Endodontic treatment in the single health system in the north and southeast region of Brazil: 15 years of evaluation

RESUMO
Objetivo: Avaliar o acesso ao Endodontista e ao tratamento endodôntico radical por usuários do SUS nas regiões Norte e Sudeste do Brasil nos últimos 15 anos. Método: Foi realizado um estudo ecológico utilizando dados secundários do SUS. A quantidade de especialistas em Endodontia e de tratamentos endodônticos radicais em dentes decíduos e permanentes realizados por tais especialistas entre 2008 e 2022 foram recuperadas e analisadas com nível de significância de 5%. Resultados: Houve uma tendência temporal crescente na quantidade de especialistas em Endodontia nas regiões Norte e Sudeste (p < 0,05). Entretanto, não houve uma tendência temporal crescente na quantidade de tratamentos endodônticos radicais na região Norte (p > 0,05), somente na Sudeste (p < 0,05). Conclusão: O acesso ao Endodontista por usuários do SUS aumentou nas regiões Norte e Sudeste do Brasil, mas a realização de tratamentos endodônticos radicais por tais especialistas aumentou somente na região Sudeste.

DESCRITORES: Endodontia; Sistema único de saúde; Serviços de saúde bucal; Assistência odontológica.

ABSTRACT
Objective: To evaluate access to Endodontists and radical endodontic treatment by SUS users in the North and Southeast regions of Brazil in the last 15 years. Method: An ecological study was carried out using secondary data from the SUS. The number of specialists in Endodontics and radical endodontic treatments in deciduous and permanent teeth performed by such specialists between 2008 and 2022 were retrieved and analyzed with a significance level of 5%. Results: There was an increasing temporal trend in the number of specialists in Endodontics in the North and Southeast regions (p < 0.05). However, there was no increasing temporal trend in the number of radical endodontic treatments in the North region (p > 0.05), only in the Southeast (p < 0.05). Conclusion: Access to Endodontists by SUS users increased in the North and Southeast regions of Brazil, but the performance of radical endodontic treatments by such specialists increased only in the Southeast region.

DESCRIPTORS: Endodontics; Health Uni System; oral health services; Dental care.

RESUMEN
Objetivo: Evaluar el acceso al endodoncista y al tratamiento endodóntico radical por los usuarios del SUS en las regiones Norte y Sudeste de Brasil en los últimos 15 años. Método: Se realizó un estudio ecológico utilizando datos secundarios del SUS. Se recuperó el número de especialistas en Endodoncia y los tratamientos de endodoncia radical en dientes deciduos y permanentes realizados por dichos especialistas entre 2008 y 2022 y se analizaron con un nivel de significación del 5%. Resultados: Hubo una tendencia temporal creciente en el número de especialistas en endodoncia en las regiones Norte y Sureste (p < 0,05). Sin embargo, no hubo una tendencia temporal creciente en la cantidad de tratamientos endodônticos radicais en la región Norte (p > 0,05), sólo en la Sudeste (p < 0,05). Conclusión: El acceso a endodoncistas por parte de los usuarios del SUS aumentó en las regiones Norte y Sudeste de Brasil, pero la realización de tratamientos endodônticos radicais por dichos especialistas sólo aumentó en la región Sudeste.

DESCRIPTORES: Endodoncia; Sistema Único de Salud; Servicios de salud bucal; Atención odontológica.

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INTRODUCTION

Understanding access to Endodontists and their procedures is a way to measure the supply and demand for oral health services. In Brazil, the Unified Health System (SUS) incorporates Endodontics among the specialties of oral health care in the public sector. However, although there are no regulatory restrictions regarding the performance of endodontic procedures among dentists, Endodontists are often linked to the secondary care level, assigned to Dental Specialty Centers (DSCs) to provide such assistance. Between 1999 and 2017, considering the outpatient productivity of the SUS, approximately 3.5 billion dental procedures were registered, of which endodontic procedures accounted for 0.5%. 

Even so, it is known that the dynamics of supply and demand for oral health services depend, among other factors, on the population size and coverage achieved in the assigned territory, in addition to management and resolving capacity, it is possible to observe micro and macro regional disparities in Brazil in access to procedures and specialties. With regard to the North and Southeast regions of Brazil, Chisini et al. (2019) reported that there was no positive linear trend in the amount of endodontic procedures over the last 19 years, indicating a stationary behavior. In contrast, the other macro-regions in Brazil showed a significant growth trend. However, it was observed that these authors did not distinguish endodontic procedures performed specifically by specialists in Endodontics, accounting for all the productivity of dentists in the SUS in relation to the procedures that were categorized in this specialty.

In parallel, it is known that the Southeast region, despite a significant expansion between 2002 and 2016, presents insufficient coverage in oral health care at the primary level (Family Health Strategy; FHS), which can generate demands for the secondary level, such as DSCs. In addition, although it has one of the largest numbers of DSCs in Brazil, the target related to Endodontics has not been satisfied in this Brazilian region in most of them. With regard to the North region, it is known that it was the macro-region with the second highest growth of oral health teams in the FHS after the implementation of Brasil Sorridente. However, the achievement of goals related to Endodontics in secondary care also showed a significantly decreasing trend between 2008 and 2018. However, the role of dentists specializing in Endodontics in the SUS in the North and Southeast regions has not been fully evaluated in recent years, such as the number of professionals working and their productivity over time in relation to radical endodontic procedures. It is reasonable to question the behavior of these variables over time, seeking to understand how they relate to DSCs’ assessments in these macro-regions and to the panorama of public policies and oral health services in these territories in the public sector.

Therefore, the aim of this study was to evaluate access to Endodontists and radical endodontic treatment by SUS users in the North and Southeast regions of Brazil over the last 15 years. The alternative
hypotheses examined were: (H1) - there was a growing temporal trend in the number of dentists specializing in Endodontics working at SUS in the North and Southeast regions of Brazil; (H2) - there was a growing temporal trend in the number of radical endodontic treatments performed by dentists specialized in Endodontics at the SUS in the North and Southeast regions of Brazil; (H3) - there was an increasing temporal trend in the productivity (radical endodontic treatments) of dentists specialized in Endodontics in the SUS in the North and Southeast regions of Brazil.

METHOD

This is an epidemiological study of the ecological type, with a longitudinal, retrospective and quantitative approach, configuring a time series. Data were collected and analyzed from the SUS Outpatient Information System (SIA/SUS), provided by the SUS Department of Informatics (DATASUS) in open access, characterizing the public domain of the information source. Therefore, according to national resolution number 510/2016 of the National Health Council, there was no need for ethical submission and appreciation. There is no data relating to any individual, establishing the population nature of the approach. The checklist of the STROBE initiative (Strengthening the Reporting of Observational Studies in Epidemiology) was used to structure and enhance the scientific report of the study.

Regarding the variables, the following were collected: (1) average annual number of dentists specializing in Endodontics who provided care in the North and Southeast regions of Brazil, (2) amount of radical endodontic treatments performed by these professionals and (3) population projection (residents) of the Brazilian Institute of Geography and Statistics. Temporally, data were collected for the period between 2008 and 2022 (last 15 full years; n = 15). There was no restriction in relation to health services, considering all outpatient production in the SUS.

The average annual number of dentists specializing in Endodontics who worked at the SUS for each year was obtained using the respective code in the Brazilian Classification of Occupations (#223212; inserted as a filter) and the filter "serves at the SUS", considering a simple average between the months of January, June and December, without restricting the type of service or level of health care, acting as a proxy measure. Regarding the evaluated radical endodontic treatments, pulpectomies in deciduous or permanent teeth (including retreatment procedures) performed by dentists specialized in Endodontics were considered.

The codes used to identify and group them in the SIA/SUS were: #0307020037 (ENDODONTIC TREATMENT OF DECIDUOUS TOOTH), #0307020061 (ENDODONTIC TREATMENT OF PERMANENT UNI-RADICULAR TOOTH), #0307020045 (ENDODONTIC TREATMENT OF PERMANENT BI-RADICULAR TOOTH), #0307020053 (ENDODONTIC TREATMENT OF PERMANENT TOOTH WITH THREE OR MORE ROOTS), #0307020100 (ENDODONTIC RETRACTION IN SINGLE-ROAD PERMANENT TOOTH), #0307020088 (ENDODONTIC RETRACTION IN BI-RADICULAR PERMANENT TOOTH) and #0307020096 (PORTRAIT ENDODONTIC CARE IN PERMANENT TOOTH WITH 3 OR MORE ROOTS).

Data collection was carried out between January and April 2023, using the TabNet tool (after qualitative training). A single researcher collected the data used in the study, following a systematic procedure based on a guideline on the use of SIA/SUS to monitor activities in oral health and in a study with a similar method. Considering the population factor, the number of dentists specialized in Endodontics and radical endodontic treatments in each year were described and analyzed in a crude and normalized way.
per 100,000 residents in Brazil, to correct the effect of demographic changes over the last 15 years. Productivity was obtained by the simple ratio between the number of procedures and professionals working in the SUS (annual average of radical endodontic treatments performed by dentists specialized in Endodontics).

The collected data were stored in spreadsheets to receive statistical treatment. PAST software (version 4.3, Oslo, Norway) was used to perform statistical analyses, with a significance level of 5% ($\alpha = 0.05$). The Shapiro-Wilk (W) test and the Q-Q plot were used to test the hypothesis of normality of the residuals. Durbin-Watson (DW) statistics were used to examine the influence of serial autocorrelation. Data were described by means (measure of central tendency) and standard deviation (measure of variability).

When feasible, minimum and maximum values were presented. The Kruskal-Wallis test was used to compare quantitative variables with non-normal distribution between three independent groups, followed by the post hoc Dwass-Steel-Critchlow-Fligner test. Magnitude (effect size; $m$) was examined in pairwise comparison by point-biserial correlation coefficient. Kendall’s tau coefficient ($\tau$) was used to examine the significance, direction, and strength of correlations between quantitative variables.

The temporal trend in non-normal data was examined by the Mann-Kendall S coefficient. For the productivity variable, the hypothesis of first order serial autocorrelation was rejected in all macro-regions and in the national estimate ($p > 0.05$ in all analyses). After logarithmic transformation in base ten ($\log_{10}$), given the assumption of normality of the residues after the Shapiro-Wilk test ($p > 0.05$), the angular coefficients ($\beta_1$) were obtained through linear regression using the ordinary least squares method to estimate the temporal trend. 12,13

### RESULTS

With regard to the projection of residents by the IBGE in the period evaluated, growth was observed in the North region, increasing from 15,658,112 in 2008 to 18,983,716 in 2022. The same outcome was observed in the Southeast region, from 80,904,319 in 2008 to 89,589,414 in 2022. In the North region, a gross increase of 3,325,604 residents was projected between 2008 and 2022, representing approximately 21.2%. In the Southeast region, the projected gross addition was 8,685,095 residents, representing an approximate increase of 10.7%. When
evaluating the average annual number of dentists specializing in Endodontics who worked in the SUS, Table 1 presents the panorama of the North and Southeast regions of Brazil per 100,000 residents in each macro-region.

It was observed that both macro-regions showed an increasing temporal trend, pointing to the progressive increase in the raw value and normalized by the population factor over the last 15 years, portraying the statistically significant increase in the number of dentists specializing in Endodontics who worked in the SUS. It is noteworthy that the largest gross addition of projected residents in the North region reduced the magnitude of growth in the analysis normalized by the Mann-Kendall S statistic during the normalized analysis, as well as none of the macro regions reached the mark of one professional per 100,000 residents. Even so, both macro-regions followed the growing trend observed nationally in the crude (S = 100, p < 0.001) and normalized (S = 92, p < 0.001) analysis in Brazil. Therefore, it is possible to understand that there was an increase in the number of dentists specializing in Endodontics who worked in the SUS in the North and Southeast regions of Brazil.

In addition, there was a statistically significant, positive and weak correlation between the average number of dentists specializing in Endodontics who worked in the SUS in the last 15 years (per 100,000 residents) between the North and Southeast regions of Brazil (τ = 0.494, p = 0.012). The same outcome was observed between the North region and Brazil (τ = 0.484, p = 0.014). On the other hand, there was a very strong correlation between the Southeast region and Brazil (τ = 0.940, p < 0.001). Comparatively, the amount of the North region was statistically smaller when compared to the Southeast region (m = 0.835, p < 0.001) and to Brazil (m = 0.862, p < 0.001), which also differed from each other (m = 0.542, p = 0.030). Therefore, it is possible to understand that, despite the progress, the North region has a lower number of dentists specialized in Endodontics who worked in the SUS per 100,000 residents when compared to the Southeast region and Brazil, whose difference was high. Finally, the Southeast region was also below the national parameter, with moderate magnitude.

In 2008, based on the average estimate of professionals and residents, 42.6% of Endodontists who worked in the SUS were in the Southeast region and 7.1% in the North region. In 2022, 37.1% in the Southeast region and 7.1% in the North region. However, evaluating proportionally (%) the national growth, it is observed that the North region presented a stationary trend (p = 0.268) and the Southeast region significantly reduced its proportion of professionals in relation to Brazil over the last 15 years (S = 91, p < 0.001). Even so, this scenario is relatively compatible with the population projection in the North and Southeast regions, in which approximately 8.8% and 41.7% of residents in Brazil are in these macro-regions, respectively.

When evaluating the number of radical endodontic treatments performed by dentists specialized in Endodontics in the SUS, it was observed that 11,330,045 procedures were performed in Brazil, with 3,382,767 (approximately 29.8%) in the Southeast region and 611,762 (approximately 5.4%) in the North region between 2008 and 2022. Table 2 and Figure 1 present, respectively, the descriptive and visual overview of this number over the last 15 years per 100,000 residents in each macro-region. It was observed that the North region showed a stationary temporal trend in the crude and normalized analysis, while the Southeast region showed a significantly increasing temporal trend, indicating a progressive increase in the number of radical endodontic treatments performed in this macro-region, whether in the crude or normalized analysis.

Furthermore, unlike the average number of professionals, there was no statistically significant correlation in the number of radical endodontic treatments per 100,000 residents between the North and Southeast regions of Brazil (p = 0.812). Both regions were not correlated with Brazil (p = 0.060 and p = 0.082, respectively). When comparing them quantitatively, there was also no statistically significant difference (p = 0.425). Such an outcome is understandable given the high variability over the last 15 years in this variable.

Finally, with regard to the productivity of dentists specializing in Endodontics...
who have worked in the SUS over the last 15 years, considering radical endodontic treatments, Table 3 and Figure 2 show, respectively, the descriptive and visual overview of this variable. It is possible to observe that the North region had a higher productivity in the initial years evaluated compared to the Southeast region, showing a decline in 2017. In contrast, the Southeast region increased its productivity over time, with a significant decline only in 2020. However, there was no statistically significant difference in productivity between them, including the comparison of both with the national estimate (p = 0.195). On the other hand, the productivity of the North region was not correlated with that of the Southeast region (p = 0.920) or Brazil (p = 0.532). Between the Southeast region and Brazil, there was a significant, positive and moderate correlation (τ = 0.593, p = 0.001) in productivity.

Although both temporal trends are stationary, as well as the national estimate (p = 0.056), it is noteworthy that after removing the productivity of the years 2020 and 2021 (outliers), the temporal trend of the North region remains stationary (p = 0.738), while the Southeast region shows a significantly increasing trend over the last 15 years (p = 0.002), as well as the national estimate (p = 0.001). In addition, it was observed that the number of radical endodontic treatments increased significantly in the year 2022 in both macro-regions, as well as in Brazil.

The productivity outcome is a reflection of behavior related to the number of professionals and procedures performed. In the North region, there was an increase in the number of dentists specializing in Endodontics working in the SUS, but there was no increase in the number of radical endodontic treatments performed by them, causing a stationary productivity with a negative angular coefficient (maintained after removing the outliers related to the years 2020 and 2021). In the Southeast region and in Brazil, in addition to the increase in professionals, there was an increase in the number of procedures, resulting in a stationary productivity with a positive angular coefficient in a first analysis. After removing the outliers, in a secondary analysis, it was observed that there would be an increasing productivity when ignoring the data for the years 2020 and 2021.

**DISCUSSION**

The present study evaluated access to Endodontists and radical endodontic treatment by SUS users in the North and Southeast regions of Brazil over the last 15 years. The first alternative hypothesis examined (H1) was fully accepted, as the-
re was a significantly increasing temporal trend in the gross and normalized number (per 100,000 residents) of dentists specializing in Endodontics working in the SUS in both macro-regions between 2008 and 2022. The second (H2) was partially accepted, since there was no significant temporal trend in the number of radical endodontic treatments performed by dentists specializing in Endodontics who worked in the SUS between 2008 and 2022 in the North region, only in the Southeast region. The third (H3) was rejected, since there was no increasing temporal trend in productivity related to radical endodontic treatments performed by dentists specialized in Endodontics in the SUS in the North and Southeast regions of Brazil.

It is important to note that the behavior of the Southeast region was correlated with that of Brazil in terms of professional numbers and productivity. In addition, the number of dentists specializing in Endodontics who worked in the SUS per 100,000 residents was significantly lower in the North region, when compared to the Southeast region and Brazil (influenced by the significant increase in the projection of residents between 2008 and 2022), although the mark of one professional per 100,000 residents was not reached in any of them.

In the first analysis, it is important to recognize that the increase in the number of Endodontists attending the SUS in the North and Southeast regions is an important perspective. With data from 2014, Rios and Colussi (2019) reported that the North region was the macro-region with the lowest number of DSCs in the country (6%), showing the worst ratio between the number of DSCs and dentists working per residents compared to the other regions. In addition, the North region had the worst scenario in relation to the adequacy of the minimum specialties. Regarding the Southeast region, the authors observed that it was the second largest holder of DSCs in the country (36%).

On the other hand, it had the largest resident population among the Brazilian macro-regions, although the concentration of professionals and specialties working in DSCs is better when compared to other regions, such as the North of Brazil. 14

The advances demonstrated here may suggest an advance in such parameters evaluated in 2014.

In addition, a previous study (2012) reported that only 54.5% and 40.4% of DSCs in the North and Southeast regions met the targets related to Endodontics in secondary oral health care, respectively. In the same study, 66.7% and 49.4% of DSCs in these regions were categorized as terrible, poor and fair in the assessment of productivity performance reported in the SIA/SUS, respectively. 14 Therefore, it is reasonable to understand that the scenario demonstrated in our approach suggests the need to reassess such parameters in recent years in the North and Southeast of Brazil, hypothesizing that the significant increase in the number of Endodontists and their procedures in the SUS may influence the performance criteria by specialties in this region of Brazil, producing a different panorama from the aforementioned evaluations in 2012 and 2014. 14,15

It is important to consider that the implementation of DSCs is a relatively recent measure in Brazil, considering that the National Oral Health Policy (PNSB - Política Nacional de Saúde Bucal) was launched in 2004 by the Ministry of Health. With national guidelines, DSCs and their specialties must be guided by the demand that is not met by primary care (PC), based on referral and counter-referral systems, reducing spontaneous demand. Even so, there is no effective consolidation of these systems, as well as the criteria for evaluating the productivity of specialists, such as Endodontists, still need adjustments, especially the need to be guided by the epidemiological profile of the population assigned to the territory. 6,16

In addition, there is no minimum number of specialists working in the SUS for each consolidated epidemiological and demographic scenario. Therefore, it is possible to question whether the number of dentists specializing in Endodontics who work in the North and Southeast regions of Brazil, even if it has increased in the last 15 years, is sufficient for the
demands of the resident population and had a positive impact on productivity goals. Such questioning is supported, in light of the evidence, with the perspective that productivity targets in the field of Endodontics were unsatisfactory at the national level for most DSCs in 2012 and 2014.\textsuperscript{14,15} ten years after the launch of the PNSB in Brazil.

The increase in the number of radical endodontic treatments performed by dentists specializing in Endodontics in the Southeast region is also an important perspective, especially when we hypothesize that the increase in the number of these professionals working in the SUS would not directly imply this outcome. It is important to consider that dental treatment has costs and the recent economic crises negatively impact access to it with individual resources (private sector), increasing the burden exerted on the public sector by users of health systems around the world, such as the SUS in Brazil, in addition to being associated with the reduction of oral health indicators.\textsuperscript{17,18}

It is known that radical endodontic treatment has evolved in recent years, but there is a significant associated cost to perform it, whether in the public or private sector.\textsuperscript{19} From this perspective, the hypothesis is generated that such an increase in the number of procedures may be due, among other factors, to the impossibility of accessing private oral health services due to the reduction in purchasing power in recent years. On the other hand, the North region, which did not have an increasing temporal trend, presented significant barriers in accessing Dentistry in the SUS, including difficulties in scheduling appointments and long waiting times to access specialists, with a lower frequency of users who did not go to the dentist in relation to the other macro-regions of the country.\textsuperscript{20} in addition to the lower number of Endodontists working in the SUS in relation to the Southeast region and Brazil, as demonstrated in this study.

Socioeconomic status, education, sex and age group, in addition to access to oral health services, present disparities between regions in Brazil, triggering a heterogeneity of oral health needs.\textsuperscript{21,22} Therefore, it is possible that the need for endodontic treatment (NET) may be distinct between them. However, NET has not been systematically evaluated and measured in Brazilian regions. At the same time, it is also possible that efforts to replace the “mutilating” culture by adopting increasingly efficient restorative and rehabilitative therapies will encourage the population to seek endodontic treatments more frequently, avoiding radical behaviors such as tooth extractions.\textsuperscript{23}

Finally, there was a sharp decline in the number of radical endodontic procedures and the productivity of Endodontists between 2020 and 2021, years strongly associated with the negative effects of the COVID-19 pandemic.\textsuperscript{11} in addition to the significant increase in 2022 (two years after the beginning of restrictive measures). Oral health in the SUS was strongly impacted by the measures adopted to deal with the pandemic context in the dental environment, such as the suspension of elective procedures and the reduction in the generation of aerosols. It is possible that such a measure, together with the users’ fear of seeking health services, were the main drivers for the reduction in the number of endodontic procedures observed in the pandemic period.\textsuperscript{24,25} As a consequence, it is reasonable to hypothesize that unmet demands during this period are triggering a greater NET in the SUS in the North and Southeast regions of Brazil today, which also requires systematic investigations.

It is important to consider the limitations of the present study when applying the results and perspectives discussed. The number of specialists in Endodontics who worked in the SUS was retrieved by the CNES - National Register of Health Establishments (Cadastro Nacional de Estabelecimentos de Saúde). Therefore, professionals without the official registration of the specialty can influence the outcome reported here. At the same time, no restriction was made regarding the type of service or level of health care in which Endodontists worked, including DSCs and others linked to the SUS. In addition, it is possible that there is some degree of underreporting of the number of radical endodontic treatments in deciduous and permanent teeth, since they depend on the adequate

When understanding such outcomes, it is also worth considering that the occurrence and prevalence of oral health conditions that may require radical endodontic treatments (e.g. caries disease and dentoalveolar trauma) present different dynamics in the Brazilian territory, whether at the micro or macro-regional level.
completion of the Outpatient Production Bulletin (BPA - Boletim de Produção Ambulatorial) by the health services. In the future, new studies may continue to monitor access to endodontic specialists and their procedures, correlating them with local oral health indicators.

CONCLUSION

It is possible to conclude that there has been an increase in the number of dentists specializing in Endodontics working in the SUS in the North and Southeast regions in the last 15 years. However, only the Southeast region showed a significant increase in the number of radical endodontic treatments in deciduous or permanent teeth performed by such professionals. The relationship between the number of procedures per professional (productivity) remained stationary in both macro-regions.

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