Original Research
Imaginology

Impact of dentists and equipment in the performing dental imaging examinations: a longitudinal analysis

Danielle Bianca de Lima FREIRE[a]
Roger Keller CELESTE[b]
Mariana Boessio VIZZOTTO[a]
Luciana Neves NUNES[c]
Nádia Assein ARÚS[a]
Heraldo Luís Dias da SILVEIRA[a]

[a]Universidade Federal do Rio Grande do Sul – UFRGS, Department of Surgery and Orthopedics, Porto Alegre, RS, Brazil.

[b]Universidade Federal do Rio Grande do Sul – UFRGS, Department of Preventive and Social Dentistry, Porto Alegre, RS, Brazil.

[c]Universidade Federal do Rio Grande do Sul – UFRGS, Department of Statistics, Porto Alegre, RS, Brazil.

Declaration of Interests: The authors certify that they have no commercial or associative interest that represents a conflict of interest in connection with the manuscript.

Corresponding Author:
Heraldo Luís Dias da Silveira
E-mail: heraldo.silveira@ufrgs.br

https://doi.org/10.1590/1807-3107bor-2022.vol36.0047

Abstract: In this study, we aimed to identify factors associated with performing dental imaging examinations in public health services. Brazilian data at the municipal level (n = 5,564) in two time periods, P0 (2005–2007) and P1 (2014–2016), were collated from health information systems. The increase in the municipal rates of intraoral and extraoral radiographic imaging procedures was the outcome. Changes in the use of clinical procedures and the rates of dentists and equipment were the main predictors. Multiple logistic regression analysis was performed to estimate the adjusted odds ratio (OR). Approximately 35.3% of the Brazilian municipalities increased the dental radiography equipment rate, 9.9% increased the fan-beam computed tomography (CT) equipment rate, and 5.9% increased the magnetic resonance imaging (MRI) equipment rate. In addition, 31.8% increased the periapical/interproximal radiography rate, 10.5% increased the CT rate, and 4.4% increased the MRI rate. Increases in the dental radiography, CT, and MRI rates were associated with higher chances of periapical/interproximal images (OR = 1.90, $p < 0.01$), face and neck images (OR =1 5.3, $p < 0.01$), and MR images (OR = 18.1, $p < 0.01$), respectively. Municipalities that increased the rates of endodontists increased the rates of periapical/interproximal (OR = 2.50, $p < 0.01$) and occlusal (OR = 1.60, $p < 0.01$) imaging procedures, and those that increased the rates of radiologists also increased the rates of occlusal (OR = 2.00, $p < 0.01$) and panoramic (OR = 1.70, $p < 0.01$) imaging procedures. The implementation of a secondary dental care center, *Centro de Especialidades Odontológicas* (CEO) was associated with an increase in the chances of performing periapical/interproximal and panoramic radiographic procedures in 1.5 and occlusal radiographic examinations in 2.0. The rates of dentists, equipment, specialized dental centers, and specific dental procedures were associated with the increased use of imaging procedures in dentistry in the Brazilian public health system.

Keywords: Radiography, Dental; Public Health; Tomography Scanners, X-Ray Computed; Radiography.

Introduction

Dental imaging examinations are directly related to diagnosis, planning, and treatment. However, population access to imaging services

Submitted: February 23, 2021
Accepted for publication: September 10, 2021
Last revision: November 1, 2021

for dental care is not always satisfactory.[1] Despite its large geographic size, the Brazilian National Health System[2] covers all municipalities in a dual public–private health system. In 2008, the public health system was used by 35.6% and 61.7% of the population who utilized the dental and medical services, respectively.[3]

In 2004, the Brazilian National Health Service, Sistema Único de Saúde (SUS) launched the National Oral Health Policy, Política Nacional de Saúde Bucal (PNSB)[4] to expand dental care at primary health care, and in 2006, specialized dental centers (CEOs) were implemented, providing endodontics, periodontics, surgery/stomatology, and treatment for patients with special needs.[5] The secondary dental care services[6] may have increased radiographic imaging use because dental radiography is not provided in primary care. As with any other patient record, imaging data can be accessed at the municipal level via health information systems[7] over time, which allows evaluation of policy impact at that level. Indeed, no study assessing the implementation of such policy on imaging procedures has been identified. Due to a pent-up demand, an increase in imaging examinations can be expected after an increase in equipment and specialized services.

Fan-beam computed tomography (CT) and magnetic resonance imaging (MRI) examinations are considered highly complex, expensive, and less available in the public health system compared with those in the private health system.[8] Some studies have shown that the supply of these services is low and underused.[9,10] In addition, there is no relation between the ideal number of CT scanners and MRI equipment per capita, with considerable variation among European countries.[11] The imaging examinations available for dentistry in the Brazilian public health system include head and neck tomography and temporomandibular joint (TMJ) MRI. Although the literature presents some studies with the use of these examinations, none has elucidated their availability and usability in a nationwide health system, such as the Brazilian one.[12-15] There is scant literature describing the use of such services at the population level, as well as factors associated with the increase in their use.[16] Therefore, this study aimed to identify the factors associated with performing dental imaging examinations in public health services.

Methodology

This study is an ecological study, including all Brazilian municipalities, and was approved by the ethics committee nº 33584). Data were collated from 2005 to 2007 (baseline) and from 2014 to 2016 (follow-up). At the baseline, there were 5,564 municipalities, and a few (n = 6) new ones emancipated later were omitted.

Secondary data were used from various health information systems administered by the Department of Informatics (DATASUS), namely, the National Register of Health Units (CNES), Outpatient Information System (SIA-SUS), Information System on Public Budgets in Health (SIOPS), and Brazilian Institute of Geography and Statistics (IBGE), as well as data extracted from the Atlas of Human Development in Brazil (ATLAS). All data sources were accessed via the Internet.

Seven dental imaging procedures were used as the dependent variables: a) occlusal radiography, b) periapical/interproximal radiography, c) panoramic radiography, d) radiography of the TMJ, e) radiography with and without cephalometric tracing (teleradiography), f) CT of the face and TMJ, and g) MRI of the TMJ. The monthly number of each group of images was extracted for each municipality, and the annual average was calculated for the baseline (2005–2007) and follow-up (2014–2016) periods. The baseline represented the period before the implementation of the CEOs.

The main independent variables were the number of dentists, equipment, clinical procedures, and dental care centers. These were most likely the factors that could directly influence the outcome.[17] Such variables were considered part of the structural factors that influence dental care use. Information on dentists was divided according to their specialty: a) dentists specialized in oral and maxillofacial radiology, b) endodontists, c) periodontists, and d) oral and maxillofacial surgeons. Information on the following equipment was collated: dental radiography, MRI, and CT. With regard to dentists and equipment, only those available for the SUS were included, given that the system (CNES) contains data from public and private services.

The clinical procedures were divided into five categories: a) endodontics, b) surgery, c) permanent tooth extractions, d) basic primary care procedures, and (e) periodontics. Information on the number of CEOs for each Brazilian municipality in the two periods, P0 and P1, was also obtained. The monthly number of each variable was extracted for each municipality, and the annual average was calculated for the baseline (2005–2007) and follow-up (2014–2016) periods.

Data on sociodemographic variables that could be potential confounders were obtained for 2010 because they were relatively stable over time. These variables were used as controls in the regression analysis and were not detailed. Based on the census data, the following were collated from information systems: a) population size, b) female population percentage, c) population living in the urban area percentage, d) age characteristics of the population (15–59 years), and (e) the value of the gross domestic product *per capita*.

The differences between the rates in the two time periods were calculated. The follow-up rate was subtracted from the baseline rate, and a positive value was considered an increase; then, the variables were categorized (reduction or no increase, 0; increase, 1). This procedure was performed for outcome and independent variables.

Statistical analysis

Descriptive statistics of the quantitative variables were calculated using the mean and standard deviation. Categorical variables were described as frequencies and percentages. The results were presented with their respective 95% confidence interval (95% CI). Bivariate analyses were presented, and associations were tested using the chi-square test. Multiple logistic regression analyses were performed using the municipal variation (reduction or no increase, 0; increase, 1) in each of the imaging procedures in the period, thus calculating the chances of a municipality having an increased production of images. For the adjusted model, variables with $p < 0.05$ were included. Analyses were performed using R version 3.4.2 (R Foundation for statistical computing, http://www.R-project.org/).

Results

In the comparative analysis between baseline and follow-up, an average increase of 23.57 in the rate of dental radiography equipment per 1 million inhabitants was verified. Table 1 shows the average increase or decrease in equipment fees, imaging procedures, dentists, and clinical procedures. In 2016, 17.38% of the Brazilian municipalities had CEOs compared with 8.32% in 2007.

The dental radiography equipment rate increased in approximately 35% of the Brazilian municipalities (Table 1), and this increase occurred in 80.3% of the large municipalities and 27.1% of the small ones (Table 2). There was an increase in the CT and MRI equipment rates in 9.9% (n = 549) and 5.9% (n = 328) of the municipalities, respectively (Table 1). Table 3 shows the MRI (62.83%) and CT (66.45%) equipment rates in large municipalities.

Regarding the intraoral radiographic procedures, the periapical/interproximal examination rate increased in 31.8% of the municipalities, while the occlusal radiographic examination rate increased in only 6.9%. Regarding the extraoral radiographic examination rates, there was an increase in the TMJ radiographic, panoramic radiographic, and teleradiographic imaging procedures in 14.0%, 8.3%, and 1.3% of the municipalities, respectively (Table 2). Regarding the three-dimensional examinations, it was observed that approximately 10.5% of the Brazilian municipalities increased the TMJ/face CT rate and only 4.4% increased the TMJ MRI rate.

In the bivariate analysis between dental radiography equipment and intraoral and extraoral radiographic examinations, the following were observed: a) of the municipalities that increased the rates of this equipment, 48.1% also increased the periapical radiography rate, and 13.8% increased the occlusal radiographic examination rate; b) regarding extraoral radiography, 15.3% of the municipalities that increased the dental radiography rates also increased the panoramic radiography rates, 22% increased the rates of radiography of the TMJ, and only 2.8% increased the teleradiography rates (Table 3).

In the bivariate analysis, of the municipalities that increased the rates of CT scans, 76.1% also

Table 1. Means and standard deviations (SD) of the rates of variables related to dental imaging in public between periods P0 (2005–2007) and P1 (2014–2016) in all Brazilian municipalities (n = 5,564).

Variables	P0 mean (SD)	P1 mean (SD)	Mean difference (SD)	% Municipalities with increase
Independent variables	Equipment rates per 1 million inhabitants			
DR equipment	39.03 (100.08)	62.60 (122.38)	23.57 (94.39)	35.3
CT equipment	1.16 (5.44)	2.94 (12.54)	1.78 (11.55)	9.9
MRI equipment	0.15 (2.12)	0.77 (4.08)	0.62 (4.09)	5.9
Dependent variables	Rates of imaging procedures per 100,000 inhabitants			
Periapical/interproximal radiography	511.79 (1734.21)	753.38 (2174.54)	241.59 (2030.7)	31.8
Occlusal radiography	21.24 (495.36)	12.92 (217.10)	−8.32 (516.5)	6.9
Panoramic radiography	3.70 (61.97)	18.56 (208.32)	14.86 (206.2)	8.3
Radiography of the TMJ	10.70 (61.07)	14.57 (108.63)	3.88 (108.5)	14.1
Teleradiography	1.26 (62.43)	2.50 (80.34)	1.24 (101.4)	1.3
Head and neck CT	2.70 (19.61)	13.59 (72.19)	10.9 (66.3)	10.5
TMJ MRI	0.01 (0.16)	0.50 (18.40)	0.49 (18.4)	4.4
Independent variables	Rates of clinical procedures per 100,000 inhabitants			
Primary care	63,141.75 (61,800.68)	96,799.80 (299,680.80)	33,658.05 (300,758)	47.7
Endodontics	2,862.28 (5,024.39)	10,253.49 (76,913.11)	7,391.21 (76,858.3)	71.9
Periodontics	10,455.83 (14,410.69)	22,732.94 (123,449.37)	12,277.1 (123,005.1)	62.1
Tooth extraction	5,620.64 (4,510.33)	8,981.15 (72,246.97)	3,360.52 (72,313.3)	36.2
Independent variables	Professional rates per 1 million inhabitants			
Oral and maxillofacial radiologist	1.30 (11.633)	1.06 (12.191)	−0.24 (16.5)	2.3
Endodontist	3.97 (25.848)	2.18 (9.863)	−1.79 (16.8)	10.8
Periodontist	1.26 (6.953)	3.35 (17.196)	2.09 (16.6)	10.2
Oral and maxillofacial surgeon	1.38 (7.032)	2.74 (11.976)	1.37 (12.7)	9.9

P0: initial study time; P1: end of study time; DR: dental radiography; CT: fan-beam computed tomography; MRI: magnetic resonance imaging; TMJ: temporomandibular joint.

Table 2. Percentage of municipalities that increased the rate of imaging equipment from 2005–2007 to 2014–2016 by city population size (n = 5,564).

Variable	Population size (thousands of inhabitants)			p-value
	> 100,000	25,000-100,000	< 25,000	
DR equipment rate	80.3	54.3	27.1	< 0.001
CT equipment rate	66.5	26.8	1.3	< 0.001
MRI equipment rate	62.8	11.8	0.2	< 0.001

DR: dental radiography; CT: fan-beam computed tomography; MRI: magnetic resonance imaging.

increased the CT/face tomography rates, and the same pattern was observed for municipalities that increased the MRI equipment rates (60.7% of these) (Table 3). Regarding dentists, it was observed that the specialties of endodontics, periodontics, and oral maxillofacial surgery increased in approximately 10% of the municipalities and, in the same period, only 2.3% of the municipalities increased their specialty dental radiology rates. The association between municipalities that increased the rates of dentists and imaging procedures was observed for all specialties ($p < 0.0001$) (Table 3).

Table 3. Percentage of municipalities that increased the rates of imaging procedures per 100,000 inhabitants from 2005–2007 to 2014–2016 by equipment type and dentists.

Variable	Periapical	Occlusal	Panoramic	TMJ	Tele	MRI	CT
Imaging equipment type							
DR equipment							
No equipment	22.9	3.1	4.4	9.8	0.5		
Some equipment	48.1	13.8	15.3	22.0	2.8		
MRI equipment							
No equipment						0.9	
Some equipment						60.7	
CT equipment							
No equipment							3.3
Some equipment							76.1
Dentists							
Oral and maxillofacial radiologist							
None	31.1	6.3	7.7	13.8	1.2	4.1	9.7
At least one	59.8	29.9	31.5	26.8	8.7	20.5	44.1
Endodontist							
None	27.0	4.8	7.2	12.4	1.0	3.8	8.3
At least one	71.4	23.5	17.0	28.2	4.0	9.3	28.5
Periodontist							
None	27.4	4.7	6.3	12.1	0.8	3.1	7.3
At least one	70.4	25.4	25.6	32.1	6.1	16.1	38.2
Oral and maxillofacial surgeon							
None	28.3	5.0	6.0	11.9	0.8	2.4	6.5
At least one	63.7	23.8	28.5	34.7	6.7	23.0	46.6
Secondary dental care centers							
None	25.3	3.4	4.7	10.5	0.3	1.4	4.5
At least one	64.7	24.6	26.4	32.5	6.6	19.9	41.1

All comparisons statistically significant with $p < 0.001$ using the chi-square test.
DR: dental radiography; CT: fan-beam computed tomography; MRI: magnetic resonance imaging; TMJ: temporomandibular joint; Tele: teleradiography.

Of the municipalities that increased the rates of the primary care procedure, 35.2% also increased the periapical/interproximal imaging procedure rates. Among the municipalities that expanded their endodontic procedures, 36% expanded the periapical radiographic examinations, and 7.9% expanded the occlusal radiographic examinations. Of the municipalities that increased the rates of periodontal examinations, approximately 36.2% also increased the rates of periapical/interproximal examinations, and 7.8% increased the rates of occlusal radiographic examinations (Table 4).

In the logistic regression analysis, after model adjustments, municipalities that increased the rates of dental radiography equipment and endodontic and periodontal procedures were more likely to produce periapical radiographs. An increase in the number of endodontists, periodontists, and oral and maxillofacial surgeon specialists in these counties increased the chance of performing periapical

Table 4. Percentage of municipalities that increased the rates of imaging procedures per 100,000 inhabitants from 2005–2007 to 2014–2016 according to clinical procedures (n = 5,507).

Clinical procedures		Increase in the rate of imaging procedures						
Type of procedure	Increase in the rate of procedure	Periapical	Occlusal	Panoramic	TMJ	Tele	MRI	Face CT
Rate of primary care procedures	No	28.6	6.4	8.8	14.4	1.4	4.8	10.8
	Yes	35.2	7.3	7.6	13.8	1.3	4.0	10.1
Rate of endodontic procedures	No	20.9	4.3	7.5	12.9	0.3	3.2	8.9
	Yes	36.0	7.9	8.5	14.6	1.7	4.9	11.1
Rate of periodontal procedures	No	24.6	5.4	8.2	12.2	1.1	4.6	9.7
	Yes	36.2	7.8	8.3	15.3	1.5	4.3	11.0
Rate of permanent tooth surgeries	No	31.6	7.2	8.9	15.3	1.4	5.2	11.9
	Yes	32.1	6.2	7.1	12.0	1.2	3.0	8.0

Values in bold italics are statistically significant ($p < 0.01$), chi-square test.
TMJ: temporomandibular joint; Tele: teleradiography; MRI: magnetic resonance imaging; CT: fan-beam computed tomography.

radiographic procedures (odds ratio [OR] = 2.5, 1.5, and 1.3, respectively). The increase in the number of specialists in oral and maxillofacial surgery also increased the chances of performing tomographic examinations (95%CI, 1.04–2.20) and panoramic radiographic procedures (95%CI, 1.09–1.90) by 1.5. The increase in the rate of oral radiologists increased the possibility of occlusal radiographic examinations (OR=2) and panoramic radiographic procedures (OR = 1.7) (Table 5). The municipalities that implemented specialized dental centers increased their chances of performing periapical/interproximal and panoramic radiographic procedures in 1.5 and occlusal radiographic examinations in 2.0.

Discussion

The results of this study showed an increase in the rates of dental radiography from 2005–2007 to 2014–2016, and this was associated with an increase in the imaging equipment rates. Although this may seem a logical association, logistic and other issues can reduce the potential impact of structural changes in daily clinical settings. The importance of evaluating dental structural factors is clear because the most common diagnostic imaging equipment in 2016 in the SUS was dental radiography[18]. However, when analyzing the distribution by population size, large- and medium-sized cities have a significant share in these increases, showing the inequalities in health-care access for diagnostic support in dentistry in the SUS. Lira-Júnior et al.[19] identified inequalities in the distribution of such equipment among the macro-regions of Brazil The present study found that a small percentage of the municipalities increased their CT and MRI equipment rates but at the same time reduced the imaging examination rate. A possible explanation is the public–private composition of the health system in Brazil, in which a large proportion of technological resources are in the private sector, acting in the medium and high complexity sectors of the SUS. In addition, the most advanced technological resources of the public sector, especially MRI, are inserted at the hospital level[8]. It can be seen that there is a low degree of equipment use, despite the enormous structure of public equipment available to the SUS[10] and equipment out of order.[20]

The findings of this study showed an increase in the CT and MRI equipment rates and their impact on imaging procedures. International studies have shown an increase in investments in CT[21] and MRI equipment among several countries, especially developed ones such as Germany, Italy, and Austria, and an increase in the rates of these examinations.[11,22,23,24] It should be noted that there is no standard for the minimum and maximum number of examinations, but what this study identified is still a low increase in the SUS. It is essential to keep in mind that it is not due to the availability of the equipment that the more complex examinations such as MRI and CT should be

Table 5. Odds ratio (95% confidence interval) of the increase in the rates of seven municipal imaging procedures according to the increase in the rates of imaging equipment, dentists, and clinical procedures from 2005–2007 to 2014–2016.

Increased in rate	Periapical		Occlusal		Panoramic		TMJ		Tele		CT		MRI	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Imaging equipment														
DR equipment														
No	1		1		1		1							
Yes	1.90	(1.67–2.19)	2.00	(1.53–2.60)	1.60	(1.24–2.01)	1.40	(1.15–1.65)						
CT equipment														
No											1		1	
Yes											15.3	(11.1–21.3)	1.80	(1.12–2.74)
MRI equipment														
No											1		1	
Yes											4.9	(3.15–7.59)	18.1	(11.5–29.1)
Dentists														
Oral and maxillofacial radiologist														
No			1		1									
Yes			2.00	(1.20–3.16)	1.70	(1.09–2.73)								
Endodontist														
No	1		1		1									
Yes	2.50	(1.99–3.25)	1.60	(1.19–2.21)	0.60	(0.46–0.87)								
Periodontist														
No	1													
Yes	1.50	(1.17–2.03)												
Oral and maxillofacial surgeon														
No	1				1		1				1			
Yes	1.30	(1.02–1.68)			1.50	(1.09–1.94)	1.30	(1.05–1.74)			1.5	(1.04–2.20)		
Rates of clinical procedures														
Basics														
No														
Yes														
Endodontics														
No	1		1						1					
Yes	1.70	(1.43–1.97)	1.40	(1.02–1.90)					4.50	(1.87–13.2)				
Periodontal														
No	1						1							
Yes	1.30	(1.15–1.57)					1.30	(1.09–1.60)						
Permanent tooth surgery														
No							1						1	
Yes							0.80	(0.64–0.97)					0.60	(0.35–0.91)

Model adjusted by gross domestic product (GDP) per capita in reais (R$), % of adults, % of women, % of urban population, health expenditure in reais (R$), population size, and dental specialty centers (CEOs). $p < 0.05$.

TMJ: temporomandibular joint; Tele: teleradiography; DR: dental radiography; CT: fan-beam computed tomography; MRI: magnetic resonance imaging; OR: odds ratio; CI: confidence interval.

requested but because of the need for diagnosis and after having exhausted the radiographic examination information.[25,26] However, a large pent-up demand for such procedures in the public health system is expected because of the very low rates of equipment.

The present study described an association between increases in the rates of equipment and imaging procedures, mainly periapical/interproximal ones. Such increases in imaging use may have occurred because of unmet demands[27,28] for diagnosis and treatment that could be solved with the implementation of secondary dental services[29]. Secondary dental care centers appear as a structural factor in the organization of services[6], insofar as they provide specialized care with radiographic examinations. In the present study, the increases in the rates of endodontic and periodontal procedures were associated with the increased rates of imaging procedures, especially periapical/interproximal examinations. Perhaps, this is because these are the first choice for diagnosis and treatment in these specialties,[30,31] accompanied by the prevalence of oral diseases[32] and treatment needs.[33,34] In a previous study,[35] CEOs were also associated with increased rates of endodontic, periodontal, and minor surgical procedures.

Cities that increased the rate of public health dentists, such as oral and maxillofacial surgeons and oral radiologists, increased the chances of performing panoramic radiography by 50%–70%. This examination has several indications in dentistry[30,36] and may also be used as a predictor of fractures in menopausal women[37] and for the evaluation of temporomandibular disorders and systemic alterations.[38,39] In the study, it was verified that the increase in the rates of the professional oral and maxillofacial ones reinforces the accomplishment of the tomographic examination by 1.5 times. The limitations of this study are that it focused only on the Brazilian public health system and not on out-of-pocket or health/dental insurance systems. Nevertheless, only data on the public health system are available nationwide. Future research in more diverse global settings should be conducted to analyze the role of imaging examinations worldwide. Finally, the coverage of oral health teams in family strategy was not used as a control variable; nonetheless, it has been shown that the rates of dental procedures are correlated with such coverage in primary care.[40]

Conclusion

Performing dental imaging examinations in the public health services was directly associated with an increase in structural factors associated with secondary dental care centers, such as the number of imaging equipment, public health dentists, and increase in the rates of clinical procedures (endodontic, periodontal, and surgical). Importantly, the rates of dental imaging examinations were low, and the increase was not large, which indicated that such examinations are underused in primary and secondary care despite the vital importance of diagnosis for clinical procedures. This study can be a useful tool for health service managers to identify access to diagnostic imaging resources in dentistry over time. Managers can plan health services by assessing their dentists, equipment, and availability of diagnostic imaging services in dentistry in their cities. This reinforces the importance of the health service structure for diagnostic imaging in dentistry and must be taken into account for the implementation and evaluation of public policies.

References

1. Assis MM, Jesus WL. [Access to health services: approaches, concepts, policies and analysis model]. Cien Saude Colet. 2012 Nov;17(11):2865-75. Portuguese. https://doi.org/10.1590/S1413-81232012001100002
2. Instituto Brasileiro de Geografia e Estatística – IBGE. Estimativas da população. [cited 2018 Dec 17]. Available from: https://www.ibge.gov.br/estatisticas-novoportal/sociais/populacao/9103-estimativas-de-populacao.html?=&t=downloads
3. Pilotto LM, Celeste RK. The relationship between private health plans and use of medical and dental health services in the Brazilian health system. Cien Saude Colet. 2019 Jul;24(7):2727-36. https://doi.org/10.1590/1413-81232018247.24112017

4. Ministério da Saúde (BR). Secretaria de Atenção à Saúde. Coordenação Nacional de Saúde Bucal. Diretrizes da política nacional de saúde bucal. Brasília, DF: Ministério da Saúde; 2004.
5. Ministério da Saúde (BR). Portaria nº 600, de 23 de março de 2006. Institui o financiamento dos Centros de Especialidades Odontológicas. Diário Oficial União, 2006 Mar 26.
6. Machado FC, Silva JV, Ferreira MÂ. Factors relatem to the performance of Specialized Dental Care Centers. Cien Saude Colet. 2015 Apr;20(4):1149-63. https://doi.org/10.1590/1413-81232015204.00532014
7. Paim J, Travassos C, Almeida C, Bahia L, Macinko J. The Brazilian health system: history, advances, and challenges. Lancet. 2011 May;377(9779):1778-97. https://doi.org/10.1016/S0140-6736(11)60054-8
8. Santos IS, Santos MAB, Borges DCL. Mix público-privado no sistema de saúde brasileiro: realidade e futuro do SUS. Rio de Janeiro: Fiocruz; 2013. (A saúde no Brasil em 2030: prospecção estratégica do sistema de saúde brasileiro: estrutura do financiamento e do gasto setorial; v. 4).
9. Santos IS, Ugá MA, Porto SM. [The public-private mix in the Brazilian Health System: financing, delivery and utilization of health services]. Cien Saude Colet. 2008 Sep-Oct;13(5):1431-40. Portuguese. https://doi.org/10.1590/S1413-81232008000500009
10. Santos DL, Leite HJ, Rasella D, Silva SA. Unified National Health System: installed capacity and utilization. Cad Saude Publica. 2014 Jun;30(6):1293-304. https://doi.org/10.1590/0102-311X00140713
11. OECD/EU. Health at a glance: Europe; 2018: state of health in the EU cycle. Paris: OECD Publishing, 2020. Disponível em: https://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-europe_23056088
12. Yamamoto FP, Silva BS, Modes RW, Fonseca FP, Pontes FS, Sousa SC. Silva BSdF, Modes RW, Fonseca FP, Pontes FSC, Sousa SCOMd. Computed tomography and scintigraphy exams for diagnosis and treatment planning of the condylar osteochondroma: a case report. Rev Odonto Ciênc. 2010;25(4):422-6. https://doi.org/10.1590/S1980-65232010000400019.
13. Sanders C, Liegey-Dougall A, Haggard R, Buschang P, Karbowski S, Riggs R, Gatchel RJ. Temporomandibular disorder diagnostic groups affect outcomes independently of treatment in patients at risk for developing chronicity: a 2-year follow-up study. Journal of Oral & Facial Pain & Headache. 2016 summer;30(3):187-202. https://doi.org/10.11607/ofph.161
14. Grossmann E, Remedi MP, Ferreira LA, Carvalho AC. Magnetic resonance image evaluation of temporomandibular joint osteophytes: influence of clinical factors and Artrogenics changes. J Craniofac Surg. 2016 Mar;27(2):334-8. https://doi.org/10.1097/SCS.0000000000002377
15. Bueno CH, Pereira DD, Pattussi MP, Grossi PK, Grossi ML. Gender differences in temporomandibular disorders in adult populational studies: A systematic review and meta-analysis. J Oral Rehabil. 2018 Sep;45(9):720-9. https://doi.org/10.1111/joor.12661
16. Freire DBL. Celeste RK, Arús NA, Vizzotto MB, Silveira HLD. [Dental imaging procedures in the Unified Health System and the expansion of secondary care: series between 2000-2016]. Cienc Saúde Coletiva; 2021 Oct;26(10) https://doi.org/10.1590/1413-812320212610.15172020
17. Donabedian A. The definition of quality and approaches to its assessment. Ann Arbor: Health Administratio Press, 1980. Vol. 1: Explorations in quality assessment and monitoring.
18. Datasus. TabNet Win32 3.0: CNES - Recursos Físicos - Equipamentos – Brasil. Brasília, DF, 2018 [cited 2018 Dec 19]. Available from: http://tabnet.datasus.gov.br/cgi/deftohtm.exe?cnes/cnv/equipobr.def
19. Lira-Júnior R, Cavalcanti YW, Almeida LFD, Sales O, Augusto M. [Overview of Dental Radiology in Brazil: availability of equipment and ambulatory production of radiographs]. Rev Cubana Estomatol. 2012 jul-set;49(3):223-31. Spanish.
20. Freitas MB, Yoshimura EM; Freitas MB. Yoshimura EM. [Survey on the distribution of imaging diagnosis equipment and frequency of radiological examinations in the State of São Paulo, Brazil]. Radiol Bras. 2005;38(5):347-54. Spanish. https://doi.org/10.1590/S0100-39842005000500008
21. Brown LF, Monsour P. The growth of Medicare rebatable cone beam computed tomography and panoramic radiography in Australia. Aust Dent J. 2015 Dec;60(4):511-9. https://doi.org/10.1111/adj.12250
22. OECD. Health at a glance. Paris: OECD Publishing, 2012 [cired 2017 Jun 28].. Available from: http://x-oecd-live-01.ingenta.com/docserver/download/8112121e.pdf?expires=1498655007&id=id&accname=guest&checksum=25767DEAC169CF25D9FFCAE3CC0369E3
23. OECD. Health at a glance Paris: OECD Publishing, 2014 [cited 2019 Jan 26]. Available from: https://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-europe-2014_health_glance_eur-2014-en
24. OECD/EU. Health at a glance: State of Health in the EU cycle. Paris: OECD Publishing, 2016 [cited 2017 Jun 28]. [Internet]. Available from: http://x-oecd-live-01.ingenta.com/docserver/download/8116231e.pdf?expires=1498650122&id=id&accname=guest&checksum=9383A6EF31B64B42B88593AD509BF86E
25. Madrigano RR, Abrão KC, Puchnick A, Regacini R. Evaluation of non-radiologist physicians' knowledge on aspects related to ionizing radiation in imaging. Radiol Bras. 2014 Jul-Aug;47(4):210-6. https://doi.org/10.1590/0100-3984.2013.1840
26. Lurie AG. Doses, benefits, safety, and risks in oral and maxillofacial diagnostic imaging. Health Phys. 2019 Feb;116(2):163-9. https://doi.org/10.1097/HP.0000000000001030

27. Barros SG, Chaves SC. [Use of the outpatient information system (SIA-SUS)to assess oral health activities]. Epidemiol Serv Saúde. 2003 Mar;12(1):49-51. Portuguese. https://doi.org/10.5123/S1679-49742003000100005
28. Andrade KL, Ferreira EF. Ferreira EF. [The evaluation of the dental service inclusion in the Family Health Program of Pompéu (MG): the user satisfaction]. Cien Saude Colet. 2006;11(1):123-30. Portuguese. https://doi.org/10.1590/S1413-81232006000100020
29. Bulgareli JV, Faria ET, Ambrosano GM, Vazquez FL, Cortellazzi KL, Meneghim MC, et al. [Information from secondary care in dentistry for evaluation of models of health care]. Rev Odontol UNESP. 2013;42(4):229-36. Portuguese. https://doi.org/10.1590/S1807-25772013000400001
30. Ministério da Saúde (BR). A saúde bucal no Sistema Único de Saúde. Brasília, DF: Ministério da Saúde; 2018 [cited 2019 Jan 26]. Available from: http://bvsms.saude.gov.br/bvs/publicacoes/saude_bucal_sistema_unico_saude.pdf
31. Moura LB, Blasco MA, Damian MF. Radiographic examination of patient's initial care in a Brazilian Dental School]. Rev Odontol UNESP. 2014;43(4):252-7. Portuguese. https://doi.org/10.1590/rou.2014.046
32. Vengerfeldt V, Mändar R, Nguyen MS, Saukas S, Saag M. Apical periodontitis in southern Estonian population: prevalence and associations with quality of root canal fillings and coronal restorations. BMC Oral Health. 2017 Dec;17. https://doi.org/10.1186/s12903-017-0429-7
33. Ministério da Saúde (BR). Secretaria de Atenção à Saúde. Secretaria de Vigilância em Saúde. SB Brasil 2010: Pesquisa Nacional de Saúde Bucal: resultados principais. Brasília, DF: Ministério da Saúde:; 2014.
34. Ziebolz D, Szabadi I, Rinke S, Hornecker E, Mausberg RF. Initial periodontal screening and radiographic findings: a comparison of two methods to evaluate the periodontal situation. BMC Oral Health. 2011 Jan;11:3.
35. Celeste RK, Moura FR, Santos CP, Tovo MF. [Analysis of outpatient care in Brazilian municipalities with and without specialized dental clinics, 2010]. Cad Saude Publica. 2014 Mar;30(3):511-21. Portuguese. https://doi.org/10.1590/0102-311X00011913
36. Al-Nazhan SA, Alsaeed SA, Al-Attas HA, Dohaithem AJ, Al-Serhan MS, Al-Maflehi NS. Prevalence of apical periodontitis and quality of root canal treatment in an adult Saudi population. Saudi Med J. 2017 Apr;38(4):413-21. https://doi.org/10.15537/smj.2017.4.16409
37. Geraets W, Jonasson G, Hakeberg M. Predicting fractures using trabecular patterns on panoramic radiographs. Clin Oral Investig. 2018 Jan;22(1):377-84. https://doi.org/10.1007/s00784-017-2122-2
38. Obamiyi S, Malik S, Wang Z, Singh S, Rossouw EP, Fishman L, et al. Radiographic features associated with temporomandibular joint disorders among African, White, Chinese, Hispanic, and Indian racial groups, Chinese. Niger J Cin Prac. 2018 Nov;21(11):1495-500. https://doi.org/10.4103/njcp.njcp_63_18
39. Bengtsson VW, Persson GR, Berglund J, Renvert S. Carotid calcifications in panoramic radiographs are associated with future stroke or ischemic heart diseases: a long-term follow-up study. Clinical Oral Investig.2019 Mar;23(3):1171-9. https://doi.org/10.1007/s00784-018-2533-8
40. Corrêa GT, Celeste RK. [Association between coverage by oral health teams in the family health and the increase in dental care output in Brazilian municipalities, 1999 and 2011]. Cad Saúde Pública. 2015 Dec;31(12):2588-98. Portuguese. https://doi.org/10.1590/0102-311X00000915