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SGH Warsaw School of Economics
Collegium of Management and Finance

Ewa Agnieszka Kosycarz
SGH Warsaw School of Economics
ORCID: 0000-0003-4272-6195

Monika Małgorzata Dędys
SGH Warsaw School of Economics
ORCID: 0000-0003-2230-7284

Maria Małgorzata Ekes
SGH Warsaw School of Economics
ORCID: 0000-0003-3800-3170

Healthcare public funding efficiency as exemplified by hospitals in Polish regions

Abstract

The aim of this study is to evaluate and compare the financial and managerial efficiency of healthcare inpatient systems in one country. The research question is: What factors give rise to efficiency variations within the regional healthcare system (hospitals)?

A two-step approach proposed by Simar and Wilson has been applied. The first step applies the Data Envelopment Analysis to estimate the unit (i.e., a Polish region in our research) efficiency scores, which is followed by truncated regression with double bootstrapping to examine the impact of uncontrolled variables on efficiency scores.

The efficiency scores obtained in 16 regions from the output-oriented model with non-increasing returns to scale indicate a full effectiveness of five regions. The DEA scores of the other regions exceed the value of 0.8 and do not differ significantly.

The bootstrap-corrected DEA scores do not considerably change the efficiency assessment. The direction of the impact of the 'percentage of people above 65 years of age' variable and the 'growth rate of total liabilities on efficiency' variable is opposite to that observed for the 'average salary' variable. The results obtained suggest that the regional healthcare system efficiency can be affected by the ageing population, pay pressure, and liabilities.

Keywords: Data Envelopment Analysis, healthcare system efficiency, centralised/decentralised healthcare system, ageing society, salaries
JEL Classification Codes: H75, H51, I1

Introduction

Healthcare budgets are strained worldwide, and financial pressures are on the rise. Healthcare costs are growing infinitely due to: (i) developments of new technologies in medical diagnostics and treatment; (ii) rapidly ageing populations; and (iii) pressures to increase remuneration of healthcare staff. The Polish healthcare system faces significant pressures of this sort.

Firstly, as a rule, Polish healthcare units are underinvested. They have to meet the requirements imposed by the Minister of Health. The requirements are stringent, so the deadlines to meet them have been postponed several times [Ministry of Finance, 2012; Ministry of Health, 2019a].

Secondly, of 37 European countries, Poland is ranked 29th in terms of the rate of ageing between 2007 and 2018. The Polish population is ageing very quickly; the analysis was made by the authors on the basis of data for the period 2007–2018 concerning the share of the population aged 65 or more in the total population [European Commission, n.d.].

Thirdly, there is an ongoing public demand for pay rise among all the healthcare staff.

Thus, apart from searching for new sources of healthcare financing, a more efficient use of available funds should be prioritised.

The aim of this study is to evaluate and compare the financial and management efficiency of healthcare inpatient systems in Poland, where healthcare regions are considered as units to be analysed. In particular, we focus on the NFZ (i.e., the Polish National Health Fund) regional branches and also local governments, which are quite often in control of hospitals as their owners.

Our research question is: What factors give rise to variations in the efficiency of Polish regional healthcare system (hospitals)?

Polish healthcare system financing

According to the Polish law, hospitals can obtain financing from the National Health Fund (NFZ), local governments, foreign funds (e.g., the European Union) and from commercial services. The costs of medical services rendered by hospitals are covered in 96.5% by the NFZ. According to NFZ reports, hospitals utilise more than 50% of total funds from the NFZ [*Finansowanie Opieki Zdrowotnej Pracowników*, 2018].

The NFZ is a centralised institution with the regional branches.

The main stream of public funds for health services comes to hospitals from the NFZ, which obtains funds primarily from social security contributions (the NFZ also obtains additional funds from the central government as a subsidy for highly specialised medical services, for emergency medical services as well as health insurance contribution for persons covered by the insurance system and not paying for it themselves). The funds are divided among regions (for all health services, not only hospitals) according to an algorithm (Table 1), which accounts for:

- the number of insured persons registered in a regional branch of the Fund;
- statistical groups formed by age and gender;
- separated groups of healthcare services, including highly specialised services;
- health risk corresponding to a given group [Ustawa z dnia 27 sierpnia 2004 r. o świadczeniach opieki zdrowotnej finansowanych ze środków publicznych, 2016].

The algorithm for regional funding allocations does not account for:

- the degree of urbanisation;
- regional variations in the population health status;
- different production costs of medical services in each region.

Moreover, the algorithm is retrospective, since the cost indices used for yearly calculations are based on the previous year's data [Misiąg, Tomalak, 2010].

In addition to the aforementioned criteria for calculating the distribution of public funding, there is one more – the impact of patients' migration across regions. It is not incorporated into the algorithm. Migrants' payments are made to regional NFZ offices after some period, sometimes with a considerable delay of even a few years [Węgrzyn, 2015].

There is some room for independent decision making by regional branch directors, for example with regard to the distribution of funds among specific types of healthcare services, or the negotiation of contracts with healthcare entities [Narodowy Fundusz Zdrowia, 2017]. Therefore, there is some diversity in the amounts spent on hospital services (Table 1).

As a result, prices paid by NFZ branches for the same medical services sometimes differ significantly. Let us consider the following medical hospital services:

- inpatient neonatology – minimum price 47.00 PLN (Małopolskie), maximum price 59.00 PLN (Mazowieckie);
- inpatient ophthalmology – minimum price 36.97 PLN (Małopolskie), maximum price 52.06 PLN (Zachodniopomorskie);
- outpatient ophthalmology (in hospital) – minimum price 42.12 PLN (Świętokrzyskie), maximum price 52.02 PLN (Kujawsko-Pomorskie);
- orthopaedics and traumatology of the musculoskeletal system hospitalisation – minimum price 41.94 PLN (Świętokrzyskie), maximum price 52.04 PLN (Mazowieckie, Zachodniopomorskie);
- inpatient cardiology – minimum price 43.11 PLN (Świętokrzyskie), maximum price 52.03 PLN (Warmińsko-Mazurskie) [Najwyższa Izba Kontroli, 2018].

Table 1. Characteristics of hospital financing in Polish regions, in the year 2017

Region	Index of participation of regional NFZ branches according to the algorithm in the year 2017 [%]	Share of NFZ branch funds spent on inpatient curative care	Total payables* in m PLN	Matured payables* in m PLN
Dolnośląskie	7.50606	51%	708.2	68.0
Kujawsko-Pomorskie	5.39320	52%	963.4	170.5
Lubelskie	5.67732	51%	1,054.4	59.2
Lubuskie	2.60681	47%	64.2	1.2
Łódzkie	6.85883	50%	683.2	67.4
Małopolskie	8.56349	49%	1,018.2	118.5
Mazowieckie	14.40121	53%	1,797.4	318.9
Opolskie	2.44228	50%	148.9	5.3
Podkarpackie	5.31493	50%	848.7	141.1
Podlaskie	3.04944	51%	372.7	22.3
Pomorskie	5.75621	48%	187.4	1.3
Śląskie	12.18837	43%	1,406.5	192.9
Świętokrzyskie	3.38197	51%	406.7	53.2
Warmińsko-Mazurskie	3.53879	50%	242.5	16.9
Wielkopolskie	8.97852	49%	786.2	132.7
Zachodniopomorskie	4.34258	50%	436.6	29.0

* Liabilities are presented for independent public healthcare hospitals only. According to data published by the Ministry of Health, there are additionally distinguished two groups of hospitals which belong to the Ministry of National Defense (total payables 279.5 m PLN, matured payables 25.6 m PLN), and the Ministry of the Interior and Administration (total payables 352.3 m PLN, matured payables 40.5 m PLN).

Source: own work based on data extracted from the website of the Ministry of Health and NFZ (*Projekt Planu Finansowego na 2018*, p.23).

The financial and managerial involvement of local governments is one of the tools to introduce decentralised funding in the healthcare sector. Local governments are owners of a significant number of hospitals and can subsidise medical entities. Local governments have a right to buy healthcare services from medical entities (based on regulations similar to NFZ's). Unfortunately, they make use of this right very rarely. Local governments have a right to invest in the infrastructure and medical equipment of medical units which belong to them, and they use this right quite often. Eventually, local governments have an obligation to cover financial losses of a medical entity (if it operates as an independent public healthcare entity owned by the local government – the most popular legal form of public hospitals).

Private spending on hospital services is not included in our analysis. According to the statistical report made by Statistics Poland (GUS) [Główny Urząd Statystyczny, 2018], private spending on hospital medical services barely exists in Poland. The average amount of money spent monthly per capita for hospitalisation (from private resources) equals 1.28 PLN (2016), i.e., below 4 euros per year per capita.

Regional variations may result from different management of hospitals which are publicly and privately funded. The problem of deficit and debt is one of the financial management

issues. In Poland, there are some regions (voivodeships) which, in some periods, use more external funds to finance medical services than others. It means that they potentially spend more money to satisfy the same healthcare needs in comparison with other regions (Table 1).

Additional financing sources for Polish hospitals come from the European Funds. Medical entities have been using different kinds of programmes related to a wide range of issues: infrastructure (environmental protection, energy), staff training, healthcare programmes, R&D, increased competition of companies, society integration, telecommunication, and e-services. The data on additional annual distribution of funding per region are unfortunately not available. So, at this moment we cannot include the European Funds in our analysis. Additionally, the extent of the European Funds use primarily depends on the resourcefulness and initiative of hospital managements, much less on local authorities, and it does not depend at all on NFZ branches policies.

Study description

Aware of the aforementioned ability of NFZ regional branches executives to create their own management of financing healthcare services and to obtain additional funding from the local governments, we tested the regional efficiency of management of public funds provided by regional NFZ branches and local governments.

Literature

The Data Envelopment Analysis (DEA), introduced by Charnes, Cooper, and Rhodes [Charnes, Cooper, Rhodes, 1978] is a nonparametric method of efficiency analysis. We consider the group of units, called decision making units (DMUs), which apply the same inputs to 'produce' the same outputs. The concept of efficiency taken into account is the Farrell efficiency [Farrell, 1957], which is the ratio of the weighted outputs and inputs. For each DMU, we solve the optimisation problem to find its optimal weights and, as a result, we obtain fully efficient DMUs which can serve as benchmarks for inefficient units. It should be emphasised that we consider the relative efficiency among the analysed group of DMUs. As we do not include prices of outputs and costs of inputs, we deal with technical efficiency [Cooper, Seiford, Tone, 2007]. DEA models may be input or output oriented and they can assume constant or variable returns to scale.

The DEA method of efficiency analysis is very widely used in many different fields of research. DEA has been applied to examine the performance of healthcare organisations quite extensively since the mid-1980s (a comprehensive analysis of the research on that subject is presented e.g., by Hollingsworth, Dawson, and Maniadakis [1999], Hollingsworth [2003], Ozcan [2008], or more recently Gouveia et al. [2016]. The analysed variables, i.e., inputs and

outputs, depend on whether we deal with the efficiency of hospitals or hospital departments, regional or national healthcare organisations, and finally, if we focus on the operation of healthcare systems in other countries. The most frequently chosen variables include the number of medical staff, i.e., general practitioners, nurses, physicians, or administrative staff [Aletras et al., 2007; Amado, Santos, 2009; Carrillo, Jorge, 2017; Halkos, Tzeremes, 2011; Hu, Qi, Yang, 2012; Ippoliti, Falavigna, 2012; Kontodimopoulos, Nanos, Niakas, 2006; Pelone et al., 2012; Polyzos et al., 2013; Stefko, Gavurova, Kocisova, 2018], equipment, i.e., the number of hospital beds [Aletras et al., 2007; Carrillo, Jorge, 2017; Halkos, Tzeremes, 2011; Hu, Qi, Yang, 2012; Ippoliti, Falavigna, 2012; Kontodimopoulos, Nanos, Niakas, 2006], the number of MRI units or other equipment [Carrillo, Jorge, 2017; Stefko, Gavurova, Kocisova, 2018], spending per capita [Carrillo, Jorge, 2017] as inputs and the number of outpatient appointments [Aletras et al., 2007; Hu, Qi, Yang, 2012; Kontodimopoulos, Nanos, Niakas, 2006], the number of consultations [Aletras et al., 2007], the days of inpatient care [Hu, Qi, Yang, 2012], the use of beds [Stefko, Gavurova, Kocisova, 2018], the number of surgical operations [Aletras et al., 2007], years of healthy life expectancy at birth, infant survival rate [Carrillo, Jorge, 2017] as outputs.

A cross-regional comparison of healthcare performance in various countries is an issue discussed in many papers. Yang [2017] makes a DEA analysis of the efficiency of the healthcare system in 22 cities and counties in Taiwan, taking into account performance indicators introduced by him and comparing the results with the results obtained for usually used population-based index. Halkos and Tzeremes [2011] evaluate the performance of public health services of the Greek prefectures after the reform of the public healthcare system by using data envelopment analysis and free disposal hull models. Carrillo and Jorge [2017] assess the efficiency of the regional healthcare systems in Spain and identify the regions that use their healthcare inputs more efficiently than others, given the observed level of health outcomes. They use the DEA-based model operating on the basis of common weights. Ippoliti and Falvigna [2012] analyse the impact of clinical research on the efficiency of medical care suppliers in Italian regions. Hu, Qi, and Yang [2012] investigate regional hospital efficiency in China adopting the data envelopment analysis to evaluate and compare the efficiency scores obtained with and without considering the undesirable output. Stefko, Gavurova, and Kocisova [2018] apply the window approach as an extension to the basic DEA models to evaluate healthcare technical efficiency in Slovakian regions and quantify the basic regional disparities and discrepancies. Aletras et al. [2007] apply the DEA method to evaluate the results of the healthcare reform in Greece. Hu et al. [2012] investigate how the health insurance reform of the New Rural Cooperative Medical System (NRCMS) affected the efficiency in Chinese regions.

Assessing healthcare system efficiency in different regions of a country by means of DEA models has also been presented by Mancuso and Valdmanis [2016] in relation to Italian regions, Mousa and Aldehayyat [2018] to Saudi Arabian regions or Herwartz and Schley [2018] to German regions.

Some authors compare the efficiency of healthcare systems in the OECD countries. Samut and Cafri [2016] evaluate hospital efficiency in 29 OECD countries between 2000 and 2010 applying the DEA and Panel Tobit analysis. Hollingsworth and Wildman [2002] consider the performance of 30 OECD countries using the DEA efficiency and cross-efficiency approach. In the paper of Hadad et al. [2013], the authors analyse the efficiency of healthcare systems in the OECD countries in two DEA models accounting for inputs within and beyond the control of the system.

The efficiency of Polish hospitals was analysed by Hass-Symotiuk [2011] and Nojszewska [2015]. The research concerning efficiency analysis of the healthcare system in Polish regions was done by Kujawska [2013a, 2013b] and Susmarski [2018].

Kujawska [2013a, 2013b] analysed healthcare efficiency in Polish regions using the number of working doctors, nurses, and midwives and the number of hospital beds as inputs, and as outputs: the number of hospitalised overnight patients and the number of hospitalised day patients. Susmarski [2016] analysed healthcare efficiency of Polish regions by comparing NFZ resources and outputs such as: the number of hospitals, the number of hospital beds and the number of clinics. Jewczak and Żółtaszek [2011] applied the DEA method to analyse technical efficiency among Polish regions. They used the number of beds (in public hospitals), the number of doctors, the number of nurses as inputs, and the number of people treated during the year together with patient days as outputs.

In our research, we focus on the efficiency of Polish healthcare regions from the financial perspective only, since we consider only financial inputs. We try to distinguish the major factors giving rise to differences in the DEA scores of Polish regions by means of the two-stage DEA with bootstrapping.

Methods

A two-step approach proposed by Simar and Wilson [2007] has been applied. The first step applies the Data Envelopment Analysis to estimate the unit (i.e., a Polish region in our research) efficiency, which is followed by truncated regression with double bootstrapping to examine the impact of uncontrolled variables on efficiency scores. Since the financial inputs in our model are determined by the policy of the NFZ and local governments, we apply output orientation.

In order to choose the proper returns to scale, we use two tests proposed by Simar and Wilson [2002, 2011]. The null hypothesis of globally constant returns to scale was rejected in favour of variable returns to scale, while the null hypothesis of globally non-increasing returns to scale was not rejected in favour of variable returns to scale. We decided to choose the model with globally non-increasing returns to scale accordingly.

We focused our research on demographic factors, pay pressure, and external support funds. Therefore, we considered three variables: the percentage of people above 65 years

of age (65_plus), average remuneration (average_salary), and proxy covariate representing external funds. In the case of external funds, we examined the use of variables such as the ratio of total liabilities to NFZ funds, absolute annual growth in total liabilities (in relation to NFZ funds and per capita), and annual growth rate of the total liabilities. Assuming that the reciprocal of efficiency score is a linear function of three covariates and truncated normally distributed disturbance, we performed the second stage of analysis for three models, differing from each other in the covariate representing external funds. For each model, we examined the statistical significance of the variables. The significance level of the 65_plus and average_salary variables was 0.05 in each model under consideration. However, the proxy variable representing external funds turned out to be significant only in the case of the growth rate of total liabilities (growth_rate). Thus, we decided that the model with this variable will be the basis for further inference.

All the calculations were made with the use of the rDEA Package in R.

The two-step bootstrapping and truncated regression were applied quite extensively in the research concerning the efficiency of the healthcare system in the regions of a country or in different countries [Afonso, St. Aubyn, 2011; Ippoliti, Falavigna, 2012; De Nicola et al., 2014; Chowdhury, Zelenyuk, 2016; Ni Luasa, Dineen, Zieba, 2018]. Additionally, the choice of returns to scale based on Simar and Wilson's tests in the healthcare efficiency context was made by Besstremyannaya [Besstremyannaya, 2013].

Data and data preparation

Input data

We use financial healthcare data from the data pool of the GUS Local Data Bank [Główny Urzad Statystyczny, 2019], the NFZ financial statement [Narodowy Fundusz Zdrowia, 2018], and financial statements made by 16 local governments. We aggregated financial funds broken down into regions separately for hospitals financed from the NFZ and four levels of local government (communes, cities with district (poviat) rights, districts (poviats), regions (voivodeships)). In the next step, we calculated health spending per one inhabitant, dividing aggregated funds in each region by the number of inhabitants of this region. These are two inputs in our model (Table 2). We observed substantially different per capita healthcare costs in every region. The financing per capita in Mazowieckie is 28% higher than in the Śląskie region.

Healthcare services financed by private insurance are not considered in the present paper, since they are not significant enough.

Table 2. Financial inputs of Polish regions, per capita; determinants of efficiency (STEP 2 of analysis); outputs; 2017 data, in PLN

	Financial inputs of Polish regions		Determinants of efficiency (STEP 2 of analysis)			Output measures in Polish regions	
Region	NHF spending on hospitals per capita in PLN	Local government spending on hospitals per capita in PLN	Average monthly salaries in the economy in the region in PLN	Percentage of people above 65 years in the population of the region	Changes in total liabilities of independent public hospitals (change in % between 2016 and 2017, 2016 basis year)	Surgical services performed per 10,000 population	Patients in general hospitals per 10,000 population
Dolnośląskie	1,021	15	4.655	17.7%	–0.16%	647	2,005
Kujawsko-Pomorskie	1,039	7	3.886	16.5%	2.20%	677	1,861
Lubelskie	1,055	5	4.020	17.4%	2.06%	679	1,933
Lubuskie	909	22	3.951	16.2%	0.31%	528	2,004
Łódzkie	1,054	9	4.142	18.9%	5.25%	718	2,253
Małopolskie	945	17	4.347	16.2%	6.67%	628	1,855
Mazowieckie	1,110	75	5.524	17.2%	4.38%	790	2,167
Opolskie	937	8	4.145	17.6%	13.15%	629	1,652
Podkarpackie	953	55	3.837	15.9%	6.63%	644	2,014
Podlaskie	979	39	4.006	16.9%	0.13%	725	2,221
Pomorskie	925	36	4.497	15.8%	–8.14%	700	1,667
Śląskie	890	37	4.482	18.0%	3.72%	788	2,050
Świętokrzyskie	1,036	9	3.911	18.4%	1.52%	588	2,274
Warmińsko-Mazurskie	928	12	3.803	15.3%	17.09%	590	2,051
Wielkopolskie	985	44	4.124	15.7%	8.67%	565	2,065
Zachodniopomorskie	976	20	4.154	17.0%	9.12%	671	2,131

Source: own work based on data extracted from GUS Local Data Bank (Główny Urzad Statystyczny, 2019), the NFZ financial statement (Narodowy Fundusz Zdrowia, 2018) and financial statements made by 16 local governments.

Factors which can affect efficiency results

There are additional factors which may affect efficiency of public spending in healthcare systems (Table 2):

- external support funds – the indicator used: changes in total liabilities;
- ageing population – the indictor used: the percentage of people above 65 in the population of a given region;
- pressure on pays – the indicator used: average pay in the economy of the region.

The regional data are different, which results in diverse conditions in which NFZ branches and local governments manage spending on healthcare.

The applied liabilities data come from the website of the Ministry of Health [Ministry of Health, 2019b]. The applied data: the percentage of people above 65 years of age in the population of a given region and average pay in the economy of the region are derived from the data pool of the GUS Local Data Bank [Główny Urzad Statystyczny, 2019].

Output data

The applied output data: surgical services performed and patients in general hospitals per 10,000 of the population come from the data pool of Health and Health Care in 2017 [Główny Urząd Statystyczny, 2019a] and Knowledge Database Health and Health Care [Główny Urząd Statystyczny, 2019b], respectively (Table 2).

The Mazowieckie and Ślaskie regions have the highest number of highly specialised clinics, performing significantly more surgical services than others. At the same time, they do not admit the highest numbers of patients in general hospitals. The reason could be that in these regions one-day hospitalisation is more frequent and/or that hospitals provide hospitalisation services more frequently to surgical patients (also to patients from other regions who have been diagnosed in their own regions).

Results

The efficiency scores obtained for 16 regions from an output-oriented model with non-increasing returns to scale are presented in the second column of Table 3. It indicates that five regions are fully effective. The DEA scores of the other regions take values above 0.8, and do not differ significantly. Moreover, the least effective region is the one that enjoys the highest average pay and the highest GDP per capita.

The bootstrap reciprocal of DEA scores with their bias determined in the second stage of the analysis are presented in Table 3. The results of the estimation of truncated regression parameters are shown in Table 4.

The bootstrap corrected DEA scores do not change the efficiency assessment in a remarkable way. Four of five fully effective regions are still characterised by the highest efficiency.

The results of the estimation of regression parameters suggest that pay pressure can affect efficiency. The average_salary increase leads, *ceteris paribus*, to the decline in the DEA scores. The direction of impact of the 65_plus and growth_rate variables on efficiency is opposite to that observed for the average_salary variable.

Table 3. The results of the DEA

REGION	DEA score	Reciprocal of DEA score	Bootstrap reciprocal of efficiency score	Bias of reciprocal DEA score
Dolnośląskie	0.902246991	1.108343957	1.120950253	–0.012606296
Kujawsko-Pomorskie	0.978077178	1.022414204	1.030865508	–0.008451303
Lubelskie	1	1	1.016148656	–0.016148656
Lubuskie	0.981102418	1.019261579	1.031492148	–0.012230569
Łódzkie	1	1	1.006508553	–0.006508553
Małopolskie	0.90342938	1.10689338	1.121845712	–0.014952332
Mazowieckie	0.847580988	1.179828257	1.208938862	–0.029110605
Opolskie	0.988375896	1.011760813	1.017233678	–0.005472865
Podkarpackie	0.917098385	1.090395553	1.10920905	–0.018813498
Podlaskie	0.987764709	1.012386847	1.029428555	–0.017041707
Pomorskie	0.869797831	1.149692451	1.180769066	–0.031076615
Śląskie	1	1	1.028413059	–0.028413059
Świętokrzyskie	1	1	1.006501158	–0.006501158
Warmińsko-Mazurskie	1	1	1.016430916	–0.016430916
Wielkopolskie	0.909928184	1.098987829	1.118896162	–0.019908332
Zachodniopomorskie	0.977088576	1.023448666	1.041348087	–0.017899421

Source: own work.

Table 4. The results of the estimation of truncated regression parameters

Covariate	Coefficient estimates	Robust coefficient estimates	Lower bounds of 95% confidence interval	Upper bounds of 95% confidence interval
Intercept	1.404259848	1.399429049	1.084199285	1.747735984
65_plus	–5.255577968	–5.489980631	–7.852979051	–3.54953443
Average_salary	0.012659051	0.014122979	0.010359758	0.017869899
Growth_rate	–0.059597955	–0.26786372	–0.532410202	–0.019824957

Source: own work.

Discussion

The results indicate that the number of efficient DMUs is quite large – there are five efficient units. The DEA scores of the other regions are fairly high and do not differ significantly, i.e., that all the 16 regions spend public funds on health services with a similar efficiency.

In comparison with the efficiency calculations made by Kujawska [2013a, 2013b] and Jewczak and Żółtaszek [2011], the results of the Mazowieckie region are completely different. According to our calculations, it is the least effective region. Such results could be caused by the fact that Kujawska [2013a, 2013] and Jewczak and Żółtaszek [2011] measured technical efficiency of resources, such as the number of doctors, nurses, or hospital beds. Our method allowed for measuring the efficiency of the financial resources. The Mazowieckie region has the highest average pay and the highest GDP per capita. Thus, the cost of human capital is higher than in other regions. In Warsaw, the Capital of Poland and the biggest city in the Mazowieckie region, there are a lot of clinical hospitals. They take care of the most serious cases, which are naturally the most expensive ones.

Additionally, our calculations used the 2017 data, and Kujawska [2013a, 2013b] as well as Jewczak and Żółtaszek [2011] used the data from the periods 2007–2010 and 1999–2009, respectively.

Unfortunately, during the research, there was no access to relevant data on the European Funds absorbed by hospitals in 2017. These funds were mainly spent on the infrastructure and medical equipment, which is not included in the study. It is a factor, however, which in some way could affect the efficiency of spending public money on medical services.

In our study we have examined environmental variables, which are variables that regional healthcare inpatient systems are incapable of influencing but may affect the efficiency of the hospitals which render the services. We consider socioeconomic and demographic variables, such as the level of wages, changes in liabilities, and populations over 65 years. The results of the truncated regression analysis have confirmed that the environmental variables are statistically significant and, therefore, have influenced the efficiency of the healthcare system in the regions.

Our results regarding the level of wages are consistent with the results of Kocisova, Gavurova, and Behun [2019], who examined efficiency at the regional level of the healthcare system of Slovakia. Increasing labour costs have a negative impact on the efficiency of healthcare facilities. Socioeconomic factors like the cost of medical staff wages were used also by Ramirez-Valdivia, Maturana, and Salvo-Garrido [2011]. According to them, medical staff wages seem to be the one that influences the most when estimating the efficiency scores and ranking of Chilean municipalities.

According to our analysis, increasing debt of hospitals in a given region has a positive impact on efficiency. We have not found any articles which have examined such external (environmental) outputs. However, there are examples of research how uncompensated hospital

care influences efficiency. Hospitals that experienced congestion related to uncompensated care had lower levels of technical efficiency [Ferrier, Rosko, Valdmanis, 2006]. This finding is not consistent with our analysis. But the analysed variables are not identical, they can be related, but not directly. We suggest that increasing debt causes an increase in spending, which is not observed in inputs data. That is why efficiency calculated in the first step of the DEA analysis could be distorted. The deficit (covered by the increasing debt) hides the real, greater financing (inputs), indicating higher efficiency.

We believe that an in-depth analysis should be carried out in subsequent research, including the impact of regional demographic characteristics on the efficiency of healthcare systems. It came as a surprise that a bigger share of older adults in the regional population positively affects the efficiency score. Ramirez-Valdivia, Maturana, and Salvo-Garrido [2011] arrived at opposite conclusions with regard to rural Chilean municipalities. However, our results are consistent with the results of Kocisova, Gavurova, and Behun [2019].

A large share of elderly people in society may be a sign of their good health and lower costs of treatment (this contradicts the fact that the cost of treatment at the end of life is the highest), but on the other hand, elderly people often suffer from chronic diseases for long periods. The question for further analysis is whether the treatment of chronic diseases of the elderly is cheaper than the treatment of diseases of young people. In our analysis, we did not divide patients by age or by treatment received. And, nowadays, it is impossible to obtain such detailed data. However, there are a few analyses from the Polish healthcare system, carried out by medical experts, which indicate that the efficiency of care for the elderly with multiple diseases can be additionally increased [Czerw, Partyka, Pajewska, 2020].

The unexpected impact of ageing population on the efficiency of regional hospital systems could have its sources in the NFZ financing algorithm, which accounts for the age structure of regional population. The higher costs of treatment of elderly patients may have been overestimated, though. The imperfections of the algorithm are confirmed by the opinions of some experts [*Rzeczpospolita*, 2019].

Summary

The research results show that Polish regions are quite homogenous with respect to the performance of healthcare units. The main reason for this is the fact that the calculation of the level of financing is based on the algorithm accounting for the characteristics of a given region, while the regulations regarding the healthcare system management are the same for the whole country. We observed slightly different efficiency in every region, which may result from the factors like delays of payments for treatment of migrating inpatients, net-borrowing of healthcare units and concentration of highly specialised hospitals in some regions.

We noticed that the demographic characteristics of the region and average pay affect the efficiency of the region. Therefore, such information can be crucial for decision makers. It

could be, for instance, one of the factors to be taken into account when designing the algorithm which allocates funds among the regions.

This study has some limitations. Firstly, we used average monthly salaries in the economy in a given region in PLN because the medical staff cost data was not available. We assume that healthcare staff salaries are correlated with the level of salaries in the region. Secondly, we were unable to distinguish the age of the patients and diagnosis-related groups (DRG), which would be useful for better assessing the impact of the demographic factor on the system efficiency.

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