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ORIGINAL ARTICLE

Regional Inequalities in the Availability of Equipment, Supplies and Specialized Reference in Oral Radiology in Brazilian Primary Health Care

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ABSTRACT

Objective: To analyze the availability of equipment, supplies and specialized reference in oral radiology in primary care health by comparing Brazilian geographic regions. **Material and Methods:** The time series analysis was carried out with secondary data extracted from official databases of the Brazilian Ministry of Health of the external evaluation cycles of the National Program for Improvement of Access and Quality of Primary Health Care (PMAQ-AB). The comparisons of Brazilian regions were performed using Chi-square and Z tests adjusted by the Bonferroni method, and among cycles (years) using the Cochran's Q test ($p<0.05$). **Results:** In Brazil, there was an increase in the availability of X-ray equipment between 2014 and 2018 (21.9% *vs.* 36.3%), and supplies where there was X-ray equipment, which included lead aprons (75.6% *vs.* 86.4%), dark chamber (darkroom) (86.4% *vs.* 93.9%) and chemical products for the X-ray film processing (80.7% *vs.* 86.1%) ($p<0.001$). The specialized reference in oral radiology was higher in 2018 (71.4%) compared to 2012 (46.8%) and 2014 (66.9%) ($p<0.001$), with the same trend in the Northeast region ($p<0.001$). North and Northeast showed growing numbers for most items evaluated, with a reduction in regional inequalities. **Conclusion:** The availability of equipment, supplies, and specialized reference among Brazilian regions increased. Although regional inequalities persist in Brazil, a reduction was observed in the analyzed period.

Keywords: Primary Health Care; Public Health Dentistry; Radiology.

Introduction

X-ray is the most used complementary exam in oral practice due to its low cost and for being a simple technique. Its main purpose is to contribute to the diagnosis and treatment plan decision as well as the monitoring of bone and dental alterations [1].

In Brazil, intraoral, periapical, and interproximal X-rays were the most common types of radiography used (94%), found in both public and private services, but the data surveyed indicated that 80% of the intraoral X-ray equipment was found in private health care [2]. Due to the high demand and applicability, low implementation cost, reasonable maintenance values, technical simplicity, and qualified professionals according to the general curriculum of dentistry courses, the use of intraoral radiography has been widely employed in the "*Sistema Único de Saúde*" - SUS (Brazilian Unified Health System).

Brazil is one of the few countries in the world with a public health service that offers oral services at different levels of care [3]. Thus, oral radiology and medical imaging diagnostic centers were initially classified at the second level of health care by the SUS, within "*Centros de Especialidades Odontológicas*" – CEO (Secondary Oral Health Care Services) [4]. Therefore, the logistics of referral to the secondary level might hamper its applicability in the clinical routine or extend the assistance clinical time due to the need for referral and counter referral. For this reason, the provision of intraoral radiography has been increasingly included in Brazilian primary health care (PHC).

Brazil is a vast country with socioeconomic and cultural inequalities that impact the distribution of oral diseases and the offer of health services [5,6]. The PHC receives funds from three sources, that is, it is supported by municipal, state, and federal resources, and the municipalities are in charge of implementing it, the program is also under social and political influence, which might increase regional differences [7]. Therefore, evaluating regional inequalities might be a way of qualifying the absorption process of health public policies.

With the increased number of Brazilian oral health teams (OHT) in PHC [3], the quality and problem solving provided by the services offered must be continuously evaluated. For this reason, in 2011, the "*Programa de Melhoria do Acesso e da Qualidade da Atenção Básica* - PMAQ-AB" (National Program for Improvement of Access and Quality of Primary Health Care) was implemented, aiming to broaden the access and qualify the services offered by the PHC in the country [8,9].

Studies have evaluated the availability of intraoral X-ray equipment in private and public oral health services at the municipal, state, regional, or national levels in Brazil [2,4,10-13], but they have been limited to the availability of X-ray equipment only [2,12]. Due to this limitation, this study aimed to analyze the expansion of the availability of equipment, supplies and specialized reference in oral radiology in primary health care among Brazilian geographic regions.

Material and Methods

Study Design and Ethical Aspects

The time series analysis was carried out with secondary data obtained from the external evaluation of the PMAQ-AB [8,9]. The PMAQ-AB data is available to the public and can be accessed from the Brazilian Health Ministry webpage (https://aps.saude.gov.br/ape/pmaq/ciclo1/; https://aps.saude.gov.br/ape/pmaq/ciclo2/; https://aps.saude.gov.br/ape/pmaq/ciclo3/).

The PMAQ-AB was created by the Brazilian Ministry of Health and is coordinated by three agencies: "*Departamento de Atenção Básica*" (Primary Health Department), "*Conselho Nacional dos Secretários de Saúde*"

(National Council of Health Secretaries) and "*Conselho Nacional dos Secretários Municipais de Saúde*" (National Council of Municipal Health) [8,9]. The Program proposed a set of strategies to broaden PHC qualification by means of evaluating and monitoring the work developed by health teams [8,9] and was divided into three cycles, each cycle lasted two years: 2011-2012 (1st cycle), 2013-2014 (2nd cycle), and 2016-2018 (3rd cycle). The PMAQ-AB had an adhesion and contact phase, for the teams to volunteer to participate, the phase of development of the actions proposed and self-evaluation, and a phase of external evaluation, in loco, by independent researchers [8,9].

The PMAQ-AB external evaluation was carried out for each cycle with a multicenter approach, under the responsibility of higher education institutions from several Brazilian states, which were divided by regions of responsibility and coordination of teams of independent interviewers. The interviewers were selected, trained, and calibrated to collect data from the professionals of primary health care units using validated forms made available on tablets and analyzing the supporting documents whenever needed. The participant professionals signed the Free and Informed Consent Form and were informed of their right to refuse to participate [8,9].

In this study, all modules were previously analyzed to find variables related to oral radiology. Therefore, the data includes radiological supplies contained in Module V (Observation in oral health services at the Primary Health Care Unit) of the 2nd (2013-2014) and 3rd cycles (2016-2018), the specialized reference in oral radiology in Module II (Interview with the Professionals/ Primary Health Teams and verification of the supporting documents) of the 1st cycle (2011-2012) and Module VI (Interview with the Oral Health Team and verification of the supporting documents) of the 2nd (2013-2014) and 3rd cycles (2016-2018).

Universe of the Study

The sampling universe included PHC units and the Brazilian OHT in primary health care of all Brazilian municipalities that adhered and received the external evaluation of the 1st, 2nd or 3rd cycle of the PMAQ-AB. It seems relevant to point out that the adhesion to the PMAQ-AB was voluntary.

In the first cycle, in 2011-2012, the Brazilian Ministry of Health limited the adhesion to the PMAQ-AB to 50% of the Primary Care Teams per municipality, but there was no limitation for the other cycles. In 2011-2012, the external evaluation was carried out in 3,965 (71.2%) Brazilian municipalities and 12,403 OHT. In 2013-2014, 5,070 municipalities were included (91.0%), and 19,946 OHT were evaluated (89.6% of the total OHT registered with the Brazilian Ministry of Health). In 2016-2018, 5,324 municipalities (95.6%) applied to PMAQ-AB and 25,090 OHT were evaluated (95.0% of the total OHT registered with the Brazilian Ministry of Health).

Variables

The study variables are shown below (Table 1), and questions were selected originating three outcomes: a) Oral radiographical equipment made available to OHT, evaluated in the second and third cycles; b) Oral radiographical supplies made available to the OHT, evaluated in the second and third cycles; and, c) Specialized reference in oral radiology made available to the OHT, evaluated in the PMAQ-AB three cycles. Regarding these outcomes, differences per year/cycle and among Brazilian geographic regions were analyzed, including the following regions: North, Northeast, Midwest, Southeast, and South.

Some questions related to supplies were only asked in the second cycle, that is, some adjustment was needed to allow comparison. The adjustments for comparison among cycles are shown below (Table 1).

Table 1. Definition of variables and categories.

Cycle	Variable/ Question	Category in the Database	Category of Analysis in the Study
	Oral radiographic equipament		
	Negatoscope		
2	V.7.21: Is there a Negatoscope?	Yes or No	Yes: There is 'Yes' AND the number in good use condition ≥ 1; No: There is 'Not' OR the number in good use condition = 0.
	V.7.21/1: How many are there in good use condition?	Continuous	
3	V.7.1: How many negatoscopes are there in good use condition?	Continuous	Yes: the number in good use condition ≥ 1; No: the number in good use condition = 0.
	Intraoral X-ray equipment		
2	V.7.2: Is there a dental X-ray?	Yes or No	Yes: There is 'Yes'AND the number in good use condition ≥ 1; No: There is 'Not'OR the number in good use condition = 0.
	V.7.2/1: How many in good use condition?	Continuous	
3	V.7.2.1: How many conventional dental X-ray machines are there in good use condition?	Continuous	Yes: The number in good use condition ≥ 1 for conventional or digital; No: The number in good use condition = 0 for conventional and digital.
	V.7.2.2: How many digital dental X-ray machines are there in good use condition?		
	Oral radiographic supplies[1]		
	Lead apron		
2	V.7.5: Is there a lead apron?	Yes or No	Yes: There is 'Yes'AND the number in good use condition ≥ 1; No: There is 'Not' OR the number in good use condition = 0.
	V.7.5/1: How many are there in good use condition?	Continuous	
3	V.7.3: How many lead aprons are there in good use condition?	Continuous	Yes: The number in good use condition ≥ 1; No: The number in good use condition = 0.
	Intraoral X-ray film		
3	V.7.6: Is dental X-ray film always available?	Yes or No	Yes: 'Yes'; No: 'No'.
View box			
3	V.7.5: Is there a view box in good use condition?	Yes or No	Yes: 'Yes'; No: 'No'.
	Dark chamber (darkroom)		
2	V.7.19: Is there a dark chamber (darkroom)	Yes or No	Yes: There is 'Yes'AND the number in good use condition ≥ 1; No: There is 'Not' OR the number in good use condition = 0.
	V.7.19/1: How many are there in good use condition?	Continuous	
3	V.7.3: How many dark chambers (darkrooms) are there in good use condition?	Continuous	Yes: The number in good use condition ≥ 1; No: The number in good use condition = 0.
	X-ray film processing chemicals		
2	V.9.15: X-ray fixer and developer	Yes or No	Yes: There is 'Yes' AND sufficient supply 'Yes'; No: There is 'Not' OR sufficient supply 'No'.
	V.9.15/1: Is the supply enough?	Yes or No	Yes: There is 'Yes' AND sufficient supply 'Yes'; No: There is 'Not' OR sufficient supply 'No'.
3	V.7.7: Is there X-ray film fixer and developer in good use condition?	Continuous	Yes: The number in good use condition ≥ 1 for fixer AND developer;
	V.7.8: Is there X-ray film fixer in good use condition?		No: The number in good use condition = 0 for fixer OR developer.
X-ray film processing different device			
3	V.7.9: Is there another X-ray film processing device in good use condition?	Yes or No	Yes: 'Yes'; No: 'No'.
	Specialized reference in Oral Radiology		
1	II.37.1 Is there a referral Dental Specialist Center (CEO-Centro Especializado de Odontologia) for your Oral Health Team (ESB-Equipe de Saúde Bucal)?	Yes or No	Yes: If 'Yes' for there is a CEO OR 'Yes' for Radiologist. No: If 'No' for there is a CEO OR 'No' for Radiology.
	II.37.2 Which specialties does the municipality have referral for? (Radiologist)	Yes or No	
2	VI.10.3/6: Among the dental specialties listed, which one(s) does the municipality offer in the Health Care Network? (Radiology)	Yes or No	
3	VI.5.3/5: Please inform which dental specialty(ies) does the ESB receive support to solve more complex cases (Radiology).	Yes or No	Yes: 'Yes'; No: 'No'.

[1]Sample corresponding to the teams that informed the X-Ray equipment availability.

Data Analysis

The data obtained was analyzed using the Statistical Package for the Social Sciences, version 20.0 (IBM Corp., Armonk, NY, USA) and presented in absolute and relative frequencies. The associations of dependent variables and the geographic regions (independent variable) were carried out using the Chi-square test, allied to the Bonferroni adjusted Z test ($p<0.05$). To compare the years of cycles (independent variable), the Cochran's Q paired test ($p<0.05$) was employed.

After the previous adjustments, all nominal variables were dichotomized into 'yes' or 'no'. We opted for presenting only the category 'yes' results in the tables. However, the category 'no' was considered in the analysis for comparison purposes.

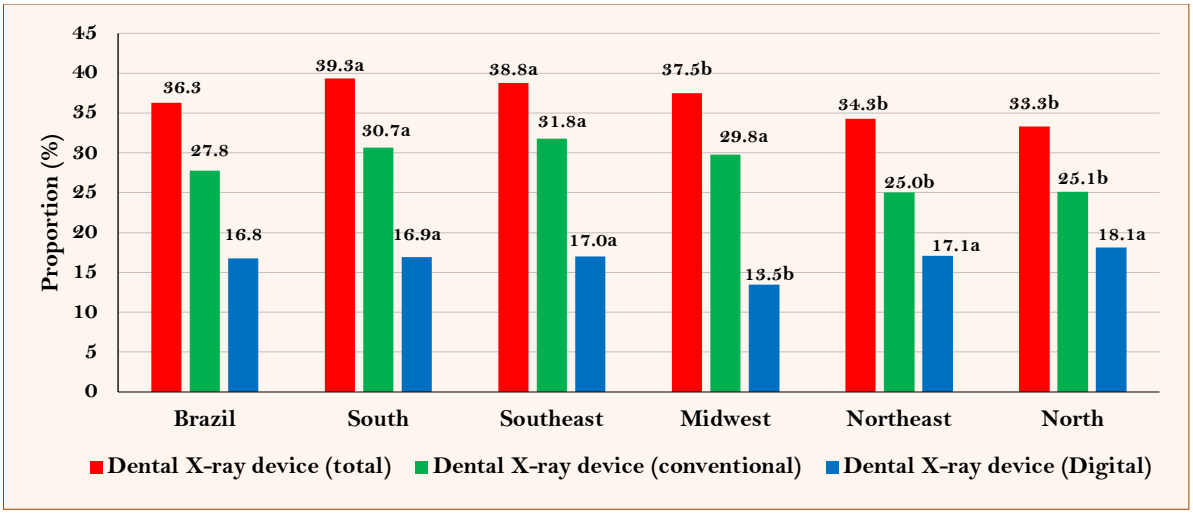
Regarding variables that allowed comparison among cycles, we performed the percentage variation calculation as follows: ((proportion in the later cycle ÷ proportion in the previous cycle) - 1) × 100. In addition, equiplots (https://www.equidade.org/equiplot_creator) were built to illustrate the inequalities found.

Results

In the time series investigated, we observed a growing trend in the OHT adhesion to PMAQ-AB. In 2012, 11,178 OHTs were evaluated. In 2014 and 2018, the number of OHTs in the program showed a 64% (n=18,333) and 95% (n=21,817) increase, respectively, when compared to the beginning of the study (2012).

When analyzing the evolution of the availability of oral radiographic equipment in PHC, we saw that between 2014 and 2018 (Table 2), there was a significant increase in the availability of negatoscopes in good use conditions (from 17.9% to 41.6%) and intraoral X-ray equipment (from 21.9% to 36.3%) in Brazil. Increased availability was observed in all Brazilian regions, with greater growth in the Northeast, North and Midwest regions, thus reducing regional inequalities (Table 2).

In 2018, the type of X-ray equipment was evaluated, and conventional equipment was less frequently seen in the Northeast and North regions, while digital equipment was scarcer in the Midwest of the country ($p<0.001$) (Figure 1).



*Chi-square test, Z test, and Bonferroni post-test: $p<0.001$ for total and conventional X-ray, $p=0.003$ for digital X-ray between regions; [a,b]The same letters for the same type of equipment mean that there is no statistically significant difference between the geographical regions indicated.

Figure 1. Proportion of the total, conventional and digital intraoral X-ray equipment in Primary Health Care according to the Brazilian geographical regions.

When analyzing only the OHT that presented intraoral X-ray equipment in good use condition, we found out that in 2014 and 2018, the OHT also reported having lead aprons (75.6% *vs.* 86.4%), dark chamber (darkroom) (86.4% *vs.* 93.9%) and chemical products for the X-ray film processing (80.7% *vs.* 86.1%) in Brazil. In 2014, the proportion of lead aprons was lower in the North, while North and Northeast showed lower numbers of darkrooms and chemicals (p<0.001). In 2018, lead aprons and X-ray film processing chemicals presented a lower proportion in the North (p<0.001) (Table 2).

An increase was observed in the availability of lead aprons among the cycles (years), and the Southeast, Northeast, and North showed the most expressive growth (p<0.001). Increased availability of X-ray film processing chemicals was only observed in the Northeast region (p<0.001). The availability of darkrooms was higher in all geographic regions between 2014 and 2018 (p<0.05), except for the Midwest region (p=0.812) (Table 2). In general, the North and Northeast showed greater expansion in the availability of intraoral X-ray supplies with a reduction in regional inequalities (Table 2).

Table 2. Availability of oral radiographic equipment and supplies in Primary Health Care according to the Brazilian geographical regions and cycles (years). Brazil.

Variables	Brazil	Brazilian Geographical Region					p-value*
		South	Southeast	Midwest	Northeast	North	
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	
Oral Radiographic Equipment							
Negatoscope							
2014 (n=17498)	3133 (17.9)	751 (31.3) [a]	1168 (27.7) [b]	190 (12.9) [c]	916 (11.2) [c]	108 (8.5) [d]	<0.001
2018 (n=22046)	9176 (41.6)	1521 (52.8) [a]	2722 (48.5) [b]	669 (37.5) [c]	3836 (37.9) [c]	428 (25.7) [d]	<0.001
p-value**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Variation (%)	132.4	68.7	75.1	190.7	238.4	202.3	
Intraoral X-ray Equipment							
2014 (n=17498)	3831 (21.9)	741 (30.9) [a]	1154 (27.4) [b]	355 (24.0) [b]	1349 (16.6) [c]	232 (18.3) [c]	<0.001
2018 (n =20046) [§]	8000 (36.3)	1131 (39.3) [a]	2175 (38.8) [a]	670 (37.5) [b]	3470 (34.3) [b]	554 (33.3) [b]	<0.001
p-value**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Variation (%)	65.7	26.2	41.6	56.2	106.6	82.0	
Oral Radiographic Supplies[1]							
Lead Apron							
2014 (n=3831)	2895 (75.6)	662 (89.3) [a]	957 (82.9) [b]	286 (80.6) [b]	865 (64.1) [c]	125 (53.9) [c]	<0.001
2018 (n=8000)	6912 (86.4)	995 (88.0) [a.b]	1952 (89.7) [b]	570 (85.1) [a]	2986 (86.1) [a]	409 (73.8) [c]	<0.001
p-value**	<0.001	0.366	<0.001	0.064	<0.001	<0.001	
Variation (%)	14.3	-1.4	8.2	5.6	34.3	36.9	

Dark Chamber (darkroom)							
2014 (n=3831)	3309 (86.4)	681 (91.9) [a]	1059 (91.8) [a]	322 (90.7) [a]	1085 (80.4) [b]	162 (69.8) [c]	<0.001
2018 (n=6139)§	5762 (93.9)	842 (95.2) [a.b]	1727 (96.9) [b]	480 (90.2) [c.d]	2352 (93.2) a.c	361 (86.6) [d]	<0.001
p-value**	<0.001	0.007	<0.001	0.812	<0.001	<0.001	
Variation (%)	8.7	3.4	5.6	-0.5	15.9	24.1	
X-ray Film Developer and Fixer for Processing							
2014 (n=3831)	3091 (80.7)	639 (86.2) [a]	1005 (87.1) [a]	299 (84.2) [a]	995 (73.8) [b]	153 (65.9) [b]	<0.001
2018 (n=4394)§	3783 (86.1)	587 (88.4) [a]	1110 (88.8) [a]	373 (85.7) [a]	1541 (86.1) [a]	172 (67.2) [b]	<0.001
p-value**	<0.001	0.224	0.197	0.551	<0.001	0.772	
Variation (%)	6.7	2.5	1.9	1.8	16.7	2.0	
X-ray Film Always Available							
2018 (n=4394)§	3889 (88.7)	601 (90.5) [a.b]	1154 (92.3) [b]	379 (87.1) [a]	1581 (88.4) [a]	184 (71.9) [c]	<0.001
View Box							
2018 (n=4394)§	3871 (88.1)	599 (90.2) [a.b]	1155 (92.4) [b]	380 (87.4) [a]	1553 (86.8) [a]	184 (71.9) [c]	<0.001
Another Device to Process X-ray Film							
2018 (n=4394)§	435 (9.9)	55 (8.3) [a]	114 (9.1) [a]	62 (14.3) [b]	182 (10.2) [a.b]	22 (8.6) [a.b]	0.013

*Chi-square test. Z test, and Bonferroni post-test: different letters in the same line mean statistically significant difference between Brazilian geographical regions per cycle (years)' (p<0.05); **Cochran's Q paired test: analysis of differences between cycles (years) (column) per Brazilian geographical region (p<0.05); [1]Sample corresponding to the teams that reported X-ray equipment availability; §It does not reach 8000 due to the missing data.

The specialized reference in oral radiology was the highest in 2018 (71.4%) when compared to 2012 (46.8%) and 2014 (66.9%) (p<0.001) in Brazil, showing the same trend in the Northeast (p<0.001) region, which presented the highest proportion in 2018 (p<0.001) (Table 3).

Table 3. Availability of specialized reference in oral radiology in Primary Care Health according to geographical regions and cycles (years).

Cycle	Brazil	Brazilian Geographical Region					p-value*
		South	Southeast	Midwest	Northeast	North	
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	
2012 (n=12547)§	5877 (46.8)[A]	972 (48.4) [Aa,b]	2055 (51.0) [Ab]	819 (66.8) [Ac]	2221 (46.5) [Aa]	322 (39.9) [Ad]	<0.001
2014 (n=16082)	10758 (66.9)[B]	1569 (66.3) [Ba]	3037 (65.4) [Ba]	723 (56.8) [Bb]	4846 (71.3) [Bc]	583 (58.4) [Bb]	<0.001
2018 (n=18006)	12864 (71.4)[C]	1599 (63.3) [Ba]	3281 (62.9) [Ca]	863(64.8) [Ca]	6394 (82.3) [Cb]	727 (62.5) [Ba]	<0.001
p-value**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Variation 2012-2014 (%)	42.9	37.0	28.2	-15.0	53.3	53.3	
Variation 2014-2018 (%)	6.7	-4.5	-3.8	14.1	15.8	15.8	
Variation 2012-2018 (%)	52.6	30.8	23.3	-3.0	77.0	56.6	

*Chi-square test, Z test, and Bonferroni post-test: different small letters in the same line mean statistically significant difference between the Brazilian geographical regions per cycle (years) (p<0.05); **Cochran's Q paired test: different capital letters in the same column mean statistically significant difference between cycle (years) between the Brazilian geographical regions (p<0.05).

Discussion

This study verified a significant increase in the availability of X-ray equipment and supplies in good use conditions for OHT in PHC in Brazil and all Brazilian regions, with a higher number of machines in the Northeast, North and Midwest regions, while supplies increased mainly in the North and Northeast. Although public health policies promoted by the federal government take some time to be implemented, mainly at the municipal level, the PMAQ-AB seems to have been a program with a positive impact, even in a short-term analysis.

Studies available in the literature tend to address the availability of intraoral X-ray equipment only [2,10-12,14]. For this reason, it is difficult to compare other supplies analyzed in this study. The use of radiography does not depend solely on the availability of X-ray equipment. Therefore, this study becomes relevant for presenting other equipment and supplies for oral radiology services in the Brazilian PHC.

This study also verified that dentistry is in the process of adopting digital technologies, and in 2018, a considerable percentage of OHT was seen to have digital X-ray equipment. This fact might explain the absence of availability of some radiographic input that is specifically used with conventional equipment. Regarding the quality of the techniques, one study showed that there is no difference between conventional and digital X-rays in the detection of interproximal caries [15]. For this reason, it is important to be attentive to other criteria in the choice of the most suitable intraoral X-ray device for the health service, considering the greater chance of errors by the operator and lower risk to the user due to the repetition of radiographs, as well as the cost of acquisition and maintenance of the input needed for its use.

During the X-ray examination, regardless of the type of X-ray equipment, the lead apron is a radioprotection input that cannot be neglected. Its function is to minimize the patient's exposure to radiation, and even the thyroid collar is strongly recommended for those more susceptible to radiation, such as children and pregnant women [16]. This study raised some concern regarding the fact that around 1/5 of the OHTs that have the intraoral X-ray equipment did not have a lead apron.

The increased availability of intraoral X-ray equipment observed in this study has been reported in the literature from the mid-2000s onwards in Brazil [2,10]. In 2009, Southeast and Northeast were the regions with the highest absolute number of devices in public service, while North and Northeast were regions with the lowest coverage [2]. A study developed between 2006 and 2011 verified that the growth in the availability of this type of equipment at the municipal level has followed an egalitarian trend, since the proportional growth was higher in the Midwest (10.9%), Northeast (10.6%), and North regions (10.2%), while it was lower in the South (8.0%) and Southeast regions (6.7%) [10].

The increased availability in the distribution of intraoral X-ray equipment verified in this study reinforces the decentralization of the oral radiography offered in the public service, following an egalitarian logic. A study in the South region showed that less than half of the municipalities had intraoral X-ray equipment in the public health service [12]. However, we must consider the difference between the proportion in this study and that reported by Lira-Junior et al. [2] in 2012 and Chisini et al. [12] in 2019, due to the difference in the researched sample, while this study focused on the OHT, those studies considered municipalities.

Significant growth in specialized reference in oral radiology was observed in Brazil, mainly due to the increase in the Northeast. The Northeast and Southeast regions are the most populated in the country, but the Northeast is outstood with the highest absolute number of CEOs implemented [17]. There was a stabilization or reduction in specialized reference in oral radiology among other Brazilian regions, which might be justified by the increased offer of oral radiology in secondary oral health services. Furthermore, this study reinforces the

greater supply of oral radiology in OHC since, at the same time that the South and Southeast increased the number of X-ray equipment in the PHC, they were the regions with the lowest offer of specialized reference in oral radiology.

These results demonstrate that even though the Brazilian Ministry of Health pointed out that oral radiology can be included in primary health care as a diagnosis support, and its request should be considered as a complementary approach, its use still requires the structure of secondary or tertiary oral services [18]. This referral recommendation should not be considered as a form of restriction on its request, but rather due to the understanding of health economics, especially in a system with wide coverage and capillarity, but with limited resources.

In addition to the reduced proportion of municipalities with X-ray equipment in the public health service (PHC), a study in the south of the country showed that half of the municipalities that had the equipment had not performed any X-ray exams [12]. In other words, despite the existence of available equipment, this was not enough to guarantee its use, and some hypotheses might be considered. Among others, there was a lack of other inputs required for the examination, such as the X-ray film or chemicals as presented in this study. However, other aspects should be taken into account, such as the background of a work process developed without the use of these resources, or unavailability of the service at the Brazilian secondary oral health care, or even, the existence of a repressed demand in need for this service.

This study revealed a trend of greater availability of oral radiology in the PHC, which might be a continuous improvement process in the service. From the users' point of view, decentralizing might speed up the treatment and broaden problem solutions, which implies in the reduction of transport costs, thus favoring the adhesion to the treatment and tooth preservation. This also reduces the need for aggressive therapies favoring teeth maintenance in the oral cavity. From the professionals' point of view, it helps to reduce the possibility of treatment errors when the procedure is carried out without referral or due to the long time the patient must wait for the service, in addition to promoting reliability in diagnostic and prognostic decisions, which guarantees legal protection.

Despite the relevant information presented, the limitations of this study must be considered. The most evident is the comparison among cycles (years) due to its cross-sectional design and also for including only OHT that adhered voluntarily to the PMAQ-AB. In addition, there were discrepancies regarding the possible number of adhesions. The first cycle, for example, imposed an adhesion limit of 50% of the UBS per municipality, while the other cycles did not have such limitations. For this reason, a significant increase in the number of teams adhering to the program, mainly between the first and second cycles, was observed, reaching over 90% of the OHT registered in the third cycle. Moreover, there were changes in the format of questions asked and/or the number of items included in each cycle, which must be considered when comparing results. Another aspect that must be considered as a limitation is the lack of data or information regarding other ways of offering dental radiology services for OHT, as in-house or outsourced.

The PMAQ-AB is an invaluable tool to keep the access and quality of oral health in basic care; however, it is currently in a process of substitution with another type of assessment proposed by the federal government, which is called "*Programa Previne Brasil*" (Prevent Brazil Programme) [19]. Considering the simplification of the evaluation process in the new program, the data presented in this study might be used in the near future to support the positive or negative impact of the substantial changes in the PHC performance evaluation process.

This study reported that despite the evident increase in the offer of oral X-ray services in the PHC, the process has been slow, possibly due to the health funding model in the country [7]. The oral health funding at

the municipal level has been greater than that of the federal government [20,21], in addition to the fact that the Brazilian Ministry of Health initial investment was in the implementation (41.8%) and operational costs (33.1%) required most of it [21]. In addition, studies have shown that operational costs involve over 80% of expenses with human resources [20,21], while the remaining 20% are destined for equipment and building maintenance, as well as other material resources [20].

Conclusion

Increased availability of most of the intraoral X-ray equipment and inputs was observed for oral health teams in primary health care in Brazil and in the Brazilian regions, with expressive increase in the Northeast, North, and Midwest regions. The specialized reference in oral radiology increased among the three cycles in Brazil, driven by expansion in the Northeast. Although regional inequalities still persist, some reduction was observed in primary health care during the time.

Authors' Contributions

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

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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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