# PERFORMANCE ANALYSIS OF BRAZILIAN PUBLIC AND PHILANTHROPIC HOSPITALS

# ANÁLISE DO DESEMPENHO DE HOSPITAIS PÚBLICOS E FILANTRÓPICOS BRASILEIROS

*Antônio Artur de Souza[1], Ewerton Alex Avelar[1], Alisson Maciel de Faria Marques[2], Douglas Rafael Moreira[3], Osmar Ferreira da Silva[1], and Daniele Oliveira Xavier[1]*

[1] Department of Administrative Sciences, FACE/UFMG; [2] Secretary of Health of Minas Gerais; [3] Université du Québec – École de Technologie Supérieure

---

**Abstract**

This paper presents the results of a research that aimed at identifying optimal performance standards of Brazilian public and philanthropic hospitals. In order to carry out the analysis, a model based on Data Envelopment Analysis (DEA) was developed. We collected financial data from hospitals' financial statements available on the internet, as well as operational data from the Information Technology Department of the Brazilian Public Health Care System – SUS (DATASUS). Data from 18 hospitals from 2007 to 2011 were analyzed. Our DEA model used both operational and financial indicators (variables). In order to develop this model, two indicators were considered inputs: Values (in Brazilian Reais) of Fixed Assets and Planned Capacity. On the other hand, the following indicators were considered outputs: Net Margin, Return on Assets and Institutional Mortality Rate. As regards the proposed model, there were five hospitals with optimal performance and four hospitals were considered inefficient, upon the analysis of the variables, considering the analyzed period. Analysis of the weights indicated the most relevant variables for determining efficiency and scale variable values, which is an important tool to aid the decision-making by hospital managers. Finally, the scale variables determined the returns on production, indicating that 14 hospitals work with scale diseconomies. This may indicate inefficiency in the resource management of the Brazilian public health-care system, by analyzing this set of proposed variables.

**Key Words**: Public and philanthropic hospitals; Data Envelopment Analysis (DEA); Financial and operational indicators.

**Resumo:**

Este artigo apresenta os resultados de uma pesquisa que visou identificar padrões ótimos de desempenho empregados por hospitais públicos e filantrópicos brasileiros. Para realizar tal análise, desenvolveu-se um modelo com base na análise envoltória de dados (*Data Envelopment Analysis* – DEA). Foram coletados dados financeiros a partir das demonstrações financeiras dos hospitais disponíveis na Internet, assim como dados operacionais coletados por meio do Departamento de Informática do Sistema Único de Saúde (DATASUS). No total, foram analisados dados de 18 hospitais entre os anos de 2007 e 2011. O modelo DEA desenvolvido considerou simultaneamente indicadores (variáveis) operacionais e financeiros. No desenvolvimento desse modelo, foram considerados como inputs (entradas) os seguintes indicadores: Valor (em R$) empregado no Imobilizado e Capacidade Planejada. Por sua vez, foram utilizados como outputs (saídas) os seguintes indicadores: Margem Líquida, Retorno Sobre o Ativo e Taxa de Mortalidade Institucional. No que tange ao modelo proposto, considerando o período analisado, cinco hospitais apresentaram um desempenho ótimo e quatro hospitais foram considerados ineficientes ao analisar o conjunto de variáveis utilizadas. Por meio da análise dos pesos foram identificadas as variáveis mais relevantes para a determinação da eficiência e dos valores da Variável de Escala, o que constitui uma importante ferramenta no auxílio da tomada de decisão por parte dos gestores hospitalares. Por fim, as variáveis de escala determinaram os retornos de produção, indicando que 14 hospitais trabalham com deseconomias de escala. Isto pode indicar uma ineficiência na gestão dos recursos na saúde pública brasileira, ao menos analisando o conjunto de variáveis propostas.

**Palavras-chave:** Hospitais públicos e filantrópicos; Análise envoltória de dados (*Data Envelopment Analysis* – DEA); Indicadores operacionais e financeiros.

## Introduction

Access to health services in Brazil has been democratized by the creation of the Unified Health Care System (in Portuguese, SUS-*Sistema Único de Saúde*) in 1990. This system was created to serve the entire population, thus any Brazilian can benefit from its free services.

In addition to the public institutions that are part of SUS, the Brazilian health-care system also relies on private and charitable hospitals. Currently, according to the National Register of Health Facilities, 27.70% of health facilities in Brazil - including hospitals, emergency units and other institutions - are public, 2.78% are philanthropic and 69.52% are private. Most of these facilities are in the southeast region of Brazil, and, although this region have only 4 of the 27 Brazilian states, it holds 42.39% of all health facilities.

In order to meet Brazilian population demands, spending in health care grows every year, both in public and in private spheres. Thus, the per capita spending by public administration on consumer goods and health services increased by 183.64% between 2000 and 2009, together with the household spending. This increase was approximately 141.89% over the analyzed period.

Due to the large amounts of resources allocated to health-care, evaluating the performance of organizations in this sector is of great importance (PEKCAN et al., 2011). According to Chilingerian and Sherman (2010), hospitals are under external pressure (competition, regulation, etc.), which is increasing throughout the world to improve their performance. In addition, Guerra (2011) points out that Brazilian hospitals usually face a series of management difficulties, especially from the financial perspective.

In this regard, Chilingerian and Sherman (2010) emphasize that the proper measure of hospital performance is very relevant. Thus, they point out that Data Envelopment Analysis (DEA) may be seen as an alternative that holds great potential for measuring hospital performance. Authors such as Cesconetto et al. (2008), Souza et al. (2012) and Guerra et al. (2012) emphasize the importance of using DEA models in the analysis of hospital performance, as well as the importance of considering both operational and financial perspectives for measuring such performance.

Given the above, this paper presents the results of a research that aimed at identifying optimal performance standards of Brazilian public and philanthropic hospitals. In this regard, the following specific objectives were proposed: (a) identify operating indicators (variables) that reflect the performance of hospital organizations; (b) identify financial indicators (variables) related to the financial performance of these organizations; (c) develop a DEA model that allows for analyzing the performance of hospitals from the financial and operational perspectives; and (d) discuss of the results for hospital management and for performance improvements.

This article is divided into 5 sections (starting with this introduction). Section 2 discusses important concepts for the proper understanding of the research presented in this paper. Section 3 describes the methodology used in the research. After that, the results are presented and discussed (in section 4). Finally, in section 5, the conclusions of this research are presented, followed by the bibliographic references.

## Theoretical framework

### *Performance of hospital organizations*

Electricity Silva et al. (2009) define hospitals as organizations that provide services such as diagnostic, prevention, treatment, accommodation, education, research, etc. Despite its importance in contemporary society, hospitals usually face serious management problems that negatively influences the performance of its core functions to the society (GUERRA, 2011). Lima Neto (2011, p. 270) states "a hospital's organizational health is crucial for it to provide adequate health care services to the population".

From a financial perspective, Souza et al. (2009) highlight that hospitals usually face serious management problems, displaying deficiencies related to the financial performance. In addition, Gruen and Howarth (2005) emphasize the importance of proper financial management in order to maintain the hospital's activities. These authors also emphasize the use of information from financial statements to help hospital managers improve the financial performance of the organizations.

Gruen and Howarth (2005) point out that information from financial statements can help hospital managers significantly. They emphasize the use of financial indicators is generally essential for this task. According to Tavares and Silva (2012), the analysis of financial indicators is rather common, and these indicators are obtained primarily from the relationships between the values extracted from the financial statements. Among the existing main groups of financial indicators, those related to profitability and cost effectiveness can be mentioned as crucial to evaluating the performance of an organization (ASSAF NETO, 2009; GITMAN, 2010).

However, other variables besides the financial ones are important to comprehensively understand hospital performance (WANG et al., 2001; VELOSO; MALIK, 2010). In this regard, authors like Cesconetto et al. (2008) demonstrate the importance of considering not only the financial dimension, but also hospitals' operational dimension in order to measure the performance of these organizations adequately.

Confirming the above, Guerra et al. (2012) emphasize that the analysis of hospital performance can be carried out more comprehensively if one considers simultaneously the financial and the operating perspective of hospitals. Thus, Guerra et al. (2012) used in their study financial and operating indicators simultaneously, and employed a model in order to operationalize the analysis.

## *Data Envelopment Analysis (DEA)*

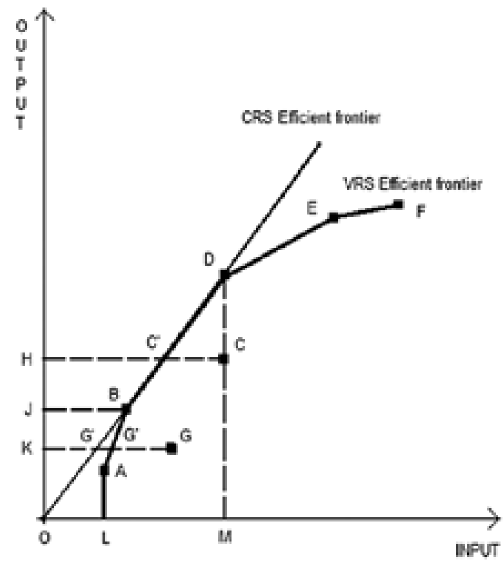
DEA is a special technique of linear programming that aims at developing an empirical boundary of productive efficiency by measuring the Decision Making Units efficiency operating at ideal performance standards (NAYAR; OZCAN, 2008). This method seeks to optimize the relationship between inputs and outputs, assigning weights to this relationship, and treating each observation (i.e. each DMU) individually, in order to achieve maximum efficiency in contrast to other units in the sample (CESCONETTO et al. , 2008; FLOKOU et al., 2011). This model deals with multiple outputs and inputs to create a production function that correlates these outputs and inputs in order to effectively measure the relative performance of each DMU, provided they constitute a homogeneous group, producing under the same technology and having similar, ultimate goals (KAO et al, 2011;. SULKU, 2011; CESCONETTO et al., 2008).

In contrast to the usual parametric approaches, a DEA model optimizes each observation individually, aiming at building a linear boundary comprising the set of DMUs that are considered efficient (CESCONETTO et al., 2008). DMUs located on the efficient boundary have maximum outputs, for a given minimum level of inputs, among all other DMUs (HU et al., 2012). A DMU has an ideal performance when it reaches an efficiency score of 1.0; thus, DMUs found outside this boundary have efficiency scores between 0 and 1.0 (MARK et al., 2009).

This boundary can be designed following two major methods: the CCR, drawing on Charnes, Cooper and Rhodes (1978), and the BCC, drawing on Banker, Charnes and Cooper (1984) (SULKU, 2011). The CCR model assumes that a linear change in inputs remains proportional to outputs, that is, it assumes that DMUs operate with constant returns to scale (MARK et al, 2009;. HU et al, 2012). The BCC model, in turn, assumes that the production units operate with variable returns to scale, that is, increasing one unit of input causes different increases outputs (MARK, et al., 2009). Thus, according to the latter model, the production technology may display constant increasing or decreasing returns to scale (SULKU, 2011).

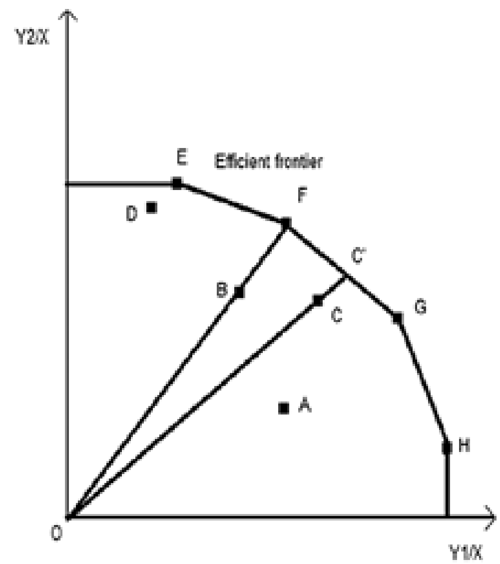
Figure 1 illustrates the relationship between the efficiency frontiers of the CCR model - also called CRS model (Constant Returns to Scale) - and of the BBC model - also called VRS (Variable Returns to Scale) - considering seven DMUs (A, B, C, D, E, F, G). As indicated in the figure, it is possible to note DMUs B and D are efficient according to both the CRS and the VRS models. DMUs A, E and F are classified as inefficient on the CRS model but are considered efficient on VRS model. As the CRS model assumes constant returns to scale, any variation in inputs results in a proportional variation in outputs, thus the graph of this model is a linear surface. The RSV model, on the other hand, assumes variable returns on scale, which causes the graph of this model to be a nonlinear surface. Finally, DMUs C and G are considered inefficient on both models.

Figure 2 is a graphical representation of the efficiency frontier in an output-oriented DEA model. DMUs E, F, G, H are efficient and are on the frontier (their efficiency is equal to 1) DMUs A, B, C, D are inefficient and are below the frontier. As for DMU B, it would be necessary for it to change its production aiming at being similar to F. In this case, DMU F is the "target" of DMU B. As regards DMU C, its target is DMU C', and the distance between C and C' corresponds to the inefficiency of DMU C. C and C' corresponds to the inefficiency of DMU C.




Source: Sozen et al. (2012)

**Figure 1: Comparison of efficient frontiers on CRS and VRS models.**




Source: Sozen et al. (2012)

**Figure 2: Output-oriented efficiency frontier**

## *Using DEA to study hospitals*

A The DEA model is one of several tools for the study of hospital performance (FLOKOU et al, 2011; MARK, et al., 2009). According to Chilingerian and Sherman (2010), this non-parametric model, which aims at analyzing the efficiency of DMUs, can be used in hospital performance analysis and may also contribute significantly to improving the management of these organizations. Thus, it is possible to note the use of DEA models throughout the world for analyzing hospital efficiency.

In Portugal, for example, Simões and Marques (2009) analyzed the efficiency of 68 Portuguese hospitals. With respect to the model used in their research, they sought to take into consideration the importance of the effect of congestion in efficiency measurement, which occurs when an increase in inputs generates a decrease in produced outputs. That study used financial and operating variables for evaluating the efficiency.

Hu et al. (2012) analyzed Chinese regional hospitals between 2002 and 2008 using a DEA model. They intended to verify the impact of health insurance reform of the New Rural Cooperative Medical System NRCMS in the efficiency of the analyzed hospitals. They also used regression analysis as a supplementary means to analyze efficiency. Finally, they concluded that the reform the NRCMS had significant effects on the increased efficiency of the analyzed hospitals.

Sulku (2011), in turn, studied the impacts of government's health reform in Turkey (called "Health Transformation Programme") on the efficiency of the Turkish public hospitals. She studied hospitals in 81 provincial markets in the years 2001 and 2006, which correspond to the years respectively before and after the Health Transformation Programme. She concluded that the Health Transformation Programme was successful and that there was an increase in the technical efficiency of the analyzed hospitals.

Ouellete and Vierstraete (2002), using a DEA model, studied 15 emergency units of 15 hospitals in Montreal (Canada) in two periods: 1997-1998 and 1998-1999. In this study, the authors tried a new approach to the use of a DEA model by taking into account the quasi-fixed nature of variables used as inputs.

In Brazil, drawing on Araújo et al. (2013), the use of DEA models for analyzing hospital efficiency seems to be increasing more recently, when compared to other countries. The authors studied 20 Brazilian private for-profit hospitals using this technique. This particular type of hospital was chosen because the authors considered that there was a gap in Brazilian studies of for-profit hospitals. The study comprised only large hospitals and the authors emphasized operating variables in the design of the model.

Guerra et al. (2012), in turn, studied 26 Brazilian public hospitals using data from 2008. In this study, the authors used financial and non-financial data for the estimation of six DEA models in order to analyze the efficiency of hospitals. In addition to the efficiency analysis, this study contributed to the identification of those financial and operational variables that can be used to study the performance of the Brazilian hospitals.

Moreover, Lobo et al. (2014) studied 104 public and philanthropic university hospitals in Brazil, also using the DEA model. The authors sought to evaluate the efficiency through variables not directly controllable by managers - such as Teaching dedication and Teaching intensity. Complementarily, the authors also used logistic regression analysis to assess the behavior of the analyzed variables, obtaining satisfactory results from the efficiency measurement of the analyzed hospitals.

Finally, after this brief account of studies that used the DEA model to evaluate hospital efficiency, the next section will present the particularities of the proposed model. Additionally, the methodological process with respect variables treatment and the analysis of results will be presented below.

## Methodology

It is possible to classify the research presented in this paper as descriptive, with a quantitative approach. According to Gil (2008), a descriptive research aims at describing the characteristics of certain populations or phenomena. In addition, Munhoz (1989) points out that this kind of research aims at understanding the phenomenon's behavior, not necessarily focusing the analysis on its causes and effects or attempting to interpret them.

As for the quantitative focus, drawing on Alyrio (2008), it is employed for quantitatively identifying knowledge level, opinions, impressions, habits, and behaviors: when trying to observe the range of the theme regarding a product, service, communication or organization from the standpoint of the researched universe. According to Hair et al. (2005), quantitative data are measurements in which numbers are used for directly representing the properties of something. Since they are registered directly as numbers, data are suited for statistical analysis.

In order to carry out the research, operational data were collected from the Information Technology Department of the Brazilian Public Health Care System – SUS (DATASUS) and financial data from the hospitals' financial statements available on the Internet. The data used in this study was obtained from non-probability sampling. Following Mattar (1996), in non-probability sampling the selection of population elements for the sample depends at least partly on the researcher's judgment. In total, data on 18 philanthropic and public Brazilian hospitals from 2007 to 2011 were collected. Some characteristics of these organizations are shown in Table 1. Please note that codes were used in order to protect sensitive data from the studied hospitals. It should be also noted that both the number of hospitals and the period of analysis were defined mostly due to data availability.

| Code | Number of beds* | Legal nature | Federation Unit (FU) |
|---|---|---|---|
| DMU 1 | 446.00 | Philanthropic | São Paulo |
| DMU 2 | 108.00 | Public | Rio Janeiro |
| DMU 3 | 324.40 | Public | Minas Gerais |
| DMU 4 | 587.00 | Public | São Paulo |
| DMU 5 | 217.00 | Philanthropic | São Paulo |
| DMU 6 | 146.00 | Philanthropic | Paraná |
| DMU 7 | 315.60 | Public | São Paulo |
| DMU 8 | 217.60 | Public | São Paulo |
| DMU 9 | 239.80 | Philanthropic | Espírito Santo |
| DMU 10 | 1171.20 | Philanthropic | São Paulo |
| DMU 11 | 909.20 | Philanthropic | Minas Gerais |
| DMU 12 | 304.20 | Philanthropic | Alagoas |
| DMU 13 | 410.80 | Philanthropic | Ceará |
| DMU 14 | 1054.60 | Philanthropic | Rio Grande do Sul |
| DMU 15 | 39.60 | Philanthropic | São Paulo |
| DMU 16 | 141.60 | Philanthropic | São Paulo |
| DMU 17 | 272.00 | Philanthropic | São Paulo |
| DMU 18 | 900.60 | Philanthropic | São Paulo |

Note: *Average number of beds between 2007 and 2011.

**Table 1: Characteristics of the organizations in the sample**

In order to analyze the data, the descriptive statistical technique was employed. According to Collis and Hussey (2005), this technique focuses on summarizing, describing or presenting data. In this regard, Freund and Simon (2000) emphasize that descriptive statistics comprises the management of data to summarize or describe them, trying not to infer beyond what the data inform. The most common ways to summarize or describe the data is using tables or graphs. However, in order to group the data, it is necessary to classify them according to their nature.

Thus, a DEA model was used to analyze the collected data. More specifically, in the study described in this article, an output-oriented BCC DEA model was employed. This model has the following formulation:

$$Min \sum_{i=1}^{m} v_i x_{i0} + v_0 \qquad (1)$$

Subject to:

$$\sum_{r=1}^{s} u_r y_{r0} = 1, \qquad (2)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + v_0 \leq 0, j = 1, \ldots, n \qquad (3)$$

$v_0$ unrestricted

$u_r \geq 0, r = 1, \ldots, s$

$v_i \geq 0, i = 1, \ldots m$

The objective function (1) of the model above aims at minimizing the virtual input and the scale variable $v0$. The virtual input can be defined as a hypothetical DMU resulting from the best individual variables from the set of DMUs analyzed. Component $vi$ is the weight (multiplier) associated with each input $xi0$. Restriction (2) sets the virtual output as a constant equal to 1 (normalization restriction), and along with the subsequent restriction (3), determines that the virtual input plus the scale variable $v0$ must be higher than or equal to the virtual output.

The production function of each DMU can be analyzed building on variable $v0$, which indicates the respective scale revenue. Increasing returns to scale are found in production functions with $v0 > 0$, and decreasing returns to scale are found in production functions with $v0 < 0$.

Finally, the DEA model was used to analyze the collected data. More specifically, in the study described in this paper a BCC model of DEA oriented to outputs was employed. As discussed above, the BCC model uses variable returns to scale, that is, it disregards the proportional relationship between inputs and outputs, assuming that the analyzed DMUs have different sizes. As for the outputs orientation, it assumes the amount produced can be maximized, not necessarily modifying the amount of inputs. In order to implement this technique, the Integrated System for Decision Support (*Sistema Integrado de Apoio à Decisão* - SIAD) was employed (ÂNGULO MEZA et al., 2005).

## Results

### *Formulations*

In the research presented in this paper, we developed a DEA model as shown in Table 2. The model's inputs and outputs were proposed in order to identify the hospital organizations with the best performance. The following variables were considered inputs in the proposed model: (i) Values (in Brazilian reais) under Fixed Assets (VFA) (financial variable); and (ii) Planned Capacity (PC) (operational variable). As for fixed assets, we considered the value applied to this group (type) of assets in Brazilian Reais (R$). The planned capacity, on the other hand, was estimated according to the number of beds installed in the hospitals.

| ***Inputs*** | ***Outputs*** |
|---|---|
| Fixed assets (in R$) | Net Margin |
| | Return on Assets |
| Planned Capacity | Institutional Mortality Rate |

Source: our own developed model

**Table 2: Inputs and Outputs of the model**

Moreover, the following financial and operational indicators were considered outputs in the proposed model: (i) Net Margin (NM), (ii) Return on Assets (ROA) and (iii) Institutional Mortality Rate (IMR). The NM measures the percentage of each currency unit from sales that remains after deducting all costs and expenses, including interest, taxes and dividends, as shown in Equation 1 (GITMAN, 2010). As for the ROA indicator, Assaf Neto (2009) points out that it features the return achieved by the company's net income on its own assets (the formula for calculating it is shown in Equation 2). Finally, the IMR is a key indicator of effectiveness, which shows the ratio between the number of deaths that happened after, at least, 24 hours of admitting patients in the hospital organization in a month and the number of patients who left the organization in the same period (ANS, 2012). The formula for calculating the IMR is shown in Equation 3.

It should be noted that the IMR variable is inversely proportional to quality and efficiency. Thus, in order to use it as output, it was necessary to use its difference (1 - IMR), enabling DMUs with lower IMR to have a greater value in the corresponding output.

$$NM = \frac{Net\ Profit}{Sales\ revenue} \quad \textbf{(1)}$$

Source: Adapted from Gitman (2010)

$$ROA = \frac{Net\ Income}{Average\ Total\ Assets} \quad \textbf{(2)}$$

Source: Adapted from Assaf Neto (2009)

$$IMR = \frac{Number\ of\ deaths\ \geq 24h\ of\ admission\ in\ the\ period}{Number\ of\ hospital\ egresses\ in\ the\ period} \quad (3)$$

Where:

Numerador: Number of deaths that happened after at least 24 hours of the patients' admission (institutional deaths in a given period).

Denominator: Number of hospital egresses (for discharge, evasion, withdrawal of treatment, external transfer or hospital death) in a given period.

Source: Adapted from ANS (2012)

We opted for the DEA BCC model oriented to outputs. It is expected for the model to indicate the hospitals with the best performance in the use of inputs to obtain outputs. In other words, the model will regard as more efficient and better-performing those hospitals that have the best financial results (ROA and NM) and the lowest IMR from the same volume of inputs (number of beds and investment on fixed assets).

The model draws on the premise that the organization uses its assets (represented by fixed assets) and its planned capacity (beds) for best operational (represented by decreased mortality) and financial results (net margin and return on assets). Therefore, this study basically investigated the degree of efficiency of this relationship.

## *Overview of the results*

Table 3 presents the descriptive statistics of the variables used in this study. It is possible to note that the studied hospitals have very different sizes, which can be seen when comparing maximum and minimum values of Fixed Assets and Planned Capacity. In order to compare the variability of variables, we used the Coefficient of Variation (CV), and observed that those variables with greater variability were Net Margin and Return on Assets, precisely those that are related to hospitals' income.

| Item | Input1 | Input2 | Output1 | Output2 | Output3 |
|---|---|---|---|---|---|
| | Fixed assets | Planned Capacity | Net Margin | Return on Assets | Institutional Mortality Rate |
| **2007** | | | | | |
| Minimum | 1 045 461.00 | 42 | -1.11 | -0.3545 | 0.6848 |
| Maximum | 550 145 000.00 | 1168.00 | 0.1404 | 0.1594 | 0.9826 |
| Mean | 91 093 046.81 | 418.00 | -0.1104 | -0.053 | 0.9211 |
| SD* | 137 061 090.28 | 329.52 | 0.2969 | 0.1472 | 0.0652 |
| VC* | 1.5046 | 0.7883 | 2.6902 | 2.7765 | 0.0709 |
| **2008** | | | | | |
| Minimum | 1 213 404.00 | 42.00 | -1.86 | -0.7599 | 0.6477 |
| Maximum | 7 031 020 000.00 | 1172.00 | 0.1903 | 0.1883 | 1.00 |
| Mean | 102 465 450.18 | 443.28 | -0.1361 | -0.1010 | 0.9254 |
| SD* | 167 573 552.04 | 347.41 | 0.4581 | 0.2690 | 0.0746 |
| VC* | 1.6354 | 0.7837 | 3.3637 | 2.6637 | 0.0806 |
| **2009** | | | | | |
| Minimum | 9 653.00 | 42.00 | -2.033791 | -1.2769 | 0.6471 |
| Maximum | 953 308 000.00 | 1172.00 | 0.2325 | 0.2129 | 1.00 |
| Mean | 121 416 298.05 | 431.39 | -0.1183 | -0.0888 | 0.9216 |
| SD* | 221 909 143.41 | 345.10 | 0.5002 | 0.3383 | 0.0751 |
| VC* | 1.8276 | 0.7999 | 4.2268 | 3.8079 | 0.0816 |
| **2010** | | | | | |
| Minimum | 34 681.00 | 36.00 | -1.0213 | -1.6343 | 0.6713 |
| Maximum | 1 120 276 000.00 | 1172.00 | 0.1958 | 0.2408 | 1.00 |
| Mean | 137 470 965.63 | 440.67 | -0.1048 | -0.2164 | 0.9217 |
| SD* | 261 628 193.62 | 358.32 | 0.2926 | 0.4854 | 0.0719 |
| VC* | 1.9032 | 0.8131 | 2.7921 | 2.2429 | 0.0772 |
| **2011** | | | | | |
| Minimum | 40 653.00 | 36.00 | -0.5868 | -0.6617 | 0.598149 |
| Maximum | 1 207 845 000.00 | 1172.00 | 0.2075 | 0.5711 | 0.9865 |
| Mean | 153 211 232.67 | 434.78 | -0.0483 | -0.0342 | 0.9265 |
| SD* | 284 173 846.73 | 357.34 | 0.2147 | 0.3033 | 0.0853 |
| VC* | 1.8548 | 0.8219 | 4.4468 | 8.8732 | 0.0921 |

Source: our own findings

*Notes: SD – standard deviation; VC – variation coefficient.

**Table 3: Description of the variables**

Before calculating the hospitals' efficiency, variables were standardized. First, negative values were eliminated from the variables by adding to the value of each variable its module with the lowest annual result. This transformation is necessary since it is not possible to analyze production functions using negative values. For example: if in 2007 the lowest value for the Net Margin variable was -0.5, the value of 0.5 will be added to the Net Margin of each of the 18 DMUs in the sample that year.

Complementarily, one was added to the value of each variable, eliminating decimal values. This was necessary for the next step: logarithmic transformations, that were calculated using the largest value found in each sequence of variables. Since logarithmic values between 0 and 1 represent negative values, it is possible to add a constant to the value for them to become positive.

After the standardization procedure, the technical efficiency of DMU was calculated, wherein the results for this model are shown in Table 4. As regards the analyzed period, it is possible to note that in 2007 44.44% of the hospitals in the sample were classified as efficient according to the model. Within the next three years the percentage of efficient DMUs was higher than in 2007: 50% of hospitals were classified as efficient in 2008, 61.11% were efficient in 2009, and 66.67% in 2010. In 2011, however, it is possible to observe the worst efficiency scores of the analyzed period, where only 33.33% of hospitals were classified as efficient by the model.

| DMUs | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| DMU 1 | 0.9895300 | 1.0000000 | 0.9725540 | 0.9632610 | 0.9974840 |
| DMU 2 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 |
| DMU 3 | 0.9832250 | 1.0000000 | 0.9951680 | 0.9858720 | 0.9805030 |
| DMU 4 | 0.9776770 | 0.9849510 | 0.9798910 | 0.9878310 | 0.9826470 |
| DMU 5 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 |
| DMU 6 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 | 0.9772600 |
| DMU 7 | 1.0000000 | 0.9959340 | 1.0000000 | 1.0000000 | 0.9772600 |
| DMU 8 | 0.9999720 | 0.9961860 | 1.0000000 | 1.0000000 | 1.0000000 |
| DMU 9 | 0.9843630 | 0.9912300 | 0.9868700 | 1.0000000 | 0.9741190 |
| DMU 10 | 1.0000000 | 0.9965280 | 1.0000000 | 1.0000000 | 0.9933860 |
| DMU 11 | 0.9797660 | 0.9834030 | 0.9856860 | 0.9901670 | 0.9855640 |
| DMU 12 | 0.9902250 | 0.9974660 | 0.9970880 | 0.9963090 | 0.9885610 |
| DMU 13 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 |
| DMU 14 | 0.9923930 | 0.9866010 | 1.0000000 | 1.0000000 | 0.9894430 |
| DMU 15 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 |
| DMU 16 | 0.9976600 | 1.0000000 | 1.0000000 | 1.0000000 | 0.9877040 |
| DMU 17 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 | 1.0000000 |
| DMU 18 | 0.9863360 | 0.9862010 | 0.9879110 | 0.9881980 | 0.9843390 |

Source: our own findings

**Table 4: Technical efficiency of hospitals from 2007 to 2011**

Comparing the results obtained for each DMU, it is possible to note that five DMUs have been classified as efficient in all five years, namely, DMUs 2, 5, 13, 15 and 17. Moreover four DMUs were considered inefficient in all years, namely, 4, 11, 12 and 18. It should be mentioned that the DEA model does not allows for extrapolating the analysis of the results beyond the studied variables. Therefore, those DMUs are identified as efficient only in relation to the other DMUs.

After analyzing hospitals efficiency as a whole, the weights of the variables were analyzed using the estimated model. Table 5 shows weights average for each year, as well as the overall average. It is possible to note that the Planned Capacity and Institutional Mortality Rate variables have the highest weights - i.e. these variables are more relevant in determining the efficiency according to the proposed model.

| Year | Fixed assets | Planned Capacity | Net Margin | Return on Assets | Institutional Mortality Rate |
|---|---|---|---|---|---|
| 2007 | 0.100150314 | 1.123327284 | 0.320124201 | 0.155964933 | 0.592230931 |
| 2008 | 0.450046901 | 0.708340102 | 0.257187968 | 0.230888998 | 0.566764005 |
| 2009 | 0.029764765 | 0.199156847 | 0.326197778 | 0.063681465 | 0.639228066 |
| 2010 | 0.327568149 | 0.670348768 | 0.128615578 | 0.186984633 | 0.720038574 |
| 2011 | 0.071629327 | 0.167586247 | 0.204155396 | 0.067863482 | 0.760095017 |
| Geral | 0.19583189 | 0.573751850 | 0.247256184 | 0.141076702 | 0.655671319 |

Source: our own findings

**Table 5: Average of variables' weights**

Following Simões and Marques (2009), sometimes an increase in inputs can produce a decrease in produced outputs. To verify this relationship in our study we used the scale variables. When scale variables have positive values, it means that an increase in inputs causes an increase in outputs; however, when they have negative values, it means that an increase in input causes a decrease in produced outputs.

Therefore, weights were also used to identify the most relevant variables in relation to the scale variables of the DMUs. DMUs 2, 6 and 7 have an average negative return scale, which means that for each unit added in inputs there is a decrease in production. It is possible to note on Table 6 that the most relevant variables for these DMUs were: Fixed Assets for DMU 7 and Planned Capacity for DMUs 2 and 6. It is necessary to highlight that Planned Capacity was the variable with the most significant weight compared with the others.

DMUs 4, 11 and 18 have the highest averages with respect to the Scale Variables. These DMUs have a Scale Variable average value higher than 1, which means that for each unit added to the inputs there is a proportional increase in production. In other words, it is advisable that managers of these DMUs increase the amount of resources allocated to inputs, as they may obtain higher return on outputs, thus improving hospital performance. It is noteworthy that the most important variable in this case was Institutional Mortality Rate - a variable that aims at measuring the quality of hospital services.

Therefore, those variables that contribute most to a positive return on scale, such as the Institutional Mortality Rate variable, should be prioritized (in conjunction with other quality measures and measures of user satisfaction of the public health service) to the detriment of those which contribute most to a lower return on scale, such as Fixed Assets and Planned Capacity.

| DMU | Weight Input1 | Weight Input2 | Weight Output1 | Weight Output2 | Weight Output3 | Scale Variable |
|---|---|---|---|---|---|---|
| DMU1 | 0.0099 | 0.0148 | 0.4973 | 0.0005 | 0.5319 | 0.9931 |
| DMU2 | 1.1899 | 4.6033 | 0.6575 | 0.6343 | 0.0000 | -3.2100 |
| DMU3 | 0.3367 | 0.4175 | 0.1317 | 0.2013 | 0.6951 | 0.3949 |
| DMU4 | 0.0000 | 0.00004 | 0.0687 | 0.0152 | 0.9485 | 1.0177 |
| DMU5 | 0.0306 | 0.3456 | 0.7625 | 0.2452 | 0.0000 | 0.7023 |
| DMU6 | 0.2287 | 2.4109 | 0.3691 | 0.2474 | 0.4732 | -0.9676 |
| DMU7 | 0.9599 | 0.6408 | 0.2007 | 0.2000 | 0.6292 | -0.1665 |
| DMU8 | 0.0494 | 0.2598 | 0.1160 | 0.0000 | 0.9081 | 0.7605 |
| DMU9 | 0.2132 | 0.2738 | 0.5828 | 0.1129 | 0.3402 | 0.6120 |
| DMU10 | 0.0056 | 0.0000 | 0.1606 | 0.0108 | 0.8495 | 0.9967 |
| DMU11 | 0.0000 | 0.0000 | 0.0037 | 0.0065 | 1.0130 | 1.0153 |
| DMU12 | 0.0077 | 0.0295 | 0.1878 | 0.0160 | 0.8256 | 0.9753 |
| DMU13 | 0.1204 | 0.1057 | 0.2179 | 0.6000 | 0.2002 | 0.8227 |
| DMU14 | 0.0014 | 0.0000 | 0.3222 | 0.0116 | 0.6896 | 1.0050 |
| DMU15 | 0.0364 | 0.3197 | 0.0018 | 0.0000 | 1.0001 | 0.7727 |
| DMU16 | 0.3351 | 0.8786 | 0.1162 | 0.1880 | 0.7661 | 0.0869 |
| DMU17 | 0.0000 | 0.0275 | 0.0504 | 0.0446 | 0.9198 | 0.9777 |
| DMU18 | 0.0000 | 0.0000 | 0.0037 | 0.0051 | 1.0118 | 1.0136 |
| **Average** | 0.1958 | 0.5738 | 0.2473 | 0.1411 | 0.6557 | 0.4335 |

Source: our own findings

**Table 6: Relation between Weights and Scale Variable**

## Conclusions

The study presented in this article aimed at identifying optimum performance standards employed by public and philanthropic hospitals. In this regard, a DEA model was developed in order to analyze the performance of these organizations from both financial and operational perspectives. This model was used to study a sample of 18 public and philanthropic hospitals.

It was noted above that five DMUs (2, 5, 13, 15, 17) had the best performance with regard to the model in the analyzed period. Thus, the model demonstrated that these hospitals were the most efficient (according to the proposed mathematical structuring), since they achieved the best financial results (ROA and NM) and the lowest IMT with the same volume of inputs (number of beds and investment on fixed assets).

As regards geographic location, three of the five best-performing DMUs are in São Paulo state, one in Rio de Janeiro state and another in Ceará state. In regard to the number of beds, three organizations had between 50 and 100 beds, three had between 100 and 300 beds and one had more than 300 beds. And with regard to the DMUs with the lowest efficiency score, they had an average number of beds considerably higher than the above-mentioned efficient hospitals. The average number of beds for those inefficient DMUs ranged from 305 to 910. Therefore, it is possible to conclude that the larger size of a hospital may lead to a decrease of efficiency.

This relationship regarding the number of beds and the hospital efficiency was demonstrated by analyzing the weights of the variables in relation to Scale Variable. As mentioned above, the Planned Capacity variable, which corresponds to the number of beds of the hospital, contributed most to the DMUs with negative returns to scale. This explains the fact that the less efficient hospitals have a greater number of beds.

Finally, it is important to discuss some limitations of the research presented in this paper. Initially, it can be said that, given the characteristics of the DEA model, results cannot be generalized to hospitals that are not in the sample. In addition, the sample used in this research is narrow and does not cover all Brazilian states. However, it can be argued that this research contributes significantly to the analysis of the performance of public and philanthropic hospitals. Moreover, it was found that the simultaneous use of operational and financial variables allows for a comprehensive analysis of the performance of hospitals, endorsing the view of authors such as Cesconetto et al (2008) and Guerra et al (2012). As regards future research, they may focus on specific aspects of hospitals with more homogeneous characteristics, in order to confirm or deny the results presented in this paper. Complementarily, we also suggest the expansion of the sample used in this study.

## References

Agência Nacional de Saúde Suplementar – ANS. (2012). *Taxa de Mortalidade Institucional.*. Available in: <http://www.ans.gov.br/espaco-dos-prestadores/qualiss/1575-indicadoreshospitalares >. Access on: 12 ago 2013.

Alyrio, R. D. (2008). *Metodologia Científica*. PPGEN: UFRRJ.

Ângulo Meza, L. et al. (2005). ISYDS - Integrated System for Decision Support (SIAD - Sistema Integrado de Apoio à Decisão): a software package for data envelopment analysis model. *Pesquisa Operacional,* v. 25, n. 3, 2005, pp. 493-503.

Araújo, C.; Barros, C. P.; Wanke, P. (2013). Efficiency determinants and capacity issues in Brazilian for-profit hospitals. *Health Care Management Science,* v.16, n. 2.

Assaf Neto, A. (2009). *Finanças corporativas* e valor. 4 ed. São Paulo: Atlas.

Banker, R. D.; Charnes, A.; Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. *Management Science, v.* 30, n. 9, p. 1078-1092.

Brasil. *Ministério da Saúde.* DATASUS. Available in: <http://datasus.saude.gov.br/>. Accessed on: 15 jul 2015.

Cesconetto, A.; Lapa, J. S.; Calvo, M. C. M. (2008). Avaliação da eficiência produtiva de hospitais do SUS de Santa Catarina, Brasil. *Caderno de Saúde Pública*, v. 24, n. 10, p. 2407-2417.

Charnes, A.; Cooper, W. W.; Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research,* i. 2, p. 429-444.

Chilingerian, J. A.; Sherman, H. D. (2010). Health-Care Applications: From Hospitals to Physicians, from Productive Efficiency to Quality Frontiers. In: COOPER, W. W.; SEIFORD, L. M.; ZHU, J. (Org.) *Handbook on data envelopment analysis.* 2ed. [S. L.]: Springer, 2010, p. 445-494.

Collis, J.; Hussey, R. (2005). *Pesquisa em administração:* um guia prático para alunos de graduação e pós-graduação. 2. ed. Porto Alegre: Bookman.

Flokou, A.; Kontodimopoulos, N.; Niakas, D. (2011). Employing post-DEA Cross-evaluation and Cluster Analysis in a Sample of Greek NHS Hospitals*. Journal of Medical Systems,* v. 35, p. 1001-1014.

Freund, J. E.; Simon, G. A. (2000). *Estatística aplicada*. 9. ed. Porto Alegre: Bookman.

Gil, A. C. (2008). *Como elaborar projetos de pesquisa.* 4. ed. São Paulo: Atlas.

Gitman, L. J. (2010). *Princípios de administração financeira.* 12. ed. São Paulo: Pearson.

Gruen, R.; Howarth, A. (2005). *Managing health services finance.* 1. ed. London: London School of Hygiene and Tropical Medicine.

Guerra, M. (2011). Análise de desempenho de organizações hospitalares. 2011. 144 f. *Dissertação* (mestrado) – Universidade Federal de Minas gerais, Centro de Pós-Graduação e Pesquisas em Contabilidade e Controladoria, Belo Horizonte.

Guerra, M.; Souza, A. A.; Moreira, D. R. (2012). Performance analysis: a study using data envelopment analysis in 26 Brazilian hospitals. *Journal of Health Care Finance*, v. 38, n. 4, p. 19-35.

Hair Jr. et al. (2005). *Fundamentos de Métodos de Pesquisa em Administração*. São Paulo: Bookman.

Hu, H.; Qi, Q.; Yang, C. (2012). Analysis of hospital technical efficiency in China: Effect of health insurance reform. *China Economic Review,* v. 23, p. 865-877.

Kao, L.; Lu, C.; Chiu, C. (2011). Efficiency measurement using independent component analysis and data envelopment analysis. *European Journal of Operational Research*, v. 210, p. 310-317.

Lima Neto, L. (2011). Análise da situação econômico-financeira de hospitais. *O Mundo da Saúde*, v. 35, n. 3, p. 270-277.

Lobo, M. S. C.; Ozcan, Y. A.; Lins, M. P. E.; Silva, A. C. M.; Fiszman, R. (2014). Teaching hospitals in Brazil: Findings on determinants for efficiency. *International Journal of Healthcare Management,* v. 7, n. 1, p. 60-68.

Mark, B. A. et al. (2009). An Examination of Technical Efficiency, Quality, and Patient Safety in Acute Care Nursing Units. *Policy, Politics, & Nursing Practice,* v. 10, n. 3, p. 180-186.

Mattar, F. (1996). *Pesquisa de marketing.* São Paulo: Atlas.

Munhoz, D. G. (1989). *Economia aplicada:* técnicas de pesquisa e análise econômica. Brasília: Universidade de Brasília.

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

Ouellette, P.; Vierstraete, V. (2004). Technological change and efficiency in the presence of quasi-fixed inputs: A DEA application to the hospital sector. *European Journal of Operational Research,* v. 154, p. 755-763.

Pekcan, Y. A.; Atan, M.; Beylik, U. (2011). Evaluation and analysis on profitability – Efficiency in hospitals affiliated with the ministry of health. *Scientific Research and Essays,* v. 6 n. 28, p. 5837-5845.

Silva, M. Z.; Borget, A.; Schultz, C. A. (2009). Sistematização de um método de custeio híbrido para o custeamento de procedimentos médicos: uma aplicação conjunta das metodologias ABC e UEP. *Revista de Ciências da Administração,* v. 11, n. 23, p. 217-244.

Sozen, A.; Alp, I.; Kilinc, C. (2012). Efficiency assessment of the hydro-power plants in Turkey by using Data Envelopment Analysis. *Renewable Energy,* v. 46, p. 192-202.

Souza, A. A. et al. (2009). Indicadores de desempenho econômico-financeiro para hospitais: um estudo teórico. *Revista de Administração Hospitalar e Inovação em Saúde*, v. 1, n. 1, p. 44-55.

Souza, A. A. et al. (2012). Uma análise da eficiência em organizações hospitalares por meio da análise envoltória de dados. XIX Simpósio de Engenharia de Produção, SIMPEP, Bauru, 2012. *Anais*.

Sulku, S. N. (2011). The health sector reforms and the efficiency of public hospitals in Turkey: provincial markets. *European Journal of Public Health*, v. 10, p. 1-5.

Tavares, A. L.; Silva, C. A. T. (2012). A análise financeira fundamentalista na previsão de melhores e piores alternativas de investimento. *Revista Universo Contábil*, v. 8, n. 1, p. 37-52.

Veloso, G. G.; Malik, A. M. (2010). Análise do desempenho econômico-financeiro de empresas de saúde. *RAE-eletrônica,* v. 9, n. 1, art. 2.

Wang, B. B.; Wan, T. T. H.; Falk, J. A.; Goodwin, D. (2001). Management Strategies and Financial Performance in Rural and Urban Hospitals. *Journal of Medical Systems*, v. 25, n. 4.