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Availability, Accessibility, and Equity: a multidimensional approach to mapping health poverty across Italian municipalities

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Availability, Accessibility, and Equity: a multidimensional approach to mapping health poverty across Italian municipalities

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Abstract. This paper proposes a novel territorial and multidimensional approach to measuring health poverty in Italy at the municipal level. Using a particular rich and unique database, we develop a Multidimensional Health Poverty non-compensatory Index based on three key dimensions: availability, accessibility, and equity of healthcare services. Results reveal a weak link between health poverty and health status, highlighting the former's limits as a proxy in countries with good average outcomes but growing access inequalities. The analysis also shows that investing in inner areas, balancing public and private services, and reducing unmet care needs and impoverishing health costs are key to tackling high health poverty, especially where elderly or disability care dominates spending. Finally, SEM models results and the different types of healthcare systems based on health poverty levels and type of governance emerging, show the effectiveness of pursuing both equity and efficiency goals in healthcare.

Keywords: Multidimensional poverty, Health inequality, Access to care, Spatial analysis, Composite indicators, Italy

JEL codes: I14, I32, R15

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1 Introduction

Following the COVID-19 pandemic, the policy debate and the literature have been increasingly focusing to comprehensively evaluate the resilience and performance of healthcare systems. Besides efficiency issues, health represents a foundational component in the assessment of multidimensional well-being, as reflected in global and national indicator frameworks (*e.g.* The Multidimensional Poverty Index, MPI[1]; Equitable and Sustainable Well-being (ESW) indicators in Italy[2]). An increasingly aging population and the sovereign debt and welfare state crisis, thus arise both efficiency and equity issues, making health become ever more central to understanding the sustainability of social and fiscal systems, individual deprivation, and unequal territorial distribution.

Traditional health poverty metrics (Handastya and Betti, 2023; Clarke and Erreygers, 2020; Simões et al., 2016) often focus narrowly on health outcomes or income-based deprivation, neglecting the structural and spatial determinants of access to care and sometimes incorporating monetary factors at most (Chi et al., 2022). Consequently, such measures primarily reflect more health system outcomes, while failing to adequately highlight persistent inequities in access and quality, and the underlying structural determinants driving them.

Therefore, a multidimensional approach to well-being requires shifting the focus of health assessment from its consequences (outcomes) to its underlying causes. This necessitates a comprehensive analysis of various determinants including healthcare system governance and welfare policies; access to specialized medical care; the availability of advanced equipment, nursing, and rehabilitation staff; and territorial characteristics such as urban-rural disparities, and orographic and environmental conditions. Additionally, transport infrastructure, the prevalence of health risk factors at both individual and territorial levels, and financial resources - including household disposable income, savings and health insurance determining out-of-pocket health expenditure and the ability to seek care in other cities or regions - must be considered. Demographic aspects, such as age, household composition, and social support networks, as well as regulatory and organizational factors - such as legal residency requirements for national healthcare coverage - represent conditional factors that may represent supply constraints. Finally, social capital, including the pres-

[1] https://ophi.org.uk/what-global-mpi.
[2] Istat, Rapporto BES.

ence of associations and voluntary sector assistance, further shapes health outcomes (Baglio and Eugeni in Albiani et al., 2022).

This holistic approach is even more essential in countries such as Italy facing both a rapidly aging population (which has a direct impact on the financial resources available, given the U-trend shape of the health expenditure function by age, Pammolli et al., 2018) and deep territorial disparities combined with regional health system governance where *"public health policy is the result of the interaction of several layers of government"* (Bordignon and Turati, 2009).
Moreover, national health expenditure data show a significant increase since the 1990s, while Regions perform considerably differently in terms of output produced, distribution of healthcare system personnel, equipment and technical efficiency (Pammolli et al., 2018). The different Italian Regions' responses to the COVID-19 pandemic have stressed these regional disparities even further, highlighting the importance of healthcare proximity to increase territories' health resilience (Baglio and Eugeni, 2021).

In this paper, we propose a multidimensional territorial approach to properly map health territorial disparities in Italy at the municipality level, estimating a new multidimensional measure of health poverty. In particular, by considering both territories, as the geographic contexts in which health services are delivered, and individuals, as carriers of legitimate health needs, a holistic definition of health poverty is here proposed to develop a first example of a Multidimensional Health Poverty Index (MHPI) structured around three key dimensions: availability, accessibility, and equity of care. As a result, the MHPI enables us to assess individuals' opportunities to access healthcare, whether through public or private provision, the weight of factors such as income, different types of healthcare expenditures, demographics and households' structure, and waiting lists, and how all these elements affect physical and mental health, and the overall quality of care received.

We contribute to the existing literature by developing a novel index at the municipal level in Italy, combining non-compensatory composite indicators with spatial econometric techniques to capture territorial disparities in healthcare availability, accessibility, and equity. Unlike traditional health poverty measures that focus primarily on outcomes or income-based deprivation, our approach integrates both supply- and demand-side factors, offering a more comprehensive and policy-relevant understanding of health poverty in a decentralized healthcare system.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature on multidimensional health poverty and territorial health inequalities. Section 3 briefly illustrate some useful characteristics of the Italian National Health Systems and its regional disparities. Section 4 describes the data sources and methodology used to construct the MHPI index and analyze it, while Section 5 presents the main empirical findings, including spatial patterns, decomposition of the index, and results from spatial econometric models. Finally, Section 6 concludes and discusses policy implications and directions for future research.

2 Literature Review

Few studies so far have defined multidimensional health poverty and measured it. Chi et al. (2022) developed a multidimensional health poverty index for China, using physical, mental, and social health and two socioeconomic factor: relative income poverty — used as necessary condition to be in health poverty — and Catastrophic Health Expenditure, used as a sufficient condition. Applying the Alkire-Foster Multidimensional Poverty Index methodology, Chi et al. (2022) underlines a major contribution of physical and mental health, and monetary dimensions to health poverty levels and the presence of territorial disparities between urban and rural areas, exhibiting higher out-of-pocket medical payments and health deprivation.
Handastya and Betti (2023) estimates health as part of a multidimensional estimate of poverty in Tunisia using the Household Budget and Consumption Survey (HBS, year 2015) and introducing a "Double-Fuzzy approach" to avoid sharp definitions of poor/non-poor households. However, despite an attempt in explaining health dynamics by using some survey questions related to healthcare accessibility, the study still consider health poverty mainly as matter of health deprivation, confirming the existence of a urban-rural divide.
Turning to Western countries, Clarke and Erreygers (2020) measure health poverty in USA and Australia by using panel survey data on three indicators capturing health status (cardiovascular risk, and SF-6D health status index) and a proxy of health quality (life expectancy) and comparing their performances by adopting the popular Foster-Greer-Thorbecke methodology based on measuring the distance of the individual's indicator level from a poverty threshold.
Finally, few studies are available on European countries. One of the most extensive in terms of health index definition, Simões et al. (2016), measures health inequality by considering self-reported health status results on five dimensions (mobility, self-care, usual activities, pain/discomfort,

and anxiety/depression), scoring and aggregating them through a deterministic algorithm for then analyzing the health inequality index determinants and its relationship with other income and wealth inequality and poverty indicators using an ordered probit model.

Therefore, two main lacks seem to arise from these papers. On the one hand, multidimensional health poverty is simply defined as health status or, at most, economic deprivation; two dimensions likely unable to describe alone the efficiency and equity of healthcare systems leading households to health poverty, especially in countries where a national health systems and welfare state are developed. On the other hand, single indicators are mainly used, sometimes associated with innovative methodologies, such as a "double-fuzzy" approach.

As for the first limitation, literature evaluating national healthcare systems can help to identify key dimensions can be taken into account to better define health poverty. Indeed, since the pandemic, both public institutions and academics in many Western countries have been showing an increasing interest in analyzing healthcare systems mainly in terms of output, efficiency, access, and quality of care[3]. In particular, the European Union developed more than one project to promote evidence-based reforms on healthcare systems' capability to respond to crisis[4].

While most of these works are focused on availability and accessibility of care, few studies also include equity dimension. In these studies the concept of equity is mainly expressed in terms of foreigners vs citizens entitlement to care (Baglio et al. in Monica-Georgiana Brînzac et al. (2024)), public vs private healthcare systems (see for instance Toth (2016) or Molander (2025)) and entitlement to special refunds on medicines (Paakkonen and Seppala, 2014), or is closely related to accessibility (Baglio et al. in Albiani et al. (2022)). In fact, according to Campbell et al. (2000) health equity can be divided into horizontal equity — equal accessibility to effective care for all sub-populations — and vertical equity — greater access to effective care for those with more need.

Therefore, equity of care appears a crucial element for a holistic healthcare

[3] Just to mention some of the most recent: In Italy, Vidoli et al. (2024a), Vidoli et al. (2024b), Baglio et al. in Albiani et al. (2022) and in Monica-Georgiana Brînzac et al. (2024), Baglio and Eugeni (2021), and Baglio et al. (2019); in Poland, Rosik et al. (2021); in Spain, Dubas-Jakóbczyk et al. (2024); in France, Bonal et al. (2024) and Chevillard et al. (2018); in France and Germany, Hassenteufel et al. (2020); reviews of works in other Western countries (mainly North America, Australia, and New Zealand), Flinterman et al. (2023).

[4] *E.g.* The OESES project; the ROUTE-HWF project; the AHEAD project.

system evaluation even in countries, such as Italy, that has been mainly characterized by a universalistic public healthcare system. In fact, as illustrated by Toth (2016), the Italian National Health Service (NHS) fails to fully cover all healthcare needs, resulting in households' out-of-pocket health spending and voluntary health insurance accounted for 24.5% of Italy's total health expenditure in 2021 — a share 30% greater than the EU average (OECD and European Observatory on Health Systems and Policies, 2023). Furthermore, in Italy and in many Western countries, income-based disparities often coexist with regional differences so that the quality of healthcare varies significantly by region, with pronounced gaps between inner and urban areas or different geographic areas (*e.g.* in Italy: North-South).

About the methodological limitations, Bankauskaite and Dargent (2007) observes that aggregate measures of demand and supply for health services lack "*precision and combine uncertain weighting systems, imprecision arising from the potential non-comparability of component measures, and misleading reliability in the form of whole-population averages that mask distribution issues*". For this reason, Vidoli et al. (2024b) underlines the importance to study health systems using composite indicators — enabling to measure complex phenomena in a synthetic way thus representing a more useful tool for policy making — and show the greater robustness and reliability of the *Benefit of the Doubt* and the Mazziotta-Pareto methodologies, where the optimal set of weights is chosen endogenously to the data and is consequently independent of the choices made by individual researchers.

However, a more granular mapping is still lacking to identify, at sub-regional level, territories with poor health under a multi-dimensional perspective and how this is related to their socioeconomic characteristics. For this reason, a multi-dimensional, multi-governance levels, and territorial approach is proposed to estimate in a robust way a new Multidimensional Health Poverty Index (MHPI) and properly mapping health territorial and income disparities in Italy at municipality level. This new index will encompass the three key healthcare dimensions arising from the literature and in line with the WHO *AAAQ* framework[5]: availability, accessibility and equity of care. MHPI will be also analyzed in its relationship with the two main healthcare outcomes, multidimensional health status and quality of care, used in the literature as proxy of health poverty.

[5] https://www.who.int/news-room/questions-and-answers/item/q-a-on-the-health-workforce-crisis.

3 Territorial Healthcare Governance and Regional Inequalities in Italy

The Italian National Health Service (NHS) was set up in 1978 by Law no. 833 in order to pursue five key objectives (Toth, 2016):

1. Universality of coverage;
2. Comprehensiveness the services provided;
3. Equity of financing;
4. Predominantly public ownership and unity of administration of providers;
5. Equality of treatment for all citizens.

This explains why availability, accessibility, and equity in healthcare services provided are the most fundamental features to be considered for a complete picture of citizens healthcare possibilities and conditions and thus for multidimensional health poverty in Italy and, in general, in countries characterized by a developed public healthcare system.
This system works through a mix of public and private operators, included the accredited private ones that are affiliated to the public services and thus guaranteeing more favorable economic conditions to citizens with respect to the rest of the private sector. The public side is represented by the NHS, mainly funded through general taxation. However, around one-third of the NHS budget is allocated to private providers. As for governance, the NHS is currently structured on three levels with different specific functions: the national (Ministry of Health), intermediate (regional governments), and the healthcare agencies providing service at local level.
In particular, the NHS structure assigns to regional governments the responsibility of redressing territorial imbalances achieving a set of guaranteed service levels (known as "*essential*" services level, LEA). As a result of the Italian dual economy, intergovernmental grants are the main source of funding in poorer southern regions, and local fiscal revenues are the main source of funding in richer northern and central regions.
In this setting, Italian regions share a common budgeting mechanism and a common institutional framework, but maintain administrative autonomy (even with respect to private expenditure co-financing) facing different local demand and supply factors (for a more complete description of the Italian healthcare system, see Levaggi and Zanola, 2003).

However, Pammolli et al. (2020) analysis highlights the presence of structural regional imbalances at the macro level that cannot be attributed to local factors but derive from technical and price efficiency and different regional supply. This is evident when looking to health expenditure as a percentage of GDP and the single regions contribution

to the overall NHS deficit (Toth, 2015), where in the last 25 years, only Southern regions and Islands increased their total health expenditure and used to account for two-third of the total health system deficit.
Furthermore, regional healthcare systems in Italy differs under a plurality of factors between and within regions, that cannot be restricted to the North-South divide, as this analysis will highlight later. For instance, looking at the OECD and European Observatory on Health Systems and Policies (2023) report, while Italy suffers from a severe shortage of general practitioners of which 55% are over the age of 55, these doctors are much more widespread in the Central and Southern regions (with the exception of Calabria) with respect to the Northern ones. Furthermore, among the seven regions failing to guarantee appropriate access to the Essential Levels of Assistance for their populations in the three macro-areas identified by the Ministry of Health (prevention and public health, outpatient and hospital care), even if most are in the South, two Northern regions appear (Aosta Valley and Bolzano Province) characterized by wide-spread inner areas, a major difficulty for healthcare systems (see Section 5).
Another dimension showing regional disparities is inter-regional healthcare mobility, namely the mobility of patients from one region to another to get better healthcare. In 2022, in the South and Island most of the regions displayed a negative balance between patients received from other regions and resident patients admitted to hospitals outside the region, but this concerns also most of the Central regions and three of the Northern ones (Liguria, Trentino-Alto-Adige, Aosta Valley)[6].
Disparities exist also within regions due to equity factors. The high out-of-pocket spending reported in Section 2 result in higher incomes individuals who can afford extra services beyond what the NHS offers, benefit from shorter waiting times, and have more choice of providers; while, those with lower-income rely primarily on public services and may struggle to access some types of care.

Finally, when turning to infrastructural aspects, we can notice different combination between public and private healthcare inputs that different regional systems have been adopting in the last 25 years. Using Principal Component Analysis (PCA) on ISTAT data[7] to aggregate la-

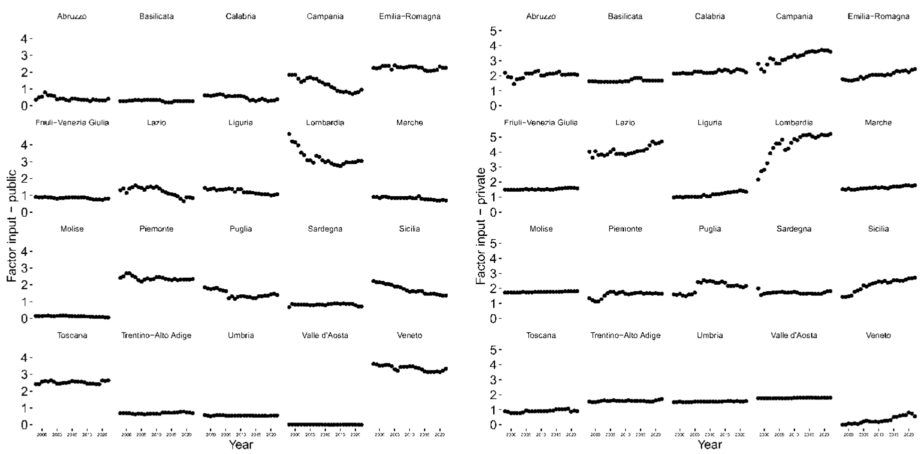
[6] The regions with positive balance are: Piedmont, Lombardy, Veneto, Friuli Venezia Giulia, and Emilia Romagna (NR); Tuscany and Lazio (CR); Molise (SR). Source: Ministry of Health, *Rapporto annuale sull'attività di ricovero ospedaliero - Dati SDO 2022.*

[7] Health For All data, (June 2024 release).

bor (healthcare staff) and capital (equipment and beds) healthcare inputs — selected to be comparable across regions — a striking result emerges. The two inputs factors resulting from PCA, explaining the 80% of the total variance, aggregate according to public and accredited private sector (and the extra-hospital equipment) and show both regional differences in input capacity (level) — reflecting infrastructural disparities — and regional differences in the public-private governance-mix. In particular,

Fig. 1: Healthcare inputs factors from PCA on healthcare staff, equipment and beds. Time series: 1998-2022

(a) Factor 1: public inputs (b) Factor 2: private inputs



the private sector is increasingly expanding against a decreasing weight of the public healthcare system in regions like Lombardy, Sicily, Lazio, and Campania. Conversely, other regional healthcare models, like those of Tuscany and Veneto, show a higher presence of the public sector that remained rather stable during the last 25 years; others, primarily Emilia-Romagna, seem to have effectively calibrated the two. Still others, like Trentino-Alto-Adige (driven by Bolzano Province), Aosta Valley, Umbria, Calabria, and Sardinia, show a more limited health infrastructural capacity combined with a flat trend in both public and private sector, even if the latter seem to show a higher capacity.

4 Empirical Framework

The analysis relies on an original cross-sectional dataset that combines the most recent individual-level survey and administrative data. In particular:

- Administrative data on healthcare supply in terms of physicians by specialty working both in public and in private sector and public and accredited private health facilities' beds for acute, long-term care, and rehabilitation — used to measure availability, accessibility, and equity single indicators;
- Administrative and survey data on gross and disposable incomes useful to derive the At-Risk-Of-Poverty indicator (AROP), income classes and deciles[8]; survey data on consumptions-based relative and absolute poverty, private health expenditure in terms of level and habits, including medical and diagnostic examinations, drugs, healthcare articles, health insurance and insurance refunds[9]; survey and administrative data on health status and unmet medical needs due to financial reasons, distance, and excessive waiting lists length[10]; territorial, demographic, and socioeconomic characteristics population characteristics determining healthcare provision, and health status and risks — used to measure both the main health poverty drivers in different territories, and indicators concerning accessibility, equity of healthcare, and health status indicators;
- Administrative data from National Healthcare Outcomes Plan (PNE, from now on, as known in Italy as Piano Nazionale Esiti) — to measure a Multidimensional Health Quality Indicator (MHQI). Given the extensive nature of this dataset (164 indicators), we focus on a curated subset of outcome indicators spanning multiple clinical areas, selected based on the National Agency for Regional Healthcare Services' criteria to ensure representativeness and relevance in capturing hospital performance[11].

[8] Gross incomes at municipal level come from the publicly available administrative data of Department of Finance (Ministry of economy and finance), while disposable income data come from IT-SILC 2022 survey data.

[9] Source: HBS 2021 survey data.

[10] Source: EHIS 2019 and Health For All 2024 (June 2024 release), used as a residual source for the single indicators forming the Multidimensional Health Status composite Indicator that are not included in EHIS 2019. For more info see: https://www.istat.it/sistema-informativo-6/health-for-all-italia/.

[11] The selected clinical areas and corresponding indicators included are listed in Table A.1.

These data originate from seven distinct databases, which are aggregated at the municipal level and merged to create a particularly rich and unique dataset that, to the best of the authors' knowledge, is being used for the first time in this type of analysis. The single indicators derived from this dataset will feed the availability, accessibility, and equity composite indicators, forming, in turn, the MHPI index.
From a methodological perspective, it is, therefore, evident that we require methods and tools that are inherently non-compensatory (Fusco, 2023; Vidoli et al., 2024a). These should not permit, for instance, the compensation of a low healthcare offering with a relatively higher income level or lower absolute poverty in terms of consumptions, thus enabling a clearer identification of areas within the territory that are significantly disadvantaged across multiple dimensions. Furthermore, dealing with spatial indicators imply checking for spatial autocorrelation and eventually using spatial error models.

In details, the first methodological step implied geolocating private and public hospitals and private health facilities where there are beds for hospitalization, as well as each place where specialized physicians, general practitioners, and pediatricians work including outpatient clinics, and private practices, considering that each doctor can work in more than one place[12]. As a result, *availability* indicators are defined as the standardized coverage rate per resident population of acute, long-term care, and rehabilitation beds in public and accredited private hospitals and other healthcare facilities, along with the standardized coverage rate of general practitioners. pediatricians and specialized physicians (classified into public and private sectors; please see Table A.1 for details).

Secondly, average distances between each municipality centroid and the n beds and the physicians' single working place closer are calculated to derive healthcare *accessibility* measures[13]. Besides average distances, accessibility single indicators include the proportion of people who underwent a medical visit or diagnostic test in the past 12 months and chose a healthcare facility either due to a shorter waiting list or because it was the only available option in their area.

As for *equity* single indicators, following Campbell et al. (2000) definition, we measure horizontal equity indicators considering equal accessibil-

[12] Therefore, if a physician work in a same municipality both in a public hospital and in a private clinic, they count twice.

[13] Where n is the average number by municipality of beds and physicians' working places by type of beds, specialty and governance.

ity to care across population of different territories. and capacity to pay. In particular, households' expenditure in food, health, total consumptions, and incomes data are used to define two indicators widely used in the literature. The first is the Catastrophic health Expenditure (CHE), defined by the WHO. It occurs when a households' amount payed for out-of-pocket health expenditure exceed a pre-defined share of its ability to pay, based on a more or less wide definition of household's income or consumption (Yerramilli et al., 2018). For this analysis, we defined ability to pay by using the actual food spending approach deducting household's actual spending on food from its total consumption and calculating catastrophic spending based on the remaining amount. 25% and 40% are adopted as health spending thresholds, being the two more used in the literature for Western countries[14].

The second type of indicator is the Impoverishment Index implying that a household above an income or consumption-based poverty threshold without considering health expenditures, ends up in poverty after having accounted for it. In this case, we use income-based relative poverty line as defined for of the EU At-Risk-of-Poverty Index (60% of median households' equivalent disposable income). In this way, our equity indicator accounts both for consumption and income-based health poverty measures.

In addition, the Equity composite indicator includes: rates on unmet medical needs due to financial reasons and indicators of public–private relative availability and proximity, namely: (i) the ratio of the number of available public to private places where each specialized physicians works, and (ii) the ratio of the average municipal distance to private versus public places where each specialized physicians works, weighted by the ratio of net to gross health expenditure based on health insurance reimbursements.

Finally, after having checked for single indicators correlations and selected the set of indicators to be included[15], Mazziotta-Pareto methodology (Mazziotta and Pareto, 2016) is used to build availability, accessibility and equity non-compensatory composite indicators not to enable for a compensatory "substitution" among the individual indicators[16].

The three dimensions ultimately form the MHPI index, consistently esti-

[14] However, CHE_25% does not enter in the equity composite indicator estimate as CHE_25% is significantly correlated with CHE_40% and more correlated with the Impoverishment index than CHE_40%.

[15] The full list of single indicators included is available in the Appendix, Table A.1.

[16] BoD and RBoD methodologies are also used for robustness checks. Results are available upon request from the authors.

mated as a Mazziotta-Pareto composite indicator. The same aggregation methodology is used to estimate a multidimensional health status index (MHSI) mainly based on the ESW health domain. Similarly, the Multidimensional Health Quality composite indicator (MHQI) is estimated by aggregating the selected PNE indicators. Details on the indicators forming AvI, AcI, EqI, MHSI, and MHQI are reported in Table A.1.

Overcoming a sharp distinction between the poor and non-poor through an arbitrary threshold, as done by most of poverty analysis, our approach will consider deprivation as a matter of degree in order to identify multidimensional poverty diffusion in the territories and target policy making. Since precise cutoffs for the individual indicators used have not yet been established in the literature, it is not possible to derive MHPI cutoffs as in Chi et al. (2022). Therefore, minimum, maximum values, and quartiles, weighted by the Itlian legal population of 2021, are used to describe MHPI levels and the degree of healthcare deprivation. As the distributions mainly display a negative asymmetry, we define MHPI and it components as: "Very low" — $[min - p(10)]$; "Low" — $(p(10), p(25)]$; "Medium" — $(p25, median]$; "High" — $(median, p75]$; "Very high" — $(p(75), maximum]$.
However, for descriptive purposes we will also quantify health poverty trough the three fundamental poverty measures — *incidence, intensity, and severity* (Cowell, 2011) — implying indicators based on a certain threshold:

- the *Headcount ratio* (incidence), proportion of municipalities considered poor: $H_p = P/N100$; adopting the 75^{th} percentile as threshold for the MHPI, and mirroredly the 25^{th} percentile for MHPI components (AvI, AcI, EqI);
- the *Poverty Gap* (intenisty), to account for heterogeneity among the poor (intensity): $PG = p(75) - \overline{MHPI_p}$, where $\overline{MHPI_p}$ is the average value of the MHPI among the poor $(MHPI > p(75))$ — the same apply for AvI, AcI, and EqI using $p(25)$;
- the *Gini index* (severity), calculated among the poor: $G_p = (2/\overline{MHPI}) * cov(MHPI_m, R^{MHPI_m})$; where $MHPI_m$ is the MHPI value for municipality m and R^{MHPI_m} is the fractional multidimensional health poverty rank of municipality m , considering municipalities with $MHPI > p(75)$ — used for MHPI indicator only.

Finally, *health inequality* is also measured by calculating the Gini index on the whole municipality population.

After having observed the main territorial dynamics through maps and territorial descriptive statistics, the analysis follows by investigating how the single health poverty dimensions contribute to the MHPI. Subsequently, spatial auto-correlations are identified and spatial error models estimated to assess the relation between health status and health quality with health poverty and its dimensions, as well as that of MHPI with the main poverty indicators, the degree of urbanization, the population structure, health expenditure by prevalent type of expense, type of household, and healthcare system efficiency.

5 Key Results

5.1 Determinants and Spatial Patterns of the Multidimensional Health Poverty Index

Having developed a new multidimensional index, a first crucial step is decomposing it to assess the extent to which each identified dimension contributes in explaining the overall index. Figure 2a shows the correlation matrix plot among the Multidimensional Health Poverty Index and the Availability (AvI), Accessibility (AcI) and Equity (EqI) composite indicators.

Firstly, it is worth noting that the three dimensions are weakly correlated with each other, but strongly correlated with the MHPI. This indicates that each composite indicator contributes unique and relevant information to the multidimensional index, without redundancy or loss of informational value due to overlap.

Secondly, each dimension contributes to a similar extent in describing health poverty underlining the relevance of analyzing them together.

However, Figure 2b shows that availability, accessibility and equity play a different role according to the level of health poverty experienced by territories. In particular, in the extreme situations, when health poverty is particularly *low* or *high*, this appears to be chiefly driven by issues in guaranteeing equity in healthcare services, and, for high levels of MHPI only, also accessibility has a relevant weight. When the health poverty level is less severe but still high, the weight of its three components seems to rebalance and the availability of public and private medical services and beds become the most relevant when health poverty stands at intermediate levels.

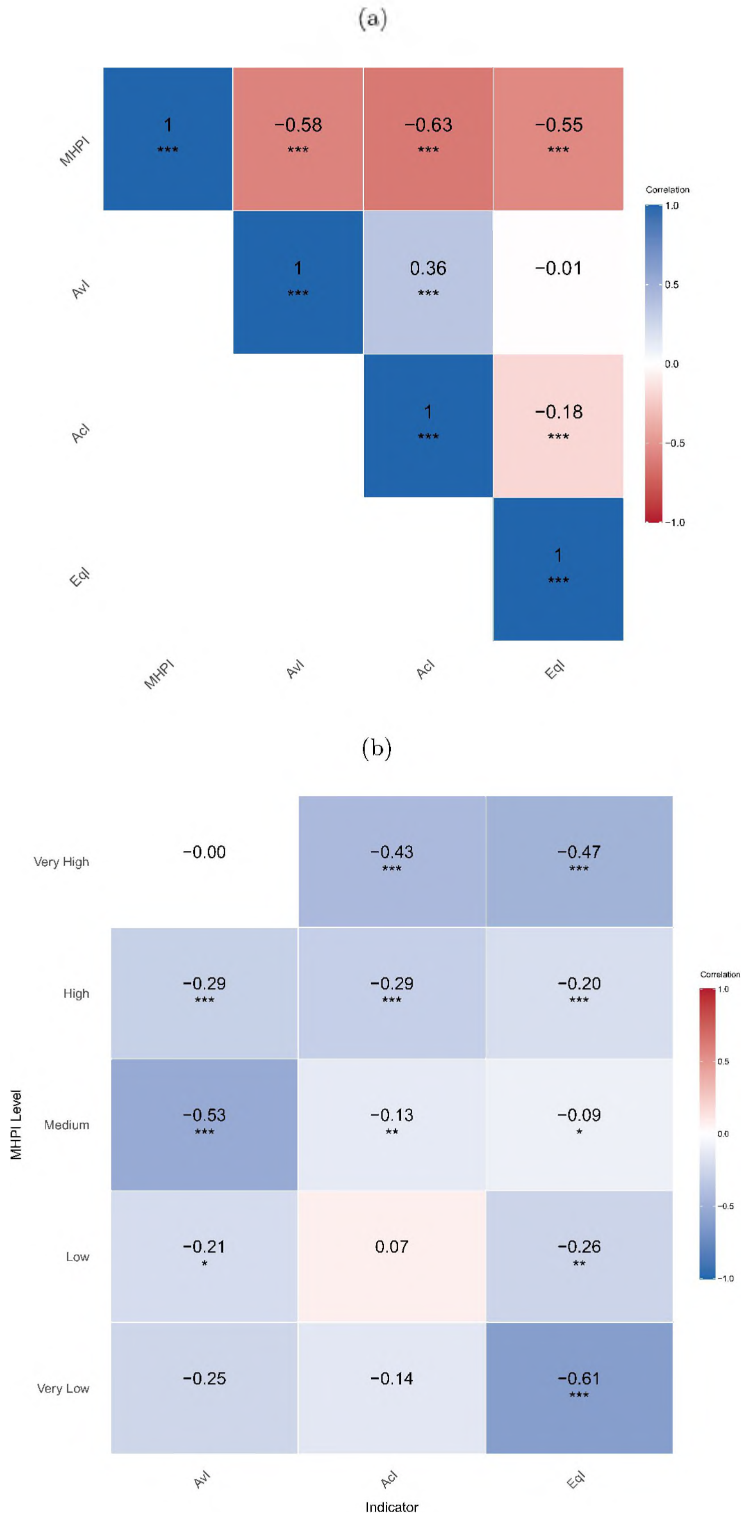
Therefore, while guaranteeing a good balancing among availability, accessibility and equity of care turns out to be important to keep health poverty stable, improving the equity in healthcare provision across Italian territories appears the most effective feature to invest on both to keep health poverty low and to decrease it in areas where availability, accessibility and equity are particularly lacking.

Similarly, a preliminary visual analysis supports the validity of adopting both a multidimensional and territorial approach to measure health poverty. Indeed, the maps corroborate that availability, accessibility, and equity capture distinct aspects of the phenomenon, with significant variation observed not only between regions but also within them.
Overall, availability and accessibility poverty incidence is rather high as 65% of municipalities suffer from low or very low coverage rate of healthcare beds and services, while in the 68% healthcare accessibility is not sufficiently guaranteed (Table A.3). While equity of care levels are on average lower than their availability and accessibility virtually in all the regions and at national level, poor equity incidence is less severe. In fact, only the 24% of municipalities display low or very low equity levels, underling that the Italian National Health System is still partially holding its universal dimension.

As for healthcare *availability* (Figure 3a) a rather high intra-regional variability is observed, as corroborated by the highest Gini index among the three MHPI components (Table A.5). This is true both in regions like Lazio — where a sharp contrast exists between the capital and the outlying areas furthest from it — and in regions characterized by a prevalence of inner areas like Molise and the Autonomous Province of Bolzano — displaying the highest poverty intensity (PG) and incidence (H_p) in healthcare availability, the last peaking at more than 80%.
Indeed, as expected, healthcare services coverage tends to be statistically significantly higher around large cities and in territories with high or medium density and lower in rural areas and along the Alps and Apennine mountain chains (Table A.6). Among these areas, Aosta Valley and Basilicata exhibit the lowest weighted average healthcare availability across regions and, as for Basilicata, low inequality (Table A.5), showing a certain intra-regional coherence in low availability of healthcare services.

Similarly, *accessibility* shows a clear orographic and inner areas pattern, while displaying a more pronounced territorial concentration resulting in lower inequalities (Figure 3b and Table A.5). Regions like Aosta Valley, Sardinia, Basilicata, and Bolzano Province exhibit both the low-

Fig. 2: Correlation matrix plots between MHPI and its three dimensions, overall (a) and by MHPI levels (b).



Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.001$

est regional weighted average accessibility values (Table A.2), but also the highest AcI poverty intensity and incidence, so that in Aosta Valley the 99% of municipalities suffer for inadequate accessibility to care (Table A.3). However, some of these regions also display the strongest intra-regional AcI inequalities, with the Gini indexes doubling the national one. In particular, while all Sardinia provinces rank among the six lowest territories for accessibility levels, Cagliari is among the 15 best. Similar inequalities are found in Liguria between Genova (the province with the highest AcI level) and the Ponente provinces (Imperia and Savona) and in the southern and coastal part of Tuscany (Grosseto, and Livorno provinces), likely due to centralized regional healthcare system structures characterized by few big public structures in the metropolitan areas and richest provinces, and, in Tuscany, a limited spread of the private sector. At the opposite side, Emilia-Romagna and Campania, seem to guarantee the highest healthcare accessibility to their citizens both in absolute terms and exhibiting the lowest ratio of municipalities with scarce access to care (H_p Table A.3) and the lowest inequality in accessibility levels (G; Table A.5), followed by Veneto and Lombardy, also displaying among the lowest AcI poverty intensity in Italy (PG; Table A.4).

The typical North–South divide characterizing Italy is more clearly evident in the *equity* dimension, in line with the main poverty and inequality indicators (Figure 3c). However, territorial variability is rather high both inside geographic areas and regions.

Northern and Central regions generally display high weighted average levels of healthcare equity (Table A.2). Though, Umbria, Friuli-Venzia-Giulia, Piedmont, and the Autonomous Province of Trento are the regions mostly guarantying horizontal equity in care in terms of levels and in terms of incidence, only Trento seem to keep low levels of both EqI poverty incidence, intensity and inequality, while in Piedmont, Umbria, and Friuli, EqI PG is higher revealing some inequalities in healthcare equity among the municipalities displaying low EqI levels (Table A.3 and Table A.5).

Interestingly, the differences in the healthcare systems of the two Autonomous Provinces of Trentino-Alto Adige sharply emerges in the equity dimension, literally splitting in two the region. While Trento and Bolzano performs similarly in terms of availability and accessibility of healthcare, almost 90% of Bolzano municipalities display scarce or medium equity values.

Conversely, the six regions with the lowest average levels of healthcare eq-

uity are all located in the South and in the Islands (Campania, Calabria, Molise, Sardinia, Sicily, and Abruzzo), so much that, besides being characterized by the highest EqI inequalities levels, low or very low healthcare equity involve more than 70% of municipalities placed in Calabria and Sicily, peaking at 90% in Molise (H_p ; Table A.3).
In contrast with availability and accessibility of medical services, healthcare equity tends to be significantly lower in medium or high densely populated areas included metropolitan areas, likely reflecting higher levels of poverty and income inequality (Table A.6).
Further exploring the relationship between equity and the other dimensions, Figure 2a shows that equity and accessibility exhibit a low but significant negative correlation. Indeed, in Italy there are territories displaying a high accessibility of healthcare services — merely measuring the distance from them and the weight of waiting lists and territorial availability of services in the patients' choice — but a low or even very low socioeconomic equity in this access, mainly due to unmet medical needs and excessive health expenditures with respect to households' budget (CHE and impoverishment indicators)[17].
Therefore, even when territories ensure widespread healthcare facilities this does not automatically result into guaranteeing right to healthcare for all citizens, as in the case of when accessibility is achieved by spreading private healthcare facilities. In a few words, when it comes to providing healthcare, the private sector (even including the accredited private one) cannot perfectly replace universal public services when both equity and efficiency goals are pursued, and not even considering efficiency alone, as showed by the recent study on OECD countries (Molander, 2025).

When turning to multidimensional health poverty, the map in Figure 4 makes evident a marked prevalence of high or very high health poverty levels in Italy. In fact, only 2% of Italian municipalities display low or very low levels of health poverty, while MHPI poverty incidence reveals that the 57% suffer from high or very high health poverty levels (Table A.3).
The the poverty and inequality indicators and the map visually corroborate the double-Italian-divide. In fact, Southern regions and Northern inner areas display the highest health poverty levels. Looking at regional weighted averages, Sardinia, Calabria, Molise, and Aosta Valley, are the

[17] This is the case of Naples, Caserta, Catania and Cagliari provinces where rates of people giving up medical care due to economic reasons or too long waiting lists can peak at average values of 16%, doubling national average.

health poorest regions (Table A.2) and, along with Sicily, and Bolzano Province turn out among the highest poverty intensity and incidence, peaking at 90% or more of municipalities with high or very high health poverty levels (Table A.3 and Tabel A.4). It should be noted that these are all regions that in 2021 failed to meet adequate levels of the performance indicators identified by the Ministry of Health to monitor the ensuring of Essential Levels of Assistance (see section 3).
The urban-rural areas divide is also corroborated by regressions in Table A.6 showing that health poverty is significantly higher in more densely populated territories and in metropolitan areas, thus reflecting more the availability and accessibility of services trend than the equity one.

However, the factors driving these results differ across regions. A high health poverty in Aosta Valley is mainly driven by a particularly scarce availability and accessibility to healthcare facilities, due to their prevalence of inner areas. Both accessibility to healthcare services and their equity are the main issue resulting in high health poverty for Bolzano Autonomous Province, while for Molise and Calabria the driver is mainly an equal access to care.
Finally, Sardinia presents the most concerning situation, with all its provinces ranking among the twelve territories exhibiting the highest levels of health poverty (except for Cagliari scoring high for accessibility but low for equity), and considering the higher costs of medical tourism towards the Peninsula for people living in a island with widespread inner areas and consumption and income-based relative poverty much above national average levels.

At the other end of the spectrum, Lazio, Emilia-Romagna, Umbria, and Liguria turn out to be the regions with the lowest multidimensional health poverty levels (Table A.2). However, besides regional average, only Emilia-Romagna consistently displays the lowest poverty incidence and all its provinces ranking among the twenty provinces with lowest MHPI scores, though having higher levels of health poverty severity (G_p) and inequality (G) with respect to the other three regions, likely driven by the Apennine part of the region (Table A.5). Indeed, significant intraregional variability is evident even in the most virtus regions, especially in the Northern and Central ones. In Liguria, for instance, Genova is the province displaying the second lowest health poverty level in Italy (preceded by Trieste), mainly thanks to the high accessibility and equity performance of its healthcare system, while scarce accessibility makes the already mentioned Ponente part of the region (Imperia and Savona

provinces) among the healthy poorest ones. Similarly, in Lombardy, while Milan benefit from relatively low health poverty levels, Bergamo, and Sondrio score among the twenty provinces with highest health poverty levels, mainly due to equity issues for the first one[18], and to poor accessibility for the latter one.
Another striking example is Tuscany, where Grosseto is among the twenty provinces with the highest MHPI levels, and also Livorno, Siena, and Pisa have high average poverty levels, whereas Florence and Prato are among the 15th lowest Italian provinces for health poverty in Italy, mainly due to healthcare accessibility reasons. Finally, the good performance of Lazio is driven by Rome metropolitan area, while mainly Viterbo, but also the provinces of Rieti, Frosinone, and Latina suffer from high health poverty average values.

To summarize, the analysis makes emerge different healthcare governance models resulting in different health poverty levels according to how much territories invested in availability, accessibility and, in particular in the equity of healthcare, being the dimension reflecting the most the public-private governance mix illustrated in section 3.
In particular, the analysis brings out four different types of models with different MHPI components' outcomes:

- *Increasingly private* models, like in the case of Lombardy, Lazio, Campania, and Sicily (just partially Apulia and Marche) characterized by high availability and accessibility of healthcare facilities, and by among the lowest healthcare equity both in terms of levels and in terms of prevalence in their municipalities, resulting in medium or high health poverty average levels (with the exception of Lazio driven by Rome results), with incidence over the 60%, and among the highest MHPI intensity, severity and inequality, due to high intra-regional variability — few big cities with low health poverty levels (Milan, Rome, and Palermo) and provincial areas suffering from high or very high health poverty levels (mainly in Lombardy, and Campania);
- *Steadily public* models, as occurs in regions like Tuscany, Friuli-Venzia Giulia, Piedmont, the Province of Trento, and Veneto, where accessibility and availability are below or in line with national average, while exhibiting high healthcare equity both in terms of levels and in terms of low EqI poverty incidence. This results in mainly medium health poverty levels at regional level, with some disparities in the inner ar-

[18] Bergamo province CHE_40% is almost three times higher than at national level and in certain municipalities distances of public doctors is even seven times higher than the private ones.

eas of the Northern regions or for the poorest provinces of Tuscany where few big healthcare centers (such as Florence) guarantee excellent performances while the other part of the region suffer from lack of offer as the public sector is not investing and the private one is not allowed to invest by the regional governance;

- *Public-private balanced* models, mainly the Emilia-Romagna cas,e characterized by a good balancing between public and private services, guaranteeing high levels of availability and accessibility in healthcare, and good equity performance, resulting in the region with the least multidimensional health poverty both in terms of levels and in terms of territorial prevalence (incidence). Similar results are found in Liguria and Umbria, though characterized by lower infrastructural capacities and, in case of Liguria, higher incidence, intensity, and inequality in accessibility;
- *Poorly public and private* models, characterizing regions like Aosta Valley, Bolzano Province, Abruzzo, Molise, Basilicata, Calabria, and Sardinia where both the public and the private sector struggle to guaranteeing appropriate healthcare services, even if the private has a greater infrastructural capacity, also due to long financial recovery plans imposed by the central government. In these regions, inner areas, poor public investments, corruption, and scarce socio-economic indicators, result in high or very high health poverty mainly caused by poor accessibility and equity of care.

5.2 Second-stage Analysis

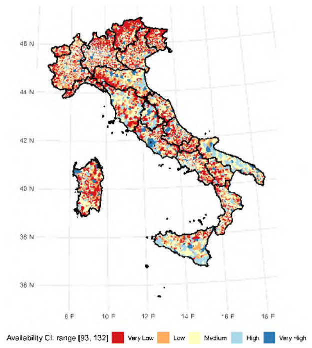
Following the definition of multidimensional health poverty, we turn to the identification of the territorial, demographic, and socioeconomic factors that may shape its distribution. Therefore, a first OLS regression is estimated (please see Tables 1 and 2, column (1)) with the MHPI as the dependent variable and the degree of urbanization[19], the municipality population structure[20], and the consumption and income-based relative

[19] We use two dummy variables: (i) *high_urbanization_degree* — equal 1 for cities and highly densely populated areas and equal 0 for both small cities and areas with intermediate density and rural areas and low densely populated areas ; (ii) *low_urbanization_degree* — equal 1 for rural areas and low densely populated areas and equal 0 for both cities and highly densely populated areas and small cities or areas with intermediate density. Classification is based on Istat classification elaborated in collaboration with Eurostat (Cfr. Reg. UE 2017/2391).

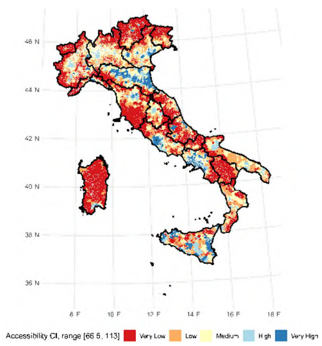
[20] Population rate by age class over total population.

Fig. 3: Maps on Availability, Accessibility, and Equity composite indicators at municipal level.

(a) AvI



(b) AcI



(c) EqI

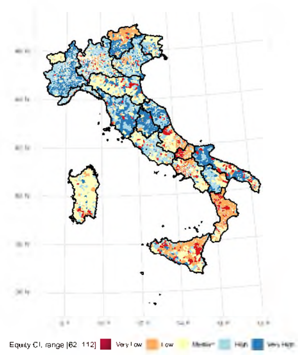
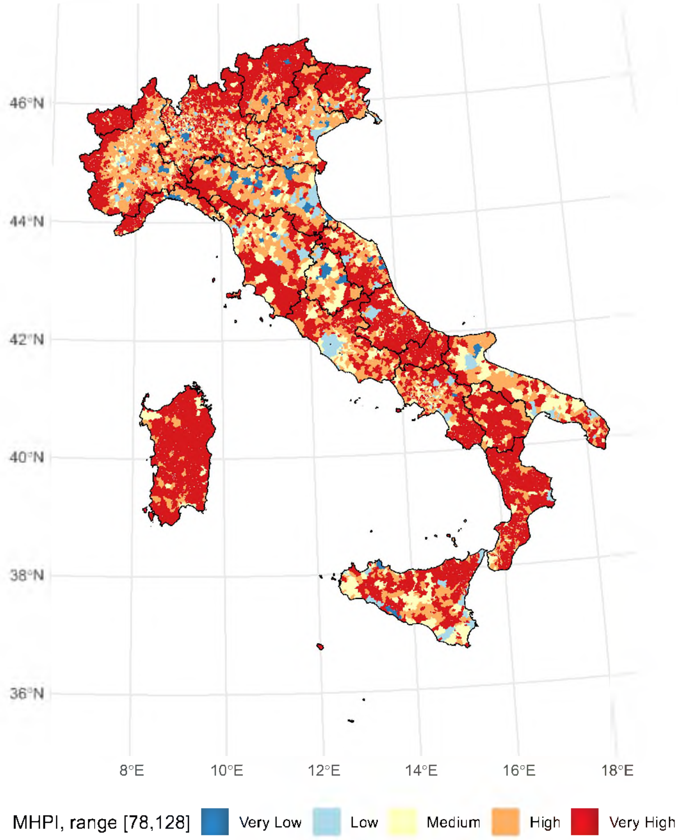


Fig. 4: Multidimensional Health Poverty Index at municipal level.



poverty indicators (both expressed as percentage over the whole population)[21] as covariates.

The linear baseline model demonstrates a good overall fit, despite some violations of standard assumptions; notably, Moran's I test indicates a strong positive spatial autocorrelation in the residuals (Figure A.1), indicating that neighboring municipalities tend to exhibit similar levels of health poverty and its components, due to the presence of spatial elements we are not considering in this analysis, thus resulting in upper biased results from OLS regression.

To address this issue, a Spatial Error Model (SEM) is employed, which incorporates a spatial contiguity matrix to capture the spatial dependence in the error terms.

The estimations presented in Table 1 column (2), corroborate the urban-rural dynamics previously illustrated; residing in a high densely populated area is associated with a significant lower health poverty level of almost 14% (-6.8 points) whereas living in rural areas is associated with a significant higher degree of health poverty (+5%; +2.6 points).

When adding interaction terms between different degrees of urbanization and high levels of availability, accessibility and equity (model specifications 3 to 5), interestingly the urban-rural divide does not occur anymore when availability levels are high. In particular, making healthcare facilities available over a certain level decreases health poverty almost at the same extent regardless the type of territory where people live: around 15% (from -7.3 to -7.4 points) in rural areas and around 17% in urban areas (from -8.2 to -8.5, according to different model specification), resulting in an almost automatic progression from one health poverty class to the next one[22].

Wile ensuring high equity in access to care in urban areas is almost as much as effective as guarantying high availability of healthcare facilities, since equity is already higher in rural areas, high equity levels produce a much lower effect in these territories. Conversely, increasing accessibility turns out to be more effective in rural areas than in urban ones (health

[21] The first indicator (*cons_based_rel_pov_rate*) based on consumption, measures the share of individuals in a municipality whose equivalent consumption expenditure is less than or equal to the national average per capita consumption expenditure. The second, the At-Risk-of-Poverty (AROP) indicator is based on disposable income and captures the share of individuals whose household equivalent disposable income is below 60 percent of the national median.

[22] Considering that MHPI classes width is between 3 and 8 MHPI points, except for the "very high" level class.

poverty reduction from 3% to 4%), where high accessibility levels does not seem to translate in a significant change in health poverty or even in a limited increase (around 2%.) This can be understood if looking to the territorial analysis results previously illustrated, revealing the presence of big cities mainly placed in the southern regions where high accessibility is concurrent with high health poverty levels.
This result, robust to different model specification, underlines the importance of acting on inner areas, especially on availability and accessibility of healthcare facilities, to reduce health poverty levels.

Population structure and income and consumption-based relative poverty indicators are consistent with the expected results and coefficients are robust to different models specifications. MHPI decreases slightly but significantly in municipalities where the rate of younger people (especially between 5 and 25 years old) marginally increases with respect to the over 74 rate.
Similarly, a 1 percentage point increase in at-risk-of-poverty index results in a greater health poverty level ranging from 6% to 11% (+3.1 — +5.6 points, according to the different model specifications). Indeed, when introducing the interaction terms previously illustrated, part of the poverty rate impact is absorbed by these factors, ending up being not significant when technical efficiency effect is considered (specification (5)). The same sign with a much weaker effect size is displayed by the consumption-based relative poverty index correlation.
This means that households whose equivalent disposable income decreases under the relative poverty threshold are more likely impoverished by health expenditure thus having a significantly higher probability of ending up in health poverty for equity reasons. Conversely, when households have to reduce their consumption so much to finish under the consumption-based poverty threshold, apparently this does not significantly reflect in an increase of health poverty due to equity reduction.
On the one hand, this could be driven by the fact that households try to keep health consumption stable avoiding to give up the treatments, as well as the non-food consumptions reduction is not so marked to end up in a catastrophic health expenditures. On the other hand, households could similarly reduce the expenditure of each part of their consumption basket so that the equity sub-indicators do not consistently change, since, by construction, they are not sensitive to limited changes in consumptions choices. In the first case the substitution effect prevails, in the second case, the income effect is greater.

In any case, the strong and stable impact that being at-poverty-risk seems to have on health poverty (except in equation 5) further support the idea that in contexts of very high health poverty, equity is the main factor to act on and could suggests that in the current Italian healthcare system, socioeconomic conditions are becoming more and more essentials for the healthcare to be guaranteed, likely due to the widespread role of the private sector and that played by the healthcare mobility across regions.

SEM specification in column (4) (Table 2) introduces a set of variables to understand on which households' category or type of expense is crucial to act to reduce health poverty[23]. While household composition seems to have a limited role — only marginally related to households with children — when in a municipality out-of-pocket health expenditure is prevalently composed either by pharmaceuticals (*prevalent_hexp_pharma*) or by medical visits, examinations, and hospitalizations (*prevalent_hexp_visists_exam_hosp*) with respect to a prevalently spending in caring elderly and people with disabilities, health poverty is lower by around 7% in the first case (model specification (5)), and by less then 3% in the second case.
This indicates, on the one hand, that children are the category at higher health poverty risk, likely due to both their worsen economic conditions (higher income poverty in Italy according to Istat data) and due to a greater health expenditure especially in the early years of life (the "U" health expenditure trend). On the other hand, more than 65% of Italian provinces has at least one forth of municipalities spending more on elderly and people with disabilities' care than on pharmaceuticals, visits and examinations, underling the real healthcare emergency that countries with an increasingly aging population are facing, also considering that this type of expense is normally more onerous than others. This is even more concerning considering OECD data (OECD and European Observatory on Health Systems and Policies, 2023) revealing that, despite having one of Europe's most aged populations, Italy's relative budget allocation for long-term care amounted only to less than 10% in 2021 (more than 6

[23] The first set of variables is the municipality rate of households' by four categories: couples, couples with children, single-parents households and residual categories (*hexp_others_households_rate*), and singles, used as reference category. The second set is the municipality rate of households whose total health expenditure is prevalently addressed to: (i) pharmaceutical expenses; (ii) visits, examinations, and hospitalizations; (iii) care of elderly and people with disabilities (including expenditure on caregivers, assisted living residence, sanitary articles and their repair), used as reference category.

percentage points below the EU average).

The last SEM specification (column (5)) considers a crucial structural aspect that can affect multidimensional health poverty: technical efficiency. This indicator has been estimated at regional level from "Health For All" Istat data (being unavailable at more granular level) using the Stochastic Frontier Analysis and considering healthcare system output composite indicator[24] and the single public and accredited private inputs used for the analysis in section 3[25] . Interestingly, it can be noticed that when a healthcare regional system marginally improves efficiency in the use of healthcare capital and labor, it can reduce health poverty by 83% (−41.2 points), virtually explaining most of the MHPI variability so that even poverty indexes turn out to be not significant. This is a crucial result indicating that equity (included in the MHPI) and efficiency goals can be pursued in parallel in the Italian healthcare system by looking at the regional models that better combine the two, such as Emilia-Romagna, and adapting these schemes to make them interact with territories having different characteristics.

Finally, the relationship between the MHPI and both the Multidimensional Health Status Index and the Multidimensional Health Quality Index — often used as a proxy for health poverty — are analyses as robustness check. SEM results reported in the Appendix (Table A.7) show, on the one hand, the expected sign — a negative correlation, indicating a decreasing in health status and health quality when health poverty increases. On the other hand, the small effect size (0.2% for MHSI and 0.1% for MHQI) reveals that neither health status nor health quality, not even in a multidimensional form, seem to be good predictors for a health system global performance as often used in the literature. This is mainly due to a partial decoupling between some of the health poverty components and health status or quality, where especially high accessibility of healthcare services can be compatible with low average health status or quality levels, like in the Southern territories (*e.g.* in Campania and Sicily).

[24] Output indicators used to build the Robust Benefit of the Doubt Output Composite Indicator reflect hospital and extra-hospital territorial healthcare and pharmaceutical care.

[25] Note that, although efficiency is related to availability as reflecting healthcare inputs but also to some EqI single indicators, the weak correlation displayed makes the risk of endogeneity very limited. In particular, these are the correlations: Eff. and AvI — -0.05**; Eff. and AcI — 0.19**; Eff. and EqI — 0.31**

Table 1: OLS and Spatial Error Model results – Dependent variable: *MHPI* - part 1

	OLS(1)	**SEM(2)**	**SEM(3)**	**SEM(4)**	**SEM(5)**
high_urbanization_degree	-4.266^{***}	-6.784^{***}			
	(0.364)	(0.393)			
low_urbanization_degree	2.601^{***}	2.487^{***}			
	(0.148)	(0.154)			
high_AvI_*high*_urb_deg			-8.512^{***}	-8.220^{***}	-8.264^{***}
			(0.660)	(0.658)	(0.654)
high_AvI_*low*_urb_deg			-7.297^{***}	-7.271^{***}	-7.387^{***}
			(0.372)	(0.368)	(0.367)
high_AcI_*high*_urb_deg			0.754	1.179^{**}	1.133^{*}
			(0.595)	(0.592)	(0.584)
high_AcI_*low*_urb_deg			-1.457^{***}	-1.815^{***}	-1.620^{***}
			(0.517)	(0.514)	(0.511)
high_EqI_*high*_urb_deg			-7.050^{***}	-7.513^{***}	-7.368^{***}
			(0.653)	(0.650)	(0.645)
high_EqI_*low*_urb_deg			-0.297^{**}	-0.287^{*}	-0.063
			(0.147)	(0.147)	(0.147)
Population rate by age class - reference category: over 74 years old					
pop_0_4_rate	0.181^{*}	0.101	0.004	-0.002	0.057
	(0.103)	(0.091)	(0.087)	(0.086)	(0.086)
pop_5_14_rate	-0.404^{***}	-0.145^{***}	-0.233^{***}	-0.223^{***}	-0.205^{***}
	(0.052)	(0.047)	(0.045)	(0.044)	(0.044)
pop_15_24_rate	-0.064	-0.053	-0.167^{***}	-0.138^{***}	-0.160^{***}
	(0.050)	(0.047)	(0.045)	(0.045)	(0.044)
pop_25_44_rate	0.053	0.025	-0.004	0.012	-0.042
	(0.037)	(0.035)	(0.033)	(0.033)	(0.033)
pop_45_64_rate	-0.133^{***}	0.005	0.0003	0.003	0.013
	(0.036)	(0.035)	(0.033)	(0.033)	(0.033)
pop_65_74_rate	0.062	0.051	0.059	0.057	0.032
	(0.051)	(0.046)	(0.044)	(0.044)	(0.044)
cons_based_rel_pov_rate	0.044^{***}	0.022^{**}	0.063^{***}	0.072^{***}	0.029^{***}
	(0.009)	(0.011)	(0.010)	(0.010)	(0.010)
AROP_rate	5.613^{***}	4.517^{***}	3.283^{***}	3.127^{***}	0.368
	(0.587)	(0.642)	(0.621)	(0.617)	(0.648)
Constant	103.526^{***}	98.943^{***}	103.321^{***}	105.088^{***}	139.278^{***}
	(2.333)	(2.239)	(2.143)	(2.245)	(3.453)
Observations	7,896	7,896	7,896	7,896	7,896
R^2	0.160				
Adjusted R^2	0.159				
Log Likelihood		$-23,937$	$-23,596$	$-23,519$	$-23,439$
σ^2		23.505	21.460	21.022	20.722
Akaike Inf. Crit.		47,901	47,226	47,083	46,924
Wald Test (df = 1)		$1,815^{***}$	$1,997^{***}$	$2,050^{***}$	$1,808^{***}$
LR Test (df = 1)		$1,478^{***}$	$1,564^{***}$	$1,565^{***}$	$1,494^{***}$

Note: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 2: OLS and Spatial Error Model results – Dependent variable: *MHPI* - part 2

	OLS(1)	**SEM(2)**	**SEM(3)**	**SEM(4)**	**SEM(5)**
Health expenditure rate by type of household - reference category: singles					
hexp_couple_rate				-0.030^{**}	-0.004
				(0.014)	(0.014)
hexp_couple_with_children_rate				-0.042^{***}	-0.039^{***}
				(0.011)	(0.010)
hexp_others_households_rate				0.005	-0.002
				(0.014)	(0.011)
Prevalent type of health expenditure - reference category: care of elderly and people with disabilities					
prevalent_hexp_pharma				-3.275^{***}	-3.419^{***}
				(0.295)	(0.292)
prevalent_hexp_visits_exam_hosp				-1.280^{***}	-1.433^{***}
				(0.260)	(0.259)
technical_efficiency					-41.220^{***}
					(3.212)
Constant	103.526^{***}	98.943^{***}	103.321^{***}	105.088^{***}	139.278^{***}
	(2.333)	(2.239)	(2.143)	(2.245)	(3.453)
Observations	7,896	7,896	7,896	7,896	7,896
R^2	0.160				
Adjusted R^2	0.159				
Log Likelihood		$-23,937$	$-23,596$	$-23,519$	$-23,439$
σ^2		23.505	21.160	21.022	20.722
Akaike Inf. Crit.		17,901	17.226	47.083	46.924
Wald Test (df = 1)		$1,815^{***}$	$1,997^{***}$	$2,050^{***}$	$1,808^{***}$
LR Test (df = 1)		$1,478^{***}$	$1,564^{***}$	$1,565^{***}$	$1,494^{***}$

Note: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

6 Final remarks

This analysis emphasizes that a territorial and multi-dimensional approach to measure health poverty by synthesizing dozens of indicators in a single composite one, turns out to be a useful tool both for policy makers and for health administrators to: (i) identify which territories and households' groups are most disadvantaged in terms of health; (ii) understand which are the healthcare dimensions to act on in order to address territorial disparities in healthcare systems,; (iii) ensure both efficiency and equity of local healthcare systems. Though being a micro-evaluation, this study highlights a methodological approach that can be helpful not only for Italy, but also for other countries where national health systems are developed, their governance is complex and their territories display different socioeconomic and geographical characteristics.

Therefore, rather than focusing solely on health deprivation, as much of the existing literature does, we propose a novel Multidimensional Health Poverty Index that incorporates the availability, accessibility, and equity of healthcare services using a particularly rich and unique dataset, combining survey and administrative data aggregated at municipal level. It conceptualizes, therefore, health status as an outcome shaped by healthcare systems that, right in countries with high average health outcomes, are increasingly reducing the availability and equitable access to healthcare — driven by the ongoing welfare state crisis — pushing citizens into health poverty. This approach provides a holistic assessment of health poverty using robust, non-compensatory composite indicators, powerful tools to inform policy recommendations, especially considering the granularity of data enabling to overcome the regional level analysis normally carried out to study the healthcare system.

By analyzing health poverty incidence, intensity, and severity and health inequality, the study confirms the value of adopting both a multidimensional and territorial approach to measuring health poverty. On one hand, availability, accessibility, and equity capture distinct dimensions of the phenomenon and each significantly contribute to explaining it. On the other hand, substantial variation is observed not only between regions but also within them.
The main results indicate that while equity shows a more pronounced North-South divide and appears lower in more densely populated areas-the availability and accessibility of healthcare follow a clear urban–rural pattern, with significantly higher levels observed in more densely populated areas—albeit with some distinctions between the two indicators. While access to health services shows a marked regional footprint, availability appears to vary more significantly within regions.
Furthermore, correlation plots reveals that ensuring equity, by finding a good balance between public and private services and limiting the rate of people forced to giving up the care or impoverished by health expenditure, appears the most crucial actions for reducing health poverty both in areas where it is particularly high and to maintain low levels of health poverty in territories where it is already limited.
Also, performances of regions with a strong public healthcare system and the partial decoupling between accessibility and equity of care, show that financing the private sector cannot perfectly substitute an universal public system to achieve both efficiency and equity purposes.

When considering multidimensional health poverty, Italy shows a significant concentration of high-poverty areas, affecting 57% of its municipalities. Furthermore, the double North-South and urban–inner area divide, along with high intra-regional variability remain evident, even in the regions with the lowest health poverty levels (especially Lazio, Emilia-Romagna, and Liguria). Overall, four different healthcare territorial models emerge, promoting a system where public and private healthcare sector are balanced and equity and efficiency trade-off is limited, like in Emilia-Romagna.

Spatial error models corroborate these results and show the necessity of not limiting health poverty analysis to health deprivation, advocating instead for a more comprehensive, multidimensional approach seen the poor correlation of the MHPI with both Multidimensional Health Status and Quality indicators .
At the opposite, a strong correlation exists between multidimensional health poverty and the main other relative poverty indices, indicating the foremost role that socioeconomic conditions are assuming for households' healthcare to be guaranteed, likely due to the private sector spreading and the role of "healthcare tourism", thus underlying one time more the equity centrality. Similarly, households' whose prevalent healthcare expenditure is absorbed by the care of elderly or people with disabilities turn out to be at higher health poverty risk, underlying another equity-relevant emergency in aging countries like Italy.
Furthermore, more technically efficient regions incur a markedly lower health poverty level corroborating the possibility of pursuing both equity and efficiency goals in healthcare.
Finally, bringing availability and, to a lesser extent, accessibility of services over a certain level, produce a marked and significant reduction of health poverty that is similar between urban and rural areas or even higher for the latter one, confirming the importance and the economic convenience of investing in inner areas.
However, the spatial autocorrelation of errors revealed by the Moran test highlights the need for further analysis using spatially constrained clustering algorithms to identify broader areas of the country that are systematically disadvantaged.

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Table A.1: Details on AvI, AcI, EqI, MHSI, and MHQI composition

ingle Indicator	Definition (a)	Year	Polarity (b)
andardized coverage rate - gen-al practitioners	Standardized rate of general practitioners per 1,500 municipal inhabitants over 14 scaled by age	2023	+
andardized coverage rate - pedia-icians	Standardized rate of pediatricians per 1,500 municipal inhabitants under 14 scaled by age	2023	+
andardized coverage rate - spe-alized physicians (public)	Standardized rate of public places where each specialized physicians works per 10,000 municipal inhabitants scaled by age	2023	+
andardized coverage rate - spe-alized physicians (private)	Standardized rate of private places where each specialized physicians per 10,000 municipal inhabitants scaled by age	2023	+
andardized coverage rate - beds r acutes (public)	Standardized rate of beds for acutes in public healthcare facilities per 1,000 municipal inhabitants scaled by age	2022	+
andardized coverage rate - beds r acutes (private)	Standardized rate of beds for acutes in private healthcare facilities per 1,000 municipal inhabitants scaled by age	2022	+
andardized coverage rate - beds r long-term care and rehabilita-on (public)	Standardized rate of beds for long-term care and rehabilitation in public healthcare facilities per 1,000 municipal inhabitants scaled by age	2022	+
andardized coverage rate - beds r long-term care and rehabilita-on (private)	Standardized rate of beds for long-term care and rehabilitation in private healthcare facilities per 1,000 municipal inhabitants scaled by age	2022	+
verage distance - general practi-oners/pediatricians	Avg. distance to nearest n providers per municipality	2023	-

Table A.1: Details on AvI, AcI, EqI, MHSI, and MHQI composition

ingle Indicator	Definition (a)	Year	Polarity (b)
verage distance - specialized nysicians (pub + priv)	Avg. distance to nearest n specialists	2023	-
verage distance - beds for acutes oub + priv)	Avg. distance to nearest n acute beds	2022	-
verage distance - long-term care eds (pub + priv)	Avg. distance to LTC and rehab beds	2022	-
ercentage choosing facility for aiting list/availability	Share of patients selecting facility due to waiting list or lack of alternatives	2019	-
vg. distance ratio public/private oecialists	Distance ratio weighted by expenditure share	2023	-
atio private/public specialists	Physician count ratio weighted by expenditure	2023	-
atastrophic Health Expenditure 10%)	Share paying ¿40% of ability to pay (excl. food)	2021	-
npoverishment Indicator	Share falling below poverty line due to health costs	2021	-
ate of unmet needs	Share foregoing care among those needing it	2019	-
ardiovascular composite	AMI, CABG, PTCA mortality/treatment	2019	-
eurology composite	Stroke, craniotomy mortality	2019	-
espiratory composite	COPD relapse mortality	2019	-
eneral Surgery composite	Post-op duration and complications	2019	-
urgical Oncology composite	Breast, lung, stomach, colon outcomes	2019	-
regnancy and Delivery composite	C-section, complications, readmissions	2019	-
fusculoskeletal composite	Hip fracture and replacement metrics	2019	-
ife expectancy at birth - male	Avg. years expected for newborn males	2019	+

Table A.1: Details on AvI, AcI, EqI, MHSI, and MHQI composition

ingle Indicator	Definition (a)	Year	Polarity (b)
fe expectancy at birth - female	Avg. years expected for newborn females	2019	+
fant mortality - standardized rate	Deaths per 10,000 live births	2019	-
oad accident mortality (15–34 s)	Standardized death rate in age group	2019	-
ancer mortality (25–64 yrs)	Standardized rate for cancer deaths	2019	-
ortality from dementia/nervous sorders (65+)	Standardized rate	2019	-
ge 75+ with chronicity and limi- tions	Standardized share with $\geq$3 chronic conditions or disabilities	2019	-
hysical pain index (SF36)	Index from 0–100 (higher = less pain)	2019	+
ental health index (SF36)	Index from 0–100 (higher = better mental health)	2019	+
verweight prevalence (17+)	Standardized proportion by BMI (WHO)	2019	-
noking rate (14+)	Self-reported smoking prevalence	2019	-
lcohol abuse rate (14+)	Prevalence of risky or binge drinking	2019	-
hysical inactivity rate (14+)	Share with no regular physical activity	2019	-
dequate nutrition rate (14+)	Daily consumption of $\geq$4 servings fruit/vegetables	2019	+

specialized physicians coverage rate, the number of public and private places where each specialized physician works idering that each physician can work in more than one healthcare facility. Standardized rates are based on the 2021 population, weighted by age using the weights defined for the allocation among the Italian Regions of the hare of financial resources for the National Health Service (Rep. atti n. 262/CSR del 9 novembre 2023), except for the of the Health Status domain, which come from Istat sources. Indicators on beds for acutes are weighted using the l inpatient remunerations for public and accredited private beds for acute and for long-term care and rehabilitation of Health, "Rapporto annuale sull'attività di ricovero ospedaliero - Dati SDO 2022").

nparability across indicators with different units of measurement and to address the issue of polarization — where indicate either better or worse performance — we use the normalized and polarized scores provided by AGENAS EEMAP exercise. These scores standardize indicator values on a scale from 1 to 5, with higher scores consistently er performance, thereby facilitating accurate aggregation and interpretation within the composite indicator framework. oncordant with the phenomenon; -: indicator discordant with the phenomenon.

Table A.2: Weighted average values of MHPI, AvI, AcI, and EqI

Area	**Regions**	**Weighted averages**			
		MPHI	*AvI*	*AcI*	*EqI*
North	Piemonte	91,6	105,5	105,9	103,3
	Valle d'Aosta	99,8	103,4	95,7	99,7
	Lombardia	94,3	105,8	106,3	99,5
	Bolzano	98,3	105,4	100,9	97,4
	Trento	94,8	105,2	101,4	102,8
	Veneto	94,7	104,0	106,4	100,0
	Friuli-Venezia Giulia	93,5	104,5	103,4	103,5
	Liguria	91,2	107,3	106,5	101,3
	Emilia-Romagna	90,1	108,4	110,0	100,9
Center	Toscana	92,8	106,3	103,4	102,8
	Umbria	90,1	108,2	105,1	104,1
	Marche	94,5	105,1	102,8	102,7
	Lazio	90,0	110,4	107,3	100,7
South	Abruzzo	96,2	106,4	104,8	96,6
	Molise	100,1	105,1	100,1	95,2
	Campania	97,7	107,3	109,5	92,1
	Puglia	95,3	106,8	104,1	98,7
	Basilicata	98,5	103,5	97,5	100,8
	Calabria	100,1	106,5	104,0	92,1
Islands	Sicilia	94,3	108,8	108,2	96,2
	Sardegna	101,5	106,9	96,9	95,5

Note: Averages are weighted by the Italian legal population of 2021.

Table A.3: Head count ratio — MHPI and its components by region

Area	**Regions**	**Head count ratio**			
		MPHI	*AvI*	*AcI*	*EqI*
North	Piemonte	32%	75%	76%	2%
	Valle d'Aosta	93%	99%	38%	5%
	Lombardia	55%	56%	68%	20%
	Bolzano	90%	94%	49%	78%
	Trento	56%	92%	63%	4%
	Veneto	38%	52%	54%	15%
	Friuli-Venezia Giulia	64%	86%	66%	5%
	Liguria	67%	76%	69%	13%
	Emilia-Romagna	30%	27%	65%	13%
Center	Toscana	49%	75%	66%	6%
	Umbria	42%	75%	78%	3%
	Marche	62%	89%	71%	6%
	Lazio	59%	73%	84%	8%
South	Abruzzo	82%	89%	75%	49%
	Molise	93%	91%	51%	90%
	Campania	60%	37%	72%	44%
	Puglia	47%	71%	58%	26%
	Basilicata	77%	98%	56%	5%
	Calabria	84%	73%	49%	79%
Islands	Sicilia	70%	60%	71%	72%
	Sardegna	92%	96%	62%	10%
Italy		**57%**	**65%**	**68%**	**24%**

Table A.4: Poverty gap — MHPI and its components by region

Area	**Regions**	**Poverty gap**			
		MPHI	*AvI*	*AcI*	*EqI*
North	Piemonte	-3,45	1,29	4,41	7,51
	Valle d'Aosta	-5,47	1,66	12,41	2,01
	Lombardia	-3,77	1,25	3,22	7,03
	Bolzano	-7,49	1,89	10,20	2,89
	Trento	-3,32	1,55	6,60	3,28
	Veneto	-4,05	1,38	3,14	6,14
	Friuli-Venezia Giulia	-3,97	1,55	5,18	6,22
	Liguria	-5,01	1,32	6,73	5,76
	Emilia-Romagna	-5,64	1,02	4,51	9,19
Center	Toscana	-4,21	1,24	6,76	8,17
	Umbria	-3,11	1,46	5,00	7,80
	Marche	-4,09	1,32	5,64	8,49
	Lazio	-4,57	1,46	5,13	8,86
South	Abruzzo	-5,85	1,51	5,02	7,00
	Molise	-7,58	1,68	7,23	5,60
	Campania	-6,28	1,34	5,53	7,04
	Puglia	-6,96	0,97	2,76	11,54
	Basilicata	-3,27	1,29	7,29	4,26
	Calabria	-5,65	1,41	4,68	6,17
Islands	Sicilia	-7,14	1,03	4,52	9,67
	Sardegna	-7,11	1,46	10,96	5,98
Italy		**-5,29**	**1,31**	**5,33**	**7,37**

Table A.5: Gini and Gini between municipalities in health poverty — MHPI and its components by region

Area	**Regions**	**Gini and Gini_p***				
		MPHI		*AvI*	*AcI*	*EqI*
		Gini	*Gini_p*	*Gini*	*Gini*	*Gini*
North	Piemonte	3,85	1,75	4,40	2,38	1,55
	Valle d'Aosta	3,92	1,86	4,64	6,49	1,25
	Lombardia	4,93	1,90	5,18	1,75	3,94
	Bolzano	5,81	2,06	5,66	5,73	3,43
	Trento	3,92	1,32	5,11	3,67	2,86
	Veneto	4,53	2,10	4,37	2,22	3,25
	Friuli-Venezia Giulia	4,63	2,04	4,58	3,26	2,67
	Liguria	3,88	1,88	4,35	4,48	2,61
	Emilia-Romagna	5,58	2,50	5,16	1,71	3,18
Center	Toscana	4,18	1,84	4,17	3,08	2,22
	Umbria	3,90	1,34	4,85	2,30	2,03
	Marche	4,31	1,76	4,59	3,06	2,84
	Lazio	2,72	2,10	5,48	2,52	2,09
South	Abruzzo	5,05	2,26	4,55	3,29	3,92
	Molise	4,55	2,12	5,30	3,45	4,65
	Campania	4,43	2,84	4,79	1,59	4,59
	Puglia	4,57	2,85	4,61	1,93	4,01
	Basilicata	2,97	1,27	3,75	2,99	2,87
	Calabria	3,94	2,10	4,90	2,58	3,75
Islands	Sicilia	5,63	2,63	5,16	2,38	4,74
	Sardegna	3,98	2,45	5,25	6,00	3,09

Note: The Gini index is on a 100 basis. For the MHPI, the Gini index between the municipality in health poverty is also estimated.

Table A.6: MHPI and its three dimensions T-tests by degree of urbanization

	Diff. of means — Deg. urb *Medium/Low* - Deg. urb *High*	Diff. of means — Deg. urb *Med./High* - Deg. of Urb. - *Low*	Diff. of means — *Out of* metrop. area - *Inside* metrop. area
AvI	-7.966***	3.381***	-1.182***
	(-29.95)	(35.23)	(-8.79)
AcI	-9.955***	8.493***	-4.674***
	(-21.37)	(57.38)	(-20.81)
EqI	2.633***	-3.096***	1.974***
	(6.63)	(-21.76)	(10.36)
MHPI	6.263***	-3.840***	1.512***
	(16.65)	(-28.67)	(8.21)

Note: Observations: 7,896. Standard errors in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Fig. A.1: Moran test on residuals of OLS regression displayed in Table 1.

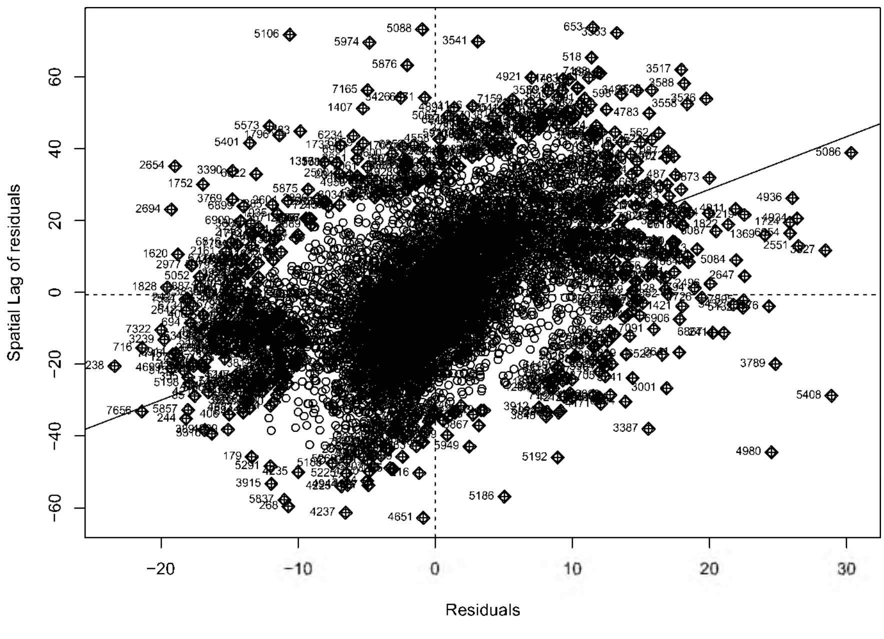

Table A.7: Spatial Error Model results – Dependent variable: *MHSI* and *MHQI*

	Dependent variable:			
	MHSI		MHQI	
	SEM(1)	SEM(2)	SEM(3)	SEM(4)
MHPI	-0.034^{***}		-0.011^{***}	
	(0.003)		(0.004)	
AvI		0.011^{***}		-0.023^{***}
		(0.004)		(0.005)
AcI		0.006		-0.015^{**}
		(0.005)		(0.006)
EqI		0.039^{***}		0.041^{***}
		(0.003)		(0.004)
high_urbanization_degree	−0.004	−0.007	−0.203	0.024
	(0.121)	(0.125)	(0.157)	(0.161)
low_urbanization_degree	0.078^{*}	−0.023	0.225^{***}	−0.021
	(0.046)	(0.050)	(0.060)	(0.065)
Population rate by age class - reference category: over 74 years old				
pop_0_4_rate	0.087^{***}	0.083^{***}	0.031	0.036
	(0.025)	(0.025)	(0.033)	(0.032)
pop_5_14_rate	-0.082^{***}	-0.079^{***}	0.016	0.020
	(0.013)	(0.013)	(0.017)	(0.017)
pop_15_24_rate	0.192^{***}	0.187^{***}	0.019	0.011
	(0.013)	(0.013)	(0.017)	(0.017)
pop_25_44_rate	-0.141^{***}	-0.140^{***}	-0.054^{***}	-0.052^{***}
	(0.010)	(0.010)	(0.013)	(0.013)
pop_45_64_rate	0.080^{***}	0.082^{***}	0.013	0.008
	(0.010)	(0.010)	(0.013)	(0.013)
pop_65_74_rate	-0.103^{***}	-0.104^{***}	0.003	0.0005
	(0.013)	(0.013)	(0.017)	(0.017)
cons_based_rel_pov_rate	-0.076^{***}	-0.076^{***}	-0.069^{***}	-0.070^{***}
	(0.004)	(0.004)	(0.005)	(0.005)
AROP_rate	-3.705^{***}	-3.707^{***}	-4.771^{***}	-4.832^{***}
	(0.198)	(0.197)	(0.257)	(0.255)
Constant	113.135^{***}	104.172^{***}	101.679^{***}	100.376^{***}
	(0.720)	(0.887)	(0.934)	(1.147)
Observations	7,896	7,896	7,896	7,896
Log Likelihood	14,714.350	14,681.590	16,779.460	16,725.400
σ^2	1.889	1.874	3.180	3.137
Akaike Inf. Crit.	29,456	29,395	33,586	33,482
Wald Test (df = 1)	421.207^{***}	310.329^{***}	$5,238.679^{***}$	$4,590.442^{***}$
LR Test (df = 1)	9.241^{***}	8.820^{***}	11.179^{***}	11.023^{***}

Note: Robust standard errors in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$