REVISTA CONTABILIDADE, GESTÃO E GOVERNANÇA
E-ISSN 1984-3925 JOURNAL OF ACCOUNTING, MANAGEMENT AND GOVERNANCE

OPEN ACCESS

Responsible Editor: Rodrigo de Souza Gonçalves
Andrea de Oliveira Gonçalves
Associate Editor: João Abreu de Faria Bilhim
Evaluation Process: Double Blind Review pelo SEER/OJS

The Efficiency of Health Spending in Brazilian States: A Cluster Based Analysis

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ABSTRACT

Objective: This study seeks to ascertain the efficiency of health spending in the Brazilian states and the Federal District.

Method: This is a descriptive quantitative study which segments the states into clusters, calculating the efficiency of each cluster and compares the results with and without clusters during the period from 2015 to 2018. To calculate the efficiency scores of the country's 27 units, we use Data Envelopment Analysis (DEA) with Constant Returns to Scale and Variable Returns to Scale models, which are oriented toward the outputs.

Originality/Relevance: Cluster segregation is the differential of the research by Andrett et al. (2018), who also analyzed the efficiency of public spending in the states. There is little approach regarding the creation of criteria for grouping, in the states, regarding public health in Brazil.

Results: The results show that the states of Minas Gerais, Maranhão and São Paulo obtained scores with an efficiency equal to 1, independent of whether they were grouped or not grouped in clusters, and for the other states in at least one period their segregation by clusters altered their efficiency scores, which suggests the existence of problems in the management of health spending, and therefore their quality of services needs to improve and maximum use needs to be made of public health resources.

Theoretical/Methodological contributions: This study makes a practical contribution not only to the academic environment but can also inform the decision making of public managers in order to improve the quality of health services through the use of cluster techniques to evaluate this spending.

Keywords: Spending efficiency. Public health. Public spending. Clusters.

Received: June 18, 2021
Revised: June 9, 2022
Accepted: July 12, 2022
Published: November 30, 2022

How to Cite (APA)

Viana, C. C. F. & Boente, D. R. (2022). The Efficiency of Health Spending in Brazilian States: A Cluster Based Analysis. *Revista Contabilidade, Gestão e Governança*, *25* (2), 236-254. http://dx.doi.org/10.51341/cgg.v25i2.2712

1 INTRODUCTION

Evaluating and managing the efficiency of health spending is one of the main challenges of current public administration say Silva & Queiroz, 2018. According to Silva, Farias, Marques, Freire, & Guimarães (2019), efficiency for the state has the capacity to measure the performance of public services, based on the management of public policies. Transparent administration from the outset permits better monitoring of services provided versus the resources utilized.

To Andrade, Klein and Wilbert (2018), efficiency is relevant in the face of the growing demand for health services to the extent that there needs to be greater efficiency in the utilization of public resources to guarantee the constitutional right to health services, given that the available resources are naturally scarce. To measure the efficiency of this public spending, we seek to optimize the inputs and the outputs at the lowest cost (Ministério da Saúde [MS], 2014), using statistical and econometric methodologies such as Data Envelopment Analysis (DEA).

According to Mattos and Terra (2015), the allocation of resources is strategy linked to the quality of spending. Technical efficiency is based on the relationship between inputs and outputs. The development of this relationship converges with the ideas of Lane (2002) regarding the need to evaluate public policies due to the substitution of a focus on controlling processes with a focus on results.

In this respect, various studies have been realized in Brazil to analyze efficiency in the public health sphere: Andrett, Lunkes, Rosa and Brizolla (2018), Mazon, Mascarenhas and Dallabrida (2015), Mazon, Freitas, & Colussi, (2021), Queiroz, (2018), and Schulz, Gollo, Da Rosa and Scarpin (2014).

In terms of providing health services to the population at large, the Brazilian Constitution (1988) structured management and provided for decentralized health assistance by creating implementation guidelines for the Unified Health System (SUS), under the justification of meeting regional specificities and population differences throughout the country (Paim, Travassos, Almeida, Bahia and Macinko, 2011).

Since then, access to public health for the entire population has become the responsibility of the state. According to the National Board of Health (CNS, 2006), SUS, even though it is one of the largest public health systems in the world, still faces countless challenges, such as the need to monitor and evaluate the system (Schulz *et al.*, 2014).

In terms of monitoring and evaluation, in comparing distinct entities, one needs to consider the homogeneity related to economic and demographic factors. In this sense, Hua (2006) argues that it is crucial to adopt ways to avoid the problem of heterogeneity in the efficiency evaluation calculations — or in other words, among decision making units (DMUs) — which can result in distorted calculations which could lead managers to make mistaken decisions.

In the same way, homogeneity is considered a necessary assumption for the application of DEA, which is one of the techniques most utilized in the literature to calculate efficiency in the public health sphere (Silva, 2017).

Thus, to calculate the efficiency scores for each group of similar units, one has to group the units which are being compared in the application of DEA into clusters. To accomplish this, there should be specific professionals to perform the monitoring and evaluation of health services, which is referred to as the application of the cluster technique, a methodology that is applied to the evaluation of decision makers (Carvalho, Cavalcante, & Miranda, 2012).

Given that the states and the Federal District have to do more and more with fewer resources, in accordance with Constitutional Amendment n.º 95/2016 (EC, 2016), and noting that there are few studies that deal with the creation of criteria in the formation of clusters relating to public health in the states of Brazil (Silva, 2017), we pose the following research question: considering the assumption of homogeneity, what is the level of efficiency in the application of public health resources in the Brazilian states and the Federal District?

Based on this question, this study seeks to ascertain the efficiency of public health spending in the Brazilian states and the Federal District from 2015 to 2018 through the use of DEA, grouping DMUs by clusters. This segregation by cluster is a differentiating characteristic of the study by Andrett *et al.* (2018), which has also analyzed the efficiency of public spending in the Brazilian states.

Thus, our sample is made up of Brazil's 26 states and the Federal District, because the states are demographically larger than municipalities (Lima & Silveira, 2017), and the area of coverage is one of the limitations of this study.

This study of the efficiency of public health spending in the states is justified because of its segregation of DMUs into clusters, and its utilization of the variables described in Figure 1 below to ensure that the results will not be underestimated and managers will not make mistaken decisions regarding Brazilian healthcare. This measure of efficiency can identify the best model which will serve as a parameter for improving the performance of the less efficient states.

In terms of the methodology it employs, this study is descriptive and quantitative, and intends to contribute not only the academic sphere, but also by informing the decision making of public managers as a benchmarking among the states to improve the quality of services and maximize the public health resources available.

This article is divided into five sections including this introduction. The second section will present our theoretical references and a review of the literature. The third will discuss our methodology, while the fourth will present our analyses and discussion of the results. We will conclude with our final considerations.

2 THEORETICAL REFERENCES

2.1 The Efficiency of Public Spending in the Health Sector

The management of public policies affects, directly and indirectly, the lives of people who need the SUS, because administrating public resources in the health area is currently one of the main challenges of public administration (Silva & Queiroz, 2018). Given this, Silva *et al.* (2019) emphasize that efficiency is of fundamental importance to the state, because it has the capacity to measure the performance of the public services provided by the government, with transparency in terms of the management of public resources making it possible to better monitor the services provided versus the resources utilized (Silva *et al.*, 2019).

From another perspective, Machado *et al.* (2018) point out that the efficiency of a state is not measured by larger or smaller spending of financial resources, but rather how this money is used. In other words, a public manager can spend a lot of financial resources and not achieve the necessary results.

Mazon *et al.* (2021) state that efficiency refers to maximizing gains in production operations while using the fewest resources possible. Given this, it is possible to relate two types of efficiency: first in terms of inputs, and the second in terms of outputs, namely the production of a good or service. Moreover, efficiency can also be linked to the control function, which is usually a part of financial management and a necessary instrument to improve public administration.

The relationship with the control function makes it possible to argue that efficient public administration can have a strategic value, given that it reduces the gap which separates a social demand and the satisfaction of this demand. To accomplish this, Mattos and Terra (2015) suggest that, to correct market failures, it is necessary to utilize the Public Budget, an instrument for making allocations and promoting adjustments in income distribution.

Under this understanding, the health of the population is the responsibility of public managers who define public policies in order to better allocate health spending. In this way, considering the results of public spending, Cardoso, Almeida, Gomes and Chagas (2017) underline the importance of transparency in public administration, because it demonstrates all of government spending that offers a return to society. To accomplish this, the taxes paid by contributors should be utilized with maximum efficiency so that these revenues can be applied equitably in accordance with the legal norms of the country's legislation (Amorim, Diniz, & Lima, 2017).

2.2 Previous Studies of The Efficiency of Public Health Services

The research cited in this study that refers to how to measure efficiency of health services in companies, governments, schools and hospitals in Brazil and throughout the world was conducted after Farrell's study (1957) which formulated the DEA model.

Mazon *et al.* study (2021) evaluated the technical efficiency of municipalities in Santa Catarina in relation to public health spending by public managers from 2009 to 2015 and the DEA method found that there was no association between the conditions of health management and the technical efficiency of the state. They concluded that there is a need to build on these results by considering the spatial distribution of the territory with a focus on clusters of inefficiency to explain the poor performance in health care in certain regions of the state of Santa Catarina.

Hsu (2013) used two stages oriented towards outputs to evaluate the efficiency of government health spending in 46 countries from 2005 to 2007. In the initial phase, the input used was health spending per capita, and the outputs were expected lifetime at birth, the child mortality rate, and immunization against the mumps. This resulted in an average efficiency of 98.8 in these countries.

Doumpos and Cohen (2014), for example, used DEA to evaluate the efficiency of municipalities in Greece from 2002 to 2009 together with a variable representing public revenues as an input. They concluded that cities with larger populations were less efficient in offering health services.

In terms of fiscal decentralization, Maciel, Piza and Penoff (2009) analyzed its effect on public health, using tax revenues and transfers as inputs in examining inequalities among Brazilian states. The results showed that more decentralized provinces had lower rates of mortality, which led the authors to conclude that current account and capital transfers to regions as well as fiscal autonomy were essential to achieving greater efficiency and equity in the providing of public health services.

In another study conducted in the United States, Chern and Wan (2000) analyzed the efficiency of public health spending in 80 hospitals in Virginia. The authors found gains in technical efficiency when using hospital size as a variable. In relation to this, according to Draibe (1997), technical efficiency results from the decentralization of social policies, and can be measured by per capita spending, the number of health professionals, and the number of hospital beds per inhabitant.

Silva's study (2017) in the state of Pernambuco used the DEA method and the cluster technique, and highlighted the importance of homogeneity among DMUs, taking into consideration health teams, the number of SUS professionals, and the number of establishments.

Finally, the elderly population was examined to capture demographic effects on efficiency in Benegas and Silva's study (2014) which concluded that population is the only variable that effectively promotes the appropriate offer of public health services.

3 METHODOLOGY

3.1 Context of the Brazilian health system

In Brazil, health protection began with the 1934 Constitution, but it was the Constitution of 1988 that gave it notoriety and created the supreme norm of health protection. From this arose the Unified Health System (SUS) under the guidance of each state funded by public resources, which is designed to ensure the population's health. However, the territorial inequalities of Brazil need to be considered (Maciel *et al.*, 2009).

Among the referred public resources, a key element consists of intergovernmental transfers which are a way to seek greater efficiency in the public sector in the implementation of policies and services and also represent a mechanism to balance public finances. Thus, given the fact that resources are limited and that managers need to use resources in a rational manner, emphasis should be place on efficiency and the evaluation of public manager performance (Amorim, Diniz, & Lima, 2017). Faced with the need to better administrate these public resources for health spending, there is a need for quality budget planning to meet the demands of the population (Cardoso *et al.*, 2017).

Moreover, important control instruments have been created to accompany the management of public spending and the transparency of governmental actions: Complementary Law n.º 101 (2000), which imposes limits on fiscal policy managers, and whose objective is to control public management to achieve spending efficiency (Fioravante, Pinheiro, & Vieira, 2006), Constitutional Amendment n.º 29 (2000), which establishes minimum percentages for the resources applied to public health (Carvalho *et al.*, 2017), and Complementary Law n.º 131 (2009), which makes budgetary and financial information related to public administration available to the public (Giambiagi & Além, 2011). Finally, in addition to these control instruments, the Budget Execution Summary Report (RREO) was created, which presents a group of statements with information about budget execution to assist their supervision (Resende, Vale, Melo, Silva, & Carvalho, 2014).

With the objective of limiting budgetary public spending, Constitutional Amendment n.º 95 (2016), Article 106, instituted a new fiscal regime within the Fiscal Budget and Social Security for twenty years. Since the adoption of this freeze, efficient management of public spending has become fundamentally relevant to achieve the best results for the population (Mazon *et al.*, 2021).

After the inclusion of these control instruments and in accordance with the principles of public administration, managers should apply public resources with efficiency diminishing demand and promoting the population's well-being in terms of healthcare. This is necessary because the appropriate management of public resources relative to health spending should place a primary emphasis on public transparency and efficient management (Andrett *et al.*, 2018)

3.2 Scope of the study

This is classified as a descriptive study, whose objective is to ascertain the efficiency of public health spending in Brazilian states and the Federal District. It adopts a quantitative approach and uses numeric data available in the Unified Health System database (Datasus) and accounting and fiscal information for the public sector from the Treasury/Ministry of Economics database (Sisconfi). This data is relevant for the calculation of DEA and the creating of a metric which will determine the segregation of the units into clusters, permitting a more appropriate comparison in terms of the efficiency of health spending. According to Brocco Maria, Besen, Araújo and Serafim Jr. (2017), there should be no influence of the researcher in examining, displaying and explaining the data.

Thus, we have sought to calculate the efficiency of the states and the Federal District by grouping them into clusters and calculating their efficiency within each cluster, comparing the efficiency results for the states and the Federal District derived from the efficiency calculations utilizing and not utilizing clusters and analyzing the influence of GDP, the Elderly Percentage, Transfers Received and Revenues Raised on the efficiency of the states.

3.3 Definition of the universe and the sample

The sample is made up of the 26 states and the Federal District which we have selected instead of the municipalities, because they are demographically larger (Lima & Silveira, 2017) and therefore the area of coverage is one of the limitations of this study. The data covers the years 2015 to 2018.

The measurement of the efficiency of our sample was realized using the DEA method which was performed with the use of the *R* software. To accomplish this, we considered the selected variables as outputs which are related to the health services provided in each state and the related input variable which is a summary of health spending. In regard to these variables, Giannakis, Jamasb and Pollitt (2005) informs us that they are very important, because it is through them that we can obtain consistent indices of efficiency, taking into consideration a comparison of each DMU in this study.

It should be noted that in order to avoid discrepancies in the public spending variable due to differences between the size of the states, mainly because a single input variable was utilized, we had to adjust the values to arrive at per capita data, because this provides reliable data and eliminates the problem of making comparisons between states with different populations (Schulz *et al.*, 2014).

We also used the *Constant returns to scale* (CRS) and *Variable returns to scale* (VRS) models, which are oriented towards outputs. The choice of an output orientation is plausible, because it takes into account the expectation of an increase in the level of products (public services), and it uses the same quantity of inputs (the budget), given that the public resources allocated are limited by the annual budgetary law (Ozcan, Lins, Lobo, Silva, Fiszman, & Pereira, 2010). Therefore, the selected input was health spending (net expenses), and the outputs are a group of selected variables (Mortality Rate, average Hospital Stay, Health Teams, the number of Establishments by type, and the number of Hospital Beds) which are available in the Unified Health System's database – Datasus.

In addition, in order to avoid the problem of heterogeneity, we also constructed three different clusters to group similar states. The variables selected for the construction of the hierarchical grouping based on Euclidean distance were GDP, Population, Elderly Percentage, Transfers Received, and Revenues Raised as displayed in Figure 1. According to Buss and Pellegrini (2007) using GDP as one of the criteria for the formation of clusters was necessary because wealth is fundamental to ensuring the best living and health conditions. In terms of the Population variable, Lima-Costa and Veras (2003) consider that it is related to the demand for public health services, and the Elderly Percentage variable, according to Andrade, Klein and Wilbert (2018), should be utilized because it is a variable that increases the demand for health services and spending. To calculate the technical statistics for the clusters we used the *Stata*® software.

Even though we initially intended to use all five variables to arrive at our clusters, our analyses showed that Transfers Received and Revenues Raised were excluded from the composition of the clusters, because they were deemed inappropriate variables due to their potential harm to the homogeneity of the clusters during at least one of the utilized periods.

3.4 Data collection and treatment

The government financial data was extracted from the Budget Execution Summary Report (RREO) which is part of the accounting and fiscal information for the public sector from the Treasury/Ministry of Economics database (Sisconfi). This system provides data about the net expenses of the execution function as well as transfers received and revenues raised for each state.

The monetary variables for revenues and transfers were adjusted to values of reais in 2018. The data for the Elderly Percentage (Benegas & Silva, 2014), Population and GDP (Kruger & Krobauer, 2012), was collected from the website of the Brazilian Institute of Geography and Statistics (IBGE), except for the calculation of GDP in 2017 and 2018 which was estimated based on the proportions of GDP in 2016. The information on the outputs related to health services were obtained from the Datasus platform, where according to Faria, Januzzi and Silva (2008) contains structured indicators which provide the information needed to conduct a competent analysis in the formulating and implementing of social policies in the health area. Thus, in Figure 1 we present the variables used to measure the level of efficiency in the management of public services.

Type	Variable	Description	References	Source
Input	Per capita spending	Total net health expenses per inhabitant	Hsu (2013), Schulz *et al.* (2014).	Siconfi
Output	Teams	Number of health teams per thousand inhabitants	Silva (2017)	Datasus
Output	Mortality Rate	1/mortality rate per thousand inhabitants	Maciel *et al.* (2009)	Datasus
Output	Hospital Stay	1/average hospital stay	Ozcan *et al.* (2010)	Datasus
Output	Establishments	Number of establishments by type – per thousand inhabitants	Silva (2017)	Datasus
Output	Hospital Beds	Number of hospital beds per thousand inhabitants	Chern and Wan (2000)	Datasus
Control	GDP	Growth of personal income	Kruger and Krobauer (2012)	IBGE
Control	Population	Population total in each state	Kruger and Krobauer (2012)	IBGE
Control	Elderly Percentage	Percentage of elderly population	Benegas and Silva (2014), Lima-Costa and Veras (2003), Kruger and Krobauer (2012)	IBGE
Control	Transfers Received	Total current account and capital transfers for health care	Hsu (2013), Maciel *et al.* (2009)	Siconfi
Control	Revenues Raised	Total revenues raised for health care	Doumpos and Cohen (2014), Maciel *et al.* (2009)	Siconfi

Figure 1. Variables used in this study

For the variables which are contrary to the maximization of efficiency scores (mortality rate and average hospital stay) we used their reciprocal values so that they would be appropriate for the methodology's analysis and would generate consistent results (Politelo, Rigo, & Hein, 2014). For these variables, the DEA method was used first without grouping the states into clusters. Thus, we initially calculated the efficiency scores of the models with constant and variable returns to scale and compared the results of these two models. Later, we calculated efficiency by using the cluster statistical technique.

3.5 Data envelopment analysis (DEA)

The DEA methodology is a mathematical technique used to measure the productivity of efficiency in units (Charnes, Cooper, & Rhodes, 1978). This measure of efficiency can be interpreted from two points of view: from the point of view of inputs, which evaluates how much inputs can be reduced while achieving the same level of production, or from the point of view of outputs, which indicates how much a production coefficient implies efficiency in a given information input (Almeida & Almeida Filho, 2014).

In the DEA methodology, there are two classic models for the analysis of efficiency: the model which works with Constant Returns to Scale - CRS (Charnes *et al.*, 1978) and the Variable Returns to Scale model - VRS (Banker, Charnes, & Cooper, 1984). Both models can be oriented toward inputs or outputs, depending on the purpose of the study.

Brocco Maria *et al*. (2017) state that the DEA model is a statistical tool used to calculate efficiency in different DMUs which serves to measure the relative performance of DMUs through the relationship between their outputs and inputs, yielding an efficiency score for each unit of production, and estimates the production function by providing a benchmark for inefficient DMUs located below the efficiency frontier.

3.6 Grouping data by clusters

As observed, there are various works which utilize DEA to evaluate aspects related to public health. However, knowing that some care has to be taken in using DEA, such as an assumption of homogeneity (Silva, 2017), some studies have opted to use clusters to avoid incongruencies in ascertaining relative efficiency (Braga, Ferreira, & Braga, 2015). This is why we use clusters in this study to segregate DMUs into groups according to pre-established criteria. Based on this, we calculated the relative efficiency of each group, comparing the DMUs with those that presented similar characteristics.

The hierarchical single linkage grouping technique and the non-hierarchical k-means technique were used to make the analysis more robust by increasing homogeneity within the groups (Fávero & Belfiore, 2017).

The utilization of clusters, in addition to mitigating heterogeneity, also tends to affect the efficiency scores, given that they restrict the number of DMUs which are being compared. In addition, according to Tamaki (2012), the construction of clusters corroborates the conducting of consistent decision-making processes in the implementation of health policies.

4 DATA ANALYSIS

4.1 The efficiency of health spending in Brazilian states

We created three clusters formed according to the premises of the selected variables to measure their dissimilarities as shown in Table 1.

Table 1
Non-hierarchical grouping

State	Cluster
Alagoas, Bahia, Ceará, Distrito Federal, Espírito Santo, Goiás, Maranhão, Mato Grosso do Sul, Mato Grosso, Paraíba, Pernambuco, Piauí, Paraná, Rio Grande do Norte, Santa Catarina, Sergipe, Tocantins	1
São Paulo, Minas Gerais, Rio de Janeiro, Rio Grande do Sul	2
Acre, Amapá, Amazonas, Pará, Rondônia, Roraima	3

Cluster 1 consists of the 17 least populous states with the lowest GDP per capita, Cluster 2 contains the states with the largest populations, the largest elderly percentages, and the greatest GDP per capita, and Cluster 3 encompasses less populous states with lower GDP per capita.

In this sense, the grouping makes it possible to compare states just with those that present similar characteristics, which tends to give them higher efficiency scores as compared to their scores before the grouping, as can be seen from the results in Figure 2 below.

4.2 Differences in efficiency scores with and without clusters

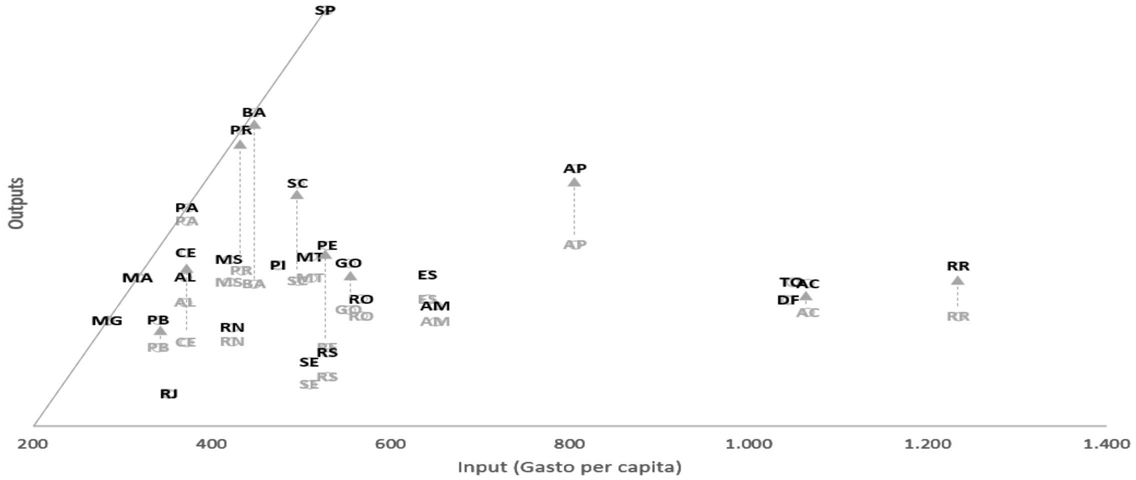

Figure 2. Differences in Efficiency in the CRS Model with and without Clusters

Figure 2 demonstrates that just three states (Maranhão, Minas Gerais and São Paulo), did not display differences between the groups with and without clusters, which indicates the efficiency of the states in the CRS model. The first (grey) group contains the average efficiency scores for the DEA model without the utilization of clusters, and the second (black) group contains the average efficiency scores for the DEA model with the utilization of clusters. The continuous line that links the efficient DMUs represents the efficiency frontier. These results are presented in greater detail in Appendix A.

For the other 24 entities, segregating them into clusters changed their efficiency scores during at least one period, with there being higher scores from the cluster model than those from the model without clusters. This is due to the fact that grouping into clusters reduces the quantity of DMUs being examined and thus states are only compared with those that have similar characteristics. In this manner, the efficiency frontier is altered and as a result, there is a variation in efficiency when comparing these results to the model without clusters.

These differences are related to the way DEA is based on relative efficiency, so that when DMUs are segregated in accordance with their similarities, there is a change in the efficiency curve which alters the efficiency slacks and scores of some DMUs. Therefore, according to Hua (2006), when there is heterogeneity, but one does not observe a separation of the DMUs into clusters, the resulting efficiency scores for some of the DMUs may be underestimated.

4.3 Study results

Of the seventeen states that comprise Cluster 1, just three were efficient in all of the periods in the CRS and VRS models. In both models, the Federal District was the DMU that presented the worst results for every period. This indicates that the analysis of the variables used in the DEA model can help us understand the low efficiency scores for the Federal District. It may be observed that in the Federal District health spending per capita was one of the highest among the DMUs. Therefore, given that efficiency is related to the optimization between inputs and outputs, the Federal District would need to also present elevated values for the output variables to achieve efficiency.

In regard to this, Andrade, Klein and Wilbert (2018) argue that the values received by the Federal District derived from the constitutional fund can explain the existence of an elevated volume of resources in the health sphere. More recent results of the health IFDM (Firjan, 2018), an indicator which evaluates development in the health area, reveals that the average for Maranhão is the third lowest in the country and that the Federal District is the highest, which is in keeping with the efficiency scores observed in this study.

In relation to Cluster 2, these states were efficient and attained the maximum average efficiency during all of the periods for both models, with and without the use of clusters.

Cluster 3, meanwhile, is made up of six states in the northern region. Only the state of Pará (PA) obtained the maximum average of efficiency in both models, with the state that obtained the worst average for efficiency being Amazonas. The reason for this state's lower scores includes the fact that it has the third highest average spending on health, with around 80% of the value of the most efficient state in this group. However, the output variables did not keep pace with this spending as can be observed by the Teams and Mortality Rate variables. It may be observed that there are inefficient states in the Brazilian public health system, and if these problems could be solved it would improve the services provided by SUS.

In any event, the non-utilization of clusters can result in distorted analyses and an underestimate of efficiency in certain states, in addition to breaking homogeneity which can invalidate the DEA model (Hua, 2006).

Considering all of these results, this study contributes to the field in a practical manner (Bogason & Brans, 2008) in terms of establishing criteria for the grouping of the Brazilian states and the Federal District into clusters, and also makes it possible for the efficiency frontier to be more appropriate for benchmarking (Hua, 2006).

Thus, we have verified in this study that the utilization of clusters, in addition to mitigating heterogeneity, also tends to affect efficiency scores, given that it restricts the number of DMUs that are compared within a cluster. Bearing this in mind, this study's hypotheses have sought to verify whether the efficiency from the application of the DEA model and grouping the states into clusters is equal to that of the DEA model without the use of clusters.

Having arrived at our results in the testing of our hypotheses, we can state that the variable analyses which affect the efficiency of the states can contribute to advances in the public health sector. This is relevant because there is a growing demand for health services, and this is why it is crucial that we improve the efficiency of our limited resources (Andrade, Klein, & Wilbert, 2018).

5 FINAL CONSIDERATIONS

Bearing in mind the problems of a fiscal nature that afflict the states of Brazil and the difficulties of ensuring a right to health services, we have identified the need to optimize government health spending. Along these lines this study has developed a metric for grouping these states into clusters in order to avoid the problem of heterogeneity, and the separation of DMUs into clusters should be observed so that the results are not underestimated which could lead managers to make mistaken decisions (Hua, 2006).

In terms of the results for efficiency, we can state that in the CRS and VRS models, the states belonging to Cluster 2 had the best efficiency scores for public health spending, with 50% of the DMUs in this group having efficiency scores of 100%. In Cluster 1, on the other hand, which represented the largest number of Brazilian states, we observed average results that were just 43% of maximum efficiency. In Cluster 3, this percentage was even lower, making it the least efficient of the clusters.

In terms of its relevance, this study makes a practical contribution to the academic environment as well as for public managers based on comparative studies among these states, permitting improvements in health services and the maximization of the resources directed towards public health spending. Thus, the main challenge facing Brazil, according to Kerr (2020) and Mattos and Terra (2015) is obtaining the greatest possible benefits with limited resources. In this sense, benchmarking is a strategic tool for decision making which states can use to compare their performance in providing health services, and it can also be used to improve the efficiency of managing inefficient DMUs.

We believe that in order to avoid problems in future studies, it is important to disseminate in the literature the need to group DMUs based on clusters in order to calculate efficiency in the public health environment and optimize the resources available in budgets.

Finally, this study has not exhausted this subject in its totality, given that an analysis of efficiency is directly linked to the maximization of inputs. Thus, we recommend that studies which analyze the efficiency of public spending be conducted to verify whether the efficiencies in the use of allocated health resources found in this study can be related to the quality of the services provided to the population at large.

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APPENDIX A

Ano	DMU	DEA CRS Sem Cluster	DEA VRS Sem Cluster	Cluster	DEA CRS com Cluster	DEA VRS com Cluster
2015	Acre	0,2191	0,76	3	0,2191	0,76
2016		0,2312	0,7636		0,2312	0,7636
2017		0,2674	0,8542		0,2674	0,8542
2018		0,2715	0,84		0,2931	0,84
2015	Alagoas	0,6225	0,7037	1	0,6724	0,8437
2016		0,7252	0,7778		0,7797	0,8909
2017		0,7365	0,7593		0,7428	0,8333
2018		0,8028	0,8607		0,8578	0,9612
2015	Amazonas	0,3319	0,7879	3	0,3319	0,7879
2016		0,3308	0,8085		0,3837	0,8622
2017		0,4365	0,8039		0,4365	0,8039
2018		0,4338	0,7925		0,454	0,7925
2015	Amapá	0,2671	0,717	3	0,2671	0,717
2016		0,2588	0,7925		0,2588	0,7925
2017		0,32	0,8039		0,32	0,8039
2018		0,4248	1		0,5	1
2015	Bahia	0,7835	0,9532	1	1	1
2016		0,6609	0,944		1	1
2017		0,6657	0,9585		1	1
2018		0,6977	0,9986		1	1
2015	Ceará	0,7087	0,7764	1	0,8602	0,8651
2016		0,6966	0,7951		0,927	0,953
2017		0,6996	0,7938		0,9312	1
2018		0,7159	0,8036		0,9076	0,9812
2015	Distrito Federal	0,0778	0,6152	1	0,0843	0,7682
2016		0,11	0,7813		0,1122	0,7897
2017		0,2029	0,6849		0,2034	0,7031
2018		0,2867	0,8994		0,2867	0,9163
2015	Espírito Santo	0,348	0,7537	1	0,3776	0,9044
2016		0,4361	0,8282		0,477	0,9234
2017		0,4486	0,8413		0,4711	0,9184
2018		0,4677	0,8444		0,4983	0,9263
2015	Goiás	0,5218	0,7577	1	0,5692	0,9136
2016		0,552	0,8423		0,6222	0,93
2017		0,5272	0,8706		0,586	0,9375
2018		0,527	0,8394		0,5938	0,9009
2015	Maranhão	1	1	1	1	1
2016		1	1		1	1
2017		1	1		1	1

2018		1	1		1	1
2015	Minas Gerais	1	1	2	1	1
2016		1	1		1	1
2017		1	1		1	1
2018		1	1		1	1
2015	Mato Grosso do Sul	0,7434	0,8448	1	0,8022	1
2016		0,663	0,8571		0,7128	0,9644
2017		0,7481	0,9111		0,7544	1
2018		0,7473	0,8936		0,7906	0,9718
2015	Mato Grosso	0,4843	0,76	1	0,5231	0,901
2016		0,5362	0,8936		0,5777	1
2017		0,6312	0,9111		0,6438	1
2018		0,62	0,8936		0,6537	0,978
2015	Pará	1	1	3	1	1
2016		1	1		1	1
2017		1	1		1	1
2018		0,9706	1		1	1
2015	Paraíba	0,696	0,7158	1	0,7391	0,8521
2016		0,7147	0,7392		0,774	0,8331
2017		0,6902	0,7194		0,7285	0,7759
2018		0,7702	0,8006		0,8345	0,8599
2015	Pernambuco	0,4715	0,7372	1	0,581	0,8087
2016		0,4913	0,786		0,6739	0,8321
2017		0,4717	0,808		0,6242	0,8378
2018		0,4949	0,8048		0,6472	0,8213
2015	Piauí	0,5921	0,8274	1	0,6383	1
2016		0,5973	0,875		0,6422	0,9925
2017		0,6105	0,8723		0,6158	0,9574
2018		0,6894	1		0,6894	1
2015	Paraná	0,8666	0,9155	1	1	1
2016		0,803	0,9751		1	1
2017		0,7307	0,9843		1	1
2018		0,7444	0,9979		1	1
2015	Rio de Janeiro	0,761	0,8259	2	0,7718	0,8259
2016		0,8409	1		0,8409	1
2017		0,6369	0,6545		0,6369	0,7122
2018		0,641	0,6911		0,641	0,7009
2015	Rio Grande do Norte	0,5289	0,6775	1	0,5545	0,8306
2016		0,5734	0,6774		0,6178	0,7718
2017		0,5932	0,6949		0,6026	0,7627
2018		0,6299	0,75		0,6565	0,8273
2015	Rondônia	0,4548	0,8387	3	0,4548	0,8387
2016		0,4908	0,875		0,4908	0,875

2017		0,5177	0,9535		0,5177	0,9535
2018		0,5051	0,8077		0,5297	0,8077
2015	Roraima	0,2054	0,7536	3	0,2054	0,7536
2016		0,2324	0,9419		0,2722	1
2017		0,203	0,8288		0,217	0,8468
2018		0,2319	0,8405		0,2643	0,8405
2015	Rio Grande do Sul	0,5716	0,7422	2	0,6507	0,9314
2016		0,5288	0,7819		0,5738	0,9113
2017		0,4724	0,7703		0,5536	0,9789
2018		0,4514	0,7652		0,4881	0,9128
2015	Santa Catarina	0,6016	0,7925	1	0,6794	0,9044
2016		0,6716	0,9197		0,7918	0,9792
2017		0,6891	0,9143		0,8515	0,9574
2018		0,6334	0,9512		0,7891	0,9783
2015	Sergipe	0,4729	0,7308	1	0,5108	0,8654
2016		0,5459	0,84		0,5869	0,94
2017		0,5175	0,7593		0,5219	0,8333
2018		0,4574	0,6774		0,4929	0,7258
2015	São Paulo	1	1	2	1	1
2016		1	1		1	1
2017		1	1		1	1
2018		1	1		1	1
2015	Tocantins	0,2458	0,7451	1	0,2655	0,8954
2016		0,2627	0,8396		0,2751	0,9128
2017		0,2941	0,8367		0,2966	0,9184
2018		0,2992	0,934		0,2992	0,9602

REVISTA CONTABILIDADE, GESTÃO E GOVERNANÇA
JOURNAL OF ACCOUNTING, MANAGEMENT AND GOVERNANCE

Eficiência dos Gastos com Saúde nos Estados Brasileiros: Análise Baseada em Clusters

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RESUMO

Objetivo: *Esta pesquisa objetivou apurar a eficiência dos gastos com saúde pública dos estados brasileiros e do Distrito Federal.*
Método: *Classificada como quantitativa e descritiva, a pesquisa buscou segmentar os estados em clusters, calcular a eficiência no âmbito de cada cluster e comparar os resultados da eficiência com e sem os clusters, no período compreendido entre 2015 e 2018. Para calcular os escores de eficiência das 27 unidades da Federação, foi utilizada a Análise Envoltória de Dados (Data Envelopment Analysis - DEA) com os modelos Retorno Constante de Escala e Retorno Variável de Escala, orientado ao output.*
Originalidade/Relevância: *A segregação em cluster é o diferencial da pesquisa de Andrett et al. (2018), que também analisou a eficiência nos gastos públicos nos estados. Há pouca abordagem acerca da criação de critérios para o agrupamento, nos estados, a respeito da saúde pública no Brasil.*
Resultados: *Os resultados mostraram que os estados de Minas Gerais, Maranhão e São Paulo obtiveram os escores de eficiência igual a 1, agrupados ou não pelos clusters, e que, nos demais estados, ao menos em um período, a segregação por clusters alterou os escores de eficiência, o que sugere a existência de problemas quanto à gestão de gastos públicos com saúde e, portanto, a necessidade de melhorar a qualidade dos serviços e de maximizar os recursos com saúde pública.*
Contribuições teóricas/metodológicas: *Esta pesquisa contribui, de maneira prática, não apenas no ambiente acadêmico, mas também na tomada de decisão dos gestores públicos com o objetivo de melhorar a qualidade dos serviços com saúde, utilizando-se das técnicas de cluster para avaliação desses gastos.*

Palavras-chave: *Eficiência do gasto. Saúde pública. Gestão pública. Cluster.*

Recebido: Junho 18, 2021
Revisado: Junho 9, 2022
Aceito: Julho 12, 2022
Publicado: Novembro 30, 2022