Centenarians in Sardinia: The Underlying Causes of the Low Sex Ratio

Graziella Caselli and Domenica Rasulo

Dipartimento di Scienze Demografiche
Università di Roma “La Sapienza”

Introduction

There is much recent interest in studying Sardinian centenarians particularly because of their extremely high frequency (Koeing, 2001, Poulain et al. 2004) and their low female/male ratio compared to elsewhere in Italy and worldwide.

When the Italian regions are ranked by the Centenarian Rate (CR[1]), an indicator recently proposed by Graziella Caselli (Caselli et al., 2003; Robine and Caselli, 2005), Sardinia is at the top of the list with a CR of 208 centenarians per 100,000, both for men and women, which is 31% higher than the Italian average. Additionally, in Sardinian male centenarians outnumber centenarians elsewhere in Italy by 107% (CR= 127 compared with 61 per 100,000), while the gap with women centenarians is only 18% (277 compared with 236 per 100,000).

The exceptionally high number of male centenarians in Sardinia accounts for the particularly low female/male ratio (SR), which in the 2001 census was 2.5 compared with an average of 4.9 for centenarians in the rest of Italy. The SR in developed countries generally ranges from 4 to 6 (Caselli et al, 2003).

This article endeavours to explain why Sardinia has such a low centenarian SR. As a premise, it should be pointed out that live births' SR for Sardinian cohorts that are now centenarians was generally in the range of 1.04 to 1.07 males born for every female. Since the SR at birth is very similar across the considered cohorts, the centenarian SR must be affected by the mortality and migration processes over the life span.

Hence, using a cohort analysis rather than a period approach, we may be able to sort out the role of mortality and migration.

In the first section of this paper, the Sardinian and Italian SRs for cohorts of centenarians at ages 59, 69, 79 and 99 are described. This approach also includes an analysis based on cohort life tables aiming at portraying the mortality pattern in Sardinia and Italy after a given time. In the following section, we apply a decomposition method and a standardisation procedure which explain the role of mortality and migration in the difference between Sardinian and Italian sex ratios.

[1] We refer to the proportion $P_{100-110}/P_{60-69}*100{,}000$, where $P_{100-110}$ = cohorts 1891-1900 at 1.1.2001 and P_{60-69}= cohorts 1891-1900 at age 60-69.

Cohort Approach

Observed sex ratio

First we describe the cohorts' profile in terms of sex ratio at different ages. Census and annual data provided by the National Institute of Statistics (ISTAT) allowed us to follow longitudinally these cohorts. In particular, we computed the ratio between females and males at age 59, 69, 79 and 99 for each cohort born between 1891 and 1902. The starting point was age 59 since after this ages the effect of migration on sex ratio appears almost negligible (Capocaccia & Caselli, 1990, Caselli et al. 2003). We found that the difference between Sardinian and Italian sex ratios becomes more and more marked as people age. In particular, the deviation - very small at age 59 and at age 69 - is slightly evident at age 79 and very large at age 99. In light of these research findings, we argue that the mortality evolution after age 80 could explain why in Sardinia the centenarian sex ratio is lower than in Italy.

Life tables from age 80

Given the substantial role played by mortality after age 80, we estimated the Sardinian and Italian life tables by sex from age 80. Afterwards, we computed the sex ratio on the number of person-years lived to obtain an index depending only on the mortality at old ages. The comparison based on these sex ratios showed that in Sardinia the sex ratio is a continuously lower than in Italy. The life expectancy from age 80 indicated, that Sardinian males have a life expectancy higher than Italian males. This result suggested that the sex ratio deviation based on life tables depends especially on the mortality advantage of Sardinian males.

To know why there is a difference at age 99[2] is not enough to consider the mortality rates. We must also take into account the differential mortality and the past migration processes that have reduced the potential amount of people still surviving at age 80.

The role of sex ratio at age 79

Clearly, the same mortality rates produce a different amount of people depending on the number of people being exposed to the event death. It follows that we must also consider the initial sex ratio (i.e. age 79 years old) through the following formula:

$$^{est}SR_{99} = {}^{obs}SR_{79}\,\frac{L_{99}^{F}}{L_{99}^{M}}$$

This formula, which comes from the linkage between population and person-years lived, computes the SR at age 99 ($^{est}SR_{99}$) multiplying the SR observed at age 79[3] ($^{obs}SR_{79}$) by the SR of person-years lived at age 99 ($\frac{L_{99}^{F}}{L_{99}^{M}}$).

Since this sex ratio provides information both on the mortality rates and the initial sex ratio, it is closer to the observed sex ratio and can be used to compare the Sardinian and Italian

[2] We consider age 99 rather than 100+ since after age 99 population data are aggregated and we can't compare our estimates with those provided by ISTAT (National Institute of Statistics in Italy).

[3] The starting point for the sex ratio adjusted is exact age 79 as it is the last age with information on male and female amount by single cohort at January 1st.

sex ratios at age 99. Next section will show a decomposition method based on this estimate of Sardinian and Italian sex ratio.

Developed Methods

Decomposition method

SR at age 79 and mortality after this age both play a key role on the total population at age 99, and a decomposition method based on the estimated SR is proposed to sort out the effects of each. Using the Kitagawa approach (Kitagawa 1955), we developed a formula (see also Caselli et al., 2003) which explains the difference at age 99 using the discrepancy in the SR at age 79 (e.g., the starting point of the mortality analysis) and mortality from age 80 to age 99. The formula is as follows:

$$\Delta = \left(SR_{79}^{S} - SR_{79}^{IT}\right)\left[\frac{\pi_{99}^{S} + \pi_{99}^{IT}}{2}\right] + \left(\pi_{99}^{S} - \pi_{99}^{IT}\right)\left[\frac{SR_{79}^{S} + SR_{79}^{IT}}{2}\right]$$

Where for sake of simplicity, we write:

$$\left(\frac{L_{99}^{F}}{L_{99}^{B}}\right)^{S} = \pi_{99}^{S} \qquad \left(\frac{L_{99}^{F}}{L_{99}^{B}}\right)^{IT} = \pi_{99}^{IT}$$

The first component in the formula provides the difference in the SR between Sardinia and Italy at age 79, weighted by the average of π. This component accounts for the effect of the discrepancy in the SR at age 79. The second component provides the difference in π between Sardinia and Italy, weighted by the average of the initial SR. This component accounts for the discrepancy in the ratio between male and female person-years (L_x) in Sardinia and Italy. In other words, it portrays the effect of the difference in SR depending on mortality from age 80 to age 99.

The results of the decomposition method show that the effect accounted by the mortality is more relevant than the effect accounted by the initial sex ratio.

Our formula has, however, a limit since the effect played by the difference of male and female mortality in Sardinia and Italy has not been included in the model. However, trough the life tables earlier mentioned, we can argue that the difference in male mortality is more relevant than the difference in female mortality. In next paragraph we move to an additional step to shed further light on sex mortality differentials.

Standardising for the Italian mortality

To shed light on the impact of male and female mortality, we standardised the Sardinian male and female mortality for the corresponding Italian mortality by sex. To standardise we used the Italian survivors at age 100, (i.e. l_{100} in the life table).

In particular, when we standardised for female mortality we used the female sex ratio $SR^{F:M}$. In that case, the difference between the standardised Sardinian female ${}^{S}SR^{F:M}$ and the Italian female ${}^{IT}SR^{F:M}$ is explained by the deviation in women's mortality (l_{100}^{F}):

$$ {}^{S}SR_{100}^{F:M} - {}^{IT}SR_{100}^{F:M} = \frac{{}^{S}l_{100}^{F}}{{}^{IT}l_{100}^{M}} - \frac{{}^{IT}l_{100}^{F}}{{}^{IT}l_{100}^{M}} = \frac{{}^{S}l_{100}^{F} - {}^{IT}l_{100}^{F}}{{}^{IT}l_{100}^{M}} $$

When we standardised for male mortality we used the male sex ratio $SR^{M:F}$. In that case, the difference between the standardised Sardinian male ${}^{S}SR^{M:F}$ and the Italian male ${}^{IT}SR^{M:F}$ is explained by the deviation in male mortality (l_{100}^{M}):

$$ {}^{S}SR_{100}^{M:F} - {}^{IT}R_{100}^{M:F} = \frac{{}^{S}l_{100}^{M}}{{}^{IT}l_{100}^{F}} - \frac{{}^{IT}l_{100}^{M}}{{}^{IT}l_{100}^{F}} = \frac{{}^{S}l_{100}^{M} - {}^{IT}l_{100}^{M}}{{}^{IT}l_{100}^{F}} $$

This method indicated that when the female mortality is constant the difference in SR is much bigger that when the male mortality is constant. Based on these research findings, we can suggest that the female SR at age 100 is much lower in Sardinia because of the mortality advantage of Sardinian men from age 80.

REFERENCES

Capocaccia, R. and Caselli, G. (1990). *Popolazione residente per età e sesso nelle province italiane. Anni 1972-1981*. Rome, Dipartimento di Scienze Demografiche.

Caselli, G., Robine, J.M. and Rasulo, D., (2003). Variations régionales du rapport de féminité en Italie, in Jacques Vallin (ed) *Du gendre et de l'Afrique. Omage à Thérèse Locoh*. Paris, INED ((document de travail).

Deiana, L., Ferrucci, L., Pes, G.M., Carru, C., Delitala, G., Ganau, A., Mariotti S., Nieddu, A., Pettinato, S., Putzu, P., Franceschi, C. and Baggio, G. (1999). The Sardinia Study of Extreme Longevity. *Aging*, Vol. 11, n. 3, 142-149.

Kitagawa, E. M. (1955). Components of a Difference between Two Rates, *Journal of the American Statistical Association*, 50 (272): 1168-94

Koenig, R. (2001). Sardinia's mysterious male Methuselah, *Science*, Vol. 291, 2074-2076.

Robine, J.M., Caselli, G. (2005). An unprecedented increase in the number of centenarians. *Genus,* n.1.