EXPLORING MORTALITY PATTERNS ACROSS TERRITORIAL AREAS IN ITALY

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Abstract. Mortality differentials across rural-urban gradients have long been of interest due to their implications for public health policies. Traditionally, rural areas were believed to have lower mortality thanks to healthier lifestyles and environmental factors. Recent trends suggest a narrowing gap, raising questions about the factors driving these disparities. The differences in mortality rates between territories depend on the different geographical characteristics, and this underscores the need of an analysis at a more detailed territorial level. This study aims to investigate mortality disparities and patterns across central and peripheral gradients and territorial areas in Italy, using the National Strategy for Inner Areas (SNAI) classification. We seek to understand how mortality rates vary between Inner and Central settings, focusing on individuals aged 60 and older. Our analysis includes standardized mortality rates and life expectancy at age 60, examined through spatial analysis techniques, such as Moran's Index and Local Indicators of Spatial Association (LISA). Additionally, we analyse mortality by major causes of death to identify the most significant contributors to the disparities.

The findings reveal considerable heterogeneity in mortality rates, with a notable U-shaped pattern indicating higher survival in Ultra-peripheral areas. While overall improvements in mortality levels are observed in recent years, these are less pronounced in the South. The reduction in mortality from circulatory system diseases and cancers contributes significantly to the improvements in both Poles and Inner Areas. However, higher mortality from respiratory and nervous system diseases is more prevalent in Inner Areas, especially in Ultra-peripheral municipalities.

By outlining mortality differentials and patterns in Italy, this study provides valuable insights for informing targeted health policies aimed at reducing disparities and improving overall public health outcomes for the older population.

1. Introduction

Mortality, the principal negative component of population dynamics, influences both the growth and age structure of populations. Mortality rates represent a critical measure of population health, shaping demographic patterns and informing public health policies. Variations in mortality rates are evident not only between countries but also within countries, across different regions, and between urban and rural

settings. Research has shown that rural areas often exhibit lower mortality compared to urban areas, largely due to healthier lifestyles and better environmental conditions (Woods, 2003). Conversely, urban areas benefit from advanced healthcare services, which can mitigate some of the health risks associated with urban living (Domínguez-Berjón *et al.*, 2005; Haynes and Gale, 1999). Mortality differentials across rural-urban gradients have long intrigued public health researchers due to their implications for health policy. However, recent trends suggest a narrowing gap, raising questions about the underlying factors driving these disparities (Woods, 2003; Allan *et al.*, 2017). These patterns are evident in several European countries where studies have been conducted, such as in England (Allan *et al.*, 2017) and Germany (Ebeling *et al.*, 2022).

Italy, known for its high life expectancy, has made significant strides in improving public health over the past few decades. The well-documented North-South gradient reveals notable regional disparities, with mortality rates varying significantly. In 2022, the North reported a mortality rate of 12.2 per thousand, while the South recorded 11.9 per thousand. Further disaggregation reveals even greater variability, with mortality rates ranging from 9.7 in Barletta to 16.4 in Alessandria at the provincial level. This variability is influenced by population structure, healthcare systems, and other factors (Domínguez-Berjón *et al.*, 2005). In Italy, the National Health Service is a regionally based public system and aims to offer free or low-cost health services, ensuring all people equal access to health care regardless of income. The historical socio-economic divide between North and South also influences health outcomes: Northern regions generally have better health infrastructure and higher income levels than Southern regions.

At a broader territorial level, Caselli et al. (2021) analysed mortality trends in Italian regions, providing a comprehensive picture of the vulnerabilities that emerged during the recent pandemic and outlining possible developments for the near future. Cavalieri and Ferrante (2020), using a Beta-convergence approach, analysed the influence of fiscal decentralisation on the convergence dynamics of infant mortality rates and life expectancy at birth among Italian regions over the period 1996-2016.

Despite the progress in the analysis of mortality in understanding its territorial determinants, there is a gap in the research on the spatial variability of mortality within the country, especially at lower territorial level.

The differences in mortality rates depend closely on the different geographical characteristics of the areas, and this underscores the necessity of an analysis at a more detailed territorial level to understand the different patterns of mortality. This study aims to fill the gap in the existing literature by providing a detailed analysis of mortality disparities across different territorial areas in Italy, considering the

National Strategy for Inner Areas (SNAI) classification[1]. In Italy, this classification of municipalities provides a valuable framework for the analysis of the spatial variability in mortality. The classification distinguishes areas based on their distance to essential services (in terms of mobility, health, and education), which are critical factors influencing mortality (Istat, 2024).

Our research hypothesizes that the differences between the types of areas defined by the SNAI classification are as significant as those between broader geographical macro-areas (North, Centre, South[2]). In particular, we hypothesize that living in a place more or less distant from essential services is more influential in determining mortality rates than the traditional advantages associated with the rural lifestyle. To explore this hypothesis, we focus on mortality among individuals aged 60 and older, a population group that records higher mortality and is most affected by variations in service availability and quality.

The aim of this research is to analyse mortality among these individuals 'at the municipal level, investigating differences between Inner and Central areas over time. We aim to determine how mortality differs between these areas, and whether this gradient is confirmed at a broader geographical level (North, Centre, South). Additionally, we seek to identify which gradient is stronger: that between Inner and Central areas, or that between Central-North and South regions. Furthermore, in order to identify the underlying factors contributing to the differences, we will explore the specific causes of death that are most responsible for survival differences at the Central/Inner level. In doing so, we want to offer insights that can inform targeted public health policies aimed at reducing mortality disparities and improving health outcomes for the old population in Italy.

2. Data and Methods

This study utilizes mortality data during the last decade sourced from the Italian National Institute of Statistics (Istat). The analysis covers Italian municipalities, divided into broader macro geographical areas (North, Centre, South). The municipalities are also classified according to the SNAI classification, which identifies areas based on the distance to essential services such as health, education, and mobility. This classification divides municipalities into: Central Areas, which in turn are divided into six categories: *Poles* (A) and *Intermunicipal Poles* (B), which

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[1] According to the greater distance to essential services, SNAI classifies municipalities into Central (Poles, Intermunicipal poles and Belts) and Inner Areas (Intermediate, Peripheral and Ultra-peripheral municipalities). See also Data and Methods paragraph.

[2] These areas are obtained by grouping the five major socio-economic regions (NUTS1 under Eurostat classification): North-West with North-East, and South with Islands.

offer all three essential services; *Belt municipalities* (C), with good access to Poles; and Inner Areas, further categorized into *Intermediate* (D), *Peripheral* (E), and *Ultra-peripheral* (F) areas, based on their increasing distance from essential services.

The primary focus is on individuals aged 60 and older, a demographic group that typically exhibits higher mortality rates and more significant health disparities.

The first indicator we consider is the standardized mortality rate for individuals aged 60 and above from 2011 to 2013 and from 2021 to 2023, calculated for each municipality using the age structure of the average Italian population in 2017 (central year to the periods considered) as the standard population. To mitigate issues related to small data sets or anomalous years, we consider three-year periods together, ensuring more robust and reliable results. To analyse spatial variability, we apply geographical analysis techniques: we calculate the Moran's Index to measure spatial autocorrelation and the local Moran's I statistic, a Local Indicator of Spatial Association (LISA), using a second-order Queen contiguity matrix. This helps us understand the degree to which mortality rates are clustered or dispersed across different areas, providing insight into spatial patterns and the potential influence of local factors.

The second indicator we analyse is life expectancy[3], calculated using the official methodology (Istat, 2001). In order to overcome the problem of possible underreporting of deaths in the smaller parts of the country (particularly in the Inner Areas of central Italy), we develop mortality tables using a two-year database. We compare life expectancy over two-years periods (2011-2012 and 2022-2023, to avoid the influence of pandemic COVID-19 on survival function estimates) by SNAI classification and major socio-economic regions.

Finally, we consider the standardized mortality rates for individuals aged 60 and more distinguished by major causes of death[4] in the years 2011 and 2019. We focus on the 60+ age group, because of the insignificance of mortality due to accidental causes from the age of 60 onwards, and because, from this age, the weight and time course of certain chronic degenerative diseases (e.g. cancer and cardiovascular diseases) are relevant. Analyses were conducted using annual age classes. Applying the composition method introduced by Pollard (1982), we identify which group of causes of death contributes most significantly to the differences in mortality between areas.

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[3] Life expectancy is a statistical measure of the average time someone is expected to live, based on the year of birth, current age and various demographic factors.

[4] In our analisys we grouped the main causes of deaths into: Circulatory system disease; Diseases of the digestive and genitourinary systems; Cancers; Infective and respiratory tract diseases; Endocrine and blood diseases; Degenerative diseases of the nervous system; Other.

3. Results

The standardized mortality rates for individuals aged 60 and older, as shown in Figure 1, exhibit considerable heterogeneity both in 2011-2013 and 2021-2023. Higher mortality rates are observed in the North-West and in some Southern regions, particularly in Campania, in both periods. However, there are also notable high mortality areas in the Alpine regions of the North-East and in the Apennines. In some areas, a decrease in mortality levels seems to appear between the two periods.

Figure 1 − *Standardized mortality rates (60+), Italian municipalities, periods 2011-2013 and 2021-2023.*
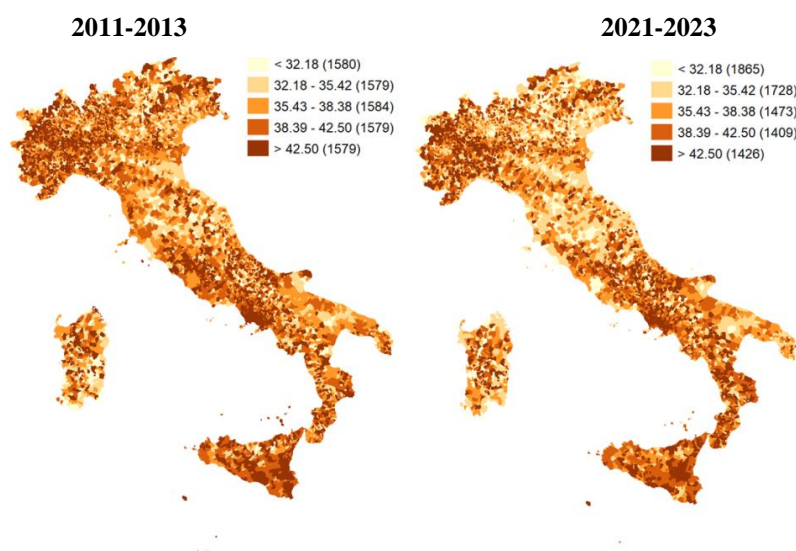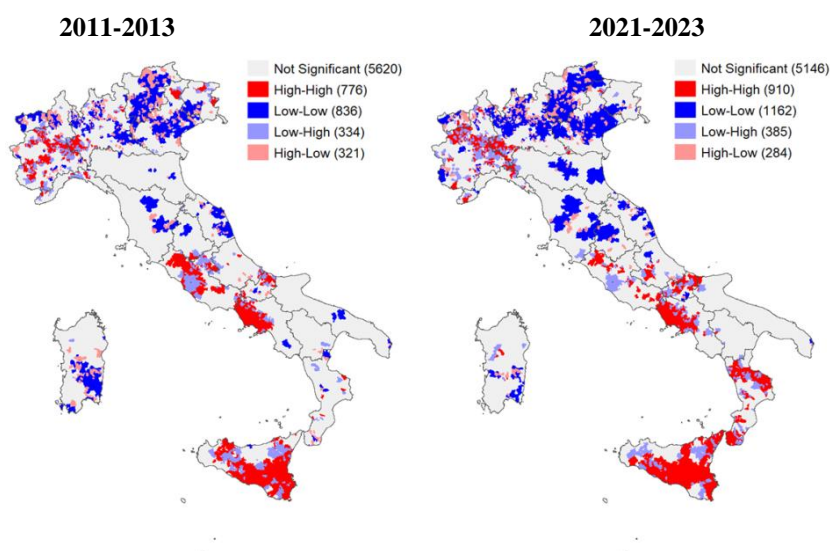

Source: our elaboration on Istat data.

The spatial analysis allowed exploring the geographical distribution of mortality rates. The Moran's Index, computed for both periods, is positive and statistically significant: 0.10 for the first period, and 0.13 for the second, with pseudo p-value smaller than 0.001. This indicates a positive global spatial autocorrelation in mortality rates, suggesting that municipalities with high mortality rates are often located near areas with similarly high mortality rates, and confirming a certain homogeneity of the phenomenon across the territory. The existence of homogeneous spatial clusters of municipalities is further confirmed by the Local Indicators of Spatial Association (LISA), which allow to see where exactly the clusters are located and to check for other types of clusters. The LISA results (showed in the LISA cluster maps in Figure 2) reveal high-high clusters in the South, particularly in Campania

and Sicily, as well as some smaller clusters in the North-West. Interestingly, there is also a high-high cluster in Lazio during the first period that disappears in the second period, suggesting that some changes over the years are consistent with improved health systems and living conditions. Conversely, low-low clusters are observed in the North-East and Central regions emphasizing the lower impact of mortality in these territories. These spatial patterns highlight the existence of significant regional disparities while high-high clusters in the South suggest persistent health disadvantages in these regions.

Figure 2 – *Local indicators of spatial autocorrelation (LISA) cluster map: standardized mortality rates (60+), Italian municipalities, periods 2011-2013 and 2021-2023.*
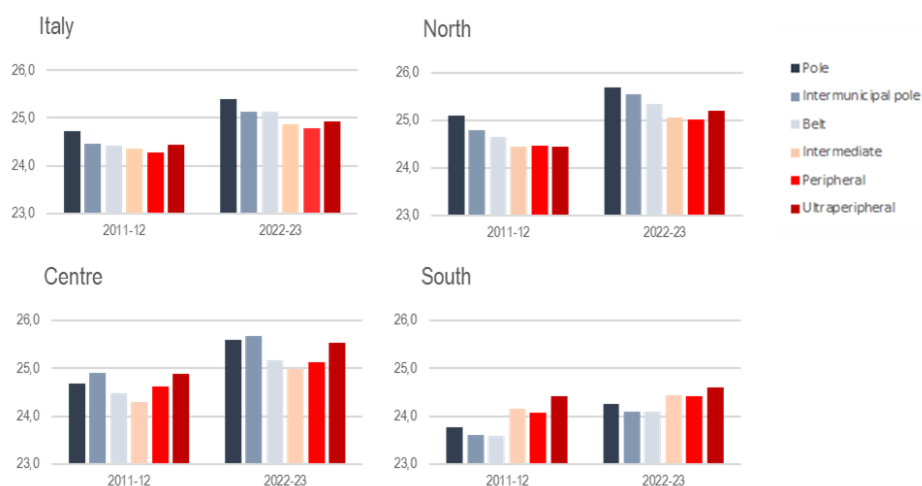

Source: our elaboration on Istat data.

Furthermore, we examined differences in life expectancy at age 60 across the different SNAI classifications (Figure 3), confirming an overall improvement in mortality levels between the period 2011-2012 and 2022-2023[5]. However, this improvement is less pronounced in the South. Life expectancy at age 60 shows a decreasing trend moving from Central to peripheral areas, with a notable U-shaped pattern indicating higher survival in Ultra-peripheral areas. This pattern is consistent across geographical divisions, although the contrast between North and South is particularly striking. In Italy as a whole and in the North, life expectancy at age 60

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[5] In the life expectancy analysis, we consider two-year periods (2011-2012 and 2022-2023) to avoid the influence of pandemic COVID-19 on survival function estimates.

is highest in Poles and decreases progressively as the distance from these urban centres increases. Notably, life expectancy in Ultra-peripheral areas is higher than in Intermediate and Peripheral areas. In the Centre, Intermunicipal Poles exhibit the highest life expectancy, closely followed by Poles. Similarly to the North, Ultra-peripheral areas in the Centre have higher life expectancy than Intermediate and Peripheral areas. In contrast, in the South, all municipalities in the Inner Areas have higher life expectancy than Poles. This suggests that Inner areas may offer a better quality of life. In the North, this advantage could be offset by the availability of more efficient services in Poles and Belt municipalities. In the Centre, the same pattern holds for the first two types of areas. In the South, however, the limited availability or lower quality of services in Central areas may be insufficient to counterbalance the lower quality of life in cities.

Figure 3 – *Life expectancy at 60 years by SNAI classification, years 2011-2012 and 2022-2023.*
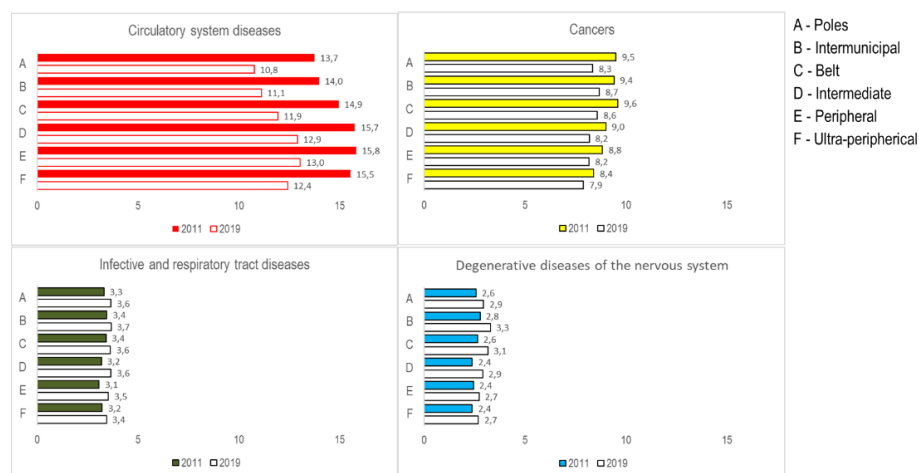

Source: our elaboration on Istat data.

To further understand the differences in mortality, we analysed the standardized mortality rates for individuals aged 60 and more, focusing on four primary groups of causes: circulatory system diseases, cancer, infectious and respiratory tract diseases, and degenerative diseases of the nervous system. This analysis allowed to identify the causes of death contributing most significantly to the mortality disparities between different types of areas within the SNAI classifications.

Diseases of the circulatory system show higher mortality rates in the Inner Areas, consistent with the importance of the immediate availability of health services for

these conditions. Notably, Ultra-peripheral areas exhibit slightly lower mortality rates from circulatory system diseases compared to Intermediate and Peripheral areas (Figure 4). This suggests that healthier lifestyles, potentially related to types of work and other factors, may prevail in these remote areas. Despite a general decrease in mortality rates from circulatory system diseases between the two periods, the relative differences between the types of municipalities remain consistent. For cancer, mortality rates decrease progressively as municipalities are located farther from the Poles (Figure 4). This trend may be attributed to the fact that cancer is heavily influenced by lifestyle and external conditions. Central areas, which tend to have higher exposure to risk factors such as pollution and stress, exhibit higher cancer mortality rates compared to more peripherical areas. Between the two periods, a decrease in cancer mortality rates is observed, yet the pattern of higher rates in Central areas compared to the Inner ones remains evident. Infective and respiratory tract diseases, as well as degenerative diseases of the nervous system, show an increase in mortality rates between the two periods. This rise is consistent with the emergence of new diseases that have become significant causes of death in recent years. For these types of mortality, lower rates are recorded in the three types of Inner Areas, particularly in Ultra-peripheral areas. This pattern may suggest that the more remote areas are less affected by the conditions that exacerbate these diseases or benefit from healthier environments.

Figure 4 – *Standardized mortality rates for some main groups of causes of death at 60 years and more, years 2011 and 2019.*
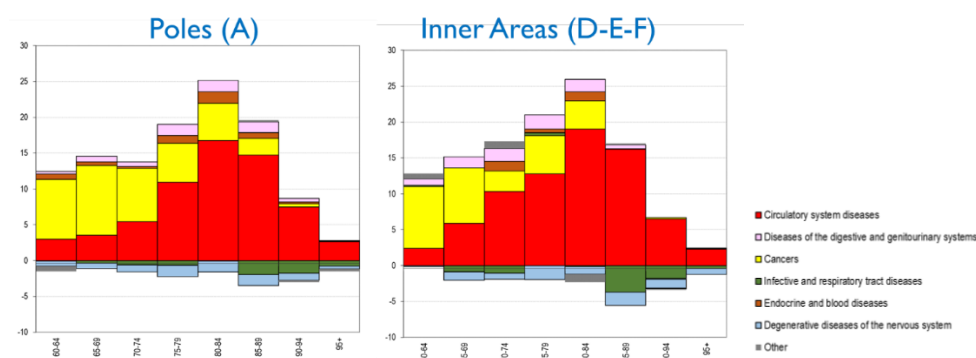

Source: our elaboration on Istat data.

These findings underscore the significant role of healthcare access in managing circulatory system diseases and suggest that healthier lifestyles in Ultra-peripheral areas may contribute to slightly lower mortality rates for these diseases. The persistence of these differences over time highlights the need for targeted public health interventions to address the needs of each area type. Additionally, the trends in cancer mortality emphasize the importance of lifestyle and environmental factors in influencing health outcomes. The rising mortality rates from infectious and respiratory tract diseases and degenerative diseases of the nervous system point to the need for ongoing public health vigilance and targeted strategies to mitigate these emerging health threats.

As observed in Figure 5, the decomposition of the change in life expectancy at age 60 by main groups of causes of death and age classes, from 2011 to 2019[6], shows that most causes of death contribute to an increase in life expectancy, especially up to age 90. The reduction in mortality from circulatory system diseases and cancers accounts for the most significant improvements in both Poles and Inner Areas. Specifically, 65% of the change in Poles comes from improvements in circulatory system diseases, and 39% from cancers. In Inner Areas, these figures are 75% and 29%, respectively. This is another confirmation of the importance of healthcare facilities, on one hand, and of healthy lifestyle, on the other hand. Additionally, it is notable that mortality from respiratory and nervous system diseases has a greater impact in Inner Areas, reflecting higher vulnerability to these conditions in more remote regions, where certain health services are absent and distant.

Figure 5 – *Decomposition of the change in life expectancy at 60 years by main groups of causes of death and age classes, from 2011 to 2019.*

Source: our elaboration on Istat data.

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[6] Also in the decomposition of the change in life expectancy by groups of causes of death, we do not consider the last years (2020-2021) to avoid the effect of the pandemic on causes of death.

4. Discussion and conclusion

From this descriptive analysis, it emerges that Italy, one of the longest-lived countries in the world, is characterized by significant heterogeneity at a territorial level. The SNAI classification proves suitable for studying these territorial differences, suggesting that lifestyles, environmental factors and the presence of social and health services play a fundamental role in shaping mortality patterns.

In the general context of lower mortality in the Centre-North compared to the South, Central and Inner Areas exhibit different survival levels. At a national level, survival decreases moving from the Centres to the periphery and then rises in the Ultra-peripheral areas, highlighting a U-shaped pattern of life expectancy. This U-shaped pattern is preserved across geographical divisions, though it accentuates the contrasting situation between the North and South. Indeed, in the latter, all the Inner Areas show a more favorable situation.

The analysis by cause of death further emphasizes these contrasts. Circulatory system diseases have higher mortality rates in Inner Areas, underscoring the critical role of healthcare services in managing these conditions. However, Ultra-peripheral areas exhibit slightly lower rates, suggesting healthier lifestyles may mitigate some risks. Despite a general decrease in mortality rates from circulatory diseases over time, the differences between municipal types remain consistent. Cancer mortality rates decrease progressively with distance from Central areas, suggesting the influence of lifestyle and environmental factors on cancer. Poles, with higher exposure to risk factors such as pollution and stress, show higher cancer mortality rates compared to Inner areas, where the rhythms of life can be less stressful and environmental conditions tend to be better. The general decrease in cancer mortality over time does not alter the pattern of higher rates in the Central Areas compared to peripheral ones. The rise in mortality rates from infectious and respiratory tract diseases and degenerative diseases of the nervous system between the two periods seems to reflect the emergence of new significant health threats. With continued advancement in life expectancy and a growing old population, these threats need to be addressed urgently, including taking into account the different access to health care facilities in different areas. Lower rates in the three types of Inner Areas, particularly Ultra-peripheral areas, suggest that these areas are less affected by conditions exacerbating these diseases or benefit from healthier environments. Analysis of the living and environmental conditions in different territories can be an important piece in a framework aimed at understanding the mechanisms behind these diseases and their treatment.

The findings suggest that while Inner areas in the North and Centre benefit from better services in Poles and Belt municipalities, the South does not have sufficient services to counterbalance the lower quality of life in Central areas. The significant

role of healthcare access in managing circulatory diseases and the healthier lifestyles in Ultra-peripheral areas highlight the complexity of public health interventions. Indeed, the analysis would seem to suggest the necessity to invest in public health and ensure easy access to health care facilities as much as to dedicate proper attention to promoting healthy lifestyles. Addressing the territorial disparities requires targeted strategies that consider the needs of each area type, aiming to reduce mortality disparities and improve health outcomes for the older population across Italy.

In summary, this study underscores the necessity of analysing spatial variability in mortality at a detailed territorial level. Such an approach provides insights for informing public health policies aimed at reducing mortality disparities and enhancing health outcomes, particularly for the older population in Italy. The persistence of differences in mortality rates and the impact of emerging health threats highlight the ongoing need for vigilant public health strategies and interventions tailored to the specific characteristics of different regions.

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