

**ORDERING AND CLASSIFICATION
OF THE SILESIA VOIVODESHIP REGION
WITH RESPECT TO A HEALTH CARE SYSTEM ACTIVITY**

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Abstract: The health care system in Poland or any other country should ensure an equal and unrestricted availability of the health service to its population. This idea, though being noble and harmonious with the country's constitution, seems to differentiate small administrative regions of the Silesian voivodeship. Therefore the presented paper is an attempt to estimate and analyse conditions of the health care system activity in this region. Those regions were systematized based on a structure of health care system. Also, a homogeneous groups of regions were created. The analysis is based on the cluster analysis.

Keywords: numerical taxonomy, synthetic ratio, health care system, state of health, availability of a health service

INTRODUCTION

The general functioning of the health care system in Poland, which was reformed in 1999, consists in the cooperation between its participants and their mutual collaboration. One can enumerate three main goals of this exchange [Kautsch, Whitfield, Klich 2001, p. 31]: service consumers, providers and payers. The role of the medical service consumer is performed by the patient who purchases health care services from a doctor or another health care provider through the payer. The National Health Fund, which is a public insurer and intermediary in the exchange of services between the healthcare provider and the patient, has been the payer since 2003.

Responsibility for the protection of the public health needs and for the financial consequences resulting therefrom does not lie exclusively on the insurer.

A significant role in the financing of health care services is also played by the state and local governments, which are the founding bodies of the majority of state healthcare centres.

Each province in Poland is therefore required to ensure that the health care needs of its inhabitants are met on an appropriate level of expertise and quality. However various economic determinants of the functioning of the provinces and geographic, demographic or economic factors typical of individual provinces, allow one to assume existence of disproportions in the access to a wide range of health care services. This problem was discussed in a study devoted to one of the most interesting regions in Poland, namely Silesia. This region is important not only because of its population density (which in 2008 amounted to 377 persons per one square kilometer and was the highest one in Poland [www.stat.gov.pl (23.02.2009)]) or an interesting regional labour market. The uniqueness of Silesia is mainly connected with its activity in the field of health care.

In 2011, 2716 outpatient clinics [Zdrowie i ochrona zdrowia w 2011, p.190] and 116 hospitals [Zdrowie i ochrona zdrowia w 2011, p. 233] operated in the Silesian province, which were the highest values in the entire country. The Silesian region is also an important center for the education of medical staff at all levels, It can also boast a recognized and well-known heart transplantation centre (Silesian Center for Heart Diseases in Zabrze), oncology centre (with the Oncology Centre in Gliwice, which is the most modern centre in the country) and finally the recognized Burns Treatment Centre in Siemianowice Śląskie [www.silesia-region.pl (23.02.2009)].

The above mentioned advantages of the Silesian region constitute a basis for monitoring the functioning of the health care system within its boundaries. This study may be thus helpful in the assessment of health care activities in this region, compared to other regions in Poland. It can also constitute a basis for the assessment of their effectiveness in particular districts and cities. Therefore the main goal of the presented paper is to check if the access to the health service is the same in different regions of Silesian voivodeship. It is focused only on the infrastructure and inputs that can help in the health service realization. Thus we don't analyse the results of the activity of the health care system, e.g. the health state. In this context, analyses of the former Częstochowa, Katowice and Bielsko-Biała provinces, merged into one region, which is an entirety in administrative terms, but remains divided in historical terms, seem to be of particular importance.

DISTRICTS AND CITIES OF THE SILESIA PROVINCE

There are 17 districts in the Silesian Province. This province is characterized by a relatively high level of diversity in terms of the number of people living in its districts (the coefficient of variation in 2011 is 43,99%).

The Bieruń–Łędziny district, which in 2011 was home to just over 58 thousand people, is the smallest one. The biggest district in terms of the number of inhabitants was at that time the Cieszyn district, with 176.6 thousand inhabitants [www.stat.gov.pl (24.02.2012)].

One of the characteristics of the Silesian districts is the professional activity of its inhabitants. The largest percentage of employed persons was in the Bieruń–Łędziny district, in which as much as 35.23% of its total population was registered as working people. An alarmingly low percentage of workers (only 14.39%) was recorded in the Rybnik district in 2010 [www.stat.gov.pl (24.02.2012)].

Natural increase of the population was extremely diverse in the Silesian districts in 2010. While the lowest value of this feature amounted at the time to -3.3 births per 1 thousand people in the Zawiercie district, the highest value of 3.5 births was recorded in the Bieruń–Łędziny district [www.stat.gov.pl (24.02.2012)].

Among the many characteristics of the population of the Silesian province, one should mention the number of infant deaths. This feature describes not only the demographic conditions in the region, but it also provides a certain insight into the condition and level of the health care system. Thus, the Będzin district, with 2.9 infant deaths per one thousand live births, could boast the lowest value of the number of deaths in the entire region in 2011 [www.stat.gov.pl (24.02.2012)]. In contrast, the highest rate was recorded in the Kłobuck district, with almost 12 deaths per one thousand live births.

The Silesian province has 19 cities with district rights. Among them one can mention such small towns as Świętochłowice (about 53 thousand people in 2011), Piekary Śląskie (about 58 thousand in 2011) or Żory (62 thousand in 2011), and large cities like Katowice (about 309 thousand in 2011), Częstochowa (236 thousand in 2011) or Sosnowiec (about 215 thousand in 2011), which are not the biggest cities in the country, but stand out in their region.

The economic environment in which the Silesian province functioned in 2010 shows that, compared to all the cities of the region, the worst market conditions were prevailing in Świętochłowice, Siemianowice Śląskie and Żory. These cities recorded the lowest percentage of workers in the entire Silesian province, compared to the number of inhabitants.

If one considers the demographic conditions of the functioning of cities with district rights of the Silesian Province, one can say that they are characterized by a similarly large dispersion in relation to the population growth, which was also the case of the districts. The highest value of this feature in 2010 was recorded in Żory, and it amounted to 5.1 births per 1000 people. This value was significantly higher than that recorded in Rybnik, for which the growth rate was 3.1 people per one thousand inhabitants. The lowest value was recorded in Sosnowiec, with the rate of - 3.2 births per 1000 people [www.stat.gov.pl (24.02.2012)].

Compared to the Silesian province districts, the cities of the region were characterized by higher values of the infant deaths, because in Katowice,

Świętochłowice and Rybnik one recorded more than 9 infant deaths per one thousand live births in 2011. The lowest infant death rate among the cities with district rights was recorded in Jastrzębie Zdrój, which had 2.2 infant deaths per one thousand live births [www.stat.gov.pl (24.02.2012)].

RANKING OF DISTRICTS AND CITIES OF THE SILESIAN PROVINCE

Assessment of the functioning of the health care system in the Silesian region, with division into districts and cities with district rights, seems to be plausible, considering the fact that the presently existing provinces (including the Silesian one) are usually a cluster of other provinces, existing before 1999. Is each district and city of the present Silesian province characterized by the same efficiency in the field of health care and can the patients of these regions expect the same access to medical services?

The above question can be answered with the application of numerical taxonomy methods, because it is the numerical taxonomy which provides one with methods to classify and rank the analysed objects.

The notion of taxonomy is derived from Greek, in which *taxis* means ordering, and *nomos* - rule. Basically, taxonomy can be defined as "a scientific discipline, dealing with the rules and procedures of classification (ordering, grouping, discriminating, eliminating, dividing)" [Kolenda 2006, p.17].

The basic concepts in the taxonomy are *object* and *feature*. The districts and cities with district rights (considered as a separate group of objects) were the object of analysis in this paper.

The analysed units were described by several features. These include:

- the number of hospitals per 1 thousand inhabitants (LS)
- the number of hospital beds per 10 thousand inhabitants (LL),
- the number of outpatient care centres, increased by the number of medical practices, per 1 thousand inhabitants (LA)
- the number of drug stores per 1 thousand inhabitants (A)
- the number of day nurseries and nursery units per 1 thousand inhabitants (LZ)
- the number of infant deaths per one thousand live births (ZN)
- the number of places in full-time social welfare centres per 1 thousand inhabitants (PS) and
- the amount of budgetary expenditure of the districts on health care in PLN thousands per 1 thousand inhabitants (W).

The author has chosen the above-mentioned variables, because, due to the availability of data, they describe in relatively thorough (as part of the health care system) and uniform terms the functioning of the health care system within the analysed area [Kozierkiewicz 2000]. All variables are a cumulative value within

each of the 17 districts and 19 cities with district rights of the Silesian province. These features allow one to assess the resources and infrastructure of the health care system in this area, and to connect them with expenditure allocated by the districts for health care protection purposes. Unfortunately, the commonly available data about the districts do not allow one to compare the results and effects of the functioning of the health care system, expressed, for example, by the number of inpatients or outpatients.

The data used in the study cover the year 2007.

In the procedure of classification and ranking of objects, one can distinguish several stages: transformation of features into stimulants, normalization of features, weighting of the feature.

So in the first place it was necessary to transform all the features that were de-stimulants and nominants to stimulants. Almost all analysed features are stimulants, except for the number of infant deaths, which, according to the transformation procedures, was transformed into a stimulant, using the formula:

$$z_i = -x_i, \quad (1)$$

where x_i are the values of the X feature (de-stimulants), and z_i is its value transformed into a stimulant.

To order the districts and cities of the Silesian province, one has determined for each of them the so-called. synthetic feature, which is a kind of resultant of all analysed features. The synthetic value was calculated based on the following formula:

$$g_i = \sum_{j=1}^k x'_{ij} w_j \quad (2)$$

where x'_{ij} - normalized values for the j -th feature and i -th object, w_j - weights for the j -th feature, k - number of features.

The first stage in determining the value of the synthetic feature was to normalize the features, because the normalization procedures enable one to compare them. In this case, the normalization was achieved by standardization.

In order to determine the degree of importance of each analysed feature, one has given them weights, with the application of a ranking method, based on orthogonal projection. The w_j weights were determined on the basis of the following formula:

$$w_j = \frac{x_{Wj} - x_{Aj}}{d(A, W)} \quad (3)$$

where: x_{Wj} - value of the so-called standard for the j -th feature, x_{Aj} - value of the so-called anti-standard for the j -th feature, $d(A, W)$ - Euclidean distance between x_{Wj} and x_{Aj} .

The literature on the subject describes a few methods of choosing the standard and anti-standard. The selection criterion is the value of the directional variance determined for the value of the synthetic feature [Kolenda 2006, pp. 139-141]. The empirical research conducted by the author shows that the highest value of the directional variance, so the best method allowing one to select the ranking method is the one for which the standard is the value of the third quartile of the normalized features, and the anti-standard - value of the first quartile.

The above procedure was used to order districts and cities with district rights, taking into account eight features analysed in 2008. Table 1 shows the obtained results.

Table 1. Values of the synthetic feature for districts and cities of the Silesian province in 2007

District	Values of the synthetic feature	City	Values of the synthetic feature
Będzin	0,22199	Bielsko-Biała	1,3946
Bielsko-Biała	-0,97432	Bytom	-0,1666
Bieruń-Lędziny	-0,94093	Chorzów	2,1583
Cieszyn	4,82349	Częstochowa	1,3609
Częstochowa	-1,81389	Dąbrowa Górnicza	-1,5072
Gliwice	0,16009	Gliwice	-0,9569
Kłobuck	-0,41443	Jastrzębie Zdrój	-0,5244
Lubliniec	2,81814	Jaworzno	-0,6459
Mikołów	0,27042	Katowice	3,5980
Myszków	-1,12775	Mysłowice	1,1979
Pszczyna	0,71931	Piekary Śląskie	0,1490
Racibórz	-0,53049	Ruda Śląska	-1,8807
Rybnik	-3,38378	Rybnik	-1,7825
Tarnowskie Góry	1,56900	Siemianowice Śląskie	1,5376
Wodzisław	0,08469	Sosnowiec	0,7522
Zawiercie	-0,44409	Świętochłowice	-1,0801
Żywiec	-1,03745	Tychy	-0,7125
		Zabrze	-0,1963
		Żory	-2,6956

Source: own study

In 2007 the Cieszyn district was leading in terms of the functioning of the health care system, with the synthetic indicator exceeding the value of 4, and significantly higher than indicators in other districts. The Lubliniec district, with the value of almost 3, ranked second.

The Rybnik district was the lowest-ranked one in 2007 (the value of the synthetic feature was about -3.4), followed by Częstochowa, Myszków and Żywiec districts, with values of the synthetic feature lower than -1

The ranking of cities is opened by Katowice, for which the value of the synthetic feature, as in the case of the districts, was far higher than that of the other cities, and amounted to 3.6. Chorzów came second in the ranking. The lowest value of the synthetic feature was recorded in Żory (value of around -2.7, Ruda Śląska (value of around -1.9) and Rybnik (value of around -1.8).

CLASSIFICATION OF DISTRICTS AND CITIES OF THE SILESIAN PROVINCE

Classification is a very important concept in taxonomy. This broad concept is connected with the "methodology of sorting a set of objects as well as the process of classification itself" [Zeliaś A (ed.) 1991, s.75]. Therefore it boils down to the division of all analysed objects into groups, so that each group will contain only homogeneous objects. Such determination of typological groups allows one to identify similar objects, to classify them into one group and to assign different objects to other clusters.

To arrange districts and cities with district rights into groups operating and functioning in the health care sector, the author has applied the concentration method, and more precisely the Ward's method. It is a linking method in which one seeks to minimize the sum of squares of any two clusters and to connect objects, so that the value of the intra-group variance of features describing the objects in the created clusters can be as low as possible.

The Ward's method is considered to be an agglomeration combinatorial method, in which each analysed object is initially treated as a single cluster, so that one can reduce the number of such groups in subsequent analyses, combining the previous clusters into the so-called groups of higher rank. The entire process ends with the creation of a single cluster, which includes all the analysed objects.

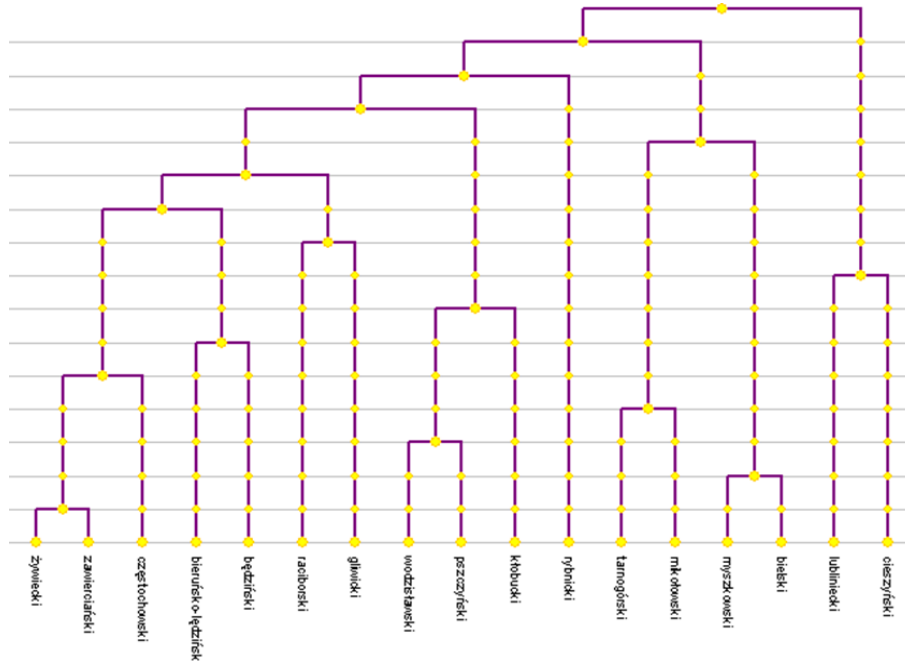
The results of clustering are usually presented in a graphic form with the so-called dendrite tree (dendrogram). Dendrite presents formation of subsequent clusters of increasingly higher orders with specific binding distances, which shows similarities and differences between the analysed objects from the point of view of the considered features.

Therefore districts were grouped first, starting from a one-element cluster, through a cluster which connects most similar districts, and ending with one, that connects all the tested objects.

District analysis results are shown in a dendrogram presented in Figure 1. In a group of 17 districts, one can identify (for example, on the level of link 11) seven groups. The first group consists of the following districts: Żywiec, Zawiercie, Częstochowa, Bieruń–Lędziny and Będzin. They are characterized by

the synthetic feature value oscillating around -1. The second group consists of the Racibórz and Gliwice districts, which seem to be better off than districts of the first group in terms of the analysed features. Third cluster consists of three regions: Wodzisław, Pszczyna and Kłobuck.

Figure 1. Dendrogram for districts of the Silesian province



Source: own study

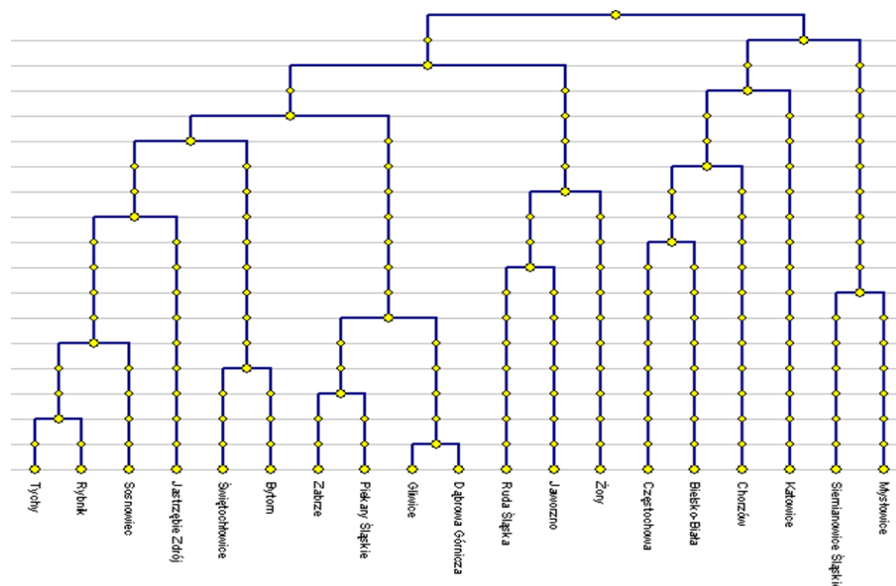
Another group includes only one district (the Rybnik district), differing significantly from the other districts, which is considered to be the worst in that group (Table 1). The next two clusters are formed by Tarnowskie Góry and Mikołów districts, and Bielsko–Biała and Myszków districts, respectively. The best functioning districts of the Silesian province include districts from the seventh group, namely: the Cieszyn and Lubliniec districts.

Cities of the Silesian province were subjected to a similar analysis, and classification and their results are presented in Figure 2. Analysis of the Silesian cities allows one to distinguish (e.g. on level 13) seven clusters of cities.

One cluster includes only one city, namely Katowice, which, according to an earlier stage of the analysis (Table 1), was considered to be the best in this group. A separate group includes Częstochowa and Bielsko–Biała, which seems to be important due to the analysed implications of incorporating these cities into the Silesian province. These cities are joined on higher level of linking by Chorzów, and finally by Katowice.

According to the calculations the results of which are presented in Table 1, the worst city in terms of the functioning of the health care system in Silesia was Żory, around which, in accordance with the classification rules, Jaworzno and Ruda Śląska were also clustered.

Figure 2. Dendrogram for cities with district rights



Source: own study

Similarities in terms of the analysed features were also noticed, in accordance with the conducted study, among Zabrze, Piekary Śląskie, Dąbrowa Górnicza and Gliwice. Separate clusters are formed by Bytom and Świętochłowice, Jastrzębie Zdrój and Sosnowiec, Rybnik and Tychy, as well as Siemianowice Śląskie and Mysłowice.

CONCLUSIONS

Application of quantitative methods in the analyses of not only the health care sector, but also of the wider economy, seems to be an important method of reading and noticing certain regularities and rules. Such analyses are of special importance in a sector in which the human health and life are at stake.

In determining relations and interactions between the objects (which can include health care institutions, branches of the National Health Fund or regions of the country), the numerical taxonomy, using quantitative methods, can be of utmost assistance. Such an approach allows one not only to establish relations between the analysed objects, but also to order and synthesize them, which in turn may become helpful in the description of a given phenomenon.

This paper focuses on the analysis of the Silesian province, taking into account available data on the functioning of the health care system in the region with respect to infrastructure of the system only. Districts and cities with district rights constitute the analysed objects.

The results of ranking of districts and cities with district rights indicate fairly significant differences between the analysed objects in terms of their functioning within the health care system. The Cieszyn district can boast the best conditions for the health care system functioning. The Rybnik district comes last. Katowice is the ranking winner. Żory has come in last. Results for the best districts and cities could be explained by the highest value of the analysed features. Similarly, the worst regions had the lowest value of the features. It is worth noting that Częstochowa and Bielsko-Biała, which prior to 1999 used to be provincial cities, in 2007 were functioning in a similar way, when one takes into account the analysed properties of the health care system. Moreover, Katowice, the best city in the region, can also be included in the cluster of these cities. Thus one can make an assumption that creation of the Silesian province in 1999 did not worsen the situation of the former provincial cities, which were incorporated into the province. The same can be said about the districts of the Silesian province, with the Lubliniec and Cieszyn ones occupying higher places than the former districts of the Katowice province.

Although the study results show an existing spatial dispersion of the analysed features, one should be satisfied with the fact that Silesia was the best Polish province in the years 2003-2005, based on similar studies using similar numerical taxonomy methods [Strzelecka, Nieszporska 2009, pp . 91-102.].

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