ANNALI DEL DIPARTIMENTO DI METODI
E MODELLI PER L'ECONOMIA
IL TERRITORIO E LA FINANZA

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WHO ARE THE OLDEST OLD IN ITALY? EVIDENCE FROM THE ITALIAN SEMI-SUPER AND SUPERCENTENARIANS SURVEY

Abstract: In a country, like Italy, where longevity is one of the most important demographic aspects, it's crucial to study the population at extreme ages in order to understand the amount and the characteristics of individuals who live so longer. The study of the oldest-old individuals requests necessarily a validated data source not affected by over-coverage or under-coverage. In order to have a yearly corrected population register the Italian National Institute of Statistics (ISTAT) has developed the SSC survey with the aim of collecting data about alive and deceased semi-super and supercentenarians, and knowing how many of them are really verified. Due to record linkage operations with other ISTAT surveys and to the quality of the data collection, the SSC's database is not implemented in any other country. It has been (and will be) an important data source to analyse longevity of population in order to contribute to study about lifespan and the human survival and to understand whether the extreme-age mortality plateaus in humans exist or not.

1. Introduction

Italy, among many other high income countries, has been facing a progressive ageing process with important consequences on the economic and social system of the country. Population of 65 years and over is 22.6% of total population at January 1st, 2018, while, at the same date, population of 80 and more is 7.0% of total population. About forty years ago (January 1st, 1980) the same percentages were respectively 13.1% and 2.1%.

In addition, the Italian population is characterized by a large proportion of people reaching ages at the limits of survival, centenarians, and the so-called semi-supercentenarians, people aged 105 years or more, and supercentenarians, people aged 110 years or more. The number of semi-super and supercentenarians has increased dramatically over the past decade and now Italy ranks first for longevity of the population worldwide. As we know, the increase of old population is due to the secular decline in mortality in young and adult ages, that allowed (and allows) people to reach the age threshold of 80 years. So, in the last decade mortality decline has produced a high percentage, about 8%, of people aged 80 years to reach the threshold of 100 years old, without considering migrations.

It is, also, well known that due to biological, social, and environmental factors, women are more likely to cross the threshold of 105 years, 90% of semi-supercentenarians in Italy are women (Caselli, 2016). However, due to recent increase in male survival, a steady decline in the femininity ratio (FR) – the number of women per man (Robine et al., 2006) – has produced, from 9.0 at January 1st 2009 to 7.0 at January 1st 2018. Men have understood that they have to follow women behaviour to live longer, in order to reduce drastically their risks of death, particularly in adult ages by cancer of the respiratory system (Caselli, 2006).

Then, the study of the oldest-old individuals requests necessarily a validated data source not affected by over-coverage or under-coverage. Population data of 105 years or over, has been traditionally affected by over-coverage and figures were adjusted only at the time of the population Census. In order to have a yearly corrected population register the Italian National Institute of Statistics (ISTAT) has developed a survey with the aim of knowing how semi-super and supercentenarians are really verified. Purpose of this paper is to provide a "picture" of the centenarians in Italy (how many they are, where they live) and to show the methodology of data collection and validation process of Italian survey.

2. Data description

Until 2009 a group of Italian researchers from the Italian National Institute of Statistics (ISTAT) and from the Department of Statistical Sciences of Sapienza University in Rome have been involved in collecting data on semi-super and supercentenarians, in order to populate, moreover, the IDL[1] database, since it was born (Doblhammer et al., 2005; Caselli et al., 2018a, 2018b). Only age-validated individuals are included in the database. The database allows to test theories of aging and mortality at extreme ages. Until 2008 the only source of information for the IDL database has been based on the Causes of Death survey realized by ISTAT, hence only deceased people were included.

In 2009 ISTAT started a new survey "Rilevazione della popolazione Supercentenaria" (hereafter SSC survey) in order to collect data about alive and deceased semi-super and supercentenarians (Battaglini and Capacci, 2011; Battaglini et al., 2012; Caselli et al., 2018a, 2018b; Caselli et al., 2019).

The SSC survey enables the identification of the population above age 105 cleaned from those individuals who cannot be "validated". The initial data source for the validation process is the "Resident Population by Age, Sex, and Marital Status" (POSAS survey). This is a survey carried out by ISTAT on the resident population in any of the Italian municipalities (about 8,000), broken down by gender, cohort, and marital status on January 1st of each year. When the information collected by municipalities is received by ISTAT each municipality, where a person aged 105 or more is present, has contacted in order to collect additional information.

The reply of municipalities can be one of the following:

1) the semi-supercentenarian individual is alive on Jan 1st of the survey year; ISTAT collects from the population register of that municipality a living existence certificate with the following information name, surname, place and date of birth, citizenship, marital status.

2) The semi-supercentenarian individual is included into the population register but there is no confirmation of an actual presence in the municipality at the last known address. ISTAT sends a request to the municipality for the cancellation of the semi-supercentenarian from the population register and hence the semi-supercentenarian individual is not included in the SSC's database;

3) the semi-supercentenarian individual died after Jan 1st of the survey year; ISTAT collects the death certificate.

The semi-supercentenarian birth certificates are collected in order to confirm (or not) the age. Certificates are carbon copies of originals, when possible, and collected from the Civil status register where the event takes place (Figure 1).

Additional questions are sent to the municipality to gather more information on the individuals of the SSC:

1. Do you know this man/woman?
2. When did you see him/her last time?
3. Has he/she contacted the administration for the last one/two years?
4. What kind of contact (change of residence, identity card, election certificate, payment of municipal taxes etc.) he/she had with the administration?

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1 The IDL (International Data base of Longevity) database is complemented by an international list of supercentenarians collected on the internet by Louis Epstein with the help of Robert Young (http://www.grg.org).

This strategy is supported by the fact that in Italy more than half of the municipalities have less than 2,500 residents, hence direct knowledge of the semi-supercentenarians is very common in such small communities (Battaglini et al., 2011).

For those people still alive at age 105 a yearly based follow-up is done until death, which is then included in the database (date of death). As long as the individual remains alive, the validation process never stops and each single year ISTAT proceeds to "re-validate" backward the data observed in the past. Therefore, the data quality check for the SSC's database is performed retrospectively day by day.

Figure 1: Some original birth and death certificates of semi-supercentenarians, and a baptismal certificate of a foreign citizen supercentenarian resident in Italy

Source: Population registers

To date the cohorts included in the database are those between 1896 and 1913. As the survey started in 2009, in the database are not included individuals born between 1896 to 1902 aged 105 and more that are dead before survey starting. Therefore, the cohorts starting from 1903 are complete and the previous cohorts are composed only of people aged 105 years and more alive at January 1st, 2009. Thus, as the survey is referred to January 1st of each year, the age of individuals can be calculated as difference between the survey's year and the birth's cohort of each individual (Figure 2).

Figure 3 provides the summary of the information needed for the validation of semi-supercentenarian individual. Summarizing, the variables needed for the validation and included in the Italian SSC survey

are: name, date of birth, date of death, completed age in YY-DD (calculated variable), place of birth, place of residence (at death), marital status (at death), citizenship (at death), and presence/absence in the database t, t+1, Note (Caselli et al., 2018a, 2018b).

In addition, the data collected from the SSC survey is periodically subjected to record linkage operations with other ISTAT surveys, such as the Causes of Death Survey and the Deaths of Resident Population Survey, improving data quality. In 2011 the SSC's database has been linked with Census data (Census referring at October 9th). Due to record linkage operations and to the quality of the data collection, the SSC's database, to the best of our knowledge, is not implemented in any other country.

Figure 2: Lexis diagram: checked and not checked semi-supercentenarians by cohorts and years of survey
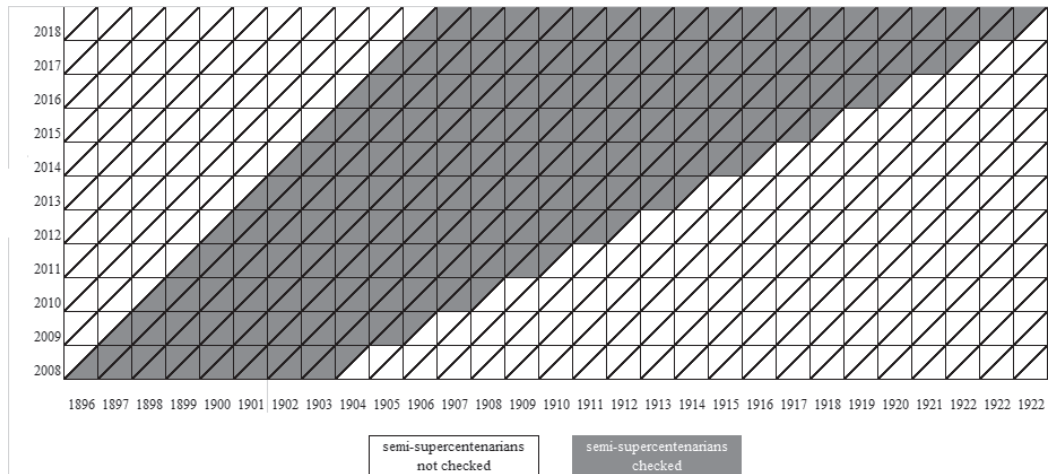
Source: ISTAT

Figure 3: A picture of SSC's database, as an example

Name	Surname	date of birth	date of death	age		place of birth	place of residence	marital status	sex	citizenship	Pres09	...	Pres18
				yaers	days								
*****	*****	05/07/1912		106	151	Caltavuturo (PA)	Alpignano (TO)	widowed	female	Italian	0	...	1
*****	*****	30/10/1909	21/04/2016	106	174	Minervino Murge (BA)	Alpignano (TO)	widowed	female	Italian	0		7
*****	*****	13/09/1903	23/03/2009	105	191	Croazia	Balangero (TO)	widowed	female	Italian	1	...	7
*****	*****	17/11/1911	16/02/2018	106	91	Guardiagrele (CH)	Beinasco (TO)	widowed	female	Italian	0		1
*****	*****	17/12/1907	17/02/2015	107	62	Verduno (CN)	Beinasco (TO)	widowed	female	Italian	0	...	7
*****	*****	01/10/1912		106	63	Borgone Susa (TO)	Borgone Susa (TO)	never married	female	Italian	0		1
*****	*****	01/03/1910	12/07/2015	105	133	Bosconero (TO)	Bosconero (TO)	widowed	female	Italian	0	...	7
*****	*****	21/08/1912	03/03/2017	104	194	Cartura (PD)	Brandizzo (TO)	widowed	male	Italian	0		7
*****	*****	15/05/1909	05/06/2014	105	21	Argentina	Bricherasio (TO)	widowed	female	Italian	0	...	7
*****	*****	12/01/1910		108	325	Argentina	Buriasco (TO)	widowed	female	Italian	0		1
*****	*****	25/06/1906	11/09/2012	106	78	Nespolo (RI)	Bussoleno (TO)	widowed	female	Italian	0	...	7
*****	*****	24/02/1905	26/12/2011	106	305	Carmagnola (TO)	Carmagnola (TO)	widowed	female	Italian	0		7
*****	*****	10/09/1911	11/02/2017	105	154	Carmagnola (TO)	Carmagnola (TO)	widowed	female	Italian	0	...	7
*****	*****	13/08/1905	14/01/2011	105	154	Argentina	Carmagnola (TO)	widowed	female	Italian	0		7
*****	*****	23/07/1905	29/01/2012	106	190	Cercenasco (TO)	Carmagnola (TO)	widowed	female	Italian	0	...	7
*****	*****	06/07/1913		105	150	Avigliana	Carmagnola	widowed	female	Italian	0		1
*****	*****	12/11/1912		106	21	Casalborgone (TO)	Casalborgone (TO)	widowed	female	Italian	0	...	1
*****	*****	14/05/1904	06/04/2010	105	327	Murazzano (CN)	Casalborgone (TO)	widowed	female	Italian	0		7
*****	*****	11/11/1904	05/11/2011	106	359	Cavagnolo (TO)	Cavagnolo (TO)	widowed	female	Italian	0	...	7
*****	*****	03/02/1905	25/02/2010	105	22	Loreggia (PD)	Chieri (TO)	widowed	female	Italian	0		7
*****	*****	24/09/1900	27/01/2009	108	125	Chieri (TO)	Chieri (TO)	widowed	female	Italian	1	...	7
*****	*****	21/10/1903	26/12/2009	106	66	Villanova d'Asti (AT)	Chieri (TO)	widowed	female	Italian	1		7
*****	*****	10/04/1905	25/06/2016	111	76	Caraglio (CN)	Chieri (TO)	widowed	female	Italian	0	...	7
*****	*****	01/06/1909	30/10/2014	105	151	Racconigi (CN)	Chieri (TO)	widowed	female	Italian	0		7
*****	*****	30/06/1910	21/10/2015	105	113	Torino (TO)	Chieri (TO)	married	male	Italian	0		7
*****	*****	26/11/1912	28/12/2017	105	32	Mede (PV)	Chivasso (TO)	widowed	female	Italian	0		7
*****	*****	08/01/1911	10/01/2017	106	2	Chivasso (TO)	Chivasso (TO)	never married	female	Italian	0	...	7
*****	*****	01/03/1910	20/03/2016	106	19	Rimini (RN)	Chivasso (TO)	widowed	female	Italian	0		7
*****	*****	03/06/1904	04/07/2011	107	31	Viù (TO)	Ciriè (TO)	widowed	female	Italian	0	...	7
*****	*****	08/05/1907	01/08/2012	105	85	Novara (NO)	Corio (TO)	widowed	female	Italian	0		7
*****	*****	29/01/1907	28/05/2012	105	120	Cumiana (TO)	Cumiana (TO)	widowed	female	Italian	0	...	7
*****	*****	18/09/1911	27/10/2016	105	39	Cuorgnè (TO)	Cuorgnè (TO)	widowed	female	Italian	0		7

3. Main results of SSC survey in Italy, and discussion

3.1. Number of semi-supercentenarians by gender and region at January 1st, 2018

On January 1st 2018, 5,171 semi-supercentenarians were successfully included in the SSC survey, 629 men and 4,542 women; 1,088 people were alive on the same date, while 4,083 were dead. From January 1st 2009 (beginning of the survey) the number of semi-supercentenarians has increased by 130%, from 472 to 1,088 to January 1st 2018.

Of the 114 people who have exceeded 110 years of age, only 9% of them were men. The dataset included a 117 years and 137 days old woman, Emma Morano, who has been the oldest individual in the world for about one year, until death (Table 1).

Table 1: Distribution of semi-supercentenarians dead and alive at January 1st 2018, by age and gender (absolute and percentage values)

| Age	Absolute values			% values		
	Men	Women	Total	Men	Women	Total
105	347	2.244	2.591	55,2	49,4	50,1
106	149	1.106	1.255	23,7	24,3	24,3
107	68	683	751	10,8	15,1	14,5
108	38	258	296	6,0	5,7	5,7
109	17	147	164	2,7	3,2	3,2
110	6	60	66	1,0	1,3	1,3
111	4	25	29	0,6	0,6	0,6
112	0	9	9	0,0	0,2	0,2
113	0	5	5	0,0	0,1	0,1
114	0	2	2	0,0	0,0	0,0
115	0	2	2	0,0	0,0	0,0
116	0	0	0	0,0	0,0	0,0
117	0	1	1	0,0	0,0	0,0
Total	**629**	**4.542**	**5.171**	**100,0**	**100,0**	**100,0**

Source: ISTAT

In SSC survey, the 85.8% of women are widows while 12.7% are unmarried and only 1.3% married. Similarly, 78.5% of men are widowers, while 14.5% are married; so that, women - who live longer than men - live mainly alone as centenarians, while men have the higher probability to live in a couple.

At a geographical level, semi-supercentenarians are principally located in the North of Italy.

The largest gender imbalance (femininity ratio) is observed in the Northern regions, while in the Southern regions the femininity ratio for this age group is lower than the 7.2 women per man observed at national level (Figure 4).

Over time the population who has reached 105 years are more than doubled by increasing the 148.6% between January 1st 2009 (220 SSC of 1903 cohort) and January 1st 2018 (547 semi-supercentenarians of 1912 cohort) (Table 2). For all cohorts the increase between 2009 (472 semi-supercentenarians) and 2018 (1,088 semi-supercentenarians) is over 100%. Similarly, an annual increase in the population aged 110 years or more has been observed from 10 individuals (January 1st 2009) to 19 (January 1st 2018).

Figure 4: Percentage values of semi-supercentenarians (left axis) and femininity ratio (right axis) by region at January 1st, 2018
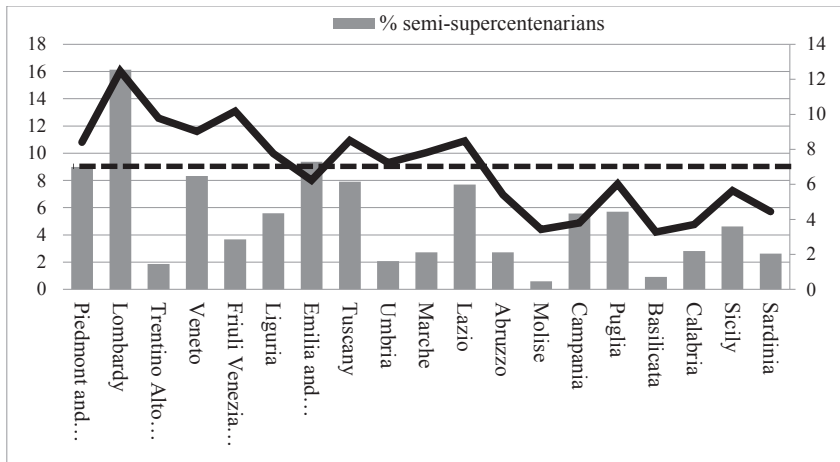
3.2. Some results by cohort like the month of birth and month of death

By January 1st 2018 all cohorts from 1896 to 1901 and the 1904 cohort were extinct; at the same date the oldest individual is a female born in Sardinia but living in Tuscany, dead at the end of 2018.

The analysis of the distribution of individuals by month of birth (MOB) is another point of interest (Doblhammer, 2004). We considered, for 1903-1912 cohorts, the subset of the semi-supercentenarians deaths in order to study the distribution of semi-supercentenarians by MOB and average days life span.

In Figure 5 the distribution of 1903-1912 cohorts by MOB and the ratio between SSC and total born of the same cohorts are showed; the ratio has been calculated using the SSC population for all cohort by MOB and the born of the same cohorts by month. In this way, the results can be compared removing the fluctuation's effect of born by month. Data source of born by month of population is obtained from yearbooks published in the considered years of cohorts (Ministero Agricoltura, Industria e Commercio, 1903-1912 years).

MOB has been associated with life expectancy of people born during the autumn and winter season having a higher probability to reach 105 years of age (Doblhammer 1999, 2002; Doblhammer and Vaupel, 2001; Vaiserman et al., 2002; Vaiserman and Voitenko, 2003; Lerchl, 2004). MOB seems, also, to have effects to the health status: it has used extensively in epidemiological research, particularly in the field of schizophrenia and other diseases of mental system; evidence for a month-of birth pattern has also been found for e.g. various types of cancer, diseases of the circulatory system, of the respiratory system (Doblhammer et al., 2005).

More than 38 per 100,000 people born in January exceeded 104 years of age and about 37 per 100,000 people were born in February, September, October, and November; while about 33 per 100,000 people born in spring and summer (especially June) exceeded that age.

In relation to the average life span of days lived by month, individuals born during the spring season live longer than those born in the other seasons. June is the month with the lowest number of semi-supercentenarians but also the month with the highest life span.

Table 2: Distribution of semi-supercentenarians alive by cohorts and years of survey

Cohorts	Semi-supercentenarians alive at January 1st									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1912										547
1911									478	265
1910								492	277	153
1909							453	249	123	64
1908						399	222	117	61	40
1907					339	179	97	46	26	10
1906				313	167	95	48	19	9	6
1905			284	149	84	41	24	11	5	1
1904		270	146	74	31	18	8	4	0	0
1903	220	114	59	24	12	4	3	2	1	1
1902	153	78	39	23	6	4	3	2	2	1
1901	53	25	16	8	3	1	0	0	0	0
1900	23	14	9	2	1	0	0	0	0	0
1899	13	9	6	2	2	1	1	1	1	0
1898	5	2	1	1	0	0	0	0	0	0
1897	1	0	0	0	0	0	0	0	0	0
1896	4	1	1	0	0	0	0	0	0	0
Totale	**472**	**513**	**561**	**596**	**645**	**742**	**859**	**943**	**983**	**1.088**

Source: ISTAT

Figure 5: Ratio between semi-supercentenarians and total born of the same cohorts (per 100,000, left axis) and semi-supercentenarians of 1903-1912 cohorts by month of birth (absolute values, right axis)
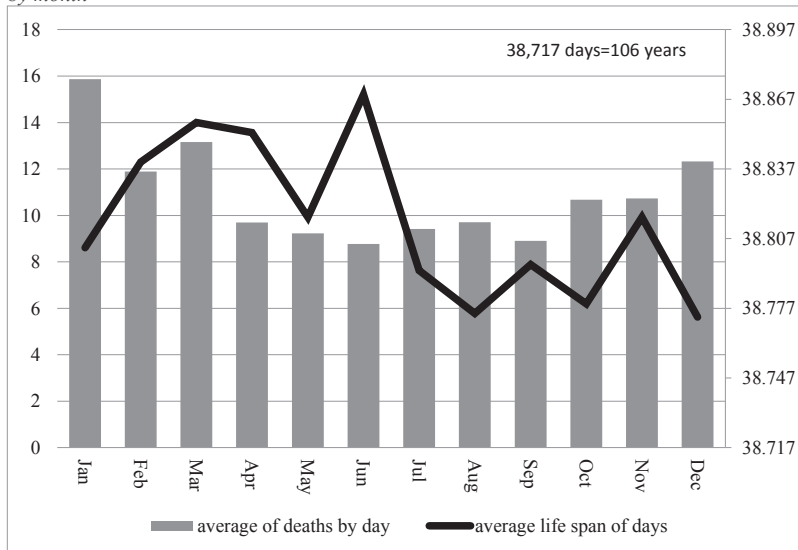

Source: ISTAT

10
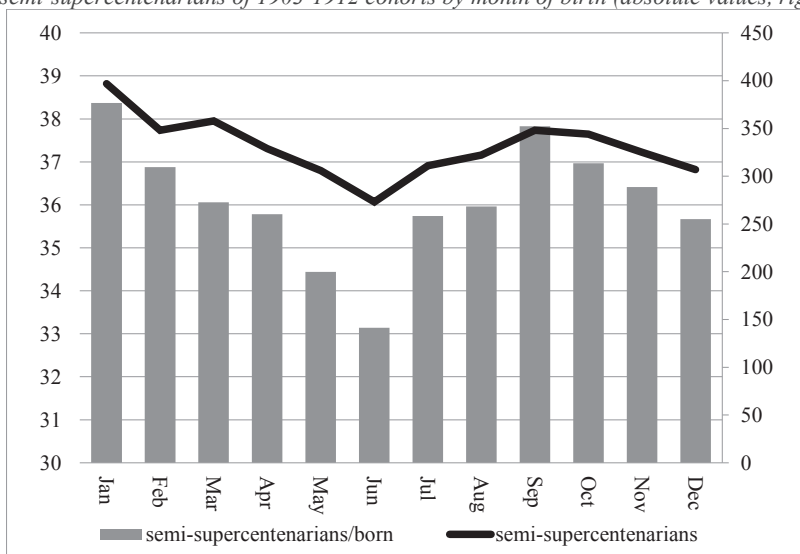
Analyzing the data by month of death, the risk of death is lowest in summer and highest in winter, where there is the highest number of semi-supercentenarians dead (Figure 6). The differences between the summer and the winter peak are considerable and they depend on the time period, age, climate, and social conditions (Doblhammer, 2004). The Eurowinter Group in their study of winter mortality in Europe found that the mortality increased with each fall in mean daily temperature below 18°C (The Eurowinter Group, 1997).

Interesting to note that trends in the distribution of deaths by month of semi-supercentenarians are similar to that of people aged 90 years and over (about 950,000 individuals), for the years 2011-2017 (data source: ISTAT, Deaths of Resident Population survey; we used the years starting from 2011 because the survey we consider has been started in 2011); the correlation index (R^2) between month of death of SSC individuals and month of death of people aged 90 years and over is strongly significant ($R^2 = 0.9$).

Figure 6: Average of deaths by days (left axis) and average life span by days of semi-supercentenarian individuals (right axis) by month

Source: ISTAT

4. Conclusions

Since the first SSC survey (2009), ISTAT's main goals were: to correct data of Population Registers for people aged 105 years and over, which have always been, in the past, subjected to an overcoverage; to improve the linkage between SSC survey and all ISTAT surveys in order to improve the quality of all ISTAT databases; to better define the closure of life tables thanks to more precise data at very advanced ages (Caselli et al., 2017); the decision to participate to IDL project considering, above all, the importance of the ageing's phenomenon in Italy, especially regarding very aged people.

In a country, like Italy, where longevity is one of the most important demographic aspects, it's crucial to study the population at extreme ages in order to understand the amount and the characteristics of individuals who live so longer. Starting from a study done some years ago about the demographic characteristics of Sardinian centenarians (Lipsi et al., 2015), it is necessary to know the characteristics of

all resident people in Italy (not only in Sardinia) who reach the threshold of longevity in order to offer to policy makers data of a national level, not only of a region.

The importance of this effort is that in none country there is such a complete and validated database that contains data of alive and dead individuals aged 105 years and over. The majority of countries observes semi-supercentenarian individuals from surveys on dead people, Italy is the only country that observes this aged population alive and dead. Furthermore, the validation procedure is extremely rigorous and individuals are included in the database only if there is the certainty that they are semi-supercentenarians. In the ISTAT database it could be a problem of under-coverage but not of over-coverage!

Last, but not least, ISTAT database has been (and will be) an important data source to analyse longevity of population in order to contribute to study about lifespan and the human survival and to understand if the extreme-age mortality plateaus in humans exist or not (Barbi et al., 2018).

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