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Maintenance of medium- and high-complexity health services in the context of high patient transition: a time series ecological study of the state of Rio de Janeiro, Brazil

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Abstract *The study addresses the historical disparities in the distribution of the medium- and high-complexity health network and the limits to budget adjustments between the municipality of Rio de Janeiro and its neighboring municipalities of the Metropolitan region 1. An ecological study was conducted with data related to the municipality of Rio de Janeiro, chosen because it has a large assistance network, while located on the borders of vulnerable and underprivileged areas, characterizing a locus that is representative of the situations faced throughout the country. A decrease in the gross values of the programmed quotas in all municipalities of Rio de Janeiro was observed from 2016 onwards. The temporal trend of the programmed quotas remained stable for all municipalities in the Metropolitan Region 1, even with significant increases in the accomplished quotas for neighboring municipalities. The resulting overload in local expenditure prevents the increase of capacity to anticipate fluctuations in demand, both known and unexpected ones, compromising the responsiveness of the health system regarding its regular operation, as well as the ability to adjust to cope with extraordinary events, essential characteristics of resilience.*

Key words *Health system financing, Health management, Health policy, Planning and management*

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Introduction

The regionalization and fiscal and administrative decentralization of the Brazilian Unified Health System (SUS, *Sistema Único de Saúde*) aims to allow local governments to better identify specific needs. Although SUS financing is tripartite, with responsibilities at the federal, state and municipal levels of government, each federated entity has decision-making autonomy in the application of resources and the implementation of programs[1]. This decentralization has made the municipal sphere a protagonist in the management of the assistance network, giving its managers the role of meeting the peculiarities of each region. Therefore, to ensure access throughout the territory, resources are allocated to funds and transferred to states and municipalities. At the municipal level, it is the Municipal Health Fund that exercises financial control and execution, allocations and transfers.

As for the government's participation, the transfers of resources to states and municipalities are defined by Ministerial Ordinance n. 204/2007, of which text was transcribed into the Consolidation Ordinance n. 6 and modified by Ordinance n. 3,992/2017, concentrating financing groups in a single funding block, including that intended for outpatient and hospital actions and services, defining them as a limit or financial ceiling for Medium and High Complexity (MHC), with these being the most significant among the levels of care[2,3] .

This scenario highlights the complexity of action planning, the organization of care networks and the dimensioning of health services, especially regarding the role of large Brazilian urban centers in regions that share borders with vulnerable territories, different population sizes and scarce access to healthcare, as is the case of the municipality of Rio de Janeiro (MRJ), bordering several municipalities with a low Human Development Index (HDI).

The SUS is historically underfunded, as the 30% of the social security budget for financing public health actions and services defined by the Federal Constitution has never been effectively met. However, after the 2015 crisis, an increase was observed in municipal health spending, as well as in the fiscal dependence to fund services, affecting mainly small municipalities with lower *per capita* income[4,5].

Although there are legal mechanisms that allow states and municipalities to request an increase in the value of the MHC ceiling to the Ministry of Health, the implementation of Constitutional Amendment (EC, *Emenda Constitucional*) n. 95[6], known as 'Expenditure ceiling', in 2016, changed the fiscal regime of health, arresting expenses for 20 years and freezing the contribution of federal resources in the health area at 2015 levels, overloading the local financing contribution[7,8].

Considering that resilience in health resides in the ability to maintain essential public health functions operating effectively and with quality, even while the system adjusts to respond to unexpected crises[9-11], the impacts of this scenario were felt, especially, in the context of the COVID-19 pandemic. However, health services are affected every day by unexpected events, more or less intensely and with varying severity[12,13]. Therefore, resilience must be an attribute developed continuously, so that SUS services are able to maintain their regular operations, even when dealing with the intense variability caused by the dynamic contexts of territories.

The MRJ, given its greater availability of resources and more established care network, performs care procedures at the MHC level for all other municipalities in the state of Rio de Janeiro. According to data related to the period between January and December 2021 – a very difficult period of the COVID-19 pandemic – this scenario meant that, by subtracting the scheduled financial quota from the executed financial quota, that is, the amount agreed with the other municipalities of the state with all the provided services, there was a deficit of R$ -886,258,093.

In this context, the MHC ceiling of the MRJ is especially pressured by demand from Metropolitan Region 1 itself, which includes very populous municipalities, such as Duque de Caxias, Belford Roxo, Nova Iguaçu, and the Capital city itself. Therefore, the present study addresses the transition of users between the MRJ and other municipalities bordering the Metropolitan region 1, aiming at exploring how historical regional disparities in the distribution of health services affect municipal management, highlighting how the concentration of the assistance network at the MHC level interferes with the maintenance of the regular operation of SUS services, damaging their state of preparedness, responsiveness and resilience.

Methods

Research design

This is an ecological cross-sectional study of a temporal series, of a quantitative nature, carried out using public data available in the information systems of the Department of Informatics of the Unified Health System (DATASUS). The study data refer to the MRJ, chosen because it has a large assistance network, at the same time as it share borders with municipalities that are underdeveloped and lacking in health services, characterizing a *locus* that, although specific, is representative of the situations faced in the scope of the SUS throughout the country.

This article was prepared in accordance with the recommendations of the EQUATOR Network guidelines and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)[14] checklist.

Research environment

According to the Rio de Janeiro Municipal Health Plan for the triennium 2022-2025[15], the MRJ assistance network is distributed among eight Programmatic Area Coordinations (CAP, *Coordenadorias de Áreas Programáticas*), covering the entire territory of the municipality (which serves approximately 6,775,561 inhabitants, according to IBGE data), namely: CAP 1.0 (central region); CAP 2.1 (south zone); CAP 3.1, CAP 3.2, CAP 3.3 (northern zone); CAP 4.0, CAP 5.2 and 5.3 (west zone).

The Rio de Janeiro Municipal Health Plan also describes that the medium- and high-complexity care network has eight urgency/emergency hospitals and two first aid hospitals, six specialized and smaller hospitals, and four psychiatric units, in addition to two pediatric hospitals and one geriatric hospital, 11 maternity wards and an in-house birth center. These units represent a total of more than 700 rooming-in beds (for mothers and babies) and 295 neonatal IC/ICU beds. The municipality also has 2 institutes: the Jorge Vaitsman Veterinary Medicine Unit and the Annes Dias Nutrition Institute (Inad).

Furthermore, the MRJ network also includes 18 Psychosocial Care Centers (CAPS, *Centro de Atenção Psicossocial*), 6 Psychosocial Care Centers for Alcohol and Other Drugs (CAPSad, *Centro de Atenção Psicossocial para Álcool e Outras Drogas*) - two of them with adult reception units (UAA, *Unidade de Acolhimento para Adultos)* - and 8 Child Psychosocial Care Centers (CAPSi, *Centro de Atenção Psicossocial Infantil*), totaling 32 specialized units of its own. Another three units from the state and federal networks complete the network of 35 CAPS.

However, this is not the same reality observed in other municipalities in the state of Rio de Janeiro, especially those bordering the capital, which show fragmented care, reduced capacity for human resources in health,an insufficient hospital network and high prevalence of vulnerable territories, since among their municipalities, they have those with the lowest HDIs in the state[16].

Collection procedures

All data used in this study are freely accessible and were collected from the DATASUS database. Information related to the process of evaluation, control, regulation of planning and financial management of the Municipal Health Secretariat of Rio de Janeiro (SMS-Rio) was included, available in the Medium- and High-Complexity Financial Limit Control System (SISMAC, *Sistema de Controle do Limite Financeiro da Média e Alta Complexidade*), the Information System on Public Health Budgets (SIOPS, *Sistema de Informações sobre Orçamentos Públicos em Saúde*) of the Ministry of Health; the Computerized System for Agreed and Integrated Programming (SISPPI, *Sistema Informatizado para a Programação Pactuada e Integrada*), of the State Health Secretariat of Rio de Janeiro (SES-RJ); in addition to the Decentralized Hospital Information System (SIHD, *Sistema de Informação Hospitalar Descentralizado*).

Analysis procedures

A temporal trend analysis was carried out using the inflection point regression model (Joinpoint Regression)[17] of data related to scheduled and executed financial quotas, and the types of hospitalizations with greater demands, carried out by hospital units in the city of Rio de Janeiro, for each of the 12 municipalities in the Metropolitan Region I of the state of Rio de Janeiro from 2013 to 2021. The Joinpoint Regression Program, version 4.9.1.0, was used for these analyses.

Joinpoint is a temporal series analysis method that identifies points of change or inflection in the trend of a data series. Regression analyses with jointpoints indicate whether one or more segments should be included in a linear regres-

sion to signal any change in temporal trend, rejecting the null hypothesis that no points should be added. The results of these analyses allow the estimation of the Annual Percent Change (APC) of the investigated trend, as well as the measurement of its 95% confidence interval (95%CI) and statistical significance. The model was adjusted assuming the possibility of one to one inflection point, which implies a straight line or a line with two segments[18].

The main difference between joinpoint and other statistical temporal analysis methods is that it is specifically designed to deal with data series that have changes in trend, whereas other methods such as linear trend analysis or least squares trend analysis , assume that the trend is constant over time. Furthermore, joinpoint allows the identification of multiple change points in the trend, whereas other methods generally only allow the identification of a single trend. The joinpoint can also be used to estimate the magnitude of change in the trend, which is important in many types of analysis, such as analyzing trends in epidemiological or economic data. In the temporal trend analysis, a significance level of 5% was established. Absolute and relative frequency tables were also used to describe the distribution of MHC financial quotas for each municipality in Metropolitan Region I and the number of hospitalization beds in the municipality of Rio de Janeiro demanded by other municipalities.

Limitations

The present study is limited to open and available data from DATASUS information systems. Furthermore, an impact analysis was not established, as this would be additional data that was not found or made available.

Results

MHC financial quotas

The programmed and executed MHC quotas in the municipalities of Metropolitan Region 1 of the state of Rio de Janeiro were evaluated from 2013 to 2021. In relation to the programmed quotas, a decrease in gross values was observed in all municipalities for the year 2016 and information for the years 2017 and 2018 was unavailable. Rio de Janeiro was the municipality with the highest programmed quota throughout the analyzed period, followed by the municipalities of Duque de Caxias, Nova Iguaçu, Belford Roxo and São João de Meriti (Table 1). From 2019 to 2021, the executed quota exceeded the programmed one in the municipalities of Belford Roxo, São João de Meriti, Duque de Caxias, Magé, Mesquita and Queimados. In Rio de Janeiro and Nova Iguaçu, observing the same period, the executed quota was lower than the programmed quota in 2020, only.

The temporal trend of programmed quotas (MHC) remained stationary for all municipalities in the Metropolitan Region of RJ, during the analyzed period (2013-2021). The municipalities of Belford Roxo, Duque de Caxias, Magé, Mesquita, Nova Iguaçu, Queimados, Rio de Janeiro and São João de Meriti showed significant increases in executed quotas (MHC) in one of the observation periods (Table 2).

Japeri was the only municipality that showed a significant decrease in the quota executed in the period 2013-2016, with an annual percent change (APC) of -20%. In the municipalities of Itaguaí, Nilópolis and Seropédica, the executed quota (MHC) remained stationary throughout the period (Table 2).

Hospitalizations

The greatest demands for hospitalizations in health units in the city of Rio de Janeiro by residents of Metropolitan Region 1 of Rio de Janeiro, from 2013 to 2021, were related to surgical, clinical, obstetric and pediatric beds (Table 3). It was observed that all municipalities in Metropolitan Region 1 required hospitalizations in health units in the city of Rio de Janeiro, highlighting the municipalities of Belford Roxo, Duque de Caxias, Nova Iguaçu and São João de Meriti (Table 4).

The temporal analysis indicated an increase of 16.7% per year (95%CI: 3.9 to 31.1) in obstetric hospitalizations in the period from 2013 to 2018 for residents of the municipality of Belford Roxo. Clinical hospitalizations of patients living in Duque de Caxias increased by 3.6% per year (95%CI: 1.5 to 5.8) in the period from 2013 to 2021.

Clinical and pediatric hospitalizations of residents of Nova Iguaçu increased, respectively, by 3.1% (95%CI: 1.1 to 5.1) and 3.2% (95%CI: 1.3 to 5.8) per year in the period from 2013 to 2021. Obstetric hospitalizations of residents of São João de Meriti showed an increase of 22.1% (95% CI: 12.5 to 32.6) per year in the period from 2013 to 2018 and a significant decrease in 22.8% (95%CI: -34.2 to -9.4) per year for the period from 2018

Table 1. Programmed and executed financial quotas (MHC) by reference year and municipality in the Metropolitan Region of Rio de Janeiro, 2013-2021. Gross values per million Reais (R$).

Municipalities/	Year								
Financial quotas	2013	2014	2015	2016	2017	2018	2019	2020	2021
Belford Roxo									
Programmed	42.22	42.87	43.07	17.98	-	-	30.1	35.59	37.08
Executed	44.02	43.74	42.62	36.96	21.49	66.45	57.01	80.07	194.12
%	4.3	2.0	-1.0	105.6	-	-	89.4	125.0	423.5
Duque de Caxias									
Programmed	76.65	77.34	78.44	32.73	-	-	60.97	81.29	82.29
Executed	55.71	78.98	93.76	82.56	75.81	100.28	127.8	160.94	818.23
%	-27.3	2.1	19.5	152.2	-	-	109.6	98.0	894.3
Itaguaí									
Programmed	6.47	6.52	6.52	2.72	-	-	5	6.67	6.73
Executed	6.69	10.95	11.57	8.31	5.37	5.41	7.55	7.44	22.34
%	3.4	67.9	77.5	205.5	-	-	51.0	11.5	231.9
Japeri									
Programmed	7.66	7.33	6.74	2.79	-	-	5.34	6.88	6.97
Executed	6.3	5.09	3.56	2.92	3.33	3.81	4.05	2.99	3.8
%	-17.8	-30.6	-47.2	4.7	-	-	-24.2	-56.5	-45.5
Magé									
Programmed	13.58	13.55	13.48	5.62	-	-	10.87	14.48	14.48
Executed	16.76	14.77	18.21	19.91	24.11	29.66	29.16	34.37	43.94
%	23.4	9.0	35.1	254.3	-	-	168.3	137.4	203.5
Mesquita									
Programmed	10.91	10.41	9.97	4.13	-	-	6.75	9	8.99
Executed	4.83	7.61	8.73	8.4	5.48	11.29	9.46	13.51	13.27
%	-55.7	-26.9	-12.4	103.4	-	-	40.1	50.1	47.6
Nilópolis									
Programmed	6.98	6.97	7.33	3.09	-	-	6.08	7.73	7.87
Executed	8.02	8.12	9.66	8.69	6.6	9.72	4.55	10.73	7.99
%	14.9	16.5	31.8	181.2	-	-	-25.2	38.8	1.5
Nova Iguaçu									
Programmed	70.79	73.67	74.82	31.19	-	-	58.08	78.03	77.31
Executed	44.91	55.04	62.66	67.44	55.61	61.32	60.43	67.48	189.7
%	-36.6	-25.3	-16.3	116.2	-	-	4.0	-13.5	145.4
Queimados									
Programmed	10.2	10.15	9.61	4	-	-	8.14	10.54	11.06
Executed	13.1	12.58	10.82	10.68	11.9	13.71	14.35	14.52	16.85
%	28.4	23.9	12.6	167.0	-	-	76.3	37.8	52.4
Rio de Janeiro									
Programmed	687.57	689.06	689.89	287.37	-	-	474.2	646.52	644.85
Executed	522.41	577.07	583.94	531.3	485.31	521.55	538.36	644.35	1587.98
%	-24.0	-16.3	-15.4	84.9	-	-	13.5	-0.3	146.3
São João de Meriti									
Programmed	29.68	30.45	30.55	12.74	-	-	23.49	29.7	30.4
Executed	24.77	26.46	32.45	39.59	32.74	39.86	44.92	38.54	128.9
%	-16.5	-13.1	6.2	210.8	-	-	91.2	29.8	324.0
Seropédica									
Programmed	3.55	3.57	3.58	1.5	-	-	2.92	3.9	3.91
Executed	4.52	3.49	2.97	2.48	2.39	4.3	3.56	3.01	11.67
%	27.3	-2.2	-17.0	65.3	-	-	21.9	-22.8	198.5

(%) Percentage of the executed quota by the programmed one.

Source: Authors.

Table 2. Estimates of percent variations in MHC programmed and executed quotas per million Reais (R$) in the municipalities of the Metropolitan Region of Rio de Janeiro, Brazil, 2013-2021.

Municipalities/type of quota	Period	APC	95%CI	AAPC	95%CI
Belford Roxo					
Programmed	2013 - 2021	-2.7	-8.5 a 3.4	-2.7	-8.5 to 3.4
Executed	2013 - 2019	4.4	-11.4 a 23.0		
	2019 - 2021	88.8*	18.3 a 201.6		
	2013 - 2021	-	-	21.1*	7.4 to 36.5
Duque de Caxias					
Programmed	2013 - 2021	0.5	-5.4 a 6.9	0.5	-5.4 to 6.9
Executed	2013 - 2019	3.0	-7.3 a 14.5		
	2019 - 2021	199.1*	140.5 a 272		
	2013 - 2021	-	-	34.5*	25.7 to 43.9
Itaguaí					
Programmed	2013 - 2021	0.1	-5.9 a 6.4	0.1	-5.9 to 6.4
Executed	2013 - 2019	-9.8	-29.9 a 16.1		
	2019 - 2021	89.1	-28.7 a 401.5		
	2013 - 2021	-	-	8.6	-12.7 to 35
Japeri					
Programmed	2013 - 2021	-1.4	-7.3 a 4.9	-1.4	-7.3 to 4.9
Executed	2013 - 2016	-20.4*	-33.8 a -4.4		
	2016 - 2021	4.2	-6.4 a 16		
	2013 - 2021	-	-	-5.8	-12.0 to 0.8
Magé					
Programmed	2013 - 2021	0.7	-5.3 a 7.0	0.7	-5.3 to 7.0
Executed	2013 - 2021	14.5*	11.5 a 17.5	14.5*	11.5 to 17.5
Mesquita					
Programmed	2013 - 2021	-3.0	-9.0 a 3.4	-3	-9.0 to 3.4
Executed	2013 - 2021	10.1*	4.3 a 16.1	10.1*	4.3 to 16.1
Nilópolis					
Programmed	2013 - 2021	1.3	-4.5 a 7.4	1.3	-4.5 to 7.4
Executed	2013 - 2021	1.2	-4.8 a 7.5	1.2	-4.8 to 7.5

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to 2021. Hospitalizations of Itaguaí residents to surgical and clinical beds increased in the period from 2013 to 2018, respectively, 9.1% (95%CI: 1.4 to 18.4) and 10.5% (95%CI: 3.9 to 17.4) per year, while obstetrics beds showed a significant reduction of 24.3 % per year (95%CI: -41.9 to -1.4) in the period from 2018 to 2021.

Occupancy of obstetric beds by Magé residents showed a percentage increase of 15% per year (95%CI: 2.8 to 28.7) in the period from 2013 to 2017 and a reduction of 12.7% per year (95%CI: - 22.7 to -1.3) in the period from 2017 to 2021, whereas pediatric beds showed a significant decrease of 3.5% per year (95%CI: -6.9 to 0.1) during the period from 2013 to 2021. Obstetric hospitalizations of residents of Mesquita required a significant increase of 53.1% per year (95% CI: 17.2 to 100.1) of beds in health units in the municipality of Rio de Janeiro, in the period from 2013 to 2017. A significant, albeit more discreet, increase was also observed for clinical beds: an increase of 6.6% per year (95%CI: 3.7 to 9.7) in the period from 2013 to 2021.

A significant annual percentage increase in the number of beds occupied by Nilópolis residents was observed for the period from 2013 to 2021. Hospitalizations due to clinical, obstetric and pediatric reasons showed, respectively, an annual increase of 8.3%, 24.3% and 20.7% for this period (Table 4).

The municipality of Japeri, even with the executed quota below the programmed one in practically all years of the analyzed period (2013 to 2021) (Table 1), required admissions to hospital

Table 2. Estimates of percent variations in MHC programmed and executed quotas per million Reais (R$) in the municipalities of the Metropolitan Region of Rio de Janeiro, Brazil, 2013-2021.

Municipalities/type of quota	Period	APC	95%CI	AAPC	95%CI
Nova Iguaçu					
Programmed	2013 - 2021	0.7	-5.3 a 7	0.7	-5.3 to 7
Executed	2013 - 2019	-0.5	-8.8 a 8.6		
	2019 - 2021	81.3*	32.9 a 147.1		
	2013 - 2021	-	-	15.6*	7.6 to 24.2
Queimados					
Programmed	2013 - 2021	0.8	-5.2 a 7.1	0.8	-5.2 to 7.1
Executed	2013 - 2016	-5.9	-14.8 a 3.9		
	2016 - 2021	8.9*	5.0 a 13.1		
	2013 - 2021	-	-	3.1	0.0 to 6.4
Rio de Janeiro					
Programmed	2013 - 2021	-1.5	-7.5 a 5.0	-1.5	-7.5 to 5
Executed	2013 - 2019	-3.3	-7.7 a 1.2		
	2019 - 2021	81.2*	52.9 a 114.8		
	2013 - 2021	-	-	13.1*	8.8 to 17.6
São João de Meriti					
Programmed	2013 - 2021	-0.4	-6.2 a 5.8	-0.4	-6.2 to 5.8
Executed	2013 - 2019	5.7	-2.8 a 14.9		
	2019 - 2021	78.8*	33.3 a 139.7		
	2013 - 2021	-	-	20.5*	12.6 to 29
Seropédica					
Programmed	2013 - 2021	1.1	-4.9 a 7.4	1.1	-4.9 to 7.4
Executed	2013 - 2019	-3.9	-17.9 a 12.4		
	2019 - 2021	91.9	-22.6 a 375.4		
	2013 - 2021	-	-	14.2	-4.6 to 36.8

APC: annual percent change; AAPC: average annual percent change; *p-value < 0.05.

Source: Authors.

Table 3. Hospitalizations in the city of Rio de Janeiro of patients residing in Metropolitan Region I of the state of Rio de Janeiro, Brazil, 2013-2021.

Type of bed/year	Total hospitalizations n (%)
Surgical	724.837 (34.9)
Clinical	571.805 (27.5)
Obstetrics	507.344 (24.4)
Pediatrics	193.693 (9.3)
Psychiatry	27.468 (1.3)
Chronic patients	17.110 (0.8)
Day bed/mental health	12.641 (0.6)
Day bed/surgical	11.593 (0.6)
Mental health (clinical)	6.400 (0.3)
Sanitary pulmonology (thisiology)	2.002 (0.1)
Day bed/Aids	1.799 (0.1)
Rehabilitation	810 (0)
Day bed/post-transplant complications	61 (0)
Total	2,077.563 (100)

Source: Authors.

units in the municipality of Rio de Janeiro (Table 4). Beds occupied by residents of the city of Japeri showed a positive annual percentage variation for clinical and pediatric hospitalizations in the period from 2013 to 2021 and obstetric hospitalizations in the period from 2013 to 2018, but they were not statistically significant (Table 4).

Discussion

According to Hollnagel[19], the resilience of organizational systems immersed in an unstable environment develops from the strengthening of permanent and evolution capabilities, particularly the capabilities of anticipating potential demands that threaten the regular operation; of monitoring the environment to identify critical short-term threats; of learning from past experiences and broadly disseminating knowledge; and thus, promptly responding to demands. In the case of

Table 4. Estimates of percent variations in hospitalizations in the municipality of Rio de Janeiro of patients from the Metropolitan Region of the state of Rio de Janeiro, Brazil, 2013-2021.

Municipalities/type of hospitalization	Hospitalizations	Period	APC	95%CI	AAPC	95%CI
Belford Roxo						
Surgical	19,525	2013 - 2021	-1.9	-4.4 to 0.7	-1.9	-4.4 to 0.7
Clinical	13,417	2013 - 2021	1.6	-1.3 to 4.6	1.6	-1.3 to 4.6
Obstetrics		2013 - 2018	16.7*	3.9 to 31.1		
		2018 - 2021	-24.7	-43.9 to 0.9		
	3,055	2013 - 2021	-	-	-1	-9.8 to 8.7
Pediatrics		2013 - 2019	3.5	-1 to 8.3		
		2019 - 2021	-12.5	-34.6 to 17.2		
	3,046	2013 - 2021	-	-	-0.7	-6.2 to 5.1
Duque de Caxias						
Surgical	33,937	2013 - 2021	-1.5	-4.1 to 1	-1.5	-4.1 to 1
Clinical	23,039	2013 - 2021	3.6*	1.5 to 5.8	3.6*	1.5 to 5.8
Obstetrics	9,074	2013 - 2021	-0.6	-10.2 to 10	-0.6	-10.2 to 10
Pediatrics	5,746	2013 - 2021	1.4	-2.6 to 5.6	1.4	-2.6 to 5.6
Nova Iguaçu						
Surgical	32,077	2013 - 2021	-1.1	-4.6 to 2.5	-1.1	-4.6 to 2.5
Clinical	20,558	2013 - 2021	3.1*	1.1 to 5.1	3.1*	1.1 to 5.1
Obstetrics	5,489	2013 - 2021	6.5	-2.2 to 16	6.5	-2.2 to 16
Pediatrics	4,441	2013 - 2021	3.2*	1.3 to 5.8	3.2*	1.3 to 5.8
São João de Meriti						
Surgical	24,039	2013 - 2021	-2	-5.1 to 1.3	-2	-5.1 to 1.3
Clinical	17,419	2013 - 2021	1.9	-0.8 to 4.6	1.9	-0.8 to 4.6
Obstetrics	4,147	2013 - 2018	22.1*	12.5 to 32.6		
		2018 - 2021	-22.8*	-34.2 to -9.4		
		2013 - 2021	-	-	2.8	-2.7 to 8.7
Pediatrics	3,517	2013 - 2021	2.3	-1.3 to 6	2.3	-1.3 to 6
Rio de Janeiro						
Surgical	574,077	2013 - 2021	-0.9	-3.6 to 1.9	-0.9	-3.6 to 1.9
Clinical	469,862	2013 - 2021	2.9*	0.3 to 5.6	2.9*	0.3 to 5.6
Obstetrics	478,027	2013 - 2017	3.6	-3.6 to 11.3		
		2017 - 2021	-5.4	-11.9 to 1.6		
		2013 - 2021	-	-	-1	-4.5 to 2.6
Pediatrics	170,751	2013 - 2021	-1.7	-3.6 to 0.1	-1.7	-3.6 to 0.1
Itaguaí						
Surgical	4,637	2013 - 2018	9.1*	1.4 to 18.4		
		2018 - 2021	-15.2	-29.4 to 1.8		
		2013 - 2021	-	-	-0.7	-6.5 to 5.4
Clinical	2,446	2013 - 2018	10.5*	3.9 to 17.4		
		2018 - 2021	-11.6	-35.6 to 21.5		
		2013 - 2021	-	-	4.5	-2.1 to 11.5
Obstetrics	1,159	2013 - 2018	51.4	-6.9 to 146.1		
		2018 - 2021	-24.3*	-41.9 to -1.4		
		2013 - 2021	-	-	7.1	-11.9 to 30.1
Pediatrics	697	2013 - 2021	5.2*	1.1 to 9.5	5.2*	1.1 to 9.5

it continues

public health systems, these capabilities must be consolidated to maintain the stability of essential public health functions, both in crisis situations and during the normal operation of services[20,21].

Table 4. Estimates of percent variations in hospitalizations in the municipality of Rio de Janeiro of patients from the Metropolitan Region of the state of Rio de Janeiro, Brazil, 2013-2021.

Municipalities/type of hospitalization	Hospitalizations	Period	APC	95%CI	AAPC	95%CI
Japeri						
Surgical	3,309	2013 - 2021	-2.4	-6.1 to 1.5	-2.4	-6.1 to 1.5
Clinical	1,914	2013 - 2021	2.2	-1.5 to 6	2.2	-1.5 to 6
Obstetrics	403	2013 - 2018	11.7	-2.8 to 28.3		
		2018 - 2021	-22.4	-43.8 to 7.2		
		2013 - 2021	-	-	-2.6	-12.3 to 8.2
Pediatrics	577	2013 - 2021	0.7	-3.8 to 5.4	0.7	-3.8 to 5.4
Magé						
Surgical	7,503	2013 - 2021	2	-3.3 to 7.6	2	-3.3 to 7.6
Clinical	4,071	2013 - 2021	2.6	-1.4 to 6.9	2.6	-1.4 to 6.9
Obstetrics	1,257	2013 - 2017	15.0*	2.8 to 28.7		
		2017 - 2021	-12.7*	-22.7 to -1.3		
		2013 - 2021	-	-	0.2	-5.5 to 6.3
Pediatrics	1,192	2013 - 2021	-3.5*	-6.9 to -0.1	-3.5*	-6.9 to -0.1
Mesquita						
Surgical	7,787	2013 - 2021	2.4	-1.8 to 6.9	2.4	-1.8 to 6.9
Clinical	5,711	2013 - 2021	6.6*	3.7 to 9.7	6.6*	3.7 to 9.7
Obstetrics	1,342	2013 - 2017	53.1*	17.2 to 100.1		
		2017 - 2021	-9	-17.5 to 0.5		
		2013 - 2021	-	-	18.1*	6.8 to 30.6
Pediatrics	1,151	2013 - 2017	18.8	-1.7 to 43.5		
		2017 - 2021	-3.2	-15.4 to 10.8		
		2013 - 2021	-	-	7.2	-1.2 to 16.4
Nilópolis						
Surgical	8,243	2013 - 2021	2.2	-1.2 to 5.6	2.2	-1.2 to 5.6
Clinical	7,511	2013 - 2021	8.3*	5.6 to 11	8.3*	5.6 to 11
Obstetrics	2,134	2013 - 2017	74.3*	32.9 to 128.6		
		2017 - 2021	-11.4*	-19.2 to -3		
		2013 - 2021	-	-	24.3*	12.3 to 37.5
Pediatrics	1,248	2013 - 2018	20.7*	5.2 to 38.4		
		2018 - 2021	-13.4	-31.4 to 9.4		
		2013 - 2021	-	-	6.6	-2.3 to 16.2
Queimados						
Surgical	6,954	2013 - 2021	-0.4	-5.2 to 4.5	-0.4	-5.2 to 4.5
Clinical	4,325	2013 - 2021	0.6	-3.4 to 4.6	0.6	-3.4 to 4.6
Obstetrics	798	2013 - 2017	19.5	-16.2 to 70.4		
		2017 - 2021	-12.7	-32.8 to 13.5		
		2013 - 2021	-	-	2.1	-12.6 to 19.4
Pediatrics	863	2013 - 2021	0.1	-2.7 to 2.9	0.1	-2.7 to 2.9
Seropédica						
Surgical	2,637	2013 - 2021	7.2	-1.8 to 17	7.2	-1.8 to 17
Clinical	1,435	2013 - 2021	6.3	-2 to 15.2	6.3	-2 to 15.2
Obstetrics	510	2013 - 2021	3.9	-6.3 to 15.3	3.9	-6.3 to 15.3
Pediatrics	464	2013 - 2015	-36.1	-69.2 to 32.5		
		2015 - 2021	6.1	-16.6 to 35.1		
		2013 - 2021	-	-	-6.5	-22 to 12.1

APC: annual percent change; AAPC: average annual percent change; *p-value < 0.05.

Source: Authors.

On average between the years 2013 and 2021, regarding hospital admissions carried out by the MRJ to other municipalities in the state, there is a prevalence of medium-complexity care. At the same time, when evaluating the nature of hospital admissions, it is observed that there is a greater provision of services to the municipality of Duque de Caxias, related mostly to elective services, despite having similar values related to the demand for urgency/emergency services. Next, Nova Iguaçu appears in the second place, São João de Meriti in the third, with Magé and Nilópolis occupying the fourth and fifth places, with the abovementioned municipalities being those that have the greatest impact on the MHC assistance network in the MRJ.

Therefore, even though the MRJ offers health services to the entire state of Rio de Janeiro and, fundamentally, to the Metropolitan Region 1, it is unable, through official mechanisms, to relocate the financial ceilings of neighboring municipalities to the provided services. Furthermore, it is evident from the data presented herein that there is an increase in the costs of MHC procedures and their long-term effects are of concern (given the population epidemiological profile), while financing remains limited to the ceiling.

As this scenario highlights weaknesses in the institutional capacity of the SUS in MRJ to monitor pressures on demand arising from nearby municipalities, the impossibility of relocating MHC ceilings brings losses to the capacity to promptly respond to both emerging and routine demands. In this sense, the difficulty of developing a resilient behavior in the short term is more evident, given the difficulty of mobilizing immediate resources to meet the demands of neighboring municipalities.

However, the institutional capacity to anticipate pressures on demand in the long term is also weakened, since the impossibility of relocating MHC ceilings makes it difficult to plan and mobilize contingency resources for sudden increases in demand, an essential aspect for resilience. Recent literature describes this scenario, highlighting its relationship with the worsening of health underfunding and the consequences for the maintenance of essential SUS operations at different levels of care in different parts of the country[22-24].

It is observed that regional proximity and commuting migration (the daily movement of people leaving the municipalities where they live and heading to another one) towards the MRJ, impact the organization capacity and time to undergo exams and screening procedures, of medium and high complexity, overloading the MRJ health system.

Moreover, the change in the epidemiological profile and the population aging, technological advances in health and high costs for the treatment of chronic degenerative diseases have increasingly and continuously challenged the institutional capacity of the SUS. However, the consolidation of the fiscal austerity agenda after the impeachment of President Dilma Roussef in mid-2016 and the promulgation of EC 95 shortly thereafter led the underfunding of the SUS to an even more severe level of defunding[8], compromising programs and preventing the adequate development of resilient capabilities to unexpected fluctuations in demand – both typical ones, such as those caused by the transition of users in Rio de Janeiro assessed in this study, and more disruptive ones, such as the COVID-19 pandemic.

As of 2019, President Bolsonaro government's ultraliberal agenda accentuated this scenario, and the results of the COVID-19 pandemic in Brazil, the second epicenter of the disease worldwide[25], illustrate to a certain extent how the resilient capabilities of the SUS were affected by the policy employed over the last six years, even though the SUS has shown potential for a resilient performance, by being able to quickly mobilize resources to respond to the pandemic even in a context of political instability, conflicting strategies between governments and health authorities and denialism[26].

Regarding the pattern of the temporal series of executed quotas, it was observed that there was a more significant increase in the trend from 2020 onwards in most municipalities in Metropolitan Region 1. A deficit was observed throughout the analyzed period in the historical series (between 2013 and 2021). However, the period of greatest medium- and high-complexity production in all municipalities in Metropolitan Region 1 occurred during the first two years of the COVID-19 pandemic (2020 and 2021) when hospitalizations were in greater demand and, consequently, there was a greater volume of spending and pressure on the institutional capacity of the SUS, as corroborated by Noronha and Ferreira[27].

The absence of financial compensation and the consequent increase in the MHC ceiling deficit demonstrated in the data of the present study also prevent the MRJ from restructuring its service portfolio based on learning from experiences that have occurred, compromising the

capacity of the MRJ to respond both in terms of the maintenance of essential functions as regards attention to emerging demands.

Studies have shown the increasing difficulty of the MRJ in regulating MHC procedures in this chronic scenario of scarcity of resources, which is aggravated by the disorderly transition of users – including during the COVID-19 pandemic, when several elective procedures were suspended[28-30]. Regulation is a central process for SUS resilience, as it is responsible for organizing the users' access according to their risks and the available resources[31,32].

Since the creation of SUS, there has been a process of increasing municipal spending on health and reducing the percentage of federal financing and, consequently, the need to increase resources for health at this level[5,33-36]. In this sense, Teles et al.[37], when analyzing the allocation of federal resources in the state of Bahia, found a large concentration of resources allocated to a few municipalities with a large population and with the highest HDI, and a low amount to regions with greater health needs, that is, with greater vulnerability, which increases regional inequity, a cause that may arise from the quality of the service network found in smaller municipalities, similar to the case of Rio de Janeiro.

Costa[38] explains that the federal government withdrew support for the expansion of expenditure on Public Health Actions and Services (PHAS), stabilizing the allocation of its resources through the veto of budgetary linkage. This change in federal directions has shifted the burden of expanding financing to local and state governments in recent decades. Thus, the stabilization of federal expenses was offset by the increase in the linking of the municipal budget to the PHAS. During the first cycle of the COVID-19 pandemic, budgetary linkage was crucial for the expansion of PHAS financing in most of the studied municipalities, allowing a resilient condition.

Espírito Santo and Tanaka[39] identified that municipal health expenditure experienced an increase directly proportional to population size, reaching a rate of 90% in municipalities between 500,000 and one million inhabitants. They also assessed that there is growing municipal spending on health that is higher than the growth in overall income and expenditure. They conclude by considering that the growth in the production of MHC procedures suggests the allocation of resources to reproduce the medical-care model (hospital-centric).

It is noteworthy that Ordinance n. 3,992, dated of December 28, 2017[3] amends Consolidation Ordinance N. 6/GM/MS, dated of September 28, 2017, to provide for the financing and transfer of federal resources aimed at SUS public health actions and services, extinguishing the financing blocks and replacing them with a single investment and funding item, maintaining fund-to-fund transfers. However, for accountability purposes, municipalities continue to follow the block logic.

Faced with a request to increase the MHC ceiling, the Bipartite Intermanagers Commission (CIB, *Comissão Intergestores Bipartite*), is the body in which assistance programming and the relocation of MHC resources in the state are approved, monitoring requests for an increase in federal contribution, only issuing resolutions related to it after all possibilities for reallocating available resources have been exhausted. At the federal level, the Ministry of Health compares the amount received with the amount of production presented and, if high production is demonstrated throughout the state, compliance with the request is conditioned on the budgetary-financial availability of the department.

In the aforementioned context, it can be inferred that the financial deficit arising from unprogrammed services that occur in MRJ end up compromising the municipality's resilient behavior because they make it difficult to plan health actions, in a vicious circle that continually compromises quality and supply. of MHC services and increasing waiting times, contrary to what the World Health Organization (WHO)[10] recommends.

Finally, the increase in the number of services outside of programmed planning impacts the municipality daily response capacity, which is unable to anticipate the volume of service, influencing the ability to monitor what is critical and to implement experiences based on learned lessons, since financial transfers related to care for people from other municipalities are not made. Consequently, the MHC ceiling deficit has a negative effect on the municipality service network, which ends up compromised and disorganized, directly impacting the supply, quality and waiting times of offered MHC services.

Conclusion

The present study highlights that the chronic underfinancing of the SUS results in even more

marked consequences in municipalities that share borders with underprivileged regions, as is the case of MRJ, which even with a developed and structured network – largely resulting from the time in which it was the capital of the country – shows difficulties in sustaining essential functions, institutional capacity and resilience in the face of the intense transition of users to which it is subjected, without being able to make adequate relocations of MHC ceilings.

In this sense, the municipality management should carry out political and technical actions with the CIB and the Ministry of Health with the objective of opening negotiations for the gradual relocation of the MHC programmed financial ceiling, mainly with the other municipalities in Metropolitan Region 1 (from Baixada Fluminense), so that institutional capacity can be restored and, consequently, improve the supply of services, the quality of assistance and promote resilient performance to typical or extraordinary fluctuations in demand.

Given the volume of services provided to residents of neighboring municipalities within the MRJ network and the financial deficit generated, the maintenance of essential public health functions in the municipality is compromised, given the degree of vulnerability of neighboring municipalities, the low capacity of monitoring the surrounding criticality, and the difficulty in anticipating the fluctuation in demand resulting from the transition of users.

Another issue that stands out is the establishment and evolution of a relationship of dependence between the other municipalities in Metropolitan Region 1 and the MRJ health network due to the scarcity of services and consistent investment in the care network of the less developed municipalities in the region.

Finally, it is worth highlighting that it will not be an easy task to reverse this situation, given the worsening of the financing crisis that has been affecting the health sector in recent years, mainly due to the limitations imposed by fiscal austerity policies, of which emphasis is placed on EC 95 and its 'spending ceiling', as well as the economic, social and pandemic crises of recent years, which seriously affected the health sector.

Collaborations

PC Nunes was responsible for the general study concept, data collection, discussion of results and writing of the manuscript; H Bellas was responsible for reviewing the results; ET Paulino was responsible for the methodology and analysis of results; A Ramos worked on the study concept and discussion of the results; A Jatobá was responsible for managing the research project, study concept, data analysis, discussion of results and writing the manuscript.

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