Original article

Spatial distribution and temporal trend of National Health System and Supplemental Health Sector human resources, Brazil, 2005-2016*

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La distribución espacial de la tendencia temporal de recursos humanos para el Sistema Único de Salud y para la Salud Suplementaria, Brasil, 2005 a 2016

A distribuição espacial e a tendência temporal de recursos humanos para o Sistema Único de Saúde e para a Saúde Suplementar, Brasil, 2005 a 2016*

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Abstract

Objective: to analyze the spatial distribution and temporal trend of human resources for the Brazilian National Health System (SUS) and the Supplemental Health sector. **Methods**: an ecological study was conducted in the country's 27 Federative Units (FUs); SUS Information Technology Department (DATASUS) data were used relating to the doctor, dental surgeon, nurse and nursing technician personnel categories for the period 2005-2016; Prais-Winsten regression was used to assess the time trend. **Results**: there was an rising trend of Supplemental Health Sector human resources in all personnel categories, with an mean annual increase of 0.054 (95%CI: 0.031;0.076); with regard to SUS, there was an increase in dental surgeons and nursing technicians, with annual increases of 0.008 (95%CI: 0.003;0.011), and 0.066 (95%CI 0.022; 0.087), respectively, while in most FU, nurses showed a stationary trend and doctors showed a stationary or falling trend. **Conclusion**: inequalities were found in human resource distribution, reflecting the health system crisis.

Keywords: Unified Health System; Supplemental Health; Workforce; Geographic Mapping; Ecological Studies; Time Series Studies.

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Introduction

The restrictive measures imposed on the Brazilian National Health System (SUS), such as Constitutional Amendment No. 95 (CA 95), which has frozen public expenditure for 20 years with effect from 2019,[1,2] bring to light challenging barriers with regard to the sustainability of a universal health system.[3] Also linked to this issue is the 2017 National Policy on Primary Care, which recognizes other care modalities and not just the Family Health Strategy (ESF).[4]

Also adding to this are political decisions that are indifferent to the progress made in Brazil since the inception of the SUS as a universal system, in terms of the reduction in health inequalities and promotion of equity. An example of this progress is the National Immunization Program (PNI) and the direct consequences thereof: reduction in cases of measles, elimination of neonatal tetanus and control of other vaccine-preventable diseases.[5] Another highlight was the creation of the former National STD/AIDS Program, which revolutionized treatment and reduced the speed at which the global epidemic of human immunodeficiency virus (HIV) infection has spread, by adopting a policy of free distribution of antiretroviral medication,[6] in addition to other important achievements.

> *Great faith has been placed in universal health systems as the most efficient strategy for reducing health-related ills, injustices and iniquities, especially in an increasingly globalized world*

It is therefore no surprise that the economic crisis and economic austerity measures put forward as a solution to it have a direct impact on Health, such as CA 95, and have led to the return of former challenges to the SUS.[7] On the other hand, great faith has been placed in universal health systems as the most efficient strategy for reducing health-related ills, injustices and iniquities, especially in an increasingly globalized world. In countries that adopt health as a universal right, there is heavy investment in human resources for this area – personnel trained in health care – and in policies providing incentives and valuing these workers, promoting improved salaries and/or a career advancement policy. Notwithstanding the positive impacts of Public Health implemented in these countries, the crisis faced by the globalized economy may significantly undermine this strategy, thus worsening the population's health situation.[8]

In Brazil, the SUS workforce can be considered to be the system's biggest challenge, principally due to political and legal decisions that facilitate the Health sector being opened to foreign capital, in addition to the proposal for a new privately managed SUS.[9] All of this implies redimensioning SUS human resources, as made evident in a document produced by the Ministry of Health: human resources approached as a priority strategy for achieving a democratic, equitable and efficient health system.[10]

Although the health policy prioritizes the organization of multi-professional teams, high personnel turnover, especially of doctors and nurses, has caused discontinuity and fragmentation of the care they provide.[11] In the face of the new barriers to the sustainability of a universal and equitable SUS concerned with its workforce as a priority, it is fitting and relevant to examine the spatial distribution and temporal trend of human resources, both in the SUS and in the Supplemental Health sector. Despite the significant presence of studies in this area,[12] few seek to provide evidence of this dialectic situation. The objective of this study was to analyze the spatial distribution and temporal trend of SUS and Supplementary Health Sector human resources in Brazil.

Methods

This was an ecological study[13] conducted in Brazil. Its units of analysis were the country's 27 Federative Units (FUs), namely: 26 states and the Federal District.

According to the Demographic Census conducted by the Brazilian Institute of Geography and Statistics (IBGE) in 2010, Brazil had a population of 190,755,799 inhabitants, a Gini index of 0.6086, gross domestic product (GNP) of BRL 3,885,847,002.9 and average per capita household income of BRL 767.02, an unemployment rate of 13.1% and 34.7% of the population with income below half a minimum wage that year.[14]

Data were compiled in relation to the following personnel categories available for health care in Brazil: doctors, dental surgeons, nurses and nursing technicians, for both the SUS and the Supplemental Health sector. The data source used was the National Health Establishment Registry (CNES), available via the Health Ministry SUS Information Technology Department (DATASUS) website.

The coverage rates provided by the health personnel categories were calculated by taking the number of health personnel in each specific category (numerator) and the total resident population (denominator), for each FU, adjusted for mid-year, multiplied by 1,000 inhabitants.

The Prais-Winsten[15] generalized linear analysis model was used for the temporal trend analysis, where the years assessed (2005-2016) were the independent variables (X) and the coverage rates of the health personnel categories were the dependent variables (Y). The straight line of best fit between the points on the time series, the trend of which was to be estimated, was defined according to the following equation:

$$Y=\beta 0 + \beta 1X$$

where:

Y: times series value

X: timescale

The Prais-Winsten auroregressive model is indicated for correcting autocorrelation in time series.[15]

In order to reduce variance heterogeneity of temporal regression analysis residuals, logarithmic transformation (log10) was applied to the Y values.[15] Personnel coverage rates were calculated using Excel, while temporal trend analysis was performed using STATA 13.

As a result of this analysis, the annual growth rates (AGR) of the personnel categories and respective 95% confidence intervals (95%CI) were obtained. Temporal trend is considered to be falling if both of the confidence interval values are negative; rising if these values are positive; and stationary when the confidence interval crosses zero, i.e. the lower limit and the upper limit have opposite signs.[15]

With regard to the spatial distribution stage, the shapefile for Brazil was obtained from the IBGE website and ArcGIS version 10.6 was used to produce maps of human resource coverage and point density per km^2.

Results

Table 1 shows the AGR and the 95%CI for the number of doctors and dental surgeons per inhabitant, for those providing services for the SUS or for the Supplemental Health sector.

With regard to doctors, when analyzing those providing services for the SUS, it can be seen that the states of Maranhão (-0.01 – 95%CI -0.02;-0.00), Piauí (-0.02 – 95%CI -0.03;-0.01), Paraíba (-0.02 – 95%CI -0.03;-0.00), Alagoas (-0.02 – 95%CI -0.03;-0.00), Bahia (-0.02 – 95%CI -0.03;-0.00) and Mato Grosso (-0.01 – 95%CI -0.03;-0.00) had a falling trend, while the remaining states showed a stationary trend in the number of personnel available to provide services to the population. With regard to doctors providing services to the Supplemental Health sector, it was found that the states of Amapá (-0.04 – 95%CI -0.07;0.00), Maranhão (0.00 – 95%CI -0.01;0.02), Rio Grande do Norte (-0.01 – 95%CI -0.03;0.00), Paraíba (0.00 – 95%CI -0.00;0.01) and Espírito Santo (0.01 – 95%CI -0.01;0.03) had a stationary trend, while there was a rising trend in the number of these personnel in the remaining FUs.

Regarding dental surgeons working for the SUS, 11 FUs had a stationary temporal trend, 14 had a rising trend and only the Federal district and Santa Catarina had a falling trend. With regard to dental surgeons working for the Supplemental Health sector, only the Federal District had a stationary trend (0.01 – 95%CI -0.02;0.03); there was a rising trend in the number of personnel in all the other FUs.

As for nurses (Table 2), in relation to the SUS, there was a rising trend in the states of Rondônia (0.03 – 95%CI 0.01;0.05), Roraima (0.04 – 95%CI 0.02;0.06), Tocantins (0.04 – 95%CI 0.02;0.06), Minas Gerais (0.03 – 95%CI 0.01;0.05), Espírito Santo (0.03 – 95%CI 0.00;0.05), Rio de Janeiro (0.03 – 95%CI 0.02;0.05), São Paulo (0.02 – 95%CI 0.01;0.03), Rio Grande do Sul (0.02 – 95%CI 0.00;0.04), Mato Grosso do Sul (0.04 – 95%CI 0.01;0.06) and the Federal District (0.02 – 95%CI 0.01;0.03). The trend was stationary in the remaining FUs.

In the Supplemental Health sector, the trend for the number of nurses was stationary in the states of Amapá (-0.04 – 95%CI -0.10;0.02), Maranhão (0.00 – 95%CI -0.01;0.02) and Piauí (0.02 – 95%CI -0.01;0.05); while there was a falling trend in Rio Grande do Norte (-0.04 – 95%CI -0.08;-0.01) (Table 2).

When analyzing SUS nursing technicians, it can be seen that all UFs had a rising trend. With regard to nursing technicians in the Supplemental Health sector, the states of Acre (-0.03 – 95%CI -0.23;0.19), Amapá (-0.00 – 95%CI -0.07;0.06), Piauí (-0.00 – 95%CI -0.04;0.04), Rio Grande do Norte (-0.02 – 95%CI -0.06;0.02) and Paraíba (0.00 – 95%CI -0.01;0.01) showed a stationary trend. A rising trend was found in the remaining states for this personnel category (Table 2).

Table 1 – Temporal trend of doctors and dental surgeons providing services to the National Health System and the Supplemental Health sector, per Federative Unit, Brazil, 2005-2016

FU[a]	SUS[b] Doctors		Supplemental Health doctors		SUS[b] Dental Surgeons		Supplemental Health dental Surgeons	
	AGR[c]* (95%CI[d])	Trend	AGR[c] (95%CI)[d]	Trend	AGR[c] (95%CI)[d]	Trend	AGR[c] (95%CI)[d]	Trend
Rondônia	0.01 (-0.01;0.03)	Stationary	0.04 (0.03;0.04)	Rising	0.01 (-0.01;0.03)	Stationary	0.11 (0.07;0.15)	Rising
Acre	0.00 (-0.02;0.02)	Stationary	0.06 (0.01;0.11)	Rising	0.01 (0.00;0.02)	Rising	0.05 (0.02;0.07)	Rising
Amazonas	0.00 (-0.033;0.041)	Stationary	0.05 (0.02;0.09)	Rising	0.01 (0.00;0.02)	Rising	0.07 (0.03;0.10)	Rising
Roraima	-0.00 (-0.02;0.02)	Stationary	0.09 (0.03;0.17)	Rising	0.01 (-0.01;0.02)	Stationary	0.17 (0.07;0.27)	Rising
Pará	-0.01 (-0.02;0.01)	Stationary	0.05 (0.03;0.07)	Rising	0.02 (0.01;0.03)	Rising	0.10 (0.06;0.15)	Rising
Amapá	-0.01 (-0.04;0.02)	Stationary	-0.04 (-0.07;0.00)	Stationary	0.04 (0.01;0.06)	Rising	0.06 (0.03;0.08)	Rising
Tocantins	-0.00 (-0.02;0.01)	Stationary	0.03 (0.02;0.04)	Rising	0.01 (0.01;0.02)	Rising	0.04 (0.02;0.05)	Rising
Maranhão	-0.01 (-0.02;-0.00)	Falling	0.00 (-0.01;0.02)	Stationary	0.01 (-0.00;0.03)	Stationary	0.06 (0.03;0.08)	Rising
Piauí	-0.02 (-0.03;-0.01)	Falling	0.04 (0.03;0.05)	Rising	0.02 (0.01;0.02)	Rising	0.07 (0.04;0.11)	Rising
Ceará	-0.00 (-0.02;0.02)	Stationary	0.03 (0.02;0.04)	Rising	0.01 (0.01;0.02)	Rising	0.04 (0.02;0.06)	Rising
Rio Grande do Norte	-0.01 (-0.03;0.00)	Stationary	-0.01 (-0.03;0.00)	Stationary	0.01 (0.00;0.01)	Rising	0.04 (0.02;0.06)	Rising
Paraíba	-0.02 (-0.03;-0.00)	Falling	0.00 (-0.00;0.01)	Stationary	0.01 (0.00;0.01)	Rising	0.02 (0.01;0.04)	Rising
Pernambuco	-0.01 (-0.03;0.00)	Stationary	0.01 (-0.01;0.03)	Rising	0.00 (0.00;0.01)	Rising	0.05 (0.02;0.08)	Rising
Alagoas	-0.02 (-0.03;-0.00)	Falling	0.03 (0.01;0.05)	Rising	0.00 (-0.00;0.01)	Stationary	0.10 (0.04;0.17)	Rising
Sergipe	-0.01 (-0.03;0.01)	Stationary	0.02 (0.01;0.03)	Rising	0.00 (-0.00;0.01)	Stationary	0.06 (0.02;0.09)	Rising
Bahia	-0.02 (-0.03;-0.00)	Falling	0.02 (0.01;0.02)	Rising	0.01 (-0.00;0.02)	Stationary	0.03 (0.02;0.05)	Rising
Minas Gerais	-0.01 (-0.02;0.01)	Stationary	0.05 (0.02;0.07)	Rising	0.00 (-0.00;0.00)	Stationary	0.05 (0.03;0.07)	Rising
Espírito Santo	-0.02 (-0.03;0.00)	Stationary	0.01 (-0.01;0.03)	Stationary	-0.00 (-0.01;0.00)	Stationary	0.04 (0.02;0.06)	Rising
Rio de Janeiro	-0.01 (-0.03;0.01)	Stationary	0.02 (0.01;0.03)	Rising	0.01 (-0.00;0.03)	Stationary	0.08 (0.05;0.19)	Rising
São Paulo	-0.01 (-0.03;0.01)	Stationary	0.04 (0.01;0.06)	Rising	0.00 (-0.00;0.00)	Stationary	0.08 (0.03;0.12)	Rising
Paraná	-0.01 (-0.02;0.01)	Stationary	0.04 (0.02;0.06)	Rising	-0.00 (-0.01;0.00)	Stationary	0.04 (0.02;0.06)	Rising
Santa Catarina	-0.00 (-0.02;0.02)	Stationary	0.04 (0.02;0.06)	Rising	-0.00 (-0.01;-0.00)	Falling	0.03 (0.02;0.05)	Rising
Rio Grande do Sul	0.0 (-0.02;0.02)	Stationary	0.04 (0.02;0.07)	Rising	0.01 (0.01;0.01)	Rising	0.09 (0.04;0.14)	Rising
Mato Grosso do Sul	0.00 -0.01;0.02	Stationary	0.03 (0.01;0.05)	Rising	0.01 (0.00;0.02)	Rising	0.03 (0.02;0.04)	Rising
Mato Grosso	-0.01 (-0.03;-0.00)	Falling	0.05 (0.02;0.08)	Rising	0.01 (0.00;0.01)	Rising	0.07 (0.03;0.12)	Rising
Goiás	-0.01 (-0.03;0.00)	Stationary	0.04 (0.03;0.05)	Rising	0.01 (0.00;0.01)	Rising	0.07 (0.03;0.11)	Rising
Federal District	-0.02 (-0.04;0.00)	Stationary	0.04 (0.03;0.05)	Rising	-0.01 (-0.02;-0.01)	Falling	0.01 (-0.02;0.03)	Stationary

a) FU: Federative Unit.

b) SUS: Brazilian National Health System.

c) AGR: annual growth rate.

d) 95%CI: 95% confidence interval.

* Prais-Winsten regression was used, following the method proposed by Antunes & Cardoso,15 to calculate the annual growth rates and 95%CIs.

Figure 1 shows the spatial distribution of SUS and Supplemental Health human resources in the FUs for the year 2013. Doctors were concentrated in the South and Southeast regions of the country and in the case of the SUS, there were between 2.21 and 2.99 doctors per 1,000 inhabitants. Disparity was found in the distribution of these professionals over the national territory; especially in the states of Amazonas, Pará, Amapá and Maranhão, where SUS doctor coverage was much lower, i.e. between 0.01 and 1.25 professionals per 1,000 inhabitants. With regard to the Supplemental Health sector, the FUs with most doctors available were Santa Catarina, Espírito Santo and the Federal District.

Differently to doctors, distribution of SUS nurses was homogenous throughout the country. These professionals were most available in the state of Rio de Janeiro and in the Federal District, where coverage per 1,000 inhabitants was between 0.93 and 1.10. In the Supplemental Health sector, the largest numbers of nurses were found in the Federal District, Rio de Janeiro and São Paulo.

Heterogeneous distribution among the FUs was found for both SUS and Supplemental Health sector nursing technicians. This disproportionality was greater in the SUS: the availability of these professionals was disproportional between states within the same macro--region. In the Supplemental Health sector, nursing technicians were more concentrated in the South and Southeast regions of the country.

With regard to SUS dental surgeons, greater availability was found in the states of Paraíba and Mato Grosso do Sul, while in the Supplemental Health sector these professionals were concentrated in the South and Southeast regions and in the Federal District.

Figure 2 shows the spatial distribution of SUS and Supplemental Health sector health personnel availability for the year 2016. Comparing the 2016 data with the 2013 data (Figure 1), in the SUS there was only a change in doctors in the state of Paraíba, where their availability reduced, and in the state of Roraima, where coverage increased, between the two years of the period under consideration. With regard to the Supplemental Health sector, availability of doctors increased in the South, Southeast and Midwest.

In the case of SUS and Supplemental Health sector nurses, in 2016 spatial distribution of coverage was similar to that found in 2013, with availability of these personnel possibly being stationary. In 2016, distribution of SUS nursing technicians apparently continued to be heterogeneous throughout the country. The states of Amapá, Tocantins, Rondônia and Paraná had between 2.49 and 3.69 nursing technicians per 1,000 inhabitants. Regarding the Supplemental Health sector, nursing technicians were most available in the state of Espírito Santo and in the Federal District: coverage of between 0.56 and 0.87 (Figure 2).

SUS dental surgeons also had heterogeneous distribution in 2016, being concentrated in the states of Paraíba, Piauí, Tocantins and Mato Grosso do Sul. In the case of the Supplemental Health sector, the Federal District and the states of Paraná and Santa Catarina had the greatest availability. The Federal District stands out in that it was one of the FUs with lowest SUS dental surgeon coverage, while Supplemental Health sector dental surgeon coverage was among the highest in the country that year (Figure 2).

Figure 3 shows the density of doctors, dental surgeons, nurses and nursing technicians in Brazil between 2013 and 2016. Each point on the maps represents one health professional per 1,000 inhabitants. It can be seen that the North and Midwest regions had the lowest density for all personnel categories and that the growth rate was lower in the period from 2013 to 2016.

Discussion

Distribution of the number of SUS and Supplemental Health sector human resources in the personnel categories studied was found to be unequal. Between 2005 and 2016, no rising trend for SUS doctors was seen, differently to the Supplemental Health sector, where trends rose in the majority of FUs. In general, SUS dental surgeons, nurses and nursing technicians showed trends that varied between stationary and rising. With regard to these personnel categories in the Supplemental Health sector, generally speaking the trends were rising.

It should be emphasized that the Supplemental Health sector comprises the private healthcare insurance market, consisting of medical work cooperatives, dental cooperatives, group medicine companies, self-management groups and insurance companies.[16] the Supplemental Health sector has expanded in Brazil since the SUS was consolidated: in the 1990s its coverage related to 18.2% of the general population while in 2016 it was 24.9% and the forecast is for a rising trend – depending

Table 2 – Temporal tend of nurses and nursing technicians providing services to the National Health System and the Supplemental Health sector, per Federative Unit, Brazil, 2005-2016

FU[a]	SUS[b] Nurses		Supplemental Health Nurses		SUS[b] Nursing Technicians		Supplemental Health Nursing Technicians	
	AGR[c]* (95%CI)[d]	Trend	AGR[c] (95%CI)[d]	Trend	AGR[c] (95%CI)[d]	Trend	AGR[c] (95%CI)[d]	Trend
Rondônia	0.03 (0.01;0.05)	Rising	0.07 (0.04;0.09)	Rising	0.08 (0.06;0.10)	Rising	0.11 (0.07;0.14)	Rising
Acre	0.02 (-0.00;0.04)	Stationary	0.13 (0.08;0.18)	Rising	0.08 (0.07;0.09)	Rising	-0.03 (-0.23;0.19)	Stationary
Amazonas	0.01 (-0.01;0.03)	Stationary	0.14 (0.08;0.19)	Rising	0.03 (0.02;0.04)	Rising	0.12 (0.08;0.15)	Rising
Roraima	0.04 (0.02;0.06)	Rising	0.13 (-0.07;0.33)	Rising	0.14 (0.10;0.18)	Rising	0.16 (0.05;0.28)	Rising
Pará	0.02 (-0.01;0.04)	Stationary	0.08 (0.06;0.10)	Rising	0.07 (0.05;0.09)	Rising	0.12 (0.08;0.17)	Rising
Amapá	0.02 (-0.02;0.06)	Stationary	-0.04 (-0.10;0.02)	Stationary	0.04 (0.02;0.05)	Rising	-0.00 (-0.07;0.06)	Stationary
Tocantins	0.04 (0.02;0.06)	Rising	0.15 (0.11;0.19)	Rising	0.04 (0.03; 0.04)	Rising	0.05 (0.04;0.07)	Rising
Maranhão	0.02 (-0.01;0.06)	Stationary	0.00 (-0.01;0.02)	Stationary	0.06 (0.05;0.08)	Rising	0.01 (0.00;0.02)	Rising
Piauí	0.01 (-0.03;0.05)	Stationary	0.02 (-0.01;0.05)	Stationary	0.06 (0.05;0.08)	Rising	-0.00 (-0.04;0.04)	Stationary
Ceará	0.01 (-0.02;0.04)	Stationary	0.01 (0.01;0.02)	Rising	0.09 (0.08;0.09)	Rising	0.13 (0.11;0.15)	Rising
Rio Grande do Norte	0.01 (-0.03;0.04)	Stationary	-0.04 (-0.08;-0.01)	Falling	0.08 (0.07;0.09)	Rising	-0.02 (-0.06;0.02)	Stationary
Paraíba	0.02 (-0.02;0.06)	Stationary	0.01 (-0.00;0.02)	Rising	0.06 (0.05;0.07)	Rising	0.00 (-0.01;0.01)	Stationary
Pernambuco	0.02 (-0.00;0.05)	Stationary	0.02 (0.01;0.03)	Rising	0.11 (0.07;0.15)	Rising	0.12 (0.10;0.14)	Rising
Alagoas	0.01 (-0.04;0.06)	Stationary	0.11 (0.05;0.18)	Rising	0.08 (0.06;0.09)	Rising	0.17 (0.06;0.28)	Rising
Sergipe	0.00 -0.03;0.04	Stationary	0.05 (0.02;0.08)	Rising	0.06 (0.05;0.07)	Rising	0.08 (0.04;0.12)	Rising
Bahia	0.02 (-0.00;0.05)	Stationary	0.04 (0.03;0.05)	Rising	0.07 (0.05;0.09)	Rising	0.08 (0.07;0.08)	Rising
Minas Gerais	0.03 (0.01;0.05)	Rising	0.05 (0.03;0.08)	Rising	0.06 (0.05;0.07)	Rising	0.07 (0.06;0.09)	Rising
Espírito Santo	0.03 (0.00;0.05)	Rising	0.05 (0.03;0.07)	Rising	0.04 (0.03;0.05)	Rising	0.07 (0.06;0.09)	Rising
Rio de Janeiro	0.03 (0.02;0.05)	Rising	0.04 (0.00;0.07)	Rising	0.07 (0.05;0.08)	Rising	0.05 (0.03;0.07)	Rising
São Paulo	0.02 (0.01;0.03)	Rising	0.06 (0.05;0.06)	Rising	0.06 (0.05;0.08)	Rising	0.08 (0.07;0.10)	Rising
Paraná	0.02 (-0.01;0.05)	Stationary	0.07 (0.06;0.09)	Rising	0.09 (0.08;0.10)	Rising	0.12 (0.08;0.17)	Rising
Santa Catarina	0.02 (-0.01;0.05)	Stationary	0.07 (0.06;0.08)	Rising	0.06 (0.04;0.07)	Rising	0.07 (0.05;0.09)	Rising
Rio Grande do Sul	0.02 (0.00;0.04)	Rising	0.04 (0.04;0.05)	Rising	0.05 (0.05;0.06)	Rising	0.05 (0.03;0.06)	Rising
Mato Grosso do Sul	0.04 (0.01;0.06)	Rising	0.06 (0.06;0.06)	Rising	0.08 (0.06;0.09)	Rising	0.09 (0.06;0.11)	Rising
Mato Grosso	0.03 (-0.00;0.06)	Stationary	0.05 (0.04;0.07)	Rising	0.05 (0.04;0.07)	Rising	0.05 (0.03;0.07)	Rising
Goiás	0.02 (-0.01;0.05)	Stationary	0.06 (0.06;0.07)	Rising	0.04 (0.03;0.04)	Rising	0.07 (0.06;0.07)	Rising
Federal District	0.02 (0.01;0.03)	Rising	0.05 (0.01;0.09)	Rising	0.04 (0.03;0.05)	Rising	0.06 (0.04;0.07)	Rising

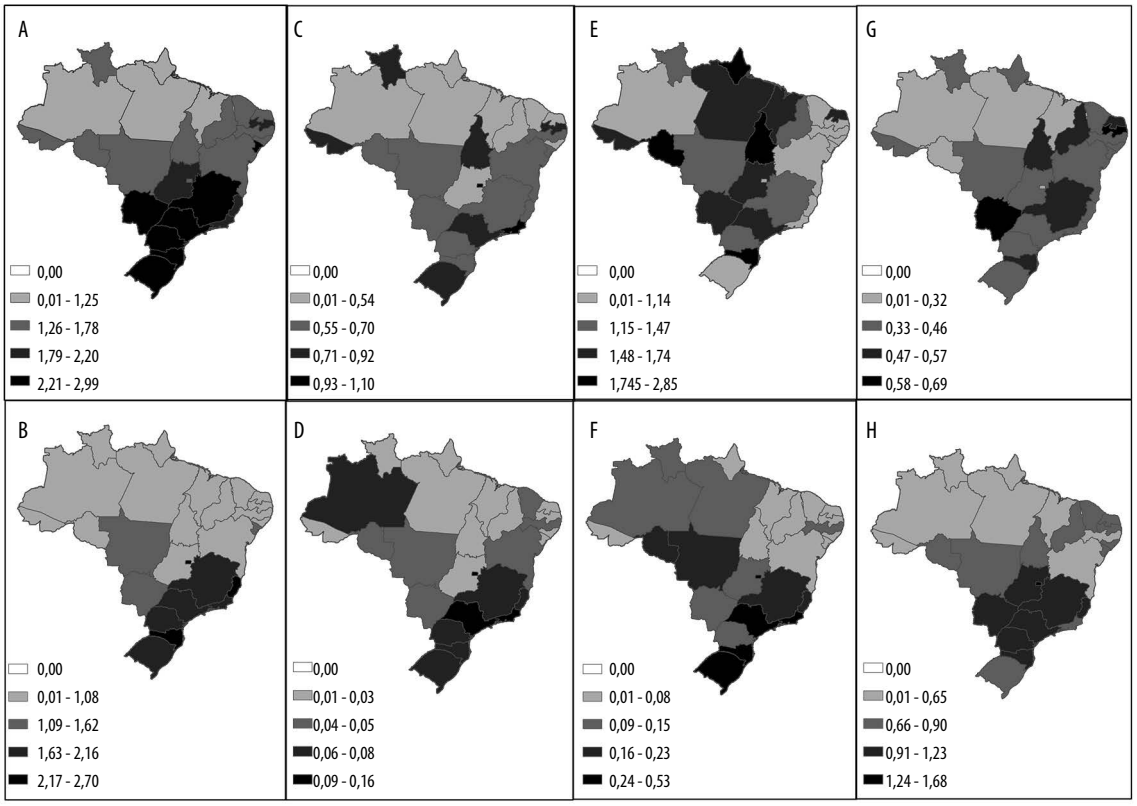
a) FU: Federative Unit.

b) SUS: Brazilian National Health System.

c) AGR: annual growth rate.

d) 95%CI: 95% confidence interval.

* Prais-Winsten regression was used, following the method proposed by Antunes & Cardoso,15 to calculate the annual growth rates and 95%CIs.



Caption:
A-SUS Doctors; B-Supplemental Health Doctors; C-SUS Nurses; D-Supplemental Health Nurses;
E-SUS Nursing Technicians; F-Supplemental Health Nursing Technicians;
G-SUS Dental Surgeons; H- Supplemental Health Dental Surgeons

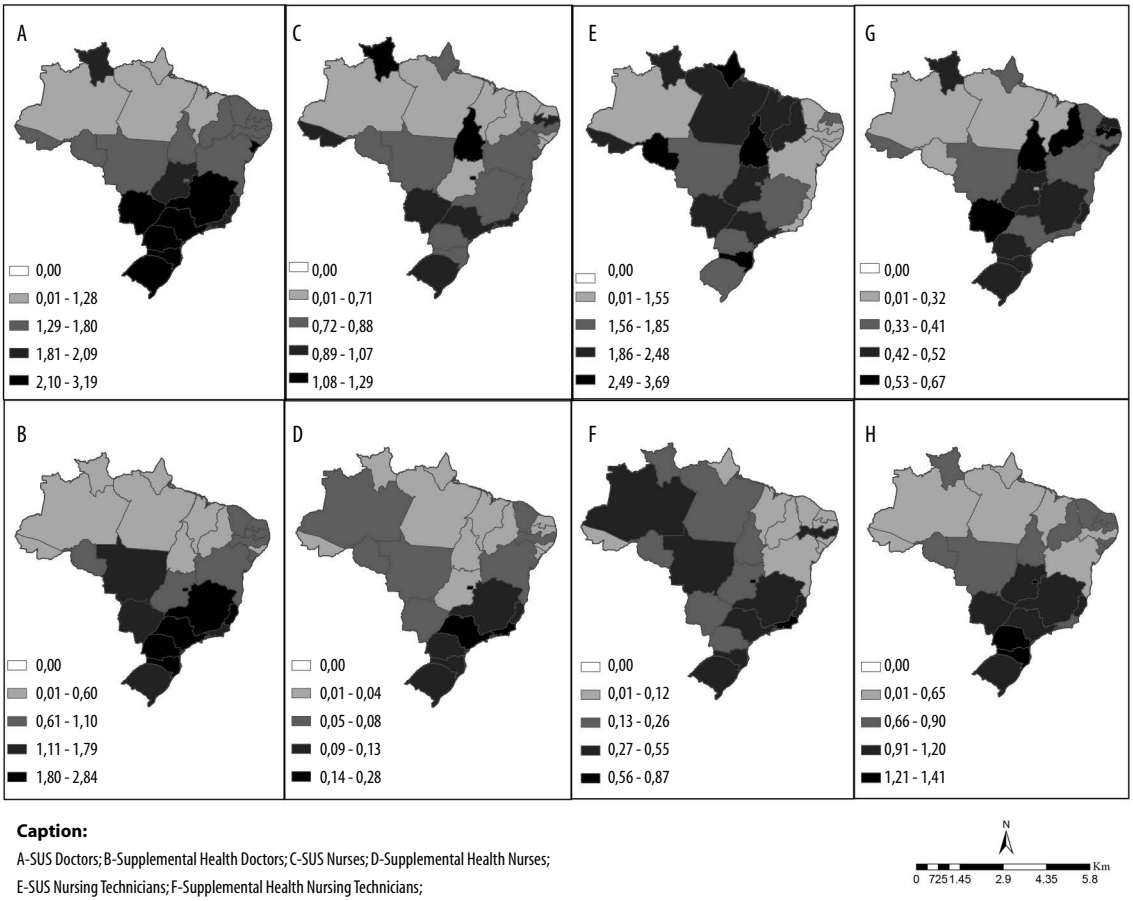
Figure 1 – Spatial distribution of health personnel coverage (per 1,000 inhabitants) by the National Health System and by the Supplemental Health sector, Brazil, 2013

on current political circumstances, measures to open the Public Health sector to foreign capital and approval of the bill of law to outsource activities that could be done internally.[17]

Another relevant point relates to the national panorama of political and economic crisis. In 2016, approximately 12 million Brazilians were unemployed, thus reducing the possibility of paying for private health insurance. Given the context of less health insurance being taken out, the population's demand for SUS healthcare will be increasingly greater. However, this demand will not be duly met by an increase in supply of services and real expansion of the SUS, this being limited above all by the restrictive measures imposed by CA 95.[2]

Nunes et al.[18] found a rising trend in the population's demand for SUS health services in most of the country's macro-regions. Furthermore, their study highlights that the rural population's demand for access is greater when compared to the urban population. This phenomenon is more intense when people have multiple comorbidities. The results of our study provide evidence of a critical node, in terms of human resources for Health in Brazil, particularly with regard to doctors, whose priority is concentrated on the Supplemental Health sector.

Malta et al.,[16] in their description of health insurance coverage in Brazil according to sociodemographic characteristics, and comparison with administrative data produced by the National Supplemental Health Agency (ANS) in 2017, found that for Brazil as a whole 27.9% of respondents reported having some kind of health insurance. Moreover, the populations of the country's Southeast and Northern regions have the highest and the lowest health insurance coverage, respectively, corroborating the data of our study – in which the only



Caption:
A-SUS Doctors; B-Supplemental Health Doctors; C-SUS Nurses; D-Supplemental Health Nurses;
E-SUS Nursing Technicians; F-Supplemental Health Nursing Technicians;
G-SUS Dental Surgeons; H- Supplemental Health Dental Surgeons

Figure 2 – Spatial distribution of health personnel coverage (per 1,000 inhabitants) by the National Health System and by the Supplemental Health sector, Brazil, 2016

state where the Supplemental Health sector did not show a rising trend was the state of Acre (Northern Brazil).

Our findings provide evidence of a decrease in doctors providing services to the SUS in the same FUs, this result being similar to that of the study entitled 'Medical Demography in Brazil 2015'.[19] The More Doctors Program (*Programa Mais Médicos* - PMM), created by the federal government in 2013, recruited 14,462 Brazilian and foreign doctors allocated to 3,785 of the country's municipalities. When comparing the distribution of doctors with the quantity of municipalities with an incipient number of this personnel category in Primary Health Care, it was found that the number of municipalities went down from 1,200 in March 2013 to 558 in 2014, this being the equivalent of a 53.5% reduction in the number of professionals available in this category.[20]

In the Northern region, 91.2% of the municipalities that had limited access to doctors in 2013 were provided with 4.9 PMM doctors per municipality on average (the greatest proportion compared to the country's other regions).[21] Despite the increase in the number of doctors thanks to the More Doctors Program, the trend for the number of these professionals working for SUS continued to fall. This reflects the preference of these professionals for working for the Supplemental Health sector, including for salary-related issues and the attractiveness of the market and liberal medicine.

An emblematic issue in the SUS is the turnover of Family Health Strategy (ESF) personnel. Strategic losses, disruption and lack of identification with the team, as well as harm caused to the cost-effectiveness and organizational efficacy of the service,[22] in addition to affecting linkage with the population, have prevented the

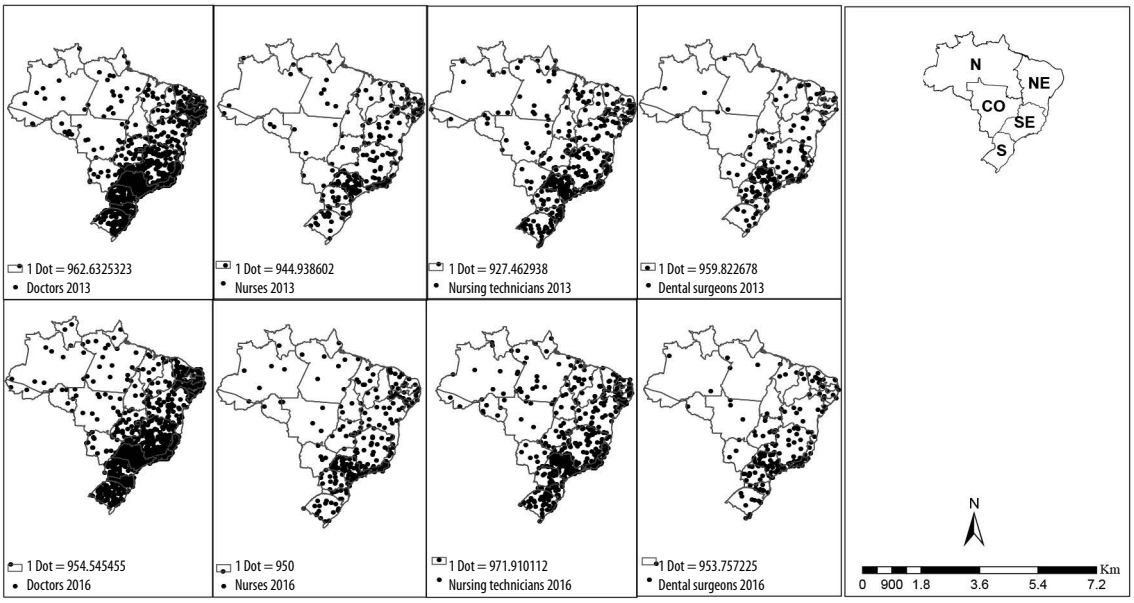


Figure 3 – Density of health personnel providing services to the National Health System and the Supplemental Health sector, Brazil, 2013-2016

expected results from being achieved.[23] A large part of the challenges and difficulties permeating the scaling-up and enhancement of the ESF arises from shortage and turnover of these professionals, especially in cities in the interior, in the North and Northeast regions and in risk areas in the poor outskirts of large towns and cities.[16]

Getting professionals to stay in the ESF is a huge challenge for the sustainability of a universal health system, where Primary Health Care is the main point of entry, as well as being a huge challenge for coordination, continuity, family health education, community linkage and guidance.[24] The systems that adopt the ESF have produced results with greater impact in terms of equity, access, service user satisfaction and the population's quality of life.[25] In the case of dental surgeons, the findings of this study point to a rising trend in the availability of these professionals, both in the SUS and in the Supplemental Health sector. In 14 FUs, the number of dental surgeons working in the SUS was rising, it was stationary in 11 FUs, and was only falling in the Federal District and Santa Catarina. On the other hand, in the Supplemental Health sector the same trend was only stationary in the Federal District and was rising in all the states. This also indicates dental surgeon preference for working in the Supplemental Health sector.

In order to increase the population's access to oral health and, in this way, encourage Primary Health Care action reorganization, in the year 2000 the Ministry of Health proposed the inclusion of Oral Health teams as part of the ESF, with the overriding objective of improving oral health epidemiological indices and increasing the Brazilian population's access to this form of health care.[26]

The National Oral Health Policy has driven improvement of the oral health care process, so as to leave behind the traditional model characterized by 'preventivism' in collective actions aimed exclusively at school children, for example, and by mutilative clinical actions. In view of this, a more positive result is expected for the use of public dental services in Brazil.[26]

With regard to SUS nurses, the results of this study showed a stationary trend in the number of these professionals in 17 states, whereas in the Supplemental Health sector this number rose in the majority of FUs and only fell in Rio Grande do Norte, differently to nursing technicians who increased in both the SUS and the Supplemental Health sector. The Institute of Applied Economic Research (IPEA), a foundation linked to the Ministry of the Economy, revealed that 'nurses and akin' were in second place among the careers that most grew in terms of numbers of work positions between January 2009 and December 2012.[27] The majority of SUS nurses and nursing technicians are allocated to the ESF, which, since 2004, works with teams comprised of a doctor, a nurse, a nursing auxiliary or technician and at least four community health agents, as well as oral

health professionals.[28] Studies demonstrate that ESF coverage has increased for the Brazilian population, reaching 53.4% in 2013.[16] However, in terms of human resources, the rising trend in nursing technicians was greater than that found for nurses. This may suggest imbalance in ESF teams.

The increase in the number of nursing technicians probably reflects Federal Nursing Council (COFEN) Resolution No. 276/2003, which determined that registration with COFEN would only be granted to professionals in this category who have qualified at the Nursing Auxiliary stage as part of the Nursing Technician Professional Education Course. As a result, an increase in the trend of these professionals can be seen in all the Federative Units, both in providing services to the SUS and also to the Supplemental Health sector.[29]

With regard to doctors, the states with the poorest increasing trends for these professionals are located in the Country's North and Northeast regions, possibly due to lack of desired local infrastructure which is propitious to turnover, apart from them being less socio-economically developed regions, where there are few professional training institutions.[30]

Rio Grande do Norte was the only state where there was a falling trend in nurses in the Supplemental Health sector, unlike the majority of the states and the Federal District where there were rising trends. According to Oliveira et al.,[27] several factors are related to the decrease in the number of nurses working in Rio Grande do Norte, ranging from lack of opportunities for many people finishing training school, to those who seek jobs without having experience or being qualified, and to job insecurity in the private sector or in the SUS, as a result of short-term employment contracts, resulting in periodical personnel turnover, as well as instability and discontinuity in the care provided.

This study has limitations related to its ecological design, as well as the use of secondary data and consequent risk of bias given the incompleteness or frequency of missing information in the DATASUS database on which this study was based.

The falling or stationary trend of SUS health professionals between 2005 and 2016 is cause for concern. It may reflect negatively on the ability of SUS to carry out its health actions and services, making it less apt and weakening it in relation to the social mission it has to fulfill, its prospective vision and the preservation of its values. The Brazilian health system crisis may lead to unequal access to health care, with significant impact on vulnerable populations. It is essential to promote human resources and increasingly integrate them into the permanent process of creating, reinventing and adapting Public Health structures, in defense of more equitable health care in line with the civil rights of those who use the Brazilian National Health System.

Authors' contributions

Campoy LT, Souza LLL, Alves LS, Berra TZ, Arroyo LH and Santos DT took part in the conception and design of the study, data interpretation and writing the manuscript.

Ramos ACV and Arcoverde MAM took part in the conception of the study, data analysis and writing the manuscript. Arcêncio RA took part in the conception and design of the study and writing the manuscript. All the authors have reviewed and approved the final version of the manuscript and are responsible for all aspects of this work, guaranteeing its accuracy and integrity.

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