







Macro-Regional Disparities in Specialized Dental Care for Children in the Brazilian Unified Health System: An Ecological Study

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ABSTRACT

Objective: To investigate macro-regional disparities in specialized outpatient dental care for children in the Brazilian Unified Health System (SUS). **Material and Methods:** An ecological study was conducted using a longitudinal, retrospective, and quantitative approach. The number of outpatient dental procedures (ODPs) performed by Pediatric Dentists in the SUS was retrieved by the Outpatient Information System (SIA/SUS), considering the period between 2008 and 2022, as well as the five macro-regions of Brazil. Statistical analysis was based on descriptive and analytical approaches. The significance level was adjusted to 5%. **Results:** More than 29 million outpatient dental procedures were performed in the last 15 years by Pediatric Dentists in the SUS. The incidence rate of ODPs was significantly lower in the Northeast macro-region compared to the other macro-regions and the national estimate ($p < 0.05$). The north was the only macro-region that showed a decreasing temporal trend over the last 15 years ($p = 0.026$), while the others were stationary ($p > 0.05$). However, when the COVID-19 pandemic years were removed, testing from 2008 to 2019, the trend was also stationary ($p = 0.351$). In addition, the North macro-region was the only one not correlated with the national estimate ($p = 0.478$), showing a distinct pattern in the incidence rate of ODPs over the last 15 years. Nonetheless, The variability of this particular variable was striking across all macro-regions, but it was especially pronounced in the north. **Conclusion:** There are macro-regional disparities in specialized dental care for children in the Brazilian Unified Health System.

Keywords: Dental Care for Children; Public Health Systems Research; Healthcare Disparities.

■ Introduction

The Brazilian Unified Health System (SUS) is one of the largest in the world, promoting universal, equitable, and comprehensive access to health services for millions of Brazilians [1]. Approximately 30 years after its implementation, the SUS has achieved several important health goals, especially strengthening primary health care (PHC) and care for chronic diseases. However, among the challenges to overcome in the following decades, it is necessary to consider the expansion of the SUS throughout Brazilian territory, considering the offer of health services and access equitably [1,2].

Health disparities in Brazil are multifactorial, including financial constraints, inefficient health management, unmet population health demands, and weaknesses in decentralization and regionalization efforts. Promoting access to health services nationwide is crucial for reducing demographic-related health disparities and ensuring equal opportunities within the SUS for all Brazilians [3,4]. However, there is evidence of macro-regional health disparities in this context, which may be associated with a different panorama of regional availability and organization of healthcare services and networks in the SUS [5].

Given the high prevalence of oral diseases globally, impacting over 3.5 billion people, these conditions have led to decreased quality of life and hindered daily activities. This poses a global public health issue, straining health systems and causing significant economic impacts [6]. Similarly, within the context of the SUS, social, economic, and demographic disparities contribute to inequalities in oral health among populations, resulting in unequal access to oral health services and increased health vulnerabilities [6,7]. In accordance with this, a previous investigation pointed out differences in the quality of dental care in PHC between Brazilian macro-regions, which negatively impacts access to oral health services and their indicators [7].

At last, the concern with the oral health of children in vulnerable conditions may be added to this context of demographic-related health disparities, considering that the place where children live can influence access to oral health services as a demographic-related risk factor [8]. The vulnerability of children in unfavorable contexts regarding access to health services is reflected in dental caries indicators in Brazilian macro-regions [9,10], demonstrating the need to understand dental care for children in different demographic settings. In the SUS, specialized dental care for children, performed by Pediatric Dentists, is often associated with the secondary level of care (Dental Specialty Center - DSC). DSCs act complementary to PHC, performing more complex dental procedures that were not feasible in Basic Health Units/Family Health Units (BHU/FHU) [11,12].

It is necessary to consider that, besides the organization of the oral health care network, Pediatric Dentistry is not a mandatory specialty in the DSCs, and there is a lack of information on the dental care of children in secondary health care [12]. This context is articulated with demographic-related disparities when considering the evidence that indicates differences in the organization and productivity of DSCs in different macro-regions of Brazil [11,13]. Therefore, it is possible to question whether there are macro-regional disparities in specialized dental care for children in the SUS. As far as it was possible to reach, no published literature addressed this question. This study aimed to investigate macro-regional disparities in specialized outpatient dental care for children in the Brazilian Unified Health System. The alternative hypothesis tested was H_1 - there are macro-regional disparities in specialized outpatient dental care for children in the SUS.

■ Material and Methods

Study Design

An ecological study was carried out, considering a longitudinal, retrospective, and quantitative approach, as a time series [14], designed to evaluate data related to Brazil (national estimate) and its five macro-

regions (North, Northeast, Southeast, South, and Midwest). The period ranged between 2008 and 2022 (maximum with data available for collection). The Portuguese version of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist was adapted to improve the scientific reporting of the study [15].

Data Collection

As a source, the data were collected from the Outpatient Information System (SIA), linked to the Department of Informatics (DATASUS) [16]. Therefore, considering national resolution number 510 of 2016 from the Brazilian National Health Council - Ministry of Health [17], there is no need for ethical appreciation since the data used are made available in open access, as public domain. Hence, no data related to SUS users allows identification or location (populational approach).

The major variable is the annual number of ODPs Pediatric Dentists perform in the SUS. The macro-regions acted as a covariate. The annual number of dental procedures was normalized per 100,000 Brazilian residents between zero and fourteen years old (as a proxy measure of the pediatric population in dental settings), characterizing the incidence rate of dental procedures per year to correct demographic variation over time and demographic density between macro-regions. Taking into account the period from 2008 to 2022, encompassing the last 15 years, 15 annual observations (numbers) were included for each macro-region and in the national estimate. There were no restrictions regarding the type of dental procedure or oral health service.

The data collection procedure is considered a framework for using the SIA/SUS in evaluating oral health activities [18], and a similar study was previously published [19]. The same researcher collected All data in May 2023 using the TabNet tool. TabNet is an online data analysis tool developed by Brazil's Ministry of Health, enabling researchers to access SUS health system data conveniently and quickly [16]. In the SIA/SUS, the number of ODPs performed by Pediatric Dentists was retrieved by the filter "*Profissional - Classificação Brasileira de Ocupações*" (Professional - Brazilian Classification of Occupations), applying the code #2232-36 (dental surgeon specialized in Pediatric Dentistry). Data were filtered by years and macro-regions, considering the approved productivity. The projection of residents in Brazil to normalize the data was also retrieved using the TabNet tool, estimated and provided by the Brazilian Institute of Geography and Statistics (IBGE).

Data Analysis

Statistical analysis was based on descriptive and analytical approaches. The significance level was adjusted to 5% for all inferences ($\alpha = 0.05$), using JAMOVI (version 2.3.15, Sydney, Australia) and PAST (version 4.03, Oslo, Norway) statistical packages. The normality of the residuals was examined by the Shapiro-Wilk test (W) and the distribution graph (Q-Q plots). The descriptive analysis was presented by the median as a measure of central tendency, considering the first (Q1) and third (Q3) quartiles as dispersion measures, including the interquartile range (IQR) and the 95% confidence interval (95%CI). Minimum and maximum values were presented, as well as absolute and relative frequencies (fr) [20].

In the analytical phase, the temporal trend of the incidence rate of dental procedures each year was examined using the Annual Percent Change (APC) method. Then, the angular coefficients (β_1 ; slope value) were estimated after *the log*₁₀ transformation of the dependent variable. The APC (%) values were estimated by the formula = $\frac{(-1+10^{\beta_1})}{\beta_1} * 100$. β_1 minimum and maximum values (95%CI) were estimated by the formula = $\beta_1 \pm (t\text{-critical value} * \beta_1\text{-standard error})$. The trend over time was classified as stationary ($p \geq 0.05$), increasing ($p < 0.05$ and positive β_1 slope), or decreasing ($p < 0.05$ and negative β_1 slope) [21,22].

The Mann-Whitney (U) test was used pairwise to establish the numerical difference and magnitude (m ; *post hoc* point-biserial correlation coefficient) in the number of dental procedures over time between each macro-region and national estimate. The rank-correlations were examined by Spearman's matrix approach, using the ρ coefficient (ρ) to verify interaction and intensity. In addition, the comparisons of incidence rate (incidence rate ratio; IRR) were examined in a Generalized Linear Model. Considering the number of ODP procedures per 100,000 residents as countable and integer values, Q-Q plots were retrieved to investigate the distribution. In the Quasi-Poisson distribution, an adjustment for robust variance (overdispersion) was carried out, considering maximum likelihood estimation in the logarithmic link function (*Log*-likelihood ratio) and fixed intercept model [20,22].

■ Results

It was observed that more than 29 million ODPs were performed by Pediatric Dentists in the SUS in the last 15 years, as 13,378,604 (45.8%) in the Southeast, 5,327,612 (18.2%) in the South, 4,261,041 (14.6%) in the north, 4,079,493 (13.9%) in the Northeast, and 2,188,222 (7.5%) in the Midwest. Table 1 presents the descriptive analysis of the annual number of outpatient dental procedures performed by Pediatric Dentists in the SUS between 2008 and 2022 for every 100,000 residents aged zero to fourteen. Table 2 presents the temporal trend.

It was observed that the North macro-region presented the most significant variability over time (largest interquartile range), while the Northeast presented the lowest. Furthermore, outliers were observed in the North, South, and Midwest macro-regions. Comparatively, in a preliminary way, it was observed that the annual numbers in the Northeast macro-region were below the other macro-regions (which did not differ statistically from each other), with a small effect size ($p=0.001$ and $\epsilon^2=0.331$). Regarding the national estimate, the Northeast and Midwest macro-regions were below, with no statistically significant difference in the other macro-regions. The lowest incidence rate was observed in 2020 in all macro-regions (the first year of the COVID-19 pandemic).

Furthermore, it was observed that only the North macro-region showed a decreasing temporal trend for the annual number of ODPs performed by Pediatric Dentists in the SUS in the last 15 years, while the others showed stationarity. After removing the annual numbers from 2020, 2021, and 2022 (considering the COVID-19 pandemic onset), the temporal trend of the North macro-region became stationary ($p=0.351$), while that of the South macro-region increased ($p=0.012$), as well as the other macro-regions remained stationary.

Table 1. Descriptive analysis of the annual number of outpatient dental procedures performed by Pediatric Dentists in the Unified Health System between 2008 and 2022 for every 100,000 residents aged zero to fourteen.

Variables	Macro-region					Brazil
	North	Northeast	Southeast	South	Midwest	
Median	2,937 ^A	1,347 ^{B†}	4,934 ^A	5,508 ^A	2,639 ^{A†}	4,512
Q1	2,293	1,264	4,359	3,648	2,356	3,612
Q3	7,652	2,066	5,694	6,038	3,635	4,813
IQR	5,359	802	1,335	2,390	1,279	1,200
Minimum (year)	983 (2020)	590 (2020)	1,333 (2020)	1,157 (2020)	1,551 (2020)	1,061 (2020)
Maximum (year)	14,045 (2011)	4,082 (2009)	7,944 (2009)	19,931 (2019)	19,714 (2014)	5,974 (2019)

Q1: First quartile; Q3: Third quartile; IQR: Interquartile range; A/B: statistically significant difference between Brazilian macro-regions ($p<0.05$ after the Kruskal-Wallis and Dwass-Steel-Critchlow-Fligner post hoc test); †Statistically significant difference between a macro-region and the national estimate ($p<0.05$ after the Mann-Whitney test).

Table 2. Temporal trend of the annual number of outpatient dental procedures performed by Pediatric Dentists in the Brazilian Unified Health System between 2008 and 2022 per 100,000 residents aged zero to fourteen.

Macro-region	β	R ²	p-value	APC (%)	Trend
North	-0.049 [-0.080, -0.018]	0.344	0.026*	-10.7 [-4.06, -16.8]	Decreasing
Northeast	-0.002 [-0.034, 0.032]	N/A	0.891	N/A	Stationary
Southeast	-0.016 [-0.039, 0.010]	N/A	0.173	N/A	Stationary
South	-0.015 [-0.066, 0.017]	N/A	0.402	N/A	Stationary
Midwest	-0.001 [-0.023, 0.029]	N/A	0.921	N/A	Stationary
Brazil	-0.016 [-0.041, 0.010]	N/A	0.180	N/A	Stationary

β : Angular coefficient; R²: Coefficient of determination; APC: Annual Percent Change (%); *Statistically significant; [-]: 95% Confidence interval; N/A: Not applicable.

Table 3 details the macro-regional comparison of the annual number of ODPs performed by Pediatric Dentists in the SUS between 2008 and 2022 for every 100,000 residents aged zero to fourteen, while Table 4 details the comparison between each macro-region and the national estimate, in addition to the correlation between them. It was observed that the differences between the Northeast macro-region and the others presented an effect size ranging from moderate (*versus* North and Midwest) to high (*versus* Southeast and South). In relation to the national estimate (Brazil), it varied between small (*versus* Midwest) and high (*versus* Northeast). Furthermore, it was observed that only the North macro-region did not show a significant correlation with the national estimate in the last 15 years, demonstrating a distinct pattern of temporal variation. The other macro-regions showed a significant, positive, and moderate correlation with the national estimate.

Table 3. Macro-regional comparison of the annual number of outpatient dental procedures performed by Pediatric Dentists in the Brazilian Unified Health System between 2008 and 2022 for every 100,000 residents aged zero to fourteen.

Comparison	Difference	p-value	m
North <i>versus</i> Northeast	1,560 [-583, 3,851]	0.036*	0.609
North <i>versus</i> Southeast	N/A	0.785	N/A
North <i>versus</i> South	N/A	0.828	N/A
North <i>versus</i> Midwest	N/A	0.993	N/A
Northeast <i>versus</i> Southeast	-3,265 [-2,103, -4,104]	<0.001*	0.884
Northeast <i>versus</i> South	-3,551 [-1,754, -4,659]	0.002*	0.804
Northeast <i>versus</i> Midwest	-1,185 [-495, -2,049]	0.041*	0.600
Southeast <i>versus</i> South	N/A	0.997	N/A
Southeast <i>versus</i> Midwest	N/A	0.052	N/A
South <i>versus</i> Midwest	N/A	0.241	N/A

*Statistically significant; [-]: 95% Confidence interval; m: Magnitude (point-biserial correlation coefficient); N/A: Not applicable.

Table 4. Comparison between macro-regions and the national estimate regarding the annual number of outpatient dental procedures performed by Pediatric Dentists in the Brazilian Unified Health System between 2008 and 2022 for every 100,000 residents aged zero to fourteen.

Comparison	Difference	p-value	m	ρ
North <i>versus</i> Brazil	N/A	0.512	N/A	0.478
Northeast <i>versus</i> Brazil	-2,703 [-1,270, -3,313]	<0.001*	0.782	0.578*
Southeast <i>versus</i> Brazil	N/A	0.137	N/A	0.617*
South <i>versus</i> Brazil	N/A	0.126	N/A	0.564*
Midwest <i>versus</i> Brazil	-1,381 [-112, -2,163]	0.033*	0.458	0.557*

*Statistically significant; [-]: 95% Confidence interval; m: Magnitude (point-biserial correlation coefficient); ρ : Spearman's rho coefficient; N/A: Not applicable.

At last, Table 5 presents the incidence rates for the annual number of ODPs performed by Pediatric Dentists in the SUS between 2008 and 2022 for every 100,000 residents aged zero to fourteen. Considering the

results of the preliminary assessments in Tables 1 and 3, the Northeast macro-region was eligible as a reference and the national estimate. It was observed that the Northeast macro-region had a lower annual incidence rate when compared to the other macro-regions of Brazil and the national estimate in the last 15 years, corroborating the differences observed in the multiple and pairwise comparisons. However, the difference between the Midwest macro-region and the national estimate was not confirmed.

Table 5. Comparison of the incidence rate of outpatient dental procedures performed by Pediatric Dentists in the Brazilian Unified Health System between 2008 and 2022 for every 100.100 residents aged zero to fourteen.

Comparison	Distribution	IRR	Limits		p-value
			Lower	Upper	
Reference (Macro-Region)			Northeast		
Intercept	QPO	4.138	3.374	4.994	<0.001*
North		2,90	1,46	6,25	0.005*
Southeast		2,64	1,32	5,73	0.010*
South		3,14	1,60	6,72	0.002*
Midwest		2,17	1,05	4,79	0.045*
Reference (National Estimate)			Brazil		
Intercept	QPO	4.133	3.487	4.845	<0.001*
North		1,32	0,79	2,23	0.284
Northeast		0,45	0,22	0,89	0.029*
Southeast		1,20	0,71	2,05	0.481
South		1,43	0,87	2,39	0.166
Midwest		0,99	0,57	1,72	0.975

QPO: Quasi-Poisson distribution; IRR: Incidence rate ratio; *Statistically significant.

■ Discussion

Considering these results, the alternative hypothesis tested (H_1) was fully accepted: there are macro-regional disparities in specialized outpatient dental care for children in the SUS. In summary, a large number of ODPs have been performed by Pediatric Dentists in the SUS over the past 15 years. However, there was a significant oscillation in annual values, often producing stationary trends in the Brazilian macro-regions, especially when the impact of the COVID-19 pandemic was removed. Nonetheless, the Northeast macro-region had the lowest incidence rate compared to the others, while the north showed a different incidence pattern over time, including a high variability.

In theory, performing fewer ODPs does not directly imply a negative outcome, as it is possible to hypothesize that the resolution of PHC or oral health needs interferes with the demand for secondary healthcare services in each territory. However, in order to understand the lower incidence of ODPs by specialists in Pediatric Dentistry in the Northeast macro-region, it is necessary to consider that evidence already pointed to the non-achievement of basic goals related to DSCs productivity and their mandatory dental specialties over the years [13,23-26].

Since Pediatric Dentistry is a non-mandatory specialty (not included in the list of mandatory specialties in the DSCs, but health managers can voluntarily include it) [12], it is reasonable to hypothesize that the specialized dental care provided by their specialists does not deviate from the general panorama. Moreover, although a large number of DSCs have been implanted in this macro-region [23], there is no information on the performance of Pediatric Dentists since the investigations, as mentioned earlier, focused on mandatory specialties, indicating the scarcity of information on specialized dental care for children in the SUS, as previously pointed out [12].

The need to include Pediatric Dentistry in the list of mandatory specialties, among other perspectives, considers the macro-regional disparities in access to oral health services, allowing the production of indicators related to this specialty and specialized dental care for children. The disparities start in the PHC services when the unsatisfactory coverage and resolving capacity result in the referral of children to more complex services (technological density higher than the PHC), such as the DSCs. In children, difficulties in managing behavior and cooperating with dental treatment are among the main motivations. However, there is no consistent information on these referrals and counter-referral system, including the availability of Pediatric Dentists acting in oral health services linked to the SUS (including DSCs), as well as access to private oral health services by children [27,28], which limits the understanding of the phenomenon in all macro-regions.

When examining the National Register of Health Establishments (*Cadastro Nacional de Estabelecimentos de Saúde*) in the TabNet tool, exploring human resources (specialists in Pediatric Dentistry who worked at the SUS from 2008 to 2022 in Brazil), it is possible to observe that the majority were linked to the type of establishment "clinic/specialty center." Nonetheless, a considerable number of pediatric dentists have worked in other health services, including PHC (such as BHU/FHU), outpatient clinics, polyclinics, hospitals, emergency care units, and management services. Therefore, it is not possible to establish precisely which services are responsible for the ODPs evaluated here, although DSCs are the most widespread in the scenario. In addition, it is important to point out that in January 2008, there were 1,343 Pediatric Dentists registered in health establishments that serve the SUS (the lowest number), increasing to 1,595 in 2022. The highest number was in August 2010 (1,745 Pediatric Dentists) [16]. Hence, the variability in the number of professionals is another important factor in the variability of the number of ODPS observed in the results, also considering the stationary trends observed.

Furthermore, it is necessary to consider that the result of the Northeast macro-region follows previous evidence on the oral health of children living in that territory. Considering the experience of tooth decay as a valuable example, based on data from the National Oral Health Survey - SBBrazil Project 2010, Cruz et al. [29] pointed to the high prevalence of cavities in children in the Northeast. In this macro-region, the prevalence of untreated dental caries reached 68.9% in interior cities (small towns) [29]. In a cohort of vulnerable children from a capital city in the Northeast macro-region, Melo et al. [30] also demonstrated the high prevalence of dental caries in the primary dentition, including the worsening of the dmft index over time (worse than the SBBrazil 2010 estimate), corroborating concerns regarding the oral health of children living in this macro-region [30].

Although dental caries is not the only concern in relation to children's oral health, it is a relevant Public Health problem in Brazil, the results of which highlight the need to evaluate the performance of public health policies and services for children's dental care. In fact, the Northeast macro-region is often described as vulnerable in socioeconomic terms, unlike the Southeast and South. Although the reasons why this vulnerability exists and persists are complex, they translate into a set of risk factors for individuals and the territories in which they live, considering access and resolvability of oral health services (especially those linked to PHC, such as BHU/FHU) [29,30].

Therefore, considering the state of the art and the results of this study, it is possible to understand that inequalities related to territory are relevant components for understanding specialized care for children's oral health in Brazil. However, expanding knowledge, the results reported here introduce a new perspective to contemporary evidence, demonstrating that specialized dental care for children (provided by Pediatric Dentists) cuts across the macro-regional disparities in this country. Indeed, it is possible to question whether these results

correlate with the unfavorable indicators of children's oral health in the Northeast. There is a gap regarding the impact of Pediatric Dentists in oral health services at the secondary level of care (such as DSCs) on children's oral health indicators.

Ultimately, it is also necessary to consider that the COVID-19 pandemic negatively affected the offer of oral health services worldwide. Significant reductions in dental procedures offered by the SUS were observed in all Brazilian macro-regions. However, there were macro-regional disparities in this outcome, in which the North and Northeast macro-regions had a more pronounced impact in relation to the others [31-33]. This perspective may justify the stationary trend of the North macro-region when the years 2020 to 2022 were removed.







As a limitation, it is essential to consider that the annual values were extremely heterogeneous. It is possible that weaknesses and delays in the transfer of numbers to the SIA/SUS produce outliers (aggregating procedures performed previously in the same period).

In addition, there was no differentiation in the type of dental procedures performed between macro-regions. At last, it is important to consider that macro-regions have their own health regions, which were not considered in this macro-analysis. Future investigations may investigate the profile and oral health demands of children who need specialized dental care in the SUS, aiming to describe the actions of Pediatric Dentists at an outpatient level, as well as to evaluate the impact of the Pediatric Dentist included in DSCs team on local/regional- indicators of children's oral health.

■ Conclusion

There are macro-regional disparities in specialized dental care for children in the Brazilian Unified Health System (SUS). The northeast macro-region presented the lowest incidence of outpatient dental procedures performed by pediatric dentists in the last 15 years, and the north showed a distinct pattern of temporal variation from the national estimate. These outcomes help address Public Health actions that provide adequate specialized dental care to children in the SUS, overcoming demographic-related inequalities in search of better indicators of children's oral health.

■ Authors' Contributions

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All authors declare that they contributed to a critical review of intellectual content and approval of the final version to be published.

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None.

■ Conflict of Interest

The authors declare no conflicts of interest.

■ Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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