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Original articles

Time trend of audiological procedures in the Brazilian Public Health System

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ABSTRACT

Purpose: to analyze the time trend of audiological procedures in the Brazilian Public Health System (SUS) between 2008 and 2019 in the geographical regions of Brazil.

Methods: a time series ecological study with data on audiological procedures from the SUS Outpatient Information System. The study calculated annual indices of audiological procedures with joinpoint regression for the trend analysis. The progress in the provision of procedures between the initial and final years in the series and the distribution of identified records was calculated.

Results: altogether, 38,500,404 records were found in the study period. The South (178.84/10,000 inhabitants) and North of Brazil (130.97/10,000 inhabitants), respectively, had the highest and lowest mean procedure indices. Both were the only regions with a trend towards a significant increase in procedures. In Brazil, they increased by 56.91%, with an emphasis on the increase in "otoacoustic evoked emissions in neonatal hearing screening" and a decrease in "visual reinforcement audiometry (air/bone conduction)." In the distribution, procedures concentrated on basic audiological assessments.

Conclusion: audiological procedures have increased at SUS, but there are discrepancies between procedures and geographical regions of Brazil.

Keywords: Audiology; Hearing Loss; Health Evaluation; Unified Health System; Health Information Systems

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INTRODUCTION

The World Health Organization estimates that over 1.5 billion people worldwide have some degree of hearing loss (HL) - a figure that tends to increase considerably in the upcoming decades[1]. Pointed out as a growing global health concern[2], HL causes communication, psychological, social, and economic harm, interfering with people's quality of life[3].

Due to the sharp increase in the condition and its implications, it is essential to invest in HL prevention, diagnosis, and treatment[4]. The priority a country gives to hearing health in its health system plays a crucial role in society, requiring measures centered on the complex challenges posed by HL[5]. In Brazil, healthcare is provided to the population through the Brazilian Public Health System (SUS, in Portuguese), a public, dynamic, and complex health system that aims to provide universal preventive and curative healthcare, based on decentralized health service administration and attention[6]. SUS is known to have significantly improved over time its care for people presented with HL[7].

The National Hearing Health Care Policy (PNASA, in Portuguese) was established in 2004 through Regulation GM/MS no. 2,073 to increase health coverage for people with HL. It organized a series of comprehensive promotion, prevention, treatment, and rehabilitation services in the various levels of SUS, with multiprofessional and interdisciplinary care[8]. In 2011, PNASA was repealed with Decree no. 7,612, which implemented the National Plan for the Rights of People with Disabilities - Living without Limits to integrate and coordinate policies and promote programs and actions to ensure the full and equal rights of people with disabilities[9]. Given the need to improve the quality of healthcare for people with disabilities and their access to it by incorporating it into the reorganization of the health system through Healthcare Networks[10], Regulation GM/MS no. 793 created the Healthcare Network for People with Disabilities[11].

After PNASA was implemented, hearing health attention and services increased in Brazil[12]. To receive hearing aids from SUS, people with HL require a thorough diagnosis, in which professionals make assessments and audiological procedures to determine its type and degree[13]. Timely diagnosis is a preponderant time factor for individuals to benefit from rehabilitation and mitigate HL impairments. Accordingly, services must be supported by appropriate diagnostic follow-up[1].

In general terms, amid the progress and increased access to healthcare ensured by SUS, Brazil is characterized by deep regional and social inequalities[6]. As hearing health is provided by SUS, it can also be weakened by social, demographic, and economic characteristics of the country, such as its large territory, socioeconomic contrasts, and unequal distribution of material and human resources[7]. Thus, audiological services in Brazil have sharp disparities[12,14].

Large countries with great differences between their regions must analyze their data on audiological services[2]. Studies with secondary data have shown unequal hearing healthcare between the Brazilian geographical regions, such as the disparate provision of hearing devices by SUS[15,16]. However, few experiences have been published based on surveyed data on outpatient hearing healthcare, particularly in terms of audiological procedures[12]. Hence, to ensure improvements, it is necessary to know the profile of procedures used in the services[17].

Data on outpatient care are greatly relevant to analyze hearing health. Such information with nationwide records of the services is available in the SUS Outpatient Information System (SIA/SUS, in Portuguese), making it possible to survey the data on audiological procedures[18]. As hearing health attention in Brazil improves, the analysis of these procedures helps understand data history, identifying critical aspects and decision-making in health.

Given the above, this study aimed to analyze the time trend of audiological procedures at SUS between 2008 and 2019 in the geographic regions of Brazil.

METHODS

This is a time series ecological study, developed with SIA/SUS data, which is administered by the SUS IT department (DATASUS, in Portuguese) of the Ministry of Health. Since secondary public-domain data were used and no humans were identified, this study was exempted from Research Ethics Committee evaluation, in compliance with Resolution no. 510/2016 of the National Health Council[19].

The study approached audiological procedures used between 2008 and 2019; the initial date was set based on procedure codes updated at the time in SIA/SUS. The analysis units corresponded to the five geographical regions of Brazil. Hence, the study was directed by the set of audiological procedures codes in the SUS Management System of the Table of

Procedures, Drugs, Orthoses, Prostheses, and Special Material (SIGTAP, in Portuguese).

The procedures of interest were found in SIGTAP under the group "diagnostic procedures", subgroup "specialty diagnostic methods", organized as "otorhinolaryngology/speech-language-hearing diagnosis", including the audiological procedures (Chart 1). Having selected the codes, data were collected from SIA/SUS in September 2020 by sequencing the items "health information (TABNET)", "health care", and "outpatient service (SIA/SUS)", filtered with "per place of service - since 2008", taking as a reference the number of procedures approved in outpatient services per year, from January to December.

Chart 1. Audiological procedures selected for study analysis

Code and description
0211070025 - Visual reinforcement audiometry (air/bone conduction)
0211070033 - Free-field audiometry
0211070041 - Pure-tone threshold audiometry (air/bone conduction)
0211070050 - Behavioral hearing assessment
0211070092 - Hearing loss diagnostic assessment
0211070106 - Hearing loss differential diagnostic assessment
0211070149 - Otoacoustic evoked emissions in neonatal hearing screening
0211070157 - Transient-evoked and distortion-product otoacoustic emissions
0211070203 - Acoustic immittance
0211070211 - Speech audiometry (VDT-SRI-SRT)
0211070262 - Short-, middle-, and long-latency auditory evoked potentials
0211070270 - Auditory evoked potentials in neonatal hearing screening
0211070297 - Hearing loss diagnostic reassessment in patients above 3 years old
0211070300 - Hearing loss diagnostic reassessment in patients under 3 years old
0211070360 - Schoolchildren hearing screening

Captions: VDT - voice detection threshold; SRI - speech recognition index; SRT - speech recognition threshold.

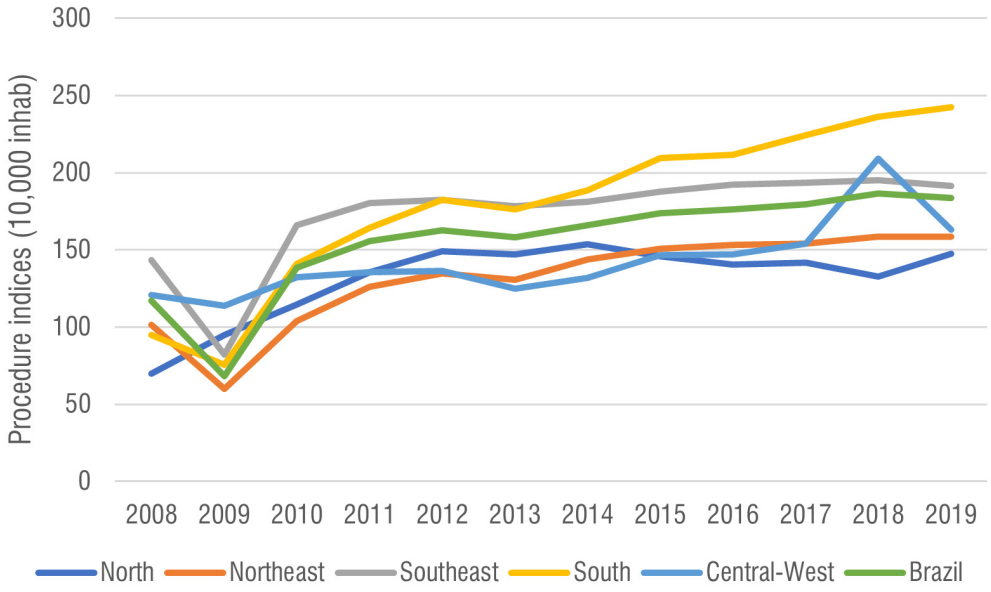
After extracting the data, the number - the sum of all surveyed procedures - was initially grouped per year. Then, the indices were calculated per 10,000 inhabitants, encompassing the number of procedures, whose denominators were the population estimates furnished by the Brazilian Institute of Geography and Statistics (IBGE, in Portuguese)[20]. Data were tabulated in Microsoft Excel 2019.

The time trends in procedures were analyzed with joinpoint regression, in the Joinpoint Regression Program (Surveillance Research Program, National Cancer Institute, USA), version 4.8.0.1. Its purpose is to identify trend pattern changes and annual percentage change (APC) in a regression, based on the trend in each segment, estimating whether values are statistically significant at the 95% confidence interval. Significance tests are guided by the Monte Carlo permutation method and the calculation of the index APC[21].

The indices of the initial and final years of the time series were calculated to analyze the progress in procedures provided throughout the period. Also, regarding the quantitative distribution of outpatient services, the percentages of each procedure were specified.

RESULTS

Between 2008 and 2019, 38,500,404 audiological procedures were recorded at SUS. The historical assessment results showed differences between the geographical regions of the country regarding the behavior of procedure indices. The Northeast, Southeast, and Central-West reached their highest indices in 2018; the North, in 2014; and the South, in 2019. On the other hand, 2009 had the lowest indices - except for the North, whose lowest index occurred in 2008 (Figure 1).



Caption: inhab - inhabitants

Figure 1. Audiological procedure indices (per 10,000 inhabitants) in the geographical regions of Brazil (2008-2019)

The mean national index of audiological procedures was 155.47/10,000 inhabitants. However, the comparison between units demonstrated that the South and North had respectively the highest and lowest mean values, as shown in Table 1. It also shows the procedure indices APC, according to joinpoint. The time trend analysis verified in APC1 a trend towards a significant increase in audiological procedures between 2008 and 2011 in the North (APC1 = 26.7; 95% CI 18.5 to 35.4) and South (APC1 = 26.9; 95% CI 1.0 to 59.5). As for APC2, only the South (APC2 = 5.3; 95% CI 0.2 to 10.7) had a trend towards a significant increase between 2011 and 2019.

Table 1. Time trend of audiological procedures (2008-2019): mean indices (10,000 inhabitants), annual percentage change, year in joinpoint regression, and 95% confidence intervals

Region	Mean indices	APC1	95% CI	APC2	95% CI
North	130.97	26.7* (2008-2011)	18.5 to 35.4	-0.4 (2011-2019)	-1.8 to 1.1
Northeast	131.29	14.2 (2008-2012)	-5.9 to 38.6	3.0 (2012-2019)	-5.1 to 11.8
Southeast	172.69	16.3 (2008-2011)	-16.1 to 61.3	1.6 (2011-2019)	-5.4 to 9.1
South	178.84	26.9* (2008-2011)	1.0 to 59.5	5.3* (2011-2019)	0.2 to 10.7
Central-West	142.91	2.0 (2008-2014)	-3.8 to 8.0	6.2 (2014-2019)	-1.6 to 14.7
Brazil	155.47	15.2 (2008-2012)	-6.8 to 42.4	2.1 (2012-2019)	-6.7 to 11.6

Captions: APC - annual percentage change; CI - 95% confidence interval; * statistical significance; % - percentage.

The audiological procedures provided in Brazil per 10,000 inhabitants were 117.05 in 2008 and 183.67 in 2019 - positively growing by 56.91%. Most procedures had positive growth, especially "otoacoustic evoked emissions in neonatal hearing screening", "auditory evoked potentials in neonatal hearing screening", and "HL diagnostic reassessment in patients above 3 years old". Contrarily, "visual reinforcement audiometry (air/bone conduction)", "HL diagnostic assessment", "HL differential diagnostic assessment", and especially "schoolchildren hearing screening" had negative growth in the comparison (Table 2).

Table 2. Audiological procedures (10,000 inhabitants) and their progress in Brazil, in 2008 and 2019

Audiological procedures	Procedures performed in 2008	Procedures performed in 2019	Progress in the number of procedures (%)
Visual reinforcement audiometry (air/bone conduction)	2.48	1.76	-28.86
Free-field audiometry	6.30	9.59	52.27
Pure-tone threshold audiometry (air/bone conduction)	24.37	36.42	49.45
Behavioral hearing assessment	5.43	11.77	116.99
Hearing loss diagnostic assessment	5.61	5.25	-6.45
Hearing loss differential diagnostic assessment	2.14	1.81	-15.54
Otoacoustic evoked emissions in neonatal hearing screening	9.31	34.06	265.82
Transient-evoked and distortion-product otoacoustic emissions	4.38	10.12	131.01
Acoustic immittance	23.19	31.43	35.54
Speech audiometry (VDT-SRI-SRT)	27.36	33.40	22.11
Short-, middle-, and long-latency auditory evoked potentials	1.98	3.02	52.63
Auditory evoked potentials in neonatal hearing screening	0.42	1.31	214.39
Hearing loss diagnostic reassessment in patients above 3 years old	0.70	2.19	211.36
Hearing loss diagnostic reassessment in patients under 3 years old	0.31	0.38	22.29
Schoolchildren hearing screening	3.07	1.13	-63.01
Total	117.05	183.67	56.91

Captions: VDT - voice detection threshold; SRI - speech recognition index; SRT - speech recognition threshold ; % - percentage.

The period encompassed in the study indicated a concentrated provision of certain procedures. The most frequent ones were "pure-tone threshold audiometry (air/bone conduction)", "speech audiometry (VDT, SRI, SRT)", "otoacoustic evoked emissions in neonatal hearing screening", and "acoustic immittance", which together corresponded to about 73% of the outpatient services. In contrast, "HL diagnostic reassessment in patients under 3 years old", "auditory evoked potentials in neonatal hearing screening", and "HL diagnostic reassessment in patients above 3 years old" were the least frequent ones, with less than 1% (Table 3).

Table 3. Distribution of audiological procedures in Brazil (2008-2019)

Audiological procedures	N	%
Visual reinforcement audiometry (air/bone conduction)	460,369	1.19
Free-field audiometry	2,132,514	5.54
Pure-tone threshold audiometry (air/bone conduction)	7,621,359	19.79
Behavioral hearing assessment	2,426,079	6.30
Hearing loss diagnostic assessment	1,311,923	3.41
Hearing loss differential diagnostic assessment	444,949	1.16
Otoacoustic evoked emissions in neonatal hearing screening	6,734,450	17.49
Transient-evoked and distortion-product otoacoustic emissions	1,979,288	5.14
Acoustic immittance	6,602,391	17.15
Speech audiometry (VDT-SRI-SRT)	7,145,635	18.56
Short-, middle-, and long-latency auditory evoked potentials	578,397	1.50
Auditory evoked potentials in neonatal hearing screening	217,745	0.57
Hearing loss diagnostic reassessment in patients above 3 years old	365,198	0.95
Hearing loss diagnostic reassessment in patients under 3 years old	80,081	0.21
Schoolchildren hearing screening	400,026	1.04

Captions: VDT - voice detection threshold; SRI - speech recognition index; SRT - speech recognition threshold; % - percentage; N - number.

DISCUSSION

This study presented data on audiological procedures at SUS between 2008 and 2019, showing trends towards significant growth in the North and South of Brazil. The overall comparison results between the two assessed years point to an increase in outpatient services in the country, while also indicating relevant dissymmetry in how they are provided in hearing health.

The five geographical regions of Brazil have different demographic, economic, social, cultural, and health aspects, as well as internal inequalities - so much so that SUS was implemented with health services concentrated in more developed regions[6]. Despite the measures taken to broaden the system and the attempts to solve the uneven distribution of hearing health services, differences in coverage persist between the regions[7]. Historically, the number of accredited medium- and high-complexity hearing health services has been unevenly distributed, with respectively greater and lower presence in the Southeast and North[12,14,18,22].

In 2010, the Southeast and South were the only regions that had already surpassed the estimated necessary service coverage, whereas the coverage in the North was only half of the necessary, and the other regions had met the expected values[12]. Nevertheless, a study showed a 60% increase in accredited hearing health services in the North from 2008 to 2012. Since such accreditation helps hearing health outpatient services[14], unequally provided services have effects on the results found in this study regarding audiological procedure indices in the geographical regions of Brazil. The greater mean indices in the South and lower ones in the North were also verified in research that analyzed the indices of hearing aids provided by SUS. Nonetheless, the North had a significant increase in the provision of such devices by SUS up until 2011[16].

Besides the accreditation of hearing health services, a study concluded that the North had the greatest increase in audiological procedures between 2000 and 2010 - even though most such procedures were concentrated in the Southeast[23]. From another perspective, it has been assessed that the South and North had the best progress in the number of medium-complexity hearing health procedures between 2008 and 2011, and the North had the best progress in high-complexity measures[12]. These results agree with the ones in the present study regarding the behavior of both regions in the significant trends detected in APC1.

Likewise, an analysis highlighted that the North had the greatest increase in various audiological procedures in SUS between 2008 and 2012 - e.g., auditory brainstem response (ABR) and basic audiological assessments (pure-tone threshold audiometry, acoustic immittance, and speech audiometry). Basic audiological assessment examinations also increased in the South, which together with the North showed values above the national results. In contrast with such progress, it is worth considering the unequal provision of audiological procedures in Brazil, as there are

weaknesses, especially in the North, Northeast, and Central-West[14].

Given such intense problems, it is argued that audiological procedure indices are subject to the interference of multiple factors. Intertwined with unequally provided procedures, the social and economic context in Brazil has consequences on access to health services[24]. In the core of healthcare assessment, the distribution of hearing health services, the patients' characteristics, and the local health needs must be pointed out[25]. Thus, access to audiological care may be permeated by reference flow organization and link to hearing health services closer to those who need them, which are usually concentrated in larger municipalities - which in turn makes adherence more difficult[22,26]. In low-income places, where human resources and hearing healthcare are not fully accessible, many people with HL have not yet had access to interventions[1].

Studies have described the heterogeneous intraregional distribution of hearing health services at SUS[25-28]. A piece of research pointed out that, despite the significant number of rehabilitation services, they were scarce in the Healthcare Network for People with Disabilities in certain locations, violating the principle of equity, especially in socially vulnerable places[28]. Therefore, some issues must be addressed in detail regarding the need for new services and their sustainability - e.g., budget for diagnosis, rehabilitation, hearing aid fitting, and transportation of patients[27], grounded on epidemiological data and procedure historical series[26].

It is important to assess data on the relationship between regional sociodemographic indicators and the HL scenario[2]. However, many countries have difficulties funding population research to further HL epidemiological distribution analyses and guide interventions[29]. Data from the 2010 Brazilian census show that the Northeast was the second region with the most self-reported HL[30], although it was fourth in the mean audiological procedure index in this study. Thus, it is inferred that the procedure indices in this region could be higher if audiological services were better provided and more accessible in socially vulnerable places.

Hence, based on the scenario identified above, public investments must be made to broaden access to audiological procedures[3,22]. On the other hand, APC2 analysis in this study verified that the APC of audiological procedure indices after 2011 was smaller than in APC1. Moreover, APC2 showed that only the South had significant progress, though smaller than in APC1. A study concluded that resources for audiological services had the highest annual growth rate in 2010, being inconstant in the following years, and then having its greatest decrease in 2017. It was also found that more resources were used for hearing rehabilitation than audiological assessment/diagnosis[31].

The Brazilian health law has improved the access of patients to rehabilitation services[13] - with emphasis on the achievements of PNASA, a policy acknowledged as a landmark that triggered great advancements in hearing health[18,22,23], though still unequal[7]. Furthermore, the 56.91% increase in outpatient services from 2008 to 2019 is grounded on the premise that health policies are following the worldwide tendency of HL increase and making efforts to detect them in early childhood to provide easier access of the population to speech-language-hearing services[5,29] - as the scarcity of such professionals limits the procedures that can be offered[2].

Even though it is heterogeneous - especially in states of the North, Northeast, and Central-West -, the availability of speech-language-hearing therapists is greatly important to reach audiological diagnoses. This was discussed in research that found an association between the greater number of speech-language-hearing therapists available at SUS and the increased coverage of neonatal hearing screening (NHS)[32]. Implemented NHS services raise society's awareness of the harm caused by HL[3], so that its early detection optimizes the children's potential and minimizes HL effects on their overall development[24]. Data analysis on "otoacoustic evoked emissions in neonatal hearing screening", a procedure that had an increase in the period, indicates the achievements of the last decade. The literature reports the increased NHS coverage in Brazil[32], supported by Federal Law no. 12,303, of 2010, which made this examination obligatory[33], and the NHS attention guidelines in the Living without Limits Plan, which furnish guidelines to multi-professional teams regarding pediatric hearing health[34].

The encouragement to early detect HL concatenates with the "auditory evoked potentials in neonatal hearing screening", which progressed in the period, but was little offered. This reflects both the assistance that was provided and the lack of studies focused on this examination[32,35], considering that both are recommended worldwide[33-35]. Research conducted in Bahia compared the NHS examinations and verified that the otoacoustic emissions corresponded to more than 90% of the outpatient services, which was expected based on established parameters. However, there was an unexpected absence of ABR records in certain areas

of the state, as well as no equipment to perform this examination[36].

As a consequence of the absence of specific equipment and the need for trained professionals[2] - as many audiology training programs are concentrated in the South and Southeast of Brazil[7] -, there was a decrease in "visual reinforcement audiometry (air/bone conduction)". The findings confirm what is already known, that such reduction creates obstacles to early diagnoses and therefore to pediatric hearing health. This examination is a behavioral hearing assessment and is the fundamental to estimate hearing thresholds in children aged 6 to 24 months[35]. On the other hand, the literature ascribes this reduction to technological advancements and equipment acquisition to perform more practical examinations, such as the objective ones[12].

The findings on "HL diagnostic assessment" and "HL differential diagnostic assessment" confirmed the incipient provision of audiological procedures in Brazil[12]. The same can be said of the decrease in "schoolchildren hearing screening", which was similar to a study on the topic that found, between 2011 and 2015, a scarcity of such examinations, difficulties in meeting the needs and age groups for the test, and regional inequalities, with gaps in the assistance. The authors reported that unlike NHS, schoolchildren hearing screening is not obligatory in Brazil, which explains why it is seldom performed, with a trend towards a decrease after 2014[24].

"Pure-tone threshold audiometry", "acoustic immittance", and "speech audiometry" encompassed little more than half the total percentage of procedures conducted in Brazil. This reality is linked to the inclusion of the three examinations in the basic audiological assessments[37]. The low values in "HL diagnostic reassessment in patients under 3 years old" and "HL diagnostic reassessment in patients above 3 years old" suggest halted audiological follow-up, which raises concern in the comprehensive hearing health care[13,16,18,22]. Undeniably, to refer users and properly provide interventions according to each case, audiological follow-up must be duly outlined[1,3].

The literature on the area has emphasized the increasing capacity of HL healthcare[2], which points to the intensified need for audiological diagnosis, following the increased provision of audiological procedures from 2008 to 2019 in Brazil. Many advancements must still take place to raise the quality standard for healthcare at SUS and ensure universal and equal provision of health services, especially considering the changes in demographic and epidemiologic characteristics of the Brazilian population[6].

It is reckoned that overall hearing health interventions depend not only on committed budgets to be potentialized - all pillars in the health system must be strengthened, bringing up the need for policies grounded on evidence from the health system of each country; ensuring the availability, training, and equal distribution of professionals; improved access to hearing resources; and adequate integration of hearing health indicators into the health information systems[38].

Lastly, although this study encompassed important audiological procedures data from SUS, its results must be approached considering its limitations, such as the short period of the time series. Collected data are subject to inconsistencies in records, influenced by underreports and incorrect records. These factors are inherent to ecological studies and do not express the subjectivity of services and patients. Moreover, data on the prevalence of HL per geographical region of Brazil should be addressed to understand more accurately this scenario.

Despite its limitations, this study helped the discussion about the provision of public audiological procedures, restating the regional discrepancies in Brazil that occur over time. Further research on the topic should focus on the wide range of territories, methods, and variables to further the debate and analyze the consequences of inequalities from different perspectives, thus producing information that helps democratize access to HL diagnosis.

CONCLUSION

The study portrayed the increased audiological procedure indices at SUS from 2008 to 2019, while also pointing out disparities between geographical regions of Brazil, as the South and North, respectively, had the highest and lowest mean indices. Both regions also had a trend towards a significant increase in audiological procedures. Overall outpatient procedures increased in the study period, although the provision of some of them decreased. The distribution comparison shows a sharp predominance of records of certain procedures, while others lack impulse. Despite the achievements, existing barriers must be overcome to speed up HL diagnosis at SUS.

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