RESEARCH ARTICLE   **OPEN ACCESS**

FINANCIAL EVALUATION OF RELATIVE EFFICIENCY: AN ANALYSIS IN FEDERAL UNIVERSITY HOSPITALS IN BRAZIL

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ARTICLE INFO

ABSTRACT

The limitation of public resources and the complexity of the environment of the Brazilian Federal University Hospitals (FUHs), the main service providers of the Brazilian Unified Health System (SUS), promoted the evaluation of efficiency in a significant evolutionary tool in this environment, in view of its results, which make it possible to ratify decisions for the enhancement of resources and the improvement of solutions in these institutions.To analyze the Brazilian FUHs regarding the relative financial efficiency, particularly in regards to outpatient and hospital assistance of medium and high complexity.It is descriptive research with quantitative approach and collection of documentary (secondary) data. Relative financial efficiency reflects the ability of a FUH to obtain the maximum outputs at the lowest cost. Data were analyzed using the Data Envelopment Analysis software (DEA). The sample was of a census approach, covering the 50 FUHs, in the quinquennium of 2013-2017.(i) DMUs showed a certain uniformity in relation to the total percentage of (in)efficient FUHs yearly, with the exception of 2016; the UHs of UFJF and UFMA, HUWC UFC and HESFA UFRJ were considered efficient throughout the analyzed period; (ii) the DMU considered a "pinnacle of excellence", for demonstrating the best practices, was MEJC UFRN, which was utilized more frequently (62 times) in the five-year period; (iii) Performance parameters were identified, with inefficient DMUs, allowing a visualization of how much is needed and the ideal value for the variables to reach the relative efficiency frontier.In summary, the proposal has relevance in the context of social interest and for the financial impact on Brazilian public accounts, promoting openness to the financial resources that permeate the FUHs, as well as the value of constructing alternatives and tools for optimizing resources and health services under the SUS.

INTRODUCTION

The scientific spread of the field of studies concerning the measurement and evaluation of the efficiency of organizations has become an expressive evolutionary vector, especially in the last two decades of the twentieth century (Cunha & Corrêa, 2013). Health organizations, such as public hospitals, faced with a diachronic, sustainable, legal process and with ideal organizational parameters were included in this field, corroborating this growth with relevant results and contributions on this issue, both around that time and in the twenty-first century (Souza, Melo, Araújo & Silva, 2013; Du, Wang, Chen, Chou, & Zhu, 2014; Silva, Moretti & Schuster, 2016; Peixoto, 2016; Nistor; Stefanescu; Crisan, 2017).

In Brazil, this proposal was reinforced with the emergence of the Unified Health System (SUS) in 1988, in which one of the central objectives of the system is efficiency, with emphasis on hospital care (Brasil, 1988; Conass, 2006). Some highlights of previous studies, both in the national and international literature, show that comparative and non-prescriptive evaluations of hospital efficiency provide managers with information essential for the deployments of units (organizations) identified as inefficient and setting efficient production targets (Du *et al.*, 2014; Peixoto, 2016); correct decision-making, based on timely, valid and interpretable financial indicators for constant threats in the hospital setting (Glandon, Counte, Holloman, & Kowalczyk, 1987); recommendations on the distribution of public resources based on efficiency (Lins, Lobo, Silva, Fiszman & Ribeiro, 2007); benchmarking, identifying the best practices of peers

in the competitive environment and leading to better overall efficiency (Silva *et al.*, 2016); capacity to reduce operational costs and the ability to ensure the rational use of resources to obtain the necessary results (Nistor *et al.*, 2017). In this context are included the Federal University Hospitals (FUH), Brazilian public hospital institutions that provide services to the SUS and promote teaching, in the health area, together with the Brazilian federal universities (Marinho & Façanha, 2000), the system's main organizations, standing out for the number of hospital beds, hospitalizations, outpatient productions and university training in the health sciences (Lobo, Lins, Silva, & Fiszman, 2009), besides their expressive representation in the amount of Brazilian public spending (Brasil, 2017).Despite having a large financial contribution to the development of its activities, with a significant participation in health promotion in the SUS, Brazilian FUHs face numerous operational and management inefficiencies (Lobo *et al.*, 2009; Silva, 2011), for which they are provided performance evaluations, such as the production efficiency of the of health and education services, public spending, among others, with the objective of measuring these impacts and directing it to the best management practices (Araújo & Leta, 2014). Thus, in light of these studies and stemming from a questioning bias regarding the use of public financial resources and production of services by Brazilian FUHs, there is evidence of the relevance in the evaluation of resources (public expenditures) and the results achieved in the health function, aiming to demonstrate that its applicability is promoting continuous improvement of health conditions in the country and well-being to society. The following search problem thus emerges: Which Brazilian Federal University Hospitals are relatively more efficient considering financial indicators?

Thus, the general objective to answer this research question is to analyze the Brazilian FUH regarding the relative financial efficiency, in regards to outpatient and hospital assistance of medium and high complexity. The proposed approach is relative, for comparing and analyzing the management of Brazilian FUHs with 100% SUS service promotes important information to understand comparatively the results of management in different hospitals, in addition to evidencing the gaps for institutions considered inefficient so that they can explore and improve their processes and, consequently, extend their results based on best practices. The research problem establishes a new perspective of research, since from the measurement and evaluation of the FUHs regarding the relative financial efficiency it is possible to verify, through proper indicators, the management performance of these resources and of the institutional production (invoicing of the services) present in the Brazilian regions. Also, as already pointed out, the indicators used in the study for relative efficiency evaluation are only focused on financial variables, which provides a contemporary approach to this type of study. It also provides empirical evidence of the inefficiencies of these FUHs, in order to redirect the managers' decisions to achieve the desired financial efficiency. Despite the fact that Brazilian public hospitals have a are large demand of public resources, and in view of the SUS creation, with the provision and financing of health actions and services and a search to increase efficiency in the management of these resources, empirical work in this area is still incipient (Souza *et al.*, 2010). Moreover, the resources of the Brazilian FUHs are increasing and require the transfer of education, given their link with the Federal Universities for teaching and research (Marinho&Façanha, 2000).Nistor*et al.* (2017) emphasize that evaluating the efficiency of public hospitals is one of the most intense research areas to be explored, given the significance of the resources involved and the serious inefficiencies that have marked this sector in recent decades.

Theory: Du *et al.* (2014) reinforce that efficiency in hospital environments is an important area of research, since, from this type of study, there are possibilities of finding significant results in way of inefficiencies to be addressed, with a potential to improve service quality and significant organizational gain. The authors also emphasize the benefit to hospital managers, as by evaluating the hospital organization it is possible to understand how their resources are being used efficiently and what the possible improvements of this efficiency are. Thus, the emphasis on control of cost and expense

elements gives rise to the measurement and evaluation of efficiency, gaining an essential prominence for the evaluation of health institutions (Varela & Pacheco, 2012). Wolff (2005). For the authors, the evaluation of hospital productivity is justified by at least four reasons: (i) the high cost of hospital care in relation to the total cost of health care; (ii) the opportunity cost related to the total cost of this assistance; (iii) use of results-based management to assess the impact of health policies on hospital services - planning new actions, rethinking priorities and identifying imbalances; (iv) monitoring the hospital's actions, comparing the (relative) technical efficiency with other members of the same health system.

FUHs are important centers in the formation of human resources and technological development in the health area, providing support services to teaching, research and extension activities in their attached Federal University. It also enables effective service delivery to users, resulting in continuous improvement in care and in the elaboration of clinical and technical protocols for the various pathologies, through better standards of efficiency in the SUS(Araújo & Leta, 2014). Also, the Operational Health Care Standard (NOAS) dated from 01/2002, which governs the SUS, establishes the evaluation and control of the services rendered and the analysis of the efficiency in the use of the resources and their results, evidencing the compliance with the established rules and goals (Brasil, 2002). It is important to emphasize the relevance and interest of public health institutions and their managers for the permanent evaluation of economic and financial performance (Veloso & Malik, 2010), since they aim at the continuous improvement of the organization in the services of education and assistance - that is, aim to develop their assistance models at the level of excellence, with the purpose of maximum exploitation in the application of resources and further expansion of the offer and qualification of the services to the users (Adhikari, Sapkota&Supakankunti, 2015). Wolff (2005) points out that with the result of efficiency evaluations in public hospital management, managers can monitor their actions, decisions, and compare the performance of their hospital with other organizations within the same health system. Therefore, one of the greatest challenges in hospital management is the increase in efficiency, given the complexity that surrounds it (Souza; Scatena & Kehrig, 2016). Aiming for robust measures of hospital efficiency, such as identifying characteristics that explain differences in performance between hospitals, are more dynamic topics on the health research agenda (Tabanera; Martin & Gonzalez, 2015). The literature offers several types of efficiency depending on the area of study (Mariano, 2007). Efficiency in units of production of goods/services is conditioned to the ability to use, at its best opportunity, the available resources and to benefit to the maximum of the conditions to obtain an excellent performance in some dimension (Mariano, 2007). Yet, the (relative) technical efficiency is determined by comparing one or more productive units which receive the same sets of resources to produce the same sets of results, that operate in similar processes and, therefore, is limited to conversion of absolute efficiency (Bhat, Verma & Reuben, 2001). Hospital efficiency affects health care expenditures, and hence costs and equity implications of health care, allowing evidence on hospital organizations' performance and policy projections for their improvement (Adhikari *et al.,* 2015). By observing the number of expenses involved in running organizations in the complexity of service delivery and management, it becomes even more important to explore any potential for improvement in hospital performance, which highlights the importance of efficiency studies (Sommersguter-Reichmann & Stepan, 2015). Adhikari *et al.* (2015) evidence that if the health market were perfectly competitive, efficiency measurement would be unnecessary. Therefore, efficiency analysis is important since extending universal health coverage is considered as a main strategy. In this scenario, it is important to expand the fiscal space of the population and services coverage (Adhikari *et al.*, 2015). In the hospital organizational context, where management demands information that is constantly identified, processed and evaluated, often in real time, indicators are essential parameters for guiding institutions in search of improvement. Decisions are based on identifying the status of hospital services provision and to evaluate the various forms of utilization of available resources (Al-Shammari,

1999). The scientific literature allows the identification of the various indicators used and validated by the hospital evaluation models, especially when it comes to the efficiency of health service providers. Figure 1 shows indicators of inputs and outputs used in hospital efficiency evaluation models by scientific references of the field.

approach to the problem it is a quantitative research, under the assumptions of Richardson (2015), based on secondary data, not establishing control and/or manipulation on this source. Silva et al. (2006) present advantages in the use of this data, such as availability and ease of access and collection, as well as the low cost of research.

Figure 1. Inputs and outputs variables used in previous studies

Reference	Variables (indicators)	
	In/Inputs (inputs)	Out/Products (outputs)
Souza *et al.* (2013)	Hospital care expenses	Nº of clinics; Nº of professionals; Nº of health facilities
Du *et al.* (2014)	Beds; Physicians; Nurses; Total Operating Expenses	Total operating revenue; Hospitalizations; Discharges
Li, Dong, and Liu (2014)	Beds; Contributors; Permanent assets; total expenses	Outpatient and emergency visits; Number of Discharges; total income
Adhikari*et al.* (2015)	Patients-day; Beds	
Sommersguter–Reichmann &Stepan (2015)	Full-time equivalents; Beds; Expenditure on consumption goods, expenses with outsourced medical services	Medical procedures; Extra medical procedures, specialized services
Tabanera*et al.* (2015)	Beds; Number of full-time equivalent professionals; Expenditure on goods and services	Number of discharges; Outpatient care
Souza *et al.* (2016)	Number of doctors and nursing professionals; Number of SUS beds; Average monthly salary in SUS hospitalizations	Hospitalizations and High Complexity Procedures (HCP); Proxy (approximate indicator) of quality
Mujasi, Asbu, and Puig-Junoy (2016)	Physicians; Beds	Outpatient visits; Hospitalization days
Peixoto (2016)	Supervision of boarding and residence; Hospitalization days; Specific projects - Ministry of Health; Type of equipment	Medical residence
Silva *et al.* (2016)	Number of Physicians and Nurses; Number of Nursing Assistants and Technicians; Mean cost of hospitalizations; Number of AIH; Number of SUS beds	Total surgical and non-surgical procedures performed per capita; Total hospitalizations per capita; inversion of the mortality rate
Silva, Costa, Abbas & Galdamez(2017)	Number of beds; Number of doctors; Number of nurses	Number of hospitalized patients; Number of hospital deaths
Nistor*et al.* (2017)	Physicians; Operational expenses, not considered expenditure on staff	Total operating revenue; Cases; Hospitalizations
Zare (2017)	Beds; Physicians; Area of hospitals; Expenses	Outpatients; Beds'occupation; Residents' time; Mortality rate

Source: Referenced literature. Review of the literature in the journals Capes (2018) and BDTD Ibict (2018).
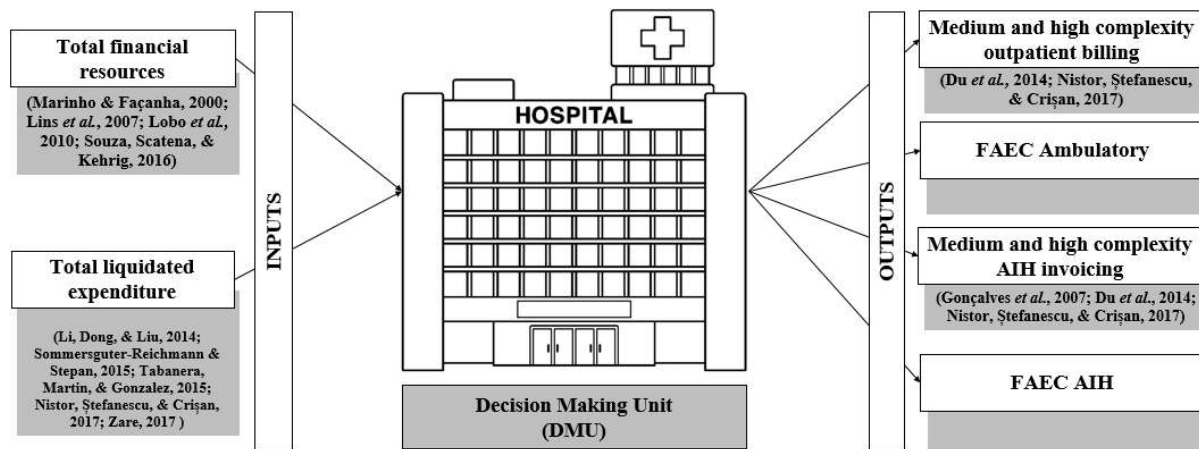
Source: Drawn by the authors.
Caption: AIH – Inpatient Hospitalization Authorization; DMU – Decision Making Unit; MAC – Medium and High Complexity; FAEC - Strategic Actions and Compensation Fund.
Source: Prepared by the authors based on the referenced literature.

Figure 2. Construct of this study's model of technical (relative) efficiency measurement on FHU

The variables used by the several studies studied to make it possible to verify that each study develops its own construct of inputs and outputs, based essentially on the dimensions and characteristics of hospital organizations that are to be analyzed. From this definition, adequate indicators were proposed for the scope of the respective objectives and responses to the research problem. Thus, there are indicators for the following dimensions: assistance, administrative, financial, teaching and health research, for public, private and philanthropic hospitals, teaching and research hospitals, federal, state or municipal hospitals, among others.

METHODS

Based on the established research problem and the proposed objective for the accomplishment of this study, descriptive research was undertaken, according to the conception of Gil (2002); regarding the

The unit of analysis of this study is composed of FUHs, representative service providers to SUS and, consequently, the Brazilian population (Araújo & Leta, 2014). Therefore, the set of elements to be analyzed is the FUH census, regardless of whether some do not have a management contract with the EBSERH, meaning it comprises all FUH in Brazil, about 50, linked to 35 Federal Universities (CNES, 2017). However, this study used data from 48 institutions (96%), since there was unavailability of data for the Tropical Diseases Hospital of the Federal University of Tocantins (HDT UFT) and for the Lagarto Regional Hospital of the Federal University of Sergipe (HRL UFS) regarding the indicators selected during the analysis phase, making their comparative analysis unfeasible. The data analysis period is between 2013 and 2017, established as such for convenience and for addressing updated FUH information regarding the secondary data used available on the DATASUS website (2017) and Brazil (2017). This particular temporal cut attempts to evaluate some impacts, such as (i) economic and financial gap of the values

and data of the analyzed indicators; (ii) given that efficiency calculations are based on statistical methodologies and techniques, a longer interval may compromise some data and lead to loss of focus. The development of the model used in this study to measure the efficiency of FUHs and its efficiency variables in the hospital scope originated from the literature and previous studies on the subject (Figure 1). Figure 2 shows the construction of inputs and outputs, in which each variable was previously tested and validated by the literature. To serve as a perspective for this study's model, it was intended to test six variables in total, being two inputs and four outputs indicators, as shown in Figure 3.

capacity, therefore, this orientation of the DEA model presupposes maximizing the use of available resources, reducing idle capacity.

RESULTS

To obtain the results of the DEA model, the efficiency frontiers were calculated based on the observations of the 48 Brazilian Federal University Hospitals. As mentioned before, the model was oriented to outputs and variable returns of scale, utilizing the Integrated System for Decision Support software (ISYDS) version 3.0 owned by the

Figure 3. Financial inputs and outputs of the DEA model

Indicator	Acronyms	Description	Type
I	RFINT	Total financial resources recognized upon the occurrence of the generating event and, independently of the budget execution in the 2013-2017 period, totaled annually.	*Input*
II	DLIQ	Total liquidated expenditure, second stage of budget expenditure, for the 2013-2017 period, totaled annually.	*Input*
III	FAMAC	Medium and high complexity outpatient billing in the period: medium and high complexity outpatient billing of the institution's SUS during the 2013-2017 period, totaled annually.	*Output*
IV	FAECA	Ambulatory Fund for Strategic Actions and Compensation (FAEC) in the period: outpatient invoicing of the institution's FAEC during the 2013-2017 period, totaled annually.	*Output*
V	FAIHMAC	Medium and high complexity AIH invoicing in the period: considering the medium and high complexity AIH invoices of the institution during the 2013-2017 period, totaled annually.	*Output*
VI	FAECAIH	Component of Strategic Actions and Compensation Fund (FAEC) AIH in the period: were considered the AIH invoices of the institution's FAEC during the period of 2013-2017, totaled annually.	*Output*

Source: Prepared by the authors.

In addition to the observation of the inputs and outputs already validated, the selection of these indicators for the construction of the model in this study was based on the relevance of this information to the FUH managers, politicians and/or public managers, and to the SUS. This is because all the actions and medium and high complexity outpatient and hospital procedures constitute a relevant list of responsibilities, services, and procedures important to guarantee the resolution and integral nature of the assistance provided to FUH users in the SUS. Furthermore, this particular component of indicators, medium and high complexity outpatient and hospital procedures for all organizations, consumes about 40% of the resources of the Union allocated in the National Health Budget (Conass, 2006). Data collection was undertaken on the electronic portal of the Department of Information Technology of SUS (DATASUS), linked to the Ministry of Health (MS), and on the National Treasury website, linked to the Ministry of Finance. After collecting the data, they were tabulated in spreadsheets and analyzed, according to the stages established by the Integrated System for Decision Support software (ISYDS) version 3.0, for the DEA, and the International Business Machines Statistical Package for Social Sciences (IBM SPSS Statistics) version 23 for multivariate statistical analyses. Data Envelopment Analysis (DEA) has already been tested and validated by several health and hospital studies to simultaneously measure and convert multiple inputs and output variables from Decision Making Units - DMU) on a technical (relative) efficiency scale, listing the reference units (benchmarking) (LINS *et al.*, 2007; Souza*et al.*, 2013; Cunha & Corrêa, 2013; Peixoto, 2016; Silva*et al.*, 2016).

In this study, the DEA model VRS was used oriented only to the outputs. Such choice is corroborated by Lins et al. (2007); Lobo, Lins, Silva and Fiszman (2010); Du *et al.*(2014); Mujasi*et al.* (2016); Silva *et al.* (2016); Souza *et al.* (2016); Peixoto (2016); Nistor *et al.*(2017). Regardingorientation, it issupportedbytheprominenceof Souza et al. (2016), which evidence that: (i) in public hospitals, managers have low governance over human resources; that is, they are publicly-owned and have employment stability, and there is a difficult decision-making process on the reduction of this situation, a fact that highlights the lack of use of the model with input orientation; (ii) the SUS is constantly seeking to guarantee more resources, since the need for health services is always increasing in the face of limited resources and, as reinforced by Marinho and Façanha (2000), the output orientation of the DEA model is justified by the fact that the main inputs of the FUH cannot be reduced easily; (iii) FUHs are organizations with high fixed costs and often working with idle

Federal Fluminense University (UFF) and Microsoft Office Excel® version 2013, for formatting the data in spreadsheets. Table 1 describes the efficiency indexes of the 48 HUF in the period from 2013 to 2017. The relative financial efficiency frontier was formed by 20 in 2013, 18 in 2014, 19 in 2015, 7 in 2016 and 21 in 2017, of all the 48 FUHs under analysis in the five-year period, presenting a diversity among the found results. The remaining, 28 (2013), 30 (2014), 29 (2015), 41 (2016) and 27 (2017) were below the frontier - that is, they should promote higher billings for Outpatient MAC, MAC AIH and FAEC MAC and AIH, given the total financial resources received and the expenses paid to institutional maintenance. The results indicate that most of the FUHs were considered inefficient, which shows the need to take measures to improve the relative efficiency with the indicators proposed for the DEA model. The information detailed in Table 1 shows the heterogeneity of FUH relative efficiency indicators over the analyzed time period, and by the total sample size, 48 hospitals, it is possible to verify this information from the lowest relative efficiency indicators calculated in the five-year period (2013-2017), which were 0.00000, in both periods, for the IDT UFRJ, a score that showed that the institution did not invoice contractualized services for the SUS, but consumed the resources for maintenance of the institution. The HUF belonging to UFRJ face a crisis in the health system of their institutions in recent years, with one of the aggravating factors being the lack of resources resulting from the decision not to join the proposed federal programs, such as adherence to Ebserh. Another highlight of the inefficiency score was the 0.00917 score (HU UFSCAR) in 2016, a fact that, in view of the second worst relative efficiency performance, prompts the institution to review its processes and the use and optimization of financial resources with the goal of achieving improvements and the relative efficiency range, compared to their peers who have demonstrated better performance and efficiency. It is also observed that only 4 institutions (HESFA UFRJ, HU UFJF, HU UFMA, and HUWC UFC) remained efficient during the five-year period 2013-2017, representing approximately 8% of the sample. In turn, 17 FUH of the sample did not reach a score 1.0000 (efficiency frontier) in any year. In addition, 27 HUF fluctuated in this period between 2013 and 2017, sometimes showing themselves above the efficiency frontier, with a score of 1.0000, and on other times inefficient, with values closer or not rising to the maximum index of 1.0000. In order to elucidate, in percentage terms, the data of Table 1, Figure 4 is presented, which collaborates with the graphical visualization in percentage terms the ratio of (in) efficient DMUs over the analyzed period (quinquennium 2013-2017).

Table 1. Calculation of relative efficiency by the DEA, using the BCC model (VRS), output orientation (2013 to 2017)

Acronyms DMUs	Standard efficiency, using the BCC model, output orientation				
	2013	2014	2015	2016	2017
HESFA UFRJ	1,00000	1,00000	1,00000	1,00000	1,00000
HU UFJF	1,00000	1,00000	1,00000	1,00000	1,00000
HU UFMA	1,00000	1,00000	1,00000	1,00000	1,00000
HUWC UFC	1,00000	1,00000	1,00000	1,00000	1,00000
HC UFMG	1,00000	1,00000	1,00000	0,80035	1,00000
HUBFS UFPA	1,00000	1,00000	1,00000	0,65433	1,00000
HUSM	1,00000	1,00000	1,00000	0,48751	1,00000
HCPA	1,00000	1,00000	1,00000	0,47047	1,00000
HC UFU	1,00000	1,00000	1,00000	0,46463	1,00000
HUPES UFBA	1,00000	1,00000	1,00000	0,42367	1,00000
HOSPITAL SÃO PAULO	1,00000	1,00000	1,00000	0,23261	1,00000
HUCFF UFRJ	1,00000	1,00000	1,00000	0,13987	0,39496
HC UFPR	1,00000	1,00000	0,98368	0,76000	1,00000
HUCAM UFES	1,00000	1,00000	0,98312	0,69545	1,00000
HE UFPEL	1,00000	1,00000	0,87675	0,45558	0,92313
HU UNIVASF	1,00000	0,79026	0,69945	0,69108	0,90447
HUAP UFF	1,00000	0,64678	0,63383	0,23755	0,58772
MEAC UFC	1,00000	0,62832	0,75564	0,37898	0,78036
HUAC UFCG	1,00000	0,47584	0,41805	0,25719	0,57990
HUJB UFCG	1,00000	0,35099	0,36522	0,29936	0,45229
IPPMG UFRJ	0,95443	0,52939	1,00000	0,62262	1,00000
HC UFPE	0,94794	0,74592	0,66405	0,37673	0,62930
HUB UNB	0,94081	0,95971	1,00000	0,33765	1,00000
HC UFG	0,91282	1,00000	0,96554	0,58563	0,75206
MEJC UFRN	0,89916	1,00000	1,00000	1,00000	1,00000
HC UFTM	0,89905	0,93909	1,00000	0,60045	0,90349
HU UFGD	0,85373	0,71732	0,73389	0,43456	0,91351
HU FURG	0,77417	0,75462	0,67599	0,34614	0,68596
IG UFRJ	0,75588	0,66533	1,00000	0,68566	1,00000
HUPAA UFAL	0,70560	0,59425	0,69327	0,44821	1,00000
HU UFSC	0,64802	0,48156	0,41578	0,30724	0,58215
HUMAP UFMS	0,59437	0,56737	0,76384	1,00000	1,00000
MCO UFBA	0,48063	0,46657	0,51947	0,45458	0,68453
IPUB UFRJ	0,46216	0,41663	0,46029	0,37787	0,58891
HUAB UFRN	0,46176	1,00000	1,00000	1,00000	1,00000
HUGV UFAM	0,45886	0,35025	0,41802	0,33994	0,41944
HUJM UFMT	0,45072	0,59633	0,64490	0,43972	0,51052
INDC UFRJ	0,44644	0,43411	1,00000	0,49031	0,61438
MVFA UFPR	0,42387	0,54727	0,70871	0,84171	1,00000
HUOL UFRN	0,41011	0,57535	0,78731	0,60892	0,72763
ME UFRJ	0,39362	0,39617	0,41641	0,47373	0,94166
HUGG UNIRIO	0,37950	0,42676	0,33450	0,13961	0,40925
HU UFS	0,37362	0,39696	0,40512	0,16963	0,64757
HULW UFPB	0,27882	0,24616	0,27170	0,15617	0,39061
HU UFPI	0,23551	0,31056	0,52529	0,42517	0,97247
HUJBB UFPA	0,18632	0,20987	0,20360	0,12668	0,24550
HU UFSCAR	0,05187	0,04129	0,05893	0,00917	0,03533
IDT UFRJ	0,00000	0,00000	0,00000	0,00000	0,00000

Source: Research results.
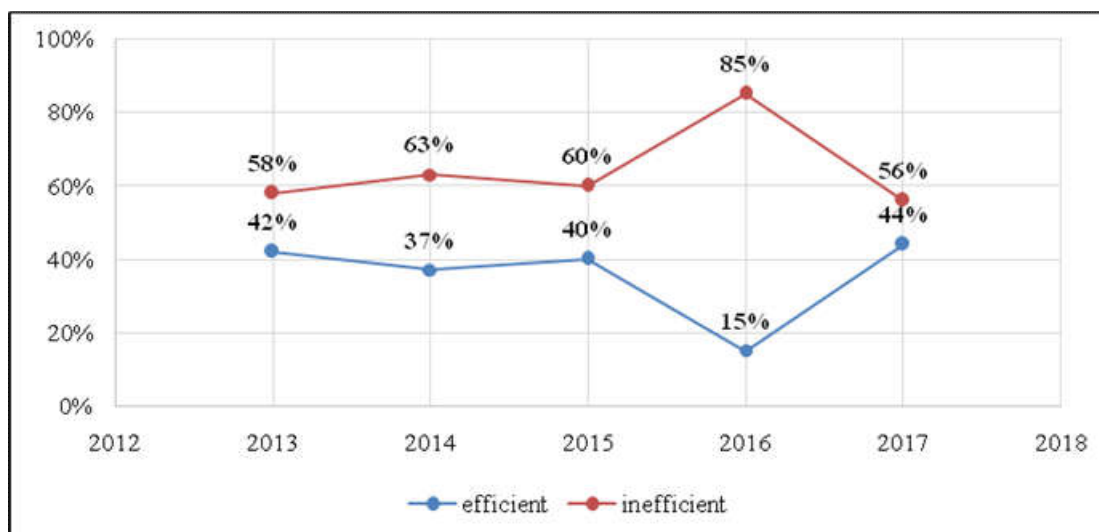
Source: Research results.

Figure 4. Information, in percent, of the total number of (in) efficient DMUs in the study timeline (2013 to 2017)

It can be seen from the observations in Figure 4 that the greatest number of inefficient institutions was verified in 2016, with 85% of the total sample, and this was the period that most stood out and more oscillated in relation to the other years analyzed. Following, in a decreasing and more constant order between the periods, were the years 2014 (63%), 2015 (60%), 2013 (58%) and 2017 (56%), a period in which there was a lower number of inefficient DMUs in the sample. Table 2 shows that the minimum relative financial efficiency score was 0% in both years of the analyzed period and the maximum was 100%, also identified in all years of analysis. Of the 48 Brazilian Federal University Hospitals, 25% (12 FUH) presented efficiency scores lower than 45.27% in 2013, 44.22% in 2014, 47.50% in 2015, 31.48% in 2016 and 58, 80% in 2017; half (24 FUH) had scores lower than 90.59% in 2013, 69.13% in 2014, 77.55% in 2015, 45.50% in 2016 and 91.83% in 2017; and 25% higher (12 FUH) than 100%, except 2016, which presented 68.97%. Among those higher, not considering the year 2016, are those classified as efficient. When analyzing only inefficient FUHs, the average efficiency scores are 73.70% in 2013, 69.29% in 2014, 73.71% in 2015, 50.51% in 2016 and 77.66% in 2017, indicating that it is possible to increase the service provision and, consequently, the FUH billing in the four selected variables 26,30% (2013), 30,71% (2014), 26,29% (2015), 49,49% (2016) and 22,34% (2017) without the need to direct more financial resources from the public budget to these federal hospital organizations. In Figure 5, the 31 FUHs classified as efficient in at least one of the analyzed periods of the quinquennium 2013-2017 were listed.

It is important to highlight that this financial efficiency is measured among the analyzed sample. Therefore, it is a relative financial efficiency, that may contain distortions and changes of results if performed compared to another sample of possible comparability among DMUs. Therefore, this evidence can be compared with Al-Shammari's (1999) assertion, which emphasizes the efficiency evaluation with the use of the DEA as an instrument for the identification of the performance of the productive units, becoming a systematic priority-setting mechanism of information regarding the needs. In the same sense, Mujasi et al.(2016) corroborate that the DEA promotes the identification of high-efficiency and inefficient production units, providing information of paramount importance for upper management and the organization to develop appropriate strategic planning to support inefficiently identified units with the objective of improving performance and, consequently, improve the service needs. Based on these considerations, the identification of efficiency is an important dimension for hospital performance (Gurgel Junior & Vieira, 2002) and its evaluation is essential (Veillard et al., 2005). However, the information and susceptibilities taken from decisions on this type of data provided by the DEA, such as the evaluated model, requires points of attention and prioritization of criteria supported by additional references, since Chang (1998) emphasizes that the evaluation of performance in non-profit organizations, in this case, the FUHs, cannot simply observe their own performance measure, but must include the identification and evaluation of relevant operational characteristics, since they are all important factors and that associate efficiency performance.

Table 2. Descriptive statistics of FUH's relative financial efficiency scores in the five-year period (2013-2017)

Statistics	2013	2014	2015	2016	2017
Mean	0,73708	0,69294	0,73713	0,50514	0,77661
Standard deviation	0,30824	0,29895	0,29303	0,28225	0,27622
Median	0,90599	0,69133	0,77558	0,45508	0,91832
Minimum	0,00000	0,00000	0,00000	0,00000	0,00000
Maximum	1,00000	1,00000	1,00000	1,00000	1,00000
First Quartile	0,45276	0,44223	0,47509	0,31484	0,58802
Median	0,90599	0,69133	0,77558	0,45508	0,91832
Third Quartile	1,00000	1,00000	1,00000	0,68973	1,00000

Source: Research results.
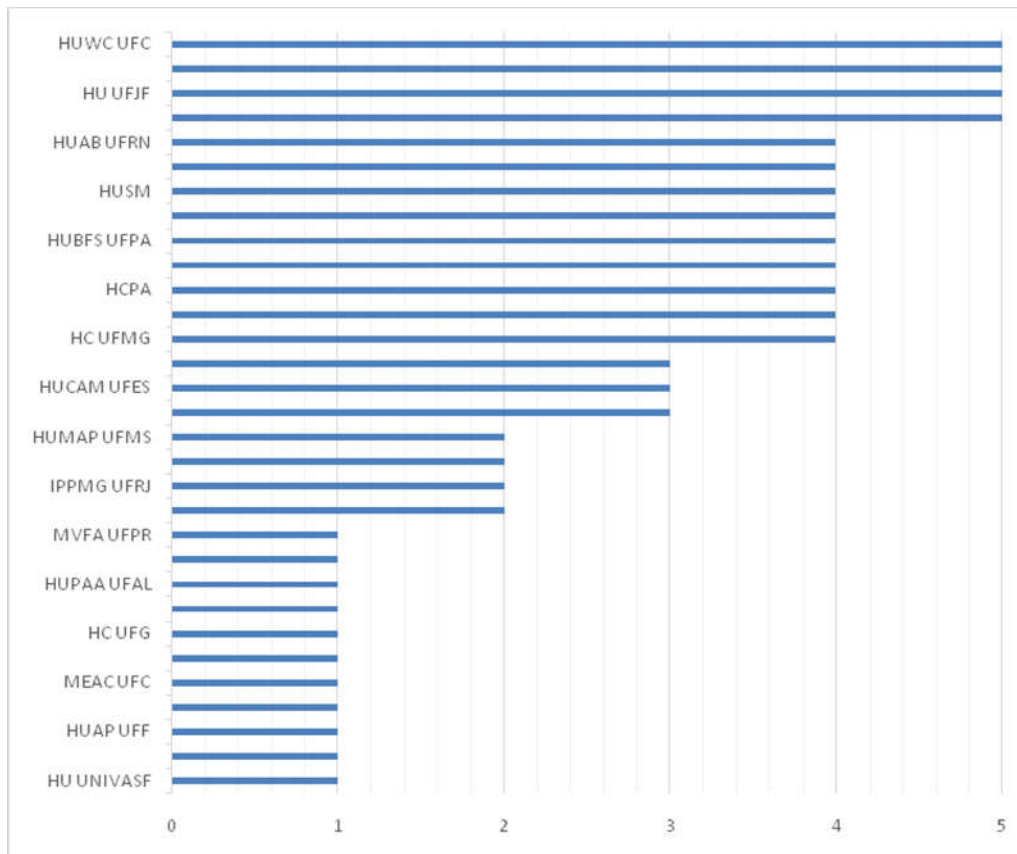
Figure 5. Frequency of times FUHs were efficient considering the accumulated quinquennium (2013-2017)

DISCUSSION

This study is delimited by the general objective of analyzing the Brazilian FUHs in terms of relative financial efficiency, in the scope of outpatient and hospital care of medium and high complexity. With a sometimes broad and other times synthetic view, but overall detailed, it was possible to graphically demonstrate that the FUHs obtained a certain uniformity in relation to the percentage of (in)efficient FUHs year by year, with the exception of 2016. Also, the amplitude of the efficiency scores between the FUHs in the five years period (2013-2017) was noteworthy, with the lowest scores being and/or approaching 0 (zero), clearly showing a relative inefficiency compared to the other DMUs, which required an emergency review of the variables used in the model. In addition to the afore mentioned uniformity, the hospitals HU UFJF, HU UFMA, HUWC UFC, and HESFA UFRJ were considered efficient in all the five years analyzed. In view of the general evaluation of value projections for output improvements in the five-year period, the FUH should promote strategies and actions directed to the FAEC billing, both Outpatient and AIH, followed by Outpatient MAC and MAC AIH. Also, it was possible to identify the FUHs that were present more frequently as benchmarks and that held the efficiency standard that should be sought by the inefficient institutions, being the MEJC UFRN the institution that served as a reference more frequently in the quinquennium 2013-2017, which is a parameter for other 62 institutions, followed by HC UFMG (55), HUWC UFC and HUBFS UFPA, both with 45, and UFMA HU, which was referenced 41 times. Otherwise, MEAC UFC and HUAP UFF were the ones that showed lower reference times, both being referenced only once. The study was complementary to the research gaps proposed by Nistor et al.(2017) and Peixoto (2016) since, in this respective order, the former authors proposed the perspective of efficiency evaluation based on the variables of financial resources involved in public hospitals. Yet, Peixoto (2016) suggested the DEA evaluation to assess if there was any development of the financial capacity and growth in the production of services with the improvement of the use of public resources in the FUHs, based on the REHUF and the Ebserh programs. Thus, the research showed, through quantitative statistics and a mathematical model, the behavior of FUHs in the face of important financial variables for these institutions, some of which had already been used in other researches but combined with non-financial indicators to propose a model (Marinho & Façanha, 2000; Lins*et al.*, 2007; Lobo *et al*., 2010; Du *et al.,* 2014; Li *et al*., 2014; Sommersguter-Reichmann & Stepan, 2015; Tabanera *et a.*, 2015; Souza *et al.* 2016; Nistor *et al.*, 2017; Zare, 2017); and others, proposed for innovation in this study, such as FAECA and FAECAIH, are important sources of financing strategy in Brazillian public health.

The model built for evaluating the financial efficiency of Brazilian FUHs, developed only with input and output financial variables, contributes, in a timely manner, to the research spaces of the scientific literature, since no related studies were identified that addressed only financial indicators in institutions of public health. Also, it is important to highlight the relevance of the study for dealing with issues of social interest and financial impact in public accounts, promoting openness to the financial resources that permeate FUHs, such as the value of constructing alternatives and tools for optimizing resources and health services under the SUS. It is important to point out that the main limitation of this research is that the relative evaluation through the DEA does not allow to substantiate the quality of the services generated from the financial resources employed since the distinction between efficient and non-efficient occurred from the supply ratio of more outputs with the same financial inputs. In terms of health, the need for a quality standard and responsibility for services provided to patients were not considered in this research, since it was assumed that all FUHs maintained the same standards in these regards. Another essential topic is data collection, which may have presented problems and distortions since the data used stemmed from the declared data by the FUHs to DATASUS and the information available on National Treasury. However, the information available from both sources has been assumed to be true, although the comparative efficiency assessment depends on the reliability of the data and therefore requires the need for its qualification. Given this fact, it is suggested as future research a deeper understanding of the results obtained with this model and in these institutions, with the insertion of different variables that could evaluate other dimensions of efficiency, such as care and teaching. This study was strongly structured with quantitative results, using statistical and mathematical techniques, and in view of this, it is recommended that the obtained results be complemented by qualitative researches and environmental evaluations (external and internal factors) with the analyzed FUH. It is also suggested to evaluate the financial efficiency of the FUHs on the impact of the adhesion to the Ebserh, with contemporary data, since the contracts and the adhesion to the company is recent by the institutions and the impacts may present themselves and influence later. Finally, in addition to the empirical results presented, it is believed that this study has contributed to indicate possibilities and restrictions regarding the performance of relative efficiency evaluations, presenting a methodological framework that helps the development of studies on efficiency in the public hospital environment.

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