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# The Impact of Hospital Accessibility on Interregional Patient Mobility in Italy

Fabrizio PECORARO[a,1], Daniela LUZI[a] and Fabrizio CLEMENTE[b]
[a] *Institute for Research on Population and Social Policies, National Research Council. Rome, Italy*
[b] *Institute of Crystallography, National Research Council. Monterotondo (Rome), Italy*

**Abstract.** Patient mobility represents a proxy measure to assess the quality and availability of hospital services, especially in decentralized health systems. Different studies have been focused on the interregional mobility in Italy to capture factors influencing this phenomenon. Among them, hospital capacity is generally captured through the number of beds per population. However, this indicator does not consider the distance to hospitals and the accessibility of extra-regional beds, in particular for patients living at the regional borders. The aim of this paper is to analyse the effect of extra-regional spatial accessibility component on patient mobility among the Italian regions. This can help to capture the level of equity in the provision of services across the country providing a snapshot of the distribution of beds over the territory. Moreover, this study contributes to gain a deeper understanding of the allocation of health resources providing input for policy makers on the basis of the principles of service accessibility.

**Keywords.** Spatial accessibility, rehabilitative services, Italy, hospital mobility

## 1. Introduction

Patient mobility is a complex phenomenon considered as a proxy for the quality and availability of hospital services [1]. This is particularly evident in Italy, a decentralized tax-funded health system affected by significant socio-economic disparities at regional level [2,3]. Moreover, compared with other European countries, in Italy, patients tend more frequently to travel long distances to access to care [4] especially for elective treatments [5]. Patient mobility across Italian regions has been widely studied to capture factors that may influence the patients' choice [1], including social, demographic and economic status [6], quality and complexity of regional services [7] as well as structural components related to personnel, technologies and equipment available [8]. Usually, hospital capacity is assessed analysing the number of beds per population, computed at regional level. However, this indicator considers only the availability of regional resources, neglecting two fundamental aspects of universal care: the accessibility in terms of travel distance and the availability of extra-regional facilities in particular for patients living at the regional borders [9]. Within this context, the aim of this study is twofold. Firstly, it provides an analysis of the extra-regional component of the hospital spatial accessibility outlining a snapshot of the distribution of beds to capture the level of equity across the country [10]. Secondly, it explores the impact of accessing to extra-

[1] Fabrizio Pecoraro, IRPPS-CNR, Via Palestro, 32, 00185 Rome, Italy (f.pecoraro@irpps.cnr.it)

regional resources on patient's mobility. This analysis may provide an input for policy makers to capture to what extent the capacity and distribution of hospitals and beds may affect patient's flows at regional level.

## 2. Materials and methods

Data on mobility is gathered from the report on hospital admissions [11] published by the Ministry of Health which provides information on activities of public and private hospitals. In this paper we focus the attention on hospitalizations within the rehabilitative wards that provide inpatient services to mitigate or remove orthopaedic and/or neurological issues. These activities are mainly elective treatments where patients are generally prepared to travel beyond their nearest provider in particular in countries that allow patients to freely choose their place of care [12]. This is also confirmed by the high percentage (15.9%) of passive mobility across Italian regions [11]. For each region *i*, a passive mobility index ($PM_i$) was computed as the rate of hospital discharges of residents occurred in other regions. $PM_i$ can be decomposed as follows to capture the mobility towards each specific region *k* ($PM_i^k$):

$$PM_i = \sum_{k\in\{k\neq i\}} PM_i^k = \frac{\sum_{k\in\{k\neq i\}} d_i^k}{d_i} = \frac{\sum_{k\in\{k\neq i\}} d_i^k}{\sum_k d_i^k}$$

where $d_i^k$ represents the number of patients residing in region *i* and discharged in region *k* and $d_i$ is the total number of discharges of patients residing in region *i*.

The accessibility index (*AI*) was computed adopting the enhanced two step floating catchment area methodology (E2SFCA) [11]. This method is based on a gravity model which relates the increasing probability to access to a hospital with the number of beds and patient-to-hospital distance. It is calculated for each municipality *m* as follows:

$$AI_m = \sum_j R_j W_{mj} = \sum_j \frac{n_j}{\sum_m (P_m * W_{mj})} W_{mj}$$

where $R_j$ represents the weighted hospital-to-population index of hospital *j,* $n_j$ is the number of beds devoted to rehabilitation services of the hospital *j* and $P_m$ is the resident population of the municipality *m*. $W_{mj}$ that represents the weighting distance between the hospital *j* and the municipality *m* has been computed using the Sigmoid decay function. For each municipality *m* the percentage of *AI* related to hospitals located outside the belonging region was subsequently defined as:

$$AI_m^{extra} = \frac{\sum_{\{k\neq reg(m)\}} AI_m^k}{AI_m} = \frac{\sum_{\{k\neq reg(m)\}} \sum_{j\in\{Reg(j)=k\}} R_j W_{mj}}{AI_m}$$

where $AI_m^k$ is the component of $AI_m$ towards hospitals located in region *k*. For each region *i*, the $AI_i^{extra}$ was computed considering the average value of $AI_m^{extra}$ weighted by population.

In addition, a dispersion index ($DI_i$) that assesses the average distance travelled by patients from their region of residence is proposed as the weighted arithmetic mean of the accessibility indices $AI_i^k$ weighted by passive mobility indices $PM_i^k$:

$$DI_i = \frac{\sum_{k\in\{k\neq i\}} AI_i^k * PM_i^k}{\sum_{k\in\{k\neq i\}} PM_i^k}$$

Data on hospitals was gathered from the Ministry of Health (MoH) website [13], while demographic data was collected from the Italian National Institute of Statistics (ISTAT) website [14]. All data refers to the year 2019, the most current information published by MoH. Travel distances were computed using the OSRM (Open-Source

Routing Machine) API [15]. Note that islands including Sardinia and Sicily were excluded from the analysis as residents cannot access to extra-regional facilities by car.

## 3. Results

The map shown in Figure 1 highlights the $AI_i^{extra}$ computed for each municipality also reporting the total number of beds available in each municipality using black circles sized in proportion to the number of weighted hospital-to-population index ($R_j$). Moreover, passive mobility and accessibility indicators are reported in Table 1.

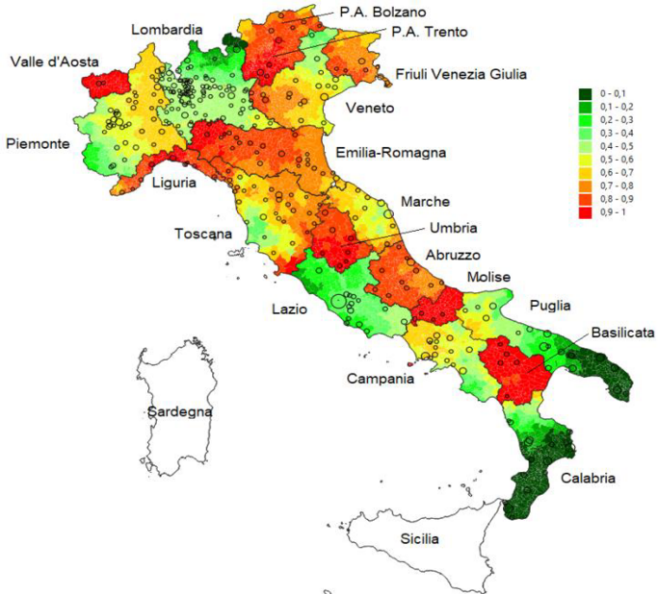


**Figure 1.** Extra-regional Accessibility Index ($AI_i^{extra}$) for rehabilitative beds in the Italian territory. Map defined and displayed using the open-source geographic information system (GIS) application QGIS [16].

To analyse how the different distributions of rehabilitative beds effects patient mobility, Figure 2 reports a scatterplot diagram that correlates it with the dispersion index. Firstly, all central-southern regions with the exception of Lazio are classified in the upper-left part of the diagram indicating a passive mobility higher than the national one and a mobility flow mainly towards health facilities which are distant from the region of residence. Basilicata and Molise, that also represent the regions with the greatest passive mobility (respectively 46.1% and 44.1%), are the two most remarkable examples, with over half of the total passive mobility directed to very distant hospitals ($AI_i^k$ close to zero). This indicates that the proximity factor only partially influences the dynamics of passive mobility of patients residing in these regions. Note that the two regions with a lower dispersion index (Calabria and Puglia) have a predominant mobility (higher than 90%) to northern regions, such as Lombardia. The right part of the diagram comprises regions with passive mobility satisfied by health facilities located in neighbouring regions. This indicates that the proximity to structures located in non-resident regions plays a crucial role in determining patients' mobility. Among them Friuli Venezia Giulia reports the highest mobility rate (38.0%) almost entirely (34.0%) satisfied by facilities with wide extra-regional accessibility, such as Veneto and Lombardia. A similar pattern

is shown in regions with a low passive mobility rate (lower-right quadrant), such as Piemonte where 75% of mobility occurs in Lombardia with the rest provided by other close regions such as Liguria.

**Table 1.** Average values of Accessibility Index ($AI_i$) and its extra-regional component ($AI_i^{extra}$), the number of beds ($PL_i$), the passive mobility ($PM_i$) and the dispersion indices ($DI_i$). Data refers to the year 2019.

| | Region | $AI_i^{extra}$ (%) | $PM_i$ (%) | $DI_i$ | $AI_i$ | $PL_i$ |
|---|---|---|---|---|---|---|
| Central-southern regions | Abruzzo | 82.0 | 21.5 | 10.73 | 27.71 | 44.10 |
| | Basilicata | 92.1 | 46.1 | 16.94 | 23.72 | 34.67 |
| | Calabria | 11.6 | 26.4 | 0.46 | 20.44 | 40.84 |
| | Campania | 64.5 | 24.8 | 6.88 | 37.23 | 31.05 |
| | Lazio | 36.0 | 11.0 | 3.02 | 39.35 | 48.29 |
| | Marche | 62.5 | 28.4 | 8.82 | 14.75 | 48.69 |
| | Molise | 95.3 | 44.1 | 9.58 | 25.06 | 45.24 |
| | Puglia | 23.6 | 20.9 | 0.39 | 21.93 | 29.89 |
| | Toscana | 71.7 | 20.9 | 11.80 | 20.12 | 53.48 |
| | Umbria | 89.8 | 22.7 | 12.03 | 28.72 | 47.46 |
| Northern regions | Emilia Romagna | 83.8 | 23.6 | 26.25 | 39.79 | 39.43 |
| | Friuli Venezia Giulia | 78.8 | 38.0 | 45.67 | 14.48 | 25.30 |
| | Liguria | 89.8 | 27.4 | 32.89 | 41.31 | 81.84 |
| | Lombardia | 46.4 | 9.3 | 13.72 | 63.35 | 34.99 |
| | P.A. Bolzano | 87.1 | 7.1 | 20.93 | 14.14 | 83.12 |
| | P.A. Trento | 92.4 | 15.4 | 25.36 | 29.32 | 88.56 |
| | Piemonte | 59.5 | 10.4 | 36.09 | 51.84 | 38.49 |
| | Valle d'Aosta | 98.2 | 20.7 | 41.60 | 41.34 | 74.76 |
| | Veneto | 69.4 | 14.7 | 18.97 | 35.38 | 46.00 |
| | **Italy** | **57.2** | **15.9** | **18.2** | **38.60** | **62.95** |

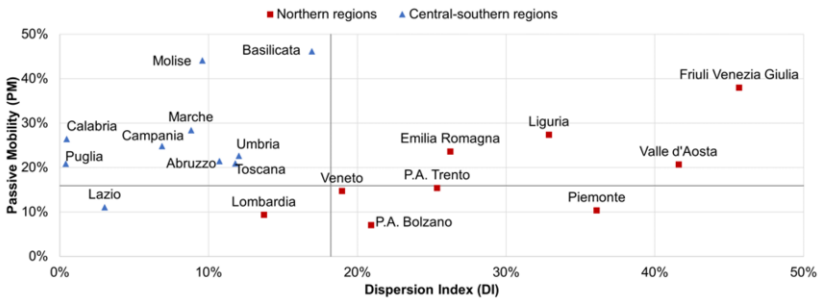


**Figure 2.** Scatterplot diagram reporting the Passive mobility index (PM) and dispersion index (DI)

## 4. Discussion

Different studies have analysed the main drivers of patient's mobility in Italy focusing on quality of services, social, demographic and economic status of patients and structural components. The aim of this study was to provide a preliminary analysis on the effect of hospital accessibility on patient's mobility across 19 Italian regions. This analysis allowed us to identify two main behavioural patterns. The first one entails regions whose patients accessed hospitals on the basis of their proximity. This is mainly found on northern regions where the request for hospital services may be associated with a capillary distribution network of extra-regional facilities that in regions, such as Friuli Venezia Giulia are easily accessible due to the conformation of the territory, the transport network and the distribution of population. The second pattern is composed by regions whose patients are willing or in need of travelling to access to hospitals located at very

long distances. This pattern is mainly found in southern regions, such as Molise and Calabria where a high percentage of patients access to extra-regional services provided by northern regions, such as Lombardia. This phenomenon can be associated to the demand of qualitative and timely services that are not always ensured by neighbouring facilities. However, this migration may be partly influenced by personal factors that are not strictly related with the quality of services, such as mobility for work or study reasons, the presence of family or relatives that can support patients during the hospitalization. In conclusion, this study confirms the main results reported in the literature highlighting that patients in the south of Italy when forced (i.e. long waiting times) or decide to migrate (i.e. searching for qualitative services) prefer to be hospitalized in facilities located in the north of the country than accessing those located in the neighbouring regions. While this finding highlights the potential inequalities both within and between regions, letting patients free to decide the professionals, facilities and places of care can be considered an opportunity to counterbalance socio-economic disparities, reducing unmet needs due to quality of territorial services and capacity of assistance. This preliminary analysis needs further investigation, for example, by analysing the mobility at meso and micro level and/or studying the effect of the extra-regional accessibility within a wider model that includes, for instance, socio-economic, demographic and other structural factors.

## References

[1] Nante N, Guarducci G, Lorenzini C, Messina G, Carle F, Carbone S, Urbani A. Inter-Regional Hospital Patients' Mobility in Italy. Healthcare. 2021; 9(9): 1182.
[2] Fattore G, Petrarca G, Torbica A. Traveling for care: Inter-regional mobility for aortic valve substitution in Italy. Health Policy. 2014; 117(1): 90-97.
[3] Ricci A, Barzan E, Longo F. How to identify the drivers of patient inter-regional mobility in beveridgean systems? Critical review and assessment matrix for policy design & managerial interventions. Health Services Management Research. 2021; 34(4): 258-268.
[4] Berta P, Guerriero C, Levaggi R. Hospitals' strategic behaviours and patient mobility: Evidence from Italy. Socio-Economic Planning Sciences. 2021: 101030.
[5] Pecoraro F, Clemente F, Luzi D. The efficiency in the ordinary hospital bed management in Italy: An in-depth analysis of intensive care unit in the areas affected by COVID-19 before the outbreak. Plos one. 2020; 15(9): e0239249.
[6] Mafrolla E, D'Amico E. Patients' mobility as an indicator for (in)efficiency: a panel data analysis on Italian health care authorities. Health Econ Rev. 2013; 3:3.
[7] De Curtis M, Bortolan F, Diliberto D, Villani L. Pediatric interregional healthcare mobility in Italy. Italian Journal of Pediatrics. 2021; 47(1): 1-7.
[8] Balia S, Brau R, Marrocu E. Interregional patient mobility in a decentralized healthcare system. Regional Studies. 2018; 52(3): 388-402
[9] Pecoraro F, Luzi D, Clemente F. Spatial Inequity in Access to Intensive Care Unit Beds at Regional Level in Italy. Studies in Health Technology and Informatics. 2021; 281: 809-813.
[10] Pecoraro F, Luzi D, Clemente F. Analysis of the Different Approaches Adopted in the Italian Regions to Care for Patients Affected by COVID-19. Int J Environ Res Public Health. 2021; 18(3): 848.
[11] Ministry of Health. Report on hospital activity in Italy. 2019. Available from: https://www.salute.gov.it/portale/temi/p2_6.jsp?id=1237&area=ricoveriOspedalieri&menu=vuoto
[12] Aggarwal A, Lewis D, Mason M, Sullivan R, Van Der Meulen J. Patient mobility for elective secondary health care services in response to patient choice policies: a systematic review. Medical Care Research and Review. 2017; 74(4): 379-403.
[13] Ministry of Health. National healthcare service database. 2019. Available from: www.salute.gov.it/portale/documentazione/p6_2_8_1_1.jsp?lingua=italiano&id=6
[14] Italian National Institute of Statistics (ISTAT). Available from: https://www.istat.it/it/archivio/222527
[15] Open Source Routing Machine (OSRM). Available from: http://router.project-osrm.org
[16] QGIS. Available from: https://www.qgis.org/it/site