

Difference in Sex Ratio at Age 99. Decomposing the Effect of Male and Female Mortality.

Differenza tra il Rapporto di Femminilità a 99 Anni. Decomposizione dell'Effetto della Mortalità Maschile e Femminile.

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Riassunto: Lo studio presenta un metodo di scomposizione sviluppato dagli autori allo scopo di valutare l'effetto della mortalità maschile e femminile sul rapporto dei sessi in età avanzata. La ricerca estende un recente studio in cui la differenza nel rapporto dei sessi a 99 anni tra due popolazioni è stata spiegata attraverso il sex ratio a 60 anni e la successiva mortalità complessiva delle popolazioni esaminate.

Il nuovo metodo è stato verificato utilizzando il rapporto di femminilità a 99 anni delle generazioni 1891-1892 in due regioni del Sud con un basso indice a tale età (Calabria e Sicilia) e due regioni del Nord con un rapporto di femminilità elevato (Lombardia e Veneto). Il metodo ha consentito di valutare l'interazione della mortalità maschile e femminile nel determinare il rapporto dei sessi a 99 anni.

Keywords: decomposition, male and female mortality, centenarians

1. Introduction

Over the last years plenty of studies have focused on the rising proportion of centenarians in low mortality countries by looking at the sex composition of centenarian population. However, so far studies have explained the sex ratio at very old ages by assessing separately the male and female mortality instead of evaluating how they jointly contribute to the ratio. The study aims to fill this gap by decomposing a difference in sex ratio amongst centenarians in the effect of male and female mortality.

Provided that centenarian cohorts are followed from an age when migration dynamics are very modest, the sex ratio at baseline and subsequent mortality allow predicting a sex ratio at later ages close to the real one. This closeness justifies, then, the application of a decomposition method on the estimated measure in order to evaluate the factors accounting for that observed.

We developed and applied a decomposition method which identifies the mortality factors behind the regional variation in female-male ratio at age 99.

For the purpose of this study, we selected two centenarian cohorts (1891-1892) and four regions where respectively the sex ratio of generations 1891-1892 was low (Calabria and Sicily) and high (Veneto and Lombardy).

The baseline of mortality follow-up was age 60, which fitted our research aim as migration turned out little from this age and its effect on the sex composition in later life was negligible.

2. Method and Data

To disentangle the effect of sex differentials in mortality, we further developed a formula proposed in a recent publication (Robine, Caselli, Rasulo, & Corneil, 2006):

$$\delta_{x+n}^{SR} = \delta_x^{SR} \mu_{x+n}^{SR_L} + \delta_{x+n}^{SR_L} \mu_x^{SR} \quad \text{formula 1}$$

This formula takes into account the observed sex ratio at age x and the sex ratio computed on person-years at age $x+n$ (SR_L). In particular, δ_{x+n}^{SR} is the divergence in sex ratio at age $x+n$ between two populations, δ_x^{SR} is the difference in sex ratio at age x , $\mu_{x+n}^{SR_L}$ is the average of person-years ratio at age $x+n$, $\delta_{x+n}^{SR_L}$ is the variation in person-years ratio at age $x+n$, and μ_x^{SR} is the average of sex ratios at age x .

Therefore, the method proposed by Robine et al. (2006) splits a difference in sex ratio at age $x+n$ in two components. The first component represents the effect of sex ratio at baseline and the second component gives the effect of variation in mortality between ages x and $x+n$.

To account for sex differentials in mortality, we further developed the above decomposition method. Through some algebraic steps, the second part of equation in formula 1 was re-written as:

$$\delta_{x+n}^F \mu_{x+n}^M \mu_x^{SR} + \delta_{x+n}^M \mu_{x+n}^F \mu_x^{SR} \quad \text{formula 2}$$

This formula accounts for sex differentials in mortality as the first component provides the contribution of female mortality and the second component gives the effect due to male mortality.

Both formulas apply to a variation in sex ratio between two populations (e.g., regions, Countries). A divergence in sex ratio can be explained through formula 1 if the research purpose consists of looking at the overall mortality effect other than the effect of sex composition at baseline. To identify the role of sex differentials in mortality, formula 2 is required.

We applied both formulas to explain a variation in female-male ratio at age 99 between two Italian regions. We applied formula 1 to obtain the general effect and formula 2 to obtain the single effect by sex.

Based on the accessibility of mortality data, analysis was restricted to generations 1891-1892, whose probabilities of death were available for six regions (Lombardy, Veneto, Tuscany, Lazio, Calabria, Sicily). Amongst these regions we chose those with the highest (Veneto, Lombardy) and lowest (Calabria, Sicily) female ratio at age 99. Then, the decomposition method was applied on each pair of North-South region.

Overall, data were represented by the population figures at baseline (e.g., age 60) of the centenarian cohorts (Golini, Ciucci, & Caselli 1983) and their mortality rates from age 60 onwards.

3. Results

The female-male ratio used in the decomposition method was that predicted according to the sex composition at age 60 and mortality between ages 60 and 99. We underline that analysis was based on regional population rather than sample data. As a result, standard errors around the predicted sex ratios were not required.

Table 1 shows that the sex ratios estimated in each region were close to those recorded (see column 5). This finding justified the application of a decomposition method on the predicted values.

The number of person-years at age 99 (Table 1, last two columns) indicates that men are more disadvantaged in the two northern regions while the female mortality risk is higher in Sicily and Lombardy. More specifically, Calabria reports the highest number of men (292) while Veneto reports the more consistent number of women (483).

Table 1: Sex ratio observed at age 60, sex ratio observed and estimated at age 99, number of male and female person-years at age 99 by region.

Regions	SR60	FR99 (estimated)	SR99 (real)	Difference $SR^{est} - SR^{real}$	Male person- years (age 99)	Female person- years (age 99)
Lombardy	1.18	5.55	5.27	0.28	79	372
Veneto	1.19	5.46	5.66	-0.20	105	483
Calabria	1.51	2.20	2.00	0.20	292	425
Sicily	1.21	2.47	2.31	0.16	145	295

The decomposition was applied on the sex ratio difference listed in Table 2 (last column), which also reports the results of the decomposition based on formula 1. We found that variation in the baseline sex ratio had an opposite effect (i.e. positive sign) on the difference at age 99 in each North-South pair (Table 2). This finding is understandable on the grounds of the magnitude of female-male ratio at baseline, which was higher in Calabria and Sicily. Remarkably, the sex ratio at age 60 results from migration and mortality dynamics occurred until then. Therefore, the small effect due to this component indicates that dynamics below age 60 have a minor role.

Table 2: Difference in sex ratio at age 99. Effects due to sex ratio at age 60 and mortality from age 60 to age 99. Cohorts 1891-1892.

Regions compared	Effect of SR_{60}	Effect of mortality from age 60 to age 99	Difference at age 99
Calabria & Veneto	0.98	-4.24	-3.26
Sicily & Veneto	0.09	-3.08	-2.99
Calabria & Lombardy	1.02	-4.37	-3.35
Sicily & Lombardy	0.12	-3.20	-3.08

The main factor accounting for the divergence at age 99 is the variation in mortality between ages 60 and 99. As Table 2 shows, the female-male ratio of person-years is much lower in Calabria and Sicily.

To know the single role of male and female mortality, the overall mortality was split up through formula 2. Table 3 illustrates that female mortality is the principal factor only in the pair Sicily-Veneto. In this case, the variation in female mortality accounts for 60% of the total mortality discrepancy. The result is attributable to the far higher mortality risk of women in Sicily than Veneto (295 female person-years vs. 483).

Table 3: Decomposition of the total mortality variation in sex differentials (%). Cohorts 1891-1892.

Regions	Effect of male mortality (%)	Effect of female mortality (%)
Calabria & Veneto	88.06	11.94
Sicily & Veneto	39.84	60.16
Calabria & Lombardy	113.27	-13.27
Sicily & Lombardy	71.87	28.13

Otherwise, the lower sex ratio in the two southern regions hinges on variation in male mortality. The effect is stronger in Calabria whose male survival is largely greater than Veneto and Lombardy and even bigger than Sicily. Indeed, the male factor explains 88% of the mortality difference from Veneto and exceeds 100% when disentangling the divergence from Lombardy. The latter result depends on the opposite sign of female and mortality variation and on the slight contribution of women's mortality. Men and women in Calabria are, indeed, 3.70 and 1.14 times the number of men and women in Lombardy (see Table 1).

The mortality decomposition by sex proposed in this paper proves to be a relevant instrument to explain the different magnitude of sex ratio. The case of Sicily is explicative in this sense. Actually, the alike divergence from Veneto (-2.99) and Lombardy (-3.08) results from opposite factors: on the one hand, female life expectancy is lower in Sicily than Veneto; on the other hand, female life expectancy is higher in Sicily than Lombardy.

References

- Golini A., L. Ciucci, G. Caselli (1983). *Ricostruzione della popolazione residente per sesso, età e regione, Anni 1952-1972*, Dipartimento di Scienze Demografiche, Rome, Fonti e Strumenti, n. 1.
- Robine J.M., G. Caselli, D. Rasulo, A. Cournil (2006). Differentials in the femininity ratio among centenarians: Variations between northern and southern Italy from 1870, *Population Studies*, Vol. 60, n. 1, 1-15.