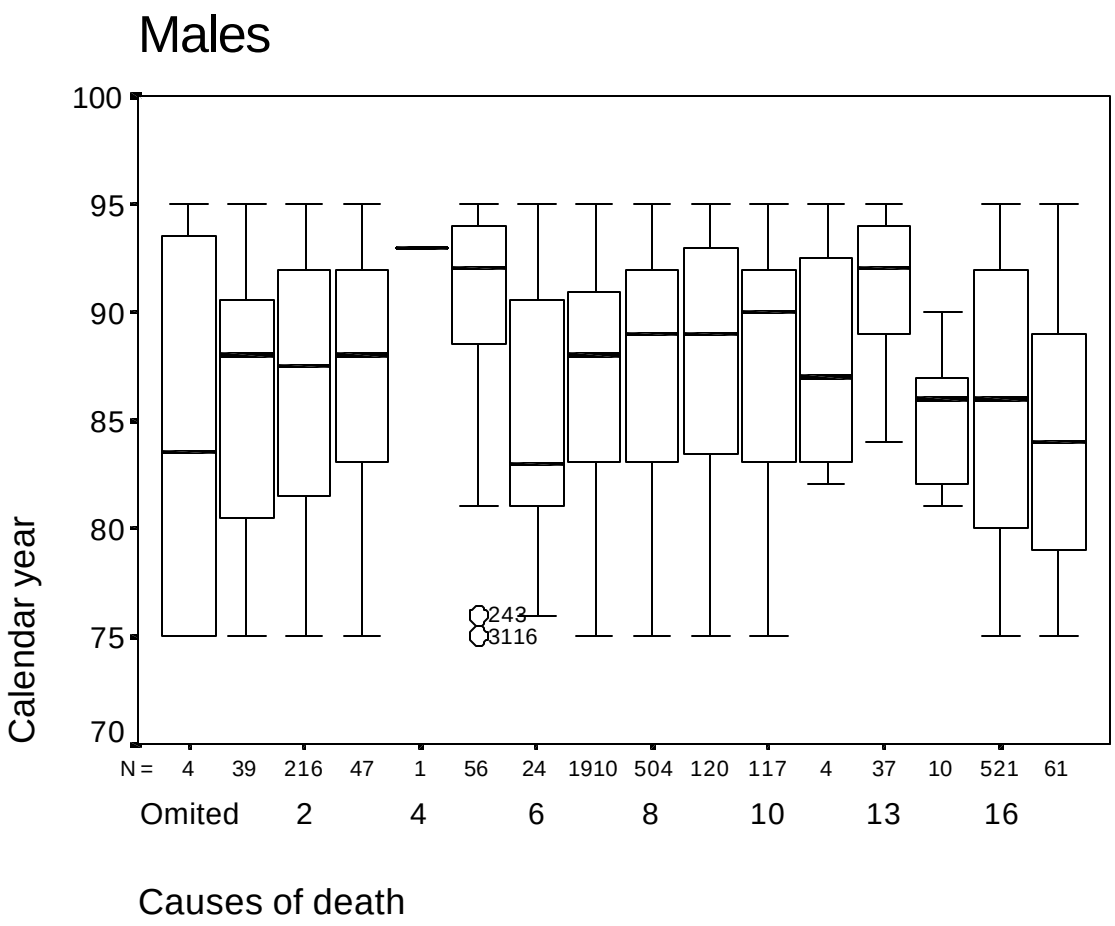

Chart 7: Males. Calendar year by Cause of death

If we had obtained enough information for different groups of diseases, and if no trend were observed in the deaths of the same groups of disease we would expect the same pattern of the distribution of total deaths. In this respect group 16 shows a fairly uniform distribution in comparison with those diseases included in groups 7 and 8 which present left tail distributions similar to the total calendar year distribution.

9.2.5. Month of Death

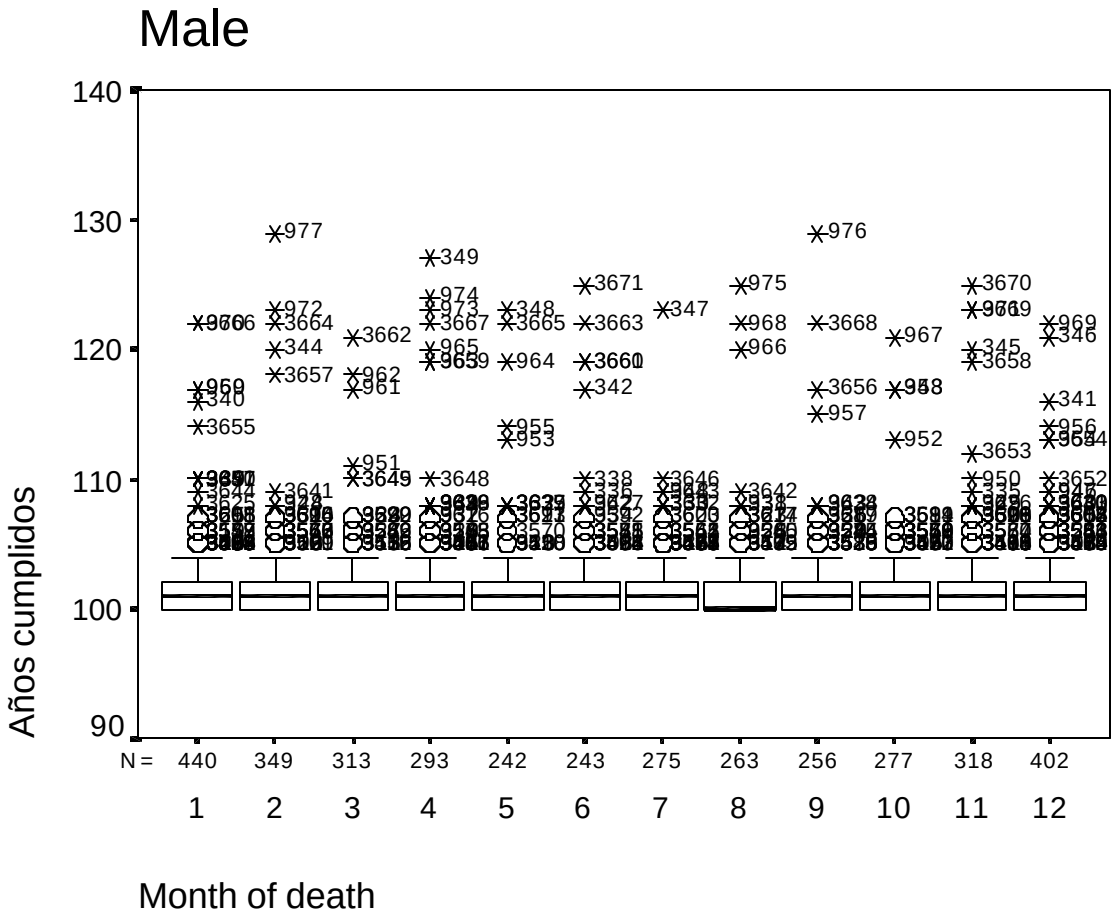

Chart 8: Males. Age by month

Except for August (the hottest month in Spain) with the average being 100 years of age, there are no differences between the total age distribution pattern and the distribution of ages by months.

9.2.6. Profession

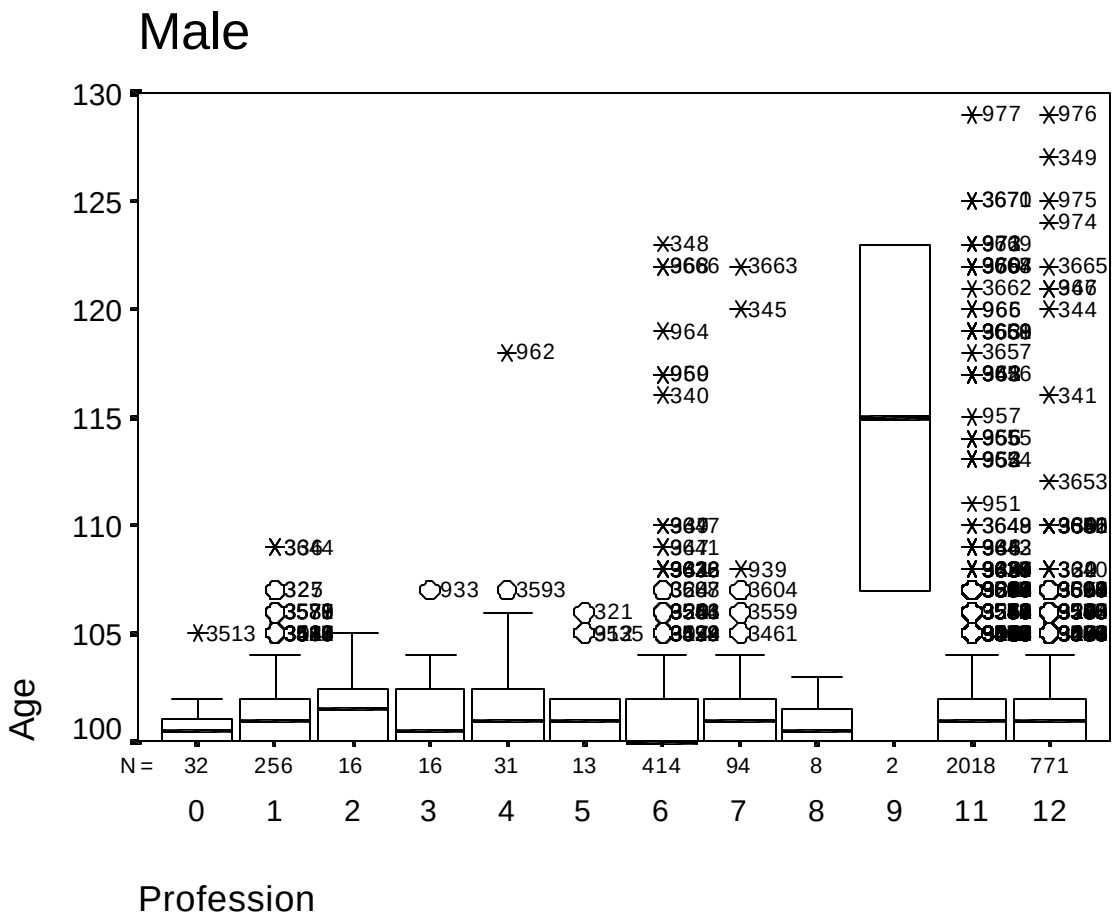

Chart 9: Males. Age by profession

A description of the professional classification in 12 groups can be found in Appendix II. The principal group with 55% of deaths relates to retired persons, followed by non-classified deaths (21%). The third group, with a relative frequency of 11.3%, includes formers and similar professions. These 3 groups account for as 76% of observed deaths over the period, and present the same pattern for age distribution as the general pattern of this variable, except for group 6 where the average is 100 years old.

9.3. FEMALE

9.3.1. Age by Calendar year

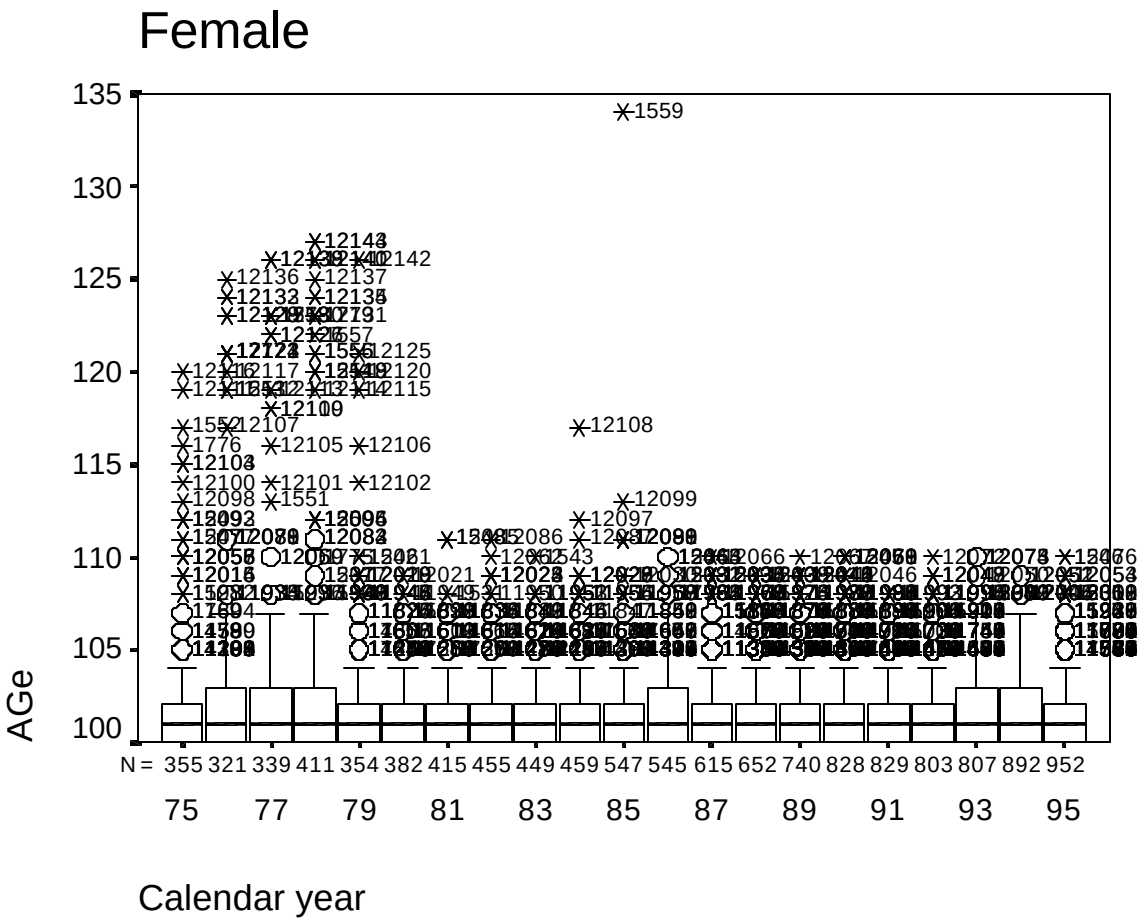

Chart 10: Females. Age by calendar year

Draft conclusions from Chart 10:

- The variability of the variable age by calendar year has decreased with years.
- The right tail of the distribution of age by calendar year has shortened with years.
- Outliers have diminished throughout the period.
- There is consistency in the value of the quartiles (100, 101 and 102) except for years 1976, 1977, 1978, 1986, 1993 and 1994 when the third quartile is reached at 103 years of age. The end of the distribution (90% of the observations) corresponds to 104

years of age except for those years mentioned previously in which 90% is reached at the age of 106.

9.3.2. Location

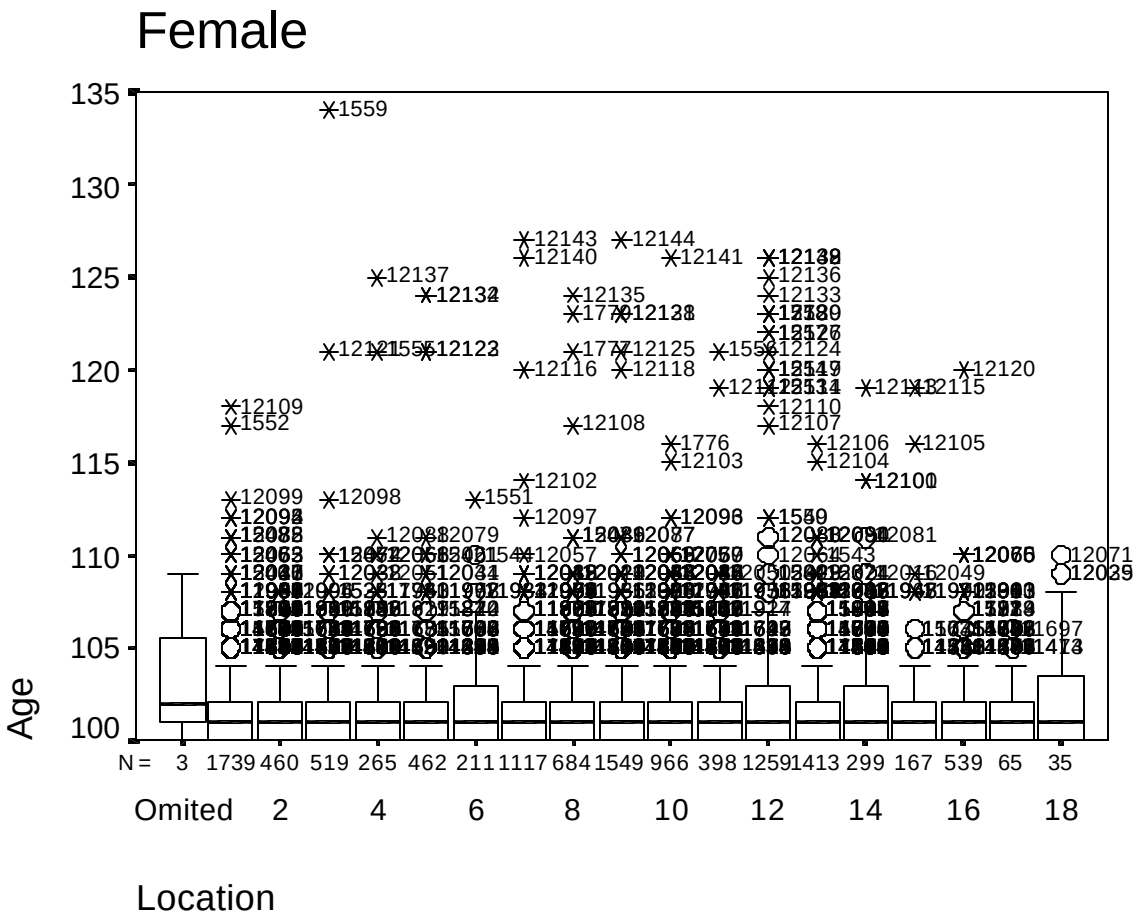

Chart 11: Females. Age by Locaton

Most of the distribution observed in regions with a number of deaths higher than 50, is similar to the total age distribution pattern. Several regions present a longer distribution different from the rest but similar between them. Those regions are Cantabria and Galicia in the North and Murcia in the east Mediterranean coast of Spain. In these three locations the 1st and 2nd quartile are the same but the 3rd quartile is reached at 103 and the end of the distribution is at 107 years of age instead of 104.

There is no evidence of a higher numbers of deaths depending on the cardinal situation (N,E,S & W) of the locations, consequently it will depend on the centenarian population of the locations.

9.3.3. Marital Status

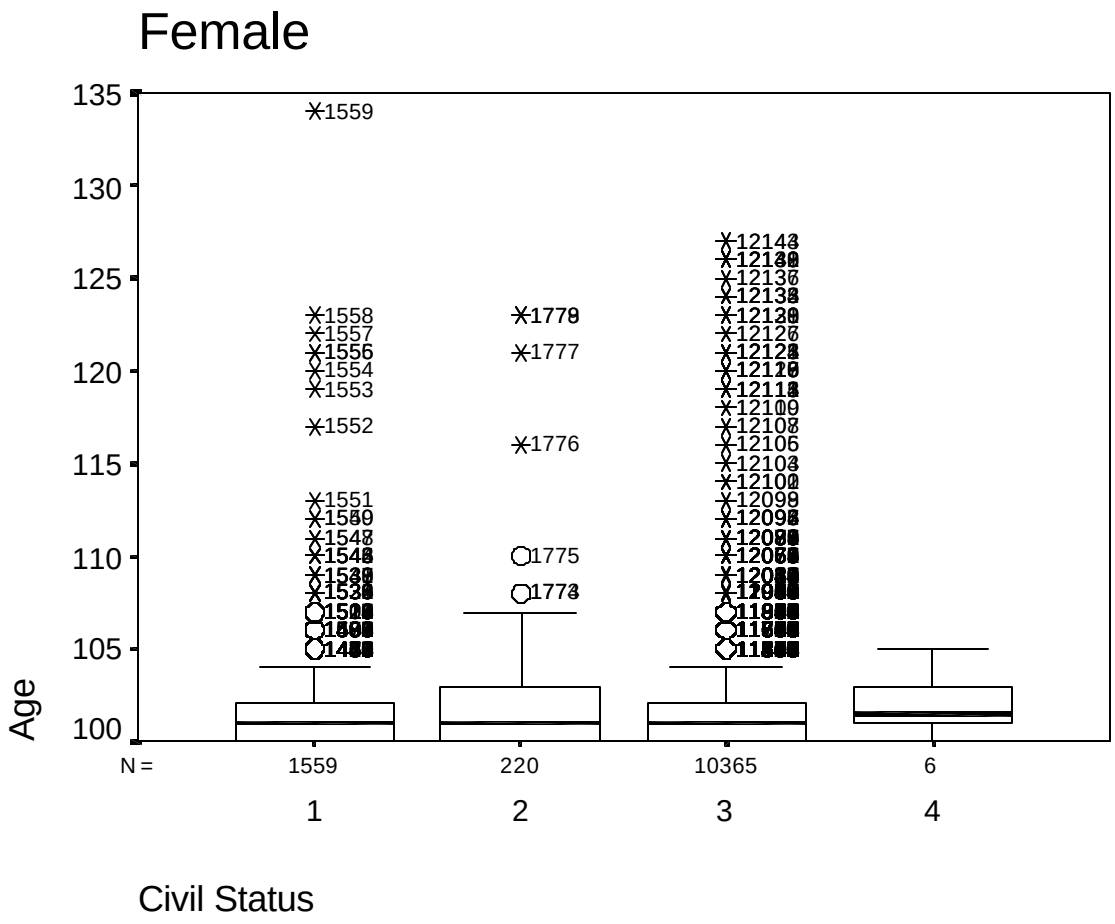

Chart 12: Females. Age by Marital Status

There are only 6 observations of legally separated women, however we must take into account that Spain has a long tradition of Catholicism where legal separations were rare in the past. However, changes in this situation may be possible in the future. Although 85.3% of centenarian deaths are of widows, 1.8% were married and 12.8 % single.

Age distribution by marital status seems to behave following a very similar pattern to that of total age distribution, except for singles and married persons where the 2nd quartile coincides with the age of 100.

9.3.4. Causes of Death

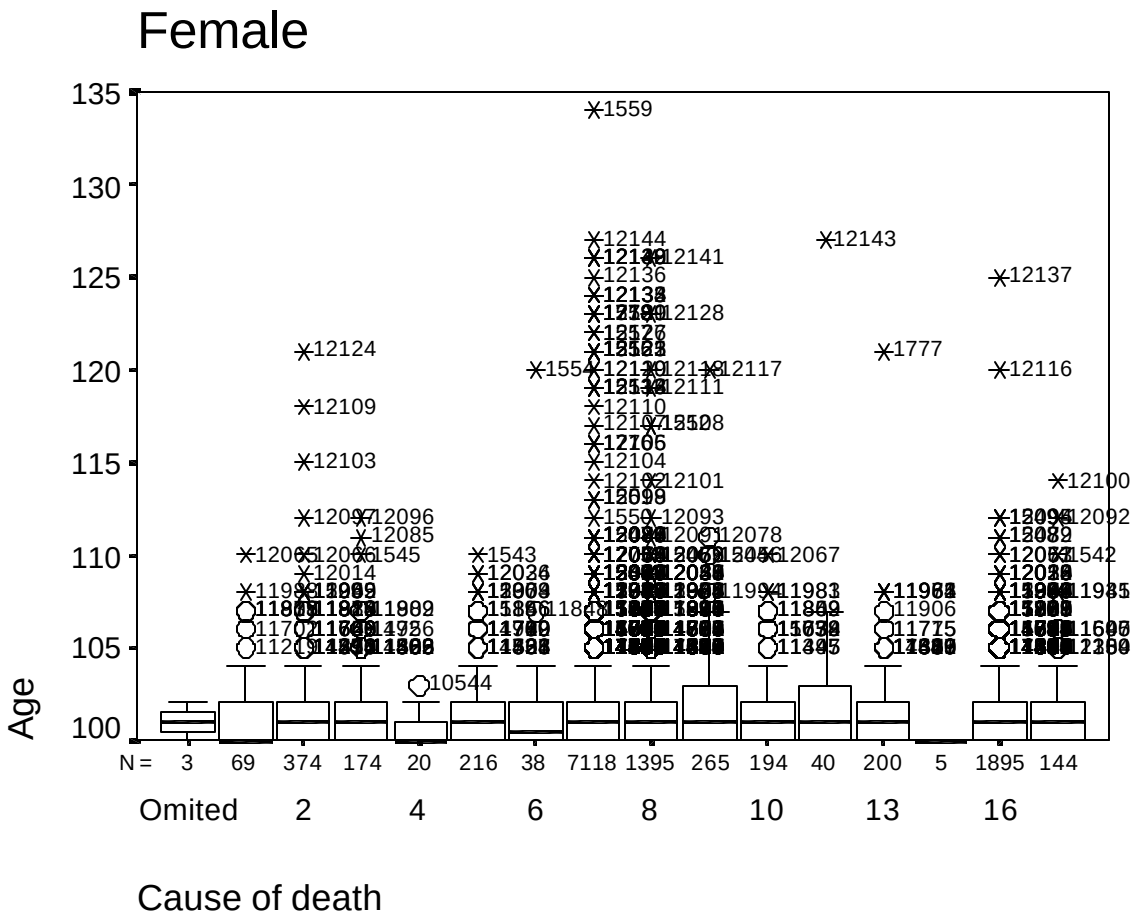

Chart 13: Females. Age by Cause of death

The three main causes of death are the same as those for males: 58.6% of deaths have been classified as circulatory diseases, mainly heart attacks. Second in importance, 15.6% badly classified symptoms; and thirdly, with a relative frequency of 11.5%, are respiratory diseases. These 3 groups amount for 85.7% of observed deaths over the period, and present the same pattern for age distribution as the general pattern of this variable.

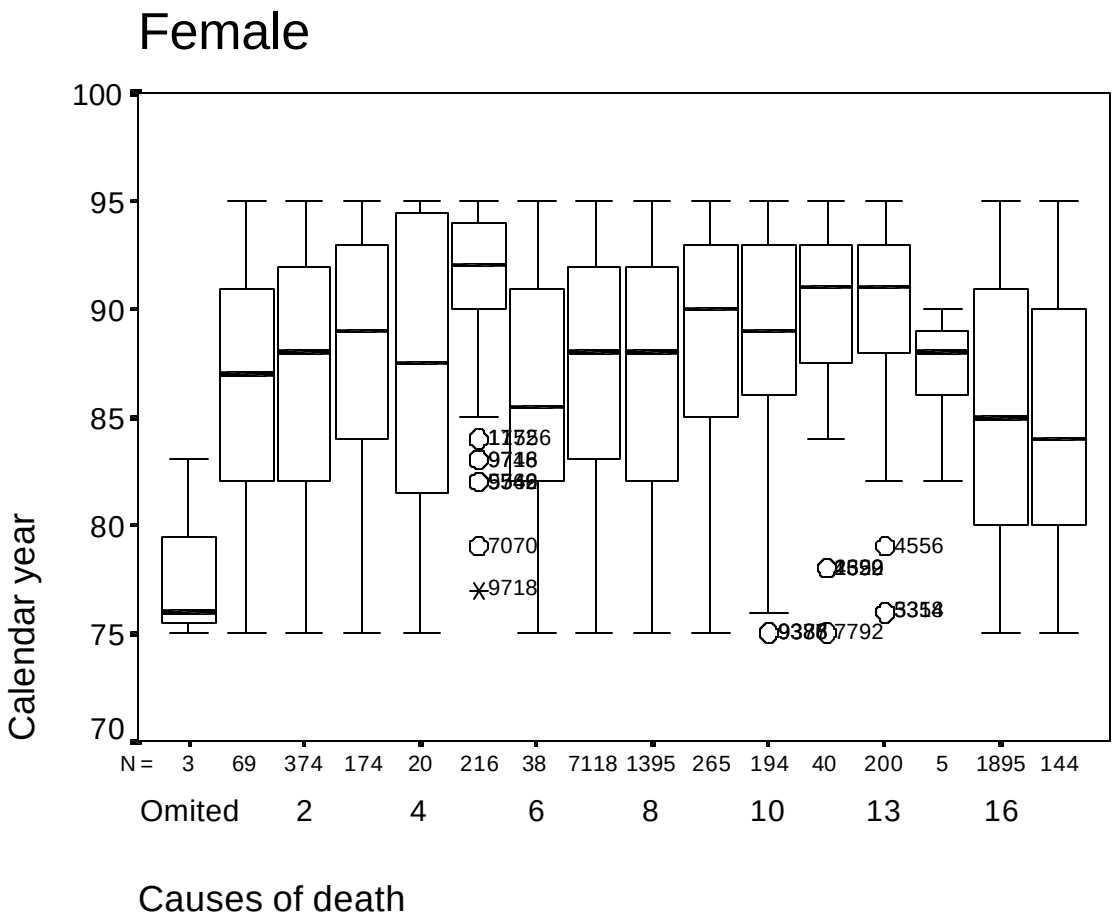

Chart 14: Females. Calendar year by cause of death

Group 16 of diseases presents a uniform distribution in comparison with those of group 7 and 8 that present left tail distributions as per their total calendar year distribution pattern, but which are different to those observed for males.

9.3.5. Month of Death

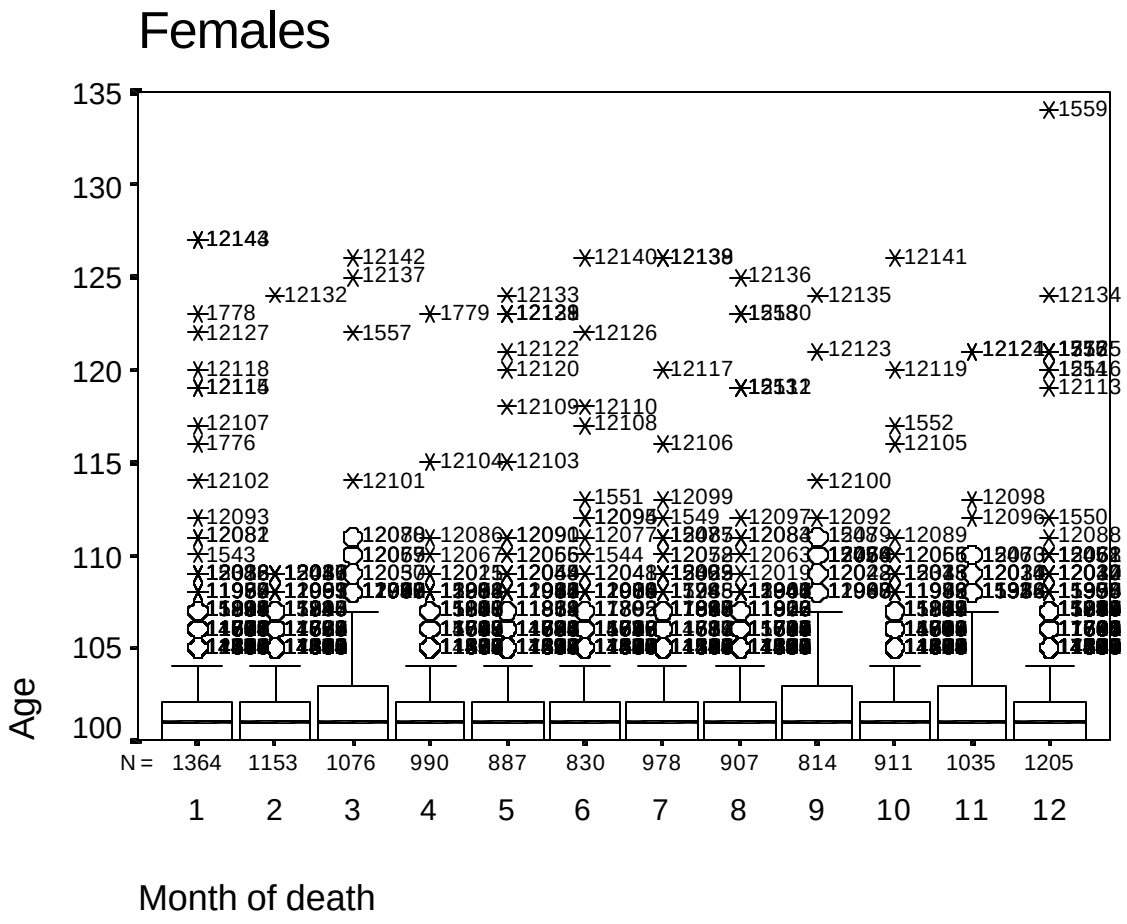

Chart 15: Female. Age by Month of death

March, September and November present a longer right tail, with the 3rd quartile at 103 years of age.

9.3.6. Profession

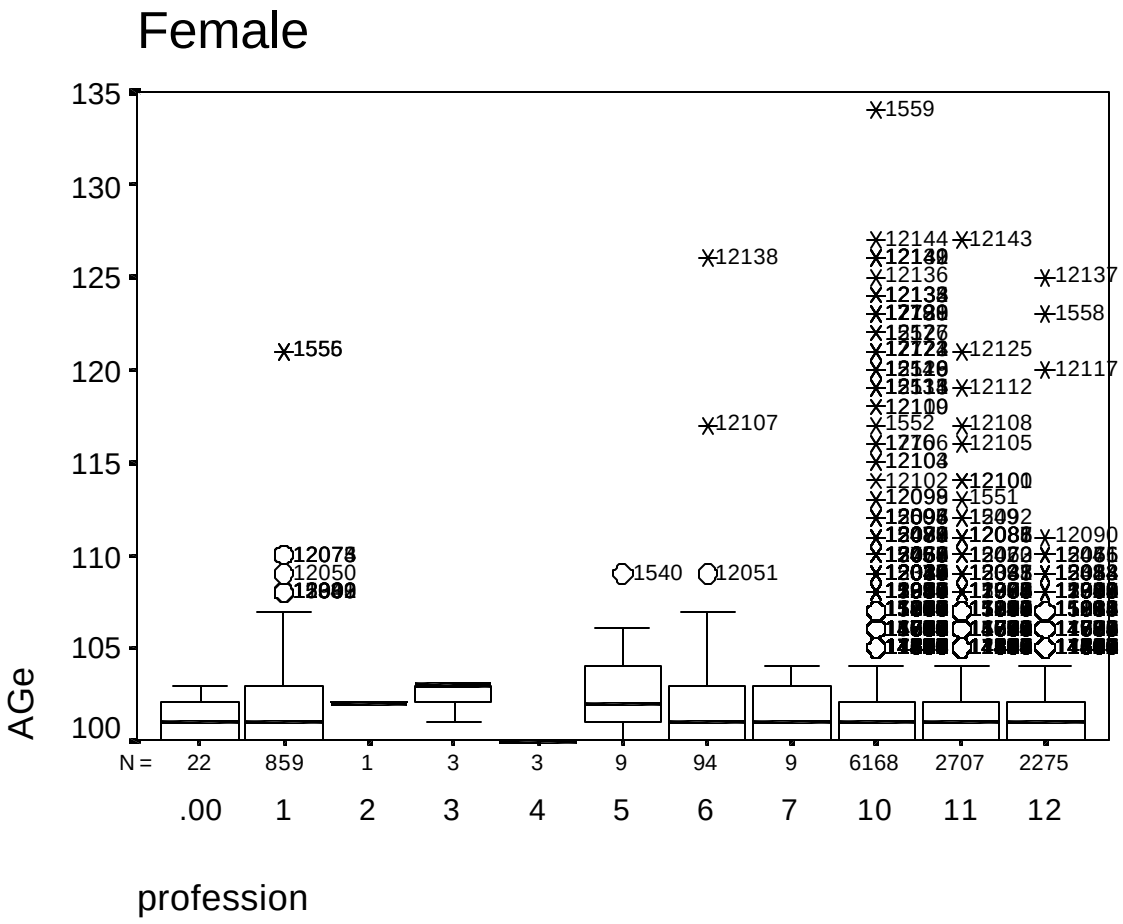

Chart 16: Females. Age by profession

The principal group of profession for females is housekeeping with 50.8% of deaths in this group followed by retired persons with 22.3%. Thirdly, with a relative frequency of 18.7%, there are non-classified professions. These 3 groups account for 91.8% of observed deaths over the period, and present the same pattern for age distribution as for the general pattern.

10. RESULTS AND CONCLUSION

The first finding related to the serious difficulties we encountered when searching for data on the centenarian population.

Most of the problem revolves around the reluctancy of the INE and the Social Security[1] in providing data other than national aggregates of centenarians, without any details of ages, etc. Furthermore, the Spanish National Institute of Statistics' recent estimates diverge from current information they provide. Hence, a great effort from all institutions must be made to share knowledge and information about centenarians and their evolution, as this has proven to be a real challenge in the past.

A second conclusion is that centenarian population has increased in number over the analyzed period (1981-1999), 43.29%. This could be normal in a population that is ageing, but the weight of centenarians over the total population has also grown. Approximately two thirds of the centenarian population are female. This percentage has slightly decreased over the period.

In view of all these trends, an acceptable forecast would be an increase in the centenarian population in Spain. The next questions to be asked would be if we are prepared for all the consequences of this situation.

Usually, insured populations survive more than general populations. Can we expect a greater number of centenarians among the insured population in comparison with the national population? We do not have an answer to this but evidence that this could be the case has been shown in a case study of a group of retired nuns, where 2 centenarians have been observed. Complementary Private Retirement Benefits are currently promoted in the EU and actively in Spain. Are we aware of the possible impact of a greater survival of centenarians in the actuarial calculation of Retirement Benefits?

Thirdly, we have analyzed the database of deaths in Spain at ages of 100 and more.

90% of the observations are under the age of 104, in fact 75% of deaths do not exceed the age of 102. Variability among outliers, i.e. older ages, have decreased over the period. Therefore, although a greater number of deaths are observed in the later years, outliers have decreased and concentrated their values.

Most of the variables analyzed among centenarian deaths have a scarce effect on the distribution pattern of ages over the age of 100.

Our challenge for the near future should be to contrast occurrence observation with exposures and obtain mortality ratios by age, as the objective of this paper was a descriptive analysis. The grouped mortality ratio we have approached shows a significant variability over the years, although most of the figures are between 0.35 to 0.4. If we approach mortality through observed frequencies of deaths, we can obtain the following estimates:

$q_{100} = 0.25$

$q_{101} = 0.33$

$q_{102} = 0.50$

Appendix III shows is a detailed explanation of the estimates of the probability of deaths at centenarian ages. In any case, this is only a raw approach, in near future methods such as extinct generations to compute probabilities of death may have to be used.

Age distribution patterns of centenarian deaths are very similar in both sexes, except for the longer right tail of females.

Calendar year distribution presents an increase in the number of deaths as time goes by, but the pattern for males is steeper and more continuous for female.

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[1] Government institution which pays public retirement pensions

Few differences have been observed between sexes for the variable location. Regional exception of the normal patterns are different by sex. However, perhaps these exceptions can be explained by distinct distribution of the centenarian population in relation to the calendar year. There is a possibility that centenarians, mainly those who are disabled, change their residence at older ages in order to live in a hospital residence or with their family (normally, their daughters). This change of residence can increase if their health deteriorates. Therefore, the location upon death for centenarians could be different to that of their usual residence.

There are differences in the marital status upon death depending on sex. In both cases widowhood is the more frequent observation, but single females are more frequent than single males.

The classification of causes of death has been highly grouped in our analysis. In this case, there are no differences between sexes or age distribution and there are no observable trends inside the important groups.

Seasonality has been tested: months related with the coldest weather present a greater number of deaths, irrespective of sex. The distribution of ages at death shows different pattern exceptions depending on sex, and in both cases, these are difficult to explain.

Retired and non-classified professions are usual classifications for professions of centenarian deaths. There are differences by sex in the relative frequency, but also in the classification of farmers or similar professions for men and housekeeping for females. No change in the pattern of age distribution has been observed, except for male farming profession.

We have observed two factors or trends:

- There is an increased centenarian population over time.
- There are more centenarian deaths over time.

Different explanations can be given:

a) Equal probability of surviving to the age of 100, together with an increase in the population.

b) An increase in the probability of surviving to the age of 100.

c) An increase in the probability of surviving beyond the age of 100.

Our conclusion is that evidence relates more closely to the second scenario than the others.

11. CITATIONS

11.1. BIBLIOGRAPHY

Felipe A. (1997) *Modelización de la evolución de la piramide poblacional en el territorio español para los años 75-93.* Barcelona: Trabajo de Investigación. Departamento de Econometría, Estadística y Economía Española. Universidad de Barcelona.

Betzuen, A.; Felipe A. ; Guillén M. (1997) "Modelos de tablas de mortalidad en España y situación actual". A: *Anales del Instituto de Actuarios Españoles*. Tercera Época, núm 3, pp. 79-104.

Felipe, A.; Guillén, M.; Artís M. (1998) "Recent Mortality Trends in the Spanish Population". *A:Transactions of the 26th International Congres of Actuaries.* Vol 9.

Forfar, D.O.; McCutcheon, J.J.; Wilkie, A.D. (1988) "On graduation by mathematical formula". A: *Journal of the Institute of Actuaries*. núm.115, pp. 1-149.

Pannenberg, M. (1997) "Old Age Risk in Germany". A: *Transactions of The Mortality Seminar.* Heriot Watt University, Edinburgh, 4 July 1997. Groupe Consultatif Des Associations D'actuaires Des Pays Des Communautes Europeennes.

Vinuesa, J. et al. (1994) *Demografía. Análisis y proyecciones*. Madrid: Síntesis.

12. APPENDICES

(as necessary for detailed presentation of results)

12.1. APPENDIX I: FEMALE GROUP OBSERVATIONS

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
65	16	20	13	10	14	13	7	10	10	10	15	17	12	12
66	9	16	20	13	10	14	13	7	10	10	10	15	17	12
67	10	9	16	20	13	9	14	13	7	10	10	10	15	17
68	12	10	9	16	20	12	9	14	13	7	10	9	10	15
69	14	12	10	9	16	20	12	9	14	13	7	10	9	10
70	10	14	12	10	9	16	20	12	9	14	13	7	10	9
71	17	10	14	12	10	9	16	19	12	9	14	13	6	9
72	10	17	10	14	12	10	9	16	19	12	9	14	13	6
73	12	10	17	10	14	12	10	9	16	19	12	9	14	13
74	10	12	10	17	10	14	12	10	9	16	19	12	9	14
75	8	10	12	10	17	9	14	12	10	9	16	17	12	9
76	7	8	10	12	10	17	9	14	12	10	9	16	17	12
77	7	7	8	10	12	8	17	9	14	12	10	9	16	16
78	10	7	6	8	10	12	8	17	9	13	12	10	9	16
79	13	9	7	6	8	9	11	8	16	9	13	12	10	8
80	7	12	9	7	6	8	9	11	8	16	9	13	12	10
81	8	7	12	9	6	6	8	8	11	7	16	9	13	12
82	10	8	7	11	8	6	6	8	7	11	6	16	7	12
83	8	9	8	7	10	8	6	6	7	6	10	6	16	6
84	6	8	9	7	7	10	8	4	4	7	5	8	6	16
85	3	5	7	9	6	7	9	7	4	4	7	5	6	6
86	2	2	5	6	8	6	6	9	6	3	4	7	5	6
87	4	2	2	5	6	8	5	6	7	6	3	4	6	4
88	4	4	2	2	5	5	8	5	6	7	6	3	4	5
89	1	4	4	2	2	5	5	7	5	4	7	4	3	4
90	4	0	2	4	1	2	5	5	7	4	3	7	3	2
91	5	4	0	1	3	1	2	3	4	5	3	2	5	3
92	0	4	4	0	1	2	1	2	2	4	4	1	1	5
93	2	0	4	4	0	1	2	1	2	1	4	3	1	1
94	1	2	0	2	4	0	0	1	0	1	1	3	2	1
95		1	2	0	2	3	0	0	1	0	1	1	2	1
96			1	2	0	0	3	0	0	0	0	1	1	2
97				1	2	0	0	3	0	0	0		1	1
98					1	1	0	0	2	0	0			1
99							1	0	0	1	0			
100								1	0	0	1			
101									1	0	0			
102										1	0			
TOTAL	230	243	252	256	263	263	265	266	264	261	269	273	273	276

Table 6: Evolution of female group by age and calendar year

12.2. APPENDIX II

12.2.1. Variable Month of Death

Explanation of the attributes or values of the variables analysed in the centenarian death database

1 to 12 corresponds to January to December

12.2.2. Variable Cause of Death

WHO 5th classification grouped into 17 causes

01 Infectious diseases and parasites

02 Tumours

03 Endocrine gland and nutritional illnesses

04 Blood and haematopoietic organ diseases

05 Mental disorders

06 Nervous system and hearing illnesses

07 Circulatory system diseases

08 Respiratory diseases

09 Digestive system diseases

10 Genital-urinary diseases

11 Pregnancy, birth and puerperium complications

12 Skin and subcutaneous tissue diseases

13 Osteomuscular and connective tissue illnesses

14 Congenital disorders

15 Certain illnesses arising during the perinatal period

16 Signs and symptoms incorrectly classified

17 External injuries and poisoning

12.2.3. Variable Regional Location

1. Andalusia	7. Castilla y Leon	13. Community of Madrid
2. Aragon	8. Castilla La Mancha	14. Region of Murcia
3. Principality of Asturias	9. Catalonia	15. Region of Navarra
4. Balearic Islands	10. Community of Valencia	16. Basque Country
5. Canary Islands	11. Extremadura	17. La Rioja
6. Cantabria	12. Galicia	18. Ceuta y Melilla

Ilustration 1: Geographical location of death in Spain

12.2.4. Variable Marital Status

1. Single
2. Married
3. Widow
4. Separated

12.2.5. Variable Profession

01 Professionals, technicians and similar workers

02 Public administration and private company management

03 Administrative and similar personnel

04 Sales representatives

05 Service personnel

06 Farmers, livestock farmers, foresters, fishermen and hunters

07 Manufacturing and similar workers, vehicle drivers and non-agricultural labourers

08 Professionals in the armed forces

09 Students

10 Housewives/husbands

11 Retired persons and pensioners

12 Non classified persons

12.3. APPENDIX III:

On the assumption that we have 100 centenarians and we observe them until the extinction of the group, applying frequencies observed as per section 9, we will expect the following deaths:

Age	Survivors	Deaths
100	100	25
101	75	25
102	50	25

Hence, the probability of death will be estimated as follows:

$q_{100} = 25/100 = 0.25$

$q_{101} = 25/75 = 0.33$

$q_{102} = 25/50 = 0.50$

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Footnotes

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[2] "Proceedings" of AAAS, 28 de agosto de 2001. La Vanguardia; DIARIO 16 23/10/2001

[3] Seminar of Fundación Pfizer at Universidad Internacional Menéndez Pelayo, 2000. Kathy Newell from General Hospital of Massachusetts of Harvard University (EEUU). El País 07/08/2000. and INE NP203, 19th of January of 2001, "Resultados Avance de la Encuesta de Discapacidades, Deficiencias y Estado de Salud".

[4] EUROSTAT population study, EUROPA PRESS 12/08/2000