EFFICIENCY FRONTIERS IN TREATING LIFESTYLE DISEASES

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Abstract

Research background: Following a rational health policy by the state is tantamount to having knowledge of society's health status and health affecting factors. It has become particularly important to focus on the 21st century diseases resulting in premature deaths. That objective dominated the 2016 Act on Public Health and the 2016–2020 National Health Programme connected with it.

Purpose: The aim of the paper is to present the results of an analysis concerning hospitals' technical efficiency assessment in treating diseases of civilization in Poland by provinces. A BCC model with a changing effects of scale and the DEA method were applied, using linear programming.

Results: The received results of assessing the technical efficiency of patient treatment related to diseases of civilization from the temporal and spatial point of view may serve as a basis for decisions on regional policy creation.

Novelty: Interest in measuring production factors of healthcare activity and outcomes may be ascribed to increased care about costs borne in the sector and pressure on responsible management in the public sphere. Thus, planning appropriate actions aimed at maintaining and improving public health leads to the rational use of funds and improved lives of the population.

Keywords: strategic management, regional analysis, public health, diseases of civilization, technical efficiency

JEL classification: C61, G39, I18, I19, R13

Introduction

The healthcare status of citizens in Poland is becoming increasingly important in both carrying out state health policy and individual citizens' decisions. The healthcare system in Poland, as an insurance and budget based one with a substantial role of the payer (the National Health Fund), covers the costs of health services and checks how money is expended. The insured may use health services rendered by public or private healthcare providers. Healthcare system reforms come down to seeking the most efficient system which would ensure healthcare to the largest possible part of the population using the least possible financial means while maintaining a certain treatment standard. According to GUS = CSO publications, the population situation of Poland remains difficult, as no significant changes guaranteeing stable demographic development can be expected in the near future. This results in low fertility and births, while extending life expectancy. The share of the oldest group in the general population is increasing significantly, so we are observing a faster aging of the population. Comparing the median age of deceased in 2018 of 77 years (71 years for men and 82 years for women) with the median age of deceased in 2000 of 73 years (69 years for men and 78 years for women) we can conclude that we are living longer but the main causes of death are cardiovascular disease and cancer, i.e. lifestyle diseases.

Thus, population treatment has not only a humanitarian value but also a specific macroeconomic dimension. Problems entailed by unemployment in Poland translated indirectly into reducing financial means flowing in the form of health contributions to the NHF as the main disposer of pecuniary means in healthcare financing. In recent years, an improved economic situation has positively affected the labour market, hence also increasing the inflow of health contributions to the NHF. However, financial needs related to healthcare are growing as modern medicine and pharmacology are becoming more and more expensive. Elderly people are using health services and reimbursed pharmacology to an increasing extent, which makes their lives longer, and at the same time it increases financial expenses for health care (Wojtyniak, Goryński, 2016). Lifestyle diseases are becoming more and more common among younger and younger generations, which also leads to rising healthcare costs (Kowalczyk, Krajewska-Kulak, Cybulski, 2016). Therefore, numerous questions arise regarding the demand for health services in treating diseases, its financing and efficient use of available resources.

An essential element of social security in the healthcare system is to ensure the greatest possible access to publicly financed health services to all entitled individuals so that financing can take place applying the national income redistribution principle. What is crucial is to utilise public means meant for healthcare in as rational a way as possible.

In order to improve and protect the health of society, the National Health Programmes (NHPs) have been developed since 1990. Strategies contained in the Programmes enable assessing achieved population effects related to the health status of society. Since 2002, strategic documents have drawn attention to harmonious regional development. In 2006, the Act (of 6 December) on Principles of Carrying out Development Policy came into effect, which contributed to the Ministry of Health (MH) preparing the Healthcare Development Strategy in Poland for the Years 2007–2015. It was a healthcare development instrument implemented by the MH as the National Health Programme for the Years 2007–2015. Another National Health Programme, in force since 2016, is an executive regulation to the Public Health Act with priority given to actions aimed at fighting obesity. The strategic goal of the National Health Programme for the Years 2016–2020 is to prolong life in health, improve health and associated life quality of the population and reduce social inequalities in health. Measures promoting appropriate dietary habits and physical activity to prevent lifestyle diseases have become important.

“Civilization diseases are diseases related to the negative effects of life in conditions of highly developed civilizations (stressful situations, nervous tension, low muscular mobility, the impact of environmental contamination and noise, irrational nutrition” – definition published (Nowy leksykon PWN, 1998) regarding lifestyle diseases is still valid. Lifestyle diseases are a health problem in highly developed countries as well as in fast developing countries, including Poland.

The Ministry of Health coordinates actions aimed at improving population health and resolving discrepancies based on the cooperation of the government, local self-governments and non-governmental organisations. Particular attention is paid to protecting and shaping the environment we live in and health promotion defined as a process enabling people to have more control over their health through making choices and decisions beneficial to health (Kowalewski, 2010). An individual’s lifestyle determines his or her health maintenance to the largest extent. Politicians, the state and local administration as well as non-governmental organisations may influence health policy development by creating favourable conditions for people to make choices beneficial to their health and increasing their awareness in that scope. Moreover, innovative Medical Centres are being set up dealing with lifestyle diseases’ prevention subsidised from EU funds (Menedżer Zdrowia, July 2017).

Conducted regional research into the population health status shows social and territorial differences and the fact that poorer health occurs in the uneducated, indigent and unemployed. Thus, the main aim of the present NHP is to improve health and associated life quality of the

population and reduce inequalities in health through using various instruments, particularly financial ones supporting families.

Repair changes have been introduced in the health sector many a time, but so far they have not significantly increased the efficiency or effectiveness of Polish healthcare (Jaworzyńska, Rozpędowska-Matraszek, Cholewa-Wiktor, 2017). At the present world development stage, the market constitutes the most effective method of management.

Economic entities operating in market economy conditions, also in the healthcare sector, rely on the efficient management of possessed resources; growing competition forces them to incessantly improve the efficiency of their operations (Ćwiakała-Małys, Nowak, 2009). Market mechanisms are difficult to apply to the efficient financing of social services with the reservation that service distribution among citizens should be determined by social rather than market considerations. The inefficiency problem occurs in every country, with principal differences lying in how well particular systems are able to limit that (Waller, Gotway, 2004), (Folland, Goodman, Stano, 2010). An efficient organisation needs both stability and openness to development and change (Frączkiewicz-Wronka, 2010).

Efficiency research is a fundamental element of the decision-making process whose aim is to maximise obtained outputs. The notion of efficiency is most commonly equated with its economic character, focusing mainly on two aspects, *i.e.* the technological and cost-related ones (Morris, Delin, Parkin, 2007). WHO experts estimate that 20–40% of healthcare expenditures, on average, are inappropriately used, hence it is worth giving attention to the problem of inefficiency.

The principles of economic efficiency theory in perfect competition conditions were formulated by Italian economist Pareto. Along with the perfect competition model, economic theory and practice apply various economic efficiency measures depending on what is assumed as the input and output. Thus, various efficiency relationships are received. Efficiency research covers activity outputs produced at specified inputs or deal with utilising inputs that allows generating assumed outputs. Samuelson and Nordhaus claimed that efficiency may be the main subject of economics; it is the absence of wastage.

Achieving economic efficiency by an entity is associated, among others, with technical efficiency. According to J. Suchecka (2009), technical efficiency consists in equalising the marginal costs of producers of a given type of production. Costs are determined by price levels established in the market play process. In health economics, technical efficiency is defined as an output of hospital service activity related to providing services at a specified time and utilising specified inputs. Efficiency assessment, therefore, is associated with determining an appropriate

combination of factors that allow maximising the enterprise activity output. In general, efficiency measurement methods may be divided into three major groups, *i.e.* index, parametric and non-parametric. Non-parametric methods are employed to measure the technical efficiency of enterprises rendering health services and enable analysing inputs and outputs (Vincova, 2005).

Since 1978, numerous publications have occurred related to methodological principles reflecting DEA method development. Articles and studies on the application of the method in various research areas and sectors, both public and private ones, have been published. Healthcare entity efficiency research employing frontier methods was proposed, among others, by R.D. Banker, R.F. Conrad and R. Strauss (1986), J.L. Fazel and T.S. Nunnikhoven (1992), as well as P. Kooreman (1994). The utility of the DEA method in analysing medical service provider efficiency was presented by A. Worthington (2004). The DEA method was utilised in many ways in analyses of non-for-profit organisations, which include healthcare (Chen, Hwang, Shao, 2005; Hajialiafzali, Moss, Mahmood, 2007). Issues connected with defining and measuring efficiency were presented by (Kisielewska, 2008), (Rutkowska, 2013). Examples of DEA method applications to the health system in Polish efficiency studies were used by (Folland et al., 2010; Kozuń-Cieślak, 2011; Jewczak, Żółtaszek, 2011; Jacobs, Smith, Street, 2006). The DEA method was employed by A. Wierzbicka (2017) to assess the technical efficiency of traumatology and orthopaedic surgery departments, and a team of researchers (Ni Luasa, Dineen, Zieba, 2018) used the DEA method to assess technical performance in public and private Irish nursing homes. There are more and more healthcare entities (including hospitals) in Poland where optimising steps are implemented, while economic results show that carrying out the patient-focused mission may be reconciled with maintaining profitability. That has contributed to applying the method in practice in the analysis of hospital treatment efficiency related to treating lifestyle diseases in the cross-section of provinces, *Menedżer Zdrowia* (Issues 4–5/2018).

The aim of the analysis is to present results of the technical efficiency assessment of hospital treatment in the scope of treating lifestyle diseases in Poland according to provinces using the frontier data method. An attempt was made at assessing identical access to hospital treatment in provinces despite their different levels of economic development. A question was posed whether it is possible to maintain hospital treatment efficiency through input reduction.

1. Research Method

Health has become an element of economic calculation and measurement of relationships between provided inputs and produced outputs. The operation of healthcare entities in competitiveness conditions is extremely difficult; hence seeking solutions related to financial savings in their activity is advisable. A non-parametric method was employed for measuring the technical efficiency of operations, which allows analysing inputs and outputs and determining an inefficiency frontier.

Developed by A. Charnes, W.W. Cooper and E.L. Rhodes (1978), the DEA method has been used in many applications as it does not require determining the functional relationship between inputs and outputs. It allows simultaneously considering many inputs and many outputs of a decision-making unit. Thanks to the method, efficient and inefficient units can be identified. The method can be used to establish specific inefficiencies, which may be unidentifiable applying other analytical instruments such as linear regression or index analysis. The same characteristics make the DEA method to be regarded as a good tool, which, however, may also pose problems. The DEA method is a frontier technique, hence disruptions in the form of a measurement error may lead to wrong decisions and data accuracy in analyses in examining a unit's efficiency is of extreme importance. The method merely indicates the achievements of a given unit in comparison to other units in a sample rather than compared to a discursive maximum. Furthermore, the DEA method application does not give a ready-to-use recipe for improving the efficiency of particular ineffective decision-making units taking into account efficiency differences. The assessment of hospital treatment efficiency in the scope of treating lifestyle diseases used the BCC method (Banker, Charnes, Cooper, 1984) with varying returns to scale

2. Assumptions of DEA Method

The DEA method is applied to estimate the operation efficiency of various entities called Decision-Making Units (DMUs). A DMU's efficiency is measured relative to other DMUs considered efficient in a studied group, hence forming an efficiency frontier. DEA method assumptions are as follows: there are n DMUs, all of which utilise m various inputs to produce s various outputs. Volumes of inputs and outputs are above or equal to zero and at least one input and one output exceed zero for each decision-making unit. The adopted method has many advantages; it, among others, does not require weights to be known; weights that maximise its

efficiency are sought for every unit. Variables describing inputs and outputs may have different units of measure and, importantly, the method does not average values but identifies extreme ones. Technical efficiency, *i.e.* the efficiency of a technology of transforming inputs into outputs, is a quotient of the weighted sum of outputs to the weighted sum of inputs:

$$\theta = \frac{\sum_{r=1}^s \mu_r \cdot Y_r}{\sum_{j=1}^m \nu_j \cdot X_j} \quad (1)$$

where:

θ – efficiency,

Y_r – r output,

X_j – j input,

s – number of outputs,

m – number of inputs,

μ_r – weights determining importance of particular outputs,

ν_j – weights determining importance of particular inputs.

When applying the method, the efficiency of a decision-making unit in relation to other units is determined by solving a linear programming problem, *i.e.* finding values of weights ν_r and μ_r optimising the objective function, *i.e.* the efficiency of an examined entity taking a positive value below or equal to 1. The value of the efficiency coefficient equal to 1 means that a given entity is at the efficiency frontier. The coefficient value below 1 allows regarding an examined entity as relatively inefficient, with a specific value of the coefficient indicating the inefficiency level.

Out of the main classification criteria of DEA models allowing for efficiency assessment, the so-called technical efficiency, *i.e.* the efficiency of a technology of transforming inputs into outputs, input-focused model was chosen (minimising inputs in such a way so that outputs remain at a set level), while the BCC varying returns to scale model was selected as a returns to scale model. The BCC model solution is the so-called pure technical efficiency equal to θ^* in an input-focused model:

$$\begin{aligned}
\theta^* = \theta &\rightarrow \min \\
\sum_{j=1}^n x_{pj} \lambda_j &\leq \theta x_{pi} \\
\sum_{j=1}^n y_{rj} \lambda_j &\geq y_{ri} \\
\sum_{j=1}^n \lambda_j &= 1 \\
\lambda_j &\geq 0
\end{aligned} \tag{2}$$

Returns to scale inform how much less inputs might be utilised if the volume of outputs was maximal.

3. Data Used in the Analysis

The analysis utilised data for the years 2003–2017 acquired from the Central Statistical Office Local Data Bank and Statistical Bulletins of the Ministry of Health. A base was created applying a list of variables for 16 provinces. The following variables were used as inputs in the study:

- $n1$ – number of nurses according to the main workplace (in 1,000 people),
- $n2$ – $n6$ – number of medical specialists employed by healthcare facilities (radiology, pulmonary diseases, psychiatry, dermatology and neurology respectively) (in 1,000 people),
- $n7$ – costs of health services – hospital treatment (per 1,000 of the population),
- $n8$ – expenditures from province budgets – Expenditures in Sector 851 – Healthcare (per 1,000 of the population),
- $n9$ – expenditures on fixed assets meant for environmental protection (per 1,000 of the population),

and outputs expressed as shares of patients treated in departments (including interdepartmental transfers) for selected diseases to numbers of beds in departments treating specified diseases:

$$1 = \frac{\text{internal cardiological diseases and cardiological high dependency}}{\text{beds in internal cardiological diseases departments}},$$

$$e2 = \frac{\text{oncological diseases}}{\text{beds in oncological diseases departments}},$$

$$e3 = \frac{\text{infectious diseases and dermatology}}{\text{beds in infectious diseases and dermatology departments}},$$

$$e4 = \frac{\text{neurological diseases}}{\text{number of neurology beds}},$$

$$e5 = \frac{\text{addiction and psychiatric research}}{\text{beds in internal cardiological diseases departments}},$$

$$e6 = \frac{\text{tuberculosis and pulmonary diseases and tuberculosis of other organs}}{\text{beds in psychiatric and addiction treatment departments}}.$$

The Act on General Insurance with the NHF was introduced in 2003 (Journal of Laws [Dz.U.] No. 45. Item 391). The Programmes of Protective Actions and Restructuring in Healthcare were the next steps in reorganising the healthcare sector. The expected health effect set in the NHP for the years 2007–2015 comprised, among others, such strategic goals as decreasing morbidity and premature mortality from cardiovascular diseases (including strokes), malignant neoplasms or reducing social and territorial discrepancies in the population health status. The NHP for the years 2016–2020 expands actions in that direction by drawing attention to factors directly and indirectly affecting lifestyle diseases.

4. Results of the Analysis

An optimization analysis was carried out using EXCEL. A disadvantage of that optimisation method was the need to repeatedly find solutions for consecutive years from 2003 to 2017. According to the DEA method requirements, it was assumed that provinces were homogenous and operated following the same principles in the same economic conditions. Partial results of determined indices λ_j for provinces are presented in (Table 1).

Based on the above linear combination coefficients of technology common to inefficient hospitals in provinces in the years 2003–2017, variables and efficient DMUs were determined, as linear combination coefficients of technology common to inefficient hospitals in provinces, for efficiency $\Theta = 1$.

Table 1. Linear combination coefficients of technology common to inefficient provinces

Year 2003

Prov.	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	λ_8	λ_9	λ_{10}	λ_{11}	λ_{12}	λ_{13}	λ_{14}	λ_{15}	λ_{16}
W1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W2	0.09	1	0	0	0	0	0	0	0	0	0.39	0	0	0	0.33	0
W3	0.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
W4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
W5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0.1	0
W6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
W7	0	0	0	0	0	0	1	0	0	0	0.07	0.12	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Year 2017

Prov.	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	λ_8	λ_9	λ_{10}	λ_{11}	λ_{12}	λ_{13}	λ_{14}	λ_{15}	λ_{16}
W1	1	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0
W2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
W4	0	0.01	0	1	0	0	0	0	0	0	0	0	0	0	0.07	0
W5	0	0.10	0	0	1	0.17	0	0	0	0	0	0	0	0	0.18	0
W6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Source: own calculations.

Thanks to the selected method application, provinces were indicated where financial expenditures and human resources were higher than the optimum operations of hospitals in the years 2003–2017. The determined efficient DMUs for 2017 are shown through a fragment of calculations (Table 2).

The optimum value of parameter λ indicates the volume of input to be used by a given item compared to efficient units. The number in line λ_j shows which efficient items became benchmarks for inefficient units.

The Polish system of financing health services takes place as part of the distribution of funds from the National Health Fund to the provincial branches of the National Health Fund, hence the analysis of the effectiveness of health care within the territorial division. As part of the corrective changes in securing the health needs of citizens (effective from 1 October 2017), the legislator wanting to stabilize the structure of hospitals and their financing, amended the Act of 27 April 2008 on health care services financed from public funds (Journal of Laws of 2016

item 1793, as amended) and subsequent amendments (Journal of Laws of 2017, item 844). As a result, a system of basic hospital provision of healthcare services (SPSZ) was introduced as part of the so-called Polish hospital network. Pursuant to the new Act, NHF provincial branches will publish (every 4 years) in the Public Information Bulletin lists of service providers qualified to individual levels of the security system with an indication of all profiles of the security system and the ranges or additional types under which they will provide healthcare services in the security system.

Table 2. Efficient DMUs for 2017

λ_j	DMU1	DMU2	DMU3	DMU4	DMU5	DMU6	DMU7	DMU8	DMU9	DMU10	DMU11	DMU12	DMU13	DMU14	DMU15	DMU16
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
λ_8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
λ_9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
λ_{10}	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
λ_{11}	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
λ_{12}	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
λ_{13}	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
λ_{14}	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
λ_{15}	0.04	0	0	0.07	0.18	0	0	0.12	0	0	0.02	0	0.23	0.21	0	0
λ_{16}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Source: own calculations.

The carried out analysis indicated that more provinces, not always the same, were characterised by efficiency coefficients below 100% from 2003 to 2011. From 2012, full technical efficiency was observed in 15 or 14 provinces, while such characteristics were observed for 12 provinces in 2003. However, the Dolnośląskie province returned to the group of inefficient ones in 2017, compare (Table 3).

In Poland, there are more and more healthcare entities (including hospitals) in which optimization measures are implemented and their economic results show that it is possible to simultaneously fulfill the mission towards patients and maintain profitability. Effective management and understanding of economic processes affects the right decision making that brings the expected results. This is confirmed by the fact of technical efficiency in the treatment of lifestyle diseases in provinces.

Table 3. Technical inefficiency of hospital treatment in provinces

Provinces	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Dolnośląskie	x			x	x	x	x	x	x			x		*	x
Kujawsko-Pomorskie			*			*						*			
Lubelskie				*					x						
Lubuskie															
Łódzkie									*						
Małopolskie			*	x	x		x				*		*		x
Mazowieckie			x	x		x					x				
Opolskie															
Podkarpackie								x						x	
Podlaskie															
Pomorskie	x	x		x	x		x								
Śląskie	x	x	x	x	x		x	x	x	x	x	x	x	x	
Świętokrzyskie							*	*							
Warmińsko-Mazurskie															
Wielkopolskie	x	*													x
Zachodniopomorskie			x	x	*		*								

x – inputs should be reduced; * – inputs used at 99%.

Source: own work.

The conducted analysis enabled indicating technical efficiency frontiers related to treating lifestyle diseases in provinces in Poland. Over the analysed fifteen years, the Śląskie province displayed full efficiency solely in 2008 and 2017. It may have been associated with the fact that the Śląskie province is a mining industry centre with large outlays on hospital treatment due to numerous accidents in coal mines. The situation was slightly better in the Dolnośląskie province. The use of inputs close to the appropriate one was observed in three provinces (Kujawsko-Pomorskie, Łódzkie and Świętokrzyskie). Full technical efficiency in the scope of treating lifestyle diseases was indicated in four provinces (Lubuskie, Opolskie, Podlaskie and Warmińsko-Mazurskie). The efficiency was connected with steps taken by the government and Ministry of Health to improve healthcare efficiency in provinces by preparing for the coming into force of the act (May 2017) on creating health maps. Hospitals belonging to the network of health maps are currently financed on a lump-sum basis but the amount was to depend on the range of services rendered and contained in financial statements in the preceding accounting period. The Śląskie province showed such characteristics until 2016.

When achieving a higher healthcare efficiency value related to treating lifestyle diseases in provinces, 100% transformation of inputs into outputs can be established. A rise in the number of efficient provinces means increased efficiency coefficients in provinces, which not necessarily arises from actual input utilisation improvement. Increased healthcare technical efficiency in the scope of treating lifestyle diseases in Poland's provinces may result in such a situation that not only well functioning hospital healthcare in provinces but also average ones will be considered efficient compared to others. Similarly, a drop in the number of efficient provinces does not directly translate into healthcare efficiency related to treating lifestyle diseases in Poland.

The received results (efficiency factors and free variables) were used to determine inefficient input values in provinces, which under other conditions unchanged would ensure efficiency. Based on new input values with set outputs in the BCC model, the exceeding of efficiency frontiers by specific percentage values for all inputs (N_j) according to provinces in particular years was calculated, which is shown in (Table 4).

Table 4. New inputs reduction at set outputs (%)

Year	Provinces	N1	N2	N3	N4	N5	N6	N7	N8	N9
1	2	3	4	5	6	7	8	9	10	11
2003	Dolnośląskie	34.7	26.1	10.3	33.10	31.5	20.1	8.7	2.7	59.10
2006		38.6	35.5	25.1	9.70	14.9	19.8	10.1	66.4	7.30
2007		28.2	11.9	5.9	19.50	13.3	2.2	3.4	47.7	2.20
2008		39.9	43.2	24.4	36.30	26.1	27.5	1.4	51.5	28.20
2009		40.9	50.7	30.6	37.90	18.6	34.2	3.6	15.3	13.10
2010		39.0	43.8	23.4	0.04	38.9	34.3	11.9	77.1	0.04
2011		42.2	37.4	42.4	23.00	37.3	30.7	8.7	52.7	4.60
2014		34.5	49.1	13.4	31.60	34.2	27.2	5.5	30.2	6.20
2017	Kujawsko-Pomorskie	36.9	39.4	28.4	43.00	35.9	32.4	16.2	66.1	9.40
2011	Lubelskie	21.8	35.4	32.0	5.00	17.1	36.6	10.5	42.8	5.00
2006	Małopolskie	52.9	50.6	69.6	50.30	45.6	57.2	2.2	0.1	0.10
2007		55.7	50.1	61.3	54.10	49.6	58.1	5.1	3.7	8.20
2009		51.1	53.2	53.0	52.20	24.0	47.0	2.7	30.8	1.10
2017		50.6	32.6	51.4	50.20	17.8	41.7	7.4	7.4	18.10
2005	Mazowieckie	62.8	68.5	60.4	70.20	65.4	68.6	21.3	63.4	15.00
2006		71.6	77.9	60.5	78.40	68.6	77.0	19.4	71.0	23.30
2008		54.4	64.0	46.2	71.90	58.5	58.4	14.8	39.5	17.80
2013		56.7	65.1	44.0	70.80	62.0	65.8	6.8	9.2	2.40
2010	Podkarpackie	46.2	48.5	52.4	25.80	41.5	48.5	8.8	43.6	13.10
2016		39.9	4.8	42.6	27.10	26.3	46.3	0.2	59.7	0.20

1	2	3	4	5	6	7	8	9	10	11
2003	Pomorskie	1.1	47.4	7.5	34.40	28.5	4.9	18.2	1.1	1.10
2004		4.6	44.5	6.1	27.80	23.4	1.7	1.7	12.4	17.00
2006		22.2	50.3	23.2	36.80	31.6	17.6	3.6	29.7	3.60
2007		31.1	50.4	34.6	37.70	40.6	32.0	5.8	63.8	25.20
2009		48.4	79.8	56.6	58.70	54.2	53.4	16.2	51.4	36.20
2003	Śląskie	65.3	60.5	62.2	51.20	72.0	71.1	57.5	23.7	15.70
2004		63.9	67.2	55.4	61.40	69.7	66.5	95.0	22.2	28.70
2005		76.6	78.7	70.7	59.10	73.0	79.3	33.3	48.4	25.40
2006		76.5	77.4	72.6	66.60	78.6	81.1	25.8	17.9	57.60
2007		77.0	81.3	73.4	66.40	77.9	82.8	21.8	11.2	70.10
2009		58.7	60.5	60.5	38.60	59.1	66.7	18.8	8.2	60.30
2010		56.2	57.0	54.7	32.20	55.6	59.3	14.7	9.6	23.20
2011		54.4	54.1	56.9	31.60	52.9	55.6	5.6	5.6	24.40
2012		46.8	60.2	45.7	46.50	48.5	57.6	4.4	35.3	4.40
2013		77.0	84.2	11.6	76.20	81.7	81.6	11.6	36.4	11.60
2014		48.1	56.8	42.9	39.60	46.8	49.6	2.5	2.5	47.90
2015		62.3	64.1	56.9	49.80	54.6	63.9	2.5	2.1	14.50
2016		68.6	74.5	62.3	64.30	59.0	73.6	13.1	8.7	38.20
2003	Wielkopolskie	34.1	43.8	15.3	44.30	40.8	34.5	53.3	39.4	8.20
2017		47.8	57.4	39.9	44.10	11.6	33.7	11.6	68.6	22.20
2005	Zachodniopomorskie	19.4	37.7	29.8	3.40	39.0	19.1	10.9	16.9	3.40
2006		18.6	42.5	33.6	0.80	48.1	18.2	6.2	35.2	52.80

Source: own work.

New input values with established outputs in the BCC model indicate to what extent the inputs of particular factors should be reduced. A detailed analysis of the results was carried out solely for the lowest ranking provinces, *i.e.* the Śląskie and Dolnośląskie provinces. In the Śląskie province, as for healthcare costs – hospital care (per 1,000 of the population) – the highest overestimation at 95% occurred in 2004 while the overestimation decreased to 2.5% in 2014 and 2015. Expenditures from province budgets (in Sector 851 – Healthcare) displayed the highest overestimation at 48.4% in 2005 while it was merely 2.1% in 2015. Outlays on fixed assets meant for environmental protection (per 1,000 of the population), exerting an indirect influence on reduction in lifestyle diseases, showed 70.1% overestimation in 2007 compared to the other studied items, to drop to 4.4% in 2012. In the Śląskie province in 2004, there was the highest overestimation of medical specialists' employment (radiology, dermatology, neurology, pulmonary diseases and psychiatry) to be reduced in 2011, 2014 (dermatology and

neurology), 2013 and 2010 respectively. In the Śląskie province, also the number of nurses employed according to the main workplace was overestimated in 2004 to experience a drop to 46.8% in 2012.

While comparing efficiency in the Dolnośląskie province in the analysed years, the most inappropriate use of outlays on fixed assets meant for environmental protection was noted in 2010, despite their much better use in 2009 and 2003. A considerable efficiency improvement occurred in expenditures from province budgets (in Sector 851 – Healthcare) where the greatest overestimation at 59.1% occurred in 2003, to the 6.2% efficiency overestimation reduction in 2014. As for healthcare costs – hospital care (per 1,000 of the population) – the greatest overestimation at 11.9% occurred in 2010 while it was merely 1.4% in 2008. A significantly lower inefficiency of using inputs compared to the Śląskie province was observed for nurses employed according to the main workplace from 42.2% in 2011 to 28.2% in 2007. The situation was better in the Dolnośląskie province regarding the employment of medical specialists in all of the analysed specialities compared to the Śląskie province. Based on the above, it can be concluded that there was a significant improvement in efficiency related to the use of inputs in hospital care over the fifteen years.

Conclusions

Inter- province diversities in Poland arise from diversities in processes that take place in specific areas of Poland and translate into the constant lack of cohesion, despite expected uniformity, especially in the healthcare sector. Healthcare efficiency is multidimensional (it can be evaluated applying numerous measures concerning such areas as: resources, costs, productivity and quality), hence becoming difficult to analyse and assess.

The use of the BCC model of the applied DEA method allowed determining the technical efficiency of hospital healthcare in provinces in the scope of treating lifestyle diseases. Over the 15 years, despite reorganisation and restructuring in the healthcare sector, full technical efficiency was not achieved in that respect. There was a significant efficiency improvement related to the use of outlays on hospital healthcare, expenditures from province budgets on healthcare and outlays on fixed assets meant for environmental protection (except for the Śląskie province in the years 2003–2016 and the Dolnośląskie province in 2003, in the years 2006–2011 and in 2014). The quality and efficiency of hospital healthcare with the growing role of social capital (employment of medical specialists and nurses) are an important element

and source of a region's competitive advantage, but full technical efficiency was not achieved in that respect.

The received results of assessing the efficiency of hospital care in the treatment of lifestyle diseases from the spatio-temporal point of view may serve as a basis of decisions on regional healthcare policy creation.

The society is ageing and we are affected by the lifestyle diseases of the 21st century that require expensive treatment, hence justifying further analyses of the efficient use of financial and human resources.

This study focuses exclusively on the overall assessment of effectiveness in the treatment of lifestyle diseases in provinces. Expanding research in this area will be possible after obtaining more detailed statistical data, or establishing cooperation with the medical community.

Hospital treatment is associated with comprehensive medical care (diagnosis, treatment, care, rehabilitation). Hospital treatment takes place in the form of: hospitalization (admission can be immediate if your health condition requires it), planned hospitalization (the date of admission to the hospital is determined in advance) and treatment one day. Providing healthcare services under the so-called "One-day treatment" did not significantly reduce queues. Hospitals provide 24-hour medical, nursing or obstetric care on all days of the week (except for service providers who only offer one day treatment), which is very expensive.

The prolonged stay of the patient in the hospital (this applies especially to the elderly, who there is no one to pick up or do not want to pick up from the hospital) than the required provision of a medical service, this leads to increased costs and therefore less efficiency, despite the greater use of bed resources. The problem of ordering resources in healthcare has not yet been solved.

Confirmation of the need for further and more detailed research using a technical efficiency analysis in the field of medical activity in provinces is the statement of a doctor, currently a politician and a local government representative (Menedżer Zdrowia, Issues 1–2/2020). Healthcare experts point to the problems arising with the valuation of services by the National Health Fund, which have led to significant differences in the profitability of medical activities. This forced managers of many institutions to prefer more profitable services. In many cases, this has nothing to do with patients' actual needs and health priorities. There are still difficulties with access to medical services, and this translates into an increase in the role of the commercial services sector and the wage expectations of staff employed in the insurance sector. Specialist doctors are increasingly providing advice outside the insurance system, where administrative requirements are much smaller.

Improving the availability of medical services for patients requires a rapid increase in health care expenditure and changes in the algorithm for allocating funds between provinces, as the diagnosed differences between regions are already too large. Then it will be possible to increase expenditure in provinces less rich in funds from the National Health Fund, without worsening the situation in regions with better access to medical services.

References

- Banker, R.D., Charnes, A., Cooper, W.W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science*, 30, 1078–1092.
- Banker, R.D., Conrad R.F., Strauss, R. (1986). A Comparative Application of Data Envelopment Analysis and Translog Methods: An Illustrative Study of Hospital Production. *Management Science*, 32, 30–44.
- Chen, A., Hwang, Y., Shao, B. (2005). Measurement and sources of overall and input inefficiencies: Evidences and implications in hospital services. *European Journal of Operational Research*, 161.
- Centrum Systemów Informacyjnych Ministerstwa Zdrowia. *Biuletyn Statystyczny Ministerstwa Zdrowia* (2004–2019). Warszawa.
- Charnes, A., Cooper, W.W, Rhodes, E.L. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2 (6), 429–444.
- Ćwiąkała-Małys, A., Nowak, W. (2009). Sposoby klasyfikacji modeli DEA. *Badania Operacyjne i Decyzyjne*, 3.
- Fizel, J.L., Nunnikhoven, T.S. (1992). Technical efficiency of for-profit and non-profit nursing homes. *Managerial and Decision Economics*, 13 (5), 429–439.
- Frączkiewicz-Wronka, A. (ed.) (2010). *Pomiar efektywności organizacji publicznych na przykładzie sektora ochrony zdrowia*. Katowice: Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach.
- Folland, S., Goodman, A.C., Stano, M. (2010). *The Economics of Health and Health Care*, Pearson Education. J. Suchecka (ed.) (2013). *Ekonomia zdrowia i opieki zdrowotnej*, Warszawa: Wolters Kluwer.
- GUS (2004–2018). *Zdrowie i ochrona zdrowia* (2003–2017). Departament Badań Społecznych i Warunków Życia. Retrieved from: www.stat.gov.pl.
- Hajialiafzali, H., Moss, J.R., Mahmood, M.A. (2007). Efficiency Measurement for Hospitals Owned by the Iranian Social Security Organisation. *Journal of Medical Systems*, 31.

- Jacobs, R., Smith, P.C., Street, A. (2006). *Measuring Efficiency in Health Care. Analytic Techniques and Health Policy*. New York: Cambridge University Press. Translated by E. Nojszewska (2013). *Mierzenie efektywności w ochronie zdrowia*. Warszawa: Wolters Kluwer.
- Jaworzyńska, M., Rozpędowska-Matraszek, D., Cholewa-Wiktor, M. (2017). *Zarządzanie w służbie zdrowia. Strategia. Marketing. Personel*. Warszawa: Wydawnictwo Texter.
- Jewczak, M., Żółtaszek, A. (2011). Ocena efektywności technicznej podmiotów sektora opieki zdrowotnej w Polsce w latach 1999–2009 w ujęciu przestrzenno-czasowym na przykładzie szpitali ogólnych. *Problemy Zarządzania*, 9, 3 (33).
- Kisielewska, M. (2008). Pojęcie efektywności w metodach analizy granicznej. *Studia i Prace WNEiZ US*, 1.
- Kooreman, P. (1994). Data envelopment analysis and parametric frontier estimation: complementary tools. *Journal of Health Economics*, 13, 345–346.
- Kowalczyk, K., Krajewska-Kułak, E., Cybulski, M. (eds.) (2016). *Wybrane choroby cywilizacyjne XXI wieku*. Tom II. Białystok: Uniwersytet Medyczny w Białymstoku Wydział Nauk o Zdrowiu.
- Kowalewski, I. (2010). *Promocja zdrowia i bezpieczeństwo w szkole wyższej*. Kraków: Wydawnictwo Naukowe Uniwersytetu Pedagogicznego.
- Kozuń-Cieślak, G. (2011). Wykorzystanie metody DEA do oceny efektywności w usługach sektora publicznego. *Wiadomości Statystyczne*, 3.
- Morris, S., Delin, N., Parkin, D. (2007). *Economic Analysis in Health Care*. Published by John Wiley and Sons. England. – Translated by, E. Nojszewska, M. Próchniak, P. Ciżkowicz (2011). *Ekonomia w ochronie zdrowia*. Warszawa: Wolters Kluwer.
- Ni Luasa, S., Dineen, D.J., Zieba, M. (2018). Technical and scale efficiency in public and private Irish nursing homes: a bootstrap DEA approach. *Health Care Management Science*, 21, 326–347.
- Rutkowska, A. (2013). Teoretyczne aspekty efektywności – pojęcie i metody pomiaru. *Zarządzanie i Finanse Journal of Management and Finance*, 11 (1/4).
- Suchecka, J. (2009). Metody oceny efektywności technicznej szpitali. In: R. Holly, J. Suchecka (eds.), *Szpital publiczny w polskim systemie ochrony zdrowia. Zarządzanie i gospodarka finansowa*. Łódź–Warszawa: Uniwersytet Medyczny w Łodzi i Krajowy Instytut Ubezpieczeń.
- Waller, L.A., Gotway, C.A. (2004). *Applied Spatial Statistics for Public Health Data*. New York: Published by John Wiley and Sons. Printed in the United States of America.
- Wierzbicka, A. (2017). *Statystyczne metody analizy efektywności oddziałów chirurgii urazowo-ortopedycznej*. Łódź: Uniwersytet Łódzki.
- Wojtyniak, B., Goryński, P. (eds.) (2016). *Sytuacja zdrowotna ludności polski i jej uwarunkowania*. Warszawa: Narodowy Instytut Zdrowia Publicznego – Państwowy Zakład Higieny.

- Worthington, A. (2004). Frontier Efficiency Measurement in Healthcare: A Review of Empirical Techniques and Selected Applications. *Medical Care Research and Review*, 61 (2), 135–170.
- Vincowá, K. (2005). Using DEA models to measure efficiency. *BIATEC*, 13 (8), 24–28.
- Menedżer Zdrowia (July 2017; 2018; 2020). Poznań: TERMEDIA Wydawnictwo Medyczne.
- Narodowy Program Zdrowia na lata 2016–2020. Rozporządzenie Rady Ministrów z 4 sierpnia 2016 r.
- Program *Wsparcie jednostek samorządu terytorialnego w działaniach stabilizujących system ochrony zdrowia* (2009–2011).
- Ustawa o działalności leczniczej (Dz.U. nr 112, poz. 654; nr 149, poz. 887; nr 174, poz. 1039; nr 185, poz. 1092 z 2012 r. poz. 742).
- Ustawa o zdrowiu publicznym z dnia 11 września 2015 r. (Dz.U. poz. 1916).
- Ustawa o świadczeniach opieki zdrowotnej finansowanych ze środków publicznych (Dz.U. 2016, poz. 1793 ze zm., Dz.U. 2017, poz. 844).