








# Heterocontrol of water fluoridation in a municipality in northeast of Brazil after the privatization of the public supply service

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**Aim:** The aim of the present study was to analyze fluoride levels in the public water supply of Teresina, Piauí, Brazil, following the change of the public supply service. **Methods:** This is a prospective descriptive laboratory study. The water samples were collected from 13 random locations over a period of 13 months. Three neighborhoods were randomly selected from each of the four zones (north, south, east and southeast) of the municipality (n=12) and one location close to the Water Treatment Plant (WTP) (n=1). The samples collect followed the VIGIFLUOR guide. Fluoride concentration analyses were performed in duplicate using a specific ion electrode (Orion 96–06; Thermo Scientific Orion., Boston, MA, USA) coupled to a VersaStar potentiometer (Thermo Scientific Orion), and the results were expressed in mg F/L (ppm F). Descriptive analysis and classification of samples were carried out according to the criteria of the Ministry of Health Collaborating Center for Oral Health Surveillance. **Results:** Out of the 169 samples analyzed, 158 samples (93.5%) were classified as inappropriate (ranging from 0.00 to 0.34 ppm F), and 11 samples were classified as appropriate (6.5%) (ranging from 0.45 to 0.74 ppm F). **Conclusions:** The majority of the water samples from the public supply in Teresina, particularly from the southeast and east zones, exhibited fluoride concentrations below the range considered optimal for controlling dental caries and minimizing the risk of fluorosis. Implementing heterocontrol is essential to maintain the quality of water distributed to the population.

**Keywords:** Fluoridation. Fluorides. Public health.

## Introduction

Fluoridation of public water supplies is an effective measure for controlling dental caries<sup>1,2</sup>, as recommended by the World Health Organization<sup>3</sup>. This practice has been shown to reduce the experience of the disease by 50% to 65% in populations exposed continuously from birth, where water is the sole source of fluoride<sup>4</sup>. Even among populations using fluoridated toothpastes, there is a correlation between fluoridated water and reduced dental caries, indicating that fluoride in water remains a significant factor in controlling and preventing the disease in individuals with similar socioeconomic and demographic conditions<sup>5,6</sup>.

Fluoridation in the municipality of Teresina, Piauí was implemented in 1978 by the state company Águas e Esgotos do Piauí S/A (AGESPISA), interrupted in 1986, and resumed in August 1997<sup>7</sup>. Studies conducted in Teresina in the early 2000s confirmed both the presence<sup>7</sup> and absence of fluoride<sup>8</sup>. Subsequent research on fluoride intake by children<sup>9-11</sup> and the evaluation of dental caries and fluorosis in schoolchildren in the municipality<sup>5,6</sup> confirmed the presence of fluoride in public water supply from 2012 to 2017. In August 2017, water supply, sewage collection, and treatment services were granted through a public-private partnership by the municipality and began to be managed by the company "Águas de Teresina"<sup>12</sup>.

In Brazil, Law 6.050/1974 specifies that in locations with a Water Treatment Station (WTS), projects aimed at building or expanding public supply systems must include plans for water fluoridation<sup>13</sup>. Surveillance of this measure is necessary to ensure optimal concentrations of fluoride, which offer the maximum anti-caries benefit while minimizing the risk of dental fluorosis<sup>14</sup>. Heterocontrol is a surveillance principle that refers to the oversight of a public service by an institution other than the one implementing the measure<sup>15</sup>. Heterocontrol studies have identified deficiencies in the water fluoridation process, evidenced by the low or high concentrations of fluoride found in the analyzed samples<sup>8,16-29</sup>.

Due to the lack of heterocontrol studies in Teresina after 2005 and the change in the company responsible for water supply, it was necessary to conduct an assessment of the fluoride concentration. This was done to determine whether the population continued to benefit from this public health measure. Therefore, the objective of this study was to perform heterocontrol of the fluoride concentration in the water supply distributed to the population.

## Methods

### Study location

Teresina is a Brazilian municipality and the capital of the State of Piauí. It has an area of 1,391.293 km<sup>2</sup> and a population of 866,300 inhabitants, with a human development index of 0.751<sup>30</sup>. Approximately 6% of this population lives in the rural area of the city and does not benefit from the water supply system and consequent fluoridation<sup>6</sup>. The average maximum daily temperature is approximately 33.8°C<sup>31</sup>. Teresina has two Water Treatment Plants (WTP). The larger plant is

responsible for treating and distributing fluoridated water to approximately 85% of the urban population.

## Study design

A prospective descriptive laboratory study and analysis of the fluoride concentration in water were carried out.

## Sample collection

The recommendations of the VIGIFLUOR Guide for Coverage and Monitoring of Water Fluoridation in Brazil for municipalities with more than 50,000 inhabitants were followed for the selection of sample collection points and the standardization of this collection<sup>32</sup>. Three neighborhoods were randomly selected from each of the four zones (north, south, east and southeast) of the municipality (n=12), and a school from each neighborhood was randomly selected, along with one location close to the Water Treatment Plant (WTP) (n=1), totaling 13 collection points. The samples were collected by school center employees, who were instructed by the research team on how to carry out these collections according to the VIGIFLUOR Guide<sup>32</sup>.

The guide stipulates that water samples should be collected at public education or health units and that a collection point should be located near the WTP exit. The water samples were collected directly from the water meter or from the first tap immediately after the water meter to ensure they reflect the fluoride concentration in the water distribution network in real time. To assess the continuity of exposure to fluoridated water, samples were collected once a month, on the same day and time, over a period of 13 months. During collection, the tap was opened for thirty seconds to eliminate any water that had stagnated in the pipes. The samples were placed in plastic bottles that were previously labeled and identified according to the area, neighborhood, and school<sup>32</sup>. The bottles were washed three times before collecting the water sample. The samples were then stored in a refrigerator until analysis in the laboratory. To ensure that all collection points were supplied by the WTP, the company "Águas de Teresina" was asked for the list of neighborhoods and their respective schools that were supplied by the WTP.

Sample tests were carried out at the Biochemistry Laboratory of the Faculdade de Odontologia de Piracicaba (FOP – UNICAMP), Piracicaba, São Paulo. The counter-tests were stored in a refrigerator in the Departamento de Patologia e Clínica Odontológica da Universidade Federal do Piauí (UFPI).

## Fluoride concentration analysis

The fluoride concentration was determined using an ion-specific electrode for fluoride (F-ISE) (Orion 96–06; Thermo Scientific Orion., Boston, MA, USA) coupled to a VersaStar potentiometer (Thermo Scientific Orion). The equipment was calibrated with standard solutions containing fluoride concentrations from 0.05 to 1.6 µg F/mL. The water samples were prepared for analysis with F-ISE as described in VIGIFLUOR Guide<sup>32</sup>. Volumes of 1.0 mL of the samples were transferred to a

coded tube and buffered with 1.0 mL of TISAB II 50% (v/v). For each analysis, a calibration curve was made. Analyses were performed in duplicate, and the fluoride concentrations in the samples were determined from the linear regression of the logarithm of fluoride concentrations of the standards with mV (millivolts) values using Excel spreadsheet® (Microsoft Corporation., Chicago, USA). The results were expressed in mg F/L (ppm F). Teresina has an average maximum temperature of approximately 33.8 degrees<sup>31</sup> and an optimum fluoride content for the region should be between 0.45 and 0.74 ppm F<sup>32</sup>.

## Data analysis

A descriptive analysis was carried out using Excel® (Microsoft Corporation., Chicago, USA), considering adequate concentrations to be between 0.45 and 0.74 ppm F, depending on the average local temperatures and the balance between the anti-caries benefit and the risk of fluorosis. This range is based on guidelines from the Collaborating Center of the Ministry of Health for Oral Health Surveillance of the University of São Paulo (CECOL/USP, 2011) (Table 1)<sup>33</sup>.

**Table 1.** Fluoride concentration in water (µg F/mL) for locations where average annual maximum temperatures are above 32.5° C – Collaborating Center of the Ministry of Health on Oral Health Surveillance, 2011.

Fluoride content in water (in ppm or mg F/mL)	Benefit (Prevent tooth decay)	Risk (Produce dental fluorosis)
0.00 to 0.34	Insignificant	Insignificant
0.35 to 0.44	Minimum	Low
<b>0.45 to 0.74 (*)</b>	<b>Maximum</b>	<b>Low</b>
0.75 to 0.84	Maximum	Moderate
0.85 to 1.44	Questionable	High
1.45 or more	Harm	Very high

\* The range of 0.45 to 0.74 mg F/L provides the best benefit-risk combination, according to the Collaborating Center of the Ministry of Health on Oral Health Surveillance, 2011.

## Results

Of the 156 samples analyzed, 145 samples (93%) were classified as inappropriate (between 0.00 and 0.34 ppm F), and 11 samples (7%) as appropriate (between 0.45 and 0.74 ppm F). Four samples occurs in the first month of this study and seven of the 11 samples classified as appropriate occurred in the last three months of the heterocontrol. The mean and standard deviation of the fluoride content of the samples collected, per collection point over the 12 months, are presented in Table 2.

In April 2023, a spot check was carried out to test fluoride levels again, as all samples (n=13) were inadequate. The majority of the values presented were below the recommended optimum value (0.45 to 0.74 ppm F). Data on the concentration of

fluoride in the water supply by administrative zone are shown in Table 3, and the results show that only north and south zones presented samples at the optimal fluoride concentration.

**Table 2.** Fluoride concentration ( $\mu\text{g F/mL}$ ) of water samples from Teresina, Piauí from October 2021 to September 2022 and in April 2023 according to each collect point.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Apr	Mean	SD
	2021						2022						2023		
1	0.42	0.35	0.31	0.36	0.18	0.23	0.33	0.24	0.24	0.54	0.33	0.50	0.27	0.33	0.10
2	0.22	0.15	0.17	0.13	0.10	0.14	0.19	0.20	0.23	0.31	0.22	0.37	0.20	0.20	0.07
3	0.51	0.33	0.43	0.24	0.22	0.22	0.39	0.41	0.27	0.49	0.52	0.06	0.20	0.33	0.14
4	0.50	0.33	0.31	0.25	0.23	0.17	0.44	0.38	0.38	0.52	0.43	0.45	0.36	0.36	0.10
5	0.55	0.44	0.41	0.19	0.19	0.18	0.19	0.25	0.21	0.36	0.41	0.43	0.29	0.32	0.12
6	0.37	0.26	0.26	0.20	0.20	0.18	0.27	0.31	0.31	0.38	0.31	0.35	0.34	0.29	0.06
7	0.24	0.26	0.25	0.18	0.12	0.14	0.28	0.25	0.31	0.33	0.37	0.34	0.28	0.26	0.07
8	0.32	0.19	0.21	0.23	0.33	0.07	0.24	0.19	0.26	0.34	0.28	0.40	0.20	0.25	0.08
9	0.09	0.12	0.16	0.16	0.06	0.20	0.19	0.24	0.25	0.16	0.22	0.22	0.20	0.17	0.05
10	0.14	0.14	0.13	0.11	0.08	0.12	0.13	0.18	0.18	0.16	0.22	0.21	0.16	0.15	0.03
11	0.33	0.12	0.18	0.11	0.11	0.10	0.17	0.17	0.18	0.17	0.18	0.30	0.17	0.17	0.06
12	0.20	0.12	0.13	0.10	0.12	0.08	0.21	0.18	0.21	0.23	0.22	0.26	0.18	0.17	0.05
13	0.54	0.35	0.31	0.27	0.25	0.28	0.21	0.33	0.21	0.36	0.48	0.26	0.16	0.31	0.10

\* The numbers 1 to 13 in the first column refer to the identification of each collection point.

**Table 3.** Fluoride concentration ( $\text{mg F/mL}$ ) of water samples from Teresina, Piauí, from October 2021 to September 2022 and in April 2023, categorized by urban area.

Zone	Below optimal concentration (0.00 to 0.44 $\mu\text{g F/mL}$ )		Optimal concentration (between 0.45 and 0.74 $\mu\text{g F/mL}$ )		Above optimal concentration (0.75 $\mu\text{g F/mL}$ or more)	
	n	%	n	%	n	%
North	35	20.8	4	2.3	0	0.0
South	45	26.7	7	4.2	0	0.0
East	39	23.0	0	0.0	0	0.0
Southeast	39	23.0	0	0.0	0	0.0
Total	158	93.5	11	6.5	0	0.0

## Discussion

Analyses of the fluoride concentration in the water of Teresina, Brazil, over thirteen months, demonstrated that the majority of samples (93,5%) presented levels below

those recommended for the control of dental caries and minimal risk of developing fluorosis. The averages per collection point were also below the optimal levels according to CECOL classification<sup>33</sup>. Only the North and South zones presented samples with fluoride concentrations within the recommended range during the period evaluated in this study. These results can be explained by their geographic proximity to the region with the largest WTP, which likely does not receive additional water from tubular wells that undergo only chlorination as treatment and are integrated into existing reservoirs throughout the city. However, a geographic analysis in the municipality, as well as an analysis of the location of these reservoirs, is necessary to substantiate this hypothesis.

The dates obtained in this study are similar to those from other studies and demonstrated less coverage of fluoridation in the North, Northeast and Center-West regions<sup>7,8,20-23,28,34</sup> comparing to South<sup>17,19,26,27,29,35-40</sup> and Southeast<sup>16,18,24,25,41-49</sup> regions. The first heterocontrol study conducted in Teresina demonstrated 37% of the samples had fluoride concentration below the optimum range, 10% above and 53% within the optimal limits for the city<sup>7</sup>. Another study in the state of Piauí, conducted in three cities (Teresina, Floriano and Parnaíba) with a total of 576 samples analyzed, found that only 4.3% (n=25) presented values within the range considered adequate for the city of Teresina<sup>8</sup>. In another Northeast regions as in Pernambuco, Brazil, in a 12-month heterocontrol conducted in the city of Guarabira, Pernambuco, where 83.3% of the analyzed samples had fluoride concentrations below the recommended level<sup>23</sup>. In the northern region, a heterocontrol study conducted in Manaus, Amazonas, between 2016 and 2018 showed that of the 2,874 samples collected, 49% had inadequate concentrations for the region<sup>50</sup>. These data show that, even with the mandatory fluoridation of water, there is no adjustment in the established fluoride concentration.

The parameters used in this study to evaluate fluoride concentration were based on the CECOL-USP criteria<sup>33</sup> (2011), which recommend that the evaluation of fluoride content in water consider the preventive benefit for dental caries and the risk of developing dental fluorosis. For the city of Teresina, with average monthly and annual daily maximum temperatures above 32.5°C<sup>31</sup>, the optimal benefit-risk combination is in the range of 0.45 to 0.74 mg F/L<sup>33</sup>. These values differ from the criteria established by Ordinance No. 635/1975<sup>51</sup>, which specifies an optimal concentration of 0.6 to 0.8 mg F/L for the water supply in the national territory. However, this Ordinance only considers the average maximum daily temperatures, introducing a confounding factor due to the differing measurement intervals for fluoride content specified by Ordinance No. 635<sup>51</sup> and those indicated by the CECOL-USP parameters. In 2015, the United States Public Health Service (PHS) updated and replaced its 1962 Drinking Water Standards related to community water fluoridation, recommending an optimal fluoride concentration of 0.7 mg/L. This concentration provides the best balance of protection from dental caries while limiting the risk of dental fluorosis. The earlier PHS recommendation for fluoride concentrations was based on outdoor air temperature of geographic areas and ranged from 0.7 to 1.2 mg/L<sup>52</sup>.

Water fluoridation is widely recognized as a crucial method for controlling dental caries<sup>1</sup>, supported by the World Health Organization<sup>3</sup> (WHO). In 2022, the International Association for Dental Research issued a position on water fluoridation, declaring that the method has a protective effect against tooth decay, is safe, effective, economical and reduces inequalities in oral health<sup>53</sup>. Fluoridation of public water supplies is the simplest collective way of maintaining a low and constant dose of fluoride in the oral cavity and there is no evidence that fluoride in water at optimal concentration causes any other systemic effects on humans other than dental fluorosis<sup>54</sup>. The interruption of water fluoridation triggers an increase in the prevalence of dental caries, equating the severity of the disease with that of groups exposed to low or no fluoride levels<sup>1</sup>. In EUA it was demonstrated that starting water fluoridation in public supply service decreased the occurrence of caries in children aged 4-17 by 30-50% and the interruption of water fluoridation increased caries experience by 18%<sup>55</sup>. A compilation of subsequent studies provided evidence confirming that the economic benefit of community water fluoridation exceeds the cost of the intervention. Furthermore, the cost-benefit ratio increases with the size of the community's population<sup>56</sup>.

Regarding the cost-benefit of fluoridated water in Brazil, it was demonstrated that the average cost per capita/year of implementing fluoridated water in the city of São Paulo was R\$ 0.08 (US\$ 0.03) in 2003, considering costs with initial installation capital, chemical product, system operation (system maintenance, electrical energy and human resources) and monitoring of fluoride levels<sup>57</sup>. In Ireland, despite the population having access to other means of fluoride, it has been demonstrated that the implementation of water fluoridation remains a cost-effective public health intervention for schoolchildren<sup>58</sup>. In New Zealand, the cost-effectiveness of community water fluoridation was found to be highly cost-effective, with the benefits in terms of averted suffering and dental care costs discernible for communities as small as 500 people. There is a nine times pay-off, with savings over two decades<sup>59</sup>.

Some limitations can be considered in this study. Although there was oversight of the water samples collection by school employees, the research team did not have in-person control during the collection process; Oversight occurred virtually through messages on the *WhatsApp*® application and by sending photos of the samples collected by employees to the research team members.

In conclusion, the majority of samples collected from the public water supply showed fluoride concentrations below the range considered optimal for the municipality of Teresina, Brazil. This was particularly evident in the Southeast and East zones, where no samples had fluoride concentrations within the optimal range for the control of tooth decay and minimal risk of developing fluorosis. It is necessary to identify flaws in the water supply for the population of Teresina, requiring joint action between the city's Municipal Health Department and the concessionaire responsible for the water supply, Águas de Teresina, to coordinate actions to resolve this issue and ensure the benefit of fluoridation of public water supply for the population. The implementation of heterocontrol is essential for maintaining the quality of water distributed to the population.

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## Conflict of Interest

The authors have no conflict of interest to disclose.

## Data availability

Datasets related to this article will be available upon request to the corresponding author.

## Author Contribution

All authors have made substantive contribution to this study and/or manuscript. **Gildenilson Oliveira Júnior:** Conceived and designed the experiment, Performed the experiments, Analyzed the data, Wrote and reviewed it critically for important intellectual content the paper. **Letícia Caminha Aguiar Lopes:** Analyzed the data, Wrote and reviewed it critically for important intellectual content the paper. **Cacilda Castelo Branco Lima:** Analyzed the data. **Marina de Deus Moura de Lima:** Analyzed the data, Wrote and reviewed it critically for important intellectual content the paper. **Lúcia de Fatima Almeida de Deus Moura:** Analyzed the data, Wrote and reviewed it critically for important intellectual content the paper. **Cinthia Pereira Machado Tabchoury:** Conceived and designed the experiment, Performed the experiments, Analyzed the data, Wrote and reviewed it critically for important intellectual content the paper. **Marcoeli Silva de Moura:** Conceived and designed the experiment, Analyzed the data, Wrote and reviewed it critically for important intellectual content the paper. All authors approved final version to be published and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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## References

1. Iheozor-Ejirofor Z, Worthington HV, Walsh T, O'Malley L, Clarkson JE, Macey R, et al. Water fluoridation for the prevention of dental caries. *Cochrane Database Syst Rev*. 2015 Jun;2015(6):CD010856. doi: 10.1002/14651858.CD010856.pub2. Update in: *Cochrane Database Syst Rev*. 2024 Oct;10:CD010856. doi: 10.1002/14651858.CD010856.pub3.
2. Rugg-Gunn AJ, Spencer AJ, Whelton HP, Jones C, Beal JF, Castle P, et al. Critique of the review of 'Water fluoridation for the prevention of dental caries' published by the Cochrane Collaboration in 2015. *Br Dent J*. 2016 Apr;220(7):335-40. doi: 10.1038/sj.bdj.2016.257.
3. World Health Organization (WHO). Sixtieth World Health Assembly: Resolution WHA60.1. Geneva: WHO; 2007.
4. O'Mullane DM, Baez RJ, Jones S, Lennon MA, Petersen PE, Rugg-Gunn AJ, et al. Fluoride and oral health. *Community Dent Health*. 2016 Jun;33(2):69-99.

5. Silva MCC, Lima CCB, Lima MDM, Moura LFAD, Tabchoury CPM, Moura MS. Effect of fluoridated water on dental caries and fluorosis in schoolchildren who use fluoridated dentifrice. *Braz Dent J*. 2021 May-Jun;32(3):75-83. doi: 10.1590/0103-6440202104167.
6. Marques RB, Lima CCB, de Abreu Costa MLV, de Deus Moura de Lima M, Moura LFAD, Tabchoury CPM, et al. Fluoridated water impact on tooth decay and fluorosis in 17-20-year-olds exposed to fluoride toothpaste. *J Public Health Dent*. 2022 Sep;82(4):385-94. doi: 10.1111/jphd.12472. Epub 2021 Aug 5.
7. Moura MS, Silva JS, Simplicio AHM, Cury JA. [Long-term assessment of fluoride level of public water supply in Teresina-Piauí]. *Rev Odont Cienc*. 2005;20(48):132-6. Portuguese.
8. da Silva JS, do Val CM, Costa JN, de Moura MS, Silva TA, Sampaio FC. [Monitoring water fluoridation in three cities in Piauí State, Brazil]. *Cad Saude Publica*. 2007 May;23(5):1083-8. Portuguese. doi: 10.1590/s0102-311x2007000500010.
9. Lima CV, Cury JA, Vale GC, Lima MD, Moura LF, Moura MS. Total Fluoride intake by children from a tropical Brazilian city. *Caries Res*. 2015;49(6):640-6. doi: 10.1159/000442029.
10. Lima CV, Pierote JJ, de Santana Neta HA, de Deus Moura de Lima M, de Deus Moura LF, de Moura MS. Caries, toothbrushing habits, and fluoride intake from toothpaste by Brazilian children according to socioeconomic status. *Pediatr Dent*. 2016;38(4):305-10.
11. Oliveira PFT, Cury JA, Lima CV, Vale GC, Lima MDM, Moura LFAD, et al. Is the fluoride intake by diet and toothpaste in children living in tropical semi-arid city safe? *Braz Oral Res*. 2018;32:e26. doi: 10.1590/1807-3107bor-2018.vol32.0026.
12. Anjos AMC, Portela IJZ, Coelho CSS, Tabchoury CPM, Lima CCB, Lima MDM, et al. [Fluoridation of Teresina waters after privatization of the public supply company]. [SBPqO abstract PN0924]. *Braz Oral Res*. 2021;35(suppl 3):340. Portuguese.
13. Presidency of the Republic of Brazil. [Law n. 6050, 1974 May 24. Provides for the fluoridation of water in supply systems when there is a treatment plant]. [cited 2024 Jul 8]. Available from: [https://www.planalto.gov.br/ccivil\\_03/leis/l6050.htm](https://www.planalto.gov.br/ccivil_03/leis/l6050.htm). Portuguese.
14. Narvai PC. [Dental caries and fluorine: a twentieth century relation]. *Cienc Saude Colet*. 2000;5(2):381-92. Portuguese. doi: 10.1590/S1413-81232000000200011.
15. Venturini CQ, Narvai PC, Manfredini MA, Frazão P. [Surveillance and monitoring of fluorides in public water supplies: a systematic review]. *Rev Ambient Água*. 2016;11(4):972-88. doi: 10.4136/ambi-agua.1929. Portuguese.
16. Maia LC, Valença AM, Soares EL, Cury JA. [Operational control of water fluoridation in Niterói, Rio de Janeiro, Brazil]. *Cad Saude Publica*. 2003 Jan-Feb;19(1):61-7. Portuguese. doi: 10.1590/s0102-311x2003000100007.
17. Wambier DS, Helena M, Pinto B, Estefano A, Kloth G, Vetorazzi ML, et al. [Analysis of the fluoride levels in the public water supplies in Ponta Grossa – PR: a ten month external control]. *Publ UEPG Cienc Biol Saude*. 2007;13(1/2):65-72. Portuguese. doi: 10.5212/Publ.Biologicas.v.13i1/2.0008.
18. Assaf AV, Teixeira ASC, Silveira FM, Valente MIB, Ditterich RG, Barcelos R. Water Fluoridation and its external control in the municipality of Nova Friburgo, Rio de Janeiro - Brazil. *UNOPAR Cient Cienc Biol Saude*. 2014;16(3):197-201. doi: 10.17921/2447-8938.2014v16n3p%25p.
19. Brito CS, Garbin RR, Mussi A, Rigo L. [Monitoring of fluorine concentration of the public water supply in Passo Fundo city - RS]. *Cad Saude Colet*. 2016;24(4):452-9. Portuguese. doi: 10.1590/1414-462X201600040240.
20. Scalize PS, Pinheiro RVN, Ruggeri Junior HC, Albuquerque A, Lobón GS, Arruda PN. External control of fluoridation in public water supply systems in the state of Goiás, Brazil. *Cien Saude Colet*. 2018 Nov;23(11):3849-60. doi: 10.1590/1413-812320182311.24712016.

21. Bezerra NVF, Leite KLF, Medeiros MMD, Martins ML, Padilha WWN, Cavalcanti YW. The fluoride concentration of the public water supply in the urban zone and indigenous villages of Baía da Traição, Paraíba, Brazil. *Rev Cient CRO – RJ*. 2018;3(1):29-35.
22. Batista HSA, Caetano VS, Rocha BS, Coelho CSS, Moura MS, Falcão CAM, et al. [Heterocontrol of the fluoridation of public water supply in Parnaíba-PI]. *Rev Interdiscip*. 2019;12(1):32-8. Portuguese.
23. Bezerra MED, Ribeiro TM, Forte FDS, Sampaio FC, Nunes JMFF. External control of water fluoridation in a small municipality of northeast of Brazil. *Rev Odontol UNESP*. 2020;49(17):e20200017. doi: 10.1590/1807-2577.01720.
24. Soares WA, Ferreira AG, Ianhez R, Matos DS. [Avaluation of fluoride concentration in public water supply in the municipalities of Arapuá and Lagoa Formosa – Minas Gerais]. *Rev Perquirere*. 2023;20(1):25-36. Portuguese.
25. Buzalaf MA, Granjeiro JM, Damante CA, Ornelas F. Fluctuations in public water fluoride level in Bauru, Brazil. *J Public Health Dent*. 2002 Summer;62(3):173-6. doi: 10.1111/j.1752-7325.2002.tb03440.
26. Vidal SG, Tovo MF, Kramer PF, Ruschel HC, Ferreira SH. [External control of fluoride levels in the public water supply in Torres/RS. *Stomatos*. 2006;12(2):5-9. Portuguese.
27. Panizzi M, Peres MA. [Ten years of external control over water fluoridation in Chapecó, Santa Catarina State, Brazil]. *Cad Saude Publica*. 2008 Sep;24(9):2021-31. Portuguese. doi: 10.1590/s0102-311x20080009000008.
28. Lacerda APAG, Oliveira NA, Pinheiro HHC, Assis KML, Cury JA. Water fluoridation in the ten largest municipalities of the state of Tocantins, Brazil. *Cien Saude Colet*. 2020 Mar;25(4):1507-18. doi: 10.1590/1413-81232020254.17722018. Epub 2018 Aug 17.
29. Lima FG, Lund RG, Justino LM, Demarco FF, Del Pino FA, Ferreira R. [Twenty-four months of external control of fluoride levels in the public water supply in Pelotas, Rio Grande do Sul, Brazil]. *Cad Saude Publica*. 2004 Mar-Apr;20(2):422-9. Portuguese. doi: 10.1590/s0102-311x2004000200009.
30. IBGE. Brazilian Institute of Geography and Statistics Foundation. [Panorama]. Rio de Janeiro: IBGE; 2022 [cited 2024 Jul 8]. Available from: <https://cidades.ibge.gov.br/brasil/pi/teresina/panorama>. Portuguese.
31. INMET. Brazil's National Meteorological Institute. [Seasons]. Brasília: INMET; 2024 [cited 2024 Jul 8]. Available from: <https://tempo.inmet.gov.br/TabelaEstacoes/A001>. Portuguese.
32. Frazão P, Narvai PC. [Water fluoridation coverage and monitoring in Brazil: municipalities with more than 50,000 inhabitants]. São Paulo: Universidade de São Paulo. Faculdade de Saúde Pública; 2017. p.87-101. Portuguese. doi: 10.11606/9788588848252.
33. CECOL/USP Ministry of Health Collaborating Center for Oral Health Surveillance in Brazil. [Technical Consensus Document: Classification of public water supplies according to fluoride content]. In: [Water Fluoridation Surveillance Seminar]. São Paulo: Faculty of Public Health of the University of São Paulo; 2011 [cited 2023 Aug 2]. Available from: [https://cecol.fsp.usp.br/dcms/uploads/arquivos/1398177715\\_CECOL-USP-ClassificacaoAguasSegundoTeorFluor-DocumentoConsensoTecnico-2011.pdf](https://cecol.fsp.usp.br/dcms/uploads/arquivos/1398177715_CECOL-USP-ClassificacaoAguasSegundoTeorFluor-DocumentoConsensoTecnico-2011.pdf). Portuguese.
34. Peixoto DF, Alencar KP, Peixoto RF, Sousa CFM, Sampaio FC, Forte FDS. [External control of fluoridation of public water supplies of the city of Jaguaribara, Ceará, Brazil]. *Rev Bras Prom Saude*. 2012;25(3):271-7. Portuguese.
35. Piva F, Tovo MF, Kramer PF. [External control of fluoridation of public water supply in the municipality of Cachoeira do Sul – RS]. *Rev Fac Odontol P Alegre*. 2008;47(2):29-32. Portuguese. doi: 10.22456/2177-0018.2957.

36. Leivas LL, Tovo MF, Ardenghi TM, Feldens CA, Kramer PF, Faraco Junior IM. [External control of fluoridation in public water supply of Canoas/RS]. *Stomatos*. 2010;16(30):11-20. Portuguese.
37. Piorunneck CMO, Ditterich RG, Gomes EC. [External control of fluoridation in the metropolitan region of Curitiba in the years of 2014 and 2015]. *Cad Saude Colet*. 2017;25(4):414-22. Portuguese. doi: 10.1590/1414-462X201700040171.
38. Kuhnen M, Gamba B, Narval PC, Toassi RFC. Quality of treated water: evaluation of fluoride levels in 10 years of heterocontrol in a city of the State of Santa Catarina. *Vigil Sanit Debate*. 2017;5(1):1-6.
39. Uchida TH, Cury JA, Tabchoury CPM, Terada RSS, Fujimaki M. [Heterocontrol of fluoridation of public water supply 15th health region (state of Paraná, Brazil)]. *Rev Saude Public Paraná*. 2018;1(1):61-9. Portuguese.
40. Lima DP, Agnoll ANVD, Amadori AL, Sebastiany AKE, Portinho D, Terreri ALM. Heterocontrol of fluoridation of the public water supply in the municipality of Cascavel in the state of Paraná. *REFACS*. 2021;9(3):598-607. doi: 10.18554/refacs.v9i3.7626.
41. Ramires I, Maia LP, Rigolizzo DS, Lauris JR, Buzalaf MA. External control over the fluoridation of the public water supply in Bauru, SP, Brazil. *Rev Saude Publica*. 2006 Oct;40(5):883-9. doi: 10.1590/s0034-89102006000600019.
42. Amaral RC, Wada RS, Sousa MLR. [Fluoride concentration in public water supply related to temperature in Piracicaba - SP]. *RFO*. 2007;12(3):24-8. Portuguese.
43. Daré F, Dall'Aglio Sobrinho M, Libânio M. [Evaluation of the fluoridation in the water supply systems of Araçatuba, São Paulo, Brazil]. *Eng Sanit Ambient*. 2009;14(2):173-82. Portuguese. doi: 10.1590/S1413-41522009000200005.
44. Marmolejo LDMG, Coutinho TCL. [External control of fluoridation of public water supply in Niterói, RJ, Brazil, from November 2008 to March 2009]. *Rev Flum Odont*. 2010;16(33):34-9. Portuguese.
45. Olivati FN, Souza MLR, Tenuta LMA, Cury JA. Quality of drinking water fluoridation of Capão Bonito, SP, Brazil, evaluated by operational and external controls. *Rev Odonto Cienc*. 2011;26(4):285-90. doi: 10.1590/S1980-65232011000400002.
46. Moimaz SAS, Saliba O, Garbin CAS, Garbin AJI, Sumida DH, Chiba FY, et al. [Fluoridation of public water supplies in the municipality of Araçatuba/SP]. *Rev Odontol Araçatuba*. 2012;33(1):54-60. Portuguese.
47. Santos CCM, Rodrigues JCS, Lopes MRV, Povinelli RF, Terreri ALM. [Fluoride concentration in the public water supply: the retrospective study and the external control]. *Rev Inst Adolfo Lutz*. 2012;71(3):507-13. Portuguese.
48. Moimaz SAS, Santos LFP, Saliba TA, Saliba NA, Saliba O. [External control of fluoride in public water supply: results and experience of 13 years of surveillance]. *Arch Health Invest*. 2018;7(7):262-8. Portuguese. doi: 10.21270/archi.v7i7.3037.
49. Moreira MR, Faquim JPS, Oliveira SV, Santos DQ, Narvai PC. Heterocontrol of fluoridation of public water supply in Uberlândia, State of Minas Gerais, Brazil. *Saude Pesq*. 2020;13(4):821-30. doi: 10.17765/2176-9206.2020v13n4p821-830.
50. Bandeira RHL, Rebelo MAB, Freitas YNL, Quadros LN, Gomes AC, Gomes AC et al. Fluoride concentration in public water supply in a city in the Amazon region. *Pesqui Bras Odontopediatria Clin Integr*. 2022;22:e210153. doi: 10.1590/pboci.2022.031.
51. Ministry of Health of Brazil. [Ordinance n. 635, 1975 Dec 26. Approves norms and standards to be followed on the fluoridation of water in public supply systems, intended for human consumption]. Available from: <https://bvsms.saude.gov.br/bvs/saudelegis/gm/2017/MatrizesConsolidacao/comum/249408.html>. Portuguese.

52. U.S. Department of Health and Human Services Federal Panel on Community Water Fluoridation. U.S. Public Health Service Recommendation for Fluoride Concentration in Drinking Water for the Prevention of Dental Caries. *Public Health Rep.* 2015 Jul-Aug;130(4):318-31. doi: 10.1177/003335491513000408.
53. Do LG, Cury JA, James P, Mossey PA, Zohoori FV, Fox CH, et al. Position statement on community water fluoridation. Alexandria: International Association for Dental Research; 2022 [cited 2024 Jul 8]. Available from: <https://www.iadr.org/science-policy/position-statement-community-water-fluoridation>.
54. Cury JA, Ricomini-Filho AP, Berti FLP, Tabchoury CP. Systemic Effects (Risks) of Water Fluoridation. *Braz Dent J.* 2019 Oct;30(5):421-8. doi: 10.1590/0103-6440201903124.
55. Truman BI, Gooch BF, Sulemana I, Gift HC, Horowitz AM, Evans CA, et al. Reviews of evidence on interventions to prevent dental caries, oral and pharyngeal cancers, and sports-related craniofacial injuries. *Am J Prev Med.* 2002 Jul;23(1 Suppl):21-54. doi: 10.1016/s0749-3797(02)00449-x.
56. Ran T, Chattopadhyay SK; Community Preventive Services Task Force. Economic Evaluation of Community Water Fluoridation: A Community Guide Systematic Review. *Am J Prev Med.* 2016 Jun;50(6):790-6. doi: 10.1016/j.amepre.2015.10.014.
57. Frias AC, Narvai PC, Araújo ME, Zilbovicius C, Antunes JLF. [Cost of fluoridating the public water supply: a study case in the city of São Paulo, Brazil, 1985-2003]. *Cad Saude Publica.* 2006;22(6):1237-46. Portuguese. doi: 10.1590/S0102-311X2006000600013.
58. Cronin J, Moore S, Harding M, Whelton H, Woods N. A cost-effectiveness analysis of community water fluoridation for schoolchildren. *BMC Oral Health.* 2021 Mar;21(1):158. doi: 10.1186/s12903-021-01490-7.
59. Moore D, Poynton M, Broadbent JM, Thomson WM. The costs and benefits of water fluoridation in NZ. *BMC Oral Health.* 2017 Nov;17(1):134. doi: 10.1186/s12903-017-0433-y.