

Efficiency of Provincial Healthcare Systems in 2017-2022 Before and During the COVID-19 Pandemic

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Abstract: The article aims to assess the efficiency of provincial healthcare systems in relation to the macroregion in which a given province is located and with regard to the entire country. During the analysed period of 2017-2022, encompassing both the time before and during the COVID-19 pandemic, increases in expenditures on provincial healthcare systems did not result in the expected improvements in health indicators. The healthcare systems of wealthier provinces demonstrated decreased efficiency during the pandemic compared to poorer regions within their respective macroregions and across the entire country. Before the pandemic, the red macroregion performed slightly better than the green and yellow macroregions. During the pandemic, the green macroregion was the most efficient, while in the second year of the pandemic, the red macroregion became the least efficient.

Keywords: efficiency, healthcare systems, Data Envelopment Analysis (DEA), Non-Profit Efficiency (NPE)

1. Introduction

Social healthcare encompasses health systems and social activities that contribute to maintaining and improving the population's health status. According to Lalonde (1981), lifestyle accounts for approximately 50% of an individual's health status, followed by environmental factors and genetic predispositions. The influence of the healthcare system on public health is estimated to be around 10%. In Poland's National Health Programme, these percentages are as follows:

45-50% for lifestyle, 20% for environmental factors, 20% for genetic factors, and 10-15% for the organization and efficiency of the healthcare system.

The most common and deadly diseases include cardiovascular diseases, cancer, and respiratory diseases. Illness, as viewed statistically, is a random event. However, every individual expects swift and effective treatment in case of sickness. Social capital depends on the population's education, skills, and health status. Ensuring social health is the responsibility of the healthcare system, whose primary goal, according to the World Health Organization (WHO) (World Health Report, 2000), is to "promote, restore, or maintain social health."

Health economics evaluates the efficiency of healthcare services in improving the population's health. Alongside effectiveness and efficiency, the equitable distribution of healthcare services is critical to, i.e., minimizing inequalities in health outcomes.

According to Romanow (2002), health is not merely an individual concern but a public good. It serves as both a consumable and capital good, relevant at the household and national levels. Therefore, the state's health policy should actively promote the well-being of its citizens.

Leigh et al. (2009) compared the health status of societies, measured by life expectancy and infant mortality rates, with per capita healthcare expenditures in OECD countries. They found that, with the exception of the United States, an increase in expenditures corresponded to an improvement in the health status of the population in the analysed OECD countries.

Joumard et al. (2010) used the DEA method to analyse the impact of factors such as per capita healthcare expenditures, socio-cultural status indicators, and lifestyle (diet) on societal health. In most OECD countries, the potential gains from increasing the efficiency of the healthcare sector, according to Joumard et al. (2010), could be significant enough to increase the average life expectancy by over two years.

According to Michalak (2013), the issue of healthcare system efficiency is universal, affecting both developing and developed nations. It is not only tied to limited financial resources. Biernacki and Prędko (2020) compared the efficiency of healthcare systems across groups of European countries. Among their findings, they noted that increased healthcare spending does not necessarily translate into proportional improvements in perceived health, as measured by the HLY index. Notably, post-communist countries, including Poland, characterized by the lowest levels of healthcare expenditure from 2012 to 2018, demonstrated the highest HLY growth dynamics.

Biernacki and Prędko (2020) compared the efficiency of healthcare systems in groups of European countries. This work noted that the increase in spending does not necessarily produce a comparable improvement in perceived health, as measured by the HLY index. Post-communist countries, including Poland, characterized by the drastically lowest level of healthcare expenditure, in 2012-2018 showed the highest HLY growth dynamics.

The article aims to analyse the relative efficiency of provincial healthcare systems in Poland, measured using DEA and NPE methods, in relation to macroregions and the entire country. It also evaluates the efficiency of healthcare systems within Poland's macroregions. The analysis focuses on the period 2017-2022, covering both the time before and during the COVID-19 pandemic.

2. Data and Correlation Analysis

The analysis focuses on the optimal performance, specifically the effectiveness and efficiency of provincial healthcare systems before and during the COVID-19 pandemic. The study was conducted at two levels: for Poland as a whole and for macroregions (Fig. 1), each consisting of

several provinces. Poland's division into three macroregions was based on the classification by Krzyśko et al. (2020), derived from the values of 27 diagnostic features characterizing sustainable development over 15 years. The agglomeration method and Ward's method were chosen as commonly used techniques.

All data for the analysis comes from the official websites of the Ministry of Health and the Central Statistical Office. System efficiency was calculated as the ratio of the weighted average of outputs to the weighted average of inputs. The result largely depends on input allocation, technological quality, and the treatment process. The non-parametric DEA method (Charnes et al., 1978; Cooper et al., 2006; Prędkie, 2016) and its modification, NPE (Non-Profit Efficiency) (Guzik, 2009), were applied for the calculations. A fundamental condition for efficiency analysis using DEA and NPE methods is a positive relationship between inputs and outputs.

The unit of analysis is a province or a macroregion comprising several provinces.

Potential input variables for efficiency calculations include:

- N2: per capita healthcare expenditure,
- N3: physicians per 10,000 population (based on primary workplace),
- N4: nurses and midwives per 10,000 population (based on primary workplace, used to calculate variable N3 + N4),
- N6: hospital beds per 10,000 population,
- N7: number of MRI machines,
- N8: number of CT scanners.

Potential output variables include:

- P0: hospital bed utilisation,
- P1: life expectancy,
- P3: average number of healthy years from birth (QALY),
- P5p: inverse infant mortality rate per 1,000 live births.

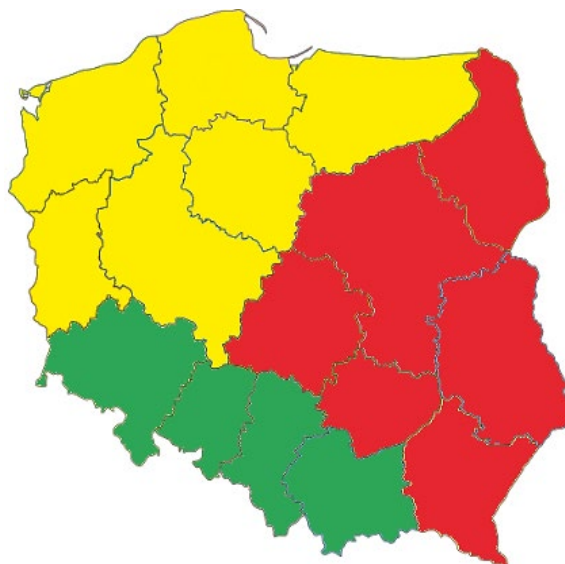


Figure 1. Division of Poland into three macroregions

Source: own elaboration.

Table 1 presents the correlation values between inputs and outputs. The first column shows the correlation results for the period before the COVID-19 pandemic (2017-2019), while the second column covers the pandemic years (2020-2022). When employing the DEA method or its modification,

NPE, which measures relative performance, the results should be positively correlated with inputs. In Table 1, negative correlations are marked in red.

The variables used for analysing the efficiency of healthcare systems in Polish provinces and macroregions are as follows.

- Inputs
 - N2: per capita healthcare expenditures,
 - N3 + N4: total number of doctors, nurses, and midwives employed in their primary workplaces per 10,000 people.
- Outputs
 - P1: life expectancy,
 - P5p: inverse number of infant deaths per 1,000 live births.

The analysis utilises the NPE model, a modification of the DEA method. This model assumes constant economies of scale and product orientation, reflecting public interest in optimal input utilisation. An input-oriented efficiency assessment was also performed.

Table 1. Correlation coefficients between inputs and outputs

2017					2020				
Variable	P0	P1	P3	P5p	Variable	P0	P1	P3	P5p
N2	−0.02881	0.373144	0.44956	0.14233	N2	0.348179	0.125524	0.315392	0.530493
N3 + N4	0.138341	0.06643	−0.22987	0.125027	N3 + N4	−0.34742	−0.05746	−0.64727	−0.34726
N5	0.148811	0.000542	0.074279	0.195729	N5	−0.47372	0.123989	−0.12841	0.412019
N6	−0.18827	−0.44924	−0.61946	−0.1519	N6	−0.37124	−0.46021	−0.7218	0.031604
N7	0.267859	0.055835	0.110693	0.187576	N7	−0.40012	0.103597	−0.17784	0.390582
N8	0.080619	0.036358	0.03767	0.134724	N8	−0.47815	0.051395	−0.24401	0.329739
2018					2021				
Variable	P0	P1	P3	P5p	Variable	P0	P1	P3	P5p
N2	0.034532	0.135408	0.15105	0.001177	N2	−0.00469	0.002723	0.179752	0.048094
N3 + N4	−0.3916	0.161429	−0.30238	0.1793	N3 + N4	0.118349	0.032524	−0.70592	0.014163
N5	−0.46648	0.057494	−0.02468	0.251751	N5	0.09806	0.11519	−0.11836	0.104274
N6	−0.58403	−0.35072	−0.60634	−0.23916	N6	−0.34698	−0.50257	−0.80239	−0.2576
N7	−0.41464	0.068861	−0.03001	0.341271	N7	0.115696	0.043832	−0.15822	0.128184
N8	−0.50536	0.002734	−0.16307	0.240326	N8	0.121699	0.015832	−0.24943	−0.01509
2019					2022				
Variable	P0	P1	P3	P5p	Variable	P0	P1	P3	P5p
N2	0.218834	0.18401	0.242558	0.241148	N2	−0.0621	0.268838	0.165761	0.424682
N3 + N4	−0.35232	0.051096	−0.60835	−0.19339	N3 + N4	0.130327	0.321693	−0.71364	0.018126
N5	−0.48211	0.155878	−0.11489	−0.00211	N5	0.164396	0.056732	0.016582	0.066098
N6	−0.52486	−0.33161	−0.74916	−0.54158	N6	−0.43101	−0.07007	0.311463	0.386197
N7	−0.42982	0.159129	−0.13791	−0.01016	N7	0.128173	0.084035	−0.02779	0.131832
N8	−0.52852	0.102981	−0.23423	−0.17084	N8	0.116688	0.06944	−0.04063	0.062973

Pink color indicates the absence of positive correlation, which is necessary to enter the variable into the model.

Source: own elaboration on the basis of data from the Ministry of Health and the Central Statistical Office.

Key Findings from Table 1

Hospital bed occupancy before the pandemic and during its first year was negatively correlated with expenditures. This result is surprising, especially considering that the waiting time for hospital treatment ranged from several months to over a year (Dubois & Leončikas, 2021). This inefficiency stems from suboptimal management and poor resource allocation. One explanation

could be the presence of under-equipped county hospitals, compelling patients to seek care at better-equipped facilities. Regardless, this indicates inadequate resource distribution.

The second column illustrates the strength of the correlation between healthcare inputs, such as expenditures, and life expectancy, a crucial indicator of population health. Unexpectedly, there was a significantly negative correlation between all outputs and the number of general hospital beds per 10,000 people throughout the analysed years. While advancements in medical technology have significantly reduced inpatient treatment durations, the lengthy wait times and low bed utilisation rates highlight the need for more hospital beds, particularly in specialised facilities.

The minimal or near-zero correlation between healthcare expenditures and QALYs (Quality-Adjusted Life Years), representing the average years of healthy life, probably reflects high medical inflation and stagnant treatment efficiency throughout the study period.

3. Efficiency of Polish Macroregions Before and During the COVID-19 Pandemic

Using the NPE method, the effectiveness of the healthcare systems of Poland's macroregions was calculated in the period 2017-2020, before the pandemic and during the pandemic 2020-2022 (Tab. 2).

Table 2. Macroregional efficiency values measured by NPE from 2017 to 2022

Macroregion \ Year	2017	2018	2019	2020	2021	2022
Red	0,981	0,960	0,965	0,953	0,942	0,743
Green	0,950	0,935	0,943	0,954	0,894	0,973
Yellow	0,910	0,924	0,919	0,885	0,919	0,885

Source: own elaboration using the DEA method based on data from the Ministry of Health and the Central Statistical Office.

Pre-pandemic efficiency: the 'red' macroregion (with Poland's capital as its hub) was slightly more efficient than the 'green' and 'yellow' ones.

Pandemic efficiency: during the pandemic, the 'green' macroregion (encompassing Małopolska, Śląsk, Śląsk Opolski, and Dolny Śląsk) proved the most efficient. By the second year of the pandemic, the 'red' macroregion became the least efficient.

Healthcare funding in Polish provinces primarily comes from health insurance contributions managed by the National Health Fund (NFZ) and the Minister of Health, as well as local government budgets. Biernacki (2014), analysing hospitals in Dolny Śląsk, demonstrated that hospitals with the highest revenues were the most profitable. This raises an important question: is there a correlation between the efficiency of provincial healthcare systems and provincial wealth, as measured by average GDP per capita?

The correlations between input-oriented relative efficiency, as shown in the last column of Tab. 3, and provincial wealth, measured by GDP per capita, are analysed below. Internal correlations pertain to macroregions, while external correlations refer to the entire country. The period 2017-2019 represents the pre-pandemic years, while 2020-2021 corresponds to the COVID-19 pandemic period.

Correlation Analysis

Table 3. Correlations between input-oriented efficiency, voivodeship wealth, and output-oriented efficiency (last column)

Macroregion	Year	DEA external correlation coefficient	DEA internal correlation coefficient
Red	2017	−0.396	0.271
	2018	0.533	0.581
	2019	−0.164	0.403
	2020	−0.104	0.317
	2021	−0.573	−0.688
Green	2017	−0.737	−0.263
	2018	−0.776	−0.388
	2019	−0.639	−0.352
	2020	0.532	0.256
	2021	−0.962	−0.729
Yellow	2017	0.207	0.226
	2018	0.171	0.152
	2019	0.241	0.160
	2020	0.323	0.309
	2021	−0.371	−0.323

Source: own elaboration.

In the 'red' and 'yellow' macroregions, wealthier provinces generally exhibited higher efficiency during the analysed period, except for the final pandemic year. In the 'green' macroregion, wealthier provinces were less efficient, except during the pandemic's first year.

At the national level, Poland's provinces in the 'red' and 'green' macroregions showed a similar pattern: wealthier provinces tended to be more efficient. However, in the 'yellow' macroregion, wealthier provinces consistently maintained more efficient healthcare systems.

Pandemic impact: during the pandemic, wealthier provinces in the 'red' and 'green' macroregions were less efficient than their poorer counterparts. Meanwhile, in the 'yellow' macroregion, wealthier provinces utilized their allocated resources more effectively throughout the entire period, except for the pandemic's second year.

4. Conclusions

From the patient's perspective, the effectiveness of medical treatments is crucial, though it often does not align with efficiency. The analysis of correlations between inputs and outputs revealed that, during the analysed period, increases in expenditures on provincial health systems did not yield the anticipated improvements in health indicators. This is probably connected to lifestyle factors which, as observed, are not necessarily dependent on wealth. However, given limited financial resources, achieving fairness in the distribution of medical services necessitates system efficiency.

The analysis indicates that the health systems of wealthier provinces saw a decline in efficiency during the pandemic compared to poorer regions. It is challenging to determine whether this was caused by changes in treatment system management or by uneven distribution of expenditures.

Before the pandemic, in terms of efficiency, the 'red' macroregion, which includes Poland's capital, performed slightly better than the 'green' and 'yellow' macroregions. During the pandemic, the 'green' macroregion, which includes Małopolska, Silesia, Opole Silesia, and Lower Silesia, was the most efficient, while the 'red' macroregion became significantly inefficient.

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Efektywność wojewódzkich systemów opieki zdrowotnej w latach 2017-2022 przed pandemią COVID-19 i w jej trakcie

Streszczenie: Celem artykułu jest ocena wydajności wojewódzkich systemów ochrony zdrowia w odniesieniu do makroregionu, w którym znajduje się dane województwo, oraz w odniesieniu do całego kraju, a także ocena wydajności systemów ochrony zdrowia makroregionów. W analizowanym okresie 2017-2022, przed pandemią COVID-19 oraz w jej trakcie, wzrost nakładów na wojewódzkie systemy zdrowia nie przyniósł spodziewanych wzrostów wielkości wskaźników zdrowotnych. Po pierwsze, były one niewystarczające, a po drugie, okres pandemii

nie służył poprawie stanu zdrowia, lecz był walką z wirusem, którą przegraliśmy. Polska należała do grupy krajów z największą nadumieralnością w czasie pandemii COVID-19. Systemy zdrowia bogatszych województw w czasie pandemii zmniejszyły swoją wydajność względem województw biedniejszych w odniesieniu do makroregionu i całego kraju. W okresie przed pandemią makroregion czerwony ze stolicą Polski był nieznacznie lepszy od makroregionów odpowiednio zielonego i żółtego. W okresie pandemii najbardziej wydajny był makroregion zielony. W drugim roku pandemii makroregion czerwony był najbardziej nieefektywny.

Słowa kluczowe: wydajność, system ochrony zdrowia, analiza otoczki danych DEA, efektywność instytucji *non-profit*
