Mapping Extreme Longevity Areas in Italy

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Introduction

Human longevity could be investigated by studying the centenarian population in order to offer the opportunity to investigate which factors contribute the most to successful aging in populations (Deiana et al., 1999). In this paper, we will study the longevity phenomenon in Italy by mapping cohort longevity indexes at the municipality level. We will use data based on distributions by sex and age. These indicators will be preliminary spatially smoothed by using a Bayesian approach in order to reduce random noise due to small numbers. We aim to assess systematically the existence of other extreme longevity areas outside the Sardinian borders.

Why studying the Italian case?

The recent demographic phenomenon of longevity is worth studying especially for those countries in which it had a strong impact, such as Italy. Among countries with the highest survivorship, such as Japan, France, Spain and Sweden, the "Bel Paese" ranks second in terms of old-age index, after Japan. Focusing on the highest proportion of people aged over 65, Italy comes first with a percentage of 34.8, compared to European countries (Eurostat 2017).

This prolongation of human survival is linked to several factors such as universal access to health care services, an efficient national health care system and dietary habits (the well-known Mediterranean diet). During the last decade, in fact, the total number of Italian centenarians passed from 11.000 to 14.000, while those aged 105 and over registered a percent variation of 136%, classifying Italy the longest-running country of Europe (Istat 2019). Their distribution on the national territory is concentrated mostly in the North, with Liguria and Friuli-Venezia Giulia regions which display the highest ratios between semi-supercentenarians (people who reach 105 years) and the total amount of resident population: 3.3 and 3.0 per 100.000 inhabitants respectively. In absolute terms, 338 semi-supercentenarians are in the North-West, 225 in the North-East, 207 in the Centre, 230 in the South and 112 in the islands (Istat, 2019).

The Sardinian 'Blue Zone'

Previous studies showed the existence of extreme longevity areas in Sardinia. This area is the so-called 'Blue Zone', where longevity is concentrated in the central-eastern part of the island and covers all the mountainous areas of central Sardinia. Considering this area, the proportion of male centenarians in the last two decades of the 19th century is more than 15 per 10.000 newborns, one of the highest values in Europe. Therefore, this sub-region of Sardinia seems to be characterized by an exceptional survival limited to males (Pes et al., 2011). Another relevant feature is the very high

proportion of males among the centenarians found in the ‘Blue Zone’. So it seems that either the environmental characteristics or the genetic factors, or both, exert their favorable effect more strongly in men than in women (Poulain et al. 2004).

Do other 'Blue Zones' exist in Italy?

In this paper, we systematically explore the centenarians' distributions in Italy as we aim to assess the existence of other possible 'Blue Zone' outside the Sardinian borders. We explore the entire national territory by means of descriptive indicators such as Longevity and Centenarity Indices and Femininity Ratio at 100 years calculated at the municipality level.

Data

We use data on the population distribution by sex and age at the municipality level from the National Institute of Statistics (Istat). More specifically, we collect data from population registers and intercensal population estimates (demo.istat.it) from 1982 to 2019.

The longevity indicators

A number of period indicator to measure the longevity phenomenon as been proposed (e.g. Caselli and Rasulo 2005; Magnolfi et al. 2007).

The Period Longevity Index, also known as High Longevity Index, is defined as the ratio between the number of centenarians and the total population. It is mainly used for comparing the incidence of centenarians on the total amount of population. Other authors (Magnolfi et al., 2007) suggest to compute this index as the ratio between the population above 90 years to those above 65. This index, however, depends on the population structure and it could be influenced by past fertility and migration flows. The Cohort Longevity Index represents a more realistic measure compared to the previous one, since it accounts for the number of living centenarians under the hypothesis of absence of migration flows. It follows people aged from 65 to 75 belonging to a certain cohort c (e.g. in our case the cohort of newborns from 1925 to 1935 that were aged from 65 to 75 in 1989) who reach ages 95-105 in a given calendar year t (in our case the year 2019). Consequently, it should be computed as the population between age 95-105 in 2019 divided by the amount between age 65-75 in 1989 (per 100).

A Bayesian Framework

We calculate the longevity indexes at the lowest possible geographical level, the municipalities. Due to the rareness of such events in small areas, spatio-temporal modelling is used to tackle the random variations in the occurrence of long-lived individuals. This approach allow us to exploit the spatial proximity to smooth the observed data. As a result, clusters of areas characterised by extreme indexes of longevity can be identified and the temporal evolution of the phenomenon depicted (Roli, Samoggia, Miglio and Rettaroli 2012).

A recent solution adopted to deal with these problems consists in the use of spatial and spatio-temporal models which involve geographical and time interactions resulting in a smoothing effect among the observations. Proper smoothing techniques need to be used in order to limit potential biases due to sample variability (Congdon et al., 2001; Congdon, 2010). Adopting a popular approach to spatiotemporal disease mapping (Kim and Lim, 2010; Knorr-Held, 2000), we estimate a Bayesian smoothing model exploiting spatial association of municipal longevity index and temporal correlation. The model allows reciprocal borrowing strength for area-level data, with the least reliable rates (based on the smallest centenarians counts) being mostly smoothed. Model fitting is performed via Integrated Nested Laplace Approximations (INLA). The application of this approach is also common for the analysis of the geographical distribution of health data (Cocchi, Greco and Scalone 2015).

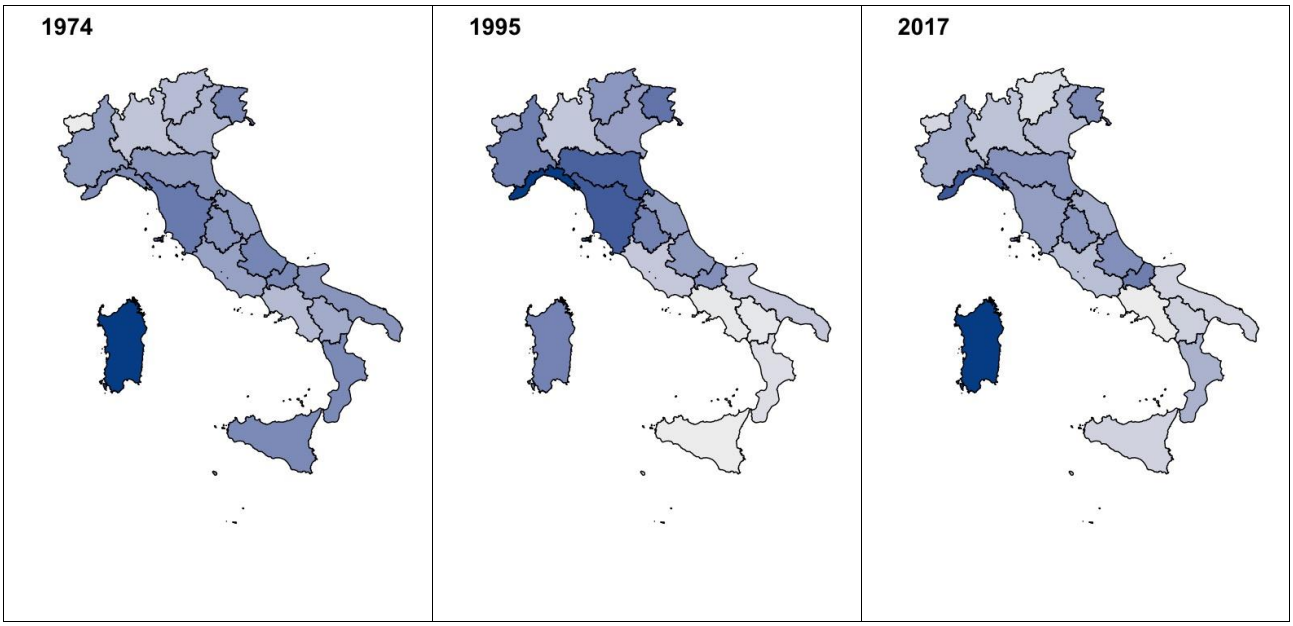
Preliminary Descriptive Results (based on regional data)

In this (very) preliminary results, the comparison is restricted to the Italian regions at 1974 and 2017. Figures 1 shows the Period Longevity Index's values for all Italian Regions. A chromatic scale colour has been assigned to each value, to get an overview of indicator's value in decreasing order. At the beginning (1974), Sardinia was the unique region with the highest proportion of centenarians on the total population; at the middle of the time interval (1995), Northern and Central Regions, especially Liguria, Emilia-Romagna and Tuscany, showed an increase in the number of people aged 100 and over, while at the end (2017) the situation was similar to the original one, with Sardinia and Liguria as the regions with the elderly population. Southern regions rank as the area with the lowest indicator's values for all the periods examined.

Indicators illustrated so far are referred to specific time points, giving us a measure affected by population's structure and migration flows. To correctly evaluate longevity's progress, it is better to rely on Cohort Longevity Index (expressed as percentage), an indicator free of distortions due to historical events affecting the examined population over time. Figure 2 reports the distribution of the Cohort Longevity Index by regions. These results show how the largest concentration of centenarians lies in Lazio (2.10), Emilia-Romagna (2.09), Umbria (2.09), Sardinia (2.08), Molise (2.07), The Marches (2.04), Abruzzo (2.03) and Veneto (2.02). In contrast with the Period Longevity Index, which highlighted Liguria and Sardinia as the regions with the oldest populations, this current measure denotes a different scenario, with Lazio, Emilia-Romagna and Umbria as the regions with the most favorable conditions to reach longevity, overcoming Sardinia.

These geographical trends are worth to be further investigated at a smaller geographical details by using municipal data and proper spatial smoothing techniques.

Figure 1 – *Period Longevity Index by regions in Italy, 1974, 1995, 2017*



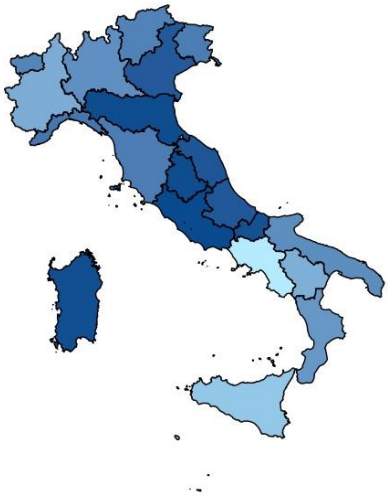


Figure 2 – *Cohort Longevity Index by regions in Italy, 2017*

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Poulain M., Pes G. M., Grasland C., Carru C., Ferrucci L., Baggio G., Franceschi C., Deiana L., *Identification of a geographic area characterized by extreme longevity in the Sardinia Island*. In Experimental Gerontology, Elsevier, 2004, 39

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