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Pre-COVID-19-pandemic differentiation of employment and wages in county hospitals in Poland

Abstract

The difficult current global situation in the aspect of Human Resources for Health was clearly seen during the COVID-19 pandemic. The spending on healthcare is still increasing and the rate of increase outpaces the growth rate of GDP. Only part of these funds is dedicated to the training of new staff and current healthcare employees migrate in search for better job conditions and work-life balance. Personnel migration combined with the demographic structure in the high-income countries simultaneously leads to increasing demand for healthcare services and limits the supply of specialists who can provide such services. The confrontation between the demand for medical personnel and its supply will lead to a reduction in the quality of care and accessibility of services. In the study based on the large group of Polish county hospitals in 2015–2018, differences and similarities between the hospitals in terms of employment, measured in full-time equivalents (FTEs) and in terms of wages were analyzed.

Similarity and dissimilarity analysis was conducted, based on distance measures and cluster analysis. Bigger differences between the hospitals were found for wages than employment levels. The hospitals with an ED and efficient units were less similar to one another than their counterparts in terms of employment (FTEs), except for 2016. When it comes to wages and both types of variables (wages and employment) considered simultaneously, the hospitals with an ED and high number of beds

were characterized by lower similarity to one another than their counterparts during the whole period. Clustering all the 3 approaches (FTEs, wages, FTEs and wages) the results were the same. One of these groups was characterized by a rather low employment level per bed, while the other one – by high.

Keywords: Human Resources for Health, hospitals, employment, wages
JEL Classification: I1, J3

Introduction

The aim of this study is to analyze the situation of Polish county hospitals with respect to employment and its cost to the hospital. We focus on both FTEs (full time equivalents) of hospital personnel (both medical and non-medical) and salary. Both of these factors are to some extent dependent on legal regulations, but hospitals have some degree of freedom to shape them according to their needs and capabilities. We studied similarities between hospitals with respect to employment and salary considering their characteristics such as size, form of ownership etc., and environment characteristics (the county in which a hospital is located).

The paper has the following structure. In the introduction we discuss the problem of Human Resources for Health (HRH) in high-income countries. Then, we present the problem from the perspective of Poland, a country with relatively low HRH and an access to the EU labour market, which provides a strong incentive for domestic professionals to emigrate. In the next part, the structure of the study is presented. Then the presentation and discussion of the results are provided. Finally, the key results are summarized, and some possibilities of further studies are shown.

HRH challenges in different countries

HRH challenges from the high-income countries' perspective

In all high-income countries, the clinical effectiveness of treatment and the economic efficiency (including financial one) of healthcare depend on the human, physical, and financial capital employed by healthcare providers and payers [WHO, 2016]. Scientific and technical progress as well as financial opportunities to use this progress are determined by the availability of well-educated health workers [WHO, 2016]. Health workers are the most important factor in improving the health of society in the coming decades. That is why it is so important to invest in them as well as in the conditions of the treatment process. The supply of properly educated health workers is a guarantee of meeting the health needs of the population, especially in the face of an ageing population. Conducting the right policy for the needs of HRH

enables achieving the highest possible health status of individuals and society. The scheme of political influence on the quality and number of medical staff can be presented as follows. The fulfillment of social and economic needs depends on higher education of both medical and non-medical workers. In order to educate an appropriate number of highly qualified HRH and non-medical employees, political decision-makers should ensure the conditions for effective education of the healthcare sector employees, including teaching staff competences, the right number of admitted students and their continuous selection. Certainly, the number of staff working in healthcare is also affected by migration. On the other hand, the dynamics of the labour market functioning for the needs of healthcare is affected by the number of the employed, the unemployed and people leaving the labour force. Thus, the healthcare sector is affected not only by the number of employees in it, but also those employed in other sectors. The quality of health services is affected by the availability of modern medical equipment, which reflects the strength of budget constraints in healthcare, both in the public and private sectors. Health workforce flows are influenced by government policies aimed at emigration and immigration processes, encouraging the unemployed and people outside the workforce to return to work in healthcare. Obviously, government policy should also be directed against the misallocation of all healthcare resources and the inefficiency of their employment. This policy should shape both the public and private parts of healthcare, always with the public's health in mind. In addition, it is worth emphasizing the importance of a strong human resource management system in the process of providing health services.

HRH issues are analyzed in numerous articles. Ferreira, Nunes, and Marques [2018] in their study of Portuguese hospitals from the perspective of scale efficiency showed the excess of full-time equivalents of both doctors and nurses.

In Bloom, Alexander, and Nuchols [1997], the role of registered nurses staffing in achieving efficiency is being stressed. The most important reason is the fact that they are charged with caring to patients and simultaneously represent a significant portion of a hospital's operating budget. Still, better qualified personnel may also contribute to the cost reduction by providing better care. Therefore, in Thungjaroenkul, Cummings, and Embleton [2007], it is concluded that hospital managers should increase the ratio of registered nurses to non-licensed personnel not only to improve the patient outcomes but also to contain costs. Staff qualifications are of great importance, since, as Quentin et al. [2018] point out, specialists employed in hospitals decide how funds for hospitals (which account for 30%–40% of total healthcare expenditure in high income countries) are being spent.

Cheng et al. [2015] reported a positive relationship between the ratio of beds to nurses and efficiency, while Ali, Debela, and Bamud [2017] reported a negative relationship between the doctor-to-total-staff ratio and inefficiency. In Sielska [2021] the relationships of the nurses-to-beds ratio, doctors-to-beds ratio, and doctors-to-total-staff ratios to inefficiency were inconclusive, while the nurses-to-total-staff ratio was negatively related to inefficiency.

There are a lot of studies discussing the role of adequate staffing in patient safety or satisfaction [Al-Dabbagh, Sulaiman, Abdulkarim, 2022; Harvey, Trudgill, 2021; Huhtala

et al. 2021; National Institute for Health Research, 2019; Timothy, 2020]. The employment structure in a hospital may influence efficiency as shown by Epane and Weech-Maldonado [2015]. In the cited paper it was shown that hospitalists (i.e. hospital-based doctors specialized in the practice of hospital medicine) reduce patients' length of stay, but it also leads to higher costs so it should be advised only in hospitals which can afford such costs. While discussing efficiency and staffing relations, an important problem should be mentioned as well. In the staffing challenge (in particular, and in general in the healthcare financing) is that the demand is difficult to forecast. Bloom, Alexander, and Nuchols [1997] point out the significance of the ability to adapt to uncertainty.

It is pointed out that work organization is crucial as well, not only from the perspective of efficiency [National Institute for Health Research, 2019], but also in order to improve working conditions, work-life balance, cooperation and to avoid burnout (which, in turn, may also reduce the probability of medical errors and improve efficiency) [Aiken, Clarke, Sloane, 2002; Everhart, Neff, Al-Amin, Nogle, Weech-Maldonado 2013; Llop-Gironés et al. 2021; Vatn, Dahl, 2022; West, Coia, 2019; Wiskow, Albreht, de Pietro, 2010]. In Everhart et al. [2013], it is pointed out that a hospital may gain a competitive advantage thanks to nurse staffing and the working environment may play an important role in hospitals' financial performance.

However, it is obvious that the relationship between the employment structure and hospital performance is two-way. An unfavourable financial situation may force hospitals to reduce payroll costs by changing their staffing strategy [Zhao et al., 2008]. In the cited paper the authors showed that there is a relation between the change in hospitals' financial performance and hospital licensed practical nurse staffing intensity. On the other hand, a mixed impact of financial change on total full time equivalent staffing was found. Everhart et al. [2013] report that the impact of nurse staffing on hospital financial performance differs depending on the market structure.

Another subject taken up in the literature is how staffing regulations are constructed. It is argued that staffing models consider different needs that may arise in different geographical areas within a country [Al-Dabbagh et al., 2022]. Also, Ferreira et al. [2018] mention the excess of staff located in urban areas. Workload indicators of staffing needs are crucial and software allowing hospitals to use such tools would be of great help in addressing imbalances and shortages [Al-Dabbagh et al., 2022]. Models need to be flexible when it comes to the dynamic environment within a hospital (different wards, emergency department, etc.). Even though emergency departments usually have dedicated staff, specialists from other wards may be called in e.g. for a consultation. For example, in Ben-Gal, Wangenheim, and Shtub [2010], a new model is proposed, which takes into account changes in patient occupancy rates and in activities in areas outside the analyzed department. The levels of staffing ratios should be carefully decided to avoid negative consequences, not only for the quality of care, but also for the supply of new personnel. Too high ratios may lead to longer waiting times or greater dependence on temporary personnel. They may also have negative consequences on the hospital financial situation [Mackenzie, 2023], since costs related to the employment of healthcare personnel contributes to the substantial share of costs [Everhart et al., 2013].

HRH issues from the perspective of Poland

The data of Statistics Poland [GUS] shows that in 2020 the number of doctors working directly with the patient amounted to 126,064 people, dentists – 33,772, nurses – 210,923 and midwives – 27,629. Moreover, the number of doctors with the right to practice increased by 1.6 thousand. and dentists by 0.4 thousand in 2020 as compared to 2019. The number of nurses working directly with patients decreased by 3.2 thousand and midwives by 0.1 thousand in 2020 as compared to 2019. The density of doctors is measured as a number of physicians working directly with patients by voivodeships per 10,000 inhabitants in each of the 16 voivodeships. At the end of 2020, in two central voivodeships (including the voivodship in which the capital is located) this number was in the range of 38.1–41.9. In four voivodeships the number ranged from 34.1 to 38.0. It is worth mentioning that two of the second largest group of physicians per 10,000 inhabitants belong to the eastern part of the country, which is characterized by the lowest level of economic development. The third largest group of physicians is made up of three voivodships, and the number ranges from 30.2 to 34.1. The fourth, penultimate group also includes three voivodeships, and the number of people is in the range of 26.2–30.1. The last, fifth group consists of 4 voivodships located throughout the country and the number of physicians is in the range of 22.2–26.1 doctors per 10,000 inhabitants. It is difficult to determine the reasons for this density distribution. In the case of the density of nurses measured by their number per 10,000 inhabitants in individual voivodeships at the end of 2020, the situation is as follows. The highest density was recorded in three voivodeships in the south-eastern part of the country, which is characterized by a lower level of economic development. The number of nurses ranges from 60.0 to 65.7. The second group of voivodeships in terms of the density of nurses are also three voivodships located across the country, and the number is in the range of 55.8–59.9. Three voivodships also belong to the third group, and the number of nurses ranges from 53.2 to 55.7. The penultimate group is once again made up of three voivodeships, and the density is in the range of 47.9–53.1. The last, fifth group includes four voivodeships, and the number of nurses is in the range of 45.0–47.8. As in the case of doctors, it is also difficult to determine the reasons for such distribution of density between individual voivodships.

Statistics Poland provided data on human resources in healthcare, and so in 2021 the number of people with the right to practise in the basic groups of medical professions increased: doctors, dentists, nurses, midwives, pharmacists, and laboratory diagnosticians. The largest increase was observed in the group of laboratory diagnosticians (an increase of 3.3 per cent) and physicians (an increase of 2.7 per cent) [Konarska, 2023].

Based on Golinowska, Sowada, Tambor, Domagała, and Kuszewski [2018], it can be concluded that the increases in HRH employment presented above are not a solution to Polish healthcare. This is because the condition of medical staff resources is unfavourable, both in terms of quantity (the lowest employment rate of physicians among OECD countries in the European region) and demographic (ageing of this professional group), which in the coming

years may cause further intensification of the problem with the access to health services. The employment situation of nurses is even worse, as their employment rate per 1,000 inhabitants is 5.2 and is one of the lowest in the EU with the OECD average of 9.0. Moreover, the largest group of professionally active nurses are people aged 46–55, which constitutes 33.5% of the total. The average age of a working nurse is 51. This situation poses a threat to the continuity of patient care. The basic way to secure properly trained and motivated medical staff is to guarantee proper remuneration. However, the analysis of the implemented payroll policy reveals that decisions made in this regard are ad hoc, as they are a reaction to waves of strikes.

In Poland the problem of the HRH shortage has been known for years. The situation is serious since the employment rates of doctors and nurses per 1,000 inhabitants are the lowest in the EU [Domagała, Klich, 2018; Domagała, 2020]. On the other hand, according to the NIK (i.e. the Supreme Audit Office) report published in 2019, beds in Polish hospitals were underutilized [NIK, 2019]. Already in 2013 Golinowska, Kocot, and Sowa [2013] referred to the shrinking resources as a phenomenon that had been noticed for more than ten years. They pointed out to the limited knowledge and a lack of proper studies. Domagała and Klich [2018] identify the basic challenges in physician workforce planning. Among them they list the lack of adequate planning.

Golinowska, Kocot, and Sowa [2013] discuss limitations in the development of resources and imbalance between the demand and supply. Supply is easier to modify than demand, for example by creating new medical professions, introducing proper job regulations and incentives for young school graduates to start study medicine (offering higher salaries and prestige). Such measures may be used to influence the demographic and economic determinants of the HRH supply. Their importance is shown in other studies. For example, Jośko et al. [2011] conducted a study on over 1,500 students at medical universities, the results of which showed that 41% of the individuals asked planned to emigrate due to the level of earnings, difficulties in accessing specializations, and low prestige of the job. Gąsiorowski, Rudowicz, and Safranow [2015] conducted a study of the same cohort of students twice, which showed that during the studies the approach of students changed. Employment preferences changed from private to public units, or to a combination of public and private. Similarly, most students asked showed a preference for working in a hospital. R. Stryjski and A. Stryjski [2016] discuss the system of organizing medical studies with regard to the dynamics of HRH (staff changes and changes in the number of people with the right to practice). It is worth noting, however, that the attempts to increase the number of students have effects in the long term [Domagała, 2020]. The NIK report [NIK, 2016] also focuses on the supply determinants. It is pointed out that the education and distribution of HRH are inadequate to the needs. It is also shown that the share of expenditure on education in the total expenditure is low, and there is a downward trend observed in the period of 2005–2012. There is also a problem with the degree of occupancy of allocated places for residents.

Similarly, in the study by Domagała [2020], the attention is drawn to the mismatch between the structure of employment and the profile of the healthcare unit and range of

services provided. The Manpower Life Science report [Kopacz, 2019] analyzed staff shortages in hospitals and the personnel they are looking for, concluding that some hospitals may have to give up some of the supplied services due to the missing personnel.

On the other hand, the demand depends on the health needs of the society and expectations regarding quality. Among the other factors that contribute to the problem as listed by the cited authors are the direction of reforms or ignoring the problem of scarcity. The demographic profile of HRH may be changed to some degree by incentives for new candidates. They draw attention to two waves of emigration of healthcare professionals. The first one took place in the 90s after the fall of communism in Poland and after the introduction of the free market structure. The reform of the healthcare system took place in that period as well. The second wave took place after Poland entered the EU in 2004. The European market became available for HRH from Poland and offered higher salaries. In the second half of the period of 2000–2013, an attempt was made to rebuild the resources [Golinowska et al., 2013].

Skinder and Jachimowicz-Gaweł [2015] refer to the problem from the perspective of management sciences. They refer to the fact that the units need to adjust to the changes in the environment. They discuss the reasons for failures, such as reactions of managers and employers or resistance to the decisions being implemented.

Quality of the working environment does not seem high due to the frequent changes of regulations regarding healthcare. Apart from the changes forced by the dynamics of the internal structure, all hospitals need to adjust to law changes. It is important to note frequent protests of the HRH personnel, among which the nurse protest referred to as 'white town' (it took place in 2007), the stamp protest (in 2012), the strike of family doctors (in 2015) related to the oncology package and the method of financing POZ (i.e. the basic healthcare units), nurses' protest in 2015, the protest of various medical personnel in 2016, the protest of resident doctors and paramedics in 2017.

The problems described in the study of Golinowska et al. [2013] are still valid today, 10 years after the publication of the paper, which proves the seriousness of the problem.

Methodological approach

In the study we use the data from the Polish Association of Employers of Poviat Hospitals (Ogólnopolski Zwiazek Pracodawców Szpitali Powiatowych – abbr. OZPSP; in this paper instead of the name 'powiat', the English word 'county' is used) for the years 2015–2019.

We analyzed the similarity between various hospitals regarding the employment structure defined in two ways. In the first approach, the employment structure was defined as FTEs of such groups of employers as doctors, resident doctors, trainee doctors, nurses, paramedics, physiotherapists, laboratory diagnosticians, pharmacists, X-ray technicians, pharmacy technicians, medical analytics technicians, other non-medical staff engaged in the core activity, other medical staff, service employees, administrative employees. A detailed statistical analysis

of the distributions of variables related to the employment is available is our previous report [Nojszewska, Sielska, Gołąb-Bełtowicz, 2020].

In the second approach, the employment structure was defined as the payroll of a given group of personnel divided by their FTE. In both cases we used at first absolute values for FTEs and then FTEs per 1 hospital bed to consider the size of the hospital.

The study was conducted in 9 following steps:

1. Select variables.
2. Copy information on the levels in the network for the years 2015 and 2016.
3. Merging hospitals' data with several county characteristics: the average monthly gross salary, average monthly gross salary as the percentage of the national average, registered unemployment rate, population density, share of the population 70 years old or older, physicians (total working staff) per 10,000 population, nurses and midwives per 10,000 of the population, total medical advice in outpatient healthcare (por), total population (og), the HHI index calculated for a voivodship based on the number of hospital beds, hospital beds in a county, hospital beds in a county as a share of hospital beds in a voivodship.
4. Hospitals which reported data only on FTEs but not on payroll were excluded, as were the hospitals with missing data.
5. Efficiency score calculation and inclusion in the dataset.
6. Excluding hospitals with the missing efficiency score.
7. Variable normalization.
8. Similarity and dissimilarity analysis based on distance measures.
9. Cluster analysis.

The average monthly salary in the area affects employment in an obvious way. Moreover, it translates into higher income of local population, which in turn may result in better possibilities of taking care of one's health, e.g. by using paid prophylactic tests, not having to resign from buying prescribed medicines, etc. Demography-related variables affect the demand side for hospital services, while hospital- and healthcare-related characteristics refer to the competition between healthcare units, which may influence both labour supply available for them to hire and expectations regarding wages.

For efficiency score calculation, a superefficiency DEA model was chosen, which was also used in Sielska [2021]. The following inputs were included: number of beds, doctors, and nurses. The output variable was the number of patient-days total. The variables were normalized to 0–1 interval with a formula:

$$x_i = \frac{x_i^* - min(x_i^*)}{max(x_i^*) - min(x_i^*)}$$

where x_i^* denotes the original value of i-th variable (before normalization) and x_i denotes normalized values.

Differences in medians were tested using a Kruskall-Wallis test.

Basic descriptive statistics of the dataset resulting from step 6 are presented in Table 1.

Table 1. Basic descriptive statistics for the analyzed hospitals

	2015			2016			2017			2018		
	min	median	max	min	median	max	min	median	max	min	median	max
Doctors	15.24	104.96	2234.62	55.26	110.1	2357.38	34.83	85.99	2379.83	33.72	83.25	2325.48
Resident doctors	1	11.86	396	1.9	14	288	1	10.75	348	1	11.5	408
Trainee doctors	0.25	3.91	87.96	0.5	4	93.96	0.4	5.08	104.04	0.26	3	92.04
Nurses	175.9	320.9	6360.5	172.6	325.2	6492	139.2	295.1	6237.9	136.4	287.9	6320.4
Paramedics	3	38.23	1240.08	5	44.37	1364.52	0.09	37.69	1412.62	0.91	38.52	1334.57
Physiotherapists	2	19.04	360	2	20	366	2	17	342	2	18.64	378
Laboratory diagnosticians	2	12	192	2	12	204	2	9.75	204	2	11.29	250.512
Pharmacists	0.35	2	24	1	2	24	0.5	2	24	0.5	2	24
X-ray technicians	6.2	13.12	282.6	5	13.25	282.84	5	12.42	282.89	5	11.5	281.232
Pharmacy technicians	1	3.05	60	1	4	60	1	3	60	0.5	3	72
Medical analytics technicians	1	18.88	347.64	1	18.33	332.4	1	15.5	321.58	1	13.86	277.14
Other non-medical staff engaged in the core activity	25.01	54.44	1812	24.63	50.28	1908	24	52	1968	6	54.9	2197.56
Other medical staff	3	17.69	142.32	3	21.38	75	2.95	18.57	164.35	3.317	18.5	154.51
Service employees	13.82	64.98	1812	15.75	57.25	1362	12.08	63.13	1398	13.57	59.45	1374
Administrative employees	25.75	50.59	1104	29.33	53.75	1056	17.04	51.46	1044	14	49.34	1089.04
Doctors (wages)	10.73	111.54	193.26	10.07	117.65	206.39	11.73	125.68	330.26	1.75	160.43	406.27
Resident doctors (wages)	3.72	42.47	126.06	3.20	44.63	137.49	3.47	59.96	144.84	2.92	75.58	202.72
Trainee doctors (wages)	2.21	32.29	103.62	0.66	32.09	57.57	2.97	32.60	57.58	3.53	42.30	193.38
Nurses (wages)	3.13	40.72	58.26	3.74	48.68	62.21	3.90	49.96	67.16	4.19	58.98	73.62
Paramedics (wages)	2.38	34.44	58.54	2.80	34.60	59.43	3.18	37.16	112.04	2.78	54.32	128.10
Physiotherapists (wages)	0.72	8.39	108.76	0.71	8.79	104.49	0.76	7.85	111.85	0.73	8.53	115.25
Pharmacists (wages)	6.45	64.61	118.53	8.18	75.91	119.51	5.32	82.13	347.47	6.20	81.18	396.10
Medical analytics technicians (wages)	2.83	34.16	390.22	0.03	0.05	1.06	2.94	42.59	388.18	0.01	0.05	1.09
X-ray technicians (wages)	2.77	43.41	61.48	2.65	45.73	60.22	2.53	44.88	64.78	2.41	49.18	72.82
Laboratory diagnosticians (wages)	3.61	56.58	94.28	4.20	55.26	92.27	3.66	64.72	100.79	3.32	67.69	108.03
Pharmacy technicians (wages)	1.35	29.95	47.09	1.85	34.31	54.57	2.04	34.93	54.90	2.19	39.19	109.34
Other staff engaged in the core activity (wages)	1.38	28.22	91.73	1.65	31.45	99.23	1.67	29.22	105.68	0.03	31.20	110.16
Other medical staff (wages)	2.14	36.36	81.29	3.49	40.94	92.67	3.86	39.51	443.63	3.09	44.25	600.68
Service employees (wages)	0.15	26.60	58.92	2.28	29.93	65.06	2.04	29.23	71.37	1.92	31.13	74.20
Administrative employees (wages)	3.69	41.82	80.96	4.07	48.65	79.82	4.10	48.63	83.35	4.09	53.25	85.16

Source: own calculations based on the OZPSP data.

In step 8, we calculated distances between all the hospitals and groups of hospitals defined based on binary variables (i.e. hospitals with and without ICU, ED, public and nonpublic hospitals, etc.)

The list of the variables is the following:

- ED (1 – hospital has an ED in the structure, 0 – other hospitals);
- ICU (1 – hospital has an ICU in the structure, 0 – other hospitals);
- Non-public (1 – non-public hospital, 0 – public hospital);
- Profit-achieving (1 – profit-achieving hospital, 0 – loss-suffering hospital);
- Laboratory (1 – hospital employing laboratory diagnosticians, 0 – other hospitals);
- Big (1 – hospital with at least 364 beds, 0 – other hospitals);
- Small (1 – hospital with less than 134 beds, 0 – other hospitals);
- Medium-sized (1 – hospital with 134–362 beds, 0 – other hospitals);
- Category 1 in the network (1 – hospital with category 1 in the network, 0 – other hospitals);
- Category 2 in the network (1 – hospital with category 2 in the network, 0 – other hospitals);
- Efficient (1 – hospital efficient according to the DEA model, 0 – other hospitals)

Due to the high share of employment-related costs in the hospitals' total cost, the employment structure may affect the overall financial performance of the medical unit. Therefore, we analyzed employment with respect to the form of ownership, efficiency, and ability to achieve profit. As shown in Sielska [2021], it is theorized in the literature that public hospitals may face a so-called soft budget constraint [Kornai, 1986], which allows them to operate at suboptimal cost levels. That, in turn, may affect the profit and efficiency. The second group of criteria which may affect the employment structure and wages consists of binary variables which define the size of a hospital (measured by the number of beds). We also include ED, ICU, and a laboratory within the hospital structure as potential determinants due to their specific staff demands. The last category is connected to the hospitals' level in the network (a system of basic hospital service provision [Dubas-Jakóbczyk, Kowalska-Bobko, Sowada, 2019]), introduced in 2017. In general, hospitals' level in the network may be used as case-mix proxy.

The distribution of binary variables is presented in Table 2. All the hospitals in the sample have an ICU in their structure, all have diagnostics, and none is categorized as small. Therefore, we will not be referring to these potential determinants in the further analysis. The majority run an ED and are medium-sized. In 2015–2017 a majority were able to achieve profit, however, no more than 40% were efficient.

The cluster analysis in step 9 was conducted using k-means method. Strongly correlated variables, i.e. with the absolute value of correlation coefficient greater than 0.9, were not considered as the basis for the clustering. The number of clusters was decided based on the values of gap statistics [Tibshirani, Walther, Hastie, 2001] and silhouette index [Rousseeuw, 1987]. When two indicators suggested different numbers of clusters, the lower number was chosen. Firstly, the hospitals were clustered based on the FTEs, secondly, based on the remuneration, and in the last case, based on both categories of variables. Similarity of clusters was studied based on the values of the Rand index [Rand, 1971].

Table 2. Shares of the hospitals for which binary variables are equal to 1 (%)

Variable	2015	2016	2017	2018
ICU	100	100	100	100
ED	80	88	76	75
Laboratory	100	100	100	100
Non-public	5	6	8	14
Profit-achieving	60	59	60	46
Big	35	41	36	36
Small	0	0	0	0
Medium-sized	65	59	64	64
Category 1 in the network	55	47	64	64
Category 2 in the network	35	41	28	29
Efficient	40	35	32	36

Source: own calculations based on the OZPSP data.

The significance of differences between the median values of chosen variables between the clusters were again tested using a Kruskall-Wallis (KW) test and, for the binary variables, a Chi2 test of independence was used to analyze the dependence of a given characteristics from a cluster.

Calculations were done using the R software [R Core Team, 2020] with packages: fossil [Vavrek, 2011], deaR [Coll-Serano, Bolos, Suarez, 2020], Nbclust [Charrad, Ghazzali, Boiteau, Niknafs, 2014], factoextra [Kassambara, Mundt, 2020] and MS Excel.

Results

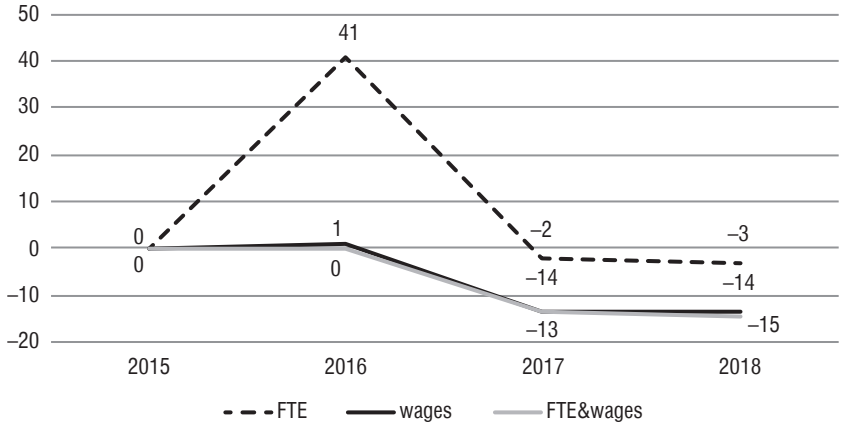
Similarities and dissimilarities between different groups of hospitals for absolute values of FTEs

Based on the Euclidean distances between the hospitals calculated in step 8 several conclusions can be reached.

The results show that median distances based on the employment only increased by 41% in 2016 (absolute values of FTEs), then slightly decreased (Figure 1). It is impossible to reach conclusions about the convergence based on the 2 years only. However, there is a convergence seen when it comes to wages. The distances between the hospitals are becoming smaller in the analyzed period. A similar tendency (increasing similarity between the hospitals) can be noticed for wages and FTEs analyzed together.

Using the KW test, we analyzed whether there were significant differences in distances between the groups created using binary variables (Tables 3–5). The results vary from year to year, but several conclusions can be reached.

Figure 1. Percentage changes in median distances as compared to 2015 (%)



Source: own calculations based on the OZPSP data.

Table 3. Median distances (based on FTEs) between hospitals from the groups constructed based on binary variables, KW test statistics and p-values

	2015		2016		2017		2018	
	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)
ED	0.1312 (0.2562)	19.64 (0)	0.2646 (0.3499)	0.3912 (0.5317)	0.1256 (0.2577)	41.137 (0)	0.1113 (0.2771)	67.78 (0)
Category 1 in the network	0.2896 (0.1874)	1.3248 (0.2497)	0.5061 (0.283)	3.125 (0.0771)	0.2046 (0.1854)	0.307 (0.5795)	0.198 (0.2256)	3.4698 (0.0625)
Profit-achieving	0.1412 (0.2764)	13.899 (0.0002)	0.2275 (0.4584)	3.198 (0.0737)	0.2271 (0.2022)	1.0514 (0.3052)	0.1735 (0.2746)	11.756 (0.0006)
Big	0.2043 (0.2316)	2.1207 (0.1453)	0.3544 (0.2839)	3.706 (0.0542)	0.1962 (0.1685)	6.5639 (0.0104)	0.2438 (0.1619)	13.003 (0.0003)
Medium-sized	0.2316 (0.2043)	2.1207 (0.1453)	0.2839 (0.3544)	3.706 (0.0542)	0.1685 (0.1962)	6.5639 (0.0104)	0.1619 (0.2438)	13.003 (0.0003)
Efficient	0.184 (0.2622)	14.517 (0.0001)	0.294 (0.3179)	0.2477 (0.6187)	0.1962 (0.2207)	7.6555 (0.0057)	0.1644 (0.2247)	20.731 (0)
Category 2 in the network	0.1908 (0.1969)	2.4128 (0.1203)	0.283 (0.3179)	0.6265 (0.4286)	0.1821 (0.1806)	5.0509 (0.0246)	0.2447 (0.1756)	10.973 (0.0009)
Non-public*					0.0718 (0.2129)	5.7776 (0.0162)	0.0981 (0.2307)	24.354(0)

* In 2015 and 2016 all but 1 out of the analyzed hospitals belonged to the group of public hospitals, which made it impossible to conduct the analysis.

Source: own calculations based on the OZPSP data.

Firstly, when the employment (FTE) is analyzed (Table 3), in 2015 there are significant differences between the hospitals chosen based on having an ED in their structure, achieving

profit and being efficient. The hospitals with an ED were significantly less similar to one another. The same statement can be made about the hospitals making profit and being efficient. These units are more dissimilar than the hospitals without an ED, suffering losses and being inefficient. It leads to the conclusion that there is more than one way of reaching a successful and beneficial situation and such a situation can be reached with different employment structures. Other differences were found to be insignificant in the KW test. In 2016, none determinants were significant. On the other hand, in 2017 most determinants turned out to be significant. There are significant differences between the hospitals chosen based on having an ED in their structure, having a high or medium number of beds, belonging to the 2nd category, being efficient, and being public units. Again, the hospitals with an ED were significantly less similar to one another. The same statement can be made about the hospitals which were commercial companies, having a medium number of beds, and being efficient. Finally, in 2018 all the analysed determinants turned out to be significant. Big hospitals and hospitals classified to the 2nd category in the network were more similar to one another than their counterparts, the hospitals belonging to other groups – less similar.

Table 4. Median distances (based on wages) between the hospitals from the groups constructed based on binary variables, KW test statistics and p-values

	2015		2016		2017		2018	
	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)
ED	0.8622 (1.5925)	16.47 (0)	0.6341 (1.4951)	4.4435 (0.035)	0.5759 (1.3254)	56.532 (0)	0.5458 (1.3367)	78.127 (0)
Category 1 in the network	1.5584 (1.2082)	8.5474 (0.0035)	1.5912 (1.2231)	6.7288 (0.0095)	1.2811 (1.0984)	5.3719 (0.0205)	1.302 (1.0613)	4.7394 (0.0295)
Profit-achieving	1.4014 (1.4764)	0.0859 (0.7695)	1.4565 (1.2885)	0.117 (0.7323)	1.3336 (1.1079)	14.458 (0.0001)	1.242 (1.1134)	2.517 (0.1126)
Big	0.925 (1.6606)	19.727 (0)	0.7876 (1.6931)	19.252 (0)	0.9033 (1.3271)	27.554 (0)	0.9241 (1.3407)	21.657 (0)
Medium-sized	1.6606 (0.925)	19.727 (0)	1.6931 (0.7876)	19.252 (0)	1.3271 (0.9033)	27.554 (0)	1.3407 (0.9241)	21.657 (0)
Efficient	1.3956 (1.3834)	0.0111 (0.916)	1.4165 (1.279)	1.3174 (0.2511)	0.7946 (1.2933)	21.265 (0)	0.7486 (1.3282)	40.868 (0)
Category 2 in the network	1.1666 (1.5081)	4.6137 (0.0317)	1.0954 (1.5501)	4.4142 (0.0356)	1.0482 (1.2354)	2.1768 (0.1401)	0.8926 (1.2644)	6.9936 (0.0082)
Non-public*					0.6198 (1.2249)	3.2586 (0.0711)	0.6176 (1.245)	12.57 (0.0004)

* In 2015 and 2016 all but 1 out of the analyzed hospitals belonged to the group of public hospitals, which made it impossible to conduct the analysis.

Source: own calculations based on the OZPSP data.

Table 4 presents the results of wages similarity. In 2015, all the determinants were found out to be significant except for achieving profit. The hospitals with an ED, a high number of beds, belonging to the 2nd category and the efficient hospitals were more dissimilar than their respective counterparts. The hospitals belonging to the first category in the network and medium-sized units were more similar than their counterparts. The results for 2016 were very similar. All the determinants were found out to be significant except for achieving profit and efficiency. The hospitals with an ED, belonging to the 2nd category and with a high number of beds were more dissimilar than their respective counterparts. The hospitals belonging to the first category in the network and medium-sized units were more similar than their counterparts. In 2017 all the determinants except for the form of ownership and belonging to the 2nd category were found out to be significant. The hospitals with an ED, efficient units, and hospitals with a high number of beds were more dissimilar than their respective counterparts. Finally, in 2018 all the determinants except for the profit were found out to be significant. The hospitals with an ED, efficient units, commercial code companies and hospitals with a high number of beds, belonging to the 2nd category were more dissimilar than their respective counterparts.

Table 5. Median distances (based on FTEs and wages) between the hospitals from the groups constructed based on binary variables, KW test statistics and p-values

	2015		2016		2017		2018	
	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)
ED	0.8734 (1.694)	20.66 (0)	0.687 (1.5674)	5.0488 (0.0246)	0.5971 (1.389)	67.104 (0)	0.555 (1.3967)	92.163 (0)
Category 1 in the network	1.702 (1.227)	6.8268 (0.009)	1.6088 (1.2415)	5.1408 (0.0234)	1.3112 (1.1149)	2.8031 (0.0941)	1.3303 (1.0709)	2.0122 (0.156)
Profit-achieving	1.4069 (1.49)	0.1237 (0.7251)	1.4676 (1.3216)	0.7908 (0.3739)	1.3659 (1.1151)	20.931 (0)	1.2657 (1.1298)	2.1627 (0.1414)
Big	0.9419 (1.7365)	11.795 (0.0006)	0.8792 (1.7018)	10.845 (0.001)	0.9244 (1.3542)	19.703 (0)	0.9348 (1.3637)	14.335 (0.0002)
Medium-sized	1.7365 (0.9419)	11.795 (0.0006)	1.7018 (0.8792)	10.845 (0.001)	1.3542 (0.9244)	19.703 (0)	1.3637 (0.9348)	14.335 (0.0002)
Efficient	1.4061 (1.6056)	1.2144 (0.2705)	1.4447 (1.3267)	0.3839 (0.5355)	0.8017 (1.3283)	26.842 (0)	0.7841 (1.3532)	44.257 (0)
Category 2 in the network	1.1818 (1.5544)	1.9476 (0.1628)	1.1909 (1.5674)	2.0077 (0.1565)	1.0608 (1.2665)	0.581 (0.4459)	0.9238 (1.3152)	3.437 (0.0638)
Non-public*					0.624 (1.274)	3.9161 (0.0478)	0.6257 (1.2926)	15.126 (0.0001)

* In 2015 and 2016 all but 1 out of the analyzed hospitals belonged to the group of public hospitals, which made it impossible to conduct the analysis.

Source: own calculations based on the OZPSP data.

When both types of variables (wages and employment) were considered (Table 5), similar results were reached. In 2015, all the determinants were found out to be significant except for the 2nd category and achieving profit. The hospitals with an ED, a high number of beds, and the efficient hospitals were more dissimilar than their respective counterparts. The hospitals belonging to the first category in the network and medium-sized units were more similar than their counterparts. These results are almost exactly the same as for the similarity of wages only. In 2016, all the determinants were found out to be significant except for the 2nd category, achieving profit and efficiency. The hospitals with an ED and a high number of beds were more dissimilar than their respective counterparts. The hospitals belonging to the first category in the network and medium-sized units were more similar than their counterparts. Again, these are almost the same results as for wages only. Similarly, in 2017 all the determinants except for both categories in the network were found out to be significant. The hospitals with an ED, efficient units, commercial code companies and hospitals with a high number of beds were more dissimilar than their respective counterparts. In 2018, all the determinants except for the profit and category 1 in the network were found out to be significant. The hospitals with an ED, efficient units, commercial code companies and hospitals with a high number of beds were more dissimilar than their respective counterparts. Once again, these results are very similar to the ones achieved in the case when only wages were considered.

When analyzed year by year, it can be noticed that the distances between the hospitals belonging to the groups constructed based on binary variables were stabilizing, which is more clearly seen after 2016.

The correlation of median distances with environment characteristics (average monthly gross salary, hospital beds in a county, the registered unemployment rate, physicians (total working staff) per 10,000 of the population, HHI, hospital beds in a county as a share of hospital beds in a voivodship, nurses and midwives per 10,000 of the population, total medical advice in the outpatient healthcare, share of the population 70 years old or older, the total population, population density, and the average monthly gross salary as the percentage of the national average) and three hospital variables (the efficiency score, total number of beds, total number of patient-days) was also analyzed. The results (Table 6) show that when hospital characteristics are considered, the distances are correlated positively, but slightly with the number of beds and patient-days. Among environment characteristics, the greatest correlation was identified between the median distance and the unemployment rate and HHI. The high values of these variables are related to the hospitals being less similar to each other. For both groups of characteristics (describing hospitals and the environment), the relatively strongest negative correlation was found with the efficiency, density, number of nurses and doctors, and the share of the population aged 70 or older. The high values of these variables are related to the hospitals being more similar to each other.

Table 6. Correlation coefficients between median distances and the chosen hospitals' and environment characteristics

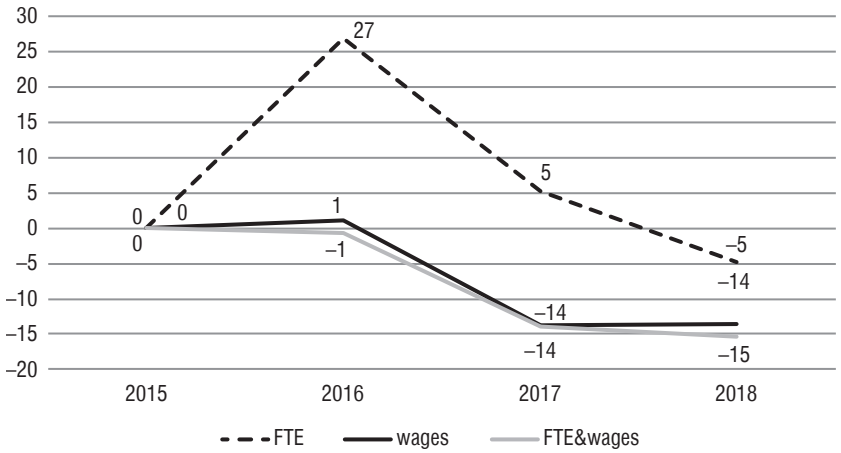
	Distance based on FTEs				Distance based on wages				Distance based on wages & FTEs				Median correlation
	2015	2016	2017	2018	2015	2016	2017	2018	2015	2016	2017	2018	
Total number of beds	0.194	0.191	0.214	0.214	–0.353	–0.298	–0.155	–0.134	0.026	–0.018	0.095	0.103	**0.0605**
Total number of patient-days	0.174	0.063	0.165	0.157	–0.311	–0.34	–0.153	–0.141	0.019	–0.113	0.059	0.058	**0.0385**
average monthly gross salary	0.011	0.089	0.106	0.101	0.157	0.209	0.284	0.301	0.059	0.159	0.176	0.178	**0.1580**
hospital beds in a county	–0.052	–0.08	–0.014	–0.029	–0.404	–0.387	–0.285	–0.3	–0.174	–0.226	–0.112	–0.133	**–0.1535**
registered unemployment rate	0.455	0.527	0.362	0.333	0.254	0.376	0.249	0.094	0.401	0.468	0.338	0.261	**0.3500**
physicians (total working staff) per 10,000 population	–0.158	–0.121	–0.101	–0.077	–0.38	–0.335	–0.228	–0.122	–0.249	–0.235	–0.163	–0.107	**–0.1605**
HHI	0.031	0.11	0.106	0.146	0.371	0.409	0.273	0.314	0.151	0.261	0.161	0.208	**0.1845**
hospital beds in a county as a share of hospital beds in a voivodship	0.085	0.056	0.024	0.013	–0.378	–0.278	–0.293	–0.343	–0.053	–0.089	–0.082	–0.113	**–0.0855**
nurses and midwives per 10,000 population	–0.2	–0.135	–0.191	–0.146	–0.467	–0.398	–0.411	–0.347	–0.316	–0.283	–0.291	–0.243	**–0.2870**
total medical advice in outpatient health care	0.185	0.183	0.173	0.166	–0.252	–0.244	–0.179	–0.146	0.068	0.005	0.066	0.069	**0.0670**
share of population 70 years old or older	–0.284	–0.089	–0.046	0.024	–0.472	–0.416	–0.247	–0.235	–0.369	–0.269	–0.134	–0.085	**–0.2410**
total population	0.196	0.213	0.133	0.119	–0.161	–0.114	–0.144	–0.129	0.123	0.101	0.055	0.046	**0.0780**
population density	–0.145	–0.132	–0.107	–0.097	–0.385	–0.352	–0.3	–0.265	–0.248	–0.255	–0.196	–0.18	**–0.2220**
average monthly gross salary as the percentage of the national average	0.011	0.09	0.106	0.101	0.157	0.209	0.284	0.301	0.059	0.159	0.176	0.178	**0.1580**
Efficiency score	–0.17	–0.145	–0.165	–0.109	–0.195	–0.128	–0.368	–0.273	–0.192	–0.151	–0.269	–0.202	**–0.1810**

Source: own calculations based on the OZPSP data.

Similarities and dissimilarities between different groups of hospitals for relative values of FTEs (FTEs per 1 hospital bed)

In this section we present the results based on the analyses of FTEs per 1 hospital bed. The results are very similar to the ones presented previously. The median distances based on the employment only were also found out to increase in 2016, only the change was smaller in this approach and amounted to ca. 27% (Figure 2). Again, the distances between hospitals are becoming smaller in the analyzed period. The conclusions for wages and FTEs analyzed together are also similar to the ones presented before.

Figure 2. Percentage changes in median distances as compared to 2015 (%)



Source: own calculations based on the OZPSP data.

Using the KW test, we analyzed whether there were significant differences in distances between the groups created using binary variables (Tables 7–8). The results vary from year to year, but several conclusions can be reached.

Firstly, when employment (FTE) is analyzed (Table 7), in 2015 there were significant differences between hospitals chosen based on having an ED in their structure, achieving profit, and being efficient. The hospitals with these characteristics were significantly less similar to one another. Other differences were found to be insignificant in the KW test. In 2016 no determinants were significant, except for being efficient. On the other hand, in 2017 there were significant differences between the hospitals chosen based on having an ED in their structure, having a high or medium number of beds, and being efficient. Again, the hospitals with an ED were significantly less similar to one another. The same statement can be made about the hospitals having a big number of beds and being efficient. On the other hand, medium-sized hospitals were more similar to one another. Finally, in 2018 four determinants turned out to be significant. The hospitals with an ED, units achieving profit and efficiency, and non-public hospitals were less similar to one another than their counterparts.

Table 7. Median distances (based on FTEs) between the hospitals from the groups constructed based on binary variables, KW test statistics and p-values

Variable	2015		2016		2017		2018	
	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)
ED	0.156 (0.2823)	11.956 (0.0005)	0.2548 (0.2932)	0.3354 (0.5625)	0.1987 (0.2858)	11.68 (0.0006)	0.1733 (0.2424)	23.415 (0)
Category 1 in the network	0.2525 (0.2132)	2.3084 (0.1287)	0.3798 (0.2585)	2.7945 (0.0946)	0.2634 (0.212)	2.6071 (0.1064)	0.2265 (0.2044)	2.7888 (0.0949)
Profit-achieving	0.1709 (0.2922)	10.094 (0.0015)	0.2174 (0.3299)	1.3072 (0.2529)	0.2399 (0.2471)	3.3596 (0.0668)	0.189 (0.2447)	7.96 (0.0048)
Big	0.1879 (0.2763)	1.9476 (0.1628)	0.2322 (0.3382)	0.6579 (0.4173)	0.212 (0.275)	4.4487 (0.0349)	0.1956 (0.2257)	3.5958 (0.0579)
Medium-sized	0.2763 (0.1879)	1.9476 (0.1628)	0.3382 (0.2322)	0.6579 (0.4173)	0.275 (0.212)	4.4487 (0.0349)	0.2257 (0.1956)	3.5958 (0.0579)
Efficient	0.1649 (0.2894)	15.702 (0.0001)	0.2174 (0.3299)	5.4106 (0.02)	0.1701 (0.2675)	9.9655 (0.0016)	0.1616 (0.2423)	20.54 (0)
Category 2 in the network	0.2355 (0.2235)	0.4294 (0.5123)	0.2751 (0.2999)	0.0505 (0.8222)	0.2123 (0.2364)	0.0009 (0.9765)	0.2044 (0.2177)	0.0119 (0.9132)
Non-public*					0.1391 (0.259)	3.7648 (0.0523)	0.1561 (0.2298)	13.979 (0.0002)

* In 2015 and 2016 all but 1 out of the analyzed hospitals belonged to the group of public hospitals, which made it impossible to conduct the analysis.

Source: own calculations based on the OZPSP data.

When both types of variables (wages and employment) were taken into account, all the determinants were found out to be significant in 2015 except for achieving profit and belonging to the 2nd category (Table 8). The hospitals with an ED, a high number of beds, and efficient units were more dissimilar than their respective counterparts. In 2016 all the determinants were found out to be significant except for achieving profit and belonging to the 2nd category. The hospitals with an ED, efficient units, and units with a high number of beds were more dissimilar than their respective counterparts. The hospitals belonging to the first category in the network and medium-sized units were more similar than their counterparts. In 2017 all the determinants except for the 2nd category in the network were found out to be significant. The hospitals with an ED, efficient units, commercial code companies, and hospitals with a high number of beds were more dissimilar than their respective counterparts. In 2018 all the determinants were found out to be significant. The hospitals with an ED, efficient units, commercial code companies, hospitals with a high number of beds, and units classified into the 2nd category in the network were more dissimilar than their respective counterparts.

Table 8. KW Median distances (based on FTEs and wages) between the hospitals from the groups constructed based on binary variables, KW test statistics and p-values

Variable	2015		2016		2017		2018	
	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)	Median distance if binary variable equals: 0 (1)	KW test statistic (p-value)
ED	0.8622 (1.5925)	16.47 (0)	0.6341 (1.4951)	4.4435 (0.035)	0.5759 (1.3254)	56.532 (0)	0.5458 (1.3367)	78.127 (0)
Category 1 in the network	1.5584 (1.2082)	8.5474 (0.0035)	1.5912 (1.2231)	6.7288 (0.0095)	1.2811 (1.0984)	5.3719 (0.0205)	1.302 (1.0613)	4.7394 (0.0295)
Profit-achieving	1.4014 (1.4764)	0.0859 (0.7695)	1.4565 (1.2885)	0.117 (0.7323)	1.3336 (1.1079)	14.458 (0.0001)	1.242 (1.1134)	2.517 (0.1126)
Big	0.925 (1.6606)	19.727 (0)	0.7876 (1.6931)	19.252 (0)	0.9033 (1.3271)	27.554 (0)	0.9241 (1.3407)	21.657 (0)
Medium-sized	1.6606 (0.925)	19.727 (0)	1.6931 (0.7876)	19.252 (0)	1.3271 (0.9033)	27.554 (0)	1.3407 (0.9241)	21.657 (0)
Efficient	1.3956 (1.3834)	0.0111 (0.916)	1.4165 (1.279)	1.3174 (0.2511)	0.7946 (1.2933)	21.265 (0)	0.7486 (1.3282)	40.868 (0)
Category 2 in the network	1.1666 (1.5081)	4.6137 (0.0317)	1.0954 (1.5501)	4.4142 (0.0356)	1.0482 (1.2354)	2.1768 (0.1401)	0.8926 (1.2644)	6.9936 (0.0082)
Non-public*					0.6198 (1.2249)	3.2586 (0.0711)	0.6176 (1.245)	12.57 (0.0004)

* In 2015 and 2016 all but 1 out of the analyzed hospitals belonged to the group of public hospitals, which made it impossible to conduct the analysis.

Source: own calculations based on the OZPSP data.

The results correlation analysis between median distances and environment characteristics and three hospital variables are shown in Table 9. The distances are correlated positively, but slightly positively with the average monthly gross salary, registered unemployment rate, and HHI. The negative and relatively high correlation was found with hospital beds in a county, hospital beds in a county as a share of hospital beds in a voivodship, nurses and midwives per 10,000 of the population, share of the population 70 years old or older, and population density.

Table 9. Correlation coefficients between median distances and the chosen hospitals' and environment characteristics

Variable	Distance based on FTEs				Distance based on wages				Distance based on wages & FTEs				Median correlation
	2015	2016	2017	2018	2015	2016	2017	2018	2015	2016	2017	2018	
Total number of beds in a hospital	–0.038	–0.07	0.014	0.026	–0.353	–0.298	–0.155	–0.134	–0.139	–0.165	–0.04	–0.031	–0.1020
Total number of patient-days in a hospital	–0.02	–0.148	–0.008	0.002	–0.311	–0.34	–0.153	–0.141	–0.116	–0.229	–0.056	–0.051	–0.1285
Average monthly gross salary	0.205	0.322	0.282	0.281	0.157	0.209	0.284	0.301	0.202	0.285	0.316	0.327	0.2830
Hospital beds in a county	–0.172	–0.223	–0.133	–0.127	–0.404	–0.387	–0.285	–0.3	–0.264	–0.306	–0.194	–0.203	–0.2435
Registered unemployment rate	0.41	0.451	0.337	0.301	0.254	0.376	0.249	0.094	0.38	0.436	0.315	0.244	0.3260
Physicians (total working staff) per 10,000 population	–0.167	–0.108	–0.097	–0.069	–0.38	–0.335	–0.228	–0.122	–0.251	–0.221	–0.144	–0.088	–0.1555
HHI	0.17	0.282	0.24	0.257	0.371	0.409	0.273	0.314	0.246	0.344	0.257	0.294	0.2775
Hospital beds in a county as a share of hospital beds in a voivodship	–0.101	–0.157	–0.125	–0.124	–0.378	–0.278	–0.293	–0.343	–0.195	–0.213	–0.182	–0.21	–0.2025
Nurses and midwives per 10,000 population	–0.233	–0.179	–0.23	–0.175	–0.467	–0.398	–0.411	–0.347	–0.33	–0.29	–0.298	–0.25	–0.2940
Total medical advice in outpatient health care	0.024	0.017	0.034	0.05	–0.252	–0.244	–0.179	–0.146	–0.058	–0.097	–0.036	–0.016	–0.0470
Share of population 70 years old or older	–0.295	–0.132	–0.072	–0.013	–0.472	–0.416	–0.247	–0.235	–0.368	–0.272	–0.137	–0.097	–0.2410
Total population	0.026	0.026	0.013	0.018	–0.161	–0.114	–0.144	–0.129	–0.018	–0.028	–0.044	–0.034	–0.0310
Population density	–0.165	–0.151	–0.125	–0.111	–0.385	–0.352	–0.3	–0.265	–0.257	–0.256	–0.196	–0.18	–0.2260
Average monthly gross salary as the percentage of the national average	0.205	0.322	0.283	0.281	0.157	0.209	0.284	0.301	0.202	0.286	0.316	0.327	0.2835
Efficiency	–0.176	–0.159	–0.166	–0.125	–0.195	–0.128	–0.368	–0.273	–0.185	–0.141	–0.248	–0.189	–0.1805

Source: own calculations based on the OZPSP data.

The most similar groups of hospitals

The hospitals were clustered using the k-means method.

When employment (FTE) is considered, 2–4 groups of hospitals were found (2015: 4 groups, 2016: 2, 2017 and 2018: 3). Among the clusters, two groups were clearly different from the rest each year except for 2017. One of these groups was characterized by a rather low employment level, while the other one – by high. Two other groups in 2015 had mixed employment levels, and the third group in 2018 had a medium one. In 2017, only the group with the lowest employment was clearly defined, while the other two had medium-high levels of employment. It should be noted that even though the number of clusters was decided based on the values of the silhouette index and gap statistics, there are cases of one-hospital groups in the years except for 2016, which gives the impression of separated individual cases in terms of FTE structure than a structure which is shared by a group of hospitals. The values of rand indices for clustering based on the absolute and relative FTEs are as follows: 0.9779(2015), 1(2016), 0.9853(2017), and 0.9853(2018). That stands for very similar grouping. When FTEs are combined with remuneration, grouping is identical in both cases (absolute FTEs and FTEs for 1 hospital bed). Because of that in the remainder of the paper we will report only the results obtained using FTEs per 1 hospital bed.

None of the analysed binary variables turned out to be statistically significant in explaining the inclusion of a hospital into a given cluster (Table 10).

Table 10. Chi2 test statistics and p-value (in brackets) for the dependence tests between binary variables and clusters

	Clustering based on FTEs				Clustering based on remuneration				Clustering based on FTEs and remuneration			
	2015	2016	2017	2018	2015	2016	2017	2018	2015	2016	2017	2018
ED	0.1758 (0.68)	0 (1)	0.3453 (0.56)	0.3889 (0.53)	0.1758 (0.68)	0 (1)	0.3453 (0.56)	0.3889 (0.53)	0.1758 (0.68)	0 (1)	0.3453 (0.56)	0.3889 (0.53)
Non-public	0 (1)	0 (1)	0 (1)	0.0122 (0.91)	0 (1)	0 (1)	0 (1)	0.0122 (0.91)	0 (1)	0 (1)	0 (1)	0.0122 (0.91)
Profit-achieving	0.013 (0.91)	0 (1)	0 (1)	0 (1)	0.013 (0.91)	0 (1)	0 (1)	0 (1)	0.013 (0.91)	0 (1)	0 (1)	0 (1)
Big	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Medium-sized	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Category 1 in the network	0.1136 (0.74)	0.0126 (0.91)	0 (1)	0 (1)	0.1136 (0.74)	0.0126 (0.91)	0 (1)	0 (1)	0.1136 (0.74)	0.0126 (0.91)	0 (1)	0 (1)
Category 2 in the network	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
Efficient	0.013 (0.91)	0 (1)	0 (1)	0 (1)	0.013 (0.91)	0 (1)	0 (1)	0 (1)	0.013 (0.91)	0 (1)	0 (1)	0 (1)

Source: own calculations based on the OZPSP data.

The values in Table 10 are identical for all the 3 clusters (FTEs, FTEs and remuneration, remuneration) since the clusters themselves in all the years were identical as shown by the Rand indices (Table 11).

Table 11. Rand indices for the clusters constructed based on different criteria

	2015	2016	2017	2018
FTE – FTE & remuneration	1.0000	1.0000	1.0000	1.0000
remuneration – FTE & remuneration	1.0000	1.0000	1.0000	1.0000
FTE – remuneration	1.0000	1.0000	1.0000	1.0000

Source: own calculations based on the OZPSP data.

Based on the values of FTEs per 1 hospital bed, hospitals were clustered into 2 groups each year. Both clusters were clearly distinguished. One of the groups was characterized by a rather low employment level per bed, while the other one – by high. In all the years, the smallest differences between the groups occurred for: resident doctors, trainee doctors, pharmacy technicians, and other medical personnel. The greatest differences were found for paramedics and other non-medical staff engaged in the core activity. In Table 12 the ratio of maximum and minimum median values of relative FTE variables between the clusters is presented. Almost all of these variables were differed significantly between the clusters as shown by the results of the KW test.

Table 12. The ratio of maximum and minimum median values of FTE variables between the clusters constructed based on FTE

	2015	2016	2017	2018
Doctors	12.2325	13.5157	12.1951	11.5019
Resident doctors	6.8373	11.9717	8.9917	8.7605
Trainee doctors	6.6083	9.0346		25.8677
Nurses	11.7297	11.4068	11.4710	11.6217
Paramedics	26.2635	24.1279	23.1746	20.9898
Physiotherapists	8.8688	11.3768	11.5266	12.5246
Laboratory diagnosticians	12.5745	13.2392	12.5669	13.1148
Pharmacists	12.0707	15.4046	15.5209	14.2949
Pharmacy technicians	6.1200	6.6903	5.7186	7.6562
Other non-medical staff engaged in the core activity	21.1452	25.3340	21.8312	24.3224
Other medical staff	5.9371	4.3327	6.0168	7.1098
Service employees	16.0628	13.2034	15.7417	16.0272
Administrative employees	13.0776	14.8442	12.6233	13.7391
X-ray technicians	13.1046	14.3362	13.2647	13.4203
Medical analytics technicians	12.6881	14.6335	13.1459	12.5975

In case of an insignificant difference ratio not reported (blank spaces).

Source: own calculations based on the OZPSP data.

Discussion

The analysis included the hospitals whose most important characteristics are that most of them have EDs, although the number of these hospitals decreased by 6% over the analyzed period. Non-public hospitals have a small share, but their number increased by 180%. About half of them are profitable, but the number of these hospitals decreased by 23%. The number of large and medium-sized hospitals practically did not change over time, and there were about 1.8 times more medium-sized than large ones. The hospitals in category 2 dominate in relation to category 1, and the number of hospitals in particular years changed and those in category 1 increased by 16%, and those in category 2 decreased by 17%. There are slightly less than half of efficient hospitals, but their number decreased by 10%.

In the analyzed period, there were differences between the hospitals (measured as the difference between the maximum and minimum median value): regarding FTEs they were clear, especially in the case of doctors and nurses (the difference equals to 26.85 and 37.3, respectively). The difference in the case of employment of pharmacists was 0. Overall, there are bigger differences when it comes to wages than employment levels. For wages, the biggest differences between the hospitals (measured as the difference between the maximum and minimum median value) were found in the case of doctors, resident doctors, and medical analytics technicians (48.886, 33.11, and 42.53866, respectively).

The hospitals with an ED and efficient units were less similar to one another than their counterparts in terms of employment (FTEs), except for 2016. For both approaches, in half of the analyzed years, the same can be said about the hospital which were able to achieve profit, and non-public units in 3 out of 4 cases. A greater differentiation of the hospitals in terms of the size of employment may result from shortages of medical staff and strong competition of the hospitals for 'buying' employees from other hospitals. Also, a greater differentiation of the hospitals in terms of efficiency may be a consequence of the undifferentiated employment of their medical staff.

When it comes to wages, the hospitals with an ED and a high number of beds were characterized by lower similarity to one another than their counterparts during the whole period. The efficient hospitals and units classified into the 2nd category in the network turned out to be more dissimilar than their counterparts in 2 out of 4 analyzed years.

Finally, when both types of variables (wages and employment) were considered, the hospitals with an ED and a high number of beds were characterized by lower similarity to one another than their counterparts during the whole period. In 3 out of 4 years the same conclusion could be drawn regarding efficient hospitals and (in 2 out of 4 years) – non-public units.

Among environment characteristics, the greatest correlation was identified between the median distance and the registered unemployment rate, wages and, HHI. The high values of these variables are related to the hospitals being less similar to each other. For both groups of characteristics (describing the hospitals and environment), the relatively strongest negative

correlation was found with the efficiency, population density, number of nurses and doctors per 10,000 of the population and the share of the population aged 70 or older. The high values of these variables are related to the hospitals being more similar to each other.

Clustering based on all 3 approaches (FTEs, wages, FTEs, and wages) was the same. One of the groups was characterized by a rather low employment level per bed, while the other one – by high. The smallest differences between the groups occurred for: resident doctors, trainee doctors, pharmacy technicians, and other medical personnel. The greatest differences were found for paramedics and other non-medical staff engaged in the core activity.

Summary

In Poland, as in many other countries, the situation of HRH is difficult and requires decisions to be made, both in the short and long term. In Polish healthcare, one of the biggest problems is the increase in salaries of primarily medical, but also non-medical employees. Decisions on the need to introduce these increases by hospitals, unfortunately, are not followed by decisions on increasing hospital revenues. Because of these political decisions, mainly taken in the face of nurses' and doctors' strikes, about 90% of poviat (county) hospitals incurred losses in the first half of 2019 [Nojszewska, Sielska, Gołąb-Bełtowicz, 2019], and over 80% of their costs were fixed costs [NIK, 2015]. In such financial conditions, no company can function effectively, especially hospitals, which are the most special enterprises. Their condition translates into the availability of treatment and its clinical effectiveness. That is why the Polish experience is so important for decision-makers in other countries struggling with employment and remuneration problems, primarily for medical staff.

In this article, in the parts describing the obtained results and in the discussion, the dependencies between the employment of particular types of employees (as many as 15 occupations were included) and their salaries, and the characteristics of county hospitals were presented in great detail. The analysis covers the years 2015–2018, as it is the period before the COVID-19 pandemic. The years of the pandemic revealed with a particular precision that the HR and payroll policies were misguided. In the new, post-pandemic conditions, it is necessary to know the conditions and factors determining employment and wages in hospitals in order to introduce appropriate changes that will not only improve the economic and financial efficiency of hospitals, but also improve the clinical effectiveness of medical activities carried out in them. Thanks to implementation of such new measures, hospitals will have a chance to be better prepared and more robust in case of the next pandemic.

Our findings show that the differences between hospitals were greater for wages than employment levels. This suggests inequalities between personnel working for different units, which may be both a reason, as well as a consequence of wage competition. The generally greater dissimilarities within the groups of hospitals with an ED, efficient ones and the group characterized by a high number of beds shows that there are different strategies of achieving

efficiency when it comes to employment and wages. Similarly, hospitals with an ED, which secure the society's needs in case a need of urgent treatment arises, are managed in different ways. The same is valid for big hospitals. However, it is worth noting that clustering based on all 3 approaches (FTEs, wages, FTEs and wages) was the same. In all 3 approaches two groups were found, one characterized by a rather low employment level per bed, and one characterized by a high employment level per bed. It shows two most general ways of securing the population's health needs in terms of staffing.

The article is innovative, because in the subject literature there is no such a way of characterizing the most important determinants of functioning of hospitals and linking the considered characteristics with employment and wages of the analyzed hospitals. We draw attention to thorny political problems related to hospital finances and HRH.

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