Efficiency of public hospital services in the state of Pará: An analysis based on the DEA method

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ABSTRACT

The present study has as its theme "the efficiency of public hospital services in the state of Pará: an analysis based on the DEA method", and its objective is to evaluate the degree of efficiency of the public services offered by medium and high complexity hospitals in the state of Pará. The methodology adopted is a quantitative analysis based on the DEA model, which allows comparing characteristics of the physical, financial and organizational structure of 25 hospitals with more than 50 beds available in 2019, for the interpretation and discussion of the results. The analysis allowed, in a preliminary way, to show that the management of hospitals managed by social health organizations does not present such a differentiated pattern in relation to the average behavior of the group, even though such hospitals are using a diversified set of hospital equipment. It was also found that there is a differential in monetary costs to which hospitals are subject, about the contracting of services. Apparently, some hospitals of the Direct Administration incurred slightly higher costs than those directed by the social health organizations. The results also showed that both under the hypothesis of constant returns (CCR model – Charnes, Cooper, and Rhodes), and variable returns (BCC model – Banker, Charnes and Cooper), five hospitals exhibit maximum efficiency scores equivalent to or very close to 1, three of which are subject to direct administration by the State and only two whose management was subordinated to OSS. In view of the above, the main result of this study indicated that of the 12 decision-making units considered efficient in the DEA BCC model, only four had their management carried out by OSS, while in the DEA CCR model, of the five units that reached the maximum efficiency score, only two were subject to social health organizations. Therefore, it cannot be categorically stated that most hospitals managed by OSS can be considered efficient.

Keywords: Hospital services, Technical efficiency, Data Envelopment Analysis.

1 INTRODUCTION

Since the ratification of the Federal Constitution in 1988 (FC/88), in its article 196, the right to health has been disseminated as a principle that must be guaranteed by the State to all citizens, through social and economic policies that aim to certify universal and equal access to actions and services for its promotion, protection and recovery (BRASIL, 1988). Since then, a Unified Health System (SUS) has been created to reach all citizens in accordance with principles such as universality, equality, equity, transparency, and others (CARVALHO, 2013). To achieve these objectives, decentralization took place, which gave greater autonomy to states and municipalities, intensifying the participation of

society in the elaboration and supervision of public policies, generating greater concern in optimizing expenses and, consequently, the search for better efficiency in the services provided (VASCONCELOS *et al*., 2017).

Since Constitutional Amendment 19/1998, which reformulated the precepts and norms of direct and indirect Public Administration (autarchies, public companies), efficiency has been defended, in its article 37, as a principle that should govern both the powers of the Union and the States, Municipalities and the Federal District (FEDERAL, 1988). According to Silva *et al*. (2017a), efficiency matters because it allows us to compare the management of various inputs used in each operation and the results produced by it. In this sense, efficiency is understood as the ability to make the most appropriate use of resources (called *inputs* due to the methodology used in this work), with the objective of achieving the intended results (FONSECA; FERREIRA, 2009).

The idea behind the modernization of the Brazilian State was that Public Administration should be based on models that would guarantee greater managerial flexibility. In the context of hospital public management, such flexibility should reach several fronts, such as the acquisition of inputs, materials and equipment, the hiring and management of human resources, flexibility in financial management, among others. In addition, it advocated the need to encourage the implementation of a management based on results, combining user satisfaction with the quality of the services provided. According to authors such as Ibañez *et al*. (2001), such transformations would occur through greater public-private interaction. Thus, legal-administrative models were developed with the purpose of promoting a transformation of bureaucratic Public Administration into managerial Public Administration.

In the wake of these changes, the role of the Social Organization (SO) emerged, which would configure private, non-profit entities focused on the management of non-exclusive activities, more specifically services that comprise areas of education, health, culture, and scientific research (BRESSER-PEREIRA, 1998). The regulation came through the Master Plan for the Reform of the State Apparatus (MPRSA), implemented by the Ministry of Administration and State Reform (MARE) of the FHC government (1995-2002).

The State of São Paulo was a pioneer in the adoption of this new management model in hospital units (BARBOSA; ELIAS, 2010; IBAÑEZ *et al.*, 2001). Although it is still considered a controversial topic regarding the limits of the relationship between State and Society, some studies based on the experience of the State of São Paulo point to a competitive advantage of this model in relation to Direct Administration (BUENO, 2007).

That said, given that some regional hospitals in the State of Pará have adhered to the new management model based on SHO, the objective of the present study is to evaluate the degree of efficiency of the public services offered by medium and high complexity hospitals in the State of Pará.

The quantitative analysis based on the DEA method allows us to compare characteristics of the physical, financial and organizational structure of 25 hospitals with more than 50 beds available in 2019, whose management capacity is subordinated to the government policy coordinated by the Health Department of the State of Pará (SESPA).

2 LITERATURE REVIEW

This section aims to describe, analyze, and contrast some theoretical bases and empirical results that support the hypothesis investigated in this study: the management model based on OS is more efficient. To this end, we examine some recent results of studies focused on the analysis of the efficiency of hospital services, obtained through Data *Envelopment Analysis (DEA*).

An important study that guided the elaboration of the methodological structure of this work was that of Bueno (2007). Based on the DEA method, the author evaluated the efficiency of the new hospital management model by Social Health Organizations (SHO) in the State of São Paulo in 1999. The sample contained a total of 64 hospitals, of which 51 were under the Direct Administration of the São Paulo Health Department, 4 under the Direct Administration of other agencies, 7 were Autarchies and 2 were OSS. The results showed that the SHO-based management model is more efficient in terms of resource allocation.

Cesconetto, Lapa and Calvo (2008) evaluated the technical efficiency of services offered by public hospitals in Santa Catarina. The authors delimited the sample to 112 hospitals affiliated with the SUS. The objective was to infer efficient results from the perspective of resource management. Indices obtained through the DEA-BCC model indicated that only 23 hospitals could be considered efficient. The trial also provided guidance on which management models could raise the average efficiency of hospitals.

The study developed by Souza and Barros (2013) is also noteworthy. Using the DEA method, the authors analyzed the degree of efficiency in the allocation of public resources for hospital care in 2009 and 2010. The results revealed that of the 22 DMUs analyzed in 2009, only 6 were considered efficient, while in 2010, there were 7 units. Among the federated states, the research concluded that the State of São Paulo was the one that best allocated public resources to hospital care, while the State of Amapá was the one that had the worst performance in this area.

Another important test using the DEA method was that of Trivelato *et al*. (2015). The study sought to analyze the efficiency of the services provided both in public hospitals and in philanthropic and private hospitals. The aim was to verify which of these groups present better results in terms of resource management. A randomization procedure was used to select 35 hospitals in the State of Minas Gerais. Based on the stratified sample, they concluded that the most efficient results were associated

with public hospitals (80.09%), followed by private hospitals (75.62%), while philanthropic hospitals (64.87%) would be the least efficient.

Another research involving the theme was developed by Souza, Scatena and Kehrig (2016). The authors used the DEA method to investigate whether public hospitals in Mato Grosso could be considered more efficient than private hospitals. Using a sample of only 10 decision-making units (DMUs), the authors concluded that, about total efficiency, private hospitals were more efficient than public hospitals. However, as far as technical efficiency is concerned, all of them proved to be efficient, regardless of their nature.

Silva, Moretti and Schuster (2016) evaluated the productive efficiency of SUS-accredited hospitals in the southern region of Brazil in 2014 and the first half of 2015. The sample consisted of 139 hospitals located in municipalities with more than 100 thousand inhabitants in the states of Paraná (PR), Rio Grande do Sul (RS) and Santa Catarina (SC). First, the authors applied spatial *cluster* techniques to decompose the sample into groups with similar characteristics. The objective of the procedure was to identify the best combination of supplies required by hospitals, according to their location. The results showed that the maximum score was reached by 34% of the hospitals in SC, 35% of those located in PR and 35% in RS. They also concluded that 41% of the hospitals analyzed are efficient in terms of managing their resources.

In their study, which examines hospital efficiency in Brazilian regions through a regionalized DEA model, Silva *et al*. (2017a) found that the North Region was more inefficient compared to the other regions, since no state in the region reached a score of 1. On the other hand, the South Region was the one that showed the most efficient results, followed by the Southeast Region. It is important to note, in this study, that the authors used the following variables to measure *the inputs*: number of hospital beds and number of doctors and nurses; for the *outputs*, they used the number of hospitalized patients and hospital deaths.

The DEA model can also be used in combination with other methodologies, as was applied in the study conducted by Vasconcelos *et al*. (2017), which sought to analyze the efficiency of SUS care in 244 municipalities in Paraná. In methodological terms, the authors employed a technique that combines AED with the Free Disposal Hull (FDH) model. According to the authors, this combination would serve to better assist in the planning of resource allocation and in the making of managerial decisions related to hospital management.

Silva (2019) examined the technical efficiency of public services offered by regional hospitals in Rio Grande do Norte (RN). The author selected six hospital units that are part of the state network, two of each size, in 2014. The best performances were observed in large units, while small units were inefficient and without a problem-solving profile, which entails higher costs for the State of RN and reduces the quality of the service provided to the population.

Finally, employing exploratory analysis on a secondary dataset from the Ministry of Health, Garmatz, Vieira, and Sirena (2021) examined the technical efficiency of the services offered by teaching hospitals in Brazil. The scores extracted from the DEA method revealed that of the 29 large hospitals that made up the sample, only 12 can be considered efficient, therefore, 17 were located below the efficiency frontier. Linked to this, it is pointed out that when efficiency is linked to the legal nature, the DMU called business entities was the most efficient, followed by non-profit entities and Public Administration.

3 METHODOLOGY

3.1 DEA MODEL SPECIFICATION

The DEA (*Data Envelopment Analysis*) method presented in this study adopts hospitals as decision-making units (DMU). The basic assumption is that there is a direct relationship between the use and allocation of resources employed in hospital services and the results produced. Thus, a DMU is said to be inefficient if it produces, in a given period of time, a lower than average level of output, demanding the same set of resources used by the other units. Similarly, any DMU that produces a smaller volume of *output*, requiring a greater volume of resources than any other, will also be considered inefficient. Thus, it is assumed that an efficient DMU is one that is not dominated by any other, such that it is closer to the efficiency frontier (COELLI *et al*., 2005).

Since DMUs use multiple inputs to *generate multiple* outputs, producing comparable indicators is not a simple task, and it is necessary to resort to mathematical programming to find a non-trivial solution. In this sense, the methodology allows the efficiency of complex organizations to be compared, through the observation of best practices (FOCHEZATTO, 2010; SOUZA, 2008). In DEA language, these indicators assigned to each DMU configure scores, ranging from 0 to 1, representative of relative performance. An advantage of the methodology is that it allows us to assess, in each unit, what are the levels of demand for resources and products that would make them efficient.

According to Souza (2008) and Fochezatto (2010), based on the pioneering study by Charnes, Cooper and Rhodes (1978), the DEA method has some important characteristics that can be considered advantageous: there are few methods to analyze and measure the technical efficiency of organizations; Efficiency is not based on theoretical formulas, but on real data; through the DEA method, it is possible to more easily identify which DMUs are inefficient due to the excess of inputs and low level of product in each unit.

One can consider as a limitation the fact that in the DEA method, the choices of DMUs must respect the principle that they have the same specificities, perform the same tasks, and their variables must be the same, that is, the DMUs must be homogeneous. In order not to incur in specification errors, the selection of variables is also a point that must be considered. They should be chosen in such a way

as to represent the most relevant input-output relationship for organizations. Given this limitation, authors such as Fochezatto (2010) argue that the number of DMUs should be at least three times the number of variables selected in the model.

Complementary concepts or different forms of efficiency analysis should also be considered. Fochezatto (2010, p. 4) defines efficiency as "the relationship between the products resulting from a production process and the amount of resources used by the respective organization, defining a numerical measure". In this conceptual scope, changes in relative prices, organizational pattern and/or technological changes affect efficiency. Therefore, the concept is better understood if analyzed from the perspective of technical, allocative, and economic efficiency, the latter being a combination of the first two.

Trivelato *et al*. (2015), for example, argue that technical efficiency is that capable of demonstrating the ability to obtain the largest amount of product, given a fixed amount of inputs. Given the changes in relative prices, allocative efficiency, in turn, refers to the possibility of allocating inputs that must be carried out optimally. The relationship between these two concepts results in economic efficiency. In this sense, Souza (2008, p. 46) argues that "technical efficiency is related to the physical-operational aspect of production, while economic efficiency is concerned with the monetary aspect".

It should also be noted that the permanent search for efficiency is subordinated to the idea of *Benchmarking*. To this end, it is important to subject organizations to a continuous and systematic process of efficiency analysis. The systematic implementation of *Benchmarking* would encourage organizations to adopt routine managerial actions that promote the best results. For authors such as Souza (2008) and Silva *et al*. (2017b), it is an important managerial instrument that enables the improvement of the technical-economic performance of organizations, as it reveals what and how much must be modified in the input-output relationship for organizations to achieve efficiency.

As stated, Charnes, Cooper and Rhodes (1978) were pioneers in the formulation of the DEA model with constant returns. Its development took place through microeconomic hypotheses of the theory of production, in which technologies are subject to decreasing, constant and increasing returns of scale (VARIAN, 2006). In practice, a technology with constant returns indicates that a small variation in the feature set implies an equivalent proportional variation in the output. So, diminishing returns result in less-than-proportional variations in output; whereas a higher increment in output is observed in technologies with increasing returns.

As a result, the CCR model of Charnes, Cooper and Rhodes (1978) began to be directly compared to the *Constant Returns to Scale* (CRS) hypothesis, in which the estimated efficiency frontier is a linear function. In order to maximize the efficiency of each organization (hospital), taking into account the set of resources distributed by the context DMUs, the first CCR *ratio form model* designated by Coelli *et al*. (2005) can be formalized by:

$$\text{Max}_{\mathbf{u},\mathbf{v}} \quad (\mathbf{u}'\mathbf{q}_i/\mathbf{v}'\mathbf{x}_i), \tag{3.1}$$

$$\text{subject to} \quad \begin{aligned} &\mathbf{u}'\mathbf{q}_j/\mathbf{v}'\mathbf{x}_j \leq 1, \quad j = 1,2,...,I, \\ &\mathbf{u},\mathbf{v} \geq 0. \end{aligned} \tag{3.2}$$

In this formulation, each DMU *i* is faced with a set of *inputs and* outputs *quantified* by xi and qi, respectively. Then, the performance measure that must be maximized is a proportion resulting from the weighted sum between *N inputus* and M outputs, such that v and u configure weighting vectors, *of order N ×1 and M ×1, which are determined to satisfy the constraints associated with the set of inputs* and outputs of the other DMUs identified by *j* = 1, 2,...,*I*.

Although simple and intuitive, the lack of uniqueness presented by the CCR *ratio form* model configures a methodological deficiency that compromises its applicability. So, to avoid an infinite number of solutions, Coelli *et al*. (2005) impose the restriction $\mathbf{v}'\mathbf{x}_i = 1$, modifying the structure of the model.

$$\begin{aligned} &\text{Max}_{\mu,\mathbf{v}} && (\mu'\mathbf{q}_i), \\ &\text{subject to} && \mathbf{v}'\mathbf{x}_i = 1, \\ &&& \mu'\mathbf{q}_j - \mathbf{v}'\mathbf{x}_j \leq 0, \quad j = 1,2,...,I, \\ &&& \mu,\mathbf{v} \geq 0. \end{aligned} \tag{3.3}$$

Where μ is a vector *M ×1 with modified weights for the outputs*.

By means of duality in linear programming, it is possible to obtain a DEA model equivalent to (3.3):

$$\begin{aligned} &\text{Min}_{\theta,\lambda} && \theta, \\ &&& -\mathbf{q}_i + \mathbf{Q}\lambda \geq 0, \\ &&& \theta\mathbf{x}_i - \mathbf{X}\lambda \geq 0, \\ &&& \lambda \geq 0. \end{aligned} \tag{3.4}$$

Where θ is a scalar and λ is a vector *I ×1 of constants*.

According to Coelli *et al*. (2005), this model called *Envelopment Form* involves fewer constraints than the *multiplier form* (3.3), so it is less exhaustive to solve. The θ value $\in (0.1)$ *is a* score of the ith DMU efficiency, while 1−θ is the magnitude of the inefficiency. Since it is a problem of minimizing *inputs*, with constant outputs, the specification (3.4) is now better known as input-oriented RCC.

The CCR model is appropriate for cases where DMUs operate at or near optimal scale and are relatively homogeneous with each other. However, the CRS hypothesis is becoming less and less adherent with market imperfections, which can be observed by the differential size of the DMUs, by factors related to the production technology, by the amount of financial capital, among other aspects. Banker, Charnes and Cooper (1984) proposed an improvement in the conventional CCR model, making the hypothesis of constant returns more flexible.

Then, the BCC model with variable returns can be obtained by introducing the constraint $\mathbf{I1}'\lambda = 1$ em (3.4).

$$
\begin{aligned}
\text{Min}_{\theta,\lambda} \quad & \theta, \\
& -\mathbf{q}_i + \mathbf{Q}\lambda \geq 0, \\
& \theta\mathbf{x}_i - \mathbf{X}\lambda \geq 0, \\
& \mathbf{I1}'\lambda = 1, \\
& \lambda \geq 0.
\end{aligned}
\qquad (3.5)
$$

Where I1 is a unit vector $I \times 1$.

According to Coelli *et al*. (2005), the convexity constraint, $I1'\lambda = 1$, reduces the set of production possibilities, $\mathbf{T} = \{(\mathbf{x},\mathbf{q}) : \mathbf{q} \leq \mathbf{Q}\lambda, \mathbf{x} \geq \mathbf{X}\lambda\}$, as well as converts a technology with constant returns into variable returns, satisfying the hypotheses of increasing or decreasing returns of scale.

According to the study carried out by Fochezatto (2010), the DEA BCC model is also known as the Variable Return to Scale (VRS) model because it considers the increasing and decreasing returns of the latter, which differentiates it from the model with constant returns, previously demonstrated. This method alludes to its creators Banker, Charnes and Cooper and is a derivation of the CCR model plus the convexity constraint, which "reduces the set of viable production possibilities and converts a constant gain-of-scale technology into a variable gain-of-scale technology" (SOUZA, 2008, p. 54). Cesconetto (2008) presents yet another characteristic of the BCC model, identifying management inefficiency, associated with the managerial ability of organizations.

3.2 DATA AND VARIABLES

Chart 1 – Variables selected to compose the DEA model

Acronym	Description of Variable	Division	Unit	Class
LTS	Beds available	CNES-LT	Unit	Input
HTH	Number of hours worked in hospital	CNES-PF	Hours	Input
EQP	Number of equipment available	CNES-EQ	Unit	Input
DINT	Days of hospitalization	SIH-RD	Days	Output
CTINT	Total cost of hospitalization	SIH-RD	R$/year	Output
CMINT	Average cost of hospitalization	SIH-RD	R$/Day	Output

Source: DATASUS/Ministry of Health.

4 RESULTS AND DISCUSSIONS

4.1 EXPLORATORY DATA ANALYSIS

The exploratory analysis applied to the dataset aims to draw a preliminary diagnosis about the complexity of services in large hospitals. To this end, the sample containing 25 public hospitals was stratified according to the supply of beds in 2019. It is expected that both resource-related variables and those selected to represent the product of hospital services will increase with the size of hospitals, measured by the number of beds.

Table 1 provides a statistical summary of the variables selected to compose the DEA model. The first three relate to the use of resources (*inputs*), while the last two refer to *outputs*. Table 1 shows a frequency distribution organized according to the size of the hospitals. It shows, for example, that: 13 hospitals made 80 beds available, on average, in 2019; aggregating approximately 65,894 hours of work involving specialized professionals (doctors, nurses, nursing technicians, etc.). This class had an average of 2,415 pieces of hospital equipment; with services requiring a total of 14,351 days of hospitalization, implying an average cost equivalent to R$ 181.14 patient/day.

Table 1 – Statistical summary of the variables that make up the DEA model

Class	Frequency	LTS	HTH	EQP	DINT	CMINT
50 to 100	13	80,1	65.894	2.414,9	14.351	181,14
100 to 150	5	114,4	72.049	1.657,6	18.671	223,58
150 to 200	3	178,0	151.891	4.914,7	40.409	236,64
200 to 300	2	242,5	279.713	6.055,0	59.798	291,97
300 to 400	0	ON	ON	ON	ON	ON
400 to 500	1	478	517.068	23.328	81.260	381,28

Note. Mean of the variables. Available beds (LTS), Number of hours worked in hospital (HTH), Number of equipment (EQP), Days of hospitalization (DINT) and Average cost of hospitalization (CMINT).

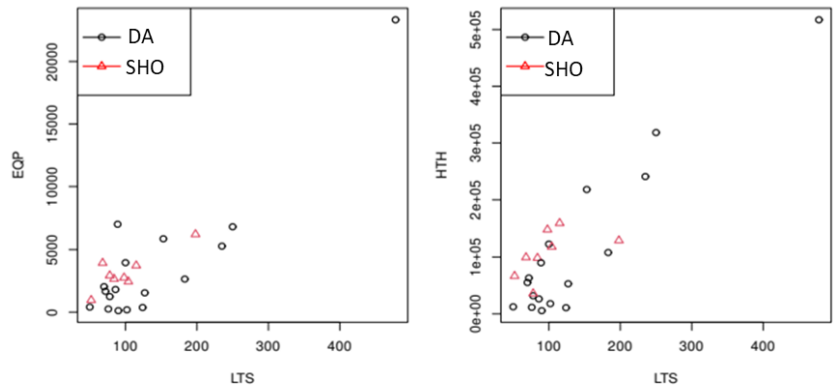
Source: Results of the research and prepared by the authors.

Table 1 also shows the presence of an outlier associated with the characteristics of a large hospital. Fundação Santa Casa is a maternity hospital located in Belém do Pará, specializing in child

health. As shown in Figures 1 and 2, its performance evaluated in terms of resource management or cost results is positively discrepant in relation to the average standard of the other hospitals.

The first scatter plot in Figure 1 emphasizes a positive, linear correlation between equipment use (EQP) and hospital size as measured by the number of beds (LTS). A similar pattern is also identified from the correlation between the working hours (HTH) of specialized professionals and the size of hospitals. The preliminary results also show that the management of hospitals managed by social health organizations does not present such a different pattern in relation to the average behavior of the group, even though these hospitals are employing a more diversified set of hospital equipment. In addition, most hospitals have 50 to 200 beds. Above that, there are three hospitals of direct administration that coordinated a group of professionals who required between 200 and 300 thousand hours worked. The discrepant point corresponds to the Santa Casa do Pará Foundation, managed by the Direct Administration, making 478 beds available in 2019.

Figure 1 – Dispersion of resource-related variables (*inputs*)



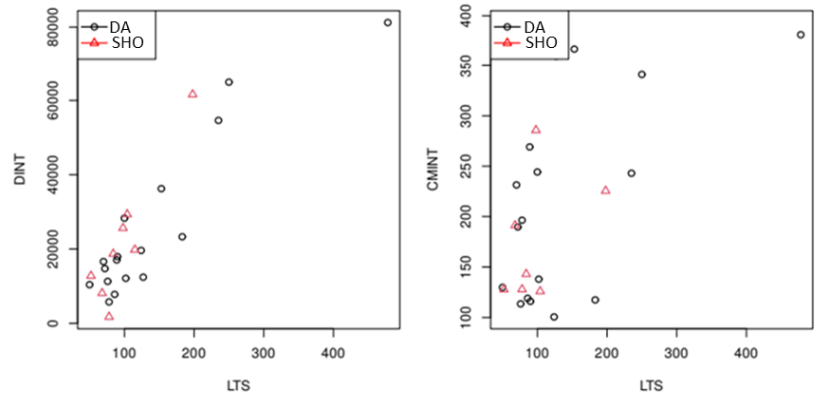
Source: research result and prepared by the authors.

Figure 2, where the *output variables* are represented, preliminarily identifies a nonlinear relationship between the variable days of hospitalization (DINT) and the number of beds (LTS). An apparent non-linearity is associated with the rate of change in the number of days of hospitalization (DINT), which increases at decreasing rates with the size of the hospital, which is consistent with the trajectory of a concave curve. Thus, preliminary results indicate that the larger and more complex the hospital, the shorter the number of days of hospitalization tends to be. This non-linearity indicates that the DEA model with variable returns (BCC) may offer a better fit than the model with constant returns (CCR).

When the analysis is directed to the graph that represents the average cost per day of hospitalization (CMINT), a greater discrepancy is observed in the non-linear relationship. This result is explained by the differential of monetary costs to which hospitals are subject about the contracting

of services. Apparently, some hospitals of the Direct Administration incurred costs slightly higher than those directed by the social health organizations.

Figure 2 – Dispersion of the representative variables of the outputs

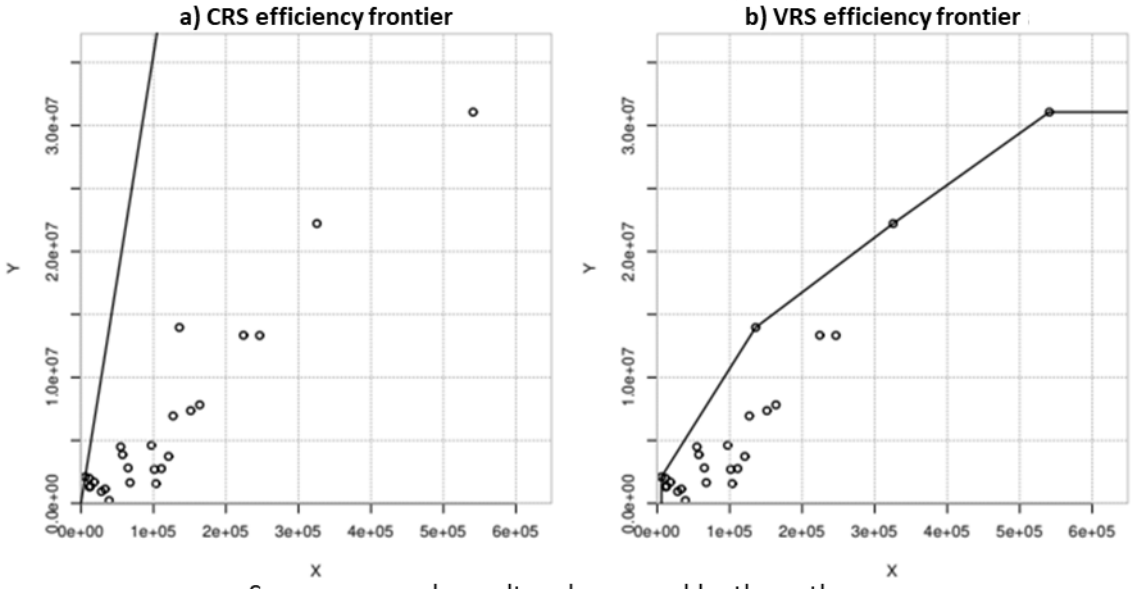


Source: research result and prepared by the authors.

4.2 RESULTS OF THE DEA MODEL

Technical efficiency is a distance relative to the efficiency frontier delineated by those units considered to be references, or following the language used in the DEA method, they are DMUs that offer the best practices and serve as *Benchmarking* for the others. As mentioned, this study is composed of 25 evaluation units represented by medium and large public hospitals operating in the State of Pará in 2019.

Figure 3 – Efficiency frontier of the DEA model with constant returns and scale variables



Source: research result and prepared by the authors.

Figure 3 shows two efficiency frontiers estimated based on the representative variables selected to characterize the public management of the 25 hospitals in 2019. Noticeably, the boundary with

Variable Returns to Scale (VRS) is better suited to the dispersion of the data, which in a way corroborates the hypothesis of non-linearity present in the input-output relationship mentioned above.

As shown in Table 2, this criterion was used to establish a ranking of the hospitals evaluated in 2019. For each DEA model, it offers a generalized view of the size of the inefficiency. Under the hypothesis of variable returns of scale (VRS), the results show that 12 hospitals reached maximum efficiency, with a score equivalent to 1. In this context, Santa Casa de Misericórdia do Pará and Hospital de Clínicas Gaspar Viana, both managed by the Direct Administration, make up the group with the best practices in 2019.

Table 2 – Efficiency scores of the DEA model with constant returns and scale variables

Hospital	Management	Beds	CRS	VRS	Ranking
Hospital Casa de Misericórdia do Pará	TO	478	1,000	1,000	First
Hospital de Clínicas Gaspar Viana	AD	250	1,000	1,000	2nd
Metropolitan Hospital for Urgency and Emergency	US	198	1,000	1,000	Third
Hospital Regional do Baixo Amazonas	TO	153	0,982	1,000	4th
Galileo State Public Hospital	US	104	1,000	1,000	5th
Araguaia Regional Public Hospital	TO	100	0,938	1,000	6th
Trans-Amazonian Regional Public Hospital	US	98	0,942	1,000	7th
Santo Antônio Maternity Hospital	TO	90	1,000	1,000	8th
Eastern Pará Regional Hospital	TO	70	0,795	1,000	9th
Thailand General Hospital	US	52	0,934	1,000	10th
Hospital Regional Olímpio Cardoso da Silveira	TO	50	0,925	1,000	11th
Hospital Ophir Loyola	TO	235	0,875	0,999	12th
Hospital Dr. Afonso Rodrigues	TO	76	0,718	0,961	13th
Hospital Julia Sefer	TO	124	0,775	0,957	14th
Regional Hospital of the Southeast of Pará	US	115	0,766	0,897	15th
Hospital Jean Bitar	TO	72	0,730	0,858	16th
Octávio Lobo Children's Oncology Hospital	TO	89	0,662	0,853	17th
St. Anthony's Hospital	TO	102	0,671	0,833	18th
Marajó Public Hospital	US	84	0,715	0,830	19th
Divine Providence Hospital	TO	127	0,781	0,800	20th

Regional Maternal and Child Hospital of Barcarena	US	68	0,384	0,756	21st
Hospital Abelardo Santos	TO	78	0,301	0,641	22nd
Abelardo Santos Public Hospital	US	78	0,081	0,641	23rd
Hospital de Conceição do Araguaia	TO	86	0,369	0,581	24th
Hospital Regional de Tucuruí	TO	183	0,513	0,516	25th

Source: Result of the research and prepared by the authors

Also observing the same table, with regard to the specification with constant or variable returns, it can be seen that the units occupying the positions of 1st, 2nd and 3rd in the ranking, as well as those occupying the 5th and 8th positions, exhibit an efficiency score equal to 1. It is also analyzed that of the 25 DMUs, only 5 (equivalent to 20%) reached maximum efficiency in the constant returns model, while 12 DMUs were efficient with the variable returns model, which is equivalent to 48% of the total sample.

Of the 12 units that exhibit maximum efficiency in the model with variable returns, only 4 are managed by social health organizations (OSS). In the model with constant returns, of the 5 units that exhibit maximum efficiency, only 2 are managed by OSS. In this sense, the Metropolitan Hospital for Urgency and Emergency and the Galileu State Public Hospital are among the units that reached maximum efficiency in 2019.

Analyzing Table 2, it can be seen that some units are located far below the degree of efficiency in both models used in this research, and thus can be considered inefficient, as in the case of the Regional Hospital of Conceição do Araguaia and the Regional Hospital of Tucuruí, which were analyzed from the perspective of the DEA BCC model and obtained scores of 0.581 and 0.516, respectively. It can be concluded that these units, along with others considered inefficient, did not make optimal use of the resources made available by the SUS.

It was also observed that more significant changes occurred from the middle class. For example, the Regional Public Hospital of Eastern Pará, managed by the Direct Administration, has a score of 1 and occupies the 9th position in the ranking *when analyzed from the perspective of the variable returns model and now occupies the 12th position in* the ranking *of the model with constant returns.*

Substantial changes also occurred in the results of the two models of the performance evaluation to which the Dr. Afonso Rodrigues Hospital, located in Igarapé-Miri, were submitted. While this unit resulted in a score of 0.961 using the DEA BCC model (a considerable score close to the maximum efficiency frontier), it reached a score of 0.718 when analyzed under the DEA model with constant returns. The same was observed in the Julia Sefer Hospital, a unit managed by the Direct

Administration, which went from a score of 0.957 in the model with variable returns to a score of 0.775 in the model with constant returns.

5 FINAL THOUGHTS

The present study aimed to evaluate the degree of efficiency of public services offered by medium and high complexity hospitals in the State of Pará in 2019. The quantitative analysis, based on the DEA method, allowed the generation of technical efficiency indicators based on the characteristics of the physical, financial and organizational structure of 25 hospitals with more than 50 beds available, whose management was subordinated to the Health Department of the State of Pará (SESPA).

Among the 25 hospitals analyzed, 8 units are coordinated by social health organizations and 17 are managed directly by the Public Administration. The main result of this trial indicated that of the 12 decision-making units considered efficient in the DEA BCC model, only 4 had their management carried out by OSS, while in the DEA CCR model of the 5 units that reached the maximum efficiency score, only 2 were subject to social health organizations. Therefore, it cannot be categorically stated that most hospitals managed by OSS can be considered efficient.

Another issue that can be deepened concerns the limits of the time interval applied in this essay. In specific cases, changes occurred in the relative classification of decision-making units (DMU). In the sample context, 4 hospitals that occupy a certain position in the efficiency ranking generated by the DEA CCR model showed a significant change in the efficiency ranking generated by the DEA BCC model. It is important to note that these changes occurred from the median of the distribution, therefore, they did not affect the classification of DMUs up to the 8th position in the efficiency ranking. Nevertheless, it is important to carry out a more consistent analysis, covering a wider period of time. Such considerations open the field for the investigation of new hypotheses, based on future trials.

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