SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 235

# MEASURING THE POTENTIAL OF HEALTH SERVICE ACCESSIBILITY – METHODOLOGY PROPOSAL AND EMPIRICAL ANALYSIS RESULTS

Adrianna MASTALERZ-KODZIS[1*], Katarzyna ZEUG-ŻEBRO[2]

[1] University of Economics in Katowice; Adrianna.Mastalerz-Kodzis@ue.katowice.pl, ORCID: 0000-0001-9099-3576
[2] University of Economics in Katowice; Katarzyna.Zeug-Żebro@ue.katowice.pl, ORCID: 0000-0001-7786-3478
* Correspondence author

**Purpose:** The theoretical goal of this article is to provide a formula for determining the accessibility of healthcare facilities for residents of specific regions in Poland. This means defining the potential for healthcare accessibility and proposing interpretations of the potential value depending on the adopted metric. The empirical goal is to analyze the potential for healthcare accessibility in Poland, broken down by territorial units. The utilitarian goal is to contribute to the methodology of quantitative analyses concerning the measurement of healthcare accessibility in order to improve the quality of life in Poland and increase the level of socioeconomic development.
**Design/methodology/approach**: The potential of a territorial unit was defined, defining healthcare resources in relation to the population of a given region.
**Findings:** A formula was proposed to determine the availability of healthcare services for residents, indicating areas with good healthcare services, but also regions where access to healthcare facilities should be improved.
**Research limitations/implications**: The data was obtained from the Eurostat database. Due to Poland's declining population, many healthcare facilities are being closed and repurposed to specialize in areas tailored to regional needs. It is necessary to update the results based on current data. Significant patient admission limits and limited hours of availability also pose constraints. This results in long queues for specialists in many medical fields. The potential value depends on the adopted metric.
**Practical implications:** There are many applications for the proposed methodology. In particular, analyzing the availability and potential of healthcare facilities will influence the optimal deployment of these facilities based on the number of potential patients. Improved access to healthcare facilities will positively impact the health of the Polish population.
**Social implications:** The optimal distribution of hospitals and clinics will improve access to health care facilities, improve the quality of life of the Polish population, and have a positive impact on the HDI, as one of its components is health measured by life expectancy.
**Originality/value:** This paper proposes an innovative approach to measuring the potential of healthcare accessibility. It is addressed to decision-makers managing healthcare in Poland at the national, provincial, and regional levels.
**Keywords:** economic potential, health care availability potential, HDI, population health.
**Category of the paper:** Research paper.

## 1. Introduction

Sustainable socio-economic development is a factor in the proper functioning of a state. Development is measured using various metrics, one of which is the HDI – Human Development Index (Borys, 2005; Borys, Rogala, 2008; Hozel-Koćmiel, 2018; Laskowska, Dańska-Borsiak, 2018; Mastalerz-Kodzis, 2018d, 2021). This index is composed of three factors: income, education, and health. The proposed topic of this article concerns the third factor – health.

The article also uses basic economic theories and standard statistical method (Diebold, Yilmaz, 2015; Gorynia, 2019; Krueger, Lindahl, 2001; Panek, 2009; Singh et al., 2009; Tanguaya et al., 2010).

The income of a given territorial unit, and thus the average income of its residents, depends on the development of the region, particularly the development of industry and services. Education levels are largely determined by the quality of schools, including teacher engagement and parental responsibility for educating children. However, according to the authors, the level of access to healthcare should be the same for every Polish citizen, for every Pole, regardless of place of residence. As mentioned, health is one of the factors influencing the level of socio-economic development. HDI analyses consider the life expectancy of residents. This life expectancy depends on lifestyle, genetics, and environmental factors, but is also largely dependent on access to healthcare facilities. State authorities, as well as local government units in voivodeships, cities, municipalities, and villages, should ensure that the needs of residents are met in terms of access to healthcare. Given the current economic and demographic changes, this poses many challenges for decision-makers. The shrinking population living in Poland, the changing age structure of the population, and the changing lifestyle of Poles compel decision-makers to adapt the quality of healthcare services to the needs of the population (Begg et al., 1992; Nelson, 2013).

This article contributes to the current trend of research in the social sciences. It contributes to science by proposing a formula for measuring access to healthcare in a given territory. A formula for measuring potential in physics is known in the literature (Suchecki, 2010). Potential is a measure of accessibility, strength, and the possibility of cooperation—interaction—with the environment.

The optimal distribution of healthcare facilities is an important and timely issue, both from a social and economic perspective. Decision-makers, including those working in the Ministry of Health and local governments, develop strategies for the operation of hospitals, clinics, and specialized practices, taking into account the population size, age structure, and incidence of specific diseases. Selecting the appropriate strategy is crucial for public safety and the functioning of the state. Strategies of territorial units should be coherent, and units should absolutely cooperate to provide the best possible healthcare to residents. The operation of

hospitals and specialized clinics and their distribution within a given territory is also a significant aspect. The availability of specialists in many fields of medicine is a significant limitation.

In the social sciences, economic potential is a measure of regional accessibility and is treated as a proxy for socio-economic development. Population and income potential are measured, and the region's own potential and the potential of its surroundings are analyzed. Sometimes a territorial unit possesses significant internal potential and serves as a base, an economic center; sometimes a given region lacks significant potential but is geographically well-positioned, benefiting from its surrounding resources. For example, large urban agglomerations with high population potential are such centers, implying social and economic development. On the other hand, the outskirts of cities with low population density have low population potential but are geographically advantageous, providing opportunities for rapid and sustainable development for their residents. This development is largely determined by the accessibility of significant centers. Accessibility should be measured using a metric. This metric can be Euclidean distance, road distance (shortest, fastest, cheapest), or another measure. The value of a region's economic potential depends on the adopted metric (Mastalerz-Kodzis, 2017, 2018d, 2021; Mastalerz-Kodzis, Pośpiech, 2017).

In the fields of management and quality science, an organization's potential can also be measured using a formula originally described in physics. In this case, the potential of an organization (enterprise, company) depends on its operational capacity, but also on cooperation with the environment, trade, and the exchange of ideas, concepts, and other intangible assets. Another important variable is metrics, which can be considered accessibility in terms of location, financial, technological, or other accessibility (Mastalerz-Kodzis, 2018b, 2018c).

## 2. Methodology

### 2.1. Potential in Physics

The concept of measuring potential originates from physics, a quantitative science. In the 1970s, it was first used by social economists specializing in geographic economics (Suchecki, 2010). This paper, drawing on physical and socioeconomic concepts, presents a methodology for measuring potential access to healthcare.

In physics, potential is a scalar field (a scalar quantity, meaning it has only a magnitude) that characterizes a vector field of potential forces, such as gravitational, electrostatic, or elastic. It is usually defined as the ratio of potential energy to charge (in the case of electric fields) or mass (in the case of gravitational fields). Potential allows for a simplified calculation of the work required to move a body in such a field—in this case, it is the potential difference between two points. The potential depends on the source charge and distance. In the example of an electric field, the potential depends on the charge that creates it (the source charge) and the distance from it. Sum of component potentials - when a given point is affected by multiple fields, the potential at that point is the algebraic sum of the potentials of the individual component fields. In physics, the potential difference between two points in a field (voltage) is equal to the work required to move a unit charge between these points.

In physics as a science, potential is a quantity describing the properties of a physical field. For a given system of physical units, the partial potential $V_{ij}$ is used to analyse the interactions between these units $(i, j = 1,\ldots,n; n \in N)$. For any two physical units, it is determined using the formula:

$$V_{ij} = \alpha \frac{M_i M_j}{d_{ij}} \tag{1}$$

The value of the partial potential is interpreted as the amount of energy between units i and j per unit mass, $M_i, M_j$ is the mass of the units, and $d_{ij}$ the distance between the physical units and $\alpha$ is a parameter.

### 2.2. The concept of economic potential

The concept of potential has also found application in economics.

Potential is defined in the social sciences, including economics, as the resource of capabilities, possibilities, or performance that can be attributed to a given territorial unit. In the 1970s, G. Dutton introduced the concept of income and population potential. Subsequently, the concept of the quotient of these two values emerged in the literature, becoming a substitute measure of socioeconomic development. The potential of a territorial unit (state, region, voivodeship) is a multidimensional concept, as it depends on many different, often interdependent factors. Potential defines the capabilities of a territorial unit based on the unit's abilities, competencies, and effectiveness, and also measures the ability to utilize these resources and those of its environment (Greene, 2003; Greenspan, 2014; Mastalerz-Kodzis, 2018d).

Based on the concept of partial potential, a model for the potential of a territorial unit is constructed. It is assumed that the territorial division system consists of *n* objects – spatial units $(n \in N)$. The potential of each unit is dependent on all other units, but to varying degrees. The model for the potential of the *i- th* spatial unit ( $i = 1,2,\ldots,n,\ n \in N$ ) in a given time period is written as follows:

$$ETP_i = EP_i + \alpha \sum_{\substack{j=1 \\ j \neq i}}^{n} \frac{B_j^{\alpha_{1,j}} EP_j^{\alpha_{2,j}}}{d_{ij}^{\beta}} \tag{2}$$

where:

$ETP_i(t)$ - economic total potential in the *i-th* territorial unit,

$EP_i$ - economic potential only in the *i-th* territorial unit (own potential),

$\sum_{\substack{j=1 \\ j \neq i}}^{n} \frac{B_j^{\alpha_{1,j}} EP_j^{\alpha_{2,j}}}{d_{ij}^{\beta}}$ - economic potential of the surroundings of the *i*-th territorial unit (ambient potential),

$B_i$ - weight of the *i*-th spatial unit,

$\alpha, \alpha_{1,j}, \alpha_{2,j}$ - structural parameters of the model,

$\beta$ - distance parameter.

The components of the above formula can have an economic interpretation. In geographic economics, the mass of a unit can be considered as production, GDP, population, employment, foreign trade turnover, or investment volume. The weight of a given spatial unit can be the occupational structure of the population, age, gender, income, or investment volume per capita. Weights can be adopted arbitrarily or calculated based on statistical data. Distance measures between units include temporal, physical, Euclidean, and economic distances. The model parameters are determined using the least squares method.

The spatial potential model assumes that the capabilities of a territorial unit depend on its strength and potential, but also on its location within the considered geographic space and the adopted metric. This can be a geographic space in which the distance between units is measured as the Euclidean distance between the geographic coordinates of distinguished points. Road distance (shortest, fastest) and the availability of connections between units can also be taken into account. Another interesting approach is to treat the metric as an economic quantity.

The total potential of the *i-th* unit is the sum of the partial potentials of all units in the system, and the dependent variable $EP_i$ is interpreted as the total influence on the *i-th* spatial unit. Economic potential can be interpreted as the intensity of the influence of all territorial units of the system on a selected unit. Potential is the sum of two components: the system's own potential and the potential of the surroundings. Geographic location has a significant impact on

the value of the surroundings' potential. In economics, the following models of spatial potential can be distinguished: income, population, and location (accessibility of the region to residents of other regions). These models of geographical economics are described in detail in Suchecki, 2010 and Mastalerz-Kodzis, 2018a.

### 2.3. The concept of the accessibility potential of health care units

In this article, the potential for healthcare accessibility for residents of a given region is defined as the ability to use healthcare resources offered within the region, but also the potential for using resources from neighboring regions (territorial units). This article proposes a methodology for determining healthcare accessibility potential that takes into account the time parameter. For these formulas, changes in the dynamics of this potential can be analyzed.

Let us assume the following notations:

$HTP_i(t)$ - health total potential - the potential of health service availability in the *i-th* territorial unit in period *t*,

$HP_i(t)$ - potential of availability of health services only in the *i-th* territorial unit in period t (own potential),

$d_{ij}$ - distance between units *i* and *j*,

$\sum_{\substack{j=1 \\ j\neq i}}^{n} \frac{HP_j(t)}{d_{ij}}$ - potential of availability of health services of the surroundings of the *i*- th territorial unit (ambient potential).

In practice, the metric can be binary. If a given region (voivodeship) is adjacent to the region being studied, the value in the distance matrix is 1; if not, the value is assigned 0. Generally, the greater the distance between regions, the smaller the potential population flow to utilize healthcare services. If a district or municipality is located in one voivodeship but lies close to another, it is very likely that residents utilize the services offered there. The metric concept can also be applied to distances between regions. Of course, the value of the potential depends on the metric adopted.

Let's assume that territorial units have the same weights $B_i$ . We also assume that all structural parameters of the model $\alpha, \alpha_{1,j}, \alpha_{2,j}, \beta$ are equal to 1. Of course, the above assumptions affect the target value of the potential. If we believe that one unit should be given a higher weight, then this is certainly advisable.

Own health potential $HP_i(t)$ was calculated as the ratio of the number of hospitals to the total number of clinics per population in a given voivodeship. The higher the value, the greater the potential for healthcare availability. This value acts as a stimulant.

Total potential of health service availability in the *i-th* territorial unit in period *t* is defined as the sum of the total potential of health service availability in the *i-th* territorial unit in period t (own potential) and potential of availability of health services of the surroundings of the *i*- th territorial unit (ambient potential).

$$HTP_i(t) = HP_i(t) + \sum_{\substack{j=1 \\ j \neq i}}^{n} \frac{HP_j(t)}{d_{ij}} \tag{3}$$

Potential is a measure of a region's spatial accessibility. It determines the intensity of interactions between regions, taking into account economic values and interregional distances. In formula (3), it is divided by the distance between units, because the greater the distance, the less impact on the analyzed characteristics.

A region may have a small number of healthcare units, but may be geographically advantageous, close to a major medical center. In this case, its own potential is small, but the potential of its surroundings is large. This will also contribute to the growth of its overall potential.

## 3. Results of empirical analyses

### 3.1 Healthcare resources in Poland

The empirical analyses focused on data from Eurostat, the Central Statistical Office of Poland, and the UNDP database. Data for Polish voivodeships in 2024 were considered. The variables used to calculate the selected measures included: population, total number of hospitals (without specialization), total number of clinics (without specialization), and distance between voivodeship capitals (optimal distance in km according to Targeo.pl). Toruń was selected as the capital of the KUJAWSKO-POMORSKIE Voivodeship, and Gorzów Wielkopolski in the LUBUSKIE Voivodeship.

**Table 1.**
*Population and healthcare resources in Poland by voivodeship in 2024*

| Voivodeship | Population in persons | Total number of hospitals | Total number of clinics | Total number of hospitals and clinics | Number of patients per health care unit |
|---|---|---|---|---|---|
| **DOLNOŚLĄSKIE** | 2 874 496 | 87 | 1729 | 1 816 | 1583 |
| **KUJAWSKO-POMORSKIE** | 1 990 323 | 81 | 1076 | 1 157 | 1720 |
| **LUBELSKIE** | 2 003 475 | 65 | 1324 | 1 389 | 1442 |
| **LUBUSKIE** | 972 140 | 30 | 624 | 654 | 1486 |
| **ŁÓDZKIE** | 2 354 135 | 82 | 1734 | 1 816 | 1296 |
| **MAŁOPOLSKIE** | 3 429 685 | 114 | 2212 | 2 326 | 1474 |
| **MAZOWIECKIE** | 5 510 618 | 204 | 3685 | 3 889 | 1417 |
| **OPOLSKIE** | 933 349 | 34 | 587 | 621 | 1503 |
| **PODKARPACKIE** | 2 067 139 | 56 | 1341 | 1 397 | 1480 |
| **PODLASKIE** | 1 135 201 | 39 | 854 | 893 | 1271 |
| **POMORSKIE** | 2 359 956 | 59 | 1310 | 1 369 | 1724 |
| **ŚLĄSKIE** | 4 305 126 | 160 | 2851 | 3 011 | 1430 |
| **ŚWIĘTOKRZYSKIE** | 1 163 001 | 37 | 683 | 720 | 1615 |
| **WARMIŃSKO-MAZURSKIE** | 1 353 374 | 44 | 916 | 960 | 1410 |
| **WIELKOPOLSKIE** | 3 484 177 | 95 | 2208 | 2 303 | 1513 |
| **ZACHODNIO-POMORSKIE** | 1 626 876 | 74 | 1091 | 1 165 | 1396 |

Source: own study based on data from bdl.stat.gov.pl

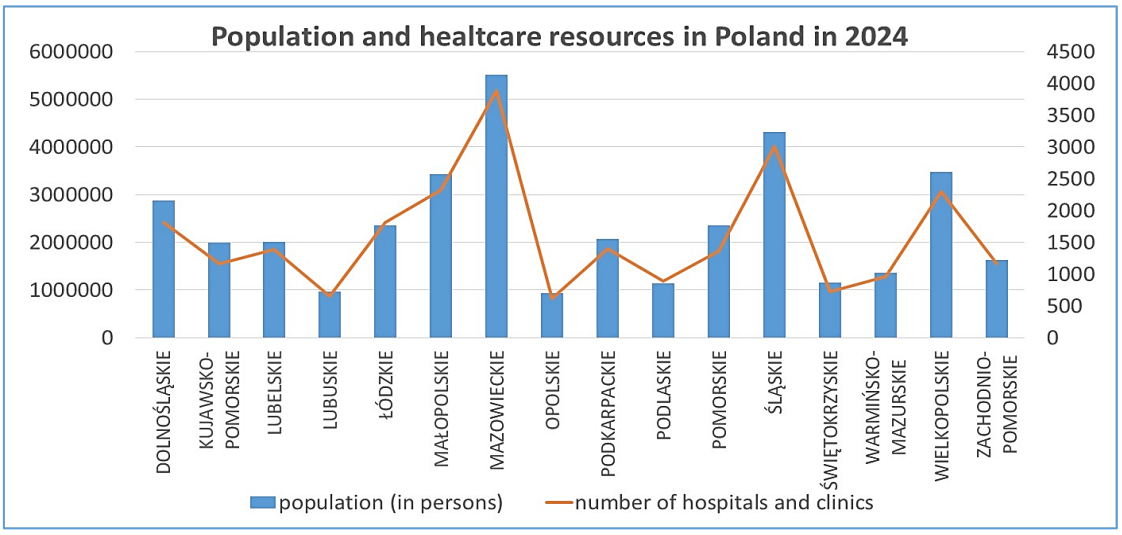


**Figure 1.** Population and number of healthcare facilities in Poland by voivodeship in 2024.
Source: own study based on data from bdl.stat.gov.pl

In Figure 1 and Figure 2, a clear relationship can be observed between the values: the larger the population in a given voivodeship, the more healthcare facilities. The Pearson correlation coefficient between the number of residents and the total number of hospitals and clinics was determined. Its value is 0.9915, indicating a very strong, positive correlation. The coefficient of determination indicates that approximately 98.31% of the number of hospitals depends on the population in the voivodeship. According to the authors, access to healthcare facilities should be the same for all Poles regardless of place of residence. Therefore, this coefficient should be close to 1. However, due to the dynamically changing population in some regions

(depopulation, influx to large agglomerations, emigration, immigration, influx of migrants), this relationship should be systematically monitored to avoid extreme situations in which the population exceeds the healthcare offered. This creates significant problems with access to healthcare facilities and reduces the quality of healthcare services. On the other hand, an overabundance of healthcare facilities, inadequate to the number of those in need, leads to suboptimal utilization of healthcare capacity. These facilities (hospitals, clinics) will then be empty, with no patients. In such a case, they should be repurposed, for example, given the changing age structure of the population, into nursing homes or geriatric or palliative care hospital wards.

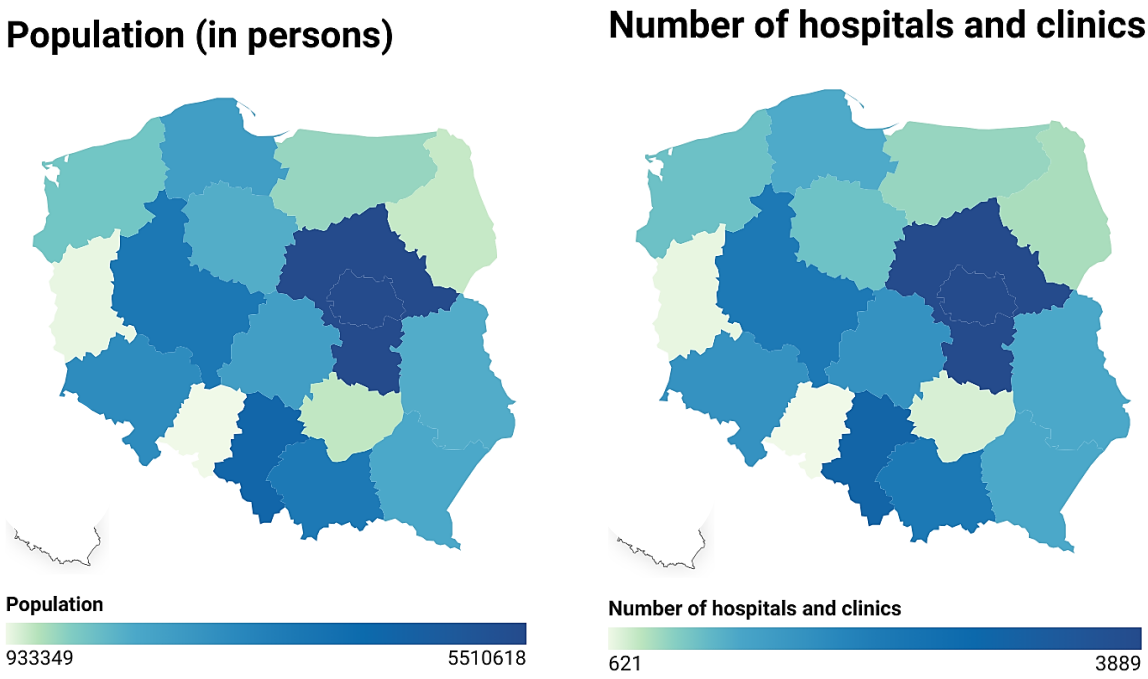


**Figure 2.** Population and number of healthcare facilities in Poland by voivodeship in 2024.
Source: own study based on data from bdl.stat.gov.pl

Figure 3 shows the relationship between population and the number of hospitals and clinics in voivodeships. The higher the population, the more healthcare facilities. The slope of the theoretical regression line (0.0007) indicates that there are approximately 7 healthcare facilities per 10 000 inhabitants in Poland, or approximately 1428 patients per healthcare facility.

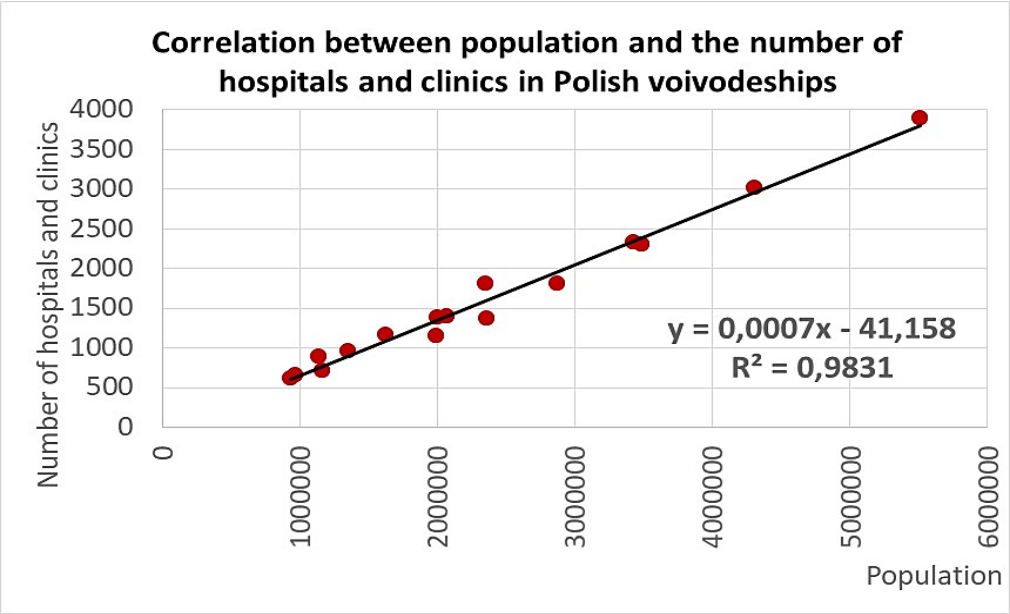


**Figure 3.** Correlation and regression line between population and the number of hospitals and clinics in Polish voivodeships in 2024.

Source: own study.

The situation varies across voivodeships (Figure 4). There are voivodeships with low rates, such as the PODLASKIE and ŁÓDZKIE Voivodeships (fewer than 1,300 patients per unit), and voivodeships with very high rates, such as the KUJAWSKO-POMORSKIE, POMORSKIE Voivodeships (over 1,700 patients per healthcare unit).

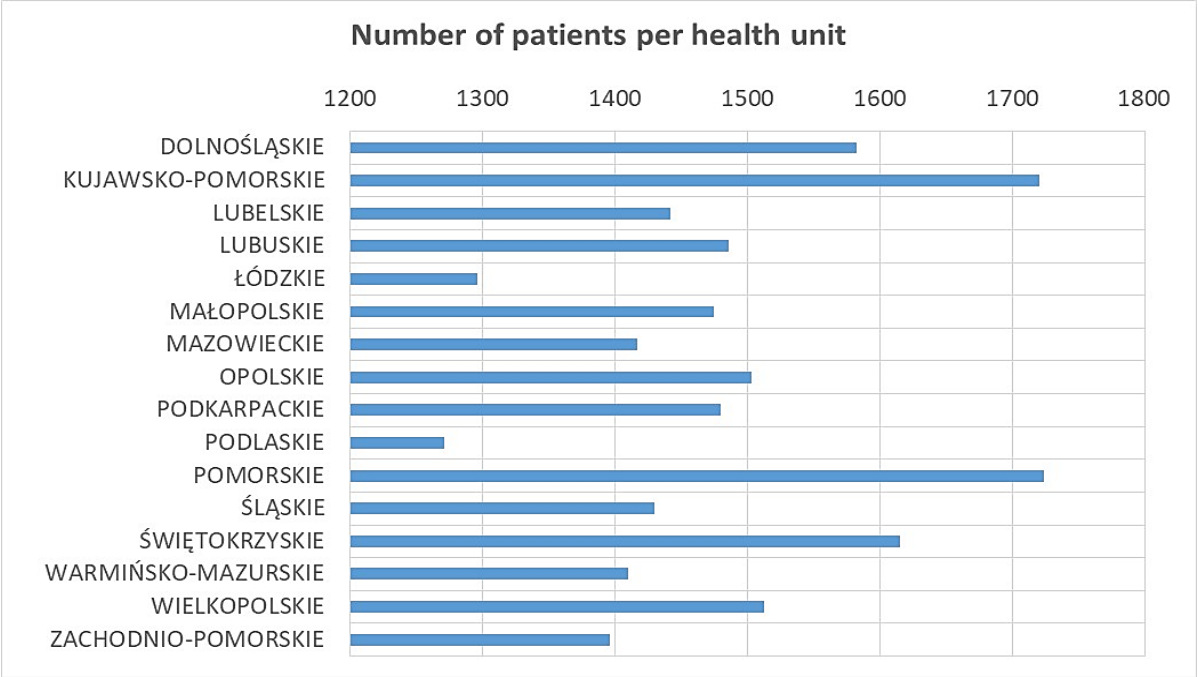


**Figure 4.** Number of patients per health care unit by voivodeship in 2024.

Source: own study.

### 3.2. The potential of healthcare accessibility in Poland in the voivodeships – results of empirical research

According to the formulas presented in the methodological section of this article, the own potential, the potential of the surrounding area, and the total potential of access to healthcare facilities were determined. The distance between provincial capitals was adopted as the metric. The results of the analyses are presented in Table 2 and Figure 5, Figure 6 and Table 2.

The own potential was rescaled using a multiplier of 1000, and the surrounding potential was rescaled using a multiplier of 10. Therefore, it was assumed that approximately 1 percent of a given voivodeship's residents use healthcare facilities located in neighboring voivodeships. It was also assumed that Poles do not use facilities located in voivodeships that are not adjacent to their voivodeship of residence. This assumption can, of course, be omitted or modified.

**Table 2.**
*Potential of healthcare resources in Polish voivodeships in 2024*

| Voivodeship | $HP_i(2024)$ | $\sum_{\substack{j=1 \\ j\neq i}}^{n} \frac{HP_j(2024)}{d_{ij}}$ | $HTP_i(2024)$ | Relationship Own health potential/ total health potential |
|---|---|---|---|---|
| **DOLNOŚLĄSKIE** | 0.6318 | 0.1277 | 0.7595 | 0.8318 |
| **KUJAWSKO-POMORSKIE** | 0.5813 | 0.1871 | 0.7684 | 0.7565 |
| **LUBELSKIE** | 0.6933 | 0.1376 | 0.8308 | 0.8344 |
| **LUBUSKIE** | 0.6727 | 0.1303 | 0.8030 | 0.8378 |
| **ŁÓDZKIE** | 0.7714 | 0.2294 | 1.0008 | 0.7708 |
| **MAŁOPOLSKIE** | 0.6782 | 0.1797 | 0.8579 | 0.7905 |
| **MAZOWIECKIE** | 0.7057 | 0.2318 | 0.9375 | 0.7528 |
| **OPOLSKIE** | 0.6653 | 0.1872 | 0.8525 | 0.7805 |
| **PODKARPACKIE** | 0.6758 | 0.1206 | 0.7964 | 0.8486 |
| **PODLASKIE** | 0.7866 | 0.0885 | 0.8752 | 0.8988 |
| **POMORSKIE** | 0.5801 | 0.1188 | 0.6989 | 0.8300 |
| **ŚLĄSKIE** | 0.6994 | 0.2134 | 0.9128 | 0.7662 |
| **ŚWIĘTOKRZYSKIE** | 0.6191 | 0.2623 | 0.8814 | 0.7024 |
| **WARMIŃSKO-MAZURSKIE** | 0.7093 | 0.1350 | 0.8443 | 0.8401 |
| **WIELKOPOLSKIE** | 0.6610 | 0.2164 | 0.8774 | 0.7534 |
| **ZACHODNIO-POMORSKIE** | 0.7161 | 0.1045 | 0.8206 | 0.8727 |

Source: own study.

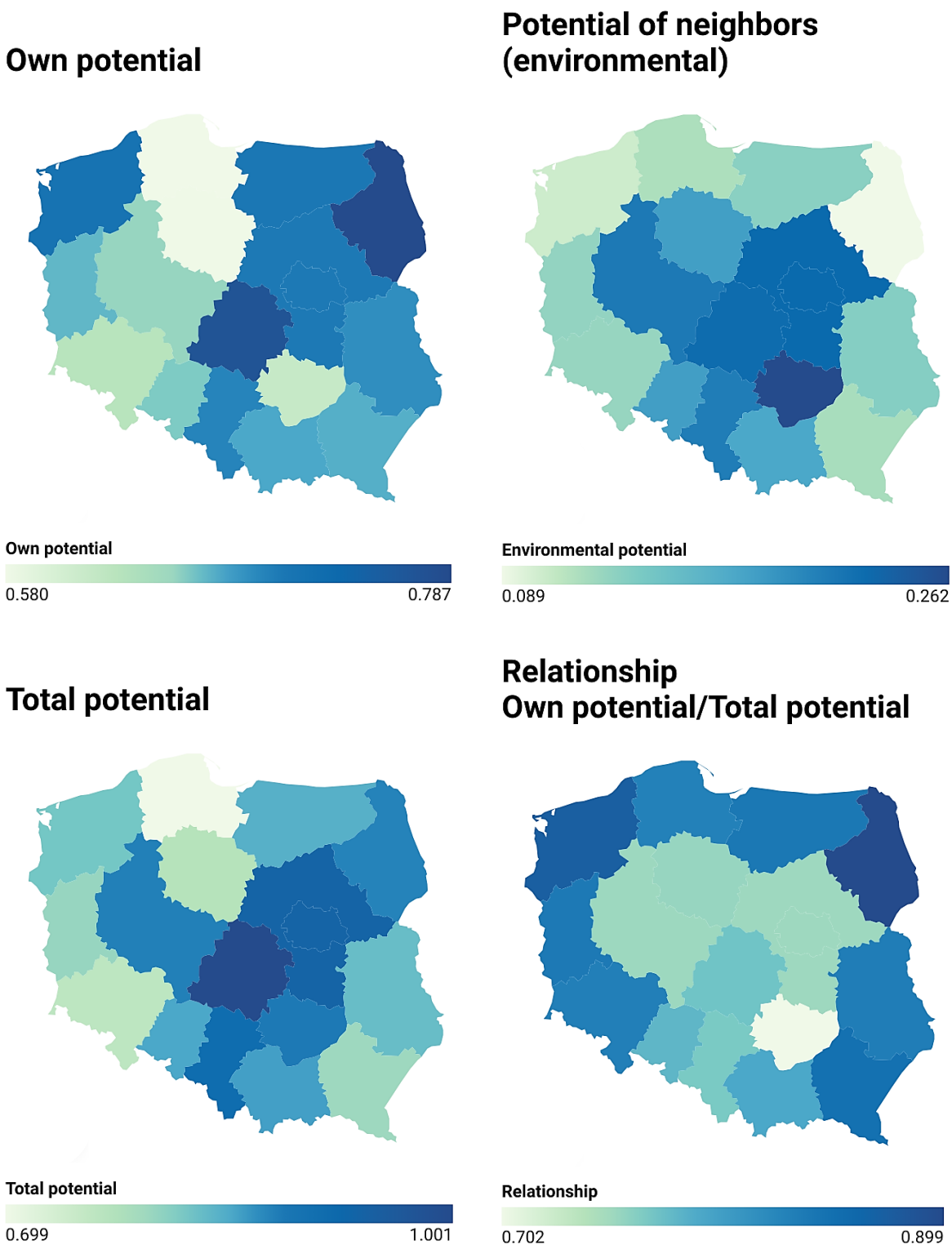


**Figure 5.** Healthcare availability potential of the voivodeships.

Source: own study.

The PODLASKIE and ŁÓDZKIE Voivodeships have the highest internal potential, while the KUJAWSKO-POMORSKIE and POMORSKIE Voivodeships have the lowest. The ŚWIĘTOKRZYSKIE Voivodeship has the highest neighboring potential (it is geographically best-positioned for this feature), while the PODLASKIE Voivodeship has the

lowest (it has a small number of weak neighbors). Total potential is highest in the ŁÓDZKIE Voivodeship, while the POMORSKIE Voivodeship has the lowest. The ŚWIĘTOKRZYSKIE Voivodeship is the most dependent on its neighbors, while the PODLASKIE Voivodeship is the strongest (Figure 5, Figure 6).

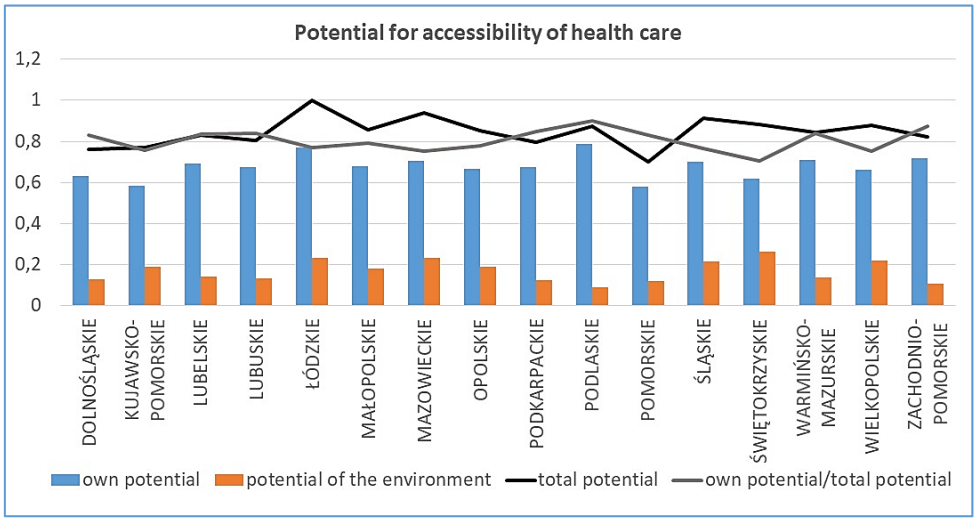


**Figure 6.** Healthcare availability potential of the voivodeships.

Source: own study.

## 4. Conclusion and recommendations

This article provides a critical and comparative assessment of healthcare resources in Poland by voivodeship, in terms of the number of hospitals and clinics available. Next, a measure – healthcare accessibility potential – is proposed. The advantages and disadvantages of this measure are discussed. The assumptions regarding the metric used in the potential formula are highlighted. The empirical section calculates healthcare service potential, identifying voivodeships that are strong and weak in this respect. The need to ensure equal access to healthcare services for all residents of Poland in need is emphasized. The proposed formulas utilize a time parameter. The data in the analysis are from 2024. However, an analysis of the dynamics of change would demonstrate the relationship between the potential over time and answer the question of whether changes in the number of healthcare facilities correspond to the needs of residents. A focus on specialist facilities would also be advisable, as the demand for specialists also varies across regions. This indicates the need for further relevant and timely research on this topic.

To ensure equal access to healthcare facilities for Polish residents, both partial (their own and those of the surrounding area) and total potential should be assessed. A high level of socioeconomic development motivates efforts to meet the needs of residents in terms of

healthcare accessibility. Changes in Poland's demographic structure, changes in the incidence of specific illnesses, and the low number of specialists compel authorities to take measures to optimally allocate available resources in a given area. The healthcare accessibility potential proposed in this article is one of the methods that can be used to optimize the satisfaction of the population's healthcare needs.

## Acknowledgements

This article is financed from funds allocated for the project "Prospects and Challenges of the Labor Market in the Age of Digitalization and AI Development Against the Background of Integration, Demographic, and Migration Processes". The project will be carried out in 2025-2027 at the University of Economics in Katowice. The project is financed by the Minister of Science under the "Regional Excellence Initiative" program, a program of scientific, research, and educational excellence at the University of Economics in Katowice.

## References

1. Begg, D., Fischer, S., Dornbusch, R. (1992). *Ekonomia, Vol. 2*. PWE.
2. Borys, T. (ed.) (2005). *Wskaźniki zrównoważonego rozwoju*. Warszawa-Białystok: Ekonomia i Środowisko.
3. Borys, T., Rogala, P. (ed.) (2008). *Jakość życia na poziomie lokalnym – ujęcie wskaźnikowe.* Warszawa: UNDP.
4. Diebold, F.X., Yilmaz, K. (2015). *Financial and macroeconomic connectedness: A network approach to measurement and monitoring*. USA: Oxford University Press.
5. Gorynia, M. (2019). Competition and globalisation in economic sciences. Selected aspects. *Economics and Business Review, 5(3),* 118-133.
6. Greene, W.H. (2003). *Econometric analysis*. Pearson Education India.
7. Greenspan, A. (2014). *Mapa i terytorium: ryzyko, natura ludzka, przewidywania.* Warszawa: Prószyński i S-ka.
8. Hozer-Koćmiel, M. (2018). Ocena rozwoju społeczno-ekonomicznego województw za pomocą HDI. *Wiadomości Statystyczne, 3(682),* pp. 40-49.
9. https://bdl.stat.gov.pl
10. https://ec.europa.eu/eurostat
11. https://hdr.undp.org

12. Krueger, A. B., Lindahl, M. (2001). Education for Growth: Why and For Whom? *Journal of Economic Literature*, *39(4),* pp. 1101-1136.
13. Laskowska, I., Dańska-Borsiak, B. (2018). Analiza przestrzennego zróżnicowania rozwoju społecznego w Polsce na poziomie NUTS 3 wykorzystaniem lokalnego indeksu HDI. *Folia Oeconomica, Acta Universitatis Lodziensis, 1(333)*. Łódź, pp. 111-131.
14. Mastalerz-Kodzis, A. (2017). Iloraz potencjałów jako narzędzie wspomagające podejmowanie decyzji i kształtowanie strategii na rynku pracy w Polsce. *Zeszyty Naukowe. Organizacja i Zarządzanie, Z. 102*, pp. 215-224.
15. Mastalerz-Kodzis, A. (2018a). *Dynamiczne modele specjalne Nowej Ekonomii Geograficznej*. Katowice: Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach.
16. Mastalerz-Kodzis, A. (2018b). *Methodology for Measuring the Economic Potential of Financial Institutions.* Managing and Modelling of Financial Risks. 9th International Scientific Conference, Proceedings (Part 2), ed. Miroslav Čulík.
17. Mastalerz-Kodzis, A. (2018c). Metodyka pomiaru potencjału ekonomicznego jednostki terytorialnej oraz organizacji. *Zeszyty Naukowe. Organizacja i Zarządzanie, nr 127,* pp. 125-134.
18. Mastalerz-Kodzis, A. (2018d). *Zastosowanie metody ilorazu potencjałów do pomiaru poziomu rozwoju społeczno-gospodarczego Polski.* Metody i modele analiz ilościowych w ekonomii i zarządzaniu. Część 9. J. Mika, M. Miśkiewicz-Nawrocka (eds.). Katowice, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, pp. 9-24.
19. Mastalerz-Kodzis, A. (2021). Quantitative analysis of the economic potential on the example of the Upper Silesian Metropolis. *Zeszyty Naukowe. Organizacja i Zarządzanie, Nr 150*, pp. 131-140.
20. Mastalerz-Kodzis, A., Pośpiech, E. (2017). *NEG methodology in socio-economic development and EU labour market research.* 35th International Conference Mathematical Methods in Economics MME 2017. Conference Proceedings. Ed. Pavel Prazak, pp. 436-441.
21. Nelson, A.C. (2013). Theories of regional development. In: R.D. Bingham, R. Mier (eds.), *Theories of Local Economic Development: Perspectives from Across the Disciplines.* London: Sage Publications.
22. Panek, T. (2009). *Statystyczne metody wielowymiarowej analizy porównawczej*. Warszawa: Szkoła Główna Handlowa w Warszawie – Oficyna Wydawnicza, pp. 58-114.
23. Singh, R.K. et al. (2009). An overview of sustainability assessment methodologies. *Ecological Indicators, 9(2).*
24. Suchecki, B. (ed.) (2010). *Ekonometria przestrzenna. Metody i modele analizy danych przestrzennych.* Warszawa: C.H. Beck.
25. Tanguaya, G.A. et al. (2010). Measuring the sustainability of cities: An analysis of the use of local indicators. *Ecological Indicators, 10(2).*