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Changes in the relative situation of district hospitals in Poland after the introduction of a system of basic hospital service provision in 2017

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Abstract

The most recent big reform of the Polish health system took place in 2017 and introduced a basic hospital service provision system. Hospitals were able to be included in the network and receive flat-rate financing from the National Health Fund. The current paper aims to assess how the relative situation of hospitals changed between 2015 and 2018. This study is based on multicriteria rankings which take into account the values of profit/loss on sales, the contract with the NHF, the income from health services outside the NHF, the income from rental and lease, the employment of doctors, the employment of nurses, liabilities, operating costs, and interns and residents per hospital bed. The similarity of rankings constructed using different methods is shown. Based on the results of the Chi-squared test, it can be concluded that the inclusion in the network does not affect whether the relative situation of a hospital between 2015 and 2018 improved or not. In the regression analysis, the dummy variable for level 1 hospital was negatively related to the median rank; however, this impact was not statistically significant.

Keywords: *district hospital, healthcare system, operating costs, employment, multicriteria ranking*

1. Introduction

Health problems are a universal challenge to societies and governments. Although no country was initially fully prepared for the ongoing COVID-19 pandemic, this situation has shown the importance of a well-performing health system – a condition which allows it to adapt quickly. The healthcare system in Poland is based on hospitals, the majority of which are public. The fact that the constitution guarantees access to healthcare for every citizen may be one of the main reasons for the public discussion about the

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system and its reforms. Since the fall of communism in Poland in 1989, the system has been subject to many changes [6, 29, 36]. Changes were introduced in the financing system and the sphere of service providers. According to Ćwiąkała-Małys et al. [6], the lack of coordination between those two contributed to the inconsistencies in the system. The evolution of the Polish healthcare system since 1990 is presented, for example, in Ćwiąkała-Małys et al. [6] and Nojszewska et al. [24], while Dubas-Jakóbczyk et al. [10] describe more recent changes of politics by comparing them with other countries of the region, which also aimed at improving their health system.

In the current paper, the focus is on the most recent reform which was introduced in Poland in 2017 and implemented a system of basic hospital service provision, also called a hospital network. This system was introduced to guarantee that the population has access to services, on the one hand, and adequate financing of those services, on the other hand [18]. Here, we study whether the relative situation of hospitals changed with the introduction of the new system. It proves clearly that it is not possible to unambiguously identify the reasons behind the changes in the hospitals' situation as they operate in a complex environment. Hospital managers need to consider the situation in a local environment (e.g., the labour market, the market for outsourced services, the needs and health status of the local population), as well as the needs and plans of the owner (private or local), but regulation changes set the boundaries within which hospitals are managed. The situation in Polish hospitals has been worsening recently, as shown by Nojszewska et al. [25]. The current study does not intend to identify reasons, but to describe those changes and provide the characteristics of hospitals which improved their situation in comparison with others. The impact of inclusion in the network is studied. The analysis is based on the district (second-level unit of local government and administration in Poland) hospitals. The rankings of Polish hospitals take into account various aspects of their performance (e.g., financial status, health care), but MCDA/M (Multiple Criteria Decision Aiding/Making) methods are rarely incorporated [33, 44-45]. The study by Miszczyńska, who uses PROMETHEE II and Balanced Scorecard to evaluate effectiveness, may be cited as one of the exceptions [19]. Research on the regulation of hospitals with the use of MCDA methods is also carried out in other countries, as an example a recent work by Pereira and Marques [28] may be referred to. The consequences of the introduction of the hospital network are discussed, e.g., by Dubas-Jakóbczyk and Kozieł [8], Rabiej [30], however, their approach is different from the one applied in the current paper. This study complements, in a way, previous studies of the costs and inefficiency of Polish hospitals in the period when the reform took place, conducted by Sielska [34, 35]. The focus is on the changes in resources and financial results.

The paper consists of three parts. In the first one, the hospital network reform and its goal are presented. The second one is focused on the methods used to study the changes in the relative situation of hospitals after the network was introduced. In the third part, the results are presented. The paper ends with the conclusions.

2. Hospital network

The system of basic hospital service provision was introduced in 2017. The Act passed on March 23, 2017 and came into force seven days after its publication date. The system began to function on October 1, 2017 [2]. Its goal was to provide the citizens with access to healthcare services in the fields of hospital treatment, highly specialised services, outpatient specialist care provided in hospital clinics, and night and holiday health care. At the same time, the continuity and complexity of the services provided, and the stability of their financing should be ensured. Robakowski and Pogorzelczyk [32] point out the importance of the network in the health security system.

Hospitals are classified in the network for four years. There are six groups into which a hospital may be classified: 1–3 level hospitals (so-called basic levels), oncological or pulmonary hospitals (both at the same level), paediatric hospitals, and nationwide hospitals. The decisions are made and published by the regional department of the NHF at the voivodeship (i.e., highest-level unit of local government and administration in Poland) level [29]. A hospital is guaranteed to participate in the network provided that it fulfils certain conditions [32].

Qualification into the network gives access to the lump sum basis financing from the NHF instead of the previous financing of treatments [6]. The amount of the lump sum was based on the services provided in 2015 and pricing from the period 2015–2017 [29]. Although participation in the network guarantees finance, its level is determined by the previous performance of a hospital. If a hospital provides services on a significantly larger scale, its costs will be covered only if some of the other hospitals in the voivodeship used a flat rate below 98% [22]. Besides, it should be kept in mind that, as Dubas-Jakóbczyk et al. point out [9], even if a hospital is qualified into the network at a given level, only selected types of wards are covered by it and the rest is financed outside the network. Hellig and Wierzowiecka [12] show the potential possibility of hospitals refusing to admit patients due to the risk of costs not being covered. Hospitals which did not qualify for the network have to enter tenders for funds. As stated Dubas-Jakóbczyk et al. [10], one of the results of the reform was pressure for financial restructuring. Problems raised in the literature and public discussion are connected to the inefficiency of the system. Hospital beds are being used less than the needed degree, as shown in the Supreme Audit Office (NIK, Najwyższa Izba Kontroli) report [22]. Byszewski points out that this low degree results from the higher than an adequate number of beds, which indicates the lack of incentives for more complexity, and he notes some potentially negative consequences, such as an increase in inefficiency [2]. The lack of the quality-of-care criterion and the lack of evaluation indicators, which would be known in advance, are also pointed out by Dubas-Jakóbczyk et al. [10].

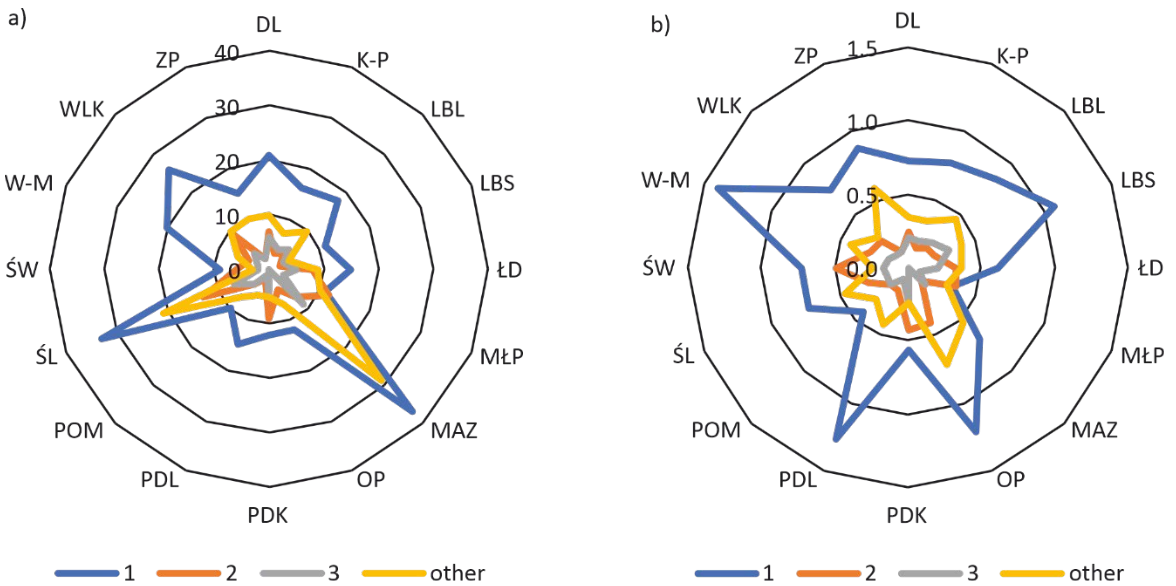

Figure 1. Distribution of the hospitals classified into the network by the level (1–3 and other) and voivodeship: a) number of hospitals, b) number of hospitals per 100 000 population based on [11, 22]; voivodeships: DL – dolnośląskie, K-P – kujawsko-pomorskie, LBL – lubelskie, LBS – lubuskie, ŁD – łódzkie, MŁP – małopolskie, MAZ – mazowieckie, OP – opolskie, PDK – podkarpackie, PDL – podlaskie, POM – pomorskie, ŚL – śląskie, ŚW – świętokrzyskie, W-M – warmińsko-mazurskie, WLK – wielkopolskie, ZP – zachodniopomorskie

In 2019, the NIK published the results of the inspection of twenty-nine hospitals participating in the network. Their report [22] states that the situation did not improve either concerning patients' access to services or the financial situation of the hospitals. Moreover, the majority of the hospitals inspected by the NIK were concerned mostly with overcoming the shortage of personnel and minimizing losses. According to the NIK, in the last years, financing was too low, taking needs into account. Even though it was increasing, the costs were growing at a higher rate [22].

In Figure 1, the number of hospitals qualified into the network in each voivodeship is presented. The author focused on the hospitals from the three basic groups (levels 1–3), which are covered by the current paper. Figure 1a shows the disproportion in the number of hospitals, with the most units in the network in mazowieckie and śląskie voivodeships, and the least units in lubuskie and świętokrzyskie. In most voivodeships, a decreasing trend may be seen, i.e., the higher the provision level, the fewer hospitals are included. There are, however, exceptions, such as mazowieckie. On the other hand, when the number of hospitals is compared with the number of inhabitants (Statistics Poland [11], population data for 2018 are used), the situation changes, as presented in Figure 1b. The provision per 100 000 population is the highest in warmińsko-mazurskie, opolskie, and podlaskie, which are among the least populated areas.

Based on the information provided by the NHF [23], Rabiej [30] points out the decline in the number of services provided within the system of basic hospital service provision in 2017–2018. The number of services provided in hospitals increased, while the number of ambulatory services and rehabilitation services decreased. The author comments that this is not a beneficial change due to the high costs of hospital services [30]. It is also reported that in the pomorskie and wielkopolskie voivodeships, both the number and the value of services provided by the network increased in 2017–2018, while the number of services provided in the lubuskie voivodeship decreased [30]. In all voivodeships, over-performance was recorded in 2018 [30].

3. Methodology

Even though most hospitals in Poland are public, there are clear differences among them. Therefore, this paper is focused on the changes in the relative situation of hospitals. Selected multicriteria and multidimensional methods are used.

The period 2015–2018 is analysed (i.e., before the network was introduced and shortly after the new law came into force). The network was introduced in 2017, but 2015 is also included in the analysis since, as mentioned before, the amount of the lump sum was based on the performance in 2015 [29].

The study is conducted in the following steps:

- Choice of criteria.
- Restriction of the dataset to years 2015–2018.
- Elimination of the hospitals that did not provide answers to all the questions concerning variables used in this study. At this stage, 62 hospitals remained.
- Pooling of all observations. As a result, 248 units (62 hospitals, each with a four-year record) can be ranked together. Such an approach allows not only to compare the relative situation of different subjects but also to compare their situation over four years and verify the direction of changes.
- Normalisation.
- Calculation of weights.
- Ranking.
- Comparison and analysis of rankings.

3.1. Criteria

In the current paper, multicriteria and multidimensional methods are used for ranking. Because of that, diagnostic variables (attributes) are also referred to as criteria. In the multidimensional analysis, it is postulated to choose the criteria which are independent of each other, while in the multicriteria analysis, two approaches can be found. The first one states that all criteria important for the decision-maker should be considered, while the second one uses weights to correct the relative importance of criteria due to either preferences or data quality. Since, in the current study, there is no decision-maker, all criteria were considered, although in one scenario they were weighted to level out both their diversification between alternatives and correlation between criteria.

The following criteria were chosen: profit/loss on sales, contract with the NHF, income from health services outside the NHF, income from rental and lease, employment of doctors, employment of nurses, liabilities, operating costs, interns and residents. All variables previously listed were calculated per bed. The size of the hospital, measured in the number of beds, is not included as an individual criterion because there is no wide consensus on whether it should be hypothetically treated as a profit or loss criterion. On the one hand, district hospitals play an important role from the point of view of local politics and more hospital beds available per person should be a sign of better healthcare. On the other hand, it is pointed out by Dubas-Jakóbczyk and Kozieł, that the number of beds in hospitals is too high [8], and the possible increase in this number should be accompanied by an increase in medical staff and financing. According to Dubas-Jakóbczyk et al. [9], the worldwide trend is that hospitals should reduce the number of beds and move to more integrated care systems. What is more, the utilisation of hospital beds is relatively low in Poland, as mentioned by Dubas-Jakóbczyk et al. [10] and the NIK [22], which coexist with the queues for medical services.

Employment of doctors, nurses and doctor trainees is included due to the shortages of personnel mentioned by Sowada et al. [36]. It is also mentioned in the literature that medical staff have an impact on the efficiency of hospitals, works by Ali et al. [1], Cheng et al. [5] may be cited as examples.

Other criteria represent the financial situation of hospitals. Profit/loss on sales is considered since, in recent years, the financial situation of district hospitals was unfavourable, as shown in Nojszewska et al. [25]. In the referred study, the median value of the profit/loss on sales was negative in 2015–2018. The contract with the NHF is included as the major source of income for district hospitals. The income from health services outside the NHF and the income from rental and lease are included as two other sources of income. Operating costs represent the costs related to the provision of services. They depend not only on the supply but also on local variables, such as the level of wages. Liabilities are included in the study, as indebtedness is one of the main problems of hospitals in Poland [8, 36], and a reason for the ongoing modifications of regulations.

3.2. Methods used for ranking

The methods were chosen due to their intuitive algorithms and relative independence of the results from the assumption made by a decision-maker or an analyst conducting the study. Since the topic discussed in the paper is not subjective and there is no decision-maker in the discussed problem, features that guarantee objectivity were considered crucial. Nermend [21] points out that the limited influence of the decision-maker (or an analyst) allows some multiple-criteria decision analysis (MCDA) methods to be used in multivariate comparative analysis. He also suggests calling them multidimensional comparative analysis decision-making (MCADC). This approach is chosen over the other data-driven methods, such as data envelopment analysis (DEA) [3] since it allows ranking and comparing hospitals without focusing on efficiency, which is not within the scope of this study. The topic of interest in the current paper is the changes in resources and financial results.

Hospitals are ranked using four different methods. The first one was proposed by Hellwig [13] and is currently used in problems of multidimensional analysis, e.g., by Klosa [15]. The second method is TOPSIS (technique for order of preference by similarity to ideal solution) [14], which originates from MCDA but is characterised by relative high objectivity. The two final methods do not require benchmarks. VIKOR (*visekriterijumska optimizacija i kompromisno resenje* in Slovenian) [26, 27] was chosen as the third method. Similarly to TOPSIS, it belongs to MCDA methods and has a relatively high degree of objectivity, because it does not require many parameters, the values of which may be decided based on the decision maker's preferences. The fourth and last method is WSA (weighted sum average). Both VIKOR and TOPSIS are classified by Nermend [21] as MCADC methods. The Hellwig and WSA methods are also characterised by a high degree of objectivity and do not require additional parameters or assumptions.

3.2.1. The Hellwig method

The Hellwig method uses a benchmark defined as the best (ideal) solution to the ranking problem. Similarly to other methods which are based on such a concept, the ideal alternative may not exist in the reality, but it is artificially constructed based on the data.

The procedure begins with the unification of the types of variables. For the Hellwig method, destimulants (loss criteria) were changed into stimulants (benefit criteria) and values of all the criteria were normalised according to equations:

- in the case of stimulants

$$z'_{ij} = \frac{x_{ij} - \min\left(x_{ij}\right)}{\max\left(x_{ij}\right) - \min\left(x_{ij}\right)} \tag{1}$$

- in the case of destimulants

$$z'_{ij} = \frac{\max\left(x_{ij}\right) - x_{ij}}{\max\left(x_{ij}\right) - \min\left(x_{ij}\right)} \tag{2}$$

where x_{ij} – the value of the *j*th criterion for the *i*th alternative before normalisation, z'_{ij} – the value of the *j*th criterion for the *i*th alternative after normalisation.

All normalisation methods have variables in the range 0–1 as result. It is possible to use the same method of normalisation for all ranking techniques (providing additional changes in algorithms if needed due to their specificities), but, in the current paper, it was decided to use normalisation approaches which seem popular in the literature.

The next step requires the calculation of the distance between each alternative and an ideal point according to

$$d_{i0} = \sqrt{\sum_{j=1}^{K}\left(z_{ij} - z_{0j}\right)^2} \tag{3}$$

The synthetic score of each alternative (called a measure of development) is given by

$$m_i = 1 - \frac{d_{i0}}{d_0} \tag{4}$$

$$d_0 = d_{0M} + 2S_0 \tag{5}$$

where

$$d_{0M} = \frac{1}{n}\sum_{i=1}^{n} d_{i0} \tag{6}$$

$$S_0 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(d_{i0} - d_{0M}\right)^2} \tag{7}$$

Higher values of m_i result in a better position in the ranking. For outlying objects, the final score may be below 0 [20]. Rankings obtained using the Hellwig method will be denoted as HE for equal weights, and HC for CRITIC (criteria importance through intercriteria correlation) weights.

3.2.2. TOPSIS method

In the first step, variables are normalised based on the equation

$$z'_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}^2} \tag{8}$$

The TOPSIS method uses two benchmarks, defined as the best solution of the ranking problem (referred to as an ideal and denoted by z_j^+), and the worst solution of the ranking problem (referred to as a negative ideal and denoted by z_j^-). Benchmarks are defined by equations the equations

$$z_j^- = \begin{cases} \min\limits_i\left(x_{ij}\right) & \text{if the } j\text{th criterion is a stimulant} \\ \max\limits_i\left(x_{ij}\right) & \text{if the } j\text{th criterion is a destimulant} \end{cases} \tag{9}$$

$$z_j^+ = \begin{cases} \max\limits_i\left(x_{ij}\right) & \text{if the } j\text{th criterion is a stimulant} \\ \min\limits_i\left(x_{ij}\right) & \text{if the } j\text{th criterion is a destimulant} \end{cases} \tag{10}$$

$$d_i^+ = \sqrt{\sum\nolimits_{j=1}^{K}\left(z_{ij} - z_j^+\right)^2} \tag{11}$$

$$d_i^- = \sqrt{\sum\nolimits_{j=1}^{K}\left(z_{ij} - z_j^-\right)^2} \tag{12}$$

where d_i^- – a distance of ith alternative from a negative ideal solution, d_i^+ – a distance of ith alternative from the ideal solution.

The final ranking is constructed based on the values of the relative distance function $d_i^{+/-}$. Higher values $d_i^{+/-}$ result in a better position in the ranking

$$d_i^{+/-} = \frac{d_i^-}{d_i^- + d_i^+} \tag{13}$$

Rankings obtained using the TOPSIS method will be denoted as TE for equal weights, and TC for CRITIC weights.

3.2.3. VIKOR method

Chatterjee and Chakraborty [4] state that simplicity is one of the main factors which lie behind the popularity of the VIKOR method. It may be modified for specific variants [4], depending on the particular problem.

For the VIKOR method, variables were normalised according to the equations: (14) in the case of stimulants, and (15) in the case of destimulants, both of which are opposite of the normalisation used for Hellwig and WSA methods.

$$z'_{ij} = \frac{\max\left(x_{ij}\right) - x_{ij}}{\max\left(x_{ij}\right) - \min\left(x_{ij}\right)} \tag{14}$$

$$z'_{ij} = \frac{\min\left(x_{ij}\right) - x_{ij}}{\min\left(x_{ij}\right) - \max\left(x_{ij}\right)} \tag{15}$$

Ranking of the alternatives is based on the complex score defined as:

$$Q_i = \upsilon \frac{S_i - \min_j\left(S_j\right)}{\max_j\left(S_j\right) - \min_j\left(S_j\right)} + \left(1-\upsilon\right)\frac{R_i - \min_j\left(R_j\right)}{\max_j\left(R_j\right) - \min_j\left(R_j\right)} \tag{16}$$

where

$$S_i = \sum_{j=i}^{K}\left(w_j z'_{ij}\right) = \sum_{j=i}^{K} z_{ij} \tag{17}$$

$$R_i = \max_j\left(w_j z'_{ij}\right) = \max_j\left(z_{ij}\right) \tag{18}$$

$$\upsilon \in \left[0, 1\right] \tag{19}$$

where w_j denotes the weight of the jth criterion, ν is a parameter used for correction due to the best scores on a particular criterion [21]. A low value of ν is adopted to promote such alternatives. As stated in Chatterjee and Chakraborty [4], a value of 0.5 representing the "consensus scenario" is usually preferred.

The final ranking is constructed based on values of Q_i, R_i and S_i. The current paper the focus is on the complex score ranking Q_i with $\upsilon = 0.5$. Lower values of Q_i result in better position in the ranking. Rankings obtained using VIKOR method will be denoted as V.E for equal weights and V.C for CRITIC weights.

3.2.4. WSA method

Similarly, to the Hellwig method, destimulants (loss criteria) were changed into stimulants (benefit criteria), and values of all the criteria were normalised according to equations: (1) in the case of stimulants and (2) in the case of destimulants. The next step requires the calculation of the aggregated score of each object, according to equation (20). Higher values of WSA_i result in a better position in the ranking.

$$WSA_i = \sum_{j=i}^{K}\left(w_j z'_{ij}\right) = \sum_{j=i}^{K} z_{ij} \tag{20}$$

Rankings obtained using WSA method will be denoted as W.E for equal weights, and W.C for CRITIC weights.

3.3. Weights

Weights may affect the ranks of hospitals even though the ranking as a whole remains similar [33]. Two weighting schemes are used in the current paper. In the first one, the weights equal 1/9 for each criterion. In the second one, the impacts of criteria on the final ranking are corrected by their interdependence. The factors describing the situation of a hospital may originate from common causes. Because of that, some underlying information may be used multiple times. To avoid such a situation, CRITIC weights suggested by Diakoulaki et al. [7] are used. The weights are given by

$$c_j = \frac{c'_j}{\sqrt{\sum_{k=1}^{K} c'_k}} \tag{21}$$

where

$$c'_j = \sigma_j \sum_{k=1}^{K} c'_k \sum\nolimits_{k=1}^{K}\left(1 - r_{jk}\right) \tag{22}$$

r_{jk} – Pearson correlation between criteria j and k, σ_j – standard deviation of the jth criterion.

CRITIC weights are calculated based on normalised values z'_{ij}. They allow correction concerning the diversity of criteria between alternatives and their correlation.

For the ranking, weighted values z_{ij} are used

$$z_{ij} = w_j z'_{ij} \tag{23}$$

where $w_j \in \left\{c_j, 1/9\right\}$.

3.4. Grouping

After ordering, hospitals were grouped into 4 classes following Namyślak [20]:

- A – hospitals with the highest scores

$$g_i \geq \overline{g} + S_g \tag{24}$$

- B – hospitals with higher-medium scores

$$\overline{g} \leq g_i \leq \overline{g} + S_g \tag{25}$$

- C – hospitals with lower-medium scores

$$\bar{g} - S_g \le g_i \le \bar{g} \tag{26}$$

- D – hospitals with the lowest scores

$$g_i \le \bar{g} - S_g \tag{27}$$

where

$$\bar{g} = \frac{1}{n}\sum_{i=1}^{n} g_i \tag{28}$$

$$S_g = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(g_i - \bar{g}\right)^2} \tag{29}$$

$$g_i \in \left\{m_i, WSA_i, Q_i, d_i^{+/-}\right\} \tag{30}$$

In the case of the VIKOR method, the groups were reversed, i.e., group A was characterised by the lowest values of Q_i, i.e., equation (27), which corresponds to group D mentioned above. The higher-medium group B was defined by equation (26), the lower-medium group C by equation (25), and the last group D containing hospitals with the worst scores was defined by equation (24).

The similarity of rankings was studied using Spearman's rank correlation coefficient. The determinants of the hospitals' rank and the change of rank were analysed using descriptive statistics and regression models.

3.5. Econometric models

Despite the limited number of hospitals in the sample, regression analysis was conducted in order to get more insights into the characteristics of the hospitals that improved in the ranking and into the most important determinants of the average ranks. Regression models are often used to identify the determinants of hospital performance, e.g. in Ali et al. [1], or Cheng et al. [5].

Two variables were introduced. Variable MR_i was defined as the median rank of an ith hospital in the 2018–2015 period. The change of rank CR_i was defined for each hospital as the difference between its rank in 2018 and 2015. The negative values CR_i are the sign of improvement in a hospital's relative situation.

MR_i and CR_i were used as dependent variables in the linear regression models. In both cases, the set of explanatory variables includes hospital size (measured by the number of beds), profit/loss on sales and number of nurses, the dummy for non-public hospitals, and dummies for level 1 and level 2 hospitals.

All used explanatory variables may have an impact on the relative situation of a hospital. The size of a hospital together with the employment of medical personnel, represented by the number of nurses, determine the supply of services and the level of costs. The role of ownership is discussed in the literature when it comes to hospital efficiency [37, 38]. For Polish hospitals, results are inconclusive [16, 35] but non-public hospitals may likely face different constraints than public ones [40]. Dummies for level 1 and level 2 hospitals represent the degree of inclusion in the network, which may be treated as a proxy for the variety of services supplied by a hospital. Furthermore, more departments included in the network and subject to the financing may translate into more stable conditions for hospital managers who make long-term a decision, for example, regarding investments. The maximum absolute value of the correlation coefficient between explanatory variables does not exceed 0.4.

Linear regression models are given by equations

$$MR_i = \alpha_0 + \alpha_1 M.beds_i + \alpha_2 Lev1_i + \alpha_3 Lev2_i + \alpha_4 NP_i + \alpha_5 M.profit.loss_i + \alpha_6 M.nurses_i + \varepsilon_i \tag{31}$$

$$CR_i = \alpha_0 + \alpha_1 M.beds_i + \alpha_2 Lev1_i + \alpha_3 Lev2_i + \alpha_4 NP_i + \alpha_5 M.profit.loss_i + \alpha_6 M.nurses_i + \varepsilon_i \tag{32}$$

where $M.beds_i$ – median number of total beds (period 2015–2018), $Lev1_i$ – dummy for a level 1 hospital, $Lev2_i$ – dummy for a level 2 hospital, NP_i – dummy for a non-public hospital, $M.profit.loss_i$ – median profit/loss on sales (period 2015–2018), $M.nurse_i$ – median employment of nurses (period 2015–2018), ε – error term

The aim of this part of the study is not to estimate and to fully test regression models, which could explain in detail the situation of hospitals, but to provide additional information on the relations between variables. Therefore, full tests of models are not conducted.

3.6. Software

The analysis was conducted in an MS EXCEL 365 spreadsheet (rankings construction, calculation of rank changes) and in R version 4.0.2 (2020-06-22) Taking Off Again [31]. Medians were tested using the Agricolae package [17]. The correlation was analysed with corrplot package [39]. In the regression analysis, robust errors were obtained from the sandwich [41, 42] and Imtest [43] packages.

4. Case study

Data used in the study were taken from the questionnaire prepared by the Polish Association of Employers of District Hospitals (OZPSP – Ogólnopolski Związek Pracodawców Szpitali Powiatowych). After the elimination of missing observations, 62 hospitals were left in the dataset.

Operating costs are calculated as the sum of the following costs: depreciation, materials (both medical and non-medical), energy, outsourced services (both medical and non-medical), salary, health insurance and employee benefits, taxes, and other costs. Liabilities were calculated as the sum of short- and long-term liabilities.

Table 1. Descriptive statistics for a dataset

Variable	Statistic	2015	2016	2017	2018	Variable	Statistic	2015	2016	2017	2018
Beds total	Min.	57	57	57	57	Employment of doctors	Min.	1	1.34	1	0.67
	Q1	178	172	172	175		Q1	40.885	41.1975	40.25	41.63
	Q2	250.5	252	245.5	239.5		Q2	59.795	60	58.338	59.475
	Mean	268.125	267.6774	267.0914	263.2823		Mean	117.4248	119.7488	117.7558	117.0327
	Q3	341.25	344.75	346.25	329.5		Q3	102.9958	101.4233	99.78275	99.98525
	Max.	596	599	599	599		Max.	845.5	905	915.6	908.8
Patient–days	Min.	14.867	12.951	12.974	14.252	Employment of residents	Min.	0	0	0	0
	Q1	42.1335	41.52775	41.7435	38.573		Q1	1	1	1.175	1.1125
	Q2	55.961	58.5825	60.143	56.718		Q2	6.115	6	6.92	7.105
	Mean	65.81435	65.83033	66.48334	64.86671		Mean	10.60108	11.26658	11.31448	12.35244
	Q3	91.051	88.99375	86.97856	87.59375		Q3	13.395	14.255	12.75	14.75
	Max.	156.355	155.195	157.06	154.375		Max.	67	72	72	76
Profit/ loss on sale	Min.	–18.3749	–18.0115	–15.8191	–19.3181	Employment of interns	Min.	0	0	0	0
	Q1	–2.20823	–2.78598	–2.69457	–4.43432		Q1	0	0	0	0

Table 1. Descriptive statistics for a dataset

Variable	Statistic	2015	2016	2017	2018	Variable	Statistic	2015	2016	2017	2018
	Q2	–1.28461	–1.38634	–1.32583	–2.74219		Q2	1.125	1.25	0.915	1.7885
	Mean	–1.7058	–1.94447	–1.91275	–3.4785		Mean	5.073532	4.966661	5.463806	6.440774
	Q3	–0.40044	–0.42439	–0.4668	–1.34005		Q3	3.955	3.4175	5.44	5
	Max.	2.725263	2.659404	3.713347	2.358943		Max.	87.96	93.96	104.04	92.04
Contract with the NHF	Min.	9.136239	9.278936	9.999902	11.83874	Employment of nurses	Min.	60	58.5	56.25	57
	Q1	22.43777	23.8374	26.53043	29.06198		Q1	133.2325	128.0875	132.1825	131.0225
	Q2	35.77914	37.70779	40.5703	43.55159		Q2	199.4875	198.15	198.7	197.879
	Mean	41.65993	43.7064	47.29415	51.82795		Mean	382.1483	373.4147	372.9541	376.934
	Q3	51.56584	54.84718	58.02478	61.12976		Q3	311.1475	319.4425	331.57	335.5675
	Max.	123.0628	125.6086	141.737	158.1393		Max.	2751.34	2658.5	2632	2664.8
Income from health services outside the NHF	Min.	0.01135	0.0122	0.0117	0.0019	Operating costs	Min.	9.30502	9.954516	10.93937	12.68534
	Q1	0.601954	0.713928	0.737627	0.702767		Q1	25.27343	27.13278	29.3793	33.77422
	Q2	1.15859	1.203975	1.158413	1.215109		Q2	37.72057	40.07358	42.21107	46.50089
	Mean	1.618349	1.694495	1.737561	1.864876		Mean	45.99251	48.77345	52.22278	58.91352
	Q3	1.674417	1.844785	1.785027	1.94043		Q3	53.85538	56.95686	61.4873	66.70287
	Max.	23.52502	23.94963	25.35953	27.03239		Max.	148.0531	153.1709	164.7796	186.2647
Income from rental and lease	Min.	0	0	0	0	Liabilities	Min.	0.726315	0.57826	0.619328	0.994482
	Q1	0.146935	0.136528	0.140867	0.141929		Q1	4.9224	5.299404	6.008764	6.505034
	Q2	0.288039	0.350737	0.317476	0.331389		Q2	8.01849	8.773797	9.127607	9.550032
	Mean	0.524582	0.51911	0.514835	0.519862		Mean	12.22164	12.69086	14.17893	15.66733
	Q3	0.659322	0.699587	0.661016	0.668569		Q3	15.44109	16.35352	19.07578	20.94366
	Max.	2.695755	2.741971	2.730732	2.820918		Max.	59.2484	65.56412	72.99858	84.2338

Patient days are presented in thousands, profit/loss on a sale, contract with the NHF, income from health services outside the NHF, income from rental and lease, operating costs and liabilities are presented in million PLN.

Based on the data from district hospitals.

Descriptive statistics of the dataset used for the ranking are shown in Table 1. At least 75% of the hospitals recorded losses in the whole analysed period, even though the contract with the NHF was still increasing. It can be seen that the reason for this situation was a rise in costs (the median increased from 37.7206 million PLN in 2015 to 46.5009 million PLN in 2018). Median liabilities were rising as well, while median income from other sources than the NHF (both from providing health services and rents) was fluctuating, as was the median employment of doctors, nurses, residents, and interns.

Table 2 presents the number of hospitals classified A–D described in 3.4. In general, the results obtained using different weighting and ranking approaches are fairly similar. The majority of the hospitals were classified into groups B and C. Groups A and D were of similar size in 2015–2017, in 2018, however, group D was larger.

Table 2. The number of hospitals classified A–D

	2015				2016				2017				2018			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
HE	5	22	30	5	5	21	30	6	7	21	30	4	6	20	29	7
HC	6	22	26	8	6	24	25	7	7	25	21	9	8	21	23	10
TE	6	28	26	2	6	25	27	4	7	24	25	6	6	11	33	12
TC	6	31	23	2	6	27	25	4	6	24	26	6	4	14	30	14
WE	6	23	28	5	6	22	29	5	8	19	28	7	7	11	33	11
WC	6	27	22	7	6	27	23	6	8	24	22	8	6	18	26	12
VE	9	21	25	7	12	16	28	6	9	18	27	8	9	14	27	12
VC	5	24	30	3	5	23	31	3	5	25	28	4	5	21	29	7

Based on the data from district hospitals.

The similarity of the rankings constructed using different methods was analysed based on values of Spearman's rank correlation coefficient. The results are presented in Table 3. All Spearman's rank correlation coefficients are statistically significant at $\alpha = 0.05$ and relatively high (with a median equal to 0.8059 and a minimum value of 0.3766). Results obtained from TOPSIS are highly similar to each other, the same holds for WSA and Hellwig. The Ranking obtained using VIKOR methods is different. Those obtained using CRITIC weights are similar to the Hellwig methods.

Table 3. Rank correlation coefficients for different ranking and weighting methods

	HE	HC	TE	TC	WE	WC	VE	VC
HE	1	0.9670	0.5654	0.5143	0.8052	0.7702	0.7298	0.9005
HC	0.9670	1	0.5123	0.4511	0.8066	0.8087	0.7038	0.9428
TE	0.5654	0.5123	1	0.9872	0.8722	0.8150	0.3982	0.6126
TC	0.5143	0.4511	0.9872	1	0.8091	0.7450	0.3766	0.5595
WE	0.8052	0.8066	0.8722	0.8091	1	0.9827	0.5722	0.8628
WC	0.7702	0.8087	0.8150	0.7450	0.9827	1	0.5544	0.8823
VE	0.7298	0.7038	0.3982	0.3766	0.5722	0.5544	1	0.6675
VC	0.9005	0.9428	0.6126	0.5595	0.8628	0.8823	0.6675	1

Based on the data from district hospitals.

As shown in Table 4, on average (measured by the median), hospitals which improved their position in the ranking improved it by 9–18 ranks, while the median drop in ranking ranged from 18 to 42 positions. The share of hospitals which improved their relative standing was the highest in the case of the Hellwig method (59.68% for both rankings) and the lowest for TOPSIS rankings (19.35% and 20.97%). Apart from the two Hellwig rankings, the situation of more than 50% of hospitals was relatively worse in 2018 than in 2015.

Table 4. Median values of CR for hospitals that improved their relative situation or dropped in the ranking for different ranking and weighting methods

Ranking	Median for		Number of hospitals whose situation	
	CR > 0 (worsening)	CR < 0 (improvement)	worsened	improved
HE	27	–15	25	37
HC	18	–18	25	37
TE	42	–12	49	13
TC	38.5	–16.5	50	12
WE	41	–9	43	19
WC	32	–10.5	44	18
VE	24	–16	37	25
VC	31.5	–15	36	26

Based on the data from district hospitals.

The statistics for distributions of the change of rank CR (difference between the rank of a hospital in 2018 and 2015) for all ranking and weighting approaches are described in the left part of Table 5. All distributions are relatively similar and right skewed, which shows the existence of individual hospitals in which the relative position worsened to a great degree. As shown, the first quartile or CR is negative for all ranking and weighting methods except for two TOPSIS rankings. It means that, for six out of eight approaches, at least 25% of hospitals improved their situation between 2015 and 2018. On the other hand, the medians were negative only in two out of eight cases (two Hellwig rankings), showing that in the majority of the approaches the relative situation of most hospitals was worse in 2018 than in 2015. The maximum rank change was found in the case of VIKOR ranking and equal weights – the difference between the rank in 2018 and 2015 amounted to 193 positions. Median values ranged from -5 (i.e., improvement by 5 positions between 2015 and 2018) to 30.5.

Table 5. Descriptive statistics for RR and CR by the ranking and weighting method

	CR						RR					
Ranking	Min.	Q1	Q2	Mean	Q3	Max.	Min.	Q1	Q2	Mean	Q3	Max.
HC	–96	–26	–5	–2.0484	9.5	134	3	13.25	27	33.4355	40.25	134
HE	–90	–16.75	–3.5	1.1774	10	160	3	13.5	27.5	32.2742	38.5	160
TC	–126	2.25	31	40.629	74	169	3	32.75	54	69.1936	107.5	176
TE	–103	6	30.5	40.7903	67.5	180	3	28.25	52.5	62.7742	95.75	180
VC	–94	–12.75	7.5	10.129	35.75	121	3	16.5	34.5	40.2903	53	140
VE	–98	–10.75	7	8.6935	28	193	3	16.5	29	41.7903	55.25	234
WC	–42	–1.75	20	23.9677	44.5	136	3	13.5	37.5	40.6452	58.5	136
WE	–45	–2.75	22	28.3226	50.25	161	3	16	42.5	44.2419	62.5	161

Based on the data from district hospitals.

The interval of rank RR was defined for each hospital as the difference between the highest and lowest rank. It gives information about the stability of the situation of each hospital. The greater the value of RR, the less stable the rank. In the case of this variable, the distributions are right skewed and relatively similar for all ranking and weighting approaches as presented in the right part of Table 5. Median RR varies from 27 (the Hellwig method and CRITIC weights) to 54 (TOPSIS with CRITIC weights). The maximum values of RR were found for VIKOR with equal weights and equal to 234. In the case of this ranking, some individual hospitals experienced a large increase (decrease) in rank. For all rankings, at least one hospital can be found when it is stable. In such a case, RR = 3, i.e., the lowest value among ranking observations from 4 years.

Table 6. Median tests for RR and CR by the level of hospital

Ranking	RR		CR	
	Chi-squared	*p*-value	Chi-squared	*p*-value
HC (categories 1 and 2)	0.4045	0.5248	2.1633	0.1413
HC (categories 1 and other)	0.1344	0.7139	3.3592	0.0668
HC (categories 2 and other)	0.0586	0.8087	0.4598	0.4977
HE (categories 1 and 2)	0.1388	0.7094	0.8142	0.3669
HE (categories 1 and other)	0.0128	0.9099	3.3592	0.0668
HE (categories 2 and other)	0.0384	0.8447	0.4598	0.4977
TC (categories 1 and 2)	0.5906	0.4422	0.5906	0.4422
TC (categories 1 and other)	0.1344	0.7139	0.1344	0.7139
TC (categories 2 and other)	1.3511	0.2451	1.3511	0.2451
TE (categories 1 and 2)	0.5906	0.4422	0.5906	0.4422
TE (categories 1 and other)	1.2093	0.2715	0.0575	0.8104
TE (categories 2 and other)	1.3511	0.2451	1.3511	0.2451
VC (categories 1 and 2)	0.4045	0.5248	5.9956	0.0143
VC (categories 1 and other)	1.2093	0.2715	3.3592	0.0668
VC (categories 2 and other)	0.4598	0.4977	0.4598	0.4977
VE (categories 1 and 2)	0.2543	0.6141	0.0044	0.9472
VE (categories 1 and other)	0.1344	0.7139	0.1344	0.7139
VE (categories 2 and other)	0.4598	0.4977	0.0586	0.8087
WC (categories 1 and 2)	1.7911	0.1808	2.1633	0.1413
WC (categories 1 and other)	0.1344	0.7139	1.2093	0.2715
WC (categories 2 and other)	0.4598	0.4977	0.4598	0.4977
WE (categories 1 and 2)	0.0044	0.9472	2.1633	0.1413
WE (categories 1 and other)	0.1344	0.7139	0.2439	0.6214
WE (categories 2 and other)	0.0384	0.8447	0.0384	0.8447

Based on the data from district hospitals.

In the next step, the relation between the hospital's category in the network and the change of rank (CR), which reflects the change in the relative situation, was analysed. As mentioned before, hospitals in the network are classified into 6 categories. In the case of this study, only 3 groups are taken into consideration: level 1 hospitals, level 2 hospitals and "other" due to the low numbers of hospitals from other categories. The group other includes hospitals of an unknown status as well.

As shown in Table 6, the relative situation of hospitals with different categories in the network is similar. At $\alpha = 0.05$ neither medians of RR nor medians of CR are statistically different for hospitals included in different categories. Statistically, significant differences could be seen only between hospitals classified 1, 2, and VIKOR rankings with CRITIC weights. This result is not sufficient to provide evidence for the relation between category and change of relative position between 2015–2018.

The Chi-squared test of independence was used to analyse the dependency of the hospital category in the network (again, 3 groups are taken into consideration: level 1 hospitals, level 2 hospitals, and others) and the improvement of its relative situation (a binary variable, with 1 denoting a rise in the ranking and 0 otherwise). The results presented in Table 7 show that qualification into the network does not affect whether or not the relative situation of a hospital improved between 2015 and 2018.

Table 7. Results for the Chi-squared test of the dependency of the hospital category in the network and the improvement of its relative situation by ranking and weighting method

	HE	HC	TE	TC	WE	WC	VE	VC
Chi-squared	1.7857	1.0415	1.8059	1.3717	3.0207	2.5135	1.6568	4.916
p-value	0.4095	0.5941	0.4054	0.5037	0.2208	0.2846	0.4367	0.08561

Based on the data from district hospitals.

Table 8. Parameter estimation results for equation (31) by ranking and weighting method

Parameter	HE	HC	TE	TC	WE	WC	VE	VC
Intercept	124.23 (26.169)	119.5 (27.922)	143.92 (24.524)	136.06 (24.046)	142.76 (29.735)	140 (31.289)	106.5 (32.985)	112.79 (31.326)
M.beds	0.063886 (0.075016)	0.05672 (0.076662)	–0.18937 (0.062861)	–0.17255 (0.062901)	–0.12338 (0.074225)	–0.11229 (0.08036)	0.036905 (0.084717)	0.039427 (0.084482)
M.profit.loss	–0.000002 (0.000003)	–0.000002 (0.000003)	–0.000016 (0.000003)	–0.000017 (0.000003)	–0.000011 (0.000002)	–0.00001 (0.000003)	<0.00001 (0.000004)	–0.000004 (0.000003)
M.nurses	–0.068749 (0.007248)	–0.066436 (0.008219)	–0.051762 (0.008861)	–0.050432 (0.008592)	–0.058397 (0.008602)	–0.057283 (0.008832)	–0.048876 (0.012122)	–0.062973 (0.00833)
Level 1	22.734 (25.021)	24.503 (26.109)	32.475 (19.544)	34.069 (18.221)	29.784 (24.992)	28.427 (25.932)	44.685 (30.176)	26.531 (26.768)
Level 2	–70.266 (30.58)	–57.669 (31)	17.025 (23.07)	18.853 (21.61)	–7.9515 (29.554)	0.19952 (32.031)	–17.597 (38.267)	–35.32 (31.899)
NP	0.9121 (20.146)	10.87 (17.494)	–51.646 (14.177)	–49.216 (14.351)	–35.487 (16.998)	–29.706 (17.372)	–21.969 (18.017)	9.6259 (20.453)

HC standard errors are given in parentheses.
Based on the data from district hospitals.

As shown in Table 8, the employment of nurses (which represents the employment of medical personnel) has a significant impact on the median rank for all rankings (at $\alpha = 0.05$). The relation between the median rank and employment is negative, which is in line with expectations, even though larger employment also means higher costs. Hospital size (measured by the number of beds) is significantly influencing the median rank only in the case of TOPSIS rankings and this relation is negative, i.e., smaller hospitals are ranked lower. Profit (loss) on sales is influencing median rank in the case of TOPSIS and WSA approaches and in both cases the relation is negative. Dummies for level 1 and level 2 hospitals assume different signs, but (with one exception) their impact is not statistically significant.

The results presented in Table 9 show that, in most cases, only a few of the suggested variables impact the change of rank at $\alpha = 0.05$. The employment of nurses has a significant impact in most cases. The relation is negative (except for Hellwig rankings), which means that greater employment leads to improvement in the relative situation. In the case of Hellwig rankings bigger hospitals, level 1 hospitals, and hospitals which reported a higher profit (lower loss) on sales can improve their relative standing. The same applies to VIKOR ranking with CRITIC weights.

It is important to note that the dummy for non-public hospitals was insignificant in both regression models, even though ownership seems to be an important determinant of hospital performance in Nojszewska et al. [25]. This result seems to support previous findings from Sielska, according to which ownership does not affect the efficiency of the hospital [35] while controlling for other factors. Additionally, the level at which hospitals operate in a network may have an impact on costs; however, the estimate for the dummy variable representing the period after the reform was introduced did not significantly differ from 0 in Sielska [34]. It is important to note, however, that the cited study focused on costs. It should be kept in mind that, together with the introduction of the hospital network, some other changes took place in Polish economics, such as an increase in wages: both the minimum wage and the wages for medical workers [8]. All hospitals were subject to those unfavourable changes in the environment regardless of their level in the network.

Table 9. Parameter estimation results for equation (32) by ranking and weighting method

	HE	HC	TE	TC	WE	WC	VE	VC
Intercept	44.11 (23.49)	33.747 (21.404)	66.714 (23.221)	64.688 (24.739)	60.935 (18.286)	57.59 (16.95)	60.951 (29.569)	54.813 (14.701)
M.beds	–0.13355 (0.054863)	–0.10788 (0.051244)	–0.039947 (0.064359)	–0.054684 (0.071414)	–0.073039 (0.049471)	–0.083818 (0.048367)	–0.141 (0.078291)	–0.13516 (0.04276)
Level 1	–34.356 (16.189)	–33.728 (15.155)	–15.465 (21.485)	–10.79 (23.91)	–21.928 (16.757)	–21.884 (14.966)	–27.541 (19.919)	–35.128 (13.006)
Level 2	10.371 (17.194)	16.539 (19.559)	28.953 (30.81)	36.606 (33.781)	19.324 (25.267)	15.762 (22.5)	7.1329 (18.452)	25.248 (18.982)
M.profit.loss	–0.000005 (0.000001)	–0.000004 (0.000001)	0.000001 (0.000002)	0.000001 (0.000002)	–0.000001 (0.000001)	–0.000001 (0.000001)	–0.000002 (0.000002)	–0.000004 (0.000001)
M.nurses	0.008034 (0.003341)	0.008877 (0.002782)	–0.017798 (0.005418)	–0.017078 (0.00608)	–0.009854 (0.003803)	–0.007592 (0.003633)	–0.000463 (0.005017)	0.004149 (0.003389)
NP	3.3522 (7.7335)	4.058 (8.4178)	3.1365 (14.861)	5.0621 (16.389)	5.8898 (11.049)	9.0011 (11.361)	0.90085 (14.55)	2.8794 (9.9679)

HC standard errors are given in parentheses.
Based on the data from district hospitals.

5. Conclusion

In general, the situation of Polish district hospitals in 2015–2018 was not beneficial, as shown previously by Nojszewska et al. [25]. The NIK report [22] pointed out some negative consequences of the 2017 reform of Polish healthcare and there was also discussion in the literature concerning some potential risks of the solutions introduced by this Act. Ranking together observations of 62 objects from 4 years shed some light on the relative changes in the set of Polish district hospitals. Even though it is impossible to assess if certain changes were caused by the latest reform, it can be seen that the situation of different hospitals is not changing to the same degree and in the same direction in the analysed period.

All ranking and weighting methods used in the paper lead to the conclusion that most hospitals may be assessed as being average (belonging to groups B and C defined earlier), while the proportion between hospitals belonging to groups A and D changed between 2015 and 2018. Detailed results vary with the method. When the difference between the rank of a hospital in 2018 and in 2015 is concerned, i.e., the change of relative situation of an individual hospital, the results of TOPSIS rankings lead to the most negative conclusions. In the case of this approach, the median drop in ranking was 38.5 ranks for CRITIC weights and 42 ranks for equal weights.

There are hospitals which were able to maintain their position. For each ranking and weighting method, at least one hospital could be found with a stable situation, and with a difference between the lowest and highest rank (RR) equal to 3. That is the lowest possible value while ranking observations from 4 years.

It is important to note that neither inclusion to the network as a level 1 nor a level 2 hospital did significantly affect the fact that the situation of a given hospital improved between 2015 and 2018. Regression analyses confirmed this result. In the great majority of cases, dummy variables for both level 1 and level 2 hospitals were not statistically significant in explaining median rank and its change.

This study has also some limitations. First of all, the dataset needed to be refined since some hospitals did not provide data. Secondly, aiming to include as many hospitals as possible in the study, the author decided not to remove from the set the hospitals which gave unclear answers regarding their status in the network. Therefore, as mentioned before, the category other used in the analysis may include some of the level 1 and level 2 hospitals, as well as those belonging to the higher levels, or not belonging to the network at all. This fact may bias the results. Thirdly, even though such hospitals were included, the number of observations is still limited and due to that fact, the author decided not to use logit models, which might have provided additional insight into the determinants of improving the relative situation of hospitals. Building such models on a larger dataset will surely bring additional information, and it seems a promising direction for future research. Knowing and understanding the reasons behind that may provide important clues for both hospital management, as well as on the further evaluation of their performance.

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