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Evaluating Spatial Accessibility to High-Tech Health Services in the Spanish Iberian Peninsula: A GIS-Based Analysis

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Abstract: This study explores the spatial accessibility of high-tech health services across municipalities on the Spanish Iberian Peninsula, focusing on the adequacy of service provision by haemodynamic facilities relative to potential demand. A comprehensive analysis utilising a Geographic Information System (GIS) was conducted to evaluate the spatial distribution of high-tech health services, employing the enhanced two-step floating catchment area (E2SFCA) method within a gravity model framework. Findings reveal a disparity in health service coverage, with peripheral municipalities in the larger Autonomous Communities exhibiting low to very low access to high-tech health services. Despite this, the majority of the population benefits from satisfactory health coverage. The study underscores the importance of improving health service accessibility in underserved areas through infrastructural enhancements or the establishment of new facilities, advocating for equitable health service distribution in line with principles of social justice. The methodology proposed herein serves as a valuable tool for health policymakers in addressing spatial inequities in health service provision. Through the lens of territorial accessibility and spatial planning, the research highlights the critical role of high-tech health infrastructure in ensuring comprehensive health coverage. The results advocate for targeted interventions to enhance health service accessibility, particularly in sparsely populated areas at the periphery of large communities, thereby contributing to the broader discourse on health equity and spatial justice in healthcare planning.

Keywords: Network analysis; Territorial accessibility; Health coverage; High-tech health services; Geographic information system; Spatial planning

1. Introduction

The problem of transportation management has many variables, but its solution must be guided by societal needs based on expected benefits and ways of achieving them. Thus, transport management can be immensely enhanced and simplified using a geospatial information system (Olusina & Olaleye, 2012). Theoretical advancements in spatial analysis have provided valuable insights into the complexities of geographic phenomena, illuminating the intricate interplay between spatial relationships and underlying processes (Goodchild & Janelle, 2004). In addition, the spatial analysis framework offers a powerful lens through which to understand the dynamics of urban development, shedding light on the underlying processes shaping the spatial distribution of populations, activities, and resources within cities (Fotheringham et al., 2009).

In this regard, as technology advances in connectivity and sensing, Mechatronics and Intelligent Transportation Systems (MITS) have attracted more and more attention from both academia and industry. Consequently, there is a consensus that introducing MITS to transportation systems could offer substantial benefits in terms of road safety, traffic mobility, and energy efficiency (Balabhadruni, 2015).

MTIS is a key enabler for future transport management systems, and they can generate a large amount of data. To extract useful and relevant information from this data, data analytics plays a crucial role with several aims. The use of data analytics provides a solution to address critical challenges in MITS. For example, quality of service and traffic mobility data can help doctors make decisions about efficient routes to destinations. Therefore, one of the critical challenges related to MITS is to ensure adequate public transport-based accessibility to health facilities in different regions, which is a major concern of social equity and public health for the government (Zhang et al., 2020). Thus, medical geography provides a unique perspective on health and disease by examining how geographic factors such as location, environment, and spatial distribution of resources influence human health outcomes and healthcare access (Kearns & Moon, 2002), and medical geography explores the spatial patterns of health and disease, emphasizing the role of social, economic, environmental, and cultural factors in shaping health outcomes and healthcare delivery (Mayer, 2010).

Accessibility is shaped by two factors, namely, land use and transportation (Geurs & Van Wee, 2004). Specifically, the land use factor can be regarded as the spatial proximity of the health facilities, whereas the transportation factor is the level of public transport services. Due to the aggregation effects of urban populations and resources, spatial differentiation between central urban areas and suburban areas of the city is an inevitable economic trend, which is also referred to as spatial heterogeneity. Therefore, the land use factor, resulting in the imbalanced distribution of health facilities, may have a more significant impact on accessibility than the development of public transport (Zhang et al., 2020). Addressing social justice in healthcare involves ensuring equitable access to healthcare services and resources, regardless of socio-economic status, ethnicity, or geographic location. In order to reduce health disparities and promote health equity and social justice in healthcare, healthcare resources need to be equally distributed, and underlying social determinants of health need to be addressed, such as poverty, discrimination, and access to education (Braveman & Gruskin, 2003; Marmot, 2005).

In terms of accessibility to health facilities, there are many empirical studies in the international literature. Luo & Wang (2003) used both the floating catchment area (FCA) method and gravity-based method to examine the spatial accessibility to primary health care in the Chicago ten-county region. They further proposed an E2SFCA method for measuring spatial accessibility for primary care physicians in northern Illinois (Luo & Qi, 2009).

The transfer of health competencies in Spain from the central government to the autonomous communities began in 1981 and ended in 2002. Since then, each autonomous community has relied on its principle of self-sufficiency to equip itself with its own health infrastructure. As a result, health technology development at the regional level has been very uneven, both in time and space. The differences are most evident in the provision of high-tech equipment, since this equipment is scarce, expensive, and also requires highly qualified human resources.

This research outlines the methodology developed to analyse the geographical accessibility to high-health technology on a peninsular scale in Spain. The methodology utilises a model of spatial interaction between supply and demand for health resources. However, due to the limited public information currently available, this model is applied to the specific health technology of hemodynamic rooms, and the specific health service of percutaneous coronary angioplasty. This methodology considers hemodynamic rooms as representative of the distribution of high technology on a peninsular scale. Hospitals must integrate them to provide urgent health services, and the patient's access time is crucial.

The general objective of this work is to measure the spatial accessibility of the population of each municipality to the provision of high-health technology. On the other hand, the two specific objectives are: firstly, to analyse whether the volume of services provided by the hemodynamic rooms is adequate for the potential demand population; and secondly, to determine whether the proximity of the demand population centres to the hemodynamic rooms is appropriate.

The hypothesis of this research is that if healthcare is provided unequally among autonomous communities, there are differences in access to high-health technology for the inhabitants of the different municipalities of the Iberian Peninsula, depending on the autonomous community where they reside; or, on the contrary, all the inhabitants of the Iberian Peninsula have the same opportunities for high-tech healthcare regardless of their place of origin.

2. Methodology

All the data used in the methodology is information published by official Spanish institutions. These sources of information include the Official Road Map of 2024 from the Ministry of Transport, Mobility and Urban Agenda, the Municipal Population Register in 2023, the Minimum Basic Set of Hospital Data (CMBD), the National Catalogue of Hospitals (CNH) prepared by the Ministry of Health, the National Cartographic Base at a scale of 1: 200,000 (BCN200), and the Geographical Reference Information of Populations from the National Geographic Institute (IGN).

The methodology begins with the design of the base cartography that withstands all analyses. Then accessibility indicators are applied to this cartography. Finally, thematic cartography is obtained, which shows the degree of high-tech health coverage available in each municipality. All these tasks are calculated using the Microsoft Access 365 database management system, the ArcGIS 10.5 GIS application, and its proprietary network analysis tool, Network Analyst.

2.1 Generation of the Base Cartography

The base cartography (Figure 1) comprises three layers of information: the road network representing the transport network, the municipal capitals representing the demand for primary percutaneous angioplasty (PCA), and the hospitals symbolising the available health supply.

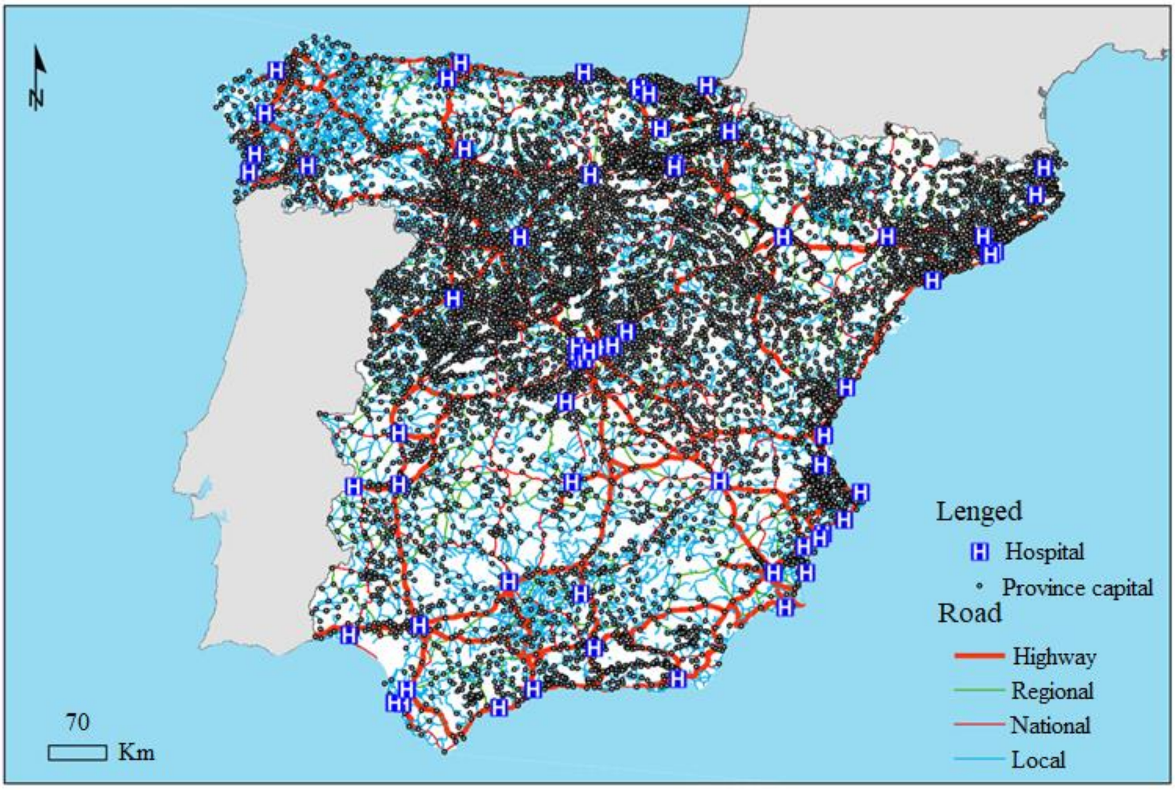

Figure 1. Base cartography
Note: This figure was prepared by the author.

The first layer of information corresponds to the modelling of the transport network using vector mapping with an arc-node topology. In this way, the lines represent the sections of roads in the transport network and store, as alphanumeric information, the impedance in minutes that it takes a vehicle to travel through each section of the road network. The impedance is calculated according to the length of each section and the maximum permitted speed of traffic. This information is obtained from the Official Road Map 2024.

The second layer of information consists of the municipal capitals, represented as points. These points correspond to the centroids of the polygons that delimit the urban area of each municipal capital. Regarding graphic information, the BCN200 and the Geographic Population Reference Information from the IGN were used as sources of information.

However, instead of the total resident population in each municipality, the alphanumeric information stored in each centroid corresponds to the number of potential inhabitants who may need a PCA in 2024. This is because the potential demand in urban centres with an ageing population is greater than in urban areas with a smaller ageing population.

Consequently, it is necessary to estimate the potential demand for PCA. This estimate can be made because PCA is a procedure that involves hospitalising the patient. For this reason, the CMBD hospital discharge database belonging to the Ministry of Health, Social Services and Equality, which is a clinical and administrative database from the medical record obtained at the patient's discharge, stores the location of the hospital where the PCA was performed, and the age and sex of the people who received it in 2020.

However, in order to access the public data offered by the CMBD, it is necessary to access the online consultation application called Advanced Indicators (i-CMBD) that provides the rates of use for the distribution of procedures of interest, including the PCA in 2020.

These rates allow us to obtain the total number of clinical cases that used a PCA in each municipality in 2020. Subsequently, in each municipality, the relationship between the number of PCAs carried out in 2020 and the total resident population in 2023, according to the Municipal Register of the INE, allows the percentage of the population that received a PCA to be obtained. Finally, this percentage is applied to the population obtained from the 2023 INE Municipal Register. In this way, it is possible to estimate the potential demand of each municipality in 2020.

The third layer of cartographic information consists of points representing the centroids of those municipal capitals that have a public or subsidized hospital equipped with a hemodynamic room.

The source of graphic and alphanumeric information for this layer of information is the CNH prepared by the Ministry of Health, Social Services and Equality. This is the only existing official public document that shows the location of hospitals and their technological endowment from 2005 to 2020.

In this manner, the CNH has selected the public hospitals belonging to the National Health System and the private hospitals that were contracted in 2020, which can carry out a PCA. Subsequently, all the hemodynamic rooms of each of the hospitals located in the same municipality have been added. Finally, the total number of hemodynamic rooms is referenced to the head nucleus that consists of the CNH.

2.2 Origin-Destination Time Matrix

The first task is to obtain access time from each municipal capital where the patient is located to the nearest hospital with a hemodynamic room. The accessibility analysis is not carried out solely on the nearest hospital but on all the nearest hospitals. This is because there is a possibility that the nearest hemodynamic room may not be available at the time the patient needs to receive the PCA. Therefore, this analysis is carried out from each capital where the potential patient resides to all hospitals that are within a threshold or maximum time of access.

The time was linked to each of the routes using the starting and ending names of each route through the Microsoft Access 365 database management system. Subsequently, the data was grouped through selection queries for each of the hospitals.

In this regard, current medical standards of action indicate that the maximum time from emergency warning to implantation of the balloon in the PCA should not exceed 90 minutes (Hippisley-Cox & Pringle, 2000; Jones et al., 2003; Palanca et al., 2011; Vanasse et al., 2005). Therefore, time is a key factor that determines the behaviour of physicians who select a hospital equipped with a hemodynamic room to which to transfer the patient. Hence, the threshold time used in the methodology is 90 minutes. Using the Microsoft Access 365 database management system, routes that exceeded the threshold time were identified and removed.

After calculating the inter-urban time between the municipal capitals that require a PCA and those that have a hospital with a hemodynamic room, it is necessary to calculate the intra-urban time. The intra-urban travel time corresponds to the time consumed by the vehicle in the urban environment, both in the municipal capital, which is the origin of the journey, as well as in the destination, which is the urban centre with a hemodynamic room. This is because the entire population of the urban settlements as well as the places where the hospitals were located have been referred to a point representing the centroid of the urban surface. The calculated time was obtained by summing each of the previously calculated times using the Microsoft Access 365 database management system, merging the tables of each route considering the common destination hospitals as the linking factor.

The estimation of intra-urban travel time has historically been approached from two different perspectives: considering travel time as constant or variable, depending on the characteristics of the urban core. Since the analysis of the time is conducted on all the municipal capitals of the peninsula, the number of elements analysed is very high and the characteristics of each urban centre are very different. Therefore, intra-urban travel time is considered variable.

The estimation of intra-urban travel time is based on the urban area and population of each urban centre. The population of each municipality was obtained from the 2023 Municipal Register of the INE, and the urban area from the BCN200. To perform the calculation, the Microsoft Access 365 database management system was used, defining numerical variables and queries that provided the results.

Subsequently, the surface area of each urban centre is assumed to be equivalent to that of a circle (Rich, 1975). In this way, it is possible to calculate the radius of each population settlement. This radius is assumed to be equal to the distance that the vehicle must travel in an urban environment. However, urban travel time also depends on speed. Therefore, urban time also depends on the urban nature of each population centre. Thus, intra-urban travel time in this methodology is estimated according to the population density of the areas through a linear adjustment that assigns a maximum of 80 km/h to the areas with lower population density and a minimum of 20 km/h to the most populated areas (Condeço-Melhorado et al., 2010). Through Microsoft Access 365, it was possible to make a query to adjust the analysis function.

Finally, the total travel time between the municipal capitals and the urban centres that have a hospital with a hemodynamic room is obtained by summing the inter-urban time plus the intra-urban time. This is the case unless the municipal capital and the urban centre with a hemodynamic room are the same population settlement. In such instances, the total travel time exclusively comprises the intra-urban time of that population centre. Again, the use of the Microsoft Access 365 database management system allows for a selection of those routes that are considered in the calculation.

2.3 The Spatial Interaction Model

The spatial interaction model used is a gravity model based on the E2SFCA method. The method improved the two-step FCA in spatial categorisation (Delamater, 2013), leading this method to emerge in the last decade as a key measure of spatial accessibility, particularly sanitary access (McGrail & Humphreys, 2009). There are even proposals to enhance the E2SFCA method (Bell et al., 2013; Wan et al., 2012), which, despite sharing the same name, are different three-step FCAs.

However, a methodology is developed in this study by enhancing this model to evaluate the spatial distribution of the hemodynamic rooms. Consequently, the analysis model provides an accessibility indicator that determines the healthcare coverage provided by each hospital with a hemodynamic room at the municipal level.

The first step of the spatial interaction model is to quantify the potential health supply that each inhabitant can receive. The mathematical formulation is:

$$OF_j = \frac{D_j}{\sum_{i=1}^{j} P_{ij}} \tag{1}$$

where, i is the origin of the journey, i.e., the urban centre where the patient resides, and j is the destination, i.e., the hospital that has one or more hemodynamic rooms to perform a PCA. In addition, OF_j is the potential offer received by each inhabitant who accesses j. In the case of this study, concerns the high level of health technology offered by a hospital with one or more hemodynamic rooms. In addition, D_j. is the endowment of the resource to which it is accessed. Therefore, it corresponds to the number of hemodynamic rooms owned by the destination hospital. Finally, P_{ij} is the population of municipality i that has access to the health resources offered in j.

Calculating the value of Pij is the second step of the methodology. This value depends on two factors: the potential demand and the time of access to hospitals with a hemodynamic room.

The potential demand was previously calculated based on the rates of use of PCAs in 2020. However, the calculation of the time from the municipal capital to the hospitals depends on the decay distance, because the spatial interaction model proposed in this study is a gravity model (de Dios Ortuzar & Willumsen, 2008). The decay distance reflects the perception of people at the origin of the route regarding the diminishing usefulness of the service offered at the destination, as the distance or travel time necessary to reach the destination increases (Fotheringham, 1981; Martínez & Viegas, 2013).

In this regard, the time of access to hospitals from the municipal capitals, according to current health standards, must not exceed 90 minutes. This serves as the maximum value of the decay distance in the proposed model. Therefore, municipal capitals with longer access time have zero accessibility to high technology. Time longer than 90 minutes corresponds to useless time for the patient to receive a PCA.

The decay distance indicates, based on the travel time separating different origins and destinations, the declining usefulness of the service offered at the destination. Its value is determined by a function known as the decay distance function. Various authors have introduced different decay distance functions, ranging from empirical statistical distributions to more sophisticated mathematical functions (Martínez & Viegas, 2013). However, most approaches in the literature rely on calibration procedures. Therefore, in the proposed model, the determination of the decay distance function is carried out by calibrating a mathematical function that fits all the access time calculated from the municipal capitals to the hospitals with a hemodynamic room with respect to the maximum time of accessibility. Out of the various ways the decay distance function could have been obtained, a regression line has been obtained. Because it is the function that provides the best mathematical fit to the values. All of this was done using Microsoft Excel 365 software. Additionally, a validation of the calculation was performed using several obtained real values. The result was the following mathematical function:

$$f\left(x_{ij}\right) = 1 - \frac{T_{ij}}{T_{máx}} \tag{2}$$

where, T_{ij} is the travel time from a municipal capital to a hospital with a hemodynamic room, and $T_{máx}$ is the maximum time to receive a PCA, such as 90 minutes.

This methodology enhances the approaches proposed by other authors in comparable works. The latter considers an access ring with a decay distance of 0 for access time of 0-10 minutes between the origin and the destination, meaning accessibility is total and without any barrier for the inhabitants who are less than 10 minutes from the hospital centre.

However, the proposed methodology does not incorporate the friction ring of 0. The period between 0 and 10 minutes mostly corresponds to urban areas and municipal capitals. In the case of this study, the urban travel time was estimated based on the urban area of the urban centre as well as its population. Therefore, these access time values obtained in urban environments enhance the fit of the decay distance function to the real mobility model represented and analysed by other authors.

Conclusively, the value of P_{ij} is determined by the mathematical expression:

$$P_{ij} = P_i * f(x_{ij}) \tag{3}$$

where, $f(x_{ij})$ is the decay distance function, and P_i is the estimate of the potential demand of inhabitants of the municipal capital who need a PCA.

Finally, the last step of the methodology is to determine the health coverage that potential patients of a PCA residing in each municipality can enjoy. The mathematical formulation is as follows:

$$CM_i = \frac{\sum_{j=1}^{n} P_{ij} * OF_j}{P_i} \quad (4)$$

3. Results

Once the access time of the population from each municipal capital to the nearest hospital with a haemodynamic ward had been determined, it was possible to draw an isochrone map (Figure 2). This allows us to identify areas with varying levels of accessibility to high-tech health services.

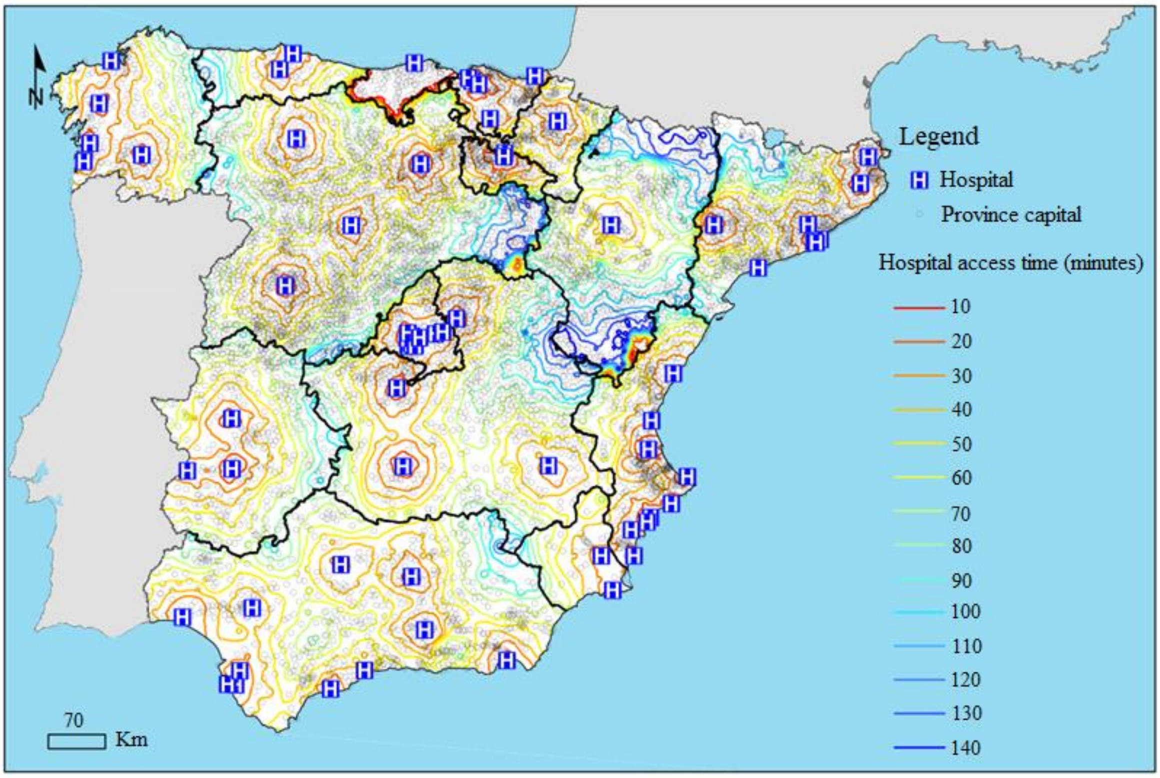

Figure 2. Map of isochrones depicting access time for inhabitants of municipal capitals to the nearest hospital
Note: This figure was prepared by the author.

The map (Figure 2) illustrates the distribution of different populations from municipal capitals around each hospital based on access time. Isochrones depicting access time are drawn at 10-minute intervals, ranging from 10 minutes for those closest to the hospitals to 140 minutes for those furthest away. This allows for the visualisation of municipal capitals located near hospitals, as well as those that are more distant. It can be observed that larger autonomous communities, such as Extremadura and Andalusia, have municipal capitals with potentially inadequate access to hospitals. Conversely, smaller autonomous communities, such as Cantabria, appear to have more satisfactory access.

Additionally, the percentage of municipal capitals and the population residing in them, based on access time, were determined from the relative positions of each municipal capital in relation to the hospitals (Table 1). This approach provides quantitative data alongside geographical location results, enabling an assessment of the extent of coverage of high-tech health services.

Table 2 clearly illustrates that although the percentage of municipalities closest to hospitals is small, they accommodate a large population. Therefore, health coverage has been planned to cater to the most densely populated municipalities. It is also evident that more than half of the population (53.94%) resides within a 30-minute distance from a hospital offering high-tech healthcare. Additionally, only 1.72% of the population is located more than 90 minutes away from a high-tech hospital. Hence, it can be concluded that while there remains a population with limited access to high-tech hospitals, the majority enjoys adequate health coverage.

Table 1. Percentage of provincial capitals and population according to access time to a hospital

Access Time (Minutes)	Provincial Capitals (%)	Population (%)
0 - 10	2,15	8,09
10 - 20	6,32	22,85
20 - 30	14,26	23,00
30 - 40	15,19	17,86
40 - 50	13,52	13,75
50 - 60	13,19	5,55
60 - 70	11,42	3,88
70 - 80	8,13	2,19
80 - 90	5,09	1,10
90 - 100	3,44	0,86
100 - 110	2,40	0,37
110 - 120	1,97	0,22
120 - 130	1,32	0,19
130 - 140	0,99	0,05
140 - 150	0,49	0,03
150 - 160	0,11	0,00

The health coverage available to residents of each municipality enables the creation of a national-scale thematic map of the peninsula. This map illustrates the health coverage of each municipality if patients are transferred to the nearest hospital.

However, a classification of calculated values sensitive to all values, rather than just the majority, is necessary. In this regard, the harmonic mean is less affected by the presence of outliers, providing a comprehensive classification of values. Therefore, the harmonic mean is employed for classifying the calculated values.

Consequently, thematic cartography was generated to classify the municipal health coverage values obtained. This cartography represents the health coverage for every 10,000 inhabitants potentially requiring a hemodynamic room in each municipality, normalized by the harmonic mean obtained from the complete dataset of values.

The analysis of accessibility to PCA services in hospitals yields class intervals normalized by the harmonic mean. By utilising different colours such as red, orange, light green, and dark green, it is feasible to assess the variation in municipal health coverage on a national scale across the Iberian Peninsula.

As shown in Figure 3, the majority of the region is comprised of areas depicted in dark green or light green, indicating very good or good health coverage. Many of these municipalities are in close proximity to hospitals equipped with at least one hemodynamic room. However, there are other municipalities farther away from hospitals that still boast optimal high-tech health care coverage. This is attributed to good land transport infrastructure or accessible roads to hospitals, coupled with relatively low potential demand for PCAs, resulting in good high-tech health coverage.

Nonetheless, there are also areas depicted in orange, indicating poor health coverage, scattered across the Iberian Peninsula. Some of these areas are even relatively close to hospitals. In contrast to the green areas, this is likely due to inadequate road infrastructure to access high-tech hospitals or a high potential demand for PCAs. Notably, the autonomous community of Castilla y León stands out, with a large number of orange-coloured municipalities dispersed throughout the region.

Lastly, the map (Figure 3) highlights large areas depicted in red where high-tech health coverage is very poor. Interestingly, these red areas are typically located in peripheral regions of the autonomous communities. The autonomous community most affected by this phenomenon is Aragon. Here, while the central areas exhibit good high-tech health coverage, the northern and southern regions have very poor coverage. This discrepancy could be attributed to the concentration of high-tech hospitals in the central region of the community.

After analysing the municipality locations and determining the areas they constitute based on health coverage, the results pertaining to the population residing in these municipalities classified according to the degree of high-tech health coverage are obtained (Table 2).

Surprisingly, once again, the data regarding the resident population in the municipalities reveals that nearly the entire resident population of the Spanish Iberian Peninsula has very good high-tech healthcare coverage (90.02%). This outcome underscores the effective planning undertaken by each autonomous community in aligning high-tech healthcare resources with their respective needs, thereby ensuring widespread access to such services for the majority of the population. However, it's imperative not to overlook the segment of the population with very poor or poor health coverage. From a standpoint of social justice, they are entitled to the same access to healthcare services under equitable conditions as the rest of the population.

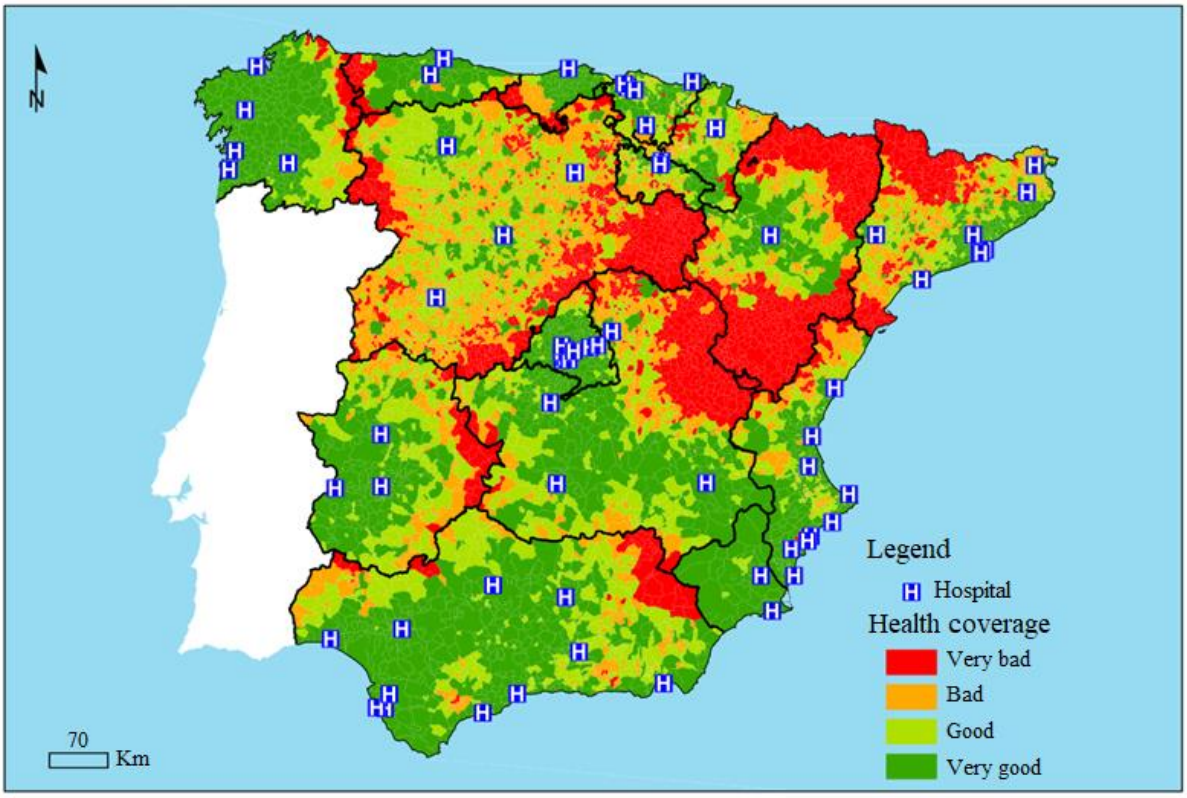

Figure 3. Map of health service capacity per 10,000 inhabitants
Note: This figure was prepared by the author.

Table 2. Percentage of the population by health coverage level

Health Coverage	Population (%)
Very bad	3,08
Bad	1,58
Good	5,31
Very good	90,02

Note: This table was prepared by the author.

4. Discussion

Based on the initial hypothesis of this research, the results obtained indicate that access to high-tech healthcare services for the potential population in demand is satisfactory. These findings are consistent with other studies conducted (Gómez et al., 2018; Gómez et al., 2021), albeit not entirely identical, possibly due to the more recent data utilized in this research.

Furthermore, much of the information regarding healthcare staffing and activity is typically published in aggregated form at the autonomous community level. However, this study assesses disparities in the provision of high-health technology at the municipal level to ascertain whether a more detailed examination reveals greater discrepancies in healthcare service provision. Consequently, this methodology can serve as a valuable tool for decision-making.

In this context, while the research results are presented succinctly, focusing on methodological aspects, the findings obtained could be beneficial for the management of the valuable resources under analysis. However, considering the geographical characteristics, population distributions, and transportation conditions, future research could specifically observe the potential reasons for differences in high-tech healthcare coverage. Besides, it must be acknowledged that this research has certain limitations that should also be addressed in future investigations. In this regard, consideration should be given to the availability of hemodynamic rooms, based not only on the number of hemodynamic rooms but also taking into account other factors such as whether there is a possibility that any of the hemodynamic rooms may not be able to operate 24 hours a day. Additionally, it is crucial to take into account the preferences of patients when it comes to receiving treatment at specific hospitals.

5. Conclusions

The first conclusion is based on the size of each autonomous community. The larger regions have municipalities with limited or no health coverage. Therefore, corrective measures should be implemented, such as improving road infrastructure to enhance access to health services or, if there is a higher potential demand for high-tech health services, constructing new hospitals closer to these remote areas.

The second conclusion hinges on the provision of health coverage to the population within a specific hospital access period. From the results obtained, it can be concluded that health services have been strategically planned to cover the larger and more densely populated municipalities. However, there is a small population with inadequate accessibility, and efforts should be made to ensure that this population also has sufficient access. Nevertheless, it is worth noting that a significant portion of the population has adequate access to healthcare services, and the provision of health services aligns with the potential demand of the population.

Thirdly, the distribution of municipalities with very poor health coverage within the larger autonomous communities suggests the existence of a centre-periphery model. This model revolves around the hospitals of each autonomous community, with the municipalities lacking adequate health coverage located on the periphery of those autonomous communities.

Another important aspect to consider is that, despite each autonomous community equipping itself with high-tech healthcare equipment tailored to its own needs, effective planning has been evident. This is demonstrated by the fact that most of the population has good accessibility to high-tech healthcare services. Finally, it is proposed to invest in telemedicine infrastructure to allow remote consultations and diagnosis, reducing the need for physical travel to healthcare facilities; implement mobile medical units equipped with essential diagnostic tools and treatment capabilities to reach remote communities on a regular basis; provide financial incentives or subsidies for healthcare professionals willing to work in remote areas to address staffing shortages; offer transportation subsidies or vouchers to residents for accessing healthcare services, including reimbursement for travel expenses; establish community health worker programs to provide basic healthcare services, health education, and referrals in remote areas; invest in infrastructure projects to improve road conditions; construct helipads for medical evacuations, or enhance public transportation options; foster partnerships between public healthcare agencies and private sector organizations to develop innovative solutions for medical access in remote regions; establish and support rural health clinics staffed by healthcare professionals capable of providing comprehensive primary care services.

Data Availability

1. The Official Road Map of 2024 [cartography] supporting our research results is deposited in [https://www.transportes.gob.es/carreteras/], which does not issue DOIs. The data can be accessed at [https://www.transportes.gob.es/carreteras/usuarios/mapa-oficial-de-carreteras] [The access was made on February 2nd, 2024].

2. The National Catalogue of Hospitals [database] supporting our research results is deposited in [https://www.sanidad.gob.es/ciudadanos/prestaciones/centrosServiciosSNS/hospitales/home.htm] which does not issue DOIs. The data can be accessed at [https://www.sanidad.gob.es/ciudadanos/hospitales.do?tipo=equipos] [The access was made on February 2nd, 2024].

3. The Geographical Reference Information of Populations [database] supporting our research results is deposited in [https://centrodedescargas.cnig.es/CentroDescargas/index.jsp] which does not issue DOIs. The data can be accessed at [https://centrodedescargas.cnig.es/CentroDescargas/index.jsp] [The access was made on February 2nd, 2024].

4. The Population data [database] supporting our research results is deposited in [https://www.ine.es/] which does not issue DOIs. The data can be accessed at [https://www.ine.es/dynInfo/Infografia/Territoriales/galeriaCapitulo.html?capitulo=4334] [The access was made on February 2nd, 2024].

Conflicts of Interest

The authors declare no conflict of interest.

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