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Prevalence of dental fluorosis in regions supplied with non-fluoridated water in the Brazilian territory: a systematic review and meta-analysis

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Abstract *This systematic review and meta-analysis aimed to estimate and compare the prevalences of dental fluorosis in Brazilian cities supplied with non-fluoridated water and in locations that uses groundwater. In December of 2016, cross-sectional studies were searched in eight databases, including the "grey literature". The prevalences were estimated through a mixed random effects model considering the locations as subgroups. The heterogeneity among the studies was assessed with I^2 statistics and the Cochran's Q test. A total of 1038 records were found, from which only 18 articles met the inclusion criteria and were subjected to analysis. The meta-analytic model estimated a prevalence of dental fluorosis of 8.92 % (95 % CI: 5.41 % to 14.36 %) in cities supplied with non-fluoridated water, and of 51.96 % (95 % CI: 31.03 % to 72.22 %) in cities supplied by artesian wells. The heterogeneity among the studies was high: I^2 = 95 % ($p < 0.01$) in the first subgroup of cities and I^2 = 98 % ($p < 0.01$) in the second subgroup. The prevalence was significantly higher ($p < 0.001$) in populations exposed to artesian well water, indicating that the presence of natural fluoride at high concentrations represents a risk factor for the occurrence of dental fluorosis.*

Key words *Dental fluorosis, Prevalence, Public health*

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Introduction

Fluoride (F) is considered the main anticaries agent used in preventive dentistry and it has been indicated as the major responsible for reducing caries prevalence worldwide[1,2]. However, concomitantly to caries decline, an increase in the prevalence of dental fluorosis has also been reported[3-6]. Dental fluorosis is the systemic effect resulting from the daily ingestion of fluoride in small amounts during amelogenesis, affecting the mineralized tissues of the body, particularly tooth enamel[7]. It is considered the only side effect from the chronic exposure to fluoride. Clinically, dental fluorosis is characterized by enamel hypomineralization and it may present from increased opacity to diffuse areas through the dental crown, with a whitish aspect and structure loss in the most severe cases[7,8], increasing the risk of caries and compromising dental aesthetics, which directly affects the quality of life of individuals[8].

The degree of severity of dental fluorosis is directly related to the ingestion dose and its duration, and it may vary from imperceptible degrees to the severe aesthetic involvement of tooth enamel. This implies that all fluoride ingested and circulating through the organism might cause some degree of fluorosis, but the clinical significance will depend on the dose and its duration[9]. The methods of fluoride use directly related to the occurrence of dental fluorosis involve frequent fluoride intake, such as fluoride present in drinking water and in foods prepared with it[10]. Indirectly, the accidental intake of fluoridated dentifrices is also associated with the increased risk of fluorosis[11,12].

In fact, when fluoridated water is ingested, the development of some degree of dental fluorosis is expected. However, it is consensus in the literature that using fluoridated water at the "optimal" concentration (0.70 ppm F for most Brazilian cities) is a safe method of fluoride use, because it produces the maximum caries reduction (benefit) with minimum side effects (aesthetically acceptable dental fluorosis)[10,13]. Moreover, the evidence that the prevalence of dental fluorosis has increased worldwide in regions supplied with either fluoridated or non-fluoridated water suggests that fluoride intake from other sources such as fluoridated dentifrices may also contribute to the occurrence of dental fluorosis[14,15]. However, in populations exposed to fluoridated water at optimal concentrations and/or using fluoridated dentifrices, the occurrence of fluorosis is limited to "low" and "very low" degrees[10,11]. These severity levels neither compromise aesthetics nor cause patient dissatisfaction with their dental appearance[16,17].

On the other hand, dental fluorosis may also be present in areas with uncontrolled fluoride concentration in public water supplies, in which the fluoride content naturally present in the water may vary significantly. Groundwater may present fluoride concentrations above the levels recommended for human consumption (1.5 ppm F is considered the maximum value allowed in Brazil[18]), which represents a risk for the occurrence of dental fluorosis[19-21]. The amount of fluoride in groundwater varies according to the region and it is influenced by factors such as rock porosity, fluoridated compound solubility, and the soils to which it is related[22]. Although rare, cases of dental fluorosis in higher severity degrees have been reported in populations chronically exposed to groundwater[23-25].

Systematic reviews[26,27] on the prevalence of dental fluorosis have been limited to the areas that add fluoride to public water supplies. However, the scientific evidence regarding the occurrence of fluorosis in populations exposed to non-fluoridated water is scarce. Therefore, this study aimed to perform a systematic review to estimate the prevalence of dental fluorosis in Brazilian cities and/or rural districts supplied with non-fluoridated water and in locations that use groundwater, as well as to draw comparisons among them. Our hypothesis is that cities and/or rural districts exposed to groundwater present higher prevalence of fluorosis.

Methods

Protocol and registration

This systematic review was performed following the PRISMA Statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[28] and the Cochrane guidelines[29]. The systematic review protocol was registered in the database PROSPERO under #CRD42017056479 (https://www.crd.york.ac.uk/PROSPERO/).

Eligibility criteria

The inclusion criteria were cross-sectional studies assessing the prevalence of dental fluorosis in Brazilian cities and/or rural districts with non-fluoridated public water supply or

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groundwater supply, with no restrictions of year, language, or publication status (ahead of print). Studies should also use validated indexes for assessing dental fluorosis.

The reasons for exclusion were : 1) Not related to the topic; 2) Reviews, letters to the editor, personal opinions, book/book chapter, didactic material, reports, abstracts, and patents; 3) Articles that did not clarify the data for the prevalence of dental fluorosis; and 4) Articles that used secondary data to obtain results.

Information sources

The primary study sources used were the databases Lilacs - Latin American and Caribbean Health Sciences (http://lilacs.bvsalud.org/), LIVIVO (https://www.livivo.de), PubMed (https://www.ncbi.nlm.nih.gov/pubmed - including MedLine), SciELO (http://www.scielo.org/php/index.php), Scopus (http://www.scopus.com/), and Web of Science (http://apps.webofknowledge.com/). Google Scholar (https://scholar.google.com.br/) and Open Grey (http://www.opengrey.eu/) were used to search the "grey literature". For Google Scholar, the first 100 results of the combination applied were used, excluding patents and citations. A manual search was performed by analyzing the references of each one of the eligible studies in this review. Additional studies were obtained by recommendation of an expert in the topic.

Search

Two authors performed the search independently (IFPL and DFN). The resources MeSH (Medical Subject Headings - https://www.ncbi.nlm.nih.gov/mesh) and DeCS (Health Science Descriptors - http://decs.bvs.br/) were used to select the keywords. The Boolean operators "AND" and "OR" were used to enhance the search strategy through several combinations. The search strategy included the following MeSH terms: "Prevalence", "Epidemiology", "Incidence", "Fluorosis, Dental", "Fluoride Poisoning", and "Brazil", associated with the entry terms: "Mottled Enamels", "Prevalences", "Occurrence", "Incidences", "Dental Fluorosis", and "Dental". The following DeCS terms were also used: "Prevalence", "Incidence", "Fluorose Dentária" [*Portuguese*], "Fluorosis Dental", and "Fluorosis, Dental". This research was performed in December 2016. The results obtained were exported to the Mendeley™ Desktop 1.13.3 software (Mendeley™ Ltd, London, England) and duplicates were removed.

Study selection

Studies were selected in two phases. In the first phase two eligibility reviewers (IFPL and DFN) systematically analyzed the titles and abstracts, independently. The reviewers were not blind to the names of authors and journals. The articles which titles met the objectives of the study, but did not have abstracts available, were fully analyzed. At this moment, studies that disagree with the objective of this research, review articles, letters to the editor, personal opinions, book/book chapters, didactic material, reports, abstracts, and patents were excluded.

In the second phase, preliminarily eligible studies had their full texts obtained and assessed to verify whether they fulfilled the eligibility criteria. When both reviewers disagreed, a third reviewer (LRP) was consulted to make a final decision. The studies rejected were registered separately, clarifying the reasons for exclusion.

Process of data collection and extraction

Two authors (IFPL and DFN) extracted the data using spreadsheets especially designed for data extraction, which included the following information: author(s), year of publication, sample size, sex, age(s) assessed, city(cities) assessed, sample size calculation/statistical power, ethical criteria, examiner(s) calibration, fluoride concentration in water, prevalence of fluorosis, index used for dental fluorosis diagnosis, severity, and condition for clinical examination. Disagreements were discussed and a third reviewer (LRP) was consulted when necessary. When the same study compared prevalences obtained at different times, only the most recent results were used.

Risk of individual bias of the studies

The risk of bias of the studies selected was assessed by the MAStARI (Meta-Analysis of Statistics Assessment and Review Instrument)[30]. Two authors (IFPL and DFN) assessed independently each domain regarding their potential risk of bias. The risk of bias was ranked as *High* when the study reached up to 49% of "yes" score, *Moderate* when the study reached from 50% to 69% of "yes" score, and *Low* when the study reached over 70% of "yes" score.

Statistical analysis

The summary measure considered was the prevalence of dental fluorosis. The prevalences estimated in the studies were combined through the meta-analytic random effects model for proportions, considering that a high heterogeneity among the estimates of the individual studies was expected. In order to explore the variability among the studies of the estimated prevalence, a subgroup meta-analysis was performed considering the type of water (non-fluoridated water and artesian well - groundwater) as the group factor. The method by DerSimonian and Laird[31] was used to estimate the parameter of variability among the studies, and the heterogeneity among the studies was assessed with I^2 statistics and the Cochran Q test. Data from the individual studies were transformed through the logit function to meet the assumption of normality of the meta-analytic random effects model. Confidence intervals for the results of individual studies were calculated with the method by Coppler-Pearson. The final results were presented as prevalence and 95% confidence intervals. The severity of fluorosis and the amount of fluoride in the waters could not be included in the analysis because of the shortage of such results in the individual studies. The publication bias was not assessed, because it does not fit the case of prevalence meta-analyses. All analyses were performed with the statistical software R.

Results

Study selection

Figure 1 presents details of the search process, identification, inclusion and exclusion of articles. During the first phase of the study selection 1038 results were found, distributed in eight electronic databases. After removing the repeated/duplicate results, 627 articles remained for the analysis of titles and abstracts. After a detailed analysis, only 21 articles were eligible for the full text analysis. The references of the 21 initially eligible articles were carefully assessed to verify any article that has possibly skipped in the main search strategy. One study was also considered as a recommendation from an expert. However, from the 22 articles included in this phase, four articles[23,32-34] were excluded for the following reasons: 1) Part of the sample resided in areas with artificial fluoride supply; 2) Incompatibility of data found in the results; and 3) No clarification of data for the prevalence of dental fluorosis. Therefore, 18 articles contributed to the analysis of results.

Characteristics of the studies included

Table 1 presents a summary of the 18 studies[25,35-51] included in the meta-analysis. From this total, 13 studies involved a total sample of 3884 individuals living in Brazilian cities with treated, non-fluoridated public water supply and seven studies involved a sample of 1920 residents of locations with untreated water supply. Two studies presented results for both groups, since the included cities with non-fluoridated water supply and cities with artesian well water supply. The ages of the populations studied ranged from 5 to 24 years, but students from 6 to 14 years were the most frequent. The studies were performed in the Brazilian states of Espírito Santo[49], Goiás[37], Minas Gerais[25,47,51], Paraná[44], Rio Grande do Sul[37,39,40], São Paulo[36,41-43,45,46,49,50], and Santa Catarina[38].

Risk of individual bias of the studies

None of the studies included met all the verification criteria of the MAStARI[30]. Fourteen studies[35,36,38,39,41-49,51] presented low risk of bias and four studies[25,37,40,50] presented moderate risk of bias assessed by the MAStARI[30]. Table 2 shows detailed information on the risk of bias of the studies included. Item 10 of Table 2 was considered Not Applicable (NA) for all studies, because the eligible studies did not aim to characterize subpopulations.

Results of individual studies and meta-analysis

Table 3 presents the main results of the studies involving cities with non-fluoridated water supply and cities with untreated water from artesian wells. One study[41] assessed the prevalence of fluorosis at 3 different years, but for our study we only considered the results of the most recent year (1997). The Thylstrup and Fejerskov index was the most used for assessing the severity of fluorosis and it was present in nine studies[25,36,37,39-41,47,48,51], followed by the Dean index, which was used in eight studies[35,38,42-46,50]. Among these studies, one[50] used this index only for assessing fluorosis in first permanent molars. The Tooth Surface Index of Fluorosis (TSIF) was also used[49].

The assessment method most used in the studies[25,39,41,46,47,51] consisted in plaque removal

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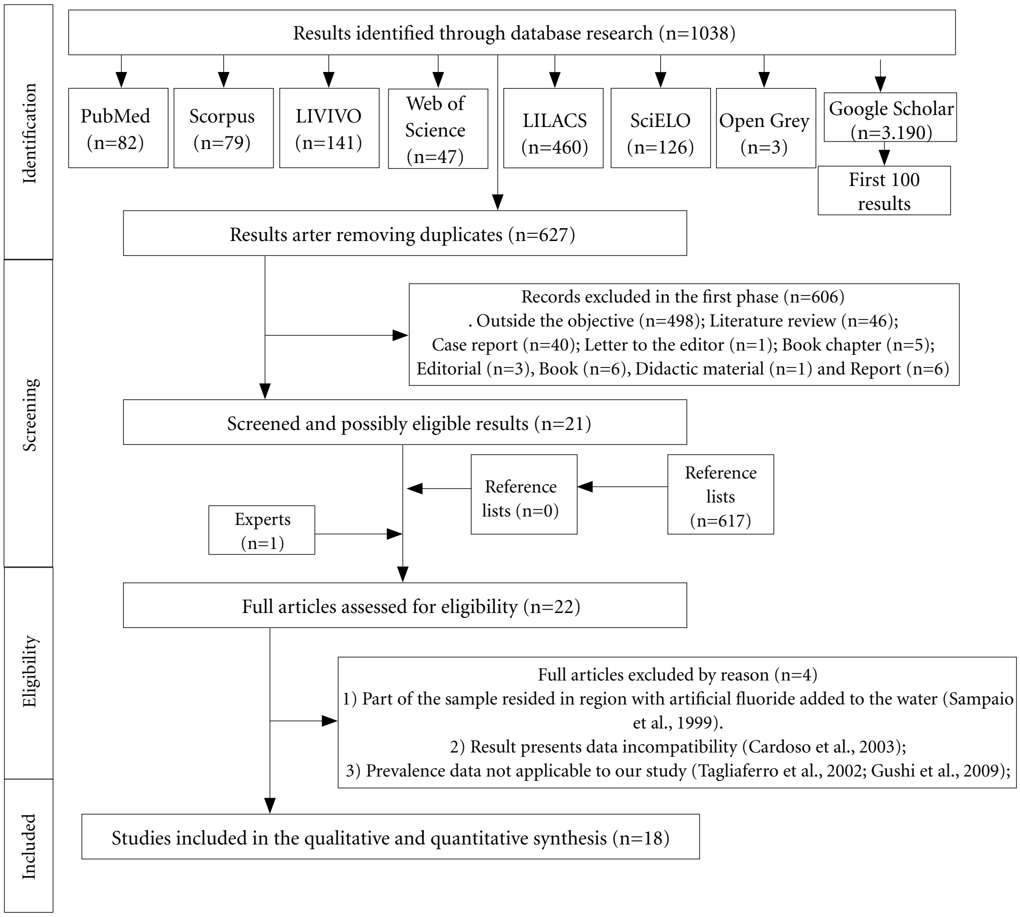

Figure 1. Detailed flowchart of search, identification, inclusion, and exclusion of articles. Adapted from PRISMA.

and drying of teeth before the examination under natural light. However, four studies[38,43,48,50] used only natural light for the analysis without previous prophylaxis.

The estimated prevalence of dental fluorosis ranged from 0.56 % to 40 % among the studies[35-39,40-43,45,46,48,49] performed in regions with non-fluoridated water supply. In most of the regions, there were only residual concentrations of fluoride in the public water supply (lower than 0.2 ppm)[36,37,41,43,49], except for the study by Sampaio[35], in which the fluoride concentration in the water was 0.6-0.9 ppm. Regarding the severity of dental fluorosis, the most prevalent scores in the regions with non-fluoridated water supply were low and very low fluorosis [35-37,39-43,45,46,48,49]. The only exception was observed in the city of Capão Alto/SC[38], where the most prevalent score (1.9 % of the sample) was for severe fluorosis (Table 3).

On the other hand, the estimated prevalence of dental fluorosis ranged from 9.7 % to 100 % among the studies[25,39,44,47,49,50,51] performed in regions supplied with water from artesian wells. These cities presented high concentrations of natural fluoride in the water, ranging from 1.2 to 4.8 ppm F[25,47,49,51], and consequently a higher prevalence of moderate and severe fluorosis[25,47,49,51]. In the cities of São Francisco/MG and Verdelândia/MG[25], which used water from artesian wells, the prevalence of severe fluorosis reached an alarming 48.9 % of the cases of dental fluorosis (Table 3).

Figure 2 presents the main results of the meta-analysis. Summarizing the prevalence estimates, the meta-analytic model estimated 8.92% (95 % CI: 5.41 % to 14.36 %) as the prevalence of fluorosis among cities with non-fluoridated water supply and 51.96 % (95 % CI: 31.03 % to

Table 1. Summary of the main characteristics of the eligible studies.

Authors and year	N/Sex	City(cities) assessed	Age(s) assessed	Sample size calculation/ Statistical power	Ethics Committee/ Consent Form	Calibration of examiner(s)
Sampaio, 1993[35]	609 (sex not informed)	Itabaiana/PB, Salgado de São Félix/PB, Mogeiro/PB	6 to 14 years	Yes	*	*
Heintze et al., 1998[36]	348 (sex not informed)	Itápolis/SP	5 to 24 years	*	*	Yes
Maltz and Farias, 1998[37]	206 (90♂;116♀)	Arroio do Tigre/RS, Luziânia/GO.	8 to 9 years	*	*	*
Furtado et al. 1999[38]	264 (130♂;134♀)	Capão Alto/SC	6 to 12 years	No	Yes	Yes
Ely and Pretto, 2000[39]	539 (non-fluoridated water) 486 (naturally fluoridated water) (sex not informed)	Agudo/RS, Giruá/RS (non-fluoridated water) Faxinal do Soturno/RS, Campina das Missões/RS (naturally fluoridated water);	7 to 14 years	Yes	Yes	Yes
Maltz et al., 2000[40]	101 (sex not informed)	Arroio do Tigre/RS	8 and 9 years	*	Yes	*
Pereira et al., 2000[41]	314 (sex not informed)	Iracemápolis/SP	11 and 12 years	*	Yes	Yes
Cypriano et al., 2003[42]	451 (sex not informed)	Bom Sucesso do Itararé/SP, Itapirapuã Paulista/SP	7 to 12 years	Yes	Yes	Yes
Saliba et al., 2006[43]	177 (69♂; 108♀)	Santo Antônio do Aracanguá/SP	11 to 19 years	*	Yes	Yes
Ditterich et al., 2008[44]	31 (16♂; 15♀)	Ponta Grossa/PR	12 years	*	Yes	Yes
Rando-Meirelles et al., 2008[45]	540 (sex not informed)	Bom Sucesso do Itararé/SP, Itapirapuã Paulista/SP	5 to 12 years	Yes	Yes	Yes
Guerra et al., 2010[46]	119 (sex not informed)	Holambra/SP	12 years	Yes	Yes	Yes
Adelário et al., 2010[47]	396 (201♂; 194♀)	São Francisco/MG, São João das Missões/MG, Verdelândia/MG	6 and 22 years	Yes	Yes	Yes
Ferreira et al., 2010[25]	276 (141♂;135♀)	São Francisco/MG, Verdelândia/MG	6 to 22 years	*	Yes	Yes
Franzolin et al., 2010[48]	120 (non-fluoridated region)	Bauru/SP	12 years	Yes	Yes	Yes
de Carvalho et al., 2011[49]	96 (non-fluoridated region) 27 (natural fluoridation)	São João de Petrópolis/ES e Serra de Cima/ES	9 to 12 years	No	Yes	Yes
Motta et al., 2012[50]	194 (95♂;99♀)	São Roque/SP	7 to 10 years	No	Yes	Yes
Costa et al., 2013[51]	511 (sex not informed)	Northern Minas Gerais	7 to 22 years	*	Yes	Yes

*Data not provided by the authors; ♂: male; ♀: female.

Table 2. Risk of bias performed with the MAStARI (Meta-Analysis of Statistics Assessment and Review Instrument)[30].

Authors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	% Yes/ Risk	Risk of Bias
Sampaio, 1993[35]	√	√	√	√	√	√	U	√	--	NA	77,77%	+
Heintze et al., 1998[36]	√	--	--	√	√	√	√	√	√	NA	77.77%	+
Maltz and Farias, 1998[37]	√	--	--	√	√	√	U	√	√	NA	66,66%	++
Furtado et al. 1999[38]	√	--	U	√	√	√	√	√	√	NA	77.77%	+
Ely and Pretto, 2000[39]	√	√	√	√	√	√	√	√	√	NA	100%	+
Maltz et al., 2000[40]	U	--	U	√	√	√	U	√	√	NA	55,55%	++
Pereira et al., 2000[41]	√	--	U	√	√	√	√	√	√	NA	77.77%	+
Cypriano et al., 2003[42]	√	√	√	√	√	√	√	√	√	NA	100%	+
Saliba et al., 2006[43]	√	√	--	√	√	√	√	√	√	NA	88,88%	+
Ditterich et al., 2008[44]	√	--	--	√	√	√	√	√	√	NA	77.77%	+
Rando-Meirelles et al., 2008[45]	√	√	√	√	√	√	√	√	√	NA	100%	+
Guerra et al., 2010[46]	√	√	√	√	√	√	√	√	√	NA	100%	+
Adelário et al., 2010[47]	√	--	√	√	√	√	√	√	√	NA	88,88%	+
Ferreira et al., 2010[25]	√	--	--	√	U	√	√	√	√	NA	66,66%	++
Franzolin et al., 2010[48]	√	√	√	√	√	√	√	√	√	NA	100%	+
Carvalho et al., 2011[49]	√	--	--	√	√	√	√	√	√	NA	77.77%	+
Motta et al., 2012[50]	U	--	U	√	√	√	√	√	√	NA	66,66%	++
Costa et al., 2013[51]	√	--	U	√	√	√	√	√	√	NA	77.77%	+

Q1: Was the sample representative of the target population?; Q2: Were study participants recruited in an appropriate way?; Q3: Was the sample size adequate?; Q4: Were the study subjects and setting described in detail?; Q5: Is the data analysis conducted with sufficient coverage of the identified sample?; Q6: Were objective, standard criteria used for measurement of the condition?; Q7: Was the condition measured reliably?; Q8: Was there appropriate statistical analysis?; Q9: Are all important confounding factors/ subgroups/differences identified and accounted for?; Q10: Were subpopulations identified using objective criteria?; √: Yes; --: No; U: Unclear; NA: Not Applicable; +++: High; ++: Moderate; +: Low.

72.22 %) among cities with artesian wells. The heterogeneity among studies was high: $I^2 = 95$ % ($p < 0.01$) in the first subgroup of cities and $I^2 = 98$ % ($p < 0.01$) in the second subgroup. The comparison test between both subgroups showed that the prevalence of fluorosis was significantly higher ($p < 0.0001$) in the subgroup of artesian well water.

Discussion

This systematic review aimed to compare the prevalence of dental fluorosis in cities with treated water supply and cities that used water from artesian wells, both non-fluoridated. Fluoride is the most consolidated anticaries agent available in dentistry. When constantly maintained in the oral cavity in its ionic form, fluoride can interfere with the dynamics of the caries process, reducing demineralization and activating tooth remineralization[52]. Among the community methods of fluoride use, its addition to drinking water is considered an important public health measure for controlling the caries disease, considering its low cost and wide coverage[53,54]. Its effectiveness for controlling dental caries is supported by systematic reviews[10,55]. For this reason, it has been recommended by the World Health Organization as a strategy for controlling the caries disease, especially in countries where it is still considered a public health problem[56]. In Brazil, the specific legislation allows a fluoride concentration in water ranging from 0.6 to 0.8 mg F/L, with optimal level at 0.7 mg F/L, varying according to the average temperatures of the Brazilian regions[57].

However, a great portion of Brazilian cities is not supplied with fluoridated water, which leads to significant social and regional inequalities for the prevalence of both dental caries and dental fluorosis[58]. In these locations, the intake of non-fluoridated water from alternative sources may deprive the population of the consolidated benefits that fluoride in the water can provide (anticaries effect supported by the world literature[10,55]) and the intake of groundwater (very common in rural areas) may expose this population to a higher risk of dental fluorosis[51]. Fluoride

Table 3. Summary of the main results of the eligible studies that assessed the prevalence of dental fluorosis in regions with non-fluoridated water and regions supplied by artesian well water (groundwater).

Author(s) and year	Fluoride concentration in water	Prevalence of dental fluorosis	Index used for diagnosing dental fluorosis	Most prevalent index score of dental fluorosis severity	Condition for clinical examination
Regions with non-fluoridated water supply					
Sampaio, 1993[35]	0.6 to 0.9 ppm	4.92%	Dean	Very low	*
Heintze et al., 1998[36]	0.02 ppm	1.7%	Thylstrup and Fejerskov	Very low	Drying of teeth
Maltz and Farias, 1998[37]	0.00 ppm	0.97%	Thylstrup and Fejerskov	Very low	Plaque removal and drying of teeth
Furtado et al. 1999[38]	*	4.16%	Dean	Severe (1.9%)	Natural light
Ely and Pretto, 2000[39]	*	0.56%	Thylstrup and Fejerskov	Very low	Plaque removal and drying of teeth under natural light
Maltz et al., 2000[40]	*	29.7%	Thylstrup and Fejerskov	Very low	Plaque removal and drying of teeth
Pereira et al., 2000[41]	< 0.2 ppm	10.1%1	Thylstrup and Fejerskov	Very low	Plaque removal and drying of teeth under natural light
Cypriano et al., 2003[42]	*	22.8%2	Dean	Very low	*
Saliba et al., 2006[43]	<0.1 ppm[5]	6.21%	Dean	Very low	Natural light
Rando-Meirelles et al., 2008[45]	*	20.37%	Dean	Very low (18.2%)	*
Guerra et al., 2010[46]	*	16.8%	Dean	*	Plaque removal and drying of teeth under natural light
Franzolin et al., 2010[48]	*	40%	Thylstrup and Fejerskov	Very low	Natural light
Carvalho et al., 2011[49]	0.12 ppm	15.6%	Tooth Surface Index of Fluorosis (TSIF) by Horowitz	Very low	Natural and artificial light and drying of teeth

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may reach concentrations of up to 35 mg/L in groundwater, depending on several factors such as the solubility of fluoridated compounds and the depth from which the water is extracted[59]. In the present study, the estimated prevalence of dental fluorosis in cities and rural districts that used water from artesian wells was 51.96%, while in the cities using non-fluoridated water, the estimated prevalence was 8.92% (Figure 2). The high prevalence of dental fluorosis found in the regions that consume water from artesian wells results from the intake of water containing high fluoride concentrations (up to 7.1 ppm F) for a long time. On the other hand, the prevalence of dental fluorosis observed in regions supplied with non-fluoridated water was low if compared to the results of the last epidemiological survey on the oral health conditions of the Brazilian population, performed in 2010, in which the prevalence of fluorosis in 12-year old children was 16.7 %[60]. It must be considered that the results of the referred epidemiological survey do not separate cities with and without access to fluoridated water. In our study, as most of the

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Table 3. Summary of the main results of the eligible studies that assessed the prevalence of dental fluorosis in regions with non-fluoridated water and regions supplied by artesian well water (groundwater).

Author(s) and year	Fluoride concentration in water	Prevalence of dental fluorosis	Index used for diagnosing dental fluorosis	Most prevalent index score of dental fluorosis severity	Condition for clinical examination
Regions supplied by artesian wells					
Ely et al., 2000[39]	*	33.6%	Thylstrup and Fejerskov	Very low (25.77%)	Plaque removal and drying of teeth under natural light
Ditterich et al., 2008[44]	*	9.7%	Dean	Very low (6.4%)	Drying of teeth under natural light
Adelário et al., 2010[47]	1.2 - 4.6 ppm	75.5% (full mouth)	Thylstrup and Fejerskov	Severe	Plaque removal and drying of teeth under natural light
Ferreira et al., 2010[25]	1.4 – 4.8 ppm	80.4%	Thylstrup and Fejerskov	Severe (48.9%)	Plaque removal and drying of teeth under natural light
Carvalho et al., 2011[49]	2.4 ppm F	100%	Tooth Surface Index of Fluorosis (TSIF) by Horowitz	Low/moderate	Natural and artificial light and drying of teeth
Motta et al., 2012[50]	*	14.43%	Dean[4]	Very low (10.3%) and low (4.1%)	Natural light
Costa et al., 2013[51]	1.4 - 4.8 ppm F	64.38%	Thylstrup and Fejerskov	Low and very low (67.9%) Severe (31.3%)	Plaque removal and drying of teeth under natural light

*Data not provided by the authors; 1 Only the year 1997 - because it is more current - was considered for the analysis of prevalence data; 2 The prevalence of this study was performed only in the group aged 7 to 12 years; 3The Thylstrup and Fejerskov index was used only for the oral aspects of upper central incisors and lower first molars; 4The Dean index was used only in first permanent molars. 5Arithmetic mean of collection points from the last collection.

regions supplied with non-fluoridated water presented only residual concentrations of F in the water (Table 3), we believe that the prevalence of 8.92 % of dental fluorosis may be related to the simultaneous use of fluoridated dentifrices[61].

For the diagnosis of dental fluorosis, the Dean[62] and the Thylstrup and Fejerskov[63] indexes were used. These are the most reported indexes used to access the prevalence and severity of dental fluorosis. While the first one is based only on clinical characteristics, the latter, which is an extension of the first, is also based on histopathological characteristics[64]. Both indexes establish increasing codes to evaluate the degree of dental structure damage. In the present systematic review, the scores "low" and "very low" were the most prevalent in the population exposed to non-fluoridated water supply. In contrast, the diagnoses of "moderate" (TF = 3 and 4) and "severe" (TF ≥ 5) fluorosis were reported almost exclusively in cities and rural districts that used water from artesian wells. These levels correspond to a loss of tooth structure higher than 50%[63], causing aesthetic and functional damages, increasing the risk of caries, and affecting directly the quality of life of individuals[8].

The prevalence of dental fluorosis ranged from 0.56 % to 40 % in cities with non-fluoridated water supply. The study by Sampaio[35] examined 609 children from 6 to 14 years old, living in regions with fluoride concentration in water ranging from 0.6 to 0.9 ppm. The results showed a low prevalence of fluorosis in this population (4.92 %) despite the region's tropical weather, high temperatures, and higher water consumption. According to the referred authors, the presence of residual fluoride in the water supply of these cities results from the presence of fluorite in Paraíba River. Some of the eligible studies included in the present systematic review presented

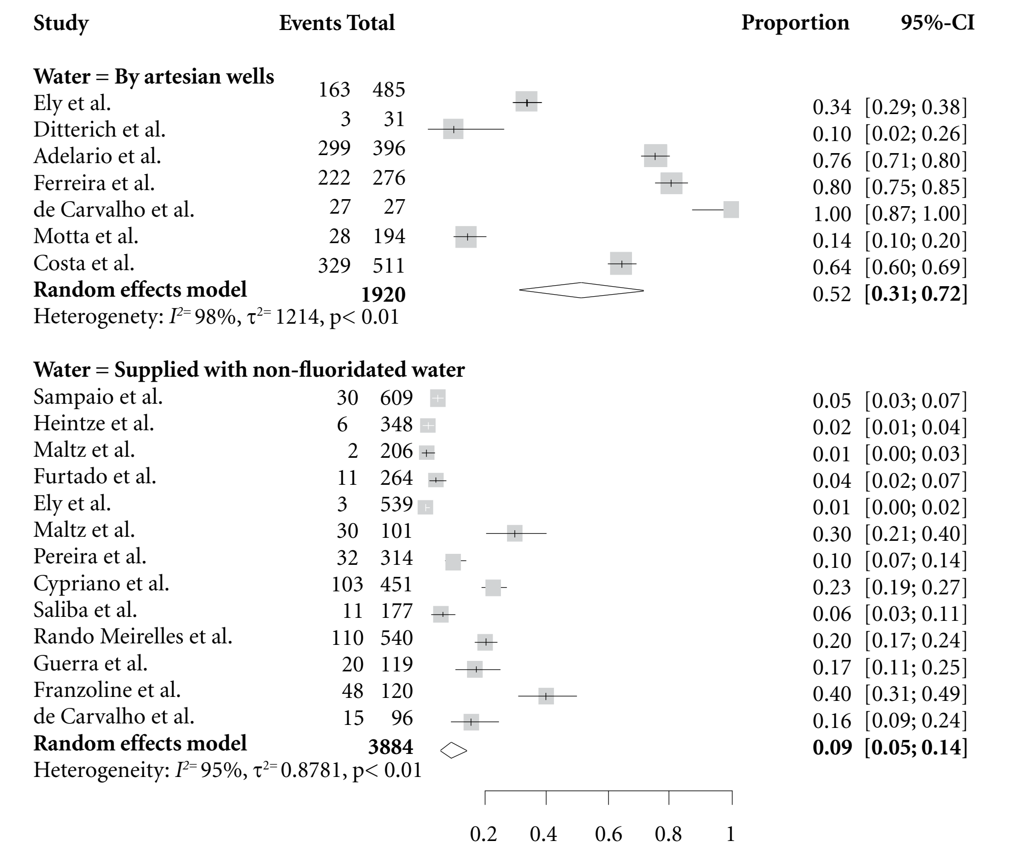

Figure 2. Forest plot with the prevalences estimated by individual studies and the prevalences estimated by the meta-analysis for the group of locations with non-fluoridated water and the group of locations with artesian well water.

non-fluoridated water supply, but with residual fluoride contents. In the study by Saliba et al.[43], which assessed 177 individuals from 11 to 92 years old in a city with non-fluoridated water supply, dental fluorosis was observed in only 11 individuals, corresponding to a prevalence of 6.2 % of the sample, restricted to "very low" (n = 9) and "low" (n = 2) severities. This low prevalence and severity reflects the fluoride concentration found in water (lower than 0.1 ppm F) and are in accordance with the current knowledge that dental fluorosis occurs as a function of the dose and the duration of the fluoride exposure[9]. On the other hand, a study[48] performed with 120 children in a region of the city of Bauru/SP with non-fluoridated water supply, presented a considerable higher prevalence of dental fluorosis (40% of the sample). Considering that the water is not fluoridated in this specific region of the city of Bauru, the authors suggest that the cause of this high prevalence is the use of fluoride from other sources.

In the cities and rural districts that used water from artesian wells, the prevalence of dental fluorosis ranged between 9.7 % and 100 %, and it was associated with the "moderate" and "severe" degrees of fluorosis. The study by Ferreira et al.[25] performed in two rural communities of the state of Minas Gerais, Brazil, in which the source of water supply is groundwater, found high concentrations of F in the water (1.4 and 4.8 ppm F) and consequently a high prevalence of dental fluorosis (80.4%). Among these cases, the score "severe" was the most common, which was present in almost half (48.9%) of the studied sample. The authors[25] classified the policies of access to

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water resources in this region as inadequate. In another study[49], dental fluorosis was present in 100% of the 27 children who used water from artesian wells. The water analysis in the city of Serra de Cima/ES showed a mean concentration of 2.4 ppm F in the water (ranging from 0.4 to 7.2 ppm F), considering that the recommendation for this region is 0.7 ppm. In the same study[49], the authors assessed dental fluorosis in a city supplied with non-fluoridated water (São João de Petrópolis/ES; 0.12 ppm F in the water) and found a prevalence of 15.6 % of dental fluorosis. Once more, it is clear that the exposure to water from artesian wells containing high fluoride concentration contributed to the higher occurrence of dental fluorosis.

Although the consumption of groundwater increases the risk of dental fluorosis (Figure 2), it is not enough to increase its prevalence. It is known that the fluoride contents present in groundwater vary according to region and are influenced by several factors (rock porosity, type of soil, fluoridated compounds solubility[22]); therefore, in some regions groundwater may present only traces of fluoride. It is the case of the studies by Ditterich et al.[44] and Motta et al.[50], which observed low prevalences of dental fluorosis (9.7 % and 14.43 %, respectively) in populations that had been exposed to the consumption of water from artesian wells.

Recent published data showed that 83.3 % of the Brazilian population had access to treated water in 2015[65]. Although the results show that the risk of fluorosis in areas supplied with non-fluoridated water is low, a smaller portion of the Brazilian population living in areas that uses untreated groundwater may be exposed to water containing F above the recommended concentration. Thus, the surveillance of fluoride concentration in the public water supply in these locations is essential to minimize the risk for developing dental fluorosis. In this context, in 2013, the levels of fluoride in the public water supply of 40 Brazilian cities were analyzed and classified based on the risk/benefit balance[66]. From a total of 18,847 fluoridated samples and 686 non-fluoridated ones, 17.90 % of the fluoridated samples were above 0.84 mg F/L and this rate increased to 35.42 % in the non-fluoridated samples[66]. Similarly, a study[67] performed in Maringá/PR observed that the rate of water samples considered out of the optimal fluoride concentration interval was 24.6% in samples obtained from artesian wells and 14% in samples from treatment stations. These data suggest that it is harder to control the fluoride concentration in water in locations supplied with non-fluoridated water, such as the studies included in this review.

This study presents strong factors, as the analytic approach from the meta-analysis application, which allowed estimating the prevalence of fluorosis. However, our results should be interpreted with caution, considering that the studies included present some methodological limitations mentioned in the publication biases, as well as high heterogeneity. The absence of more detailed data regarding the severity of fluorosis in the studies, specific characteristics of fluoride concentration in the water, and the reduced number of eligible studies did not allow performing the meta-regression to explain what factor(s) would be responsible for the high heterogeneity among the studies. It should also be considered that the use of different indexes to measure dental fluorosis compromises the comparability among studies. Moreover, in population studies, the conditions inherent to the examination (use of natural light, absence of prophylaxis, and drying of teeth) may attribute some subjectivity to the clinical examination, making diagnosis difficult, as well as the and determination of dental fluorosis severity. Thus, there is an evident need to assess fluorosis in a comprehensive manner, investigating its association with the different methods of fluoride use. The results of this study are rather useful for future research on dental fluorosis, aiming to elucidate objectively the factors that influence the prevalence rates of this condition.

Conclusion

In summary, the results of the present study showed a higher prevalence of dental fluorosis in populations exposed to water from artesian wells, indicating that the presence of natural fluoride at high concentrations represents a risk factor for the occurrence of dental fluorosis, which should be carefully assessed by the Brazilian authorities.

Collaborations

IFP Lima, DF Nóbrega and LR Paranhos were the eligibility reviewers who participated in the entire process of recruiting, selecting articles and extracting the data for the result. PK Ziegelmann was responsible for the statistical part. IFP Lima, DF Nóbrega, LR Paranhos and GO Cericato had participation in the design of the manuscript and final writing.

References

1. Bratthall D, Hänsel-Petersson G, Sundberg H. Reasons for the caries decline: what do the experts believe? *Eur J Oral Sci* 1996; 104(4):416-422.
2. Marthaler TM. Changes in dental caries 1953-2003. *Caries Res* 2004; 38(3):173-181.
3. Aoba T, Fejerskov O. Dental fluorosis: chemistry and biology. *Crit. Rev. Oral Biol. Med.* 2002; 13(2):155-170.
4. Khan A, Moola MH, Cleaton-Jones P. Global trends in dental fluorosis from 1980 to 2000: a systematic review. *SADJ* 2005; 60(10):418-421.
5. Moysés SJ, Moysés ST, Allegretti ACV, Argenta M, Werneck R. Fluorose dental: ficção epidemiológica? *Rev Panam Salud Publica* 2002; 15(5):339-346.
6. Meneghim MC, Tagliaferro EP, Tengan C, Meneghim ZM, Pereira AC, Ambrosano GM, Assaf AV. Trends in caries experience and fluorosis prevalence in 11- to 12-year old Brazilian children between 1991 and 2004. *Oral Health Prev. Dent.* 2006; 4(3):193-198.
7. Fejerskov O, Thylstrup A, Larsen MJ: Clinical and structural features and possible pathogenic mechanisms of dental fluorosis. *Scand J Dent Res* 1977; 85(7):510-534.
8. Denbesten P, Li W. Chronic fluoride toxicity: dental fluorosis. *Monogr. Oral Sci* 2011; 22:81-96.
9. Angmar-Månsson B, Ericsson Y, Ekberg O. Plasma fluoride and enamel fluorosis. *Calcif. Tissue Res* 1976; 22(1):77-84.
10. McDonagh MS, Whiting PF, Wilson PM, Sutton AJ, Chestnutt I, Cooper J, Misso K, Bradley M, Treasure E, Kleijnen J. Systematic review of water fluoridation. *BMJ* 2000; 321(7265):855-859.
11. Wong MC, Glenny AM, Tsang BW, Lo EC, Worthington HV, Marinho VC. Topical fluoride as a cause of dental fluorosis in children. *Cochrane Database Syst Rev* 2010; 20(1):CD007693.
12. Santos AP, Oliveira BH, Nadanovsky P. Effects of low and standard fluoride toothpastes on caries and fluorosis: systematic review and meta-analysis. *Caries Res* 2013; 47(5):382-390.
13. Iheozor-Ejiofor Z, Worthington HV, Walsh T, O'Malley L, Clarkson JE, Macey R, Alam R, Tugwell P, Welch V, Glenny AM. Water fluoridation for the prevention of dental caries. *Cochrane Database Syst. Rev.* 2015; 18(6):CD010856.
14. Rozier RG. The prevalence and severity of enamel fluorosis in North American children. *J Public Health Dent* 1999; 59(4):239-246.
15. Cangussu MC, Narvai PC, Castellanos Fernandez R, Djehizian V. Dental fluorosis in Brazil: a critical review. *Cad Saude Publica* 2002; 18(1):7-15.
16. Do LG, Spencer A. Oral health-related quality of life of children by dental caries and fluorosis experience. *J Public Health Dent* 2007; 67(3):132-139.
17. Chankanka O, Levy SM, Warren JJ, Chalmers JM. A literature review of aesthetic perceptions of dental fluorosis and relationships with psychosocial aspects/ oral health-related quality of life. *Community Dent Oral Epidemiol* 2010; 38(2):97-109.
18. Brasil. Portaria nº 2.914, de 12 de dezembro de 2011. Dispõe sobre os procedimentos de controle e de vigilância da qualidade da água para consumo humano e seu padrão de potabilidade. *Diário Oficial União* 2011; 14 dez.

19. World Health Organization (WHO). *Oral health surveys: basic methods.* 5th ed. Geneva: WHO; 2013.
20. Terra LG, Borba WF, Fernando GD, Trombeta HW, Silva JLS. Caracterização hidroquímica e vulnerabilidade natural à contaminação das águas subterrâneas no município de Ametista do Sul-RS. *RECEN* 2016; 15(1):94-104.
21. Komati SH, Figueiredo BR. Flúor em água e prevalência de fluorose em Amparo (SP). *Geociências* 2013; 32(3):547-559.
22. Kumar PJS, Jegathambal P, James EJ. Factors influencing the high fluoride concentration in groundwater of Vellore District, South India. *Environ Earth Sci* 2014; 72(7):2437-2446.
23. Sampaio FC, Ramm von der Fehr F, Arneberg P, Petrucci-Gigante D, Hatløy A. Dental fluorosis and nutritional status of 6- to 11-year-old children living in rural areas of Paraíba, Brazil. *Caries Res* 1999; 33(1):66-73.
24. Wondwossen F, Astrøm AN, Bjorvatn K, Bårdsen A. Sociodemographic and behavioural correlates of severe dental fluorosis. *Int J Paediatr Dent* 2006; 16(2):95-103.
25. Ferreira EF, Vargas AM, Castilho LS, Velásquez LN, Fantinel LM, Abreu MH. Factors Associated to Endemic Dental Fluorosis in Brazilian Rural Communities. *Int J Environ Res Public Health* 2010; 7(8):3115-3128.
26. Cunha LF, Tomita NE. Dental fluorosis in Brazil: a systematic review from 1993 to 2004. *Cad Saude Publica* 2006; 22(9):1809-1816.
27. Azami-Aghdash S, Ghojazadeh M, Pournaghi Azar F, Naghavi-Behzad M, Mahmoudi M, Jamali Z. Fluoride concentration of drinking waters and prevalence of fluorosis in iran: a systematic review. *J Dent Res Dent Clin Dent Prospects* 2013; 7(1):1-7.
28. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JPA, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *BMJ* 2009; 339:b2700.
29. Deeks J, Gatsonis C. The Cochrane Collaboration. Cochrane handbook for systematic reviews of diagnostic test accuracy version 1.0. [acessado 2016 Nov 16]. Disponível em: http://srdta.cochrane.org/
30. The Joanna Briggs Institute. *Joanna Briggs Institute Reviewers' Manual: 2014 edition*. Adelaide: The Joanna Briggs Institute; 2014.
31. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Controlled Clinical Trials*. 1986; 7(3):177-188.
32. Cardoso ACC, Moraes LRS. A associação entre cárie e fluorose dentária com a fluoretação das águas em dois municípios do estado da Bahia. *Rev baiana Saude Publica* 2003; 27(1/2):7-18.
33. Tagliaferro EPS, Rihs LB, de Sousa MLR. Prevalência de cárie, fluorose dentária e necessidades de tratamento em escolares, Leme, SP. *Arq Cent Estud Curso Odontol 2002; 38(3):213-221.*
34. Gushi LL, Lobo MM, Wada RS, Meirelles MPMR, Sousa MLR. Prevalência e severidade da cárie e fluorose em escolares e pré-escolares de um município de médio porte sem água fluoretada. *Odonto clín-cient* 2009; 8(4):343-347.
35. Sampaio FC. Prevalência de cárie e fluorose dentária em cidades da Paraíba com teores residuais de fluoretos na água de abastecimento. *CCS* 1993; 12(2):11-19.
36. Heintze SD, Bastos JR, Bastos R. Urinary fluoride levels and prevalence of dental fluorosis in three Brazilian cities with different fluoride concentrations in the drinking water. *Community Dent Oral Epidemiol* 1998; 26(5):316-323.
37. Maltz M, Farias C. Fluorose dentária em escolares de quatro cidades brasileiras com e sem água artificialmente fluoretada. *Rev. Fac. Odontol P Alegre* 1998; 39(2):18-21.
38. Furtado A, Traebert JL, Marcenes WS. Prevalência de doenças bucais e necessidade de tratamento em Capäo Alto, Santa Catarina. *Rev. ABO Nac.* 1999; 7(4):226-230.
39. Ely HC, Pretto SM. Fluorose e cárie dentária: estudo epidemiológico em cidades do Rio Grande do Sul com diferentes níveis de flúor nas águas de abastecimento. *Rev. Odonto Ciênc* 2000; 15(31):143-173.
40. Maltz M, Silva BB, Schaeffer A, Farias C. Prevalência de fluorose em duas cidades brasileiras, uma com água artificialmente fluoretada e outra com baixo teor de flúor, em 1987 e 1997/98. *Rev. Fac. Odontol P Alegre* 2000; 42(2):51-55.
41. Pereira AC, Cunha FL, Meneghim MC, Werner CW. Dental caries and fluorosis prevalence study in a nonfluoridated Brazilian community: Trend analysis and toothpaste association. *J Dent Child* 2000; 67(2):132-135.
42. Cypriano S, Pecharki GD, Sousa MLR, Wada RS. A saúde bucal de escolares residentes em locais com ou sem fluoretação nas águas de abastecimento público na região de Sorocaba, São Paulo, Brasil. *Cad Saude Publica* 2003; 19(4):1063-1071.
43. Saliba NA, Moimaz SAS, Saliba O, Santos KT, Sundfeld RH, Lelis RT. Fluorose dentária em jovens não expostos à água fluoretada durante a formação dentária. *Arq. Cent. Estud. Curso Odontol* 2006; 42(2):113-123.
44. Ditterich RG, Portero PP, Gabardo MCL, Wambier DS. Prevalência de fluorose dentária e de opacidades de origem não-fluorótica em áreas com e sem fluoretação artificial da água de abastecimento público. *Arq. Cent. Estud. Curso Odontol* 2008; 44(2):11-17.
45. Rando-Meirelles MPM, Hoffmann RHS, Silva DD, Sousa MLR. Fluorose dentária em pré-escolares e escolares de municípios com e sem água fluoretada na região de Sorocaba, SP, Brasil. *Braz. Dent. Sci* 2008; 11(1):84-90.
46. Guerra LM, Pereira AC, Pereira SM, Meneghim MC. Assessment of socioeconomic variables in the caries and fluorosis prevalence in cities with and without water supply fluoridation. *Rev Odontol UNESP* 2010; 39(5):255-262.
47. Adelário AK, Vilas-Novas LF, Castilho LS, Vargas AM, Ferreira EF, Abreu MH. Accuracy of the simplified Thylstrup & Fejerskov index in rural communities with endemic fluorosis. *Int J Environ Res Public Health* 2010; 7(3):927-937.
48. Franzolin SOB, Gonçalves A, Padovani CR, Francischone LA, Marta SN. Epidemiology of fluorosis and dental caries according to different types of water supplies. *Cien Saude Colet* 2010; 15(Supl. 1):1841-1847.

49. Carvalho RB, Medeiros UV, Santos KT, Pacheco Filho AC. Influência de diferentes concentrações de flúor na água em indicadores epidemiológicos de saúde/doença bucal. *Cien Saude Colet* 2011; 16(8):3509-3518.
50. Motta LJ, Santos JG, Alfaya TA, Godoy CHL, Bussadori SK. Clinical status of permanent first molars inchildren aged seven to ten years in abrazilian rural community. *Braz J Oral Sci* 2012; 11(4):475-480.
51. Costa AB, Lobo EA, Soares J, Kirst A. Desfluoretação de águas subterrâneas utilizando filtros de carvão ativado de osso. *Águas Subterrâneas* 2013; 27(3):60-70.
52. Proceedings of a Joint IADR/ ORCA International Symposium on Fluorides: Mechanisms of action and recommendations for use, March 21-24, 1989, Callaway Gardens Conference Center, Pine Mountain, Georgia. *J Dent Res* 1990; 69:Special Issue.
53. Horowitz HS. The 2001 CDC recommendations for using fluoride to prevent and control dental caries in United States. *J Public Health Dent* 2003; 63(1):3-10.
54. Pauleto AR, Pereira ML, Cyrino EG. Saúde bucal: uma visão crítica sobre programações educativas para escolares. *Cien Saude Colet* 2004; 9(1):121-130.
55. Parnell C, Whelton H, O'Mullane D. Water fluoridation. *Eur Arch Paediatr Dent* 2009; 10(3):141-148.
56. World Health Organization (WHO). *The Sixtieth World Health Assembly. Agenda item 12.9: Oral health: action plan for promotion and integrated disease prevention*. Geneva: WHO; 2007. Technical Report.
57. Brasil. Lei n. 6.050, de 24 de maio de 1974. Dispõe sobre a fluoretação da água em sistemas de abastecimento público quando existir estação de tratamento. *Diário Oficial da União* 1974; 27 maio.
58. Antunes JLF, Narvai PC. Políticas de saúde bucal no Brasil e seu impacto sobre as desigualdades em saúde. *Rev Saude Publica* 2010; 44(2):360-365.
59. United Nations Children's Fund (UNICEF). *UNICEF's Position on Water Fluoridation* [acessado 2017 Maio 25]. Disponível em: http://www.nofluoride.com/unicef_fluor.htm.
60. Brasil. Ministério da Saúde (MS). Departamento de Atenção Básica. SB Brasil 2010. *Pesquisa nacional de saúde bucal: Resultados principais*. Brasília: MS; 2011. [acessado 2017 Maio 26]. Disponível em: http://dab.saude.gov.br/CNSB/sbbrasil/arquivos/projeto_sb2010_relatorio_final.pdf
61. Mascarenhas AK. Risk factors for dental fluorosis: a review of the recent literature. *Pediatr. Dent.* 2000; 22(4):269-277.
62. Dean HT. Fluorine in the control of dental caries. *J. Am. Dent. Assoc.* 1956; 52(1):1-8.
63. Thylstrup A, Fejerskov O. Clinical appearance of dental fluorosis in permanent teeth in relation to histologic changes. *Community Dent. Oral Epidemiol* 1978; 6(6):315-328.
64. Fejerskov O, Cury JA, Tenuta LMA, Marinho VC. Fluoride in caries control; Em: Fejerskov O, Nyvad B, Kidd E, editors. *Dental Caries*: *The Disease and Its Clinical Management*. Oxford: Wiley Blackwell; 2015. p. 277-285.
65. Freitas FG, Magnabosco AL. *Benefícios econômicos e sociais da expansão do saneamento no Brasil*. São Paulo: Instituto Trata Brasil; 2017.
66. Moimaz SA, Saliba NA, Saliba O, Sumida DH, Souza NP, Chiba FY, Garbin CA. Water fluoridation in 40 Brazilian cities: 7 year analysis. *J Appl Oral Sci* 2013; 21(1):13-29.
67. Bergamo ETP, Barbana M, Terada RSS, Cury JA, Fujimaki M. Fluoride concentrations in the water of Maringá, Brazil, considering the benefit/risk balance of caries and fluorosis. *Braz Oral Res* 2015; 29(1):1-6.

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