Where would you rather live?
Blue and Green Zones of Longevity in Italy

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Background

Italy, with its regional peculiarities, offers perhaps the best opportunity to investigate different conditions of high survival and longevity. It is among the countries with the highest longevity in the world, with a life expectancy at birth that in 2024 exceeded 85 years for women and 81 years for men, but it still presents quite large variability through the country. Italy also boasts the presence in Sardinia of one of the 5 geographical areas of the planet, the so-called Blue Zones, characterized by a surprisingly high concentration of centenarians (Poulain et. al. 2002, 2013, 2023). As the number of centenarians is exponentially growing throughout the country (Istat, 2024), other potential Blue zones might be identified in Italy. Over the last twenty years, the original Blue Zone in Sardinia too has expanded somewhat towards the South and North.

However, a high concentration of centenarians does not necessarily imply a higher life expectancy. In fact on one hand mortality is postponed thanks to progressive improvements in population survival at increasingly older ages, on the other the most long-lived individuals reach more and more extreme ages. The first process corresponds to the rectangularization of the survival curve, the second one to its extension. Of course longevity pertains both the two processes but while the rectangularization of the survival curve implies great gains in life expectancy, its extension implies much less significant gains.

This study aims at identifying areas of longevity in Italy according to the two meanings of longevity, i.e. areas with high concentration of long-lived individuals, the Blue zones, and areas with high life expectancy at birth, that we named Green zones. By distinguishing between these two forms of longevity, this research seeks to shed light on the different factors that drive each condition.

Data and Method

The analysis presented here focuses on mortality and population data at municipality level in Italy for the period 2021-2024 (Istat). We computed life expectancy at birth, at age 65 and at age 80 for each municipalities based on death rates calculated by pooling deaths and exposures across the 4-year time interval.

There are about 8000 municipalities in Italy. More than 45% have fewer than 2,000 inhabitants and about 70% fewer than 5,000. This high degree of demographic fragmentation makes it difficult to estimate life expectancy at the municipal level, as the annual number of deaths is often very low or even zero (Alexander, Zagheni and Barbieri 2017). To overcome this limitation, we developed a spatial clustering algorithm designed to ensure statistical stability while preserving local geographic structure.

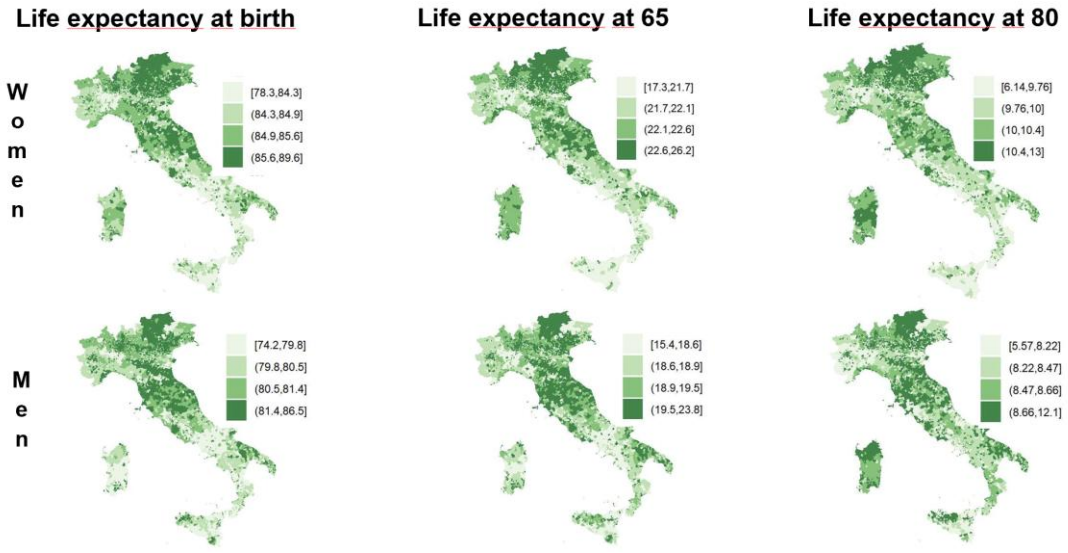
The method assumes that neighboring municipalities share similar mortality patterns. In a first step, municipalities are iteratively aggregated with adjacent areas until the total number of deaths within each group reaches a predefined minimum threshold (e.g., 1,000 deaths). Larger municipalities exceeding this threshold remain as individual clusters, while smaller ones are merged based on geographic contiguity until the criterion is met. A second refinement step then adjusts residual inconsistencies: clusters that remain below the threshold, or municipalities enclosed between sufficiently large clusters, are reassigned to the neighboring cluster with the smallest total number of deaths. Because the algorithm includes a stochastic component—introduced through the random ordering of municipalities—the clustering is repeated n times. For each municipality, life expectancy is then computed as the average across the n iterations. We found that n=10 repetitions are sufficient to ensure robust and stable estimates.

We also calculated the centenarian rate and a longitudinal centenarian index—defined as the current centenarian population relative to the octogenarian population 20 years prior—to control for migration across Italian municipalities from 2021 to 2024. The geographical distribution of the centenarians concentration has been then compared with that of the internal areas according to the definition of the government agency for territorial cohesion (SNAI, 2021-2027), that is those areas characterized by a significant distance from the main urban centers offering services, particularly those relating to education, mobility and social and health services.

Preliminary Results

Maps of life expectancy at birth show that the municipalities included in the Sardinian Blue zone do not experience the highest life expectancy at birth observed in Italy. This is true for women and particularly for men who in fact experience the lowest values of the country. Only when considering life expectancy at older ages then the presence of a high concentration of centenarians implies, as expected, high levels of life expectancy both for women and men (Fig.1).

Figure 1. Green zones of longevity in Italy



The spatial distribution of the centenarian rate closely aligns with the geographical map of internal areas as defined by SNAI (Fig. 2). These areas are predominantly mountainous and hilly, characterized

by lower life expectancy and less accessible or efficient healthcare services compared to the national average. Except for life expectancy at age 80, all estimated differences between inner and non-inner areas are statistically significant. These findings confirm that while inner areas exhibit lower overall life expectancy, they paradoxically display significantly higher rates of centenarians (Fig. 3). However, these disadvantaged municipalities have experienced severe long-term depopulation. Consequently, the longitudinal centenarian index, which accounts for migration, reveals a different unbiased pattern; yet, it still highlights higher concentrations of centenarians in specific disadvantaged inner areas, particularly in the Southern Apennines (Fig 4). We can therefore conclude that while not all inner areas show higher centenarian concentrations, these are almost systematically found within those inner areas characterized by lower overall life expectancy.

This suggests that other factors, different than the efficiency of the health services offered, must play a role in determining individual longevity in these apparently such disadvantaged areas. Virtuous life styles, balanced diet, physical activity integrated into daily life, strong family bonds., good family tradition, and an inclusive and cohesive community protect individuals of specific inner areas, perhaps those genetically predisposed, favoring thus an high concentration of centenarians. On the other hand, with few exceptions, the non-inner municipalities are instead those with the best health facilities, more easily accessible, where the health care is timeliness and health prevention is supported, favoring thus higher level of life expectancy at birth.

Figure 2. Centenarian Rate

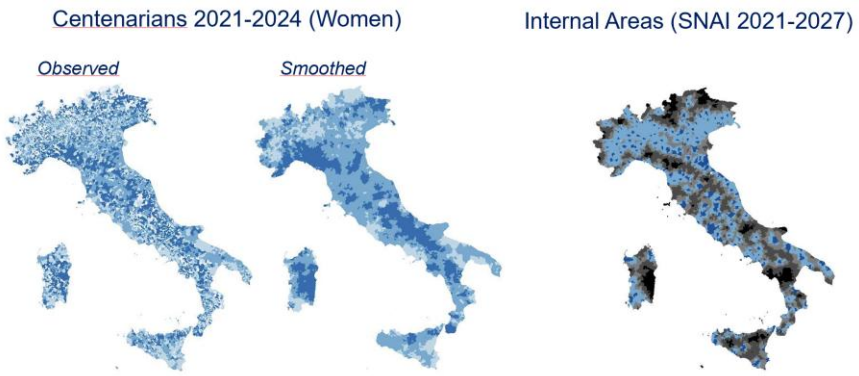


Figure 3. Estimated differences between Inner Areas and non-Inner Areas

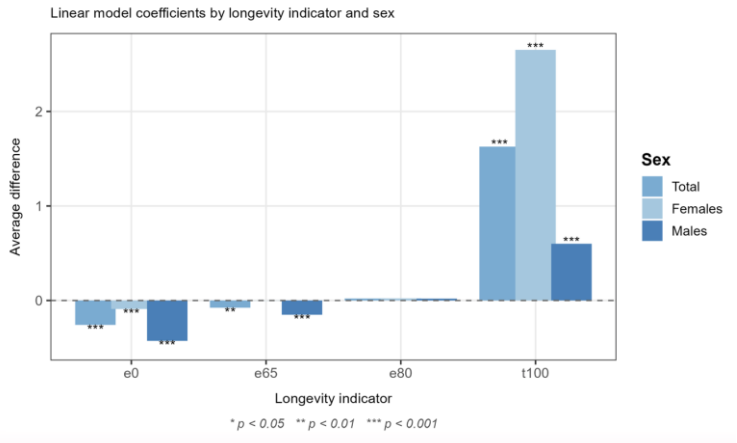


Figure 4. Longitudinal Centenarian Index

Implications

Mapping the Italian territory according to different meanings of longevity can help to identify the different factors that have determined in specific areas of the country particularly favorable conditions for increasing survival and longevity. This is of fundamental importance to implement synergic, integrated, targeted interventions and policies at the finest territorial level. This not only will make longevity more and more extended but will also make it fairer.

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