Research Article

Performance of Subnational Governments in the COVID-19 Pandemic: An Analysis of the Public and Private Health Services in Brazil

Marco Antonio Catussi Paschoalotto[1]
José Eduardo Ferreira Lopes[2]
Pedro Henrique de Oliveira[3]
Pedro Pita Barros[1]

[1] Universidade Nova de Lisboa, Portugal
[2] Universidade Federal de Uberlândia, Uberlândia, MG, Brazil
[3] Universidade de São Paulo, São Carlos, SP, Brazil

ABSTRACT

This article analyzes the differences between public and private health services regarding infrastructure and human resources at the state (subnational) and macro-regional levels in Brazil. The research collected monthly data on inpatient beds and the number of nurses, physiotherapists, and doctors from Brazilian states for 2020. Indicators were created following quarterly changes and comparing the actions of public and private healthcare entities. Variations were analyzed using temporal graphs based on means and standard deviation. The findings suggest: (1) exponential growth in health care infrastructure and human resources led by public sector investment in the second quarter, followed by a slowdown; (2) a more significant variation in the acceleration and deceleration of the public sector response in the North of Brazil and the states of Maranhão, Rio Grande do Norte, and the Federal District; (3) the public sector was the primary response mechanism to the pandemic considering the variations throughout the year. The study concludes that the government was the leading actor in response to the COVID-19 pandemic in Brazil in 2020, pointing out that responses were uneven in the states.

Keywords: performance of subnational governments; state capacity; public sector; private sector; health care.

JEL code: I210, I240.

INTRODUCTION

In March 2020, the World Health Organization declared the outbreak of the coronavirus disease (COVID-19) a pandemic (World Health Organization [WHO], 2020). From then on, the coronavirus spread quickly, leading to many cases and deaths. Brazil was one of the most affected countries, the third in the cumulative number of cases and the second in cumulative deaths up to October 2021 (Johns Hopkins University, 2021). Compared to another countries, Brazil faced problems implementing measures to fight COVID-19 — such as mobility restrictions and social distancing — demonstrating a lack of coordination to carry out intergovernmental action (Abrucio et al., 2020; Rocha et al., 2021; Knaul et al., 2021). Against this backdrop, the rapid increase in cases and deaths led to critical moments of lack of human and physical resources in the country (Castro et al., 2021; Johns Hopkins University, 2021; Marson & Ortega, 2020).

Initially, it is necessary to understand how the Brazilian government reacted to the pandemic. The low participation of the federal government in intergovernmental coordination made states take on the responsibility of meeting the population's demand for health services (Abrucio et al., 2020; Fernandes & Pereira, 2020; Gofen & Lotta, 2021), a demand that also reached private health service providers (Croda et al., 2020; Moreira, 2020). The scenario presented many phenomena worth researching, such as the process of adopting social distancing measures, vaccination programs, and the elaboration and enactment of norms and decrees to govern the responses to health crises. Amid these opportunities, this study focuses on understanding the capacity of the public and private health sectors to respond to the pandemic, particularly by making available infrastructure and human resources (Croda et al., 2020; Massuda et al., 2018; Paschoalotto et al., 2021).

This choice considered the fact that Brazil has a universal and integrated health system — the unified health system (Sistema Único de Saúde — SUS), which has counted on increasing participation of the private sector (Aquino et al., 2020; Castro et al., 2019; Costa et al, 2020; Massuda et al., 2018). The research problem addressed in this study emerges from the presence of such a system with the participation of private service providers: How did the Brazilian subnational governments respond to the COVID-19 pandemic when considering the performance of both public and private health services?

Thus, the main objective of this article is to analyze the quarterly variations of infrastructure and human resources related to health care at the subnational level in Brazil, encompassing the participation of both the public and private sectors. The study has two specific objectives. First, it seeks patterns of variations in the relationship between the public and private health sectors at different moments of the pandemic in terms of inpatient beds and the number of nurses, physiotherapists, and doctors. Second, it aims to identify variations in Brazil's capacity, at the state and macro-regional levels, to respond to the COVID-19 pandemic.

This study offers a theoretical contribution to help understand the subnational issues related to the capacity of public and private health services to respond to the COVID-19 pandemic (Lima et al., 2021; Liu et al., 2021; Moreira, 2020; Noronha et al., 2020). As for practical contributions, this research supports decision-makers, health professionals, and citizens by offering scientific

information about the importance of SUS and its response capacity to strengthen subnational governments in the scope of the Brazilian public health system (De la Cruz et al., 2020; Massuda et al., 2018; Noronha et al., 2020).

THEORETICAL FRAMEWORK

The performance of subnational governments is relevant to worldwide public administration studies, particularly in understanding these governments' ability to deliver services and improve indicators (Olvera & Avellaneda, 2019; Paschoalotto et al., 2020). Studies such as Bello-Gomez (2020) have observed the influence of subnational governments' performance on health, education, and economic policies. The actions of state-level authorities were also important during the COVID-19 pandemic when they took on the responsibility of supporting local governments or directly delivering services (Talabis et al., 2021; Bigoni et al., 2022). Measures adopted as a response by state governments during this health crisis encompassed financial transfers to local governments and direct investment in infrastructure, human resources, and services (Sevindik et al., 2021; Massuda et al., 2022).

State capacity reflects the government's ability to address a given issue, financing human resources and infrastructure, for example (Haque et al., 2021). The government may act directly by operating policies or regulating services in a specific area, such as the Brazilian government in healthcare with the National Health Agency (Agência Nacional de Saúde – ANS) (Grin, 2021; Segatto et al., 2021). The Brazilian healthcare model is classified as a hybrid, i.e., between the bureaucratic and the market-oriented models (Cunha et al., 2017).

More profoundly, state capacity has many dimensions, and the dimension of resources is an example; in the case of the COVID-19 pandemic, it is worth highlighting the human and infrastructure resources (Gomide et al., 2021). In times of crisis, state capacity requires reciprocal relationships, communication, and trust between decision-makers, health professionals, and citizens (Mao, 2021; Yen et al., 2022). For example, SUS has approximately 290,000 health professionals, indicating the state's capacity to deliver public health policy (Lotta et al., 2020). Within the studies of state capacity, those related to administrative and resource management stand out, measured through performance indicators (Haque et al., 2021; Yen et al., 2022).

Brazilian public health policy has a strong state appeal, marked by SUS and its administrative decentralization throughout the states and municipalities (Massuda et al., 2018; Aquino et al., 2020). The government is the leading actor in delivering public health services, which count on supplementary participation of the business and nonprofit sectors (Paschoalotto et al., 2018; Castro et al., 2019).

Therefore, state capacity is a vital element of the Brazilian public health policy, emphasizing the transfer of resources between federal, state, and local governments (Gofen & Lotta, 2021; Segatto et al., 2021). An essential variable in the Brazilian case is the system's (SUS) capacity to respond to the pandemic by allocating financial and human resources and offering infrastructure (e.g., inpatient beds and ventilators) (Castro et al., 2019; Fernandes & Pereira, 2020).

In Brazil, there is an insufficient volume of public resources to combat the pandemic, which opens opportunities for private health service providers (Fernandes & Pereira, 2020; Funcia et al., 2022). In addition, SUS must seek alternatives by improving management and performance to guarantee resources and save lives, ensuring an appropriate number of beds in intensive care units (ICU) and ventilators in a timely manner, while observing the regional nature of the public health services (Daumas et al., 2020; Bigoni et al., 2022).

Thus, understanding the number of health professionals (Lotta et al., 2020), ICU beds, and ventilators (Bezerra et al., 2020; Daumas et al., 2020; Moreira, 2020), and the spatial distribution of cases in the country (Bezerra et al., 2020; Castro et al., 2019; Noronha et al., 2020), it is possible to assess the dimension of the crisis that we are experiencing, and it helps outline effective action paths between the public and the private sector.

Different clinical and demographic factors influence the management of responses to the pandemic, such as social inequality and difference in the structure and quality of public health services (Andrade et al., 2020). In this sense, it is crucial to learn the state and macro-regional differences between public and private health services (Paschoalotto et al., 2018). The analysis must be contextualized for each reality, respecting the assumptions of responsiveness and Brazil's geographic dimensions (Daumas et al., 2020).

The study by Castro et al. (2021) offered a deeper look at the pandemic in Brazil, demonstrating how the state's response occurred unevenly and uncoordinatedly across the states. The authors observed a reduction of cases and deaths in the states that used social distancing measures (ex.: Ceará) and an increase in the states that did not enforce social distancing as effectively (2021) (ex.: Rio de Janeiro). In the same direction, Rocha et al. (2021) and Baqui et al. (2020) pointed out that Brazil's North and Northeast macro-regions were more affected by having less hospital infrastructure and needed a quick response to meet the demand.

METHODS

This quantitative and descriptive research was based on data collected from the Brazilian government databases through Tabnet — a system of the Department of Informatics of the Unified Health System (SUS). The data retrieved referred to health services characterized as belonging or not to SUS: inpatient beds (SUS and non-SUS), number of nurses (working for SUS and not working for SUS), number of physiotherapists (working for SUS and not working for SUS), and number of doctors (working for SUS and not working for SUS) (Brazil, 2021a). Thus, the 'SUS' variables reflect the indicators of the Brazilian public health sector, and the 'non-SUS' variables refer to the structure of private health services in the country.

As for data granularity, the study worked with data collected at the state level — since Brazilian states became primarily responsible for responding to the COVID-19 pandemic in the absence of the federal government (Aquino et al., 2020) — and per month, from January to December 2020. The variable inpatient beds was chosen to represent the main response mechanism to the COVID-19 pandemic in terms of infrastructure (Pedrosa & de Albuquerque, 2020).

Unfortunately, data on 'non-SUS' ventilators were unavailable, so this indicator could not be adopted for comparative analysis. Data on human resources (number of nurses, physiotherapists, and doctors) were available and used in the analysis (Caetano et al., 2020).

The data collected was used to create variations at the state, macro-regional, and national levels. These variations are presented per quarter, following the movements observed in the *Painel Coronavírus Brasil (COVID-19) – Casos e óbitos por COVID-19* (Coronavirus Brazil Panel – Cases and deaths by COVID-19): first quarter – beginning of the COVID-19 pandemic; second quarter – growth in the number of cases and deaths; third quarter – decrease in the number of cases and deaths; and fourth quarter – beginning of the second wave (Brazil, 2021b). Equation 1 portrays this first stage of change:

$$\Delta Xyz = (NumXyz3/NumXyz0) - 1 \ (1)$$

X – Inpatient beds, nurses, physiotherapists, or doctors; y – state, macro-regional, or national levels; z – months of the quarter

After creating the quarterly variations, a second step of measuring the relationship between public and private sectors was carried out (Equation 2):

$$\Delta FXyz = \Delta XyzSUS - \ \Delta XyzNONSUS \ (2)$$

X – Inpatient beds, nurses, physiotherapists, or doctors; y – state, macro-regional, or national levels; z – months of the quarter; F – final

After applying the equations, the final database presented the indicators measuring the relationship between the public and private health services on a quarterly basis and at the state, macro-regional, and national levels. In order to facilitate understanding of the data variation during the quarters, line graphs (states or macro-regions) and area graphs (macro-region or Brazil) were used, with horizontal lines representing the mean (black line) and upper and lower control limits (red lines). The red lines were calculated as the sum (LSC) or subtraction (LIC) of the mean by the national standard deviation. Scatter plots were used to understand the annual public and private response patterns considering the four indicators.

For quarterly comparisons, when there is growth in a given period, and the variation approaches zero for subsequent periods, it just means that the structure stopped growing in relation to the previous period. Thus, when there was expansion in the first quarter, it remained throughout the other periods. A supplementary figure to support the analysis was created (Appendix 1), showing the monthly number of COVID-19 cases and deaths in 2020 per Brazilian state and macro-region.

RESULTS

This section is divided into three topics to understand the distribution of the indicators' quarterly variations and the annual response capacity: inpatient beds (infrastructure), human resources,

and the indicators' two-dimensional relationship. The graphs in Figures 1 to 4 are listed and distributed for better visualization. The first graph on the left represents the national performance of the five macro-regions, and the others represent the respective macro-regions and the states that comprise them.

In addition, Table 1 presents the numerical variation in the year 2020 of each of the indicators addressed — the subtraction of December 2020 by January 2020 from the absolute numbers.

- The public sector's relative response capacity in all indicators is greater than that of the private sector, and its variation in absolute values in 2020 was also higher;
- By having higher absolute numbers in all indicators, the public sector and its variations convey a more significant increase in infrastructure and human resources than the same percentage of variation in the private sector;
- The private sector in the Southeast macro-region is more active when compared to the other macro-regions, but the public sector still plays a leading role.

Table 1

Quarterly variation in the number of inpatient beds — public sector vs. private sector

Unit	Inp_SUS	Inp_NSUS	Nur_SUS	Nur_NSUS	Physio_SUS	Physio_NSUS	Doc_SUS	Doc_NSUS
Brazil	18,758	2,940	30,510	3,438	6,585	894	16,455	4,345
North	2,264	318	3,333	166	525	140	985	236
Northeast	6,985	614	8,310	261	1,860	184	3,811	202
Southest	6,382	2,689	11,976	2,746	2,921	84	5,967	2,629
South	1,188	-777	3,901	420	688	215	3,155	1,141
Midwest	1,939	96	2,990	-155	591	271	2,537	137
Rondônia	199	128	449	67	142	41	141	97
Acre	167	-38	109	-3	25	4	24	24
Amazonas	190	23	926	28	117	29	142	14
Roraima	179	58	221	-9	30	0	77	16
Pará	1,306	291	949	54	114	58	356	55
Amapá	157	-23	190	-9	23	2	62	3
Tocantins	66	-121	489	38	74	6	183	27
Maranhão	1,027	94	620	147	149	70	211	89
Piauí	460	136	637	50	139	42	242	-18
Ceará	979	98	1,561	-170	265	-1	913	-92
Rio Grande do Norte	436	234	512	-58	167	-18	288	-113
Paraíba	375	169	526	18	139	15	272	80
Pernam-buco	1,787	213	1,564	66	394	43	755	-8
Alagoas	684	-34	536	-1	109	-9	323	26
Sergipe	61	-4	483	1	81	9	159	18
Bahia	1,176	-292	1,871	208	417	33	648	220

Continues

Table 1 (continued)

Unit	Inp_SUS	Inp_NSUS	Nur_SUS	Nur_NSUS	Physio_SUS	Physio_NSUS	Doc_SUS	Doc_NSUS
Minas Gerais	1,909	-319	2,336	410	518	38	1,779	403
Espírito Santo	64	-132	722	-6	128	31	414	137
Rio de Janeiro	1,438	2,804	2,568	1,335	434	-72	1,029	-189
São Paulo	2,971	336	6,350	1,007	1,841	87	2,745	2,278
Paraná	783	-406	1,563	50	237	84	1,219	402
Santa Catarina	149	-71	972	71	203	62	875	377
Rio Grande do Sul	256	-300	1,366	299	248	69	1,061	362
Mato Grosso do Sul	239	-61	512	20	37	23	357	18
Mato Grosso	238	-208	762	26	189	19	395	47
Goiás	894	-91	807	43	178	55	786	208
Distrito Federal	568	456	909	-244	187	174	999	-136

Inpatient beds (infrastructure)

The first graph in Figure 1 shows a strong positive variation in the second quarter of 2020 (greater relative supply made by the public sector when compared to the private sector) in the Midwest, Northeast, and North macro-regions, above the national variation, while the Southeast macro-region remained within the national variation and the South macro-region remained below, indicating a greater influence of the private sector in response to the pandemic. Subsequently, in the third and fourth quarters, the variations in almost all Brazilian macro-regions presented less influence from the public sector, except for the South, where the government showed a more significant response in the fourth quarter.
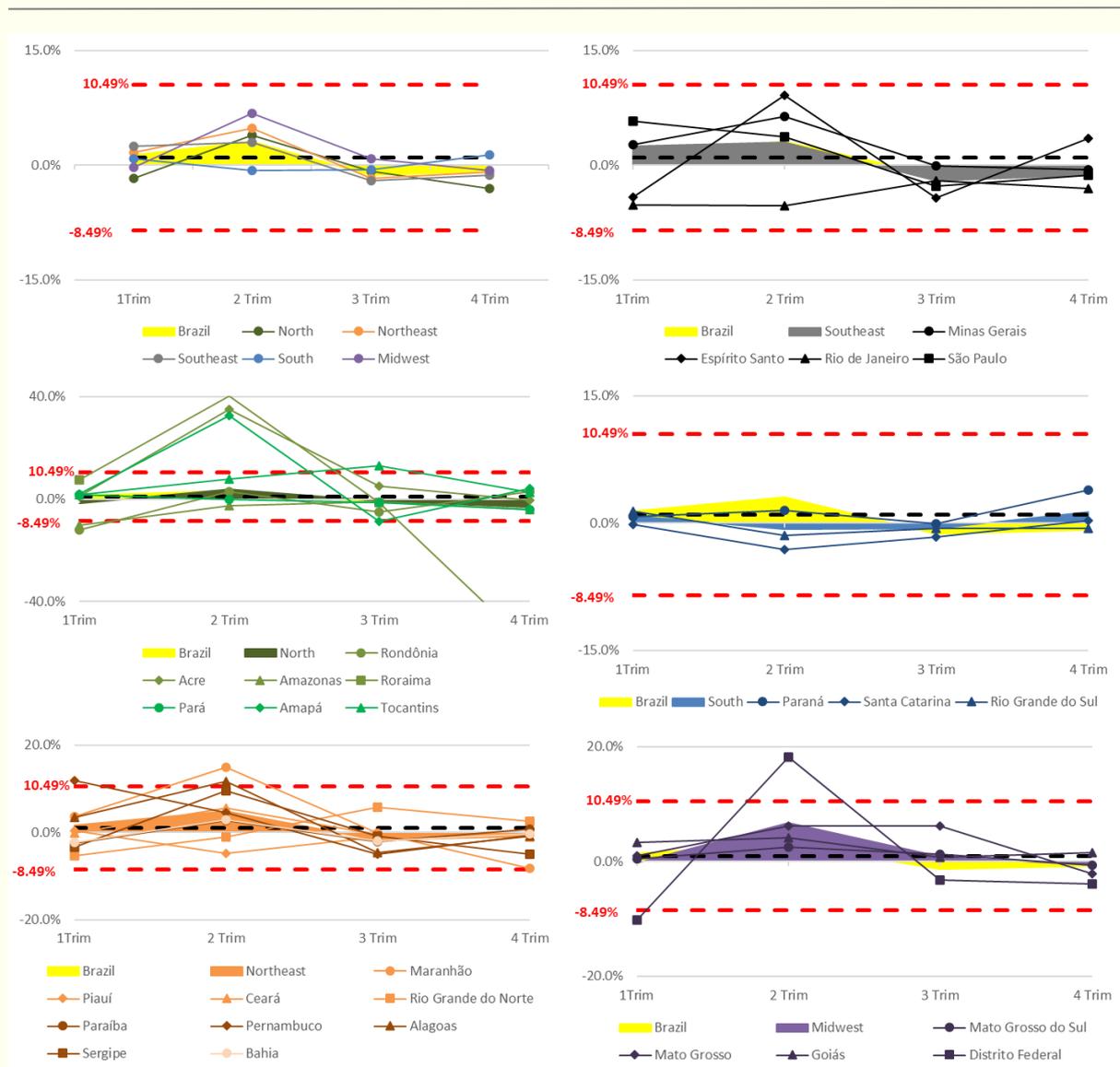
Figure 1. Quarterly variation in the number of inpatient beds — public sector vs. private sector.
Points greater than zero mean that the supply of inpatient beds in the public sector has increased more than in the private sector. Points less than zero mean the inverse relationship.

The increase in the public sector's response in the North macro-region was visible in the second quarter in the states of Roraima, Acre, and Amapá, above the average year variation. Tocantins showed an increase in the variation of public inpatient beds, while the other states significantly decreased to the point that Roraima escaped the variation pattern. In the Northeast macro-region, the state of Pernambuco stood out in its response in the first quarter, above the average national variation of SUS inpatient beds. Then, in the second quarter, the state governments in Maranhão, Alagoas, and Sergipe strongly responded to the pandemic, while the state of Piauí presented a decrease in the number of beds.

Then, there is a smaller variation in the states in the Southeast macro-region. The state of Rio de Janeiro had a greater variation in the private sector throughout the year, contrary to the patterns of most states. In the other states: (a) Minas Gerais had a variation of beds in the public sector in

the second quarter, with a decrease in the others; (b) São Paulo had a variation of beds in the public sector in the first quarter, below 0% in the others; and (c) Espírito Santo had high variations in the public sector in the second and fourth quarters. The South macro-region, as already highlighted, had a pattern of variation contrary to the other macro-regions. The states follow this logic with slight variation and response from the public administration, except for the state of Paraná, which exceeded the national average in the fourth quarter.

Finally, the Midwest macro-region presented two results that deviate from the pattern already described. The state of Mato Grosso had variations above the Brazilian average of the public sector in the second and third quarters, and the government of the Federal District had a low performance in the first quarter (below the standard deviation of the Brazilian states), but above the national standard deviation, reaching close to the 20% level.

Human resources

Human resources analysis is divided into three indicators: the number of nurses, physiotherapists, and doctors. Figure 2 illustrates a movement of public sector response in the second quarter, mainly in the Midwest and Northeast macro-regions, the latter being the most significant variation in the first quarter. In the third and fourth quarters, there is a trend of deceleration in the response of the Brazilian public administration. The high variation between quarters can again be observed, with a greater focus on the North macro-region. Roraima had the highest variation in the public sector since the first quarter, decelerating only in the fourth. The state of Amapá had a high variation in the second quarter (almost 60%) and subsequent deceleration. Acre had a constant increase in the variation regarding the number of health professionals in the public sector in the second and third quarters, whereas Tocantins and Rondônia presented a more significant variation in the private sector in the third quarter.

For the most part, the states of the Northeast macro-region presented behavior within the pattern already observed, with a small increase in the variation in the public sector until the second quarter, with a subsequent decrease. Two states deviate from this pattern, Rio Grande do Norte, where the variation in the public sector increases until the third quarter, and Maranhão, where a substantial deceleration in the public administration's response was observed in the third quarter (almost 60% higher than the variation in the private sector). As for the Southeast, two aspects are worth highlighting. The first is the low response capacity of Rio de Janeiro, with a high value in the first quarter of variation for the private sector (close to 20%). The second is the response of the state of Espírito Santo, above the Brazilian average, in the second and fourth quarters, with high variation in the public sector.
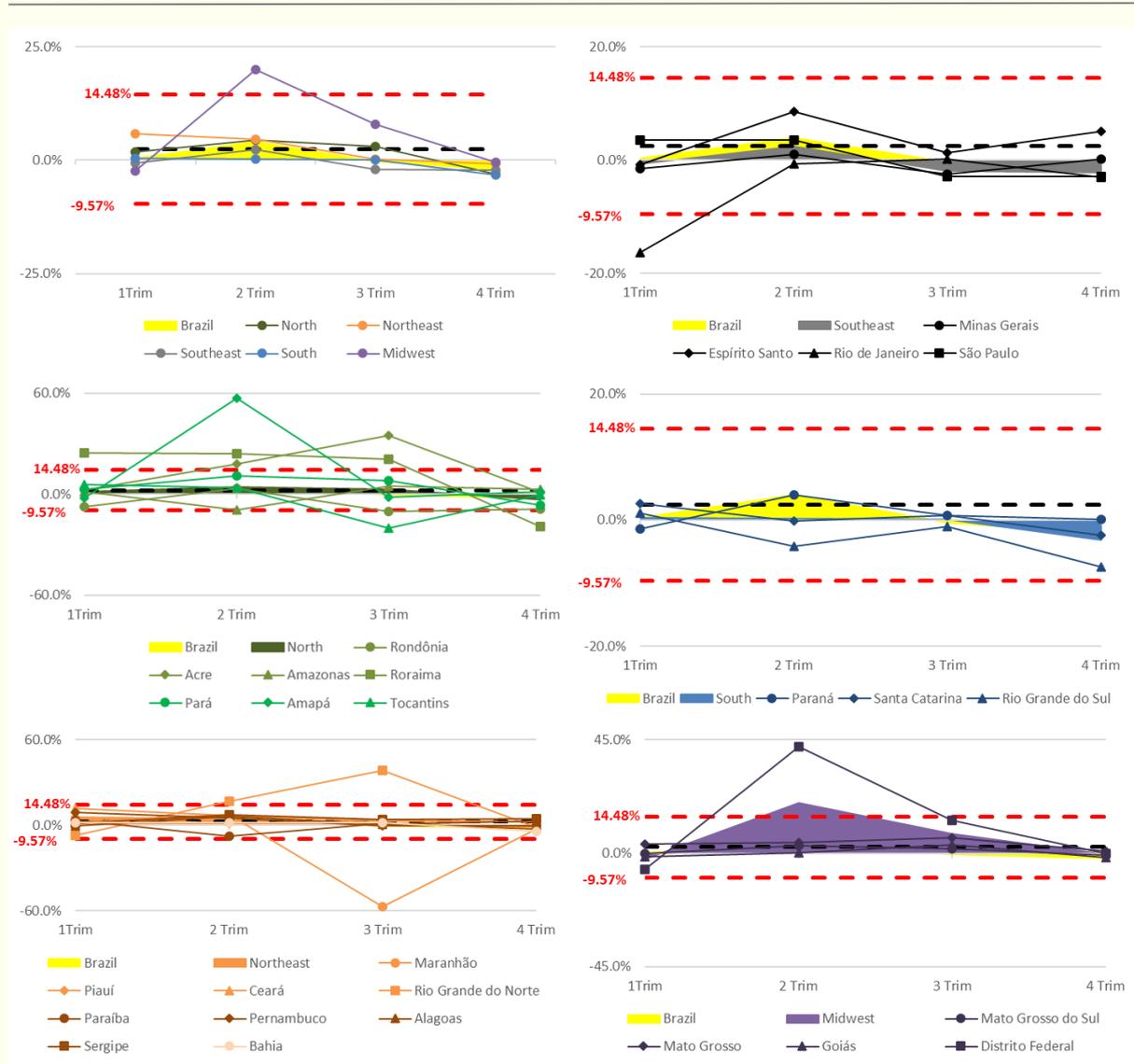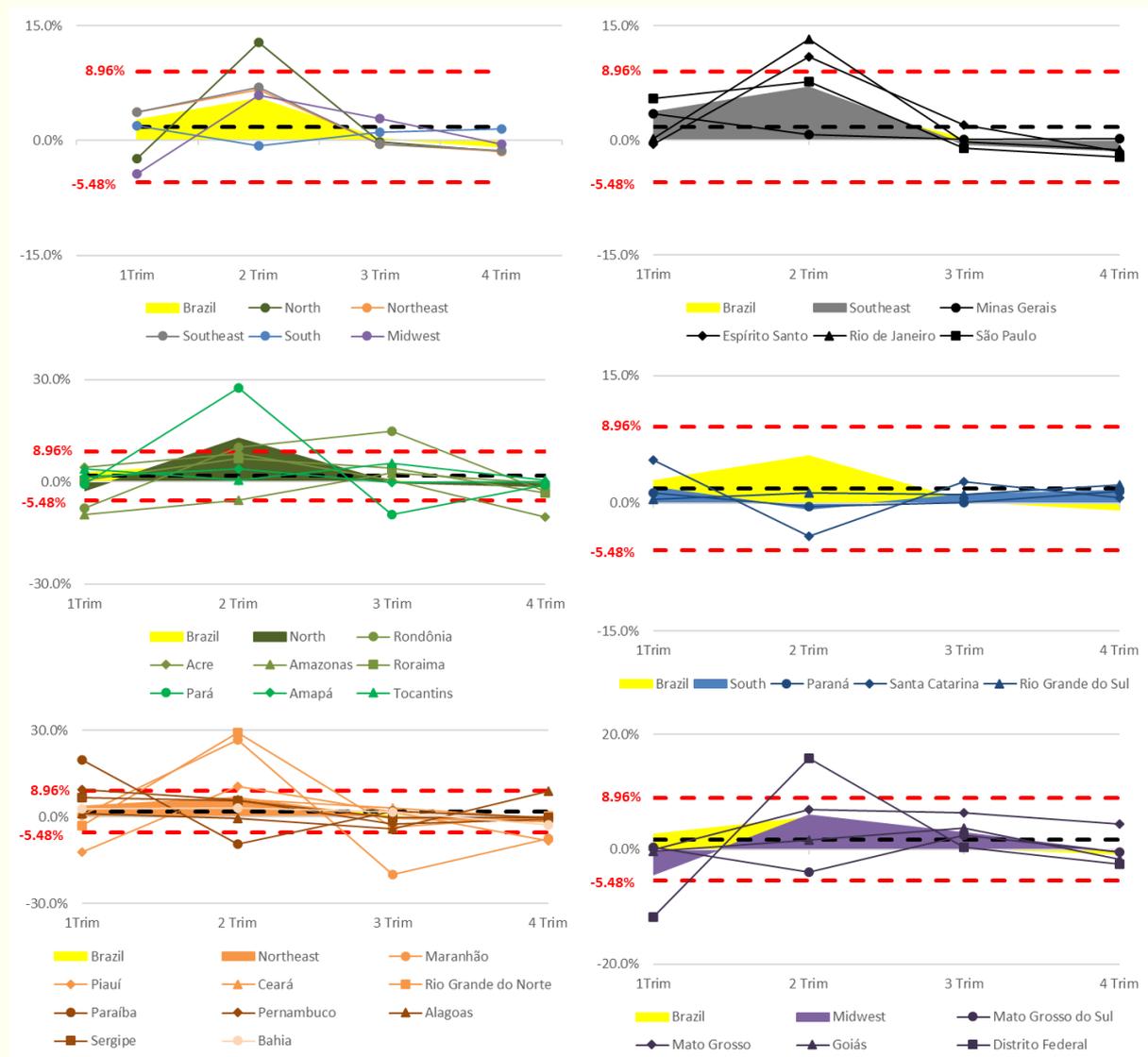
Figure 2. Quarterly variation in the number of nurses — public sector vs. private sector.

Points greater than zero mean that the supply of nurses in the public sector has increased more than in the private sector.
Points less than zero mean the inverse relationship.

There were few variations in the South macro-region, also following the trend already seen with inpatient beds. The only point of attention is the state of Rio Grande do Sul, with greater variations for the private sector in the second and fourth quarters. Finally, the Midwest macro-region, fostered mainly by the Federal District, shows a strong response from the public sector in the second quarter.

Regarding the number of physiotherapists (Figure 3), the previous trends remain — high response from the public sector in the second quarter. However, in this case, almost all macro-regions presented this movement, except for the South. Within the North, the state of Pará had high responses from the public sector in the second quarter, a variation of almost 30% more than that of the private sector, but with a trend of reversal in the third quarter, above the standard deviation for the private sector.

It is also worth mentioning the states of Amazonas and Rondônia, which had greater variations for the private sector in the first quarter. In the Northeast macro-region, Paraíba had a high variation in the response of the public administration in the first quarter and presented a movement inverse to that of the other states in the second quarter. Maranhão and Rio Grande do Norte had significant responses from the public sector in the second quarter regarding the number of physiotherapists, but in the case of Maranhão, there was a strong deceleration for the private sector in the third quarter.

Figure 3. Quarterly variation in the number of physiotherapists — public sector vs. private sector.
Points greater than zero mean that the supply of physiotherapists in the public sector has increased more than in the private sector. Points less than zero mean the inverse relationship.

In the Southeast macro-region, all states followed the movement of strong response from the public sector in the second quarter and stagnation (close to 0%) in the third and fourth quarters, except the state of Minas Gerais. It is also important to highlight the constant high variation of

the public sector in the state of São Paulo in the first two quarters. Following the indicators of the number of inpatient beds and nurses offered by private and public sectors of the three states in the South, only the state of Santa Catarina showed significant variations.

The state of Santa Catarina presented a high variation in the number of physiotherapists in the public sector for the first quarter, which was reverted in the second quarter. Intense variations in the Federal District influence the numbers in the Midwest. The first quarter showed an increase in professionals in the private sector, and the second indicated an increase in the public sector. The state of Mato Grosso also showed a constant variation in the second and third quarters.

The last indicator regarding human resources was the number of doctors (Figure 4). It followed the previous patterns shown in the macro-regions, with strong variation for the public sector in the second quarter and then deceleration and stabilization, except the Southeast, which had a high value in the first quarter, then continued to decelerate, and the South with slight variation and little response. Within the North macro-region, the states of Amapá and Pará led the response in favor of the public sector in the second quarter, while Roraima went in the opposite direction, recovering again in the fourth quarter.

The state of Acre had a different behavior, in which the variation of the private sector reached its peak in the third quarter. In the Northeast macro-region, the states remain without significant variations for both sides, with emphasis only on Piauí, which responded more strongly in the first quarter, and Rio Grande do Norte, which presented significant variation for the public sector in the second quarter.
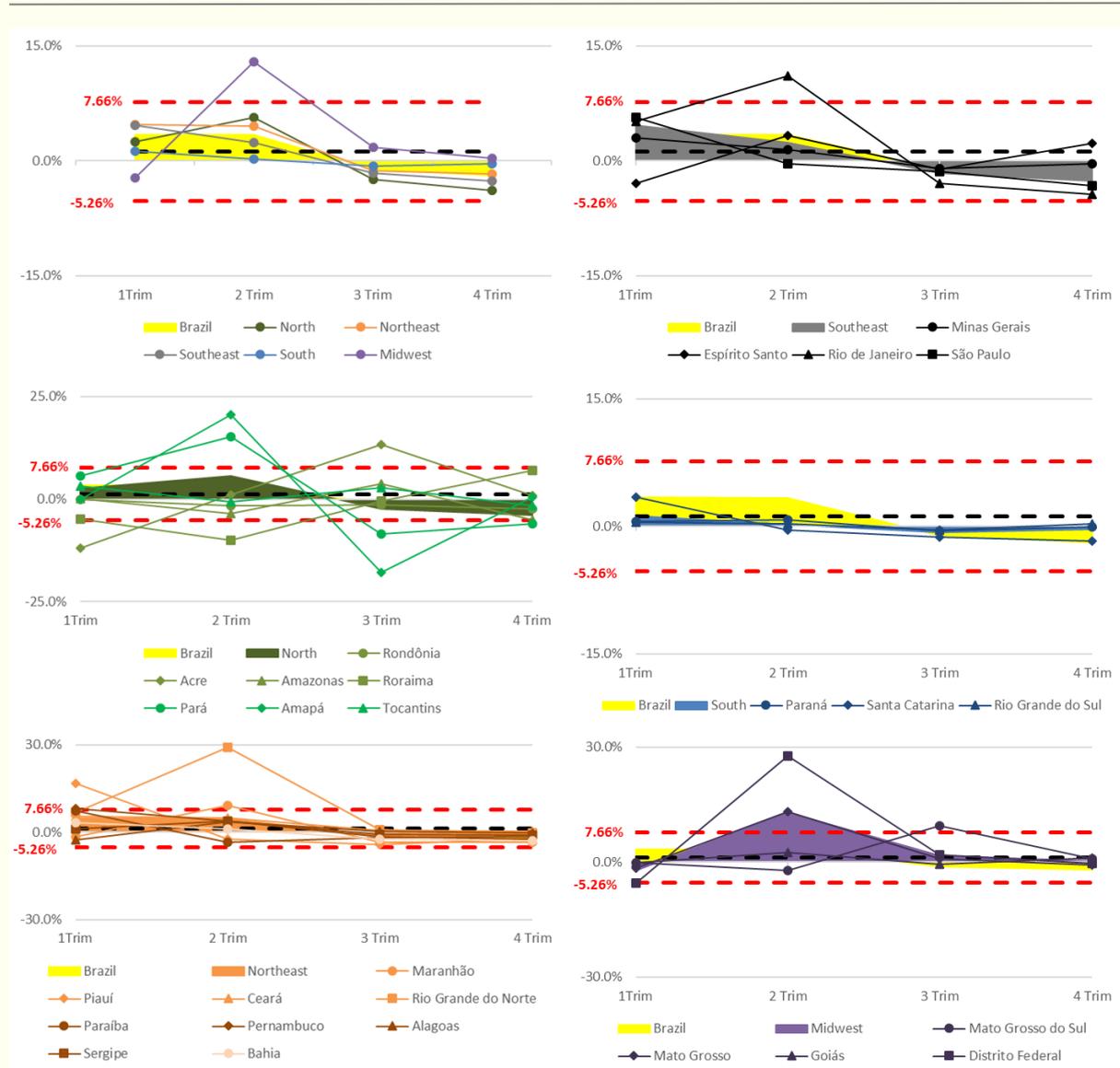
Figure 4. Quarterly variation in the number of doctors — public sector vs. private sector.

Points greater than zero mean that the supply of doctors in the public sector has increased more than in the private sector. Points less than zero mean the inverse relationship.

The results in the first and second quarters in the Southeast macro-region are worth highlighting. In the first quarter, Rio de Janeiro and São Paulo had high variations in the number of doctors in the public sector, while Espírito Santo showed the opposite. In the second quarter, all states moved toward the average, while Rio de Janeiro increased its public sector response to a variation above the upper standard deviation.

The South macro-region and its states presented slight variation in all quarters. Finally, in the Midwest, the Federal District maintained the pattern shown above, with a variation close to the lower standard deviation in the first quarter and a large variation (close to the upper 30%) in the public sector response in the second quarter, with subsequent stabilization. Mato Grosso also had an increase in the variation of the public sector in the second quarter and Mato Grosso do Sul in the third.

Two-dimensional relationship of indicators

This last stage demonstrates two-dimensional analyses of the variations throughout the year of the four indicators used in the research (Figure 5). The first point of great importance is that in all indicators at the national level, the variation was consistently higher for the public sector (4.1% higher for inpatient beds, 3.68% for the number of nurses, 5.78% for physiotherapists, and 1.49% for doctors).

In the two-dimensional relationships, the number of states with higher variations for SUS is Inp-Nur — 14; Inp-Physio — 14; Inp-Doc — 14; Nur-Physio — 12; Nur-Doc — 13; Physio-Doc — 12. In other words, in two-dimensional comparisons, the number of states with the highest public sector response is close to the average of the total existing number (26 + Federal District). It is also worth mentioning the non-egalitarian variation between the indicators to increase or decrease the number of inpatient beds (infrastructure) in a way that is not correlated with the increase or decrease in the number of nurses, physiotherapists, and doctors (human resources).

Figure 5. Two-dimensional relationship of variations throughout the year.

Finally, the states of the North macro-region have the most significant variations in all two-dimensional analyses, followed by the states of the Northeast macro-region. The states that stood out in these two regions were Roraima, Amapá, Tocantins, Maranhão, Piauí, and Rio Grande do Norte. The analyses revealed that the greatest variations occurred mainly in two indicators, the number of inpatient beds and the number of nurses.

DISCUSSION

The importance of knowing the state's capacity to respond to the pandemic through its health system (SUS) is discussed in terms of increasing human resources and infrastructure (Gomide et al., 2021; Grin, 2021). The increase in the number of hospital admissions (inpatient beds and intensive care units) in Brazil (Johns Hopkins University, 2021) makes it even more necessary to understand the state's capacity to react to such a health crisis.

The lack of action by the federal government in the fight against the virus (Castro et al., 2021; Knaul et al., 2022; Lotta et al., 2020; Paschoalotto et al., 2021) raised the responsibility of the states in conducting the necessary measures to address the challenges posed. Thus, the first point of discussion is the public sector's significant response regarding the healthcare infrastructure and human resources in most Brazilian states in the second quarter of 2020, when faced with the increase in COVID-19 cases and deaths (Rocha et al., 2021). However, despite the demonstration of state capacity at that moment (Cunha et al., 2017; Gofen & Lotta, 2021; Segatto et al., 2021), this dynamic of response may suggest short-term planning or lack of long-term vision to address the pandemic. Some states could have observed and learned what happened in other states first, better preparing their reaction.

The second point discusses the exponential growth of hospital resources and personnel in the second quarter, with a deceleration in the variation of public sector services in most states, starting to equal the variations with the private sector, or being even lower in that particular quarter (Bigoni et al., 2022; Castro et al., 2021). Therefore, greater precaution and long-term thinking may have been lacking for the second wave of the pandemic that emerged in the fourth quarter, for example. There is also a discussion between the supply and demand of these services and a lack of resources for full-time hospital services in large quantities and a given period (Bigoni et al., 2022; Fernandes & Pereira, 2020; Funcia et al., 2022). Therefore, the thought of efficiency in public and private spending is supported so that there is an intelligent use of resources (Daumas et al., 2020; Segatto et al., 2021). The deceleration does not mean a decrease in installed capacity, but rather that, at a certain point in time, the availability of the infrastructure has stabilized. This stabilization can signal the depletion of the response capacity or just an adaptation to the new scenario (Massuda et al., 2022).

The third point is that the North macro-region, together with the states of Maranhão, Rio Grande do Norte, and the Federal District, had the greatest variations in terms of growth in the public sector response in the second quarter, and deceleration later in the provision of services. This finding is in line with the literature, especially on the minor issue of response capacity in the

North region and some states in the Northeast (Andrade et al., 2020; Castro et al., 2019; Lima et al., 2021; Massuda et al., 2018; Moreira, 2020; Noronha et al., 2020).

The fourth point argues that despite the numerous problems observed in managing the health crisis, there is no way to blame the Brazilian public system in a singular way (Daumas et al., 2020). The variations throughout the year demonstrated that the public sector was the leading player responding to the pandemic, increasing its capacity in the first wave, in the second quarter, all over the country. Therefore, without SUS, the pandemic data in Brazil could be even more catastrophic (Castro et al., 2021).

It is worth noting that the difference between Brazilian regions in terms of geographic, political, and socioeconomic issues may also have impacted the performance of SUS in the fight against COVID-19 (Castro et al., 2019; Massuda et al., 2018; Paschoalotto et al., 2018; Rocha et al., 2021). In this sense, the results found of the strong performance of the private sector in the Southeast region, and its states, were already expected due to their socioeconomic characteristics and care network structure, with solid hospital intervention and outsourcing of services to the private health sector (Paschoalotto et al., 2018; Rocha et al., 2021).

The lack of coordination by the federal government in managing the fight against the pandemic (Abrucio et al., 2020; Lotta et al., 2020) was reflected in the different responses by states and the public and private sectors. This scenario may have been a negative factor when looking at the dimension of the second wave the country went through in the following year (Knaul et al., 2021). The reactive and short-term view of the decrease in the response in the third and fourth quarters may have worsened the subsequent scenario found in 2021, already observed in the last two months of 2020, with the increase of COVID-19 cases and deaths. This fifth point is also related to the second item discussed — some states may have failed to have a preventive attitude in providing human and hospital resources, even with the experience of the second wave in other countries. Although limited, resources could be managed more efficiently (Daumas et al., 2020; Fernandes & Pereira, 2020).

FINAL CONSIDERATIONS

This article analyzed the variations of the health care infrastructure and human resources in Brazilian states and macro-regions over 2020, observing the participation of the public and private sectors. It was observed that the Unified Health System (SUS) was the main actor in responding to the COVID-19 pandemic in Brazil, as opposed to the private sector (Croda et al., 2020; Gofen & Lotta, 2021; Lotta et al., 2020). In addition, the private sector showed a lower response capacity in providing health actions and services at the time of the pandemic, especially in an immediate and agile way.

The first specific objective of this research was achieved. It was possible to visualize the moments of variations in the relationship between the public and private sectors regarding infrastructure and human resources in the pandemic. Thus, the reaction to the first and beginning of the second wave of the pandemic was clearly perceived in the 2020 first and second quarters and at the end

of the fourth quarter. The analysis suggests that short-term thinking, the lack of coordination between entities, and non-learning with other correlated experiences were negative aspects of the system's operation. It is reinforced that the moment of greatest need fell to the state action through SUS and the state governments (albeit with criticism) to employ the greatest effort to treat sick people, with minimal infrastructure. Therefore, the second specific objective was also achieved.

The theoretical contributions of this work, in addition to those raised in the introduction, are (a) the advance in discussions of subnational governments' performance in public administration, intersecting with theories of state capacity and response to the pandemic — theories of public administration and public health, (b) broadening the view of state capacity and subnational performance from aspects of inequality in the response, and (c) the application of theories in a complex and emergency public health context. The practical contribution is in providing scientific information through simple mathematical equations to understand the patterns of responses and dynamic visualizations in the four quarters of 2020 and highlighting the role of SUS in structural issues and the performance in the fight against the COVID-19 pandemic. The limitations of the article are (a) the lack of data on ventilators in the Brazilian private health system, another important indicator of the infrastructure of the response to the COVID-19 pandemic, (b) the lack of depth with multivariate statistics to understand the difference in performance between the public and private sectors, and (c) the descriptive aspects of the article that contribute to the explanation of the response, but that little explain the reason for this behavior. Finally, for future work, it is proposed to extend the analyses to 2021 and qualitative work to understand the public-private relationship during the pandemic.

REFERENCES

Abrucio, F. L., Grin, E. J., Franzese, C., Segatto, C. I., & Couto, C. G. (2020). Combate à COVID-19 sob o federalismo bolsonarista: Um caso de descoordenação intergovernamental. *Revista de Administração Pública*, 54(4), 663-677. http://dx.doi.org/10.1590/0034-761220200354

Andrade, C. L. T., Pereira, C. C. de A., Martins, M., Lima, S. M. L., & Portela, M. C. (2020). COVID-19 hospitalizations in Brazil's Unified Health System (SUS). *PLoS ONE*, *15*(12 December), 1–17. https://doi.org/10.1371/journal.pone.0243126

Aquino, E. M. L., Silveira, I. H., Pescarini, J. M., Aquino, R., & Souza-Filho, J. A. de (2020). Social distancing measures to control the COVID-19 pandemic: Potential impacts and challenges in Brazil. *Ciencia e Saude Coletiva*, *25*(Suplpl. 1), 2423–2446. https://doi.org/10.1590/1413-81232020256.1.10502020

Baqui, P.; Bica, I.; Marra, V.; Ercole, A., & Schaar, M. van der. (2020). Ethnic and regional variations in hospital mortality from COVID-19 in Brazil: A cross-sectional observational study. *The Lancet Global Health*, 8(8), E1018-E1026. https://doi.org/10.1016/S2214-109X(20)30285-0

Bello-Gomez, R. A. (2020). Interacting capacities: The indirect national contribution to subnational service provision. *Public Administration Review*, 80(6), 1011-1023. https://doi.org/10.1111/puar.13192

Bezerra, C. B., Saintrain, M. V. de L., Braga, D. R. A., Santos, F. da S., Lima, A. O. P., Brito, E. H. S. de, & Pontes, C. de B. (2020). Impacto psicossocial do isolamento durante pandemia de COVID-19 na população brasileira: Análise transversal preliminar. *Saúde e Sociedade*, *29*(4), 1–10. https://doi.org/10.1590/s0104-12902020200412

Bigoni, A., Malik, A. M., Tasca, R., Carrera, M. B. M., Schiesari, L. M. C., Garbamdella, D. D. & Massuda, A. (2022). Brazil's health system functionality amidst of the COVID-19 pandemic: An analysis of resilience. *The*

Lancet – Regional Health Americas, *10*, 100222. https://doi.org/10.1016/j.lana.2022.100222

Brasil. (2021a). Departamento de Informática do SUS (DATASUS). Rede Assistencial. Retrieved 5th February, 2021, from http://www2.datasus.gov.br/DATASUS/index.php?area=0204

Brasil. (2021b). Painel Coronavírus Brasil (COVID-19). Casos e óbitos por COVID-19. Retrieved 5th February, 2021, from https://covid.saude.gov.br/

Castro, M. C., Sun, K., Barberia, L., Ribeiro, A. F., Gurzenda, S., Ribeiro, K. G., Abbott, E., Blossom, J., Rache, J., Singer, A. B. (2021). Spatiotemporal pattern of COVID-19 spread in Brazil. *Science*, *372*(6544). https://doi.org/10.1126/science.abh1558

Castro, M. C., Massuda, A., Almeida, G.,Menezes-Filho, M. A., Andrade, M. V., Noronha, K. V. M. de S., Rocha, R., Macinko, J., Hone, T., Tasca, R., Giovanella, L., Malik, A. M., Werneck, H., Fachini, L. A. & Atun, R. (2019). Brazil's unified health system: the first 30 years and prospects for the future. *The Lancet*, *394*(10195), 345-356. https://doi.org/10.1016/S0140-6736(19)31243-7

Caetano, R., Silva, A. B., Guedes, A. C. C. M., Paiva, C. C. N. de, da Rocha Ribeiro, G., Santos, D. L., & da Silva, R. M. (2020). Challenges and opportunities for telehealth during the COVID-19 pandemic: Ideas on spaces and initiatives in the Brazilian context. *Cadernos de Saude Publica*, *36*(5), 1–16. https://doi.org/10.1590/0102-311X00088920

Costa, A. M., Rizzotto, M. L. F., & Lobato, L. de V. C. (2020). In the COVID-19 pandemic, Brazil sees the SUS. *Saúde em Debate*, *44*(125), 289–296. https://doi.org/10.1590/0103-1104202012500i

Croda, J., Oliveira, W. K. de, Frutuoso, R. L., Mandetta, L. H., Baia-Da-silva, D. C., Brito-Sousa, J. D., Monteiro, W. M., & Lacerda, M. V. G. (2020). COVID-19 in Brazil: Advantages of a socialized unified health system and preparation to contain cases. *Revista da Sociedade Brasileira de Medicina Tropical*, *53*(April), 2–7. https://doi.org/10.1590/0037-8682-0167-2020

Cunha, B. Q., Pereira, A. K., & Gomide, A. de Á. (2017). State capacity and utilities regulation in Brazil: Exploring bureaucracy. *Utilities Policy*, *49*, 116–126. https://doi.org/10.1016/j.jup.2017.06.004

Daumas, R. P., Azevedo e Silva, G., Tasca, R., da Costa Leite, I., Brasil, P., Greco, D. B., Grabois, V. & Campos, G. W. de S. (2020). The role of primary care in the Brazilian healthcare system: Limits and possibilities for fighting COVID-19. *Cadernos de Saude Publica*, *36*(6). https://doi.org/10.1590/0102-311X00104120

De La Cruz, E. E .R., Grin, E. J., Sanabria-Pulido, P., Cravacuore, D. & Orellana, A. (2020). The transaction costs of government responses to the COVID-19 emergency in Latin America. *Public Administration Review*, *80*(4), 683-695. https://doi.org/10.1111/puar.13259

Fernandes, G. A. de A. L., & Pereira, B. L. S. (2020). The challenges of funding the Brazilian health system in fighting the COVID-19 pandemic in the context of the federative pact. *Revista de Administracao Publica*, *54*(4), 595–613. https://doi.org/10.1590/0034-761220200290x

Funcia, F., Bresciani, L. P., Benevides, R. & Ocké-Reis, C. O. (2022). Análise do financiamento federal do Sistema Único de Saúde para o enfrentamento da COVID-19. *Saúde em Debate*, *46*(133). https://doi.org/10.1590/0103-1104202213301

Gofen, A., & Lotta, G. (2021). Street-Level bureaucrats at the forefront of pandemic response: A comparative perspective. *Journal of Comparative Policy Analysis: Research and Practice*, *23*(1), 3–15. https://doi.org/10.1080/13876988.2020.1861421

Gomide, A. de Ávila, Machado, R. A., & Albuquerque, P. M. (2021). Capacidade estatal e desempenho na percepção dos burocratas brasileiros: Desenvolvimento e validação de um modelo de equações estruturais. *Cadernos EBAPE.BR*, *19*(n. especial). https://doi.org/10.1590/1679-395120200159

Grin, E. (2021). O verso e o reverso da cooperação federativa e da difusão vertical de políticas para promover capacidade estatal nos municípios brasileiros. *Administração Pública e Gestão Social*, *13*(2). https://doi.org/10.21118/apgs.v13i2.9686

Haque, M.S., Ramesh, M., Puppim de Oliveira, J.A. & Gomide, A. A. (2021). Building administrative capacity for development: limits and prospects. *International Review of Administrative Sciences*, *87*(2), 211-219. https://doi.org/10.1177%2F00208523211002605

Johns Hopkins University. (2021). Coronavirus COVID-19 Global Cases by the Center for Systems Science and Engineering (CSEE) at Johns Hopkins University. https://coronavirus.jhu.edu/map.html

Knaul, F. M., Touchton, M., Arreolas-Ornelas, H., Atun, R., Anyosa, R. J. C. C., Frenk, J., Martínez-Valle, A., McDonald, T., Porteny, T., Sánches-Talanquer, M. & Victoria, C. (2021). Punt politics as failure of health system stewardship: Evidence from the COVID-19 pandemic response in Brazil and Mexico. *The Lancet – Regional Health Americas*, 4, 100086. https://doi.org/10.1016/j.lana.2021.100086

Lima, E. E. C. de, Gayawan, E., Baptista, E. A., & Queiroz, B. L. (2021). Spatial pattern of COVID-19 deaths and infections in small areas of Brazil. *Plos One*, *16*(2), e0246808. https://doi.org/10.1371/journal.pone.0246808

Liu, Z., Guo, J., Zhong, W. & Gui, T. (2021). Multi-Level governance, policy coordination and subnational responses to COVID-19: Comparing China and the US. *Journal of Comparative Policy Analysis: Research and Practice*, *23*(2), 204-218. https://doi.org/10.1080/13876988.2021.1873703

Lotta, G., Wenham, C., Nunes, J., & Pimenta, D. N. (2020). Community health workers reveal COVID-19 disaster in Brazil. *The Lancet*, *396*(10248), 365–366. https://doi.org/10.1016/S0140-6736(20)31521-X

Marson, F. A. L., & Ortega, M. M. (2020). COVID-19 in Brazil. *Pulmonology*, *26*(4), 241–244. https://doi.org/10.1016/j.pulmoe.2020.04.008

Massuda, A., Bigoni, A., Paschoalotto, M. A. C. & Tasca, R. (2022). Rumos para um sistema de saúde resiliente. *GV Executivo*, *21*(2), 1-8. https://doi.org/10.12660/gvexec.v21n2.2022.85938

Massuda, A., Hone, T., Leles, F. A. G., Castro, M. C. de & Atun, R. (2018). The Brazilian health system at crossroads: progress, crisis and resilience. *BMJ Global Health*, *3*(4), e000829. http://dx.doi.org/10.1136/bmjgh-2018-000829

Mao, Y. (2021). Political institutions, state capacity, and crisis management: A comparison of China and South Korea. *International Political Science Review*, *42*(3): 316-332. https://doi.org/10.1177%2F0192512121994026

Moreira, R. da S. (2020). COVID-19: Intensive care units, mechanical ventilators, and latent mortality profiles associated with case-fatality in Brazil. *Cadernos de Saúde Publica*, *36*(5), 1–12. https://doi.org/10.1590/0102-311X00080020

Noronha, K. V. M. de S., Guedes, G. R., Turra, C. M., Andrade, M. V., Botega, L., Nogueira, D., Calazans, J. A. Carvalho, L., Servo, L., & Ferreira, M. F. (2020). The COVID-19 pandemic in Brazil: analysis of supply and demand of hospital and ICU beds and mechanical ventilators under different scenarios. *Cadernos de Saúde Pública*, *36*(2), e00115320. https://doi.org/10.1590/0102-311X00115320

Olvera, J. G. & Avellaneda, C. N. (2019). Subnational Government Performance: Testing Multiple Dimensions of Governors' Experience. *Public Administration Review*, *79*(3), 383-398. https://doi.org/10.1111/puar.13035

Paschoalotto, M. A. C., Costa, E. P. P. A., Almeida, S. V. de, Cima, J., Costa, J. G. da, Santos, J. V., Barros, P. P., Passador, C. S., & Passador, J. L. (2021). Running away from the jab: Factors associated with COVID-19 vaccine hesitancy in Brazil. *Revista de Saúde Pública*, *55*, 97. https://doi.org/10.11606/s1518-8787.2021055003903

Paschoalotto, M. A. C., Passador, J. L., de Oliveira, L. R., Lopes, J. E. F., Dantas, M. K., & Passador, C. S. (2018). The regionalization of the Brazilian national health system: Proposition for performance evaluation of the regional health departments of São Paulo state, Brazil. *Saúde e Sociedade*, *27*(1), 80–93. https://doi.org/10.1590/s0104-12902018170095

Paschoalotto, M. A. C., Passador J. L., Passador, C. S. & Oliveira, P. H. (2020). Local government performance: Evaluating efficiency, efficacy, and effectiveness at the basic education level. *Brazilian Administration Review*, *17*(4), e190149. https://doi.org/10.1590/1807-7692bar2020190149

Pedrosa, N. L., & de Albuquerque, N. L. S. (2020). Spatial analysis of COVID-19 cases and intensive care beds in the state of Ceará, Brazil. *Ciencia e Saude Coletiva*, *25*, 2461–2468. https://doi.org/10.1590/1413-81232020256.1.10952020

Rocha, R., Atun, R., Massuda, A., Rache, B, Spinola, P., Nunes, L., Lago, M. & Castro, M. C. (2021). Effect of socioeconomic inequalities and vulnerabilities on health-system preparedness and response to COVID-19 in Brazil: a comprehensive analysis. *The Lancet Global Health*, *9*(6), E782-E792. https://doi.org/10.1016/S2214-109X(21)00081-4

Segatto, C. I., Maciel, F. & Abrucio, F. (2021). Capacidades estatais e seus efeitos nas Políticas Municipais de Educação. *Cadernos Gestão Pública e Cidadania*, *26*(84), e-81938. http://dx.doi.org/10.12660/cgpc.v26n84.81938

Sevindik, I., Tosun, M. S. & Yilmaz, S. (2021). Local Response to the COVID-19 Pandemic: The case of Indonesia. *Sustainability*, *13*(10), 5620. https://doi.org/10.3390/su13105620

Talabis, D. A. S., Babierra, A. L., Buhat, C. A. H., Lutero, D. S., Quindala III, K. M. & Rabajante, J. F. (2021). Local government responses for COVID-19 management in the Philippines. *BMC Public Health*, 21(1711). https://doi.org/10.1186/s12889-021-11746-0

World Health Organization (2020). Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. World Health Organization. 2020. Retrieved 15th March 2021 from https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-COVID-19---11-march-2020

Yen, W. T., Liu, L. Y., Won. E. & Testriono. (2022). The imperative of state capacity in public health crisis: Asia's early COVID-19 policy responses. *Governance*, *35*(3): 777-798. https://doi.org/10.1111/gove.12695

Authors' contributions CRT

1st author: conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), software (equal), supervision (equal), validation (equal), visualization (equal), writing – original draft (equal), writing – review & editing (equal).

2nd author: conceptualization (equal), formal analysis (equal), investigation (equal), methodology (equal), validation (equal), visualization (equal), writing – original draft (equal), writing – review & editing (equal).

3rd author: conceptualization (equal), investigation (equal), supervision (equal), validation (equal), visualization (equal), writing – original draft (equal), writing – review & editing (equal).

4th author: conceptualization (equal), methodology (equal), validation (equal), visualization (equal), writing – original draft (equal), writing – review & editing (equal).

Authors

Marco Antonio Catussi Paschoalotto *
Universidade Nova de Lisboa, Nova School of Business and Economics
Carreira das Sesmerias, 6, 2705-458, Sintra, Portugal
marcocatussi@gmail.com
https://orcid.org/0000-0003-2276-8531

José Eduardo Ferreira Lopes
Universidade Federal de Uberlândia
Av. João Naves de Ávila, n. 2121, Bloco 1F - Sala 216, Santa Mônica, 38408-100, Uberlândia, MG, Brazil
jeflopes@ufu.br
https://orcid.org/0000-0001-5504-3321

Pedro Henrique de Oliveira
Universidade de São Paulo, Escola de Engenharia de São Carlos
Av. Trab. São Carlense, n. 400, Parque Arnold Schimidt, 13566-590, São Carlos, SP, Brazil
oliveiraph1@gmail.com
https://orcid.org/0000-0002-1616-6465

Pedro Pita Barros
Universidade Nova de Lisboa, Nova School of Business and Economics
Rua da Holanda, n.1, 2775-405, Carcavelos, Portugal
ppbarros@novasbe.pt
https://orcid.org/0000-0002-0881-4928

* Corresponding author