Analysis of the Efficiency of Public Spending on Health Care by the Municipalities of Rondônia, Brazil, using the Data Envelopment Analysis Method

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Abstract. For a better access to the public Brazilian health care system and in order for the citizens to see the results of the taxes they paid, a correct and efficient allocation of public resources is necessary. Based on the theory of Social Management and on the agency theory, this research aims to analyze the efficiency of the public resources allocated in the function of government or of expenditure Health Care by the municipalities of the state of Rondônia, in the north of Brazil. The population was characterized as a census, since all the 52 municipalities were analyzed. The methodological preparation was based on a quantitative approach, using the Data Envelopment Analysis method, through a BCC input oriented model. The results showed that most municipalities (54%) can be classified as having "strong inefficiency" – the other 40% were classified as presenting "weak inefficiency" or "moderate inefficiency". The municipalities with the highest level, characterized as benchmarks, were Alto Paraíso, Buritis and Porto Velho (the capital of the state). There was no correlation between expenditures on health care and the following variables: number of registered families in primary care, number of hospitalizations, number of outpatient care production and number of health care facilities. The results highlighted a need for a revision to the management practices currently in place regarding the allocation of the resources for this particular sector (health care). The study is of potential interest to public accountants, controllers, auditors, managers and advisors managing public health policies and to the society in general, aiming at instrumentalizing social control.

Keywords: Data Envelopment Analysis, efficiency, Brazilian municipalities, public resources

Introduction

The State plays a particularly important role – that of allocating resources that are the result of the taxes paid by the population for the provision of services and basic products. Therefore, it is evident that there is a need for a correct use of these resources so that everyone – or as many people as possible – is equally attended by public services. Besides of having to fulfil the duty of applying such resources in accordance with the law, the government has the obligation to be as efficient as possible in social public policies, including in the area of health care. In Brazil, the allocation of funds for resources in this area is still precarious, which constitutes a major challenge for public officials in order to guarantee the universality and comprehensiveness of health assistance to the population. Citizens want an efficient administration in this area, but there is still a huge barrier for its implementation in Brazil (Mazon, Mascarenhas, & Dallabrida, 2015).

Due to advanced technology and to the constantly evolving scientific knowledge, health organizations are constantly changing. If there is not a process of change also in the way the resources are allocated, taking into account the reality of each area, there will be no success in the procedures and, therefore, there will be prolonged precarious results in the health care processes. In spite of the advances that enabled the creation of the *Sistema Único de Saúde* (SUS), Brazil's publicly funded health care system, the country still presents a poor performance regarding the attention that such service needs, making the constitutional

provision that declares health care as a right to everyone and a duty of the State have no substantial practical meaning (Marques, & Mendes, 2012).

The SUS was founded by the Brazilian Federal Constitution of 1988 (articles from 196 to 200) and consolidated by Laws 8,080 and 8,142 (1990), which provide that the State must ensure health and safety to the population and reduce the risk of diseases through social and economic policies. Brazil is a developing country, when compared to other economies. This is reflected in the efficiency of the provision of public services and has direct consequences in the realm of health care. Such area should be a priority for public officials (Lepchak, Lima Filho, Silva, & Peixe, 2019). This complex situation faced by Brazilian authorities requires further researches. Another justification for this study is linked to the fact that the world is currently facing a pandemic – the Coronavirus (Covid-19) pandemic –, which has severely impacted the global economy. This crisis makes it opportune to carry out new studies related to the efficiency of public health management in Brazilian municipalities and in other spheres of government.

There is a complex competitiveness between buyers and service providers, forging a connection between the public and the private sectors, a link that is financed mainly by private resources, consequently originating the Brazilian health system (Paim, Travassos, Almeida, Bahia, Macinko, 2011). The allocation of resources, no matter how significant or modest they are, must be carried out efficiently to guarantee the quality of the services provided to the population. Considering this context, the objective of this study is to analyze the efficiency of public resources allocated for the function of government or expenditure Health Care by municipalities in the state of Rondônia, in the north of Brazil.

Theoretical Framework

Public Health Management and Expenditures

Good results are the consequence of professionals who perform a job according to the rules and principles that the organization itself has determined. Strong performances of organizations are due to investments in the preparation, qualification and development of human resources. As a consequence, organizational objectives and strategies can be achieved (Novais, & Pavan, 2017). Management and measurement systems are extremely important. In the context of public health, through such systems, care processes can be more efficient and attend to the increased lack of safety for patients in health units. With such systems, assistance is improved and important information can be applied in the decision making processes (Novais, & Pavan, 2017).

With the intention of enganing society in the debate and in the conception of public policies, new institutional configurations have been developed in Brazil, such as the *Conselhos Gestores de Saúde* (CGS), health management councils which were institutionalized in 1990 as a result of a history of fighting for improvements in sanitary and health conditions in the country. These councils are an appropriate environment for the deliberation and inspection of public policies, being formed by members of the civil society and of the government. However, there is a *lacuna* between the existence of these councils and their operation. Some standards that should already have been reached are still a matter of concern, which makes the work of these councils more difficult. They should be constantly evaluated in order to inject more efficiency into the health care system in Brazil (Lopes, Silva, Ferreira, & Emmendoerfer, 2014).

In the public budget and in the Brazilian public accounting, there are specific classifications for public expenditures. Among them, the functional ones stand out. In the *Portaria* number 42/1999, functional expenditures are divided into "functions" and "subfunctions". There are 28 different functions. They refer to the general objective of a

given sector – for example, the Health Care function refers to the health care system. Subfunctions, on the other hand, are subparts of the function – that is, institutions or programs linked directly or indirectly to the function. Through these classifications, it is possible to identify the allocation of resources for each function and its Subfunctions. The Subfunctions related to the Health Care function are shown in table 1.

Table 1. Functions and subfunctions of government – health care

Function	Subfunctions
10 – Health Care	301 – Primary Care
	302 – Hospitalization and Outpatient Care
	303 – Prophylactic and Therapeutic Support
	304 – Health Surveillance
	305 – Epidemiological Surveillance
	306 – Food and Nutrition

Source: Brazil, *Portaria* number 42 (Ministry of Planning, Budget and Management), April 14th 1999.

Based on the premisse that the efficiency reflects the capacity of a municipality to obtain maximum results with the lowest consumption of resources possible, it is understood that the larger the sum of money invested in health care is, the greater the efficiency will be when promoting services related to the Primary Health Care Subfunction within the direct health care administration (Melo, 2013). Baleeiro and Machado Segundo (2015, p. 88) explain that, regarding public expenditure, the government should be inspired by the principle of "maximum social advantage", by orienting itself towards "how to obtain maximum efficiency and social convenience with a corresponding minimum pecuniary sacrifice", on the occasion, for example, of deciding whether to build or expand hospitals and health care falicities or purchase medicines and other materials.

Patient safety, effectiveness, patient-centered approach, timely assistance, efficiency and equity are the six domains of health care quality put forth by the Institute of Medicine (IOM). These aims for the health care system must be taken into account when a country or institution wants to achieve quality management in health care (Novais, & Pavan, 2017).

New Public Management, Social Management and the Agency Theory

Some of the practices of the private sector were incorporated into public administration in the 1970s, in a movement that became known as the New Public Management (NPM). According to Denhardt (2012), the expressions "NPM", "New Public Management", "New Public Administration" and "Managerial Public Administration" are synonymous. The main objective of the NMP is to increase the efficiency of the public sector. It presupposes the application of the notion of "efficiency" of the private sector to the public sector (Engida, & Bardill, 2013).

In its article 37, the Brazilian Federal Constitution mentions the principle of efficiency, which was included by the Constitutional Amendment Number 19/1998: " The governmental entities and entities owned by the Government in any of the powers of the Union, the states, the Federal District and the Municipalities shall obey the principles of lawfulness, impersonality, morality, transparency and efficiency". The article 37 provides that the public administrators must fully base their action on the legal grounds during the administration of the public machine. Therefore, the principle of efficiency is linked to that of lawfulness, as it is expected that the resources are properly allocated and comply with all legal requirements. Establishing the objective of efficiency in public management should be

considered a strategic decision to reduce the deficit when attending to the various government goods and services (Zoghbi, 2016).

In the context of the movement New Public Management, efficiency derives from an effort to improve management in the organizations, with evaluation measures based on clear and well-defined objectives, focus on control and results, separation of large units of the public sector, introduction of competition in the public sector, use of private sector management practices, focus on discipline and use of resources (Hood, 1991). There is no consensus in the literature that such a movement is a theory. Regardless of that, it has evolved into what is called "Social Management", which advocates greater transparency, participation and social emancipation for the public sector (Cançado, Pereira, & Tenório, 2015).

Cançado *et al*. (2015) describe the evolution of the public administration through a series of disruptions. According to these authors, the absolutist State and its typical way of exercising power through management stands for a patrimonialist administration. After that, still according to the authors, there were two ruptures. In the first, that of a centralized power by the State, the capitalist market emerged, with its typical way of managing State power and the market, which corresponded to a bureaucratic administration. In the second rupture of power, contemporary democratic society was formed, emancipated from the State and from the market, followed by a deliberative democratic power management, called "Social Management" (Cançado *et al*., 2015, p. 85). Therefore, according to Cançado *et al*. (2015), NGP, Managerial Administration or Social Management are synonyms. The authors submitted Social Management to the sieve of scientific demarcation and consider it as a process that is theoretically based on three major categories: public interest, public sphere and social emancipation (Cançado *et al*., 2015, p. 136).

Given the analysis of public policies in relation to the agency theory, it can be observed that organizations present two branches of great importance – the agent and the principal. The meaning of such theory derives from the fact that the public manager is not able to coordinate and manage all of his assets. According to Jensen and Meckling (1976), the theory is based on a contractual relationship, in which the main part (the principal), which is the contractor, grants functions to the agent; the agent is therefore responsible for making the necessary decisions and/or taking actions on behalf of another person or entity.

Eisenhardt (1989) states that, because of this relationship, agency conflicts may exist due to the clash between the principal and the agent and the differences between their goals and desires in the organization. According to Slomski (2007), government accounting can help by providing accountability models, aiming at reducing external and internal information asymmetry, moderating agency conflicts. By reducing informational asymmetry, an improvement in efficiency can be achieved.

According to Secchi (2013), there are some criteria that provide feedback and are used in the evaluation process that add value to the present study. They are: economic efficiency and administrative efficiency. Economic efficiency refers to the relationship between inputs and outputs; administrative efficiency refers to the execution according to predetermined methods. According to Gaiger (2009), efficiency is linked to the degree of effectiveness of the employees in order to achieve the planned results.

According to Malena, Batista Filho, Oliveira and Castro (2013), the concept of "efficiency" involves the correct use of the capital destined to a certain objective – i.e. it is about reaching the specific purpose using the resources available for that specific purpose, whether they are minimal or not, and achieving success in the goals previously set. Rech, Comunelo and Godarth (2014) refer to efficiency as obtaining great yields with the minimum possible time and resources – even doing so, quality in the final result is not lost.

There are several types of efficiency, according to Ferreira and Gomes (2012). Among them, there is the technical efficiency, which is particularly important for this research, as it

refers to the lowest possible use of the resources. It is about seeking efficiency by minimizing resources; it means doing more with less; it is to reach the goal previously set with minimum means.

The Data Envelopment Analysis (DEA) method refers to the combination of the necessary inputs and methods (inputs) in the production process, so that they generate the maximum number of products (outputs). This definition is related to the concept of "technical efficiency" (Ferreira, & Gomes, 2012). Efficiency is the ability to do things in the right way and to minimize the input-output relationship. It aims to ensure the optimization of the use of resources and, therefore, it is related to the means, and not to the ends (Peña, 2008).

Previous Studies

Carneiro, Lima and Souza (2015) studied the efficiency of public expenditure in the municipalities of Rondônia for the Education function. In such study, DEA was used. The authors concluded that the efficiency in the educational area is not necessarily linked to bigger investments. In bigger municipalities, where there is more investment, there was less effectiveness. Such municipalities even secured a low place in the ranking. Smaller municipalities, with lower costs, ranked first in efficiency. The authors suggested further studies on the Health Care function.

Recent studies related to measuring efficiency in public health using DEA modeling are described below. Its objectives and main conclusions are mentioned as well.

Table 2. Previous studies on public health using DEA

Authors	Research objectives	Main findings
Lepchak *et al.* (2019)	To analyze the efficiency in the use of resources allocated for public health care in the largest municipalities in Brazil and, therefore, to establish a comparison among different Brazilian regions.	There are differences among the efficiency scores in the largest Brazilian municipalities , in addition to a diversity in the allocation of resources for health care.
Andrett and Rosa (2015)	To verify the efficient application of public resources in health care in Brazilian states and the impact that these investments bring to the population.	The level of efficiency in most federative units is not satisfactory – 69.6% of the states present a performance lower than 80%, and only 17% of the federative units are classified between 80% e 100%.
Silva and Ferreira (2014)	To measure the level of technical efficiency in the allocation of public resources in health care services in the metropolitan region of the Vale do Paraíba and in the north coast of São Paulo, in 2014.	The results showed that 50% of the municipalities studied showed relative technical efficiency of 100% in 2014. The average index reached by the region was 87.7%. For a city in the sample to reach the frontier of technical efficiency, it is not necessarily necessary to make greater investments.
Silva, Ferreira, Braga and Abrantes (2012)	To assess, in the municipalities from the state of Minas Gerais, in the southeast region of Brazil, the efficiency in the allocation of funds and resources for education, health care and housing.	Most municipalities in Minas Gerais had low and average efficiency scores, which indicates the need for improvements in the allocation of resources. This need is emphasized by the small number of municipalities that presented high efficiency scores in each area.

Source: Research data (2020).

In these researches, the potential of using DEA as a tool to assess efficiency in social programs is demonstrated. It is an alternative to the technical reference of economic research based on mathematical analysis. There is also a need to include the state of Rondônia in this list of social public policies, with a focus on health care.

Method

Methodological Approach

Statistical studies that capture the characteristics of a population and not its depth are of relevance for this study (Cooper, & Schindler, 2016). The research approach is quantitative (empiricism). According to Martins and Theóphilo (2016), empiricism privileged quantitative measurement combined with empirical observation and experimental testing as criteria of scientificity. The authors also state that the evaluation research is a research strategy applied to the evaluation of programs, projects, policies etc. This study was developed based on the empirical-analytical method (archive/empiricist – database), which corresponds to the use of data collection, treatment and analysis with quantitative metrics. Data Envelopment Analysis (DEA) will be the method used. It assesses the efficiency of the Decision Making Units (DMU), which, in their turn, in this study, are the 52 municipalities from Rondônia.

Population and Data Collection

The population is characterized as a census, because all of the 52 municipalities from the state of Rondônia were included in this study. The data collection is characterized as documentary, considering that the construction of the database used to obtain the appropriate inputs and outputs for the analysis was based on the accounting documents published on official government websites. Inputs and outputs were collected on the platform of the Brazilian Ministry of Health's *Departamento de Informática do Sistema Único de Saúde* (Datasus), the SUS' department of informatics.

Data Envelopment Analysis (DEA)

As previously mentioned, the data will be analyzed through DEA. Ramanathan (2003) defines this method as a technique to measure the efficiency of the performance of organizational units, called "Decision Making Units" (DMUs). Based on non-parametric mathematical models (Ferreira, & Gomes, 2012), DEA was used for the first time in 1978. Immediately, many researchers realized that, because this method was easy to use in modeling operational processes to evaluate performances, it was a very efficient methodology (Gregoriou, & Zhu, 2005, p. 5-6). For this reason, it has been widely used in operational research, when users want to be sure about the use of optimal data for the decision making in their industrial production processes. Different information may lead to confusion, due to the uncertainty that arises when different factors are involved. Therefore, DEA is chosen when one wants to opt for a safer research (Saharidis, 2017). It is an instrument widely used in foreign researches, but its use in Brazil is also growing, especially to analyze the efficiency of DMUs, when comparing inputs with outputs, using linear mathematical programming (Charnes, Cooper, Rhodes, 1978). As for inputs and outputs, Ramanathan (2003 p. 174) states that "normally, inputs are defined as resources used by DMUs or conditions that affect their performance, while outputs are the benefits generated as a result of the operation of DMUs".

In order to use DEA appropriately, it is important to understand the main concepts involved, namely "effectiveness", "efficiency" and "productivity". "Effectiveness" can be defined as the capacity of achieving the aimed results for the goals previously set, without worrying about the resources used; productivity is the way in which raw materials are used, that is, the ratio between what is produced and what was spent on production; efficiency means producing the same quantity of a good with fewer inputs or producing more with the same number of inputs (Ferreira, & Gomes, 2012).

For the application of DEA, according to Peña (2008), a sequence of steps is required: 1) selection of the production units (DMUs); 2) selection of variables (inputs and outputs); 3)

application of DEA models, using a software. In this third and final step, the orientation (inputs or outputs) and the type of model, CCR or BCC, are defined. After selecting DMUs and variables (inputs and outputs), orientation and model type are defined, according to what is the most appropriate for specific cases.

In the research, the best way to apply the modeling was analyzed and studied. From the previous readings, the configuration, as presented in table 3, was established. The periods considered were the most recent ones for the publication of accounting data and government indicators.

Table 3. DEA application in public health care in the municipalities of Rondônia

Order	Modeling	Description	Years
1	Selection of DMUs	52 municipalities from the state of Rondônia, Brazil	
2	*Input* Variables	(GSau) Public expenditure on health care *per capita* (resources)	2018
3	*Output* Variables	(CobVac) Immunization coverage (vaccines) (FamCad) Registered families (NI)　　　Number of hospitalizations (NPA)　　Outpatient production (NE)　　　Number of health care facilities	2019 2014 2018 2018 2018
4	*Software*	SIAD 3.0 – *Sistema Integrado de Apoio à Decisão* (Integrated System for Decision Support) – Fluminense Federal University (UFF)	
5	Model	BBC	
6	Orientation	*Input*	

Source: Research data (2020).

The choice of the input variables was based on the studies by Lepchak *et al.* (2019), Mazon, Mascarenhas and Dallabrida (2015), Andrett and Rosa (2015) and Mendes (2005). The Output variables (products/services/assistances) were based on the study by Andrett and Rosa (2015). The resident population, also collected in the Datasus, refers to 2015. The correlation between the input and output variables was analyzed using the Pearson correlation coefficient.

According to Kassai (2002), as a restriction of the DEA model, the number of DMUs must be, at least, two times greater than the number of inputs and products considered so the model can present consistent results. For the application of the method in this research, the number of DMUs was 52; the sum of the variables was six. Thefore, the restriction was observed. Other precautions were also considered (Kassai, 2002): comparable units of analysis were used, that is, they were operated under the same conditions; factors (inputs and outputs) were the same for each unit.

After collection, the data were organized in electronic spreadsheets in which all the variables formed a database, in every stage. For the analysis, the software SIAD was used. It is a reliable and accessible tool, developed by the Fluminense Federal University to provide complete results, including new theoretical model developments that, in addition to implementing the classic models, provide complete results and involve advanced models (Angle Meza, Biondi Neto, Mello, & Gomes, 2005). This software was developed in response to the emergence of a growing interest in DEA on behalf of many researchers. It can be used on a Windows platform and allows working with up to 100 DMUs and 20 variables (inputs and outputs). These numbers are considered sufficient (Ângulo Meza *et al.*, 2005).

The input-oriented BCC model (DEA-BCC-in) was chosen due to the adoption of a premise of minimizing health care expenditures in the municipalities (input), based on the use of products (established outputs), according to the guidance of Lepchak *et al.* (2019). This logic of analysis of the efficiency refers to the discussion of an efficient application of

resources, in order to use and optimize all the value invested by governments – the premise is necessary so that we have parameters in the search for the efficient frontier (Lepchak *et al.*, 2019). In other words, in the interpretation of the premise, no inferences are made when reductions in municipal health care investments are assumed, there is no suggestion of a real reduction in investments in public health care (Lepchak *et al.*, 2019). Usually, what is aimed at is the expansion of such resources, not the reduction of the absolute value of the allocated resources (Mazon, Mascarenhas, Dallabrida, 2015). "An interesting feature of the model is the possibility of seeing optimal levels of production. These optimum levels can serve as a reference for the design of inefficient units for the efficiency frontier" (Lepchak *et al.*, 2019, p. 144).

Efficiency scores can vary on a scale from 0 to 1. For the analysis of the performance and of the efficiency level of the municipalities, a classification for the efficiency ranging between 0 (zero), which is considered inefficient, and 1 (one), that corresponds to the maximum level of efficiency, was adopted. The scale is divided as shown in table 4.

Table 4. Performance and level of efficiency

Performance	Level of efficiency
0	Inefficient
From 0.1 to 0.25	Low level of efficiency
From 0.26 to 0.50	Average level of efficiency
From 0.51 to 0.75	Good level of efficiency
From 0.76 to 0.99	High level of efficiency
1	Maximum efficiency level

Source: Research data (2020).

Presentation, Analysis and Discussion of Results

The results will be presented initially through the descriptive statistics of the study variables and, after that, through the efficiency indicators. Subsequently, a discussion based on previous studies is presented.

Descriptive Statistics of the Variables

Table 5 presents the descriptive analyses of the inputs and outputs used to obtain the efficiency scores of the municipalities analyzed.

Table 5. Descriptive statistics of the variables

Variables	Minimum	Maximum	Arithmetic mean	Median	Standard deviation
GSau	309.96	1,963.48	588.40	527.25	245.78
CobVac	91.30	111.92	100.61	99.59	5.45
FamCad	645.00	68,759.00	6,539.63	3,193.00	10,183.66
NI	26.00	44,830.00	2,318.06	505.00	6,555.46
NPA	6,888.00	16,315,864.00	657,845.58	125,952.50	2,380,861.76
NE	3.00	812.00	57.29	13.00	132.78
Expenditures on health care	2,664,460.05	251,857,355.31	17,812.672.75	7,489,543.73	36,322,065.79
Population	2,423.00	502,747.00	34,003.12	16,262.50	71,441.07

Source: Research data (2020).

Porto Velho, capital of the state of Rondônia, is the most populous municipality and has the highest health expenditure, the highest total number of families registered in the primary care (FamCad), the highest number of hospitalizations (NI), the highest number of outpatient

production (NPA) and the highest number of health care facilities (NE). Porto Velho was also one of the three municipalities that presented the highest level of efficiency. The capital only did not reach the maximum level in the immunization coverage (CobVac), leaving the first place in the ranking for the municipality of Teixeirópolis, and in the public expenditure on health care *per capita* – the first place was occupied by the municipality of Pimenteiras do Oeste, which is also the municipality with the minimum population variable and the only one with a low degree of efficiency.

When studying the correlation between the input and output variables by the Pearson correction coefficient, the following results were obtained:

Table 6. Correlation among the variables

Input	Outputs	Correlation coefficient	Interpretation
GSau	CobVac	0.09119	Positive, very low
GSau	FamCad	-0.17115	Negative, low
GSau	NI	-0.08696	Negative, very low
GSau	NPA	-0.08498	Negative, very low
GSau	NE	-0.09396	Negative, very low

Source: Research data (2020).

The correlation between health expenditure *per capita* is only positive with the variable immunization coverage (CobVac). It can be understood that, as the expenditures executed increase, there is an increase, in the same direction, of this number in relation to the coverage output indicator. However, the correlation is very low. For the other outputs, the relationship is reversed, that is, for the increases in the executed expenditures, there is no increase, in the same direction, of those numbers referring to the indicators.

Efficiency Scores

Efficiency scores were obtained using variables that define an indicator for each municipality. These scores are classified as "maximum", "high", "good", "average", "low" and "inefficient", from the highest to the lowest, and organized in a state ranking, as shown in table 7. Three municipalities showed an 100% efficiency level (indicator 1) – they represent benchmarks for the others.

Table 7. Ranking of the efficiency in municipal health care in the state Rondônia

Ranking	Municipalities	Efficiency indicator	Level of efficiency
1	Alto Paraíso	1.000000	Maximum
	Buritis	1.000000	Maximum
	Porto Velho	1.000000	Maximum
2	Cujubim	0.944281	High
3	Cacoal	0.844889	High
4	Seringueiras	0.831776	High
5	Ji-Paraná	0.806880	High
6	Candeias do Jamari	0.806753	High
7	Costa Marques	0.766370	High
8	Ministro Andreazza	0.756017	Good
9	Nova Mamoré	0.746307	Good
10	Guajará-Mirim	0.739998	Good
11	Nova Brasilândia do Oeste	0.724723	Good
12	Jaru	0.710493	Good
13	Mirante da Serra	0.681264	Good

14	Espigão do Oeste	0.677902	Good
15	Governador Jorge Teixeira	0.667171	Good
16	Ouro Preto do Oeste	0.639601	Good
17	Colorado do Oeste	0.637038	Good
18	Itapuã do Oeste	0.626747	Good
19	Alvorada do Oeste	0.623564	Good
20	Rolim de Moura	0.622378	Good
21	Nova União	0.614393	Good
22	São Miguel do Guaporé	0.603807	Good
23	Alto Alegre dos Parecis	0.594358	Good
24	Machadinho do Oeste	0.590228	Good
25	Urupá	0.582121	Good
26	Teixeirópolis	0.576300	Good
27	Alta Floresta do Oeste	0.573294	Good
28	Ariquemes	0.560669	Good
29	Presidente Médici	0.554724	Good
30	Vale do Anari	0.552144	Good
31	São Francisco do Guaporé	0.548927	Good
32	Theobroma	0.546676	Good
33	Novo Horizonte do Oeste	0.539635	Good
34	Cerejeiras	0.529750	Good
35	Campo Novo de Rondônia	0.523176	Good
36	Pimenta Bueno	0.522511	Good
37	São Felipe do Oeste	0.518462	Good
38	Cacaulândia	0.496373	Average
39	Monte Negro	0.494871	Average
40	Vilhena	0.479558	Average
41	Vale do Paraíso	0.455830	Average
42	Santa Lúcia do Oeste	0.448415	Average
43	Corumbiara	0.445184	Average
44	Chupinguaia	0.427691	Average
45	Cabixi	0.408307	Average
46	Parecis	0.404546	Average
47	Primavera de Rondônia	0.399043	Average
48	Rio Crespo	0.306754	Average
49	Castanheiras	0.293923	Average
50	Pimenteiras do Oeste	0.174385	Low

Source: Research data (2020).

Alto Paraíso, with a population corresponding to only 4.02% of the total population of the capital Porto Velho, presented the lowest health expenditure, but achieved the same level of efficiency. Table 8 presents the descriptive analyses of the efficiency scores of the municipalities analyzed.

Table 8. Descriptive efficiency statistics

	Minimum	**Maximum**	**Arithmetic mean**	**Median**	**Standard deviation**
Efficiency	0.174	1.000	0.608	0.586	0.176

Source: Research data (2020).

According to table 7, the municipality with the lowest indicator was Pimenteiras do Oeste, with a difference of 0.826 for the maximum level of efficiency (1,000), achieved by only three municipalities. Table 9 shows the intervals of the efficiency levels of the municipalities.

Table 9. Levels of efficiency

Efficiency (E)	Quantity	Percentage
Efficient (E = 1)	3	5.77
Weak inefficiency (0.8 ≤ E < 1.0)	5	9.61
Moderate inefficiency (0.6 ≤ E < 0.8)	16	30.77
Strong inefficiency (E < 0.6)	28	53.85
Total	52	100.00

Source: Research data (2020).

The intervals show the percentage of efficiency. It can be noted that more than half of the municipalities are classified as having a strong inefficiency, which sums a percentage of approximately 54%. Only 5.77% were classified as efficient; the remaining 40% were classified as having weak and moderate inefficiency. When considering the sum of those classified as having strong and moderate inefficiency, the percentage of approximately 85% is obtained. This may be linked to the fact that there is no correlation between health expenditure *per capita* and the output variables (table 6 – registered families in primary care, number of hospitalizations, outpatient production and number of health care facilities).

Comparison with Previous Studies
First, we compare the results of this study with the research by Carneiro, Lima and Souza (2015), which focused on the efficiency of the expenditure on education in the same municipalities of the state of Rondônia. The authors (2015) concluded that the efficiency in education is not linked to bigger investments, as they found that the municipalities with the biggest investments were not the most efficient, falling into the lowest positions in the ranking; the smaller municipalities, on the other hand, with the lowest expenditures, ranked first. These results are similar to those of the present research, which focused on health care and showed that municipalities with high and low investments present a maximum level of efficiency. For example, Porto Velho, that spent R$ 252 million in health care, and Alto Paraíso, that spent R$ 6 million, present the same level of efficiency, despite a huge difference in investments.

The study by Lepchak *et al.* (2019), which aimed at analyzing the efficiency in the use of resources destined to public health care in the largest municipalities in Brazil, concluded that there are differences among the efficiency scores in such cities. By comparison, it is important to note that the four largest municipalities in the state of Rondônia are Porto Velho, Ji-Paraná, Ariquemes and Vilhena. Different levels of efficiency were assessed for these locations. Porto Velho was classified with the maximum level, Vilhena presented an average level of efficiency, and Ji-Paraná and Ariquemes occupied, respectively, high and good levels.

Andrett and Rosa (2015) concluded that the level of efficiency in most Brazilian federative units is not satisfactory. 69.6% of the states perform below 80%, and only 17% of the federative units are classified between 80% and 100%. These results are also similar to those of the present research, in which it was found that most municipalities (54%) can be classified as having strong inefficiency.

Silva and Ferreira (2014) aimed to measure the level of technical efficiency in the allocation of public resources for health care services in the metropolitan area of Vale do Paraíba and in the north coast of São Paulo, in 2014. The results showed that 50% of the municipalities surveyed presented relative technical efficiency of 100% in the year analyzed. The average level reached by the region was 87.7%. For a city in the sample to reach the technical efficiency frontier, it does not necessarily need to make the biggest investments. In the present study, it was found that 53.85% of the municipalities were classified as having strong inefficiency, and the average of the indexes was 0.608 –at the state level, such result

could be classified as good. It was also observed that, for a municipality to reach the maximum efficiency level defined in this research, it does not necessarily depend on being the one that makes the biggest investments, as municipalities with low investments occupy the top of the ranking.

Silva *et al.* (2012) evaluated the efficiency in the allocation of funds and resources for education, health and housing in the municipalities of the state of Minas Gerais. The authors concluded that most of these municipalities presented low and medium efficiency scores, which points to the need for improvements in the allocation of resources – a small portion of municipalities had high efficiency scores in each area. As previously mentioned, the results of the present research also point to the same findings by Silva *et al.* (2012).

Final Considerations

The objective of this research was to analyze, using the Data Envelopment Analysis method, the efficiency of the allocation of public resources in the expenditure function Health Care by the municipalities of the state of Rondônia, Brazil. The analysis was carried out considering the resources allocated for the government or expenditure function Health Care (input), and five variables related to the assistance services provided to the population (products, outputs).

From the data collected, it was possible to verify that, for a municipality to achieve a high level of efficiency, it does not have to rely on bigger investments, but rather on a better management in the allocation of the resources. It was found that the capital Porto Velho, the largest municipality in the state, reached the maximum level of efficiency, having been followed by smaller municipalities, Buritis and Alto Paraíso, which present a relevant difference in their investments in relation to the capital. It was also possible to observe a huge difference in the efficiency ranking among the four largest municipalities of the state: Porto Velho, Ji-Paraná, Ariquemes and Vilhena.

The results showed a high degree of inefficiency. The level "strong inefficiency" encompassed approximately 54% of the population of the study. There was a difference in the results when compared to another area (function) of the municipalities' performance. In the study carried out by Carneiro, Lima and Souza (2015) for the Education function, in addition to demonstrating a higher level of efficiency, it was found that certain municipalities, such as Pimenteiras do Oeste, with maximum levels of efficiency, presented, in this study, a low level for the Health Care function.

The results showed that the efficiency levels of the municipalities are not satisfactory. Only seven municipalities out of the 52 analyzed managed to reach the maximum and high levels in the ranking. It is therefore necessary to review management practices in the allocation of these social resources in the municipalities of Rondônia, in order to improve the state's level of efficiency. In order to do so, municipalities with higher levels of efficiency may be taken as a reference.

The results here presented are limited to the adopted inputs and outputs. When choosing other inputs and outputs, there may be changes in the results. The entry or withdrawal of one or more units in the observation set changes the values of the relative productivity for all other units being evaluated. In addition, no model will assess data perfectly; what one can do is to learn something from them, even if imperfectly. Models are tools that help shape our understanding, allowing us to better perceive the world and sharpen our questioning, as once stated by George Box (1979 *apud* Dietz, & Kalof, 2015).

A practical recommendation for the less efficient or even inefficient municipal governments is that they follow those municipalities that were efficient (benchmarks), for a more efficient allocation of resources for health care and for a better performance and enhanced political learning. Empirically, new studies are recommended in other

municipalities in the states of the northern region of Brazil and in other regions of the country. An extended time period can also be considered, for other comparisons. Another possible research object is to understand the reasons for the high inefficiency scores and the lack of correlation between health care expenditure and the number of registered families, number of hospitalizations, outpatient production and number of health care facilities.

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