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Resilience and health systems performance: admissions for ambulatory care-sensitive chronic conditions

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Abstract *Anchored in the concern to strengthen the resilience of the Unified Health System (SUS), this study aimed to develop a methodology for comparing Brazilian municipalities based on the standardized ratio of hospitalizations for chronic primary care-sensitive conditions (HPCSC). This cross-sectional study was based on data from the SUS hospital production. We adopted multilevel modeling for each Brazilian region. The ratio of observed to predicted hospitalizations, estimated by risk adjustment, was used to classify municipalities by level of occurrence of HPCSC (higher than expected, at the expected level, or lower than expected). The relationship between primary health care (PHC) coverage and HPCSC varied across Brazilian regions, with a lower percentage of municipalities with poorer performance in those with the highest availability of work hours of doctors and nurses. Due to its scope and role as a care coordinator in the healthcare network, PHC serves as the basis for building SUS resilience across various fields. Thus, the proposed methodology contributes to the continuous monitoring of PHC, an essential skill for resilience, enabling the timely guidance of actions and strategies in stress and crisis.*
Key words *Health system resilience, Ambulatory care sensitive conditions, Quality of health care*

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Introduction

The importance of promoting the resilience of health systems has increased its space on the health agenda and academic production during the COVID-19 pandemic. The performance of health systems, overwhelmed by demand and a lack of infrastructure and supplies, indicated that the success of strategies to combat the pandemic depended on preconditions and emergency measures, including those related to governance, financing, organization, workforce, and coordination among different care levels[1,2]. The concern with resilience emerged as a learning experience to develop strategies that ensure the continuous improvement of health systems' performance, particularly in extreme situations, mitigating threats to the ability to provide high-quality services and care equally according to health needs[3].

Diverse resilience conceptualizations originating from engineering, psychology, ecology, organizational theory, and community resilience shape its approach to health. Although applied to reducing the risk of epidemics or adverse events in care, it is still incipient[3-6]. Among the several definitions of health systems' resilience[7], we emphasize the capacity of institutions and stakeholders to prepare for, recover from, and absorb shocks, thereby preserving essential functions and responding to the continuous and acute care needs of their target populations[1]. Despite the assigned relevance, we highlight the challenges of operationalizing, measuring, and improving resilience, considering the complexity of health systems and their adaptive capacity[3-6,8,9].

Today, the discussion of health systems' comparative performance, guided by issues related to equity, universal access, sustainability, waste, and quality of services provided, prioritizes their resilience. This issue is included, for example, in the agenda of the European Observatory on Health Systems and Policies[7,10]. In this context, we can observe a reinterpretation of performance assessment guided by resilient performance, which combines the ability to absorb and adapt to disruptive circumstances with stability in responding to routine demands[6]. Resilient performance expands the traditional boundaries of conceptual health system performance frameworks. It presupposes continuous monitoring of the quality of actions and services provided, as well as efforts to learn, prepare, and be ready to act in destabilizing scenarios. However, it still requires information, measures, and standards[10,11] that identify areas for improvement through internal and external comparison, providing inputs and lessons learned between different systems and their performance in the face of ordinary and extraordinary demands.

The perennially underfunded Unified Health System (SUS) is continually tested, requiring compensatory strategies to guarantee the principles of equity and universality[12]. Primary health care (PHC), primarily through the Family Health Strategy (ESF), plays a pivotal role as the gateway to the SUS and as a care coordinator in the health service network, whether in routine or emergency contexts. It is an essential basis for building the resilience of the SUS in different local to national areas.

The responsibilities of PHC in health promotion, disease prevention, and care aim to address the diverse health needs of the population, depending on the degree of quality of access to and use of health services. Given this challenge, assessments of its performance and resilience are still rare, and the use of the indicator of hospitalizations due to primary care-sensitive conditions (HPCSC) is common, probably due to the greater availability of information on hospitalizations than on outpatient visits[13,14].

The indicator encompasses hospitalizations for conditions that could be prevented or mitigated with timely and effective primary care, thereby avoiding or reducing their exacerbation. In Brazil, the list of HPCSC diagnostic groups encompasses 20 diagnostic groups, including some chronic conditions such as asthma, hypertension, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and diabetes[15]. Recognizing the relevance of these chronic conditions for assessing the effectiveness of health systems and their management in primary care, the Organization for Economic Cooperation and Development (OECD) routinely monitors them in its member countries, as well as in Latin America and the Caribbean[16]. National studies indicate declining HPCSC rates in recent years[17-23], some of which suggest that this fall was associated with expanded PHC coverage[17-21]. However, there is no knowledge of using this indicator in the direct comparison of municipalities regarding acceptable or unacceptable HPCSC patterns.

Considering the necessary skills of anticipation, monitoring, response, and learning for health systems to be resilient[3,12,24,25], HPCSC lend themselves to monitoring the performance of PHC, and the study of their variation allows anticipating critical elements for their ability to respond to routine demands and adjust in stress and crises. The application of monitoring methodologies in municipal primary care to identify gaps, improve the quality of care, and learn *ante factum* is fundamental for resilient performance in the face of new realities projected for the coming decades in low- and middle-income countries within demographic and epidemiological changes, growing health inequalities, and successive health crises.

Using the ratio between the observed value and the expected value of a particular event to compare and classify entities at acceptable or unacceptable levels has been applied to monitor performance in studies of hospital mortality[26,27] or hospitalizations[28,29]. Similar to such applications, this study aimed to develop a method for comparing Brazilian municipalities, considering the ratio between the observed and expected occurrence of HPCSC, estimated from risk adjustment by hospitalization and municipality characteristics. The ultimate purpose is to identify critical elements for PHC resilience, allowing its continuous monitoring and, consequently, anticipating warning signs that enable actions to improve the quality of care provided and reduce variation in its performance.

Methods

Study design

This observational cross-sectional study was based on secondary data from the Hospital Information System (SIH). To apply a new methodology and strategy of HPCSC assessment in the Brazilian municipalities, we calculated the ratio between the total number of observed hospitalizations (O) due to chronic HPCSC and the total number of predicted hospitalizations (P) for each municipality:

Standardized HPCSC ratio= O/P

A multilevel regression model[30] estimated the predicted number of hospitalizations at the hospitalization level, considering patient and municipality characteristics. This measure (O/P) classified municipalities by the level of occurrence of HPCSC as higher than expected, expected level, or lower than expected.

Data source and study universe

The database was constructed from SIH records related to hospital admission authorizations (HAA) referred to as "normal type 1" for the 2017-2019 period. The January-May 2020 period was checked to identify hospitalizations from the previous year. Selecting this period is justified because it was the most recent one before the COVID-19 pandemic, which altered the pattern of hospitalizations in general within the SUS between 2020 and 2021[31].

We excluded from the database long-stay hospitalizations, those related to pregnancy, childbirth, and puerperium, as well as transfers and hospitalizations concluded due to administrative closure exit reasons. Hospitalizations of patients aged 15 or over were considered (Figure 1) under the method applied by the OECD[16]. Ultimately, 21,858,173 hospitalizations were computed. The Brazilian Deprivation Index (BDI) was used at the patient's municipality of residence level to adjust for socioeconomic status. The value of the municipal BDI is provided in quintiles, with the first quintile being the least deprived, and the fifth being the most deprived[32]. A total of 21,787,842 hospitalizations were selected by comparing the SIH and BDI databases, resulting from the exclusion of hospitalizations in municipalities not covered by the BDI. There was also a cross-check with the primary care coverage database, made available by the Ministry of Health through the e-Gestor Primary Care portal.

Hospitalizations were then aggregated by the municipality of patient residence, resulting in five databases, one for each of the principal Brazilian regions (North, Northeast, Southeast, South, and Midwest) (Figure 1). The study universe included 1,453,553 hospitalizations in the North, 5,357,423 in the Northeast, 8,982,555 in the Southeast, 4,426,353 in the South, and 1,567,958 in the Midwest.

In each database, the dependent variable was dichotomous, indicating whether the hospitalization corresponded to an HPCSC. Only HPCSC related to chronic conditions were considered – asthma, diabetes, CHF, COPD, and hypertension, as proposed by the OECD. The three-digit codes of the International Statistical Classification of Diseases, tenth revision (ICD-10), which comprised the outcome of avoidable hospitalizations, were J45, J46, E10, E11, E12, E13, E14, I50, J40, J41, J42, J43, J44, I10, and I11.

The ratio between the number of observed and expected HPCSC, estimated by a risk ad-

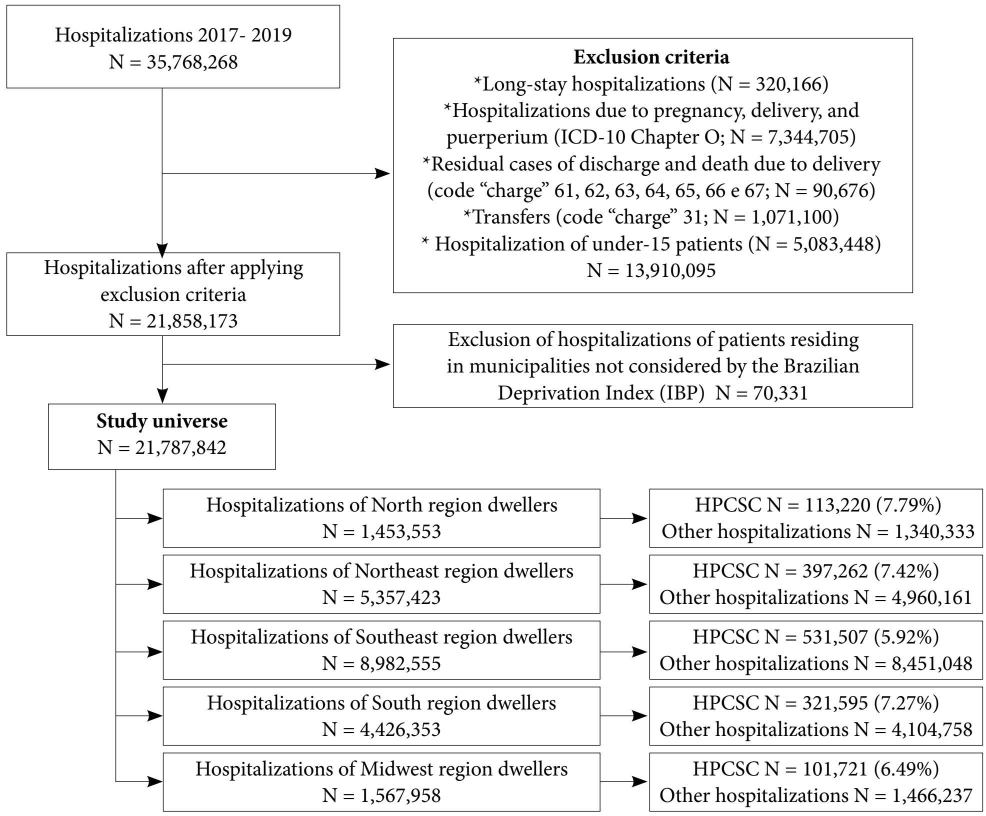

Figure 1. Flowchart of the application of the study universe selection criteria.

HPCSC: asthma, diabetes, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and hypertension.

Source: Authors.

justment model at the level of each hospitalization, can help understand how much hospitalizations observed for these conditions are higher than what could be predicted and could be avoided by improving primary care. Therefore, this ratio would be a way, albeit indirect, of evaluating the performance of primary care in a municipality.

Thus, to estimate the denominator, the following variables of relevance in predicting the selected HPCSC are considered: gender; age, stratified as 15-39, 40-49, 50-59, and 60 years or older; ethnicity/skin color (white/Black/brown/yellow/Indigenous/unknown); comorbidity, measured using the Elixhauser index (0/1/≥2); hospitalization type (elective/emergency); and year of admission (2017/2018/2019). The BDI (1/2/3/4/5) was included at the municipal level. The Elixhauser index was calculated from the nine secondary diagnoses available in the SIH, considering only those before hospitalization (secondary diagnosis type variable equal to 1). The Charlson index was initially tested, but it was ultimately decided to include the Elixhauser index because it demonstrated a greater magnitude of association in the final model.

After classifying the municipalities by the ratio between observed and predicted HPCSC, we considered cross-referencing this ratio with variables from the PHC's eGestor system database and the municipality's population size obtained from the IBGE. The PHC-related variables considered were primary care coverage, family health team coverage, and the availability of doctors' and nurses' work hours.

Data analysis

The estimated number of expected HPCSC in the municipalities was based on the conditional probabilities of hospital records corresponding to HPCSC. For this purpose, a risk

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adjustment model was adopted at each hospitalization level with the logistic regression technique and a multilevel approach to account for the data's hierarchical structure. The model was tested for discriminative capacity using the C-statistic, the area under the ROC (Receiver Operating Characteristics) curve, where values equal to or greater than 0.7 were adequate[33].

The predicted risk value for the selected HPCSCs was saved for each hospitalization. It was calculated from the fixed effects component of the multilevel model, excluding random effects (municipality). An aggregated database by municipality of residence was constructed from the total observed HPCSCs and the total predicted HPCSCs to calculate the ratio between observed and predicted HPCSCs for each municipality. The intraclass correlation coefficient (ICC) was evaluated for each model, expressing the proportion of total variation in hospitalization attributed to the municipalities.

Funnel plots with limits of 2 and 3 standard deviations were applied, where the ratio was plotted on the vertical axis and the sum of hospitalizations predicted by the risk adjustment model on the horizontal axis. The plot allowed for identifying and classifying municipalities with the best performance (ratio below the expected value), expected performance (ratio equal to the expected value), and worst performance (ratio above the expected value), considering limits of 3 standard deviations.

A panel with specific characteristics of the primary care network, according to the municipality's performance, considered primary care coverage (up to 70%/over 70%); ESF coverage (up to 70%/over 70%); doctors' workload (first to fourth quartile); nurses' workload (first to fourth quartile); and municipality size (up to 20,000 inhabitants/20,001 to 50,000/50,001 to 100,000/≥100,001). The mean coverage values of Primary Care and ESF, as well as the work hours of doctors and nurses in each municipality, were calculated over 36 months (January 2017 to December 2019). Then, the mean work time of doctors and nurses in each Brazilian region was calculated, and the quartiles served as the cutoff point for analysis. Statistical analyses were performed using R software, version 4.2.2.

This study employed exclusively secondary, non-identifiable, and publicly accessible data, therefore meeting the criteria for exemption from submission and approval by the Research Ethics Committee.

Results

The North and Northeast had the highest HPCSC percentages among the principal Brazilian regions. Among men in the North, these hospitalizations represented 7.60% of the total, and among women, 7.98% of the total, from 2017 to 2019. In the Southeast, which had the lowest HPCSC percentage during the period, HPCSCs accounted for 5.79% of hospitalizations among men and 6.05% among women. In all regions, the frequency of these hospitalizations increased due to the growing age of the affected groups. In the North, Northeast, and Southeast, the HPCSC percentage in Black people was higher than in white, brown, Asian, and Indigenous people. In the South and Midwest, HPCSCs among Indigenous people stood out, with 9.11% and 10.96% of total hospitalizations, respectively. We observed a decrease in the HPCSC percentage in all Brazilian regions from 2017 to 2019 (Table 1).

In the multilevel models for all principal regions (Table 2), female patients, older age groups, and emergency hospitalizations were more likely to incur HPCSCs. Black patients were more likely to incur HPCSCs than white patients; this likelihood was 39% higher in the North, 36% higher in the Northeast and Southeast, and 28% higher in the South and Midwest. Furthermore, Indigenous people were 50% more likely than whites to incur HPCSC in the South and 36% more likely in the Midwest. A higher number of comorbidities in the Elixhauser index was associated with HPCSCs. In all principal regions, the likelihood of HPCSCs decreased in 2018 and 2019 compared to 2017, after adjusting for the other variables in the models. The BDI was statistically significant at the municipal level, with a higher likelihood of HPCSCs among the most deprived municipalities (Table 2).

All models' discriminative capacity was adequate, with C statistics above 0.7. Through the ICC of the empty models (null model), we observed that most of the total variation was attributed to the municipalities' characteristics in the Northeast and South.

Table 1. Characteristics of hospitalizations for chronic primary care-sensitive conditions in hospitals reimbursed by the SUS from 2017 to 2019 in the principal Brazilian regions.

Variable	North			Northeast			Southeast			South			Midwest		
	HPCSC	Other causes	P-value	HPCSC	Other causes	P-value	HPCSC	Other causes	P-value	HPCSC	Other causes	P-value	HPCSC	Other causes	P-value
	n (%)	n (%)		n (%)	n (%)		n (%)	n (%)		n (%)	n (%)		n (%)	n (%)	
Gender			<0.01			<0.01			<0.01			<0.01			<0.01
Male	56,718 (7.60)	688,751 (92.39)		185,367 (7.01)	2,460,106 (92.99)		265,932 (5.79)	4,326,322 (94.21)		152,960 (6.78)	2,103,496 (93.22)		50,954 (6.24)	765,057 (93.75)	
Female	56,502 (7.98)	651,582 (91.02)		211,895 (7.81)	2,500,055 (92.19)		265,575 (6.05)	4,124,726 (93.95)		168,635 (7.77)	2,001,262 (92.23)		50,767 (6.75)	701,180 (93.25)	
Age group			<0.01			<0.01			<0.01			<0.01			<0.01
15-29 years	7,642 (2.28)	327,560 (97.72)		22,719 (2.47)	898,459 (97.53)		18,405 (1.56)	1,157,776 (98.44)		10,633 (1.76)	594,136 (98.24)		4,225 (1.56)	266,576 (98.44)	
30-39 years	7,146 (2.91)	238,702 (97.09)		22,712 (2.88)	765,864 (97.12)		21,179 (1.94)	1,068,678 (98.06)		9,830 (1.94)	497,399 (98.06)		4,710 (2.05)	224,944 (97.95)	
40-49 years	11,787 (5.20)	214,740 (94.80)		37,350 (4.58)	777,760 (95.42)		41,970 (3.26)	1,243,489 (96.73)		20,360 (3.28)	600,530 (96.72)		9,278 (3.69)	241,923 (96.31)	
50-59 years	19,795 (9.47)	189,213 (90.53)		63,721 (7.73)	760,828 (92.27)		89,315 (5.64)	1,493,855 (94.36)		48,905 (6.13)	748,675 (93.87)		17.221 (6.65)	241,793 (93.35)	
≥60 years	66,850 (15.30)	370,118 (84.70)		250,760 (12.49)	1,757,250 (87.51)		360,638 (9.37)	3,487,250 (90.63)		231,867 (12.23)	1,664,018 (87.77)		66,287 (11.89)	491,001 (88.10)	
Ethnicity/Skin color			<0.01			<0.01			<0.01			<0.01			<0.01
White	4,330 (6.67)	60,592 (93.33)		25,873 (7.01)	343,416 (92.99)		227,446 (5.59)	3,840,674 (94.41)		232,293 (6.89)	3,137,152 (93.10)		19,924 (7.53)	244,524 (92.46)	
Black	1,912 (8.87)	19,645 (91.13)		13,647 (9.23)	134,172 (90.77)		38,763 (6.96)	517,805 (93.03)		9,511 (7.51)	117,058 (92.48)		2,817 (8.80)	29,179 (91.19)	
Brown	66,295 (7.62)	803,728 (92.38)		211,727 (7.90)	2,692,480 (92.71)		157,000 (5.73)	2,582,499 (94.27)		22,714 (6.84)	309,397 (93.16)		45,374 (6.49)	653,490 (93.51)	
Yellow	3,105 (6.80)	42,581 (93.20)		25,108 (9.76)	232,103 (90.24)		9,306 (6.52)	133,460 (93.48)		2,560 (7.61)	31,072 (92.39)		4,106 (9.37)	39,699 (90.63)	
Indigenous	597 (6.11)	9,176 (93.89)		389 (8.36)	4,266 (91.64)		69 (4.88)	1,345 (95.12)		336 (9.11)	3,350 (90.88)		993 (10.96)	8,070 (89.04)	
No information	36,981 (8.37)	404,611 (91.62)		120,518 (7.20)	1,553,724 (92.80)		98,923 (6.71)	1,375,265 (93.29)		54,181 (9.66)	506,729 (90.34)		28,507 (5.48)	491,275 (94.51)	

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Table 1. Characteristics of hospitalizations for chronic primary care-sensitive conditions in hospitals reimbursed by the SUS from 2017 to 2019 in the principal Brazilian regions.

Variable	North			Northeast			Southeast			South			Midwest		
	HPCSC	Other causes	P-value	HPCSC	Other causes	P-value	HPCSC	Other causes	P-value	HPCSC	Other causes	P-value	HPCSC	Other causes	P-value
	n (%)	n (%)		n (%)	n (%)		n (%)	n (%)		n (%)	n (%)		n (%)	n (%)	
Elixhauser Index			<0.01			<0.01			<0.01			<0.01			<0.01
0	112,223 (7.75)	1,334,364 (92.24)		391,638 (7.38)	4,915,912 (92.62)		475,577 (5.71)	7,857,010 (94.29)		316,615 (7.21)	4,075,140 (92.79)		100,626 (6.47)	1,455,330 (93.53)	
1	795 (13.25)	5,03 (86.74)		4,594 (11.12)	36,723 (88.88)		40,681 (8.19)	455,887 (91.81)		3,314 (11.84)	24,663 (88.15)		967 (8.65)	10,206 (91.34)	
≥ 2	202 (20.87)	766 (79.13)		1,030 (12.04)	7,526 (87.96)		15,249 (9.94)	138,151 (90.06)		1,666 (25.16)	4,955 (74.84)		128 (15.44)	701 (84.56)	
Hospitalization type			<0.01			<0.01			<0.01			<0.01			<0.01
Elective	7,449 (2.35)	310,012 (97.65)		22,905 (1.43)	1,572,227 (98.56)		24,794 (0.90)	2,722,843 (99.10)		14,958 (1.28)	1,154,805 (98.72)		3,645 (1.09)	330,000 (98.91)	
Urgent	105,771 (9.31)	1,030,321 (90.69)		374,357 (9.95)	3,387,934 (90.05)		506,713 (8.13)	5,728,205 (91.87)		306,637 (9.41)	2,949,953 (90.58)		98,076 (7.94)	1,136,237 (92.05)	
Hospitalization year			<0.01			<0.01			<0.01			<0.01			<0.01
2017	37,450 (7.90)	436,539 (92.10)		138,539 (8.05)	1,582,243 (91.95)		183,822 (6.36)	2,707,298 (93.64)		111,042 (7.70)	1,329,959 (92.29)		33,314 (7.09)	436,279 (92.90)	
2018	38,121 (7.77)	452,362 (92.23)		131.710 (7.34)	1,661,291 (92.65)		175,183 (5.85)	2,819,450 (94.15)		107,437 (7.28)	1,368,457 (92.72)		35,189 (6.56)	501,371 (93.44)	
2019	37,649 (7.70)	451,432 (92.30)		127,013 (6.89)	1,716,627 (93.11)		172,502 (5.57)	2,924,300 (94.43)		103,116 (6.83)	1,406,342 (93.17)		33,218 (5.91)	528,587 (94.09)	
IBP			<0.01			<0.01			<0.01			<0.01			<0.01
1	-	-		-	-		120,684 (4.73)	2,431,901 (95.27)		75.054 (5.01)	1,421,781 (94.98)		-	-	
2	-	-		-	-		145,917 (5.34)	2,587,693 (94.66)		52,739 (5.97)	829,880 (94.02)		19,303 (4.80)	382,970 (95.20)	
3	6,019 (3.44)	168,705 (96.55)		33,032 (5.21)	600,899 (94.79)		140,688 (6.24)	2,114,923 (93.76)		74,257 (7.52)	913,042 (92.48)		21,695 (4.92)	418,770 (95.07)	
4	39,097 (7.39)	489,863 (92.61)		70,122 (4.66)	1,435,101 (95.34)		84,580 (7.95)	978,545 (92.04)		104,760 (10.93)	853,655 (89.07)		52,806 (8.19)	591,562 (91.80)	
5	68,104 (9.08)	681,765 (90.92)		294,108 (9.14)	2,924,161 (90.86)		39,638 (10.50)	337,986 (89.50)		14,785 (14.61)	86,400 (85.39)		7,917 (9.79)	72,935 (90.21)	

HPCSC: Hospitalizations due to primary care-sensitive conditions. Selected specific HPCSCs: asthma, diabetes, COPD, CHF, and hypertension. CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease.

Source: Hospital Information System, DATASUS, data obtained in July 2022.

Table 2. Multilevel logistic regression model for hospitalizations due to primary care-sensitive chronic conditions in hospitals reimbursed by the SUS from 2017 to 2019 in the principal Brazilian regions.

Variable	North		Northeast		Southeast		South		Midwest	
	OR	IC95%	OR	IC95%	OR	IC95%	OR	IC95%	OR	IC95%
Gender										
Female	1.14	1.12-1.15	1.18	1.17-1.19	1.11	1.10-1.12	1.19	1.18-1.20	1.14	1.13-1.16
Male	1		1		1		1		1	
Age group										
15-29 years	1		1		1		1		1	
30-39 years	1.42	1.37-1.47	1.39	1.36-1.41	1.38	1.36-1.40	1.23	1.19-1.26	1.48	1.42-1.54
40-49 years	2.74	2.66-2.82	2.46	2.42-2.50	2.37	2.33-2.41	2.13	2.08-2.17	2.78	2.69-2.88
50-59 years	5.34	5.20-5.48	4.29	4.23-4.36	4.06	4.00-4.12	4.11	4.03-4.19	5.17	5.00-5.34
≥ 60 years	8.74	8.53-8.96	6.44	6.35-6.53	6.13	6.05-6.21	7.83	7.69-7.97	8.95	8.69-9.23
Ethnicity/Skin color										
White	1		1		1		1		1	
Black	1.39	1.32-1.47	1.36	1.33-1.39	1.36	1.34-1.37	1.28	1.25-1.31	1.28	1.22-1.33
Brown	1.20	1.17-1.24	0.99	0.97-1.00	1.08	1.07-1.09	1.15	1.14-1.17	0.99	0.97-1.01
Yellow	1.21	1.16-1.27	1.11	1.09-1.13	1.24	1.21-1.27	1.10	1.06-1.15	1.23	1.19-1.28
Indigenous	0.96	0.88-1.05	0.97	0.91-1.04	1.03	0.98-1.08	1.50	1.38-1.63	1.36	1.27-1.46
No information	1.33	1.28-1.37	0.99	0.97-1.00	1.31	1.30-1.32	1.35	1.33-1.36	0.78	0.76-0.80
Elixhauser Index										
0	1		1		1		1		1	
1	1.60	1.49-1.72	1.52	1.48-1.57	1.41	1.39-1.42	1.42	1.37-1.47	0.98	0.92-1.05
≥ 2	2.99	2.61-3.44	1.26	1.20-1.32	1.48	1.45-1.50	2.84	2.69-3.00	1.64	1.43-1.88
Hospitalization type										
Elective	1		1		1		1		1	
Urgent	4.16	4.05-4.26	7.02	6.92-7.12	8.25	8.15-8.36	7.00	6.89-7.12	7.24	7.00-7.49
Hospitalization year										
2017	1		1		1		1		1	
2018	0.97	0.96-0.99	0.92	0.91-0.93	0.93	0.92-0.94	0.95	0.94-0.96	0.91	0.90-0.93
2019	0.95	0.93-0.96	0.86	0.85-0.87	0.88	0.87-0.89	0.90	0.89-0.91	0.82	0.81-0.83
IBP										
1	-		-		1		1		-	
2	-		-		1.19	1.14-1.24	1.10	0.99-1.21	1	
3	1		1		1.24	1.17-1.32	1.31	1.21-1.42	1.03	0.83-1.28
4	1.99	1.64-2.42	1.05	0.98-1.13	1.36	1.29-1.44	1.60	1.49-1.72	1.24	1.05-1.47
5	2.09	1.74-2.51	1.53	1.42-1.64	1.64	1.53-1.75	1.92	1.68-2.19	1.40	1.16-1.69
ICC null model	0.062		0.108		0.076		0.102		0.082	
C Statistic	0.782		0.794		0.768		0.788		0.784	

IBP: Brazilian Deprivation Index. ICC: Intraclass Correlation Coefficient. *Asthma, diabetes, COPD, CHF, and hypertension. CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease.

Source: Hospital Information System, DATASUS. Data obtained in July 2022.

In all principal regions, approximately 35% of municipalities with 20,000 to 50,000 inhabitants had more HPCSCs than expected (worst performance). The percentage varied between 34.6% in the Midwest and 38.0% in the South. On the other hand, municipalities with more than 100,000 inhabitants had better results. In the Northeast, Southeast, and South, 19.1% to 21.2% of municipalities with more than 100,000 inhabitants had more HPCSCs than expected (worst performance). In the North, 11.1% of municipalities had more HPCSCs than expected, and the percentage reached 31.8% only in the Midwest, similar to that observed in municipalities with populations of 50,000 to 100,000 inhabitants (Table 3, Figure 2).

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When assessing the coverage of primary care and ESF regarding performance, a lower percentage of municipalities with worse performance was observed in the North among those with >70% coverage. The same was observed in the Midwest among municipalities with >70% primary care coverage. However, in the other cases, the differences in worse results against the level of coverage of primary care and the ESF are reduced and lose significance.

Among the municipalities with the highest doctors' workloads (4th quartile), we observed a lower percentage of the worst performance in all principal Brazilian regions. In the Northeast, Southeast, and South, an increasing trend was identified between doctors' workload and the percentage of municipalities with the best performance. However, regardless of the doctors' workload, the percentage of municipalities with the worst performance remained around 20%. As observed regarding the doctors' workload, a lower percentage of worst performance was noted among the municipalities with the highest number of nurses' workloads (4th quartile).

Discussion

The resilience of health systems in the face of increasingly intense and successive shock situations[34] requires a comprehensive and complex understanding of their backgrounds[35] – decentralization, available funds, investments and resources, team environment and motivation, integration, networking, and team diversification – in the face of scenarios of transformed health conditions, needs, and vulnerabilities of the populations in each region. Given that such health system baseline conditions affect its resilience capacity, the results presented here anticipate elements that unequally affect the routine performance of PHC in Brazilian regions. Indeed, there are difficulties in its response in critical situations.

Despite the socioeconomic advances in recent decades, municipalities in the Northeast and, especially, those in the North have the worst deprivation quintiles in Brazil (BDI). Although extreme inequalities are evident throughout the country, the socioeconomic vulnerabilities of these regions have been strongly associated with HPCSCs. All principal Brazilian regions have shown an association between deprivation (BDI) and HPCSCs, reinforcing the importance of strengthening PHC in curbing inequalities, especially in the most vulnerable populations and territories[36].

Addressed as background, prerequisites, or facilitators of resilience[35], PHC's structural conditions, which include funding, coverage, and availability of professionals, also directly influence the effectiveness of care provided to the population. Although ESF coverage has expanded in recent decades, it remains uneven across Brazilian regions, and the challenge remains in the quality of care provided. The results are surprising because they do not establish a consistent relationship between the HPCSC ratio and PHC and ESF coverage. However, interestingly, this relationship occurs precisely in the North, which has the greatest need for healthcare resources. According to the indicator, better performance was associated with greater availability of doctors and nurses, measures related to the healthcare team that are relevant but limited in that they do not account for the diversity of professionals, nor their environment, level of training, and motivation, elements also central to the resilience of the healthcare system[35,37,38].

High turnover of health professionals, limited access, inadequate infrastructure, shortages of supplies, and difficulties in effectively implementing the ESF also compromise PHC resilience. Specifically, regarding chronic conditions, restricted access to continuous, high-quality care can lead to increased hospitalizations for these conditions.

With the growing burden of chronic conditions and population aging, coupled with increasing health inequalities and risks associated with new public health emergencies globally, challenges will be faced in preserving the quality of care and streamlining resources, avoiding excessive and unnecessary use and unequal access, and promoting care effectiveness[2,39-41]. This study suggests acute problems in PHC in more vulnerable regions, generally associated with a shortage of professionals. It also highlights the impact of chronic conditions in these regions, resulting from demographic, socioeconomic, and epidemiological changes, as well as increased inequalities and deteriorating living and health conditions, amid the challenges posed by the country's political crisis.

Table 3. Characteristics of municipalities by level of performance based on the ratio of hospitalizations due to chronic primary care-sensitive conditions* observed and expected.

Variables	North			Northeast			Southeast			South			Midwest		
	Performance			Performance			Performance			Performance			Performance		
	Worse	Expected	Better	Worse	Expected	Better	Worse	Expected	Better	Worse	Expected	Better	Worse	Expected	Better
Municipalities	95	268	86	460	887	447	386	925	357	320	562	306	103	282	81
Size (inhabitants)															
Up to 20,000	31 (11.8)	196 (74.8)	35 (13.3)	250 (21.7)	675 (58.5)	229 (19.8)	226 (20.2)	711 (63.5)	183 (16.3)	235 (25.6)	492 (53.6)	191 (20.8)	62 (18.1)	235 (68.5)	46 (13.4)
20,001-50,000	43 (37.4)	54 (46.9)	18 (15.6)	169 (37.1)	159 (34.9)	127 (27.9)	102 (35.3)	131 (45.3)	56 (19.4)	62 (38.0)	44 (27.0)	57 (35.0)	28 (34.6)	36 (44.4)	17 (21.0)
50,001-100,000	18 (40.0)	14 (31.1)	13 (28.9)	29 (23.7)	32 (26.2)	61 (50.0)	30 (26.6)	45 (39.8)	38 (33.6)	12 (21.8)	15 (27.3)	28 (50.9)	06 (30.0)	05 (25.0)	09 (45.0)
≥100,001	03 (11.1)	04 (14.8)	20 (74.0)	12 (19.1)	21 (33.3)	30 (47.6)	28 (19.2)	38 (26.0)	80 (54.8)	11 (21.2)	11 (21.2)	30 (57.6)	07 (31.8)	06 (27.3)	09 (40.9)
PHC coverage (%)															
Up to 70%	27 (35.1)	32 (41.5)	18 (23.4)	12 (29.3)	19 (46.3)	10 (24.4)	58 (22.2)	110 (42.1)	93 (35.6)	27 (27.6)	32 (32.6)	39 (39.8)	12 (31.6)	12 (31.6)	14 (36.8)
>70%	68 (18.3)	236 (63.4)	68 (18.3)	448 (25.6)	868 (49.5)	437 (24.9)	328 (23.3)	815 (57.9)	264 (18.8)	293 (26.9)	530 (48.6)	267 (24.5)	91 (21.3)	270 (63.1)	67 (15.6)
FH coverage (%)															
Up to 70%	24 (36.9)	21 (32.3)	20 (30.8)	18 (28.6)	26 (41.3)	19 (30.2)	100 (24.0)	194 (46.5)	123 (29.5)	56 (28.0)	64 (32.0)	80 (40.0)	12 (23.0)	20 (38.5)	20 (38.5)
>70%	71 (18.5)	247 (64.3)	66 (17.2)	442 (25.5)	861 (49.7)	428 (24.7)	286 (22.9)	731 (58.4)	234 (18.7)	264 (26.7)	498 (50.4)	226 (22.9)	91 (22.0)	262 (63.3)	61 (14.7)
Doctor's WL															
1st quartile	11 (10.9)	78 (77.2)	12 (11.9)	95 (23.3)	239 (58.6)	74 (18.1)	106 (25.4)	256 (61.4)	55 (13.2)	73 (24.6)	174 (58.6)	50 (16.8)	29 (25.0)	75 (64.7)	12 (10.3)
2nd quartile	24 (19.3)	79 (63.7)	21 (16.9)	120 (24.5)	264 (54.0)	105 (21.5)	106 (25.4)	244 (58.5)	67 (16.1)	81 (27.2)	157 (52.7)	60 (20.1)	28 (23.9)	71 (60.7)	18 (15.4)
3rd quartile	30 (26.5)	69 (61.1)	14 (12.4)	120 (26.7)	206 (45.9)	123 (27.4)	80 (19.2)	247 (59.2)	90 (21.6)	80 (27.0)	145 (49.0)	71 (24.0)	20 (16.9)	82 (69.5)	16 (13.6)
4th quartile	30 (27.0)	42 (37.8)	39 (35.1)	125 (27.9)	178 (39.7)	145 (32.4)	94 (22.5)	178 (42.7)	145 (34.8)	86 (29.0)	86 (29.0)	125 (42.0)	26 (22.6)	54 (47.0)	35 (30.4)
Nurse WL															
1st quartile	25 (21.4)	76 (64.9)	16 (13.7)	99 (22.0)	265 (59.0)	85 (18.9)	117 (28.2)	236 (56.9)	62 (14.9)	64 (22.1)	169 (58.5)	56 (19.4)	27 (25.0)	70 (64.8)	11 (10.2)
2nd quartile	23 (21.3)	73 (67.5)	12 (11.1)	112 (25.0)	219 (49.0)	116 (25.9)	99 (23.6)	262 (62.4)	59 (14.0)	90 (27.5)	164 (50.2)	73 (22.3)	33 (26.6)	72 (58.1)	19 (15.3)
3rd quartile	29 (25.9)	65 (58.0)	18 (16.1)	127 (28.5)	214 (48.0)	105 (23.5)	90 (21.6)	239 (57.5)	87 (20.9)	97 (35.3)	117 (42.5)	61 (22.2)	23 (19.5)	76 (64.4)	19 (16.1)
4th quartile	18 (16.1)	54 (48.2)	40 (35.7)	122 (27,0)	189 (41,8)	141 (31,2)	80 (19,2)	188 (45,1)	149 (35,7)	69 (23,2)	112 (37,7)	116 (39,1)	20 (17,2)	64 (55,2)	32 (27,6)

* Asthma, diabetes, COPD, CHF, and hypertension. CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease. PHC: Primary Healthcare; FH: Family Health. PHC and FH coverage: Calculated based on average coverage over the 36 months of the study (period 201701 to 201912). Doctor and Nurse WL: Calculated from the average workload in the 36 months of the study (period 201701 to 201912). Regarding the doctors' and nurses' workloads, each region's cutoff points (quartile) were applied. The first quartile represented the lowest workload of doctors/nurses, and the fourth was their highest workload.

Source: https://egestorab.saude.gov.br/paginas/acessoPublico/relatorios/relHistoricoCoberturaAB.xhtml.

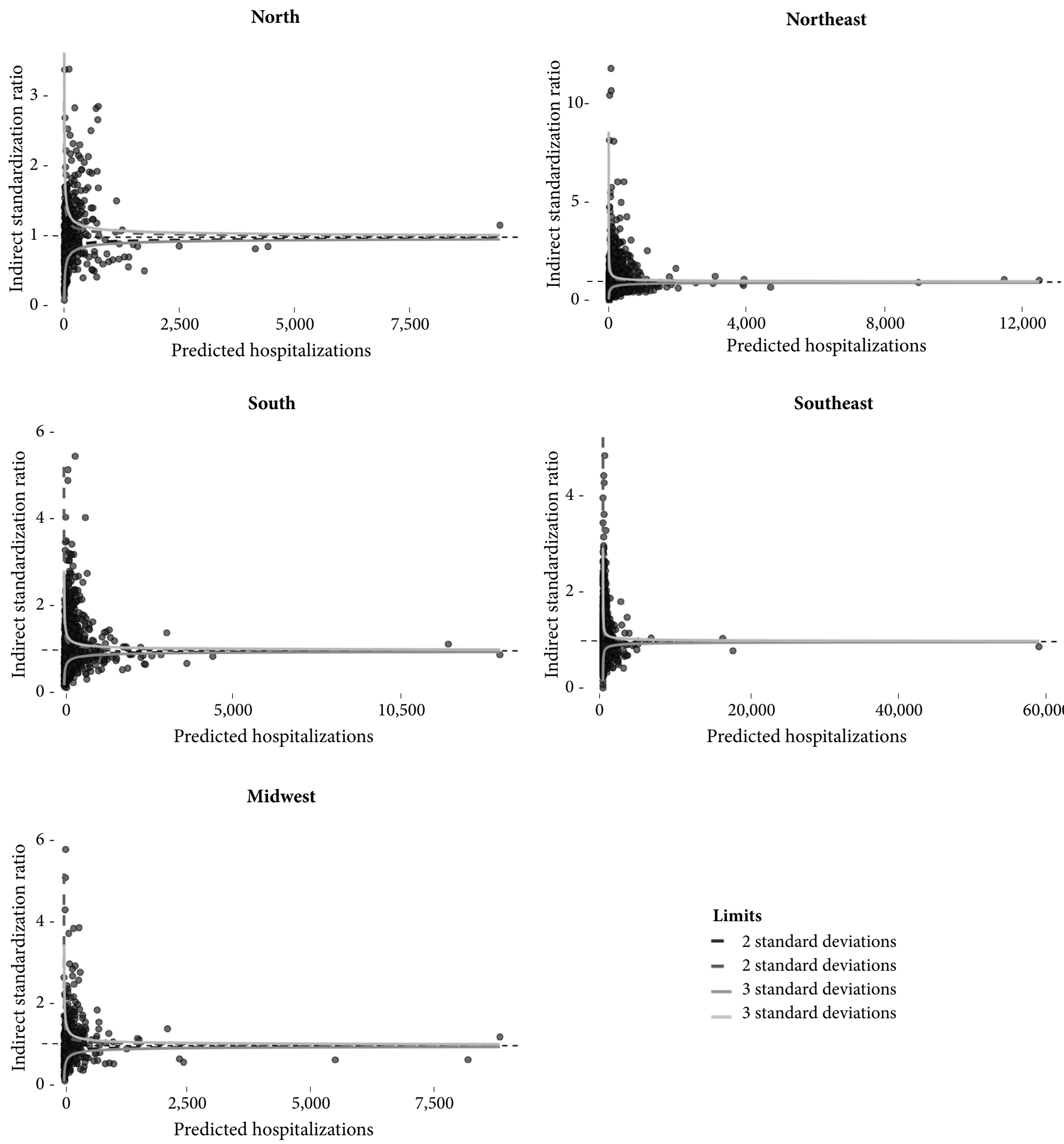

Figure 2. Funnel plots of the ratio of hospitalizations due to chronic primary care-sensitive conditions observed and expected for the principal Brazilian regions.

Source: Authors.

Among the skills needed to develop a resilient health system, monitoring is an evaluation system that controls data collection, analysis, maintenance, and sanitization under control[35]. In this sense, the need to develop and apply relatively simple tools, such as the one used in this study, is reinforced. These tools enable the observation of variations in the performance of services responsible for primary care and the anticipation of critical problems affecting their ability to respond to routine demands and, more significantly, crises.

The method proposed here is based on average standards, establishing HPCSC estimates that are adjusted for individual demographic and clinical characteristics, as well as the municipality's material deprivation level. On the one hand, this procedure aims to establish comparable conditions in comparisons, enabling higher observed HPCSC levels to be classified as expected under more unfavorable conditions. On the other hand, it raises questions about considering insufficient acceptable standards, which dialogues with questions about "poor resilience"[42].

In any case, the ratio between observed and expected HPCSCs, as a parameter for classifying primary care performance in municipalities, was applicable and usable across different geographic areas, identifying responses to interventions aimed at improving PHC, considering the declining HPCSC indicator and the lower variation between municipalities and regions. Furthermore, such monitoring strengthens SUS resilience as a whole.

The results highlight important issues for discussing a resilient, more effective, and equitable system, pointing out the burden of HPCSC on vulnerable populations, systems, and territories (municipalities). However, although they suggest that the reduced likelihood of HPCSC is related to better care provided in primary care, we cannot ignore that other factors related to the health system can overly affect the indicator. HPCSCs can indicate PHC weaknesses and incapacities as well as the impact of the supply of hospital beds, highlighting healthcare disparities[43]. Regardless, the use and validity of this indicator for monitoring requires improved information about healthcare provided in Brazil[27].

This study's limitations are related to the quality of hospital information, completeness, and sufficiency of variables that express the risk of more severe cases and consequent need for hospitalization. Notably, as some individuals may have undergone multiple hospitalizations due to chronic conditions[13,44,45] during the study period, this indicator describes the ratio of hospitalization (events) and not the ratio of hospitalized patients. Therefore, readmissions were not differentiated and may have biased the results, potentially overestimating the genuine association, i.e., multiple admissions of a single patient, which is a significant limitation. Furthermore, the BDI is based on data from the 2010 population census. There are inherent limitations to the hospitalization-based indicator for measuring the quality of care provided in primary care[13] directly. We should also mention that the different elements underlying the health system's complexity and those that explain resilient performance and threats to it, in this case, the SUS, were not measured due to the study design, availability of information, and interest in exploring the HPCSC indicator's potential and limitations, which has been widely analyzed in national studies.

In contrast, HPCSCs have been widely used as an indirect indicator of the quality of health systems[13]. The selection of specific primary care-sensitive chronic conditions[16] facilitates comparisons and contributes to actions aimed at improving primary and specialized care for patients with these diseases. Furthermore, considering the range of conditions in the HPCSC list, this article enhances the indicator's predictive validity by examining a subset of more homogeneous conditions.

The results suggest that the methodology is valid, as it indicates that municipalities with larger sizes and greater availability of doctors and nurses perform better. The breakdown by macro-regions and the risk adjustment based on the regional means are aspects that can be made more flexible, given, for example, the assessment that stricter standards should include reference cases (benchmarking) instead of means. Additionally, we should emphasize that the methodology identifies the worst-performing territories, allowing for a more in-depth examination of potential improvements and PHC resilience conditions.

Conclusion

The proposed methodology fosters PHC resilient performance because it is simple and based on a widely used indicator, facilitating continuous monitoring. It enables anticipating conditions that can compromise PHC resilience capacity in routine situations and, more specifically, in crises, informing about the need for resource allocation, adaptations, and transformations in a timely fashion. Considering the centrality of PHC in the health system, the methodology also offers elements that can strengthen SUS resilience by identifying gaps, deepening debates, and redesigning actions to improve access and ensure the effectiveness of care provided at various levels and territories.

Collaborations

MPR Schilling was responsible for the conception, analysis, interpretation of data, writing of the manuscript, and review of the final manuscript. MC Portela was responsible for the conception, interpretation of data, writing of the manuscript, critical review, and review of the final manuscript. MV Albuquerque was responsible for interpreting the data, writing the manuscript, critical review, and review of the final manuscript. M Martins was responsible for the conception, interpretation of data, writing of the manuscript, critical review, and review of the final manuscript.

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