THE MATERIAL RESOURCES USING EFFICIENCY IN POLISH PUBLIC HOSPITALS

Agnieszka KRAWCZYK-SOŁTYS[1]
Agnieszka TŁUCZAK[2]

ABSTRACT
Within many health care systems worldwide, increased attention is being focused on resources management. Specifically, resources are one of three principle health system inputs. Resources are the basis for developing the capabilities and competences of public hospitals. The resources protect functioning of public hospitals, at the same time determining the efficiency achievement of the objectives - they are the basis for their efficiency and competitiveness.
The article is focused on an identification of spatio-temporal diversification of material resources using efficiency in Polish public hospitals. The data collection was achieved through secondary sources such as The Ministry of Health in Poland. The main resources issues and questions, along with the analysis of the resources impact on the health care system was examined, as well as the identification of the trends in health sector reform. These trends include efficiency, equity and quality objectives.

KEYWORDS: *efficiency, material resources, public hospitals*

JEL CLASSIFICATION: *D61, H21, I18*

1. INTRODUCTION

Resources are the basis for developing the capabilities and competences of public hospitals. The resources protect functioning of public hospitals, at the same time determining the efficiency achievement of the objectives - they are the basis for their efficiency and competitiveness.
There is no universal resources classification. Authors differently represent the structure of resources, taking into account various criteria: type of resource, strategic importance, importance for competitive advantage, origin of the resource.
J.B. Barney, the forerunner of the resources based view (*RBV*) has identified three categories of resources (Barney, 1991): material, human and organizational. The resources can be divided according to many criteria, e.g.:

- subject - type of resource, e.g. human, financial, material;
- functions or subsystems of the organization - marketing, financial, used in the production;
- characteristics of resources - visible and invisible, material and immaterial, "hard" and "soft".

There are many factors that determine the efficiency of organization (Matwiejczuk, 2000). To the basic categories of efficiency in health care can be included: allocative efficiency (also called Pareto efficiency) and technical efficiency (Golinowska, 2012). The allocative efficiency refers to the results evaluation, their distribution in the spatial and social structure and its relation to incurred expenditures. The assumption of this efficiency category is the assertion about limited resources,

[1] Opole University, Poland, akrawczyk.soltys@uni.opole.pl
[2] Opole University, Poland, atluczak@uni.opole.pl

which are supposed to be reallocated in order to bring the best health outcomes to whole society. The allocative efficiency depends on the decision of entities responsible for the location of resources in the health care system. In Poland, these entities are: payers contracting health services, institutions that deliver these services (including public hospitals) and control organizations. The technical efficiency can be understood as creation a certain number of services at the least possible effort, or creation as many services as possible at a certain expenditures.

Therefore, it generally refers to verify the efficiency of various health entities, to assess, how an organization manages its resources (personnel, technical equipment, infrastructure, materials and tools, finances, etc.). This kind of efficiency is measured by a number of indicators, of which the most common are as follows (Krawczyk- Sołtys and Tłuczak, 2017):

- evaluating the level of resources using, e.g. the level of medical personnel and hospital beds using;
- specifying the amount of resources per capita, e.g. the number of doctors and nurses and hospital beds per 100 thous. residents.

The integrated approach of effectiveness should include an assessment of three characteristics included:

1. Social purpose of activity, which represents the degree of achieving organization's goal understood as social needs of goods or services,
2. Economic rationality of organizational processes, regarding to the rational use of resources involved in achieving the goal,
3. Financial efficiency which is a synthetic form of the financial result of the organization activity.

The aim of efficiency analysis is also making systemic allocation decisions, e.g. public funding of medical technology. In every situation, the outcome of an effectiveness evaluation depends on the perspective of the input and outcome analysis (patient, society, payer), and whether the time factor (dynamic efficiency), i.e. the health effects for future generations, is taken into account (Lubicz, 2010).

There are many elements in the health system, between which there are various relationships and which reach different goals. These systems are characterized by the specific human and material resources (including hospital beds), processing objects (patients with specific attributes), and processing results (health effects of specific patients).

Efficiency in environmental variability is becoming an important success determinant of public hospitals. It is the basis for assessing the effectiveness of projects and the multi-criteria evaluation of inputs and outputs related with these projects. It is a tool for measuring management effectiveness and an important tool for building competitive advantage.

The aim of the article is identification of spatio-temporal diversification of material resources using efficiency in Polish public hospitals.

2. METHODOLOGY

Efficiency is one of the most important economical categories, it lets to analyze activity, its perceived as estimation of correctness of completing a task through a certain system. Efficiency reflects relations between effects, goals, issues and costs considered in structural and dynamic recognition (Blaik, 2010; Manheim et al., 1992). In general meaning efficiency is a ratio of effects and issues which can be shown as an equation (Diez –Ticio and Mancebon, 2002; Hofmarcher et al., 2002):

$$E=e/n \quad (1)$$

where:
E – efficiency;
e – obtained effects;
n – incurred issues.

Measurement of efficiency can be made in different ways depending on range system operation. We can distinguish organizational efficiency which means ability of the system to adapting to changes of the environment and beneficial use of sources. Economical efficiency concerning rational managing of sources. Another kinds of efficiency is technical efficiency that measures value size of production with use of issues, next one is quality efficiency that reflects competitiveness of system relatively to others, characterized by different values (Sherman, 1984; Linna, 1998; Biorn et al., 2003).

Nowadays its more common to consider efficiency through defining optimal relations between issues and effects. One of these methods is *Data Envelopment Analysis (DEA)* (Yang et al., 2009). It lets to study efficiency of assumptions depending on sustained issues, its nonparametrical method, based on linear programming. There is a few fundamental advantages of DEA method as a tool of estimating effectiveness of the subject of public sector are:

1) empirical orientation DEA assumes lack of fate component and eliminates necessity of receiving a *prior* functional conclusions between analysed variables and degree of fitting a model. That's why it is a good tool for estimating effectiveness in area of delivering public goods in case in which knowledge about functional topics of dependencies between supply and effects is lacked;
2) DEA allows to practice data presented in lots of units. In case of measuring effectiveness non-market driven had a big meaning because it lets avoid fact of non-existence of market prices of many supplies goods and used supplies;
3) main characteristic of DEA is that certain amount of supplies and effects is being directed to single values of synthetic supply and synthetic effect which are used to count measure of effectiveness of an object;
4) DEA is a method directed to identification of frontier abilities. Different than parametrical methods which are trying to fit area of regression through inside data. DEA is creating frontier based on data , that's why it turns out to be good to discover extremal sizes which are unseen during using different techniques;
5) DEA lets to create models with a lot of supplies and results. It's a method that studies relationship between productivity of a certain object and productivity of effective object; Highlighting certain group (with 100% effectiveness) lets to recommend to units non effective ways of behaviour to improve effects of their work.

Additionally we should remember about limits which like all methods DEA also has

1. DEA delivers results with effectiveness of a certain unit according to studied group and there's no way to move on to absolute measure of effectiveness;
2. it doesn't take to account statistical mistake in its calculations;
3. it characterizes with big sensitivity ty to mistaken data;
4. even small changes about choosing units of studied group can have important impact on final result of study;
5. it needs to have good relationship between number of studied units and number of changes used in a study.

Efficiency in DEA method describes itself as quotient of sums considered issues and effects which we can describe as (Edirisinghe and Zhang, 2007; Nayar and Ozcan, 2008; Cook et al., 2009):

$$E = \frac{\sum_{k=1}^{p} \mu_k \, y_k}{\sum_{i=1}^{m} v_i \, x_i} \qquad (2)$$

where:

y_k - size of assumption;

μ_k – weight of certain assumption;

x_i – size of issue;

v_i – weight of certain assumption.

The oldest DEA model is CCR (*Charnes, Cooper, Rhodes*) its canonical model which is also a base for publications about DEA. Model CCR considers efficiency in Farrells sense. It is assumed there that change of efficiency means proportional changes in issues or proportional changes is results. Idea of estimation of efficiency of the object through CCR model focuses on estimating if in set A of projects, the right one is the one which implements tasks in the most efficient way (Cooper et al., 2000; Ferrier et al., 2006; Jacobs, 2001).
In many researches from setting efficiency and CCR model, graphics is shown as the only method to solve it. This method it can be used when two issues is needed to get the results. In this case graphical picture pf a problem on the R^2 surface should be created (Yu and Lin, 2005; Wen and Li, 2009).

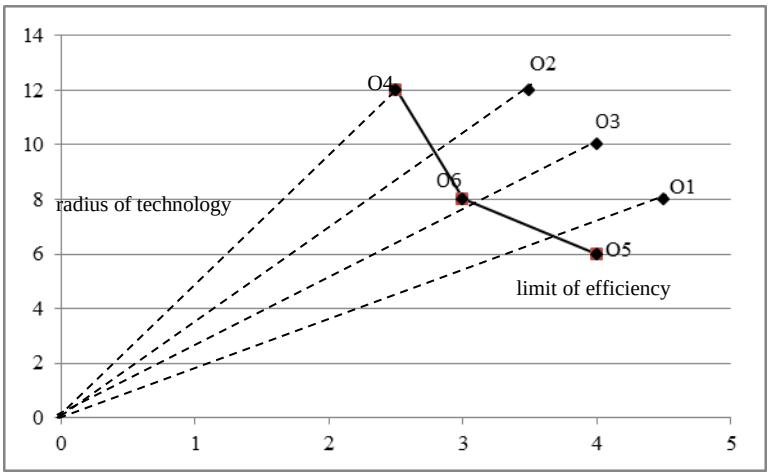

Figure 1. Graphical representation outlays in the analysed points
Source: own study

Broken line in figure 1 is the border of efficiency on which there are all efficient points in Pareto sense (O'Neill et al., 2008). For every object every evidence of vector of empirical issues is not smaller than $x_{nj} \geq GE(x_j)$ for n=1,…, N; j=1,…,J.
Efficiency of object is quotient of distance of interaction point of technological radius j^{th} object and border of efficiency P_j from the beginning of coordinate system and distance of certain object from coordinate system:

$$\frac{d(0,P_j)}{d(0,O_j)} \qquad (3)$$

where distance between 2 points A(x_A, y_A) i B(x_B, y_B) can be counted by using this pattern:

$$d(A,B) = \sqrt{(x_A - x_B)^2 + (y_A - y_B)^2}. \qquad (4)$$

Values that we've got from third equation, which are at least equal 1, are efficient and the ones that are smaller than 1 are inefficient. Resources using efficiency in polish public hospitals can be also tested by the second degree polynomials (Krawczyk-Sołtys, 2013).

3. RESULTS

Studying efficiency of using resources in polish public hospitals has been made for 2007 and 2013. The data used in research are from statistical newsletter from Ministry of Health and from Statistical Yearbook of the polish regions from Central Statistical Office. The information used in research were about number of public hospitals and patients hospitalized, hospital beds in polish public hospital in analysed period.
The biggest amount of public hospitals per 100 thous. residents has been noticed in 2007 in łódzkie voivodship. The average for Poland in 2007 was almost 2,0 hospitals per 100 thous. residents but in 2013 it was 2,5 hospitals. In 2007 in 10 voivodeships there was less hospitals than the average show (podkarpackie, pomorskie, świętokrzyskie, lubelskie, mazowieckie, wielkopolskie, kujawsko-

pomorskie, małopolskie, zachodniopomorskie, opoleskie). In 2013 not much has changed even though the number of hospitals has increased, podkarpackie still was one of voivodships with the smallest amount of public hospitals per 100 thous. residents when łódzkie and śląskie still were on top of the list with the biggest amount of public hospitals per 100 thous. Residents

Table 1. Number of public hospitals and patients hospitalized, hospital beds in polish public hospital in 2007 and 2013

Voivodship		number of patients hospitalized in public hospitals per 100 thous. residents		number of hospital beds in public hospitals per 100 thous. residents		number of public hospitals per 100 thous. residents	
	Code	2007	2013	2007	2013	2007	2013
dolnośląskie	DSL	20012,5	22090,8	385,0	447,4	2,2	2,7
kujawsko-pomorskie	K-P	17177,1	19284,1	352,7	390,9	1,9	2,0
lubelskie	LBL	20099	22523,5	488,5	503,3	1,7	2,6
lubuskie	LBU	17170,8	19702,4	362,9	371,3	2,2	2,3
łódzkie	LDZ	20877,6	25996,2	505,7	505,7	2,4	2,9
małopolskie	MLP	16755	18703,7	394,8	439,6	1,9	2,5
mazowieckie	MAZ	18536,3	23532,9	430,6	480,6	1,7	2,2
opolskie	OPO	16265,3	18924,5	371,5	405,7	2,0	2,6
podkarpackie	PKR	18148,2	21504,5	425,7	475,2	1,5	1,8
podlaskie	PDL	20098,3	22057,2	485,8	464,8	2,3	2,8
pomorskie	POM	15383,1	18480,2	343,4	393,0	1,6	2,3
śląskie	SL	19116,1	21233,6	537,1	532,6	2,3	3,1
świętokrzyskie	SW	19757,8	24058,4	431,9	466,7	1,6	1,9
warmińsko-mazurskie	W-M	18483,8	19682,4	359,5	390,8	2,3	2,8
wielkopolskie	WLP	20837,9	22405,2	431,9	400,6	1,8	1,8
zachodniopomorskie	ZPM	18802,4	20591,5	447,1	470,1	2,0	2,8

Source: own study based on Biuletyn Statystyczny Ministerstwa Zdrowia 2007, 2013; Centrum Systemów Informacyjnych Ochrony Zdrowia, Warszawa, https://www.csioz.gov.pl/statystyka/biuletyn-statystyczny

The biggest increase in number of public hospitals has been noticed in lubelskie – 54%; in order there was pomorskie 47%. Pomorskie and kujawsko-pomorskie voivodeship where places in which in 2007 has been noticed the smallest amount of hospital beds in public hospitals per 100 thous. residents. It was in order: warmińsko-mazurskie 359, lubuskie 362. Analyzing coefficient of variation of number of hospital beds in voivodships we could estimate that differentiation is not big, in 2007 dispersion was 14 % and in 2013 - 11%. The biggest number of patients has been noticed in łódzkie voivodship where the biggest amount of medical staff has been employed. Level of differentiation of number of patient in researched time is equal, a noticed change from 9% level in 2007 to 10% in 2013. Opolskie, pomorskie and wielkopolskie voivodships are the ones that had the smallest amount of patients cured in public hospitals (per 100 thous. residents).

Figures 2 to 5 are graphical presentation of issues considered sources in public hospitals. Broken lines reflect borders of efficiency, based on them and information's in table 1, it was possible to describe efficiency of analyzed system of National Health System through public hospitals. Voivodships that are on the line picture border of the system in which national health system are efficient. This mean that the number of hospital beds and hospitals is enough to provide good medical help for patients in public hospital in Poland. Those voivodships that distance from the beginning of coordinate system is the biggest, we can say that this system of health isn't efficient.

On the border of efficiency there is always pomorskie voivodship, where the number of hospital beds is efficiently used according to number of patients cured in those hospitals.

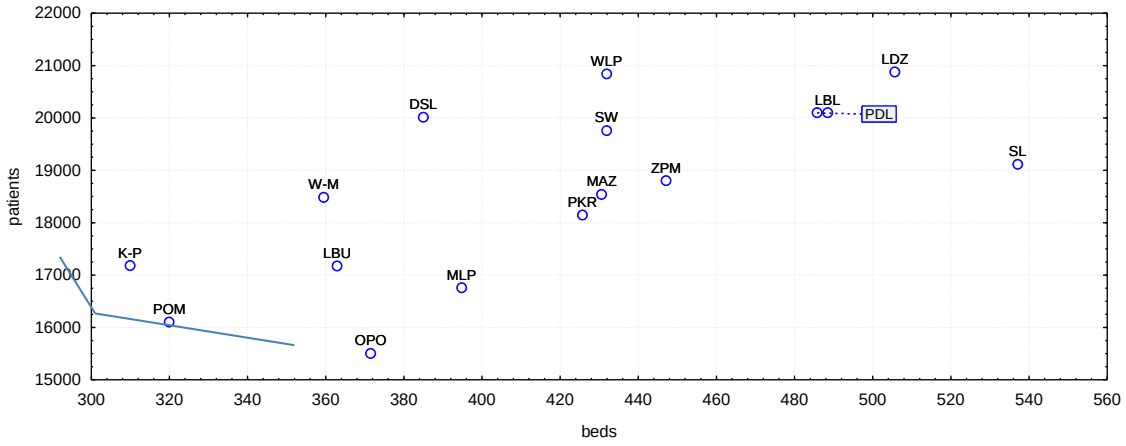

Figure 2. Relation: hospital beds – patients in 2007

Source: own study based on Biuletyn Statystyczny Ministerstwa Zdrowia 2007, 2013; Centrum Systemów Informacyjnych Ochrony Zdrowia, Warszawa

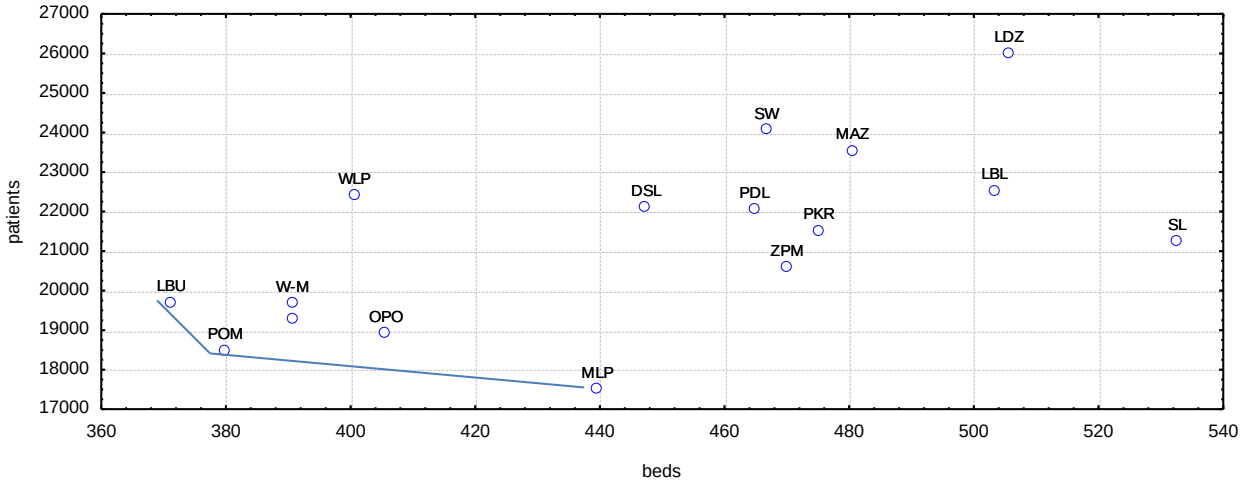

Figure 3. Relation: hospital beds – patients in 2013.

Source: own study based on Biuletyn Statystyczny Ministerstwa Zdrowia 2007, 2013; Centrum Systemów Informacyjnych Ochrony Zdrowia, Warszawa

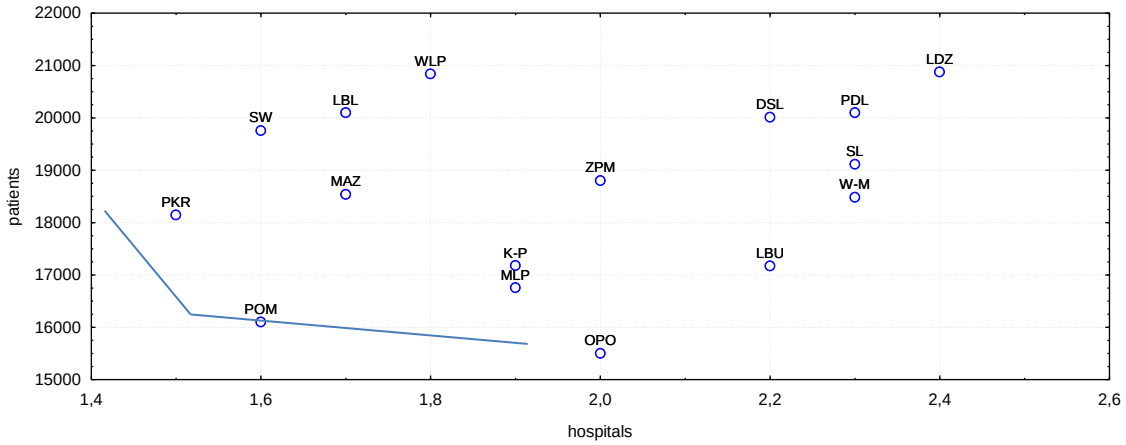

Figure 4. Relation: public hospitals – patients in 2007

Source: own study based on Biuletyn Statystyczny Ministerstwa Zdrowia 2007, 2013; Centrum Systemów Informacyjnych Ochrony Zdrowia, Warszawa

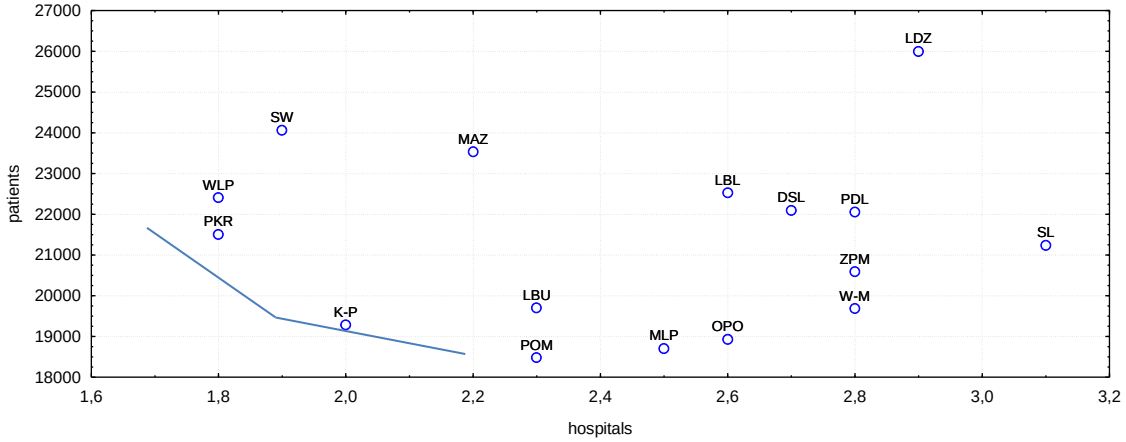

Figure 5 - Relation: public hospitals – patients in 2013
Source: own study based on Biuletyn Statystyczny Ministerstwa Zdrowia 2007, 2013; Centrum Systemów Informacyjnych Ochrony Zdrowia, Warszawa

Using graphical interpretation and equation number 3 to measure efficiency we could say that in 2007 in issue expenditure hospital beds – patient: opolskie, pomorskie and kujawsko-pomorskie were on the border of efficiency, but in 2013 it was lubelskie, pomorskie and wielkopolskie (tab.2).

Table 2. Efficiency of public hospitals in 2007 and 2013

Voivodship	Efficiency of public hospitals based on relation: hospital beds – patients		Efficiency of public hospitals based on relation: public hospitals – patients	
	2007	2013	2007	2013
Dolnośląskie	0,58	0,83	0,78	0,84
Kujawsko-pomorskie	0,75	0,95	0,91	1,00
Lubelskie	0,97	0,83	0,73	0,84
Lubuskie	0,80	0,93	0,96	0,95
Łódzkie	0,92	0,70	0,76	0,73
Małopolskie	1,06	1,00	0,94	0,97
Mazowieckie	0,92	0,78	0,80	0,84
Opolskie	1,00	0,98	1,00	0,95
Podkarpackie	0,96	0,86	0,80	0,94
Podlaskie	0,95	0,84	0,79	0,83
Pomorskie	1,00	1,00	1,00	1,00
Śląskie	2,04	0,89	0,84	0,83
Świętokrzyskie	0,74	0,76	0,73	0,85
Warmińsko-mazurskie	0,64	0,93	0,88	0,91
Wielkopolskie	0,63	0,81	0,70	0,91
Zachodniopomorskie	0,97	0,91	0,82	0,88

Source: own study based on Biuletyn Statystyczny Ministerstwa Zdrowia 2007, 2013; Centrum Systemów Informacyjnych Ochrony Zdrowia, Warszawa

It means that needs of patients had been pleased by certain amount of hospital beds. In ratio of issues number of public hospital – patient in 2007 opolskie, pomorskie and podkarpackie when in 2013 podkarpackie, kujawsko – pomorskie and pomorskie were on border of efficiency, they should be recognized as the ones where resources are effectively used.
Leaders in rankings of efficiency are pomorskie, opolskie, kujawsko-pomorskie which should be recognized as highly efficient. Dolnośląskie and łódzkie can be recognized as the lest efficient, that's mean that the resources aren't fully used.

4. CONCLUSION

One of the issues that links society's wealth with efficiency and rationality is the effectiveness of non-profit organizations, such as public hospitals.
In OECD countries the number of beds per capita is decreasing. The main reason is the progress of medicine, which can be illustrated by the constantly increasing share of the so-called "one-day treatments", shortening the average length of hospital stay, and decreasing hospitalization. This last effect is the indication of increasing efficiency the so-called "basic health care" and prevention. Although the number of hospital beds per 10 thous. residents is also decreasing in Poland, more rationalization of their number and structure seems to be an urgent necessity.
Majority efficiency research has roots in strategic management. Targeted approach indicates the key role of fulfilling the goals of the organization. The differentiated objectives realized individually by each organization significantly makes the comparability of the obtained results difficult. The system approach partially compensates this problem through a simultaneous view at the overall activity effects. However, these approaches will not explain how efficiency measures meet the needs of stakeholders. Only a stakeholder approach gives an answer how to how satisfied them (Connoly et al., 1980; Zammuto, 1984).
In the literature many researches on the efficiency of health care can be found, at the system level as well as the individual health care providers (Alfonso and Aubyn, 2005; Häkkien and Joumard, 2007; Horwitz and Nichols, 2009; Jourmard et al., 2010; Hollingsworth, 2008; Mullen, 2004). This is a recommendation to continue in-depth research in this area.

REFERENCES

Alfonso, A., Aubyn, M. St. (2005). Non-parametric approaches to education and health efficiency in OECE countries. *Journal of Applied Economics, 8(2),* 227-246.

Barney, J. B. (1991). Firm Resources and Sustained Competitive Advantage, *Journal of Management, 1*, 99-120.

Biorn, E., Hagen, T. P., Iversen, T., Magnussen, J. (2003). The Effect of Activity-Based Financing on Hospital Efficiency: A Panel Data Analysis of DEA Efficiency Scores 1992–2000. *Health Care Management Science, 6(4),* 271–283.

Blaik, P. (2010). *Logistyka. Koncepcja zintegrowanego zarządzania*. Warszawa: PWE.

Connoly, T., Conlon, E.J., Deutsh, S.J. (1980). Organizational effectiveness: A multiple constituency approach. *Academy of Management Review, 55,* 211-217.

Cook, W. D., Liang, L., Zha, Y., Zhu, J. (2009). A modified super-efficiency DEA model for infeasibility. *Journal of the Operational Research Society, 60(2),* 276–281.

Cooper, W. W., Seiford, L. M., Tone, K. (2000). The Basic CCR model. In: W. W. Cooper, L. M. Seiford, K. Tone (Eds.): *Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software* (pp. 21 – 39). Boston: Kluwer.

Diez –Ticio, A., Mancebon, M.-J. (2002). The efficiency of the Spanish police service: an application of the multiactivity DEA model. *Applied Economics, 34(3),* 51-62.

Edirisinghe, N. C. P., Zhang, X. (2007). Generalized DEA model of fundamental analysis and its application to portfolio optimization. *Journal of Banking & Finance, 31(11),* 3311–3335.

Ferrier, G. D., Rosko, M. D., Valdmanis, V. G. (2006). Analysis of uncompensated hospital care using a DEA model of output congestion. *Health Care Manage Science, 9*, 181–188.

Golinowska, S. (Ed.) (2012). *Zarys Systemu Ochrony Zdrowia. Polska 2012*, NFZ, Warszawa.

Häkkien, U., Joumard, I. (2007). *Cross-country Analysis of Efficiency in OECD Health Care Sectors. Opinions for Research,* OECD Economics Department Working Papers, no. 554, Paris: OECD Publishing.

Hofmarcher, M. M., Paterson, I., Riedel, M. (2002). Measuring Hospital Efficiency in Austria – A DEA Approach. *Health Care Management Science, 5(1),* 7–14.

Hollingsworth, B. (2008). The measurement of efficiency and productivity of healthcare delivery, *Health Economics, 17(10),* 1107-1128.

Horwitz, J.R., Nichols, A. (2009). Hospital ownership and medical services: Market mix, spillover effects and nonprofit objectives, *Journal of Health Economics, 28(5),* 924-937.

Jacobs, R. (2001). Alternative Methods to Examine Hospital Efficiency: Data Envelopment Analysis and Stochastic Frontier Analysis. *Health Care Management Science, 4(2),* 103–115.

Jourmard, I., André, C., Nicq, C., Chatal, O. (2010). *Health Status Determinants: Lifestyle, Environment, Healthcare Resources and Efficiency,* OECD Economics Department Working Papers, no. 627, Paris: OECD Publishing.

Krawczyk-Sołtys, A. (2013). *Zarządzanie wiedzą w szpitalach publicznych. Identyfikacja poziomu i kierunki doskonalenia,* Studia i Monografie nr 485, Opole: Wydawnictwo Uniwersytetu Opolskiego.

Krawczyk-Sołtys, A., Tłuczak, A. (2017) The human resources using efficiency in polish public hospitals - spatio-temporal analysis; in edit.

Linna, M. (1998). Measuring hospital cost efficiency with panel data models**.** *Health Economics, 7(5),* 415–427.

Lubicz, M. (2010). Efektywność i inne miary konsekwencji działań e sektorze ochrony zdrowia. Międzynarodowe analizy porównawcze (wstępne wyniki badań). In*:* T. Dudycz, G. Oberst-Pociecha (Eds.), *Efektywność – rozważania nad istotą i pomiarem* (pp. 299-335). „Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu", nr 144. Wrocław: Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu.

Matwiejczuk, R. (2000). Efektywność – próba interpretacji. *Przegląd Organizacji, 11*, 27-31.

Mullen, P.M. (2004). Limits to Efficiency: Reflections on Efficiency in Health Care, In: M. Dlouhy (Ed.), *Modelling Efficiency and Quality in Healthcare* (pp. 118-129). Prague: VSE Praha.

Nayar, P., Ozcan, Y.A. (2008). Data Envelopment Analysis Comparison of Hospital Efficiency and Quality. *Journal of Medical Systems, 32(3),* 193–199.

O'Neill, L., Rauner, M., Heidnberger, K., Kraus, M. (2008). A cross-national comparison and taxonomy of DEA-based hospital efficiency studies. *Socio-Economic Planning Sciences, 42(3),* 158–189.

Sherman, D. H. (1984). Hospital Efficiency Measurement and Evaluation: Empirical Test of a New Technique. *Medical Care, 22(10),* 922-938.

Wen, M., Li, H. (2009). Fuzzy data envelopment analysis (DEA): Model and ranking method. *Journal of Computational and Applied Mathematics, 223(2),* 872–878.

Yang, Y., Ma, B., Koike, M. (2000). Efficiency-measuring DEA model for production system with independent subsystems. *Journal of the Operations Research Society of Japan, 43(3),* 343–354.

Yu, M.-M., Lin, E. T. J. (2008). Efficiency and effectiveness in railway performance using a multi-activity network DEA model. *Omega, 36(6),* 1005–1017.

Zammuto, R.F. (1984). A comparison of multiple constituency models of organizational effectiveness. *Academy of Management Review, 9*, 606-616.