



Saúde em Debate

ISSN: 0103-1104

ISSN: 2358-2898

Centro Brasileiro de Estudos de Saúde

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Saúde em Debate, vol. 43, no. 121, 2019, April-June, pp. 329-340

Centro Brasileiro de Estudos de Saúde

DOI: <https://doi.org/10.1590/0103-1104201912103>

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# Resource allocation for equity in Brazilian health care: a methodological model

## *Alocação de recursos para equidade na atenção à saúde no Brasil: um modelo metodológico*

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DOI: 10.1590/0103-1104201912103

**ABSTRACT** It is a fundamental requirement of governments that they allocate resources to public services among institutions or populations that are potential competitors for funding. In Brazil, a country with clear social inequalities, equitable allocation of resources in the Unified Health System (SUS) poses a particular challenge. The present study proposes an individual-level matrix model for allocating health resources in the SUS based on data from the National Health Survey (PNS) 2013. This model is founded on a matrix of the following variables: age, sex, education, employment and income and the relationships between them. A morbidity score is used to estimate weights for each category. This model provides an opportunity for managers to use objective methods to provide a clear guide for decision-making in accordance with principles laid down in Brazilian law and in a manner based on health needs and epidemiological and demographic factors, in addition to the capacity to offer services.

**KEYWORDS** Resource allocation. Health equity. Delivery of health care. Methodology.

**RESUMO** É um requisito fundamental dos governos alocar recursos para serviços públicos entre instituições ou populações que são concorrentes potenciais para financiamento. No Brasil, país com desigualdades sociais claras, alocar recursos no Sistema Único de Saúde (SUS) se torna particularmente desafiador e equitativo. O estudo tem por objetivo apresentar um modelo matricial de nível individual para alocação de recursos em saúde no SUS com base em dados da Pesquisa Nacional de Saúde (PNS) 2013. Este modelo é baseado na matriz de variáveis idade, sexo, educação, emprego e renda e seus relacionamentos. Um escore de morbidade é usado para estimar pesos para cada categoria. Este modelo oferece uma oportunidade para que os gestores utilizem métodos objetivos que auxiliem a tomada de decisão de forma clara e baseada nas leis brasileiras, considerando as necessidades de saúde, aspectos epidemiológicos, demográficos, bem como a capacidade de oferecer serviços.

**PALAVRAS-CHAVE** Alocação de recursos. Equidade em saúde. Assistência à saúde. Metodologia.

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## Introduction

It is a fundamental requirement of governments on all levels that they be able to allocate funds for public services among institutions or populations that are potential competitors for such funds<sup>1,2</sup>. In recent years, the structural social problems that have plagued Brazil come to threaten the progress already achieved in the field of health care. The Unified Health System (SUS) is unlikely to move forward with the proposed defunding, austerity and allocation of ineffective resources that exacerbate inequality and have an enormous negative impact on the poorest and most vulnerable populations<sup>3</sup>.

In countries where social and geographical inequalities are great, such as Brazil, this is a particularly urgent challenge. In most countries, capitation systems have increasingly been used to set such prospective health care purchaser budgets or premium subsidies for a defined population and time period. Rather than relying on arbitrary methods of solving the resource allocation problem using historical precedent or political patronage, Brazil and many other countries have been seeking to implement the use of systematic funding formulas for a risk-adjusted capitation scheme<sup>4,5</sup>. This paper will discuss some of the methods considered so far and suggest a survey-based model of resource allocation for the public health care services of Brazil.

The Brazilian national health service (SUS) is financed by indirect and direct taxes. There are indirect taxes on commercial revenues, industrial output, and goods and services. Direct taxation falls on an individual's income, urban property and motor vehicles. These revenue streams are pooled in funds at federal, state and local municipal level and all three levels contribute to the financing of the SUS<sup>6,7</sup>. The SUS financing mechanism has since 2007 been divided into blocks to allocate money for basic care, medium and high complexity care, pharmaceutical assistance, health surveillance and management, each with its own sources of

revenue, different criteria for use and service performance reporting requirements. The proportion originating from the federal level has gradually been reduced but still has a powerful influence on the prioritization of programs. The proportion of local level revenue has increased. Most federal resources for health are allocated to state and local level as a way of devolving responsibility in order to ensure that health care is accessible and to comply with the principles of fairness and equity<sup>7</sup>. In this respect, Brazil is no different from many other countries where such responsibility is devolved to a variety of purchasers<sup>1,8</sup>. These may be local governments, as in Brazil and Scandinavia, GP-fund holders, as in the UK, local administrative boards, as in Canada, or commercial insurance pools, as in the US Medicare system.

In Brazil, Law 8.080/1990<sup>9</sup> (Art. 35) establishes certain principles for allocating resources geographically within the SUS. These principles were confirmed in Law 141/2012<sup>10</sup> (Art. 17-19) regarding allocation of resources to states and municipalities. Resource allocation should consider the following partially overlapping and partially conflicting criteria<sup>11</sup>: 1) the health needs of the population; 2) epidemiological, demographic, socio-economic and spatial dimensions; 3) the supply capacity of services; 4) quantitative and qualitative characteristics of the health network in the area; 5) technical, economic and financial performance in the previous period; 6) health sector participation levels in state and local budgets; 7) spending of five-year plan network investment; 8) reimbursement of care services provided to other governments; 9) different demographic criteria for states and municipalities related to migration. Unfortunately, however, these are not followed in a manner that faithfully reflects their intended purpose and complies with the law.

Regional inequalities in health and health care coverage have long been a focus of attention in Brazil. The Family Health Program initiated in the 1990s was implemented as a

national policy for primary care, allocating new resources to deprived municipalities.

Considerable improvements in primary care coverage were achieved particularly in poor areas in the northern regions<sup>11</sup>. Later another initiative was taken: the Mais Médicos Program in 2013<sup>12</sup>. Its aim was to supply primary care doctors to areas with high levels of poverty and those in remote areas far from secondary care providers. Recently, however, decisions have been made that could reverse some of these developments. In 2015, the Brazilian Congress ratified Constitutional Amendment 86 stipulating that 1.2% of the current revenue should go to projects designed by the deputies primarily for their own constituency, where 50% will be invested in health care infrastructure. Through this mechanism, more resources are allocated according to personal and partisan interests. Furthermore, in late 2016, Constitutional Amendment 95 was approved in order to freeze real-term social spending in Brazil for 20 years. This has put even greater pressure on SUS funding and efforts to reallocate resources to areas in greater need.

## Inequities in health care utilization

The establishment and expansion of the SUS have over the past 30 years greatly improved access to care, in particular in the poorer rural and northern regions of Brazil. Social inequality in utilization of health care has been measured by national health surveys (PNAD & PNS) since 1998. The utilization rates adjusted for self-reported health became more equitable between 1998 and 2008<sup>13</sup>, but a new measurement in 2013 showed that there have been changes in this trend<sup>14</sup> with an increase in pro-rich inequity utilization of doctor's visits but a decline in the pro-rich inequity of hospital utilization. These social inequities can be caused by geographical differences in health care resources, but also by several other factors including the growing

private insurance market, still very high out of pocket spending (56%)<sup>6</sup> and unequal health literacy. Geographical disparities in resources and health care supply between and within states have declined, but they are still substantial both in terms staff and hospital beds, and more so in secondary and tertiary than in primary care<sup>6</sup>.

In view of this, it is not surprising that there has been great interest in developing principles for the capitation formulae used for geographical resource allocation of federal resources to states and to local primary care within states.

## Resource allocation models

Most health systems in high-income countries use some form of risk-adjusted capitation<sup>1,8</sup>. In countries with insurance markets these have primarily been used to improve efficiency and cost control by reducing incentives for moral risk by minimizing variation between individual capitation payments and the expected expenditure of insurance plans with private health care.

From a completely different perspective, risk-adjusted capitation in public health care systems like the Brazilian SUS, the NHS-systems in the UK and Scandinavia, which have devolved responsibility for organizing or purchasing services to a geographic area such as a region or municipality, is more concerned with equity issues in terms of ensuring equal funding for equal need. While these models are commonly applied to universal health care systems, the actual methods used are different and have typically changed gradually over a few years<sup>1</sup>.

The ultimate purpose of these models is to allocate monetary resources, but the analysis includes three elements<sup>8</sup> within countries where this dataset is available: 1) estimating the need for services, 2) estimating the intensity of service utilization associated with that need, and 3) estimating the cost of providing these services in a specific area.

In many countries, the procedure used for producing estimates is divided into two stages<sup>15</sup>. The first is to estimate the average relationship between indicators of need and health care costs. If, for example, age is an indicator of need, this stage estimates health care costs across age groups and these can be used to weight each individual according to age. Age is but one, albeit important, factor and many countries have included other available indicators of need, such as an individual's socioeconomic status, or geographic level characteristics<sup>16</sup>. The second stage applies these weights to the population characteristics of each region. Relative *per capita* resource allocations thus reflect differences in the number and distribution of indicators of need, not regional differences in actual levels of utilization and costs. Populations with a higher share of individuals with higher weightings, indicating greater need, will be assigned a higher *per capita* allocation.

The first efforts in this direction were undertaken in the UK, where deprivation scores based on items measured in the census were used to identify underprivileged areas where primary care GPs might need extra resources to provide the care needed<sup>17,18</sup>. Indicators of need such as rates of unemployment, poverty, and single mothers were weighted according to how a sample of GPs estimated the workload associated with these different types of patient<sup>16</sup>. For hospital and community care, age-standardized and cause-specific mortality rates were used as local weights of need applied to age-specific utilization rates in the well-known first English resource allocation formula (RAWP)<sup>19</sup>.

However, neither of these approaches provides an empirically based quantitative association between indicators of need and costs. This has led most countries to a model where the first step in the analysis uses data on health care costs – at individual<sup>16</sup> or area level<sup>20</sup> – to produce weights of need. Since costs and utilization are influenced not only by need, but also by supply, such an analysis

requires detailed information on supply, as this may confound the effect of need<sup>121,22</sup>. In 1995, the English model for resource allocation was replaced by such a model based on age-stratified variations of utilization rates at the small area level, regressed against different indicators of social deprivation, morbidity, and mortality and adjusted for geographical variations in supply<sup>19,20</sup>.

Some variables such as the proportion of ethnic minorities were found to have negative relationships with utilization and this has been interpreted as an indicator of unmet need, or at least relative underutilization. These variables have often been included in the model but excluded from resource allocation calculations, thereby giving areas with these groups an element of allocation for unmet need<sup>8</sup>. Separate indices for somatic hospital care, psychiatry, primary care and prescribed drugs are often drawn up for overall adjustment of the allocation process.

In those countries where individual level data are available and where individual annual health care costs can thus be linked to a broader range of socio-demographic variables, it is possible to calculate a more complex individual level matrix with a similar range of socioeconomic variables, as is possible at area level in most countries<sup>16,20</sup>. The advantage of this is that individual-level information is more predictive and less confounded by geographical variations in supply than ecological data<sup>1,8</sup>.

## Brazilian models of resource allocation

Porto<sup>23</sup> produced the first Brazilian proposal inspired by the original English RAWP formula applying cause-specific SMRs to age-stratified utilization data. Compared to the actual allocation to states of federal public resources for the SUS, (considering that private resources were not included in the calculation in 1994), a RAWP-model would increase the allocation in the states of the North and Northeast

regions of Brazil by 10-90%. This means that approximately 13% of the total national budget at that time would have been transferred to the North and Northeast from other regions.

Porto et al.<sup>24</sup> also applied the newer English methodology where indicators of need for 134 local areas were regressed against utilization rates. She found that a range of need indicators such as Child Mortality Rate, illiteracy rate and single breadwinner households were negatively associated with utilization. This was interpreted as a sign of underutilization and unmet needs in a number of large socially deprived groups, confirming results from the surveys mentioned above<sup>12,13</sup>. The conclusion was that using the different indicators of need related to deprivation might be useful but weighting them with the help of regression coefficients on utilization would not be appropriate in the Brazilian context<sup>24</sup>.

This has led to studies that are more like the above-mentioned use of deprivation items<sup>17</sup> without any effort to weight them according to measures of utilization or workload. Mendes et al.<sup>25</sup> conducted an ecological analysis of deprivation indicators in Brazil's 5564 municipalities. Starting with several variables on mortality as well as socioeconomic and sanitary conditions, a principal component analysis generated a model based on one factor with under-five mortality rate, illiteracy rate and percentage of households not connected to the sewage system. The authors suggested using this factor for resource allocation to primary care.

For secondary and tertiary care, a more complex model was tested with two factors including ten area-level variables related to sewage network, general water network, garbage collection, head of household income under one minimum salary, illiteracy rate, average number of persons per household, rural population, infant mortality rate, mortality rate of 65+ and mortality rate 1 to 64 years.

Several studies of more need-related resource allocation within Brazilian states have followed similar methodologies<sup>26,27</sup>. Nunes

et al.<sup>28</sup> added the ability to self-finance based on local tax revenue as a moderating factor. Rosas undertook an analysis of the municipalities of Pernambuco with the same purpose but using the different technique of neural computation<sup>29</sup>.

The indicators suggested are those easily available at low geographical level, but, as some of the authors have noted, these models raise several issues. One is that mortality as an indicator of need is increasingly limited when morbidity constitutes a growing proportion of the burden of disease in Brazil, increasing from 28% in 1990 to 40% in 2016<sup>30</sup>. Indicators related to housing and sanitation have also more limited importance when the burden of disease related to communicable disorders in the same period has fallen by two thirds, and non-communicable diseases account for 71% of the burden in Brazil today<sup>30</sup>.

Many middle- and high-income countries face a changing socioeconomic pattern whereby NCDs increasingly are clustered in less privileged groups. A cross-sectional study from the 2013 National Health Survey in Brazil shows clear social inequalities for several chronic disorders, especially when analysing those that severely restrict day-to-day activities<sup>31</sup>. Even though social and local variations in supply may influence the reporting of illnesses, particularly if non-limiting<sup>32</sup>, a combination of different self-reported health indicators has been used as indicators of need<sup>13,14</sup>. The increasing clustering of low levels of education, lack of employment and multi-morbidity of activity-limiting mental and somatic disorders presents a challenge for health care, especially in a country where access to care beyond basic primary care is considerably better for those with a less precarious position on the labour market owing to private or employer-paid health insurance. In short, it can be concluded that resource allocation equity in health care in Brazil faces the following challenges:

- Despite major improvements, there are still



inequities in health care utilization in Brazil that may be caused in part by inequities in geographical resource allocation.

- Capitation models based on mortality and indicators of sanitary conditions need to be complemented with other indicators more related to non-communicable morbidity.
- Measures of costs and utilization cannot be used as weightings in capitation formulae, in view of very unequal levels of supply.
- Measures of self-reported health might be used as indicators of need. They may be biased by inequities in utilization but probably less so when self-rated symptoms and functions are used.

We have therefore explored the possibility of using the large Brazilian national health survey to estimate weightings to be used in a matrix model based on socio-demographic variables available at local level.

## Methodology

The 2013 National Health Survey (PNS) was used to build up a matrix model based on socio-demographic variables available at local level. The design – a stratified random sample of census tracts and households – is described in detail elsewhere<sup>33</sup>. One person (18+ years) from each household was sampled (N=60.202). Weights were calculated to adjust for sampling-effects and non-response.

Similar to Mullacherry et al.<sup>14</sup> we calculated a prevalence measure of morbidity or ‘need’ based on a principal component analysis of five different health items: self-rated health, general limitation of activities due to illness, the logarithm of the number of self-reported chronic illnesses (out of list of 14), and the

number of disorders with activity limitation of moderate or severe degree. We have also included a measure of mental health – the PHQ9-score<sup>34</sup>. It has been suggested that, in LMI-countries, self-reported prevalence of disease may be more socially biased than symptoms<sup>32</sup>. All items were Z-normalized before entering the PCA. The highest quintile of the resulting score was defined as the prevalence measure for morbidity and ‘need’.

A large number of covariates were analyzed, with age, sex, race, schooling, employment, sanitary conditions all included. A score for material wealth was also calculated (including ownership of a washing machine, a microwave oven, a PC, internet access, and a car). Access to private health care insurance and living in a metropolitan area were also registered, as these may reflect the level of health care supply.

Since earlier studies<sup>35</sup> have found that the North and Northeastern regions had higher self-rated morbidity than estimated by the socio-demographic structure of the population, region has also been included here. All calculations were carried out using SPSS v.25.

## Results

The result of the logistic regression with Odds Ratios (OR) and 95% Confidence Intervals (CI) for the prevalence of the indicator of ‘need’ (i.e. high level of morbidity) is shown in *table 1*, along with all the significant variables in the model. It shows, as expected, a strong association with age, sex, education, employment, income, and living in metropolitan region. When controlled for these six variables, all the other covariates included have non-significant associations, with ORs <1.05, and do not contribute to the model fit. Almost all two-way interactions between the six main covariates were significant with  $P < 0.0005$ .

Table 1. Odds Ratio for prevalent morbidity indicator in relation sex, race, age, education, employment, income, wealth and private health insurance. Brazil. Age 18+. PNS 2013. N=60,202 Weighted for sampling and non-response. All variables in the equation

Variables	OR	95% CI
Women (men =1)	1.66	1.59-1.74
25-44 years (18-24 years =1)	2.16	1.98-2.36
45-64 years	4.80	4.39-5.24
65+ years	5.07	4.57-5.62
Medium (higher =1)	1.16	1.07-1.26
Basic schooling	1.69	1.56-1.83
No basic schooling	2.08	1.88-2.31
Not employed (employed =1)	1.53	1.45-1.62
2-3 minimum income (>3 min.inc =1)	1.08	0.99-1.19
1-2 minimum income	1.26	1.16-1.37
< 1 minimum income	1.61	1.48-1.74
No reported income	1.11	1.00-1.22
Metropolitan area	0.84	0.80-0.88

Source: National Health Survey (PNS) 2013 (Szwarcwald et al.)<sup>33</sup>.

A model including age (4 groups), sex, education (4 groups), employment (2 groups) and income (5 groups) and all two-way interactions was then used to estimate the average prevalence in each state. The index with national average (20%) set to 100 was calculated and is shown in *table 2*. Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, and Alagoas all register an index of more than 105. Amazonas, Roraima, and Amapá register

less than 90, mainly as a result of their young (albeit relatively poor) populations. *Table 2* also lists the actual relative spending *per capita* on the SUS in 2013. The average spending for Brazil in 2013, which was R\$ 536.15 *per capita*, is set at 100 percent<sup>33</sup>. It can be seen that the relative spending in states in the North and North-East regions is much lower than that expected according to our model, while the opposite is the case for states in other regions.

Table 2. Estimated relative resource allocation to states according to the model and population of the PNS 2013. Compared to actual spending per capita in SUS 2013. Index where all =100. Weighted to compensate for sampling and non-response

State	Relative need according to model	Actual spending 2013	State	Relative need according to model	Actual spending 2013
Rondônia	96.4	80.6	Sergipe	101.6	87.7
Acre	94.1	50.7	Bahia	104.3	71.0
Amazonas	89.1	63.4	Minas Gerais	104.4	114.3
Roraima	85.2	86.8	Espírito Santo	101.5	84.0
Pará	95.2	67.3	Rio de Janeiro	100.5	121.8
Amapá	86.0	45.0	São Paulo	94.5	117.9
Tocantins	99.7	79.0	Paraná	93.6	103.4



Table 2. (cont.)

Maranhão	109.9	76.6	Santa Catarina	96.3	107.3
Piauí	112.3	104.3	Rio Grande do Sul	102.8	102.6
Ceará	109.1	85.1	Mato Grosso do Sul	95.4	142.4
Rio Grande do Norte	108.8	91.5	Mato Grosso	97.6	109.6
Paraíba	111.8	97.1	Goiás	95.7	101.0
Pernambuco	105.1	72.0	Distrito Federal	84.1	251.7
Alagoas	109.3	87.4	<b>Total</b>	<b>100</b>	<b>100</b>

Source: National Health Survey (PNS) 2013 (Szwarcwald et al.)<sup>33</sup>.

For use at lower geographical levels, such as municipalities, a simplified collapsed matrix with fewer groups was drawn up (see *table 3*). In view of the strength of the interactions, a matrix is used. Sex is not included, as the sex distribution is very similar across municipalities. With an average of 100, the

weight varies from around 30 for the young and well educated to around 215 for the elderly and poorly educated. The figures in *table 3* represent weights that can be multiplied by the number of individuals in each category in each local area. Data on this is available from censuses.

Table 3. Prevalence of high morbidity score. Simplified matrix based on age, education, employment and income. PNS 2013. Index where total population average =100

Education	Employment	Income	18-24	25-44	45-64	65+
Higher education	Employed	> 1 MI	37.6	40.1	71.4	95.5
		≤ 1 MIQ	36.6	55.1	115.3	140.2
	Not employed	> 1 MI	55.6	85.5	110.8	117.6
		≤ 1 MIQ	31.3	76.2	166.4	162.5
Basic or less education	Employed	> 1 MI	48.4	62.4	93.9	119.3
		≤ 1 MIQ	33.4	79.1	144.7	155.6
	Not employed	> 1 MI	80.4	146.3	174.4	176.0
		≤ 1 MIQ	39.5	128.0	215.3	217.7

Source: National Health Survey (PNS) 2013 (Szwarcwald et al.)<sup>33</sup>.

## Discussion

This proposed capitation formula model involves a number of assumptions and limitations that should be taken into consideration. First of all, it only estimates relative levels of morbidity or 'need' and does not estimate expected

utilization or costs. Data on costs are not available at individual level and may, as mentioned above, be influenced by utilization and supply. The construction of the self-reported morbidity variable includes many choices. There are two items relating to activity-limiting illnesses and one for symptoms as these are believed to

require more care and to be less influenced by supply than non-limiting cases<sup>31,32</sup>.

Since multi-morbidity is important for the need of primary care, we have also used the overall number of self-reported chronic disorders, irrespective of whether they limit activities. The dataset does not include any information about levels of health care supply. The question of whether the person has complementary private insurance, including employer- paid insurance is, however, one indicator that could reflect access to care. The fact that this has only a small effect (OR=1.05, 95% CI 0.99-1.11) on the morbidity score when adjusted for socio-demographic confounders increases the validity of the score as an indicator of need.

We have also included an item for living in metropolitan areas, which probably also reflects supply and may be a health determinant. A proxy for level of supply could be established, but region did not influence morbidity beyond socio-demographic variables. The morbidity score could also be calculated as a continuous variable with means estimated for each group and state, but, since it is far from a normal distribution, the dichotomous variable, in combination with binary logistic regression, provides more stable estimates.

Morbidity and need have indeed many more socio-demographic determinants and consequences than those included in the model. The choices made here are based on information available in the 2013 PNS and also from census data at local area level. It is further influenced by those factors that turned out to be associated with our need-score and in cases where geographical variance in the variable makes it significant for resource allocation.

The actual redistributing effect of applying a model like this is limited by the fact that in Brazil the more deprived states tend also to be those with a younger population, owing to higher fertility rates. There is here an important choice to be made. If the

purpose is, as with the model suggested in the present paper, to align resources better with needs, age becomes a major factor. If the main purpose is to reduce social inequalities in health, it should also include indicators of unmet and un-expressed need including need for prevention. Socio-economic factors may then play a greater role and the age weighting should be different, since many of the most effective health equity policies target young people.

A very important limitation of this model is that it only pertains to the population aged 18 years or older. The PNS<sup>13</sup> includes children but the health questions asked to them are very different and much less detailed. A separate model for children will thus have to be included.

It is clear from *table 2* that estimated levels of 'need' based on the 2013 survey differ substantially from current spending in 2013 and would, if applied, suggest considerable reallocation of funds from the south to the north of Brazil. The relative spending in 2017 seems only to suggest that this is even more the case today<sup>36</sup>. The current *per capita* spending and degree of support from federal resources varies greatly in ways that probably have historical and political explanations. It is beyond the scope of this paper to explore those issues.

The development of the SUS over the past 30 years has, as mentioned above, implied that a far greater quantity of resources has been allocated to deprived regions with high levels of need, and as a result inequity in access and care has been reduced<sup>6,11</sup>. A number of studies have provided evidence that this has been followed by a reduction in geographical inequalities in health outcomes, not only for children but also adults<sup>37</sup>. However, even in England, where inequities are much less severe than in Brazil, recent studies have shown that implementation of this type of resource allocation with extra allocations to deprived areas has a significant impact on mortality

in cases amenable to health care<sup>38</sup>. However, it also shows that allocation criteria should be applied to local areas rather than large populations, such as those of Brazilian states as a whole.

## Conclusions

The model suggested here has many limitations, but it makes use of one of the most valid and comprehensive data sources on current morbidity in Brazil and the analysis provides weights of need, unbiased by supply, for variables available for local areas. Much could be achieved by better alignment of needs and health care resources in Brazil. This model applies epidemiological data but geographical variations in the cost of providing care for equal needs should also be considered.

This is influenced by the capacity to offer the needed services, geography, and the cost of the wages and so forth needed to provide it. The model proposed here is relatively simple compared to the complex econometric models applied in some countries<sup>4,5,8,16</sup> and does not cover all the geographical variations in need. However, it may provide

some guidance as to where resources should be gradually reallocated.

## Collaborators

Gurgel Junior GD (0000-0002-2557-7338)\* contributed by designing the model, made the statistical analysis and wrote the first draft, analysis and interpretation of data; and approval of the final version of the manuscript. Leal EMM (0000-0002-6052-6501)\* contributed in the collection of data, analysis, interpretation of data, and approval of the final version of the manuscript. Oliveira SRA (0000-0002-6349-2917)\* contributed to the design, planning, analysis and interpretation of data; and approval of the final version of the manuscript. Santos FAS (0000-0002-7082-7092)\* contributed to the design, planning, analysis and interpretation of data; and approval of the final version of the manuscript. Sousa IMC (0000-0001-9324-4896)\* contributed to the design, planning, analysis and interpretation of data; and approval of the final version of the manuscript. Diderichsen F (0000-0002-9998-4972)\* contributed by designing the model, made the statistical analysis and wrote the first draft. ■

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Received on 09/18/2018  
 Approved on 05/15/2019  
 Conflict of interests: non-existent  
 Financial support: non-existent