

Geographical differences (by cohort) in longevity and gender gap among Italian semi-supercentenarians

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Summary. Objectives. To analyze the geography of the Italian semi-supercentenarians (people who lived past the age of 105), in order to highlight a relation between demographics and the differences that can be observed in longevity and gender gap. **Methods.** Collection and validation of Istat Semi-SuperCentenarian (SSC) Survey data at regional level for the period 2009-2019. A methodological analysis of the trajectories that led the subjects born in one Region to live or die in another. In our analysis, we apply two indicators: the ratio of the number of semi-supercentenarians to the number in the birth cohort of the same ones by gender and the ratio of the number of semi-supercentenarians to the number of survivors at the age of 60. **Results.** The dynamics of the semi-supercentenarians' 'migratory flows' from the Region of birth to the Region of current residence underlined the Region's capacity to expel or attract them. The most significant quota of semi-supercentenarians is located in the Region where they were born, with a maximum in the North and a minimum in the South; for the gender gap there is a minimum in the Southern and a maximum in the Northern Regions, due to the lower level of male semi-supercentenarian rate. **Discussion.** Our analysis highlighted the role of the lower mortality in the old ages found among Southern men in determining the geographical differences observed. Considering the individual characteristics detected by the SSC Survey and some contextual variables of the place of residence, in the following paper we try to give some explanations by applying statistical models, at both aggregated and individual level.

Key words. Semi-supercentenarian by cohort, geography of longevity, regional differences in gender gap, trajectories of migrations.

Differenze territoriali della longevità, per coorte e genere, dei semi-supercentenari in Italia

Riassunto. Obiettivi. Analizzare la geografia dei semi-supercentenari italiani (persone che hanno raggiunto e superato i 105 anni) per mettere in luce le relazioni tra le caratteristiche demografiche e le differenze regionali che si osservano nella longevità e nelle differenze di genere. **Metodo.** Metodologia per la raccolta e la validazione dei semi-supercentenari dell'indagine Istat (SSC Survey) per il periodo 2009-2019. Proposta metodologica per l'analisi degli spostamenti di ogni individuo dal luogo di nascita al luogo di residenza o di decesso. Nello studio sono stati utilizzati due indicatori distintamente per uomini e donne: il rapporto tra il numero dei semi-super-

centenari e i nati della stessa generazione; il rapporto tra il numero dei semi-supercentenari e il numero dei sopravvissuti della stessa generazione all'età di 60 anni. **Risultati.** Analizzando la dinamica dei 'flussi migratori' tra il luogo di nascita e quello dell'ultima residenza si è evidenziata la capacità di espellere o di attrarre di ogni regione. Il numero più elevato di semi-supercentenari si conta nella regione di nascita, con un massimo nelle regioni del nord e un minimo in quelle del sud, dove gli spostamenti sono stati più intensi. Relativamente alle differenze di genere, sia considerando la regione di nascita che di residenza, il rapporto donne/uomini è basso al sud e più alto al nord in ragione di un più basso tasso di semi-supercentenarietà degli uomini. **Discussione.** L'analisi ha evidenziato l'importanza del ruolo giocato dalla più bassa mortalità degli uomini delle regioni del sud dopo i 60 anni di età nel determinare la geografia delle differenze di genere. Considerando alcune caratteristiche individuali dei semi-supercentenari e alcune variabili del contesto, proprie dei luoghi di residenza, la prossima tappa di questo studio sarà quella di cercare di spiegare le differenze osservate utilizzando modelli statistici in grado di tener conto dei due livelli, individuale e di contesto.

Parole chiave. Semi-supercentenari per coorte, geografia della longevità, differenze di genere per regione, percorsi migratori.

Introduction

Aging and longevity are very topical issues on the current Italian agenda. People have less chance of dying during their young and adult age, meaning that more and more people reach old age and, once the old-age threshold is crossed, death occurs always later.^{1,2} In Italy, according to the 2018 life tables,³ more than 70% (77% women and 63% men) of the population will die after their 80th birthday. It should be noted that, for women, about 51% of the deaths after 80 take place after they have reached 90 years of age (vs only 39% for men). The number of people still alive at age 100 is also increasing over time, so that, according to the life tables for 2018, the proportion of those who reach age 100 and over has doubled in just 17 years (2.5% in 2018 vs 1% in 2000). This phenomenon in the face of death is producing an unprecedented impact on the growth in the number of subjects in the

extreme ages of life. More and more attention is being paid to this population in almost all the developed Countries worldwide and, indeed, increased research activities are being conducted in order to collect data that can better estimate the number of those who have lived to age 100 and over (see www.super-centenarians.org). These data often allow us not only to know the size of this population, but also to analyze the characteristics of their survival after this age, and particularly after age 105.^{1,4-8} For Countries like Italy, where there is a very significant number of centenarians (those still alive on January 1, 2019, are more than 14,000, according to national statistics³), it is almost impossible to apply to all of them the validation procedures suggested by the International Database Project on Longevity (IDL) for the semi- (105-109 years) and supercentenarians (over 110 years old).^{6,8-12}

Following the IDL protocol, the Italian National Institute of Statistics (Istat) has been collecting and validating data about living and dead semi-supercentenarians since 2009, as a first stage of the Semi-SuperCentenarian (SSC) Survey.¹³ On January 1, 2019, ten years after the start of the survey, 5,866 living and dead subjects aged 105 and over (5,151 women and 715 men, 88% and 12%, respectively) were identified and validated for the cohorts born between 1896 and 1913.

The complete information collected provides the trajectory of the last transition of each individual from one municipality to another and/or one province to another, and/or one Region to another, depending on the territorial level of the analysis. Recently, Caselli, Battaglini and Capacci carried out a wide-ranging, as comprehensive as possible analysis of Italian semi-supercentenarian belonging to the cohorts under study, considering the developing characteristics of the phenomenon moving from the first to the last cohort, and examining the gender gap in light of the differential trends of male and female longevity after age 60.^{1,2,14}

The aim of this study is to focus on the geography of the semi-supercentenarians in the SSC Survey, for the whole period of observation 2009-2019, by the 1896-1913 cohorts and at a regional level, in order to identify a relation between demographics and the differences that can be observed in longevity levels and gender gaps.

In particular, two specific aspects will be analyzed. First, we would like to identify the main directions of movement of the semi-supercentenarians by analyzing the trajectories that led the subjects born in one Region to live or die in another, and highlighting the Region's capacity to expel or attract them. Second, the extent of the phenomenon will be examined with reference to two indicators: the ratio of the number of semi-supercentenarians to the number in the cohort of birth, and the ratio of the number of semi-supercentenarians to the number of survivors in each cohort at age 60.¹⁵ In this way, we can examine the geography of the phenomenon

from two different points of view: place of birth and place of residence. The geography of the gender gap will also be described, by using the so-called femininity ratio (FR; number of women to number of men). Geographical and gender differences will also be analyzed, taking into account the differential mortality in old age, referring to the cohort life tables available for a group of Regions.

Data and method

In this study we analyze the Istat SSC Survey data. Taking the data from January 1, 2009, until today, it was possible to establish with certainty if the subjects had reached the age of 105 and over, and – if they had died during the survey – their age at death.

The variables collected for each individual – included in the SSC Survey – are: Name, Date of birth, Date of death, Completed age in YYYYDD (calculated), Place of birth, Place of residence (last), Marital status (last), Citizenship (last), Year of birth, Presence/Absence in the database t, t+1, and all the information about migration from/to another municipality. In this way, every semi-supercentenarian validated is classified according to their place of birth and residence at the time of the survey, and the complete information tells us not only the demographics of each individual, but also the trajectory of their last movements in Italy from one municipality to another, and/or from one province or Region to another.¹

The information in the SSC Survey by age after 105 is completed not only according to the period 2009-2019, but also by cohorts born between 1896 and 1913.

Regional life tables by cohorts

This study also uses the life tables of the cohorts 1900-1901 for Italy, and also for Lombardy, Veneto, Calabria and Sicily, up to the age of 99.¹⁶ After this age and until the complete extinction of the cohorts, the Regional tables were completed using the death figures from other Istat surveys (Causes of death survey), as well as the SSC Survey.¹ The methodology employed was that suggested by Vincent,¹⁷ known as the Vincent's Extinct-Cohort Method. It is well known that, starting from the cohort's last survivor – last death – it is possible to determine the number of people who survived at any age x after 100, by successively combining the deaths observed at prior ages.¹

Indicators

The analysis uses two indicators, calculated by Region and gender. The first, known as SSC_B, is obtained by dividing the number of subjects of the cohorts 1896-1913 aged 105 and over (${}_{Rb}N_{105}$), classified by Region of birth, by that of the births (B) of the same cohorts in

each Region. SSC_B is equal to $R_b N_{105}/B$ per 100,000. The second, known as semi-supercentenarian rate, $SSCR_{60}$, proposed by Caselli,⁷ is obtained by dividing the number of the semi-supercentenarians of the cohorts studied by Region of residence by the number of survivors in the same cohorts at age 60, where $SSCR_{60} = R_r N_{105}/R_r N_{60}$ per 100,000. This last indicator excludes the differential effect of migrations (supposing them to be zero for the generations studied after age 60), but also the direct differential effects of the number of births and of mortality before age 60. Essentially, the $SSCR_{60}$ measures the proportion of 60-year old subjects who survived to age 105 in each Region. Clearly, the two indicators are equally important, as they provide information that allows to bring out the different aspects of the phenomenon and, therefore, to speculate on them.

Results

The dynamics of the 'migratory flows' from the Region of birth to the Region of current residence

The number of semi-supercentenarians by Region (Table 1, columns 1 and 2) is obviously affected by the size of the population of each Region, but we may note that 23% of the 5,866 subjects aged 105+ are living in a different Region from that of their birth (Table 1, col. 4). The figures in the third column allow us to compare the Regions of 'expulsion' (ratios greater than 1) with those of 'attraction' (ratios lower than 1). As we might expect, the Regions of the South (the Southern Regions and the Islands), traditional areas of emigration, are those with values greater than 1; in these Regions the proportion of semi-supercentenarians who have left their place of

Table 1. SSC Survey: Italian cohorts of semi-supercentenarians by Region of birth and by Region of residence. Total number and ratios. Percentage born in a Region but resident in another Region and percentage born and resident in the same Region. Years 2009-2019 at January 1

Regions	Number of SSC by Region of birth (1)	Number of SSC by Region of residence (2)	Ratios (1)/(2) (3)	% born in the Region but resident in another Region (4)	% born and resident in the same Region (5)
North					
Piedmont and Valle d'Aosta	461	527	0.9	17.4	82.6
Lombardy	750	978	0.8	10.5	89.5
Trentino-Alto Adige	103	104	1.0	19.4	80.6
Veneto	577	494	1.2	27.0	73.0
Friuli Venezia Giulia	206	208	1.0	33.0	67.0
Liguria	217	321	0.7	15.7	84.3
Emilia-Romagna	560	545	1.0	17.9	82.1
Center					
Tuscany	452	463	1.0	16.6	83.4
Umbria	113	119	0.9	23.9	76.1
Marche	179	159	1.1	24.6	75.4
Lazio	260	478	0.5	12.3	87.7
South					
Abruzzo and Molise	238	193	1.2	29.0	71.0
Campania	321	271	1.2	23.4	76.6
Puglia	397	344	1.2	19.9	80.1
Basilicata	69	51	1.4	33.3	66.7
Calabria	194	158	1.2	22.7	77.3
Sicily	370	291	1.3	25.9	74.1
Sardinia	183	162	1.1	16.9	83.1
Foreign-born	216	..			
Italy	5,866	5,866	1	19.3	80.7
Born out of the Region of current residence*	..	1,348		23.0	

* Including the foreign-born population.

birth to go and live in another Region is higher than elsewhere (often greater than 25%; Table 1). If we exclude Lazio, the Regions of greater attraction (values less than 1) are clearly those of the North, led by Liguria and the rich Lombardy (Table 1).

The most significant quota of semi-supercenarians in the study, however, is that of those residing in the Region where they were born, with a maximum in Lombardy (almost 90%) and the Center-North of the Country in general, and a minimum in Basilicata (66.7%) and the other Regions of the South (Table 1, column 5).

Figure 1 visualizes the migration flows. The most important items are the locations of origin and destination, the volume of the movement, and the direction of the flows. The origins and destinations of migrants are represented by the circle's segments. Each Region is assigned its own color. The volume of the movement is indicated by the width of the flow. The number of migrants depends on the total volume across all Regions, and is indicated. The direction of the flow is encoded by the origin color. Lombardy, for example, is the largest Region. For each Region, there are two 'rectangles' at the base of the circle's segments: the white one (the larger, looking at the circle's segments) depicts the destination Region of the in-migration flows, and the other colored one (the smaller) depicts the origin Region of the out-migration flows. Observing only the most significant trajectories, it can be noted that the semi-supercenarians of Lombardy and Piedmont come, as we have just mentioned, from all the Regions of the South, but also

from Veneto, a Region of the North-East that went through economic difficulties in the years before World War II and, therefore, was a Region of emigration until the threshold of Italy's economic boom, from the 1960s onwards.^{16,18} The subjects of the SSC Survey born in the South who are now living in the richest Regions of the North almost always left their Region in search of work. Many subjects headed towards Liguria, a Region that for decades was also a destination for wealthy pensioners from some areas of the North, who decided to spend their old age on the Ligurian coast, to enjoy a milder and healthier climate than that of the Regions of the cold, damp Po Valley. The trajectories confirm this. Liguria has seen the arrival of subjects from Piedmont and Lombardy, Regions that attract young adults and from which wealthy pensioners depart. We can see how a significant part of the flows towards Lazio originate, as we have just said, from the Regions of the South (Abruzzo and Molise, Campania and Puglia in particular), and, above all, from those of the Center (Marche and Umbria). Subjects heading for Lazio, and in particular for its capital, Rome, generally arrived in search of better social and health services for their children.¹⁸⁻²¹

One of the many pieces of information on the flows that we can derive from Figure 1 is those entering Sardinia. We may speculate that: those from Lombardy were the children (now semi-supercenarians) of the first migrants in the late nineteenth century,¹⁸ while those from Friuli Venezia Giulia were the Giuliano Dalmati exiles, settled in the new city of Fertilia after the end of the war,²² and that those from Veneto were sent by the fascist government to reclaim the malarial areas of Campidano.²³ Some confirmation is also provided by name checks in the SSC Survey. Furthermore, the children of the migrants of the late nineteenth century could be those identified in the North-South route (arrival in Campania, Puglia and Sicily).

As mentioned, the figures available allow us to check only the movements within the Country, and not at international level. Therefore, we do not know how many subjects left their Region after their birth, probably at young-adult age, for foreign Countries, nor how many returned at a later age. Obviously – although it is well known that for the cohorts under study the international migratory flows penalized above all the Southern Regions, and particularly Sicily and Campania^{24,25} – we cannot estimate how many semi-supercenarians in each Region have died or are still alive abroad.

Geography of semi-supercenarian rates by Region of birth and residence

We may wonder what is the best reference base to assess the importance of the quota of semi-supercenarians observed in the various Regions, net of the population

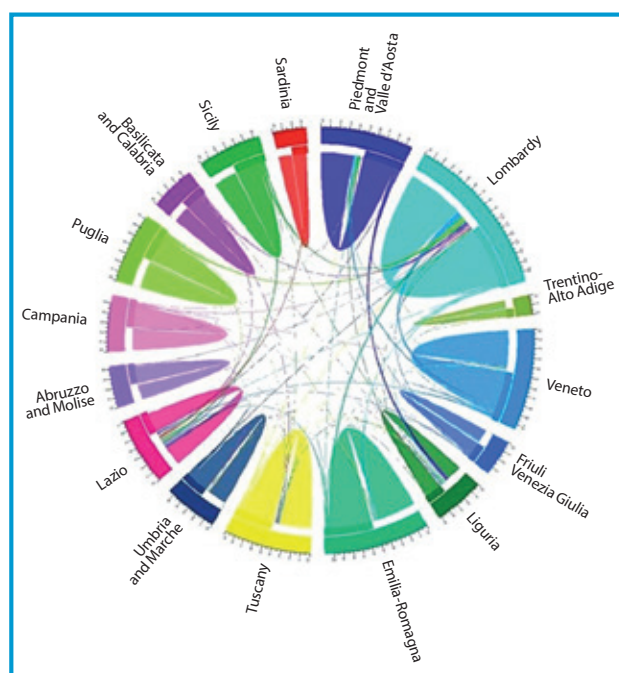


Figure 1. The migration flows between Regions, created using the circlize R package.²⁶ Cohorts 1896-1913. Ticks indicate the volume of migration in SSC-Istat Semi-Supercenarian Survey.

size. The number of semi-supercentenarians in the SSC Survey depends, firstly, on the number of those born 105 years before, but, as stated, internal and international migration has had a significant influence in modifying the number of potential semi-supercentenarians, both in the Regions of emigration and in those of immigration. For those born in each cohort,²⁷ the SSC_B indicator is now the one most frequently used at international level.^{7,28} In the absence of a migratory movement, this indicator is preferred in the studies that seek to stress the role played on longevity by bio-genetic factors and/or those that typify the area of origin. Clearly, the SSC_B is not the most suitable indicator to analyze the Italian situation and, above all, that of its Regions. In effect, the $SSCR_{60}$ is more appropriate for our analysis, particularly if we consider that Italian migrations for the cohorts considered in the study were essentially related to working activities and that a return to the area of origin was irrelevant after the age of 60, since for these generations the retirement age was on average less than 60.²⁹ In addition, the $SSCR_{60}$ is certainly more appropriate if we also want to stress the role played on longevity – negatively and/or positively – by risk factors typical of the Region of residence, where the semi-supercentenarians who arrived at young-adult age worked and lived for many years. It may be that better social, economic, hygienic and health conditions helped determine their extreme longevity. But, alternatively, it may also be that a more stressful and dangerous working life reduced their vital potential.^{30,31}

Figure 2 (whose figures are shown in Table 2) illustrates the geography with two indicators: on the left the SSC_B , and on the right the $SSCR_{60}$.

Figure 2 (left), which depicts the semi-supercentenarians in the cohorts 1896-1913 in relation to the births in those cohorts, shows that the four Regions with the highest levels are, in order, Liguria, Lazio, Sardinia and Emilia-Romagna. In these Regions of super-longevity, out of every 100,000 births in the cohorts 1896-1913 about 40 reached age 105 (Table 2). For the semi-supercentenarians and the centenarians alike, Sardinia is at the same level as the Regions of the North, despite being a Region of emigration.³² Among Regions with intermediate levels, where on average there are 30 semi-supercentenarians per 100,000 births, are those of the North (Piedmont and Valle d'Aosta, Lombardy and Veneto) together with the Regions of the Center (Tuscany, Umbria and Marche), and two from the South (Puglia and Abruzzo-Molise). Unfortunately, it was not possible to calculate the SSC_B for Friuli Venezia Giulia and Trentino-Alto Adige, as these two Regions belonged to Austria-Hungary in the years when the semi-supercentenarians were born, and Italy has no information on the number of births per cohort there.

From Campania to Sicily, all the Southern Regions of the Tyrrhenian coast are those with the lowest values. Only 18-23 per 100,000 births reached age 105, but, of these, the two Regions most penalized are Campania and Sicily (Table 2). They are also, as we mentioned, the two Regions that paid the highest price in term of international migration. But does their lower number of semi-supercentenarians depend only on this?

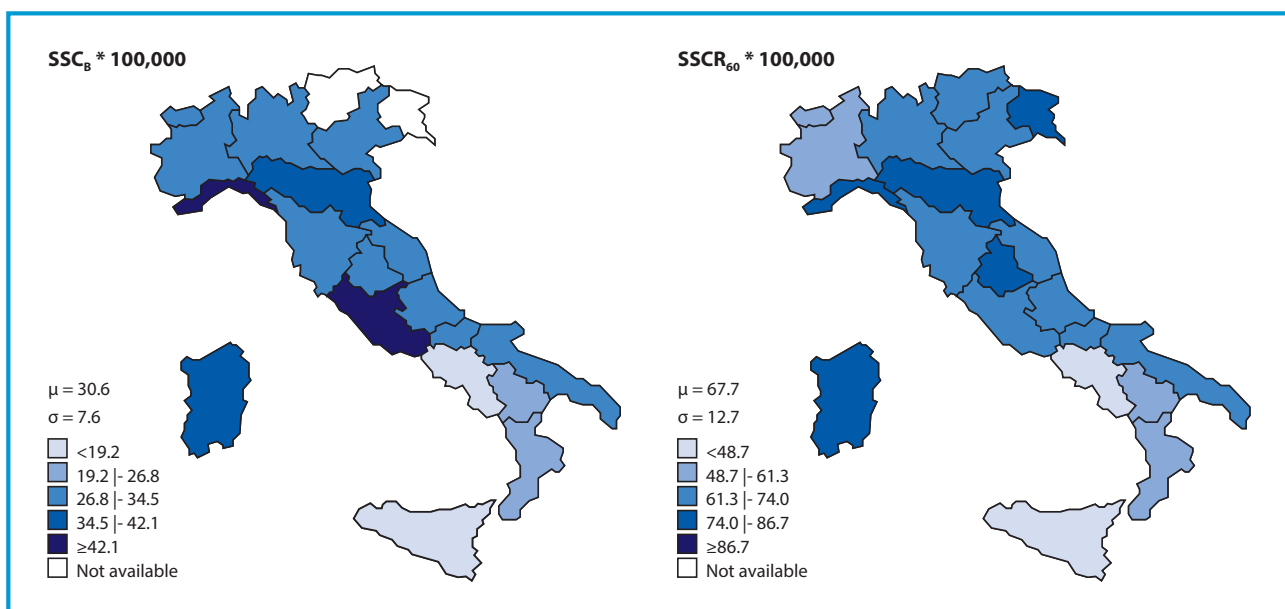
One answer may emerge immediately if we take note (Table 2) of the semi-supercentenarian rates calculated for men alone. The highest value is given to two Regions of emigration, with Sardinia ranking first (14.7 per 100,000) and Calabria fifth (9.2 per 100,000), while the men of Lombardy, notably a Region of immigration, bring up the rear (3.5 per 100,000). Sardinia and Calabria, as several researchers have observed^{15,33,34} while analyzing the centenarian population, also have the record of male longevity for semi-supercentenarians. For women, this record is held by Liguria, followed by Lazio and Emilia-Romagna. Women in the South come last, with those of Campania, Sicily, Calabria and Basilicata, in this order. If men in the Regions of the South emigrated (either elsewhere in Italy or abroad) more than those from the Regions of the North, why are the levels of male SSC_B higher in the former than in the latter?

In response to the two previous questions, we may observe the values of the second $SSCR_{60}$ indicator (Figure 2-right and Table 2), which are calculated net of the effect of migrations (internal and international). This indicator provides an overall geography of the phenomenon for semi-supercentenarians that is only partly different from that illustrated by the SSC_B , while leaving substantially unchanged the ranking for the top and bottom Regions already seen in Figure 2 (left). The three leading Regions, those with the highest levels (Liguria, Emilia-Romagna and Sardinia), are joined by the two excluded from the other indicator (Friuli Venezia Giulia and Trentino-Alto Adige), giving us a different picture of the North-East of the Country, particularly if we bear in mind that Veneto now closely follows the other two Regions. The Regions of super-longevity now also include Umbria, while Lazio is closer to the rest of Central Italy. Once again, Southern Regions have the lowest values, and Sicily confirms to be the most penalized Region. Once again, the indicator that excludes the role of migrations has higher values for the men of Sardinia and Calabria, together with those of Basilicata. Among women, there is a sort of North-Center gradient, that also includes Sardinia, against a more penalized South. Calabria remains advantaged for men and penalized for women. In light of these results, we can already claim that the territorial differences observed in Figure 2 (right) for semi-supercentenarians overall do not seem to depend on differential migrations.³⁵

Table 2. SSC Survey: geographical differences of semi-supercentenarian rates by gender, by Region of birth (SSC_B ratios) and by Region of residence ($SSCR_{60}$ rates) (values per 100,000), and femininity ratio (FR_B and FR_R). Cohorts 1896-1913

Regions	Ratios $SSC_B * 100,000$ and FR_B				Rates $SSCR_{60} * 100,000$ and FR_R			
	Men	Women	Total	FR_B	Men	Women	Total	FR_R
North								
Piedmont and Valle d'Aosta	6.1	54.0	29.5	8.4	13.9	100.5	59.9	8.2
Lombardy	3.5	56.3	29.2	15.3	10.6	117.7	68.2	13.0
Trentino-Alto Adige*	-	-	-	7.6	18.1	122.7	73.7	7.7
Veneto	5.8	52.4	28.4	8.5	16.0	123.6	73.5	8.9
Friuli Venezia Giulia*	-	-	-	9.3	17.0	133.7	80.6	9.4
Liguria	8.1	79.5	43.0	9.3	19.9	135.7	82.1	7.9
Emilia-Romagna	10.2	69.9	39.2	6.5	21.3	124.1	75.0	6.4
Center								
Tuscany	7.2	62.3	34.0	8.2	15.8	114.4	67.8	8.1
Umbria	7.1	57.6	31.6	7.7	21.7	143.7	84.2	6.9
Marche	6.5	54.4	29.7	8.0	16.6	107.9	65.1	7.4
Lazio	12.7	76.2	42.6	5.3	18.4	121.9	72.5	7.2
South								
Abruzzo and Molise	10.2	49.0	29.1	4.5	27.3	112.2	72.5	4.7
Campania	5.5	30.9	17.9	5.3	14.5	62.9	40.4	5.0
Puglia	8.4	54.7	31.0	6.2	23.1	115.2	71.3	5.5
Basilicata	7.8	39.1	23.1	4.8	24.2	82.8	54.4	3.6
Calabria	9.2	38.3	23.4	4.0	23.8	83.2	55.9	4.1
Sicily	5.8	30.9	18.0	5.1	13.5	64.6	40.0	5.2
Sardinia	14.7	68.7	40.8	4.4	32.5	126.9	80.7	4.1
Italy	-	-	-	-	17.0	108.5	65.5	7.2

*These Regions did not belong to Italy in the years of birth of the cohorts 1896-1913. For this reason, we do not know the birth data for SSC_B .

**Figure 2.** SSC Survey: geographical differences of semi-supercentenarian rates by Region of birth (SSC_B) on the left and by Region of residence at age 60 ($SSCR_{60}$) on the right. Cohorts 1896-1913.

Geography of the gender gap and the role of territorial mortality differences in old ages

Clearly, the results presented so far anticipate the geography of the FR. Whether we consider the semi-supercentenarians by Region of birth or Region of residence, the lowest values (on average 4-5 female semi-supercentenarian for every male) are to be found in the Regions of the South, and the highest (up to 11-14) in those of the North (Figure 3, whose figures are shown in Table 2). Calabria and Basilicata are the Regions with the lowest FR values, while Lombardy dominates among those with the highest. The geography of the gender gap among semi-supercentenarians follows exactly that proposed in the studies of centenarians carried out using the non-validated figures of the official statistics.^{15,34,36} Sardinia is an exception, since – despite being one of the Regions with the highest semi-supercentenarian rates – it is also the one with the lowest values of FR.

It may be interesting to provide a picture of how the FR among the population of the cohorts under study developed from birth up to the extreme ages of life. Table 3, which refers to four Regions as well as to Italy as a whole, shows that the values of FR are practically equal at birth and, as expected, at age 80 too, if we exclude Sicily. It is between the age of 60 and 80 that the Regions differentiate, reaching maximum values in the extreme ages of life (SSCs). So, the FR differential starts from the ages in which distances are determined almost exclusively by the differential evolution of mortality between men and women.³⁷

To confirm the role played by the differential characteristics of mortality in old age on the regional differences observed in the FRs (FR_B and FR_R), we can refer to the curves of the FR_{Lx} in four Regions of Italy, obtained as a relation between the stationary female and male populations of the mortality tables (F_{Lx}/M_{Lx}) of the cohorts 1900-1901 after age 60 (Figure 4).

The highest FR_{Lx} are obtained when the levels of male and female mortality differentiate the most, and this happens in all Regions (except for Sicily in extreme ages) as age increases, reaching maximum values at extreme ages, as observed in the real populations. This time, however, the evolution of the FRs depends only on the differential evolution of mortality by age of the two genders. The greatest distances between men and women are found in the Regions of the North (Lombardy and Veneto), where the FR_{Lx} are highest, as opposed to the lowest in the Regions of the South (Calabria and Sicily). Clearly, we do not know if the differential trends observed depends on the developing characteristics of male or female mortality, and/or of both. For this reason, we can examine the characteristics of the survival curves of the two genders, placing the life tables root at age 60, but starting, for men, from values that take into account the fact that more of them have been eliminated up to this age (radix in the life tables at age 60 for men equal to: Italy 89,217; Lombardy 88,546; Veneto 86,327; Calabria 85,815; Sicily 91,815. Radix equal to 100,000 for women. See Figure 5). As suggested by Robine et al.,¹⁵ we see in Figure 5 the trajectories of male and female survival up to age 105. The comparison shows at once that, for example,

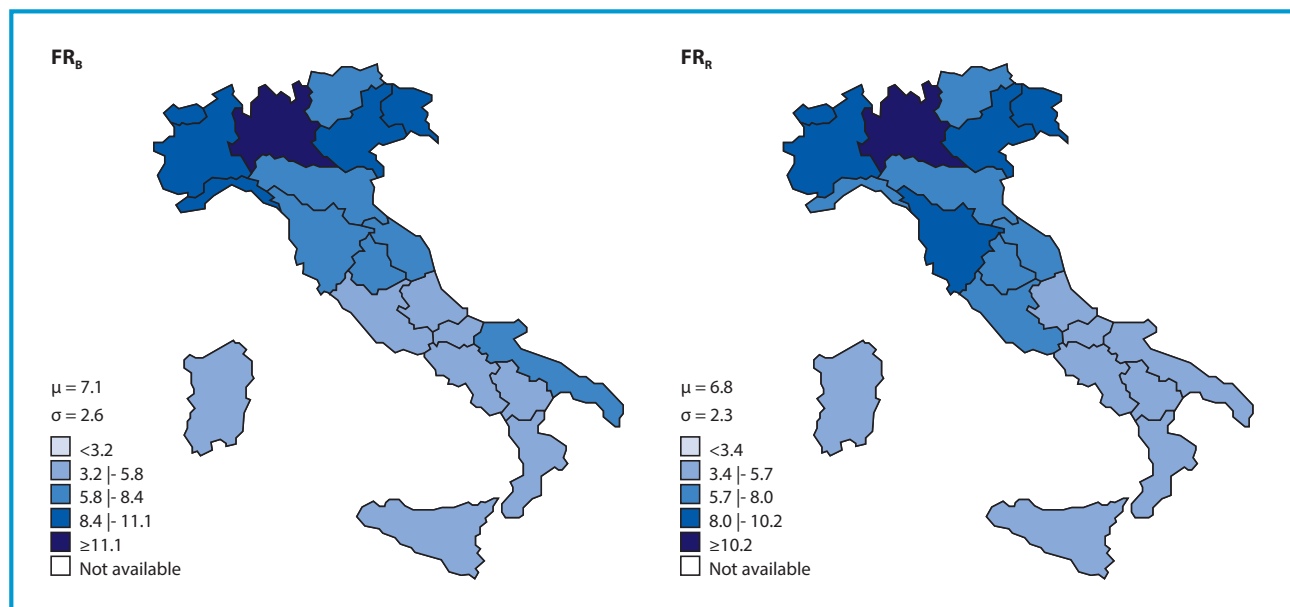


Figure 3. SSC Survey: geographical differences of femininity ratio by Region of birth (FR_B) on the left and by Region of residence (FR_R) on the right. Cohorts 1896-1913.

Table 3. Number of births and size of the population still surviving at different ages for men and women, semi-supercentenarians of the SSC Survey, and femininity ratio (FR_x) for the cohorts of 1896-1913, Italy and four Regions. Births and population until age 80 years (thousands)

Population	Italy			Lombardy			Veneto			Calabria			Sicily		
	M	W	W/M	M	W	W/M	M	W	W/M	M	W	W/M	M	W	W/M
Total number of births	100,994	95,495	0.95	14,005	13,242	0.95	11,103	10,482	0.94	4,527.5	4,297.4	0.95	11,212	10,590	0.94
Total number of 60+	42,059	47,455	1.13	6,614	7,717	1.17	3,123	3,593	1.15	1,302	1,526	1.17	3,491	3,777	1.08
Total number of 80+	14,814	25,468	1.72	1,895	3,998	2.11	1,021	2,011	1.97	513	7,787	1.52	1,327	1,822	1.37
SSC semi-supercentenarians	715	5,151	7.20	70	908	12.97	50	444	8.88	31	127	4.10	47	244	5.19

the survival of men in Calabria is considered higher at all ages, which means that their mortality is lower than that of men from Lombardy and Veneto; whereas, for the women, the result is fairly similar wherever they live in the Country, with a lower survival for Sicilian women (focus of Figure 5). This result suggests that the geographical inversion observed in the FR_x of semi-supercentenarians compared with the rates of semi-supercentenarians should be considered above all in relation to the lower mortality of men at old ages in the South, while the role played by the characteristics of female mortality seems to be marginal. For Sicily, the inversion of the trend of the curve of the FR_{Lx} observed after age 90 (Figure 4) is due to the combination of a lower mortality for men with a higher mortality for women after the age of 80, and especially after 90.

Conclusion and discussion

To summarize, we may say that $SSCR_{60}$ is certainly the most significant indicator: in fact, if we exclude the effect of migrations, it helps to clarify two very important aspects of the phenomenon. First, considering all the semi-supercentenarians while leaving gender aside, the Southern Regions, with the exception of Sardinia, Abruzzo-Molise and Puglia, have the lowest values. This means that the South's disadvantage does not depend on the migrations towards the richer Regions of the Country, nor on international migrations. Second, these disadvantaged Regions follow different paths with regard to men. In this case, Calabria and Basilicata, along with Sardinia, rank first for both indicators. Men in these Regions, as we have mentioned, have the highest level of semi-supercentenarian rate.

When we analyze the $SSCR_{60}$ values – and in particular the FR values – by gender and from a demographic point of view, we know that men in the South

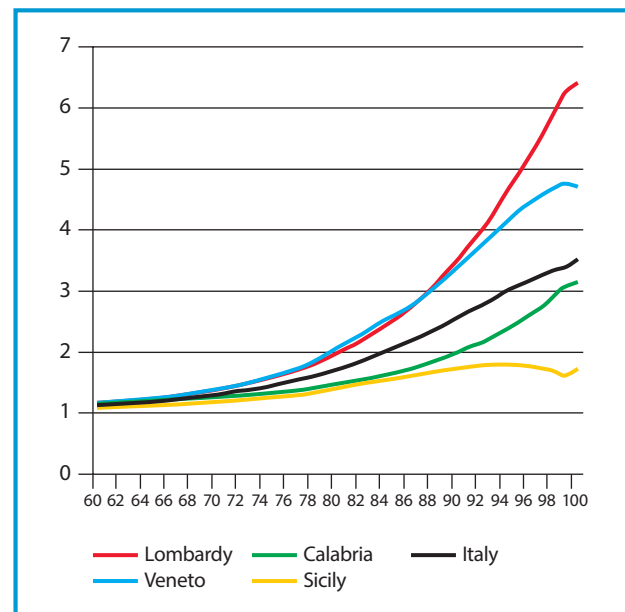


Figure 4. Geographical differences in femininity ratio from age 60 to 100 in the stationary population (FR_{Lx}) of the cohort life tables 1900-1901. Italy and 4 Regions.

have benefited from a mortality level lower than elsewhere after age 60, and particularly after age 80.

The $SSCR_{60}$ values also exclude the direct effect of differential mortality before age 60, but do not take into account that – as happens in old age – it is also the result of one's life history, and therefore of the mortality experienced in previous ages. In other words, the territorial (and gender) differences that are observable in survival levels after age 60 could be related to the levels of mortality experienced during infancy, youth and adult age. To better understand the role played by mortality on the territorial differences in longevity, we therefore need to consider the role played by selection or debilitation factors on the elderly survival for the population differently affected by mortality at previous

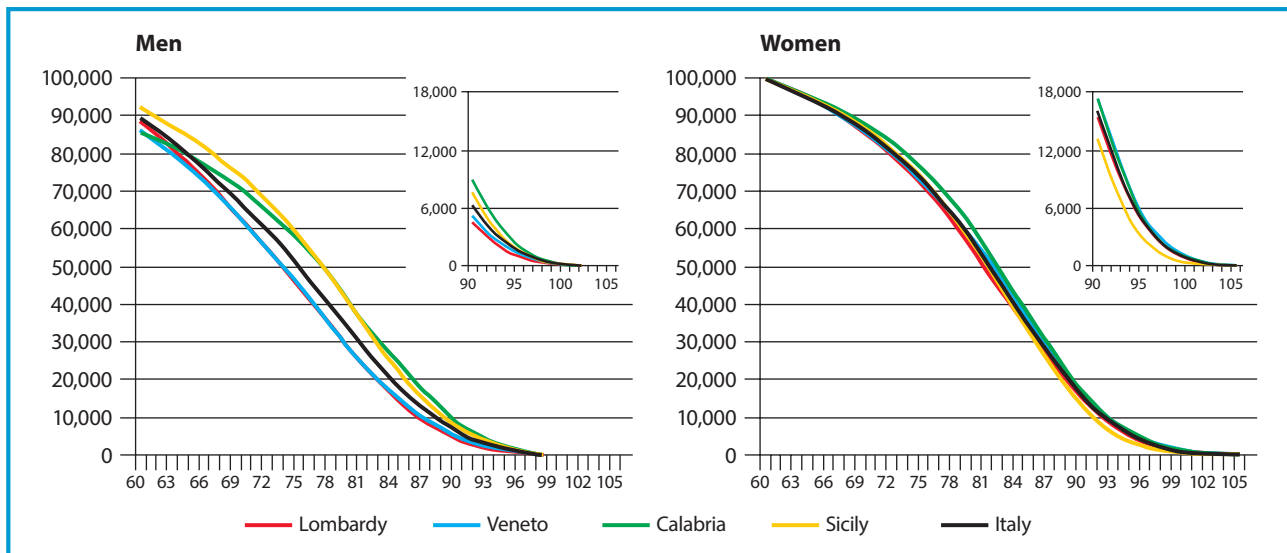


Figure 5. Survival curves for men and women from age 60 to age 105 for the cohorts 1900-1901 for two kind of life tables (radix = 100,000 for women and radix = FR at age 60 for men).

ages. So, we need to bear in mind the role of the different heterogeneity of the populations after age 60.

At regional level, we know that infant mortality in our cohorts of semi-supercentenarians was higher in the South, reaching maximum values in Calabria and Sicily, but with high levels in Lombardy too.³⁸ Livi Bacci demonstrated that there was a positive correlation between the high levels of infant mortality and the lower levels of old age for the cohorts of 1871 and 1891 in sixteen Italian Regions, indicating the importance of the effects of selection. By contrast, he found no effect on old-age mortality in the Regions with low levels of infant mortality. In a more recent study, Barbi and Caselli,³⁹ using the frailty model of Vaupel and his colleagues,⁴⁰ analyzed the effects of selection on the regional differences in survival levels in Italy for two cohorts (1891 and 1892) and four Regions (Lombardy, Tuscany, Calabria and Sicily). The study shows that the effects of the selection due to infant and youth mortality seemed to disappear after age 80. When they applied a frailty model that also took the role of adult mortality into account – higher than elsewhere for men in the richer areas of the Country – they found that selection is predominant only at young-old ages, between ages 50 and 60, depending on the Region, only for men (p. 56). For women from the same cohorts, the differences in mortality between Regions after age 60 were not relevant and, consequently, no significant differences in the models of selection for the various Regions emerged. Since 88% of the semi-supercentenarians in the SSC Survey are women, in light of the results of the work of Barbi and Caselli, we can say that neither the different selection experienced in early age nor that in later ages should have affected the regional differences observed in the semi-supercentenarian rates.

As regards the regional differences observed in the levels of FRs at 105, in particular between those from the North and the South, we noted that these should be related to the higher male mortality in old age for the former compared to the lower rate for the latter. This male super-mortality in the North is presumably due to the harmful effects of risk factors acquired during working life. The super-mortality of male adults in the North compared with those in the South has been described in many studies, which showed the importance of the role of cancers – particularly of the lung – and ischemic diseases;^{30,41} causes of death linked to environmental factors and life styles that, despite the role played by selection,³⁹ could manifest their negative debilitating effects in older ages too, keeping mortality higher than elsewhere throughout life, as is shown in Figure 5 for Lombardy and Veneto. For women, however, cerebrovascular and diabetic super-mortality – which is registered in adult and old ages in the South, particularly in Sicily – is compensated by a super-mortality from cancer and ischemic diseases in the North, explaining why total female mortality varies very little from one Region to another.⁴²

The figures analyzed suggest that the explanation of the particularly low FR in some Regions of the South is very complex. Passarino and his colleagues³⁴ mention the male genetic component to explain the result of a relatively higher number of male centenarians in Calabria and, therefore, a lower value of FRs at these ages. A similar interpretation would also explain the relatively higher numbers of men among the centenarians in Sardinia⁴³⁻⁴⁵ and in Sicily.⁴⁶ Here, we should recall that the transmission of genes is not the only component acting on longevity. As well as genes, families also transmit behaviors and life styles.⁴⁷⁻⁴⁹ In addition, the territo-

rial factors – where one works and lives – continue to act positively or negatively at every age of life, including the oldest ones. Living in an area where there is an excellent healthcare system, which is very important in old age, and a “good quality” of life, and where families care for their elderly, may also prolong the survival of semi-supercentenarians by several months.

In a further analysis, building on our knowledge of some individual characteristics of semi-supercentenarians in the SSC Survey (gender, month and year of birth, whether or not the subject has migrated, etc.) and of some contextual characteristics of the place of residence (eg., socio-economic, health and demographic variables), we shall try to give some explanation of the geographical differences in SSCR₆₀ and FR by applying some statistical models, at both aggregated and individual level.

Key messages

- Semi-SuperCentenarian by Region of residence at age 60 (SSCR₆₀) is certainly the most significant indicator, since – if we exclude the effect of migrations – it helps to clarify two very important aspects of the phenomenon. First, considering all the semi-supercentenarians while leaving gender aside, the Southern Regions have the lowest values, with the exception of Sardinia, Abruzzo-Molise and Puglia. This means that the South's disadvantage does not depend on the migrations towards the richer Regions of the Country, nor on international migrations. Second, these disadvantaged Regions follow different paths as regards men.
- Since 88% of the semi-supercentenarians in the SSC Survey are women, also in light of the results of the previous work of Barbi and Caselli, we can state that neither the different selection experienced in early age nor that in later ages should have affected the regional differences observed in the semi-supercentenarian rates.
- As regards the regional differences observed at the gender gap level (femininity ratios-FR at 105), in particular between subjects from the North and from the South, we observed that these should be related to the higher male mortality in old age among the former compared to the lower rate among the latter. This male supermortality in the North is presumably due to the harmful effects of risk factors acquired during the working life.
- The explanation for the particularly low FR in some Regions of the South is very complex. Passarino and his colleagues mention the male genetic component to explain the relatively higher number of male centenarians in Calabria and, therefore, the lower value of FRs at these ages. A similar interpretation would also explain the relatively higher number of men among the centenarians in Sardinia. Here, we should recall that gene transmission is not the only component acting on longevity. The territorial factors – the place where one works and lives – continue to act positively or negatively at every age of life, including the oldest old.

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