ANALYZING HEALTH INEQUALITIES IN ITALIAN METROPOLITAN CITIES: A MULTIDIMENSIONAL APPROACH[1]

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Abstract. This study aims to verify whether, as with other previously investigated demographic and socio-economic phenomena (Cangialosi *et al.*, 2023; Istat, 2023), in Italian metropolitan cities, the relationships between the capital city and other surrounding territorial aggregates, divided based on geographical proximity, can explain health inequalities among the population. Health, defined as a state of complete physical, mental, and social well-being (WHO, 1948), is influenced by various determinants, including individual, social, economic, and environmental factors. It is plausible to hypothesize the existence of a territorial health gradient among municipalities with high availability of health infrastructures, low out-of-region hospital mobility, and favorable socio-economic conditions, compared to those with less accessibility to such services and less advantageous socio-economic conditions. Capitals (and sometimes municipalities in the first urban belt) often exhibit these advantageous conditions and play a central role in the organization of the territory (Logan *et al.*, 2002). Furthermore, the geographical positioning of territories is a significant factor in the proposed analysis, traditionally highlighting an increasing North-South discrepancy (Istat, 2024). A cluster analysis carried out on representative indicators of health conditions, health supply and economic situation facilitated the identification of homogeneous territorial groups and the description of their characteristics.

1. The concept of health and its determinants

The concept of health is fundamental to human life. The World Health Organisation (WHO, 1948) defines it as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". This approach, which is multidimensional in nature, places the individual at the centre of analysis. Furthermore, it emphasises the interrelated importance of three inseparable components, namely physical, mental and social health (Engel, 1977; Marmot *et al*., 2006). Each of these components is influenced by health determinants, which are factors that can influence the onset or progression of disease without being its direct cause (Dahlgren *et al*., 1991). An analysis of these determinants allows the

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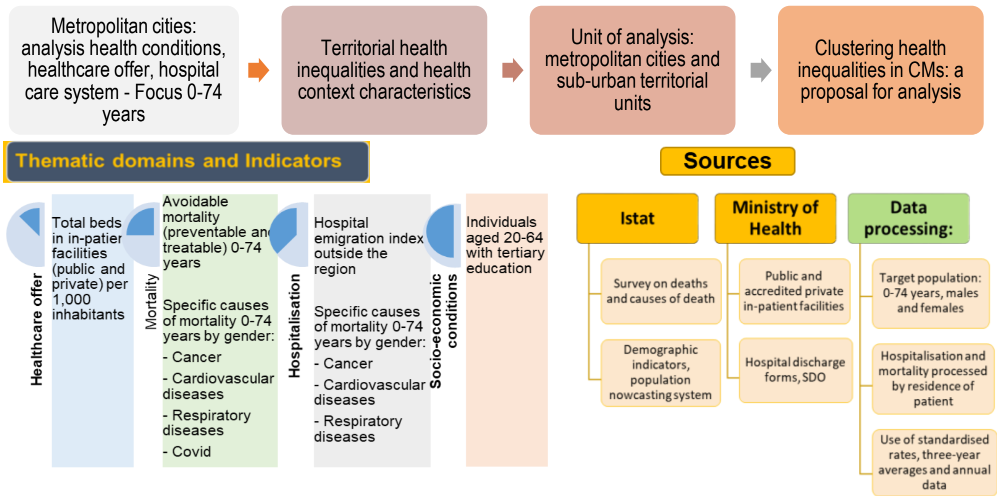
identification of the 'rules' by which disease occurs and develops, as well as the assessment of their presence, strength and direction. This enables the guidance of potential public health interventions. These determinants include a wide range of factors such as individual behaviours, social advantages or disadvantages, living and working conditions, access to health services, and socio-economic, cultural, environmental, and genetic influences (Commission on Social Determinants of Health, 2008). In recent decades, public health scholars have focused on social determinants of health (SDH) factors directly influenced by social policies and the socio-economic, cultural, and environmental conditions in which people live and work. Urban planning and regeneration programs, due to their direct impact on living environments, hold significant potential for improving public health outcomes (Kawachi *et al*., 2003). Strategies promoting inclusivity and community well-being are crucial for enhancing quality of life and reducing health disparities (WHO, 2016). Examples of such strategies include improving walkability, providing recreational areas, and ensuring access to nutritious foods, which collectively shape the quality of living environments (Barton *et al*., 2006). Cities, at both national and international levels, are pivotal in the implementation of health policies and programs that are crucial for achieving global public health objectives. The WHO identifies urbanization as a critical challenge for 21st-century health, with projections indicating that by 2050, two-thirds of the global population will reside in urban areas (WHO, 2016). Urban environments present a complex interplay of challenges and opportunities: while high population density can exacerbate issues such as pollution and disparities in access to services (Diez Roux *et al*., 2010), it also provides opportunities for targeted interventions and the optimization of health resources (Barton *et al*., 2006). Consequently, cities can serve as experimental settings for innovative strategies aimed at improving access to health services and fostering healthier living conditions by leveraging geographic proximity and urban infrastructure connectivity (Vlahov *et al*., 2007; Braveman *et al*., 2014). Public health, long a priority in policy-making, is now more than ever tasked with ensuring equitable and distributed levels of care and support, positioning it as a fundamental and integrative sector upon which all other decisions depend (Istat, 2022).

2. Data and Methods

This study analyses health conditions and healthcare provision in Italian urban contexts to identify the strengths and weaknesses of the areas examined. The 14 Italian metropolitan cities are compared according to a scheme that divides each area into four territorial typologies, defined in accordance with criteria of geographical contiguity. These types include capital cities, first belt municipalities, second belt municipalities and other municipalities. In total, 56 metropolitan areas were identified, comprising 1,268 municipalities (16% of the total municipalities) and around 21 million inhabitants. The objective of the research is to ascertain whether the relationships between the Capital Municipalities and the surrounding areas can be used to explain the differences in the population's health status, in a manner analogous to the explanation of other demographic and socio-economic phenomena (Cangialosi et al., 2023; Istat, 2023). The study puts forward the hypothesis of a territorial health inequalities between municipalities with a high availability of health infrastructure and favourable socio-economic conditions and those with less access to these services and less favourable socio-economic conditions (Istat, 2024). In general, the capitals of metropolitan areas, which are central to spatial organisation (Rothwell et al., 2015), and municipalities in the first urban belt with greater connectivity to the central city, tend to have more favourable conditions.

Figure 1 – *Framework: Indicators and data sources.*



The geographic location of metropolitan cities is also regarded as a significant factor in the exacerbation of the health disparity between different regions of the country, particularly in its contribution to the North-South divide (Istat, 2019).

The testing of these assumptions is aligned with the modern multidimensional approach to studying health status, necessitating the application of a holistic and complex framework that considers all relevant dimensions of the phenomenon and its interactions. The adopted conceptual framework (Figure 1) is based on identifying a plurality of thematic domains within which to select the most pertinent and explanatory indicators (Istat, 2024), balancing data availability with the descriptive capacity of the selected measures. In particular, the health status of the population is assessed using mortality indicators, disaggregated by cause and age. Avoidable mortality indicators are used, segmented into preventable and treatable components.

The number of hospital beds provides insight into the accessibility of health services. The rates of hospitalisation by cause and age, along with hospital mobility data, indicate the prevalence of specific diseases and the utilisation of health services. The level of education provides insight into the socio-economic context of the areas, indicating potential relations between education and health status or access to health service. Mortality and hospitalisation rates are age-standardised with the European standard population 2013. The key data for this analysis derive from multiple sources: infrastructural capacity and hospitalization data from the Ministry of Health, while death and cause-of-death data are provided by Istat. The analysis is conducted based on patient residence (hospital discharges) and deceased residence (deaths and causes of death). The indicators predominantly pertain to the population aged 0-74 and refer to the year 2021. For preventable mortality, the three-year average of 2017-2019 was considered in order to understand the effects of the Coronavirus Pandemic Disease 2019 (Covid-19) on the health and care landscape within the specified territory. Indeed, the experiences of the global population following the COVID-19 pandemic have expanded the audience of policymakers interested in quantitative information and brought attention from the general public (government bodies, private citizens, media organizations, etc.) to issues related to the understanding and measurement of public health. In order to capture the complexity of the analysis and to represent the thematic dimensions considered (health conditions, health services and socio-economic situation), a substantial number of indicators were used.

Cluster analysis was applied to these data, which enabled the identification of homogeneous groups and highlighted patterns and inequalities in health conditions and access to health services (Murray et al., 2020; Williams et al., 2018).

3. Cluster analysis

A cluster analysis was conducted using the k-means algorithm on twelve indicators representative of the different domains of interest (MacQueen, 1967).

The k-means algorithm, is a non-hierarchical clustering tool that is straightforward to operate. Its objective is to partition a dataset into k clusters based to their similarity. The goal of the algorithm is to minimize the total intra-cluster variance and maximize the variance between clusters[2]. The optimal number of

[2] The algorithm begins by randomly defining k centroids and assigning the closest samples to the j-th centroid, utilizing a Euclidean distance metric (commonly the square of the difference). Once the initial assignment of points to clusters has been made, the algorithm recalculates the centroid of each cluster as the average of the points assigned to that cluster. This process of assigning and updating the centroid

clusters into which to subdivide the dataset is not known a priori, but is an input necessary to start the algorithm. The clustering analysis is then performed for different values of k, starting with a minimum of 2, and the goodness of the clustering analysis is assessed a posteriori. In order to validate the results of clustering we considered the following measures: the Total Within Sum of Squared errors (SSW) and the Total Between Sum of Squared errors (SSB). Higher SSB values (and consequently lower SSW values, since SSW+SSB=TSS, constant) are more desirable, as they are indicative of greater internal group cohesion and data separation. These measures, however, although useful and quick to implement, are dependent on the number of clusters, and, therefore, are not suitable for comparing clustering results with a different number of clusters. In order to evaluate the clustering method and the choice of the k number the Silhouettes method was also used (Rousseeuw 1987). This method is based on the calculation of intra- and inter-cluster distances and provides a measure of how similar the data are to the assigned cluster in comparison to other clusters. It is done by calculating the silhouette value[3] for each data point and averaging the result over the entire dataset. The silhouette average can range between -1 and 1: a value close to 1 means the cluster is well formed, a value close to 0 means the position is unclear and a value close to – 1 means the dataset is badly partitioned.

Table 1 – *Values of Silhoutte, WSS, BSS e BSS/TSS (%) for different clustering with k varying from k=2 to k=6.*

k	Silhouette	WSS	BSS	TSS	BSS/TSS(%)
2	0.2821	455	205	660	31.1
3	0.2062	376	284	660	43.0
4	0.2204	324	336	660	50.9
5	0.2276	285	375	660	56.9
6	0.1920	257	403	660	61.1

To ascertain the optimal value of k, it is useful to examine the value of the Silhouette measure within the classes in the five- and six-group clusters.

Table 2 shows the values of the Silhouette measure for the five- and six-group clustering, for each k group. The highest Silhouette value was observed in the second group of the six-group cluster, with a value of 0.3753; the third group of this cluster

is repeated until it converges, i.e. until there is minimal change between iterations, or until the maximum number of iterations has been reached.

[3] The silhouette value for a single data point is calculated using the following equation:

Silhouette = (AverageOut – AverageIn)/ max (AverageOut, AverageIn)

AverageOut is the minimum average distance between the data point and data within other clusters, and AverageIn is the average distance between the data point and other data within the same cluster.

was also well represented, with a value of 0.3000. In contrast, the first class of the six-group cluster had the lowest silhouette value (0.0060), indicating a suboptimal positioning of some territories. Considering the different measures selected (Silhouette in total and in the groups, BBS/TSS%), the six-group cluster is assessed as optimal, having satisfactory values of the silhouette measures and BBS/TSS(%).

Table 2 – *Silhouette values for clustering with 5 and 6 groups for each group (k).*

k	5-groups		6-groups	
	n.	Silhouette	n.	Silhouette
1	23	0,2413	13	0,0060
2	10	0,2286	12	0,3753
3	10	0,1693	10	0,3000
4	9	0,2072	9	0,1420
5	4	0,3388	7	0,1360
6			5	0,1884
Total	**56**	**0,2276**	**56**	**0,1920**

4. Results

The cluster analysis, described in Section 3 and conducted on the twelve selected multi-source indicators, made it possible to identify homogeneous groups and to understand the key characteristics associated with them in terms of health status, health care provision and socio-economic conditions.

The results of the cluster analysis serve to substantiate the assumptions set forth in Section 2, which postulated a relation between enhanced health status and high accessibility to health services and superior socio-economic conditions. In the case of metropolitan cities, these conditions are predominantly concentrated in the Capital cities and the majority of territories situated in the Centre-North.

In order to interpret the results and describe the group profiles, the 'cluster centres' obtained from the cluster analysis performed were used (see Table 3). The analysis led to the classification of the 56 territories, comprising the capital cities, first- and second-belt municipalities, and other metropolitan city municipalities, into one of six clusters, as illustrated in the map (Figure 2).

Descriptive characteristics of each group are represented below.

The first group (CL1) includes the extra-urban territories mainly belonging to the Mezzogiorno, together with the municipalities bordering the capital cities of Genoa and Venice and the territories furthest away from them. They are characterised by acceptable health conditions of the population up to 74 years of age, but with higher levels of treatable mortality (6.9 deaths per 10 thousand inhabitants), which show shortcomings attributable above all to the quality and effectiveness of health care, which is not always timely and effective (Table 3).

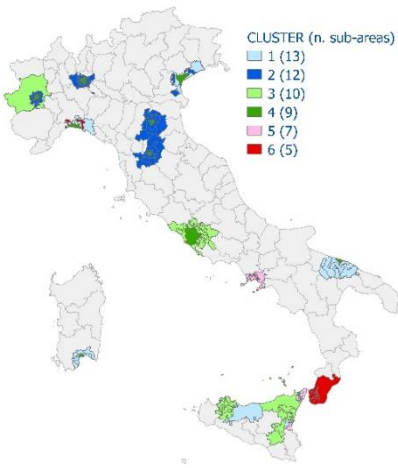
Table 3 – *Indicators - Cluster centers and values for capital city, MC and Italy.*

Indicators	Cluster centers						Capi-tal city	MC	ITALY
	CL1	CL2	CL3	CL4	CL5	CL6			
Tot hospital beds 2021 (per 1,000 in.)	1.1	2.5	2.1	8.4	4.7	2.3	7.2	4.3	3.9
Hospital emigration index outside the region 2021 (%)	7.3	3.7	5.2	5.4	6.3	21.9	5.7	5.8	7.8
Hospitalizations from cancer 0-74 years 2021 (per 10,000 in.)	96.6	91.8	98.3	100.7	114.3	101.8	103.0	99.3	97.5
Hospitalizations from cardiovascular system disease 0-74 years 2021 (per 10,000 in.)	75.3	78.6	82.9	77.9	97.2	73.8	83.7	84.0	84.5
Hospitalizations respiratory disease 0-74 years 2021 (per 10,000 in.)	55.9	74.5	67.9	70.5	58.7	51.9	73.2	68.7	67.9
Preventable mortality 2017-19 (per 10,000 in.)	9.8	9.5	11.5	9.9	12.8	10.5	10.6	10.7	10.5
Preventable mortality '21 (per 10,000 in.)	12.7	11.6	14.6	12.2	17.1	12.4	13.6	13.6	12.8
Treatable mortality '21 (per 10,000 in.)	6.9	5.4	7.6	6.0	9.0	7.6	6.8	6.9	6.4
Mortality from cancer 0-74 years 2021 (per 10,000 in.)	12.1	10.9	12.3	11.2	14.3	11.9	12.0	12.1	11.7
Mortality from cardiovascular system disease 0-74 years 21 (per 10,000 in.)	5.0	4.0	6.3	4.8	7.8	6.1	5.6	5.5	5.2
Mortality from respiratory disease 0-74 years 2021 (per 10,000 in.)	0.9	0.9	1.5	1.0	1.7	1.6	1.3	1.2	1.1
Individuals aged 25-64 with tertiary education 2021 (%)	17.9	21.4	18.0	33.1	19.1	20.9	31.5	24.5	21.7

In contrast, primary prevention and public health interventions generate a good level of preventable mortality (12.7 deaths per 10 thousand inhabitants), although the pandemic has had a sustained impact on the health conditions of these areas (+2.8 percentage points in 2021 compared to 2017-2019). It includes 2.247 million people, 44.1% of whom belong to the first belt municipalities, 17.5% to the second belt municipalities and 38.3% residing in the ring areas (Table 4). The socio-economic context of the population is fragile with respect to both the level of tertiary education of the adult population (17.9%) and per capita income (12,819 euros per inhabitant), used as a further descriptive variable outside the cluster analysis.

The second cluster (CL2) includes the extra-urban territories of the metropolitan cities in the Centre-North, excluding Genoa. These territories have the best health conditions, with lower rates of all-cause and avoidable mortality, supported by an efficient and accessible healthcare system that does not rely exclusively on hospital care. This is confirmed by the low hospitalisation rates for cancer and cardiovascular diseases, as well as the out-of-region hospitalisation rate (3.7%). Together with cluster 4, it has the highest rate of hospitalisation for respiratory diseases, at 74.5 admissions per 10 thousand inhabitants, likely due by the effects of the Covid 19 pandemic on hospital care.

Figure 2 – *Distribution of metropolitan city sub-areas among clusters.*



The socio-economic context is characterised by more favourable levels of tertiary education population ages 20-64 (21.4%), in line with the national average, and high levels of income (16,284 euros per inhabitant). About 3.970 million inhabitants reside in this group, of which 36% in the first belts, 30.6% in the second belts, and 33.4% in the territories further out from the capital.

The third cluster (CL3) comprises mainly extra-urban territories, with the exception of the municipality of Palermo, which cross Italy from North to South. It is characterised by poor health conditions, a higher recourse to hospital care for cancer and cardiovascular diseases, compared to the two previous clusters, a significant preventable mortality (14.6 per 10 thousand inhabitants), up by 3 percentage points compared to 2017-2019, accompanied by high values also of treatable and preventable mortality (7.6 deaths per 10 thousand inhabitants) and by cause. Socio-economic conditions are rather critical, with low levels of tertiary education of the adult population, similar to those in cluster 1 and associated with very low values of per capita income (10,356 euros per inhabitant). Population in this cluster is about 4 million inhabitants of which 15.7 % in the capital municipalities, 21.9 % in the first belts, 21.5 % in the second belts and 40.8 % in the Other Metropolitan City municipalities.

Table 4 – *Cluster territorial profile.*

Cluster description	Territories	N. of territories		Population (31/12/21)		Municipalitie s	
		a. v.	**%**	**a. v.**	**%**	**a. v.**	**%**
CL1: Suburban areas mainly belonging to the Mezzogiorno. To these are added I Belt and the Other Municipalities of the CMs of Genoa and Venice	Total (% on Total of groups)	**13**	**23.2**	**2,247,117**	**10.5**	**208**	**16.4**
	Capital cities of MC (% on Total of CL1)	0	0.0	0	0.0	0	0.0
	I Belt (% on Total of CL1)	**6**	46.2	991,457	44.1	60	28.8
	II Belt (% on Total of CL1)	**2**	15.4	393,933	17.5	22	10.6
	Other Mun. of MC (% on Total of CL1)	**5**	38.5	861,727	38.3	126	60.6
CL2: Suburban territories mainly in the Centre North	Total (% on Total of groups)	**12**	**21.4**	**3,970,645**	**18.6**	**280**	**22.1**
	Capital cities of CM (% on Total of CL2)	0	0.0	0	0.0	0	0.0
	I Belt (% on Total of CL2)	4	33.3	1,427,789	36.0	54	19.3
	II Belt (% on Total of CL2)	5	41.7	1,215,809	30.6	84	30.0
	Other Mun. of MC (% on Total of CL2)	3	25.0	1,327,047	33.4	142	50.7
CL3: Mainly extra-urban areas with the exception of Palermo that cross Italy from North to South	Total (% on Total of groups)	**10**	**17.9**	**4,037,722**	**18.9**	**557**	**43.9**
	Capital cities of CM (% on Total of CL3)	1	10.0	635,439	15.7	1	0.2
	I Belt (% on Total of CL3)	2	20.0	885,441	21.9	37	6.6
	II Belt (% on Total of CL3)	3	30.0	868,809	21.5	64	11.5
	Other Mun. of MC (% on Total of CL3)	4	40.0	1,648,033	40.8	455	81.7
CL4: Main municipalities with health advantage situations	Total (% on Total of groups)	**9**	**16.1**	**6,975,357**	**32.7**	**9**	**0.7**
	Capital cities of CM (% on Total of CL4)	9	100.0	6,975,357	100.0	9	100.0
	I Belt (% on Total of CL4)	0	0.0	0	0.0	0	0.0
	II Belt (% on Total of CL4)	0	0.0	0	0.0	0	0.0
	Other Mun.of MC (% on Total of CL4)	0	0.0	0	0.0	0	0.0
CL5: The South with critical health conditions	Total (% on Total of groups)	**7**	**12.5**	**3,541,784**	**16.6**	**104**	**8.2**
	Capital cities of CM (% on Total of CL5)	3	42.9	1,443,492	40.8	3	2.9
	I Belt (% on Total of CL5)	1	14.3	532,593	15.0	14	13.5
	II Belt (% on Total of CL5)	2	28.6	502,244	14.2	23	22.1
	Other Mun. Of MC (% on Total of CL5)	1	14.3	1,063,455	30.0	64	61.5
Cl6: High hospitalisation outside the region. Critical socio-economic context conditions. Reggio Calabria and Genoa II Belt	Total (% on Total of groups)	**5**	**8.9**	**568,349**	**2.7**	**110**	**8.7**
	Main Mun. (% on Total of CL6)	1	20.0	288,286	50.7	77	70.0
	I Belt (% on Total of CL6)	1	20.0	172,479	30.3	1	0.9
	II Belt (% on Total of CL6)	2	40.0	34,848	6.1	12	10.9
	Other Mun. Of MC (% on Total of CL6)	1	20.0	72,736	12.8	20	18.2
TOTAL		**56**	**100**	**21,340,974**	**100.0**	**1**	**100.0**

The fourth group (CL4) is that of large urban centres, as it includes only capital cities, 9 out of 14, and affects about 7 million inhabitants. This is the group with the best health offer and good health conditions. The rates of preventable (12.2 deaths per 10,000 inhabitants), treatable (6 deaths per 10,000 inhabitants) and all-cause mortality are low and only slightly lower than those of cluster 2. The hospital supply in the area of residence is the highest (8.4 beds per thousand inhabitants) and associated with a high use of hospital care for cancer and respiratory diseases. The socio-economic context is excellent. In fact, these territories have the highest level of tertiary education, with one third of people aged between 25 and 64, and the highest per capita income (17,500 euros per inhabitant).

The fifth cluster (CL5) consists of territories in the South with more critical health conditions. It involves the entire metropolitan city of Naples and extends to the pole municipalities of Catania and Messina, including the first belt of the latter. These territories are characterised by very high values of preventable (17.1 deaths per 10,000 inhabitants), treatable (9 deaths per 10,000 inhabitants) and all-cause mortality. Recourse to hospital care also reaches maximum levels with reference to hospitalisation for cancer (114.3 admissions per 10 thousand) and for cardiovascular diseases (97.2 admissions per 10 thousand). The epidemiological profile of these territories highlights the need of these areas for urgent interventions of primary prevention, public health and improvement of the accessibility and efficiency of the healthcare systems, also confirmed by a high recourse to hospital care outside the region of residence (6.3%). The resident population in this group is about 3.5 million inhabitants of which 40.8 % in the capital municipalities, 15 % in the first belts, 14.2 % in the second belts and 30 % in the Other Metropolitan City municipalities.

In conclusion, the sixth cluster (CL6) includes all the territories of the Metropolitan City of Reggio Calabria and the second belt of Genoa and involves about 568,000 people, mainly residing in the city of Reggio di Calabria and its first belt (81.1%). The cluster is characterised by the population's strong propensity to use hospital care outside the region and a significant treatable mortality rate. Health conditions are poor with various health and health-related fragilities. There is a high hospitalisation for cancer (101.8 admissions per 10 thousand inhabitants), a high preventable mortality (12.4 deaths per 10 thousand) suggesting that public health and primary prevention interventions should be strengthened although the impact of Covid 19 was lower than in other groups (+1.9 percentage points compared to 2017-2019). The main criticality of the group is the high treatable mortality (7.6 deaths per 10 thousand inhabitants) and cardiovascular (6.1 deaths per 10 thousand) and respiratory (1.6 deaths per 10 thousand) diseases. The socio-economic conditions, as in group 5, are disadvantaged, characterised by low average levels of tertiary education of the adult population (20.9%) and low per capita income (10,900 euros per inhabitant).

5. Summary

This analysis has highlighted several significant trends regarding the distribution of healthcare services and health conditions in Italian metropolitan cities and their suburban areas. Hospital services are predominantly concentrated in major urban centers, while the propensity for hospital mobility increases as one moves away from the main cities. Some areas exhibit a very high rate of out-of-region hospitalizations. The analysis underscores the importance of developing targeted health policies to address territorial inequalities and improve access to healthcare services, especially in disadvantaged areas. Specific interventions need to be implemented to improve health conditions in the most critical regions, with a particular focus on Southern Italy. These interventions should aim to reduce avoidable mortality and enhance healthcare infrastructure to ensure equitable access to hospital care. By addressing the initial assumptions, the study confirms that the relationships between the capital city and other surrounding territorial aggregates, divided according to geographical proximity, can indeed explain health inequalities among the population. The health differences identified suggest that municipalities with high availability of healthcare infrastructure and favourable socio-economic conditions exhibit better health outcomes compared to those with limited access to these services and less advantageous socio-economic conditions. The classic North-South divide also plays a significant role in influencing health conditions and outcomes, further emphasizing the need for region-specific health interventions.

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