DOI: 10.1590/1413-81232020254.17722018

Water fluoridation in the ten largest municipalities of the state of Tocantins, Brazil

Ana Paula Alves Gonçalves Lacerda (https://orcid.org/0000-0001-5050-351X) [1]
Neilton Araujo de Oliveira (https://orcid.org/0000-0002-8976-7237) [2]
Helder Henrique Costa Pinheiro (https://orcid.org/0000-0001-5567-3550) [3]
Karina Maschietto de Lima Assis (https://orcid.org/0000-0002-8037-2386) [4]
Jaime Aparecido Cury (https://orcid.org/0000-0003-1046-5605) [5]

Abstract *Water fluoridation is a strategy for caries control recommended by the WHO. In Brazil, it is regulated by law but this program has not been successfully implemented in the North region. This research aimed to collect data on the existence of external control (heterocontrol) in the ten largest municipalities in the state of Tocantins, Brazil, and to analyze fluoride concentration in the public water supply of these cities. The study was conducted from May-August/17, and its theoretical-methodological framework was a quantitative, descriptive and cross-sectional analysis. Water collections were carried out monthly, using sampling protocol of water collection of the network. Fluoride concentration in the waters was determined with ion specific electrode by the direct technique. It was verified that water fluoridation monitoring is only been done in Palmas, capital of the state, starting in 2016. Thirty-two percent of waters samples analyzed showed fluoride concentration to obtain the maximum benefit of reduction caries and 27.5% of them presented a high or very high risk of dental fluorosis. It is necessary to implement a program to control the concentration of fluoride in the water of the municipalities of Tocantins, in order to ensure that the population is not deprived of the anticaries' benefits of the adjustment of fluoride concentration of the treated water.*

Key words *Fluoridation, Surveillance, Fluorine, Water analysis*

[1] Saúde Coletiva, Faculdade Presidente Antonio Carlos. 508 norte, Alameda 5 Lote 2, QI4. 77006-658 Palmas TO Brasil. apaglacerda@hotmail.com
[2] Universidade Federal do Tocantins. Palmas TO Brasil.
[3] Faculdade de Odontologia, Universidade Federal do Pará. Belém PA Brasil.
[4] Grupo condutor de Odontologia, Secretaria Municipal de Saúde de Palmas. Palmas TO Brasil.
[5] Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas. Campinas SP Brasil.

Introduction

Access to treated and fluoridated water is essential for the establishment of broad population health conditions, and the implementation of public policies that ensure the implantation, monitoring and evaluation of the fluoridation of drinking water[1] is very relevant.

Fluoridation is essential for health promotion and is a useful public health intervention technology recommended by the World Health Organization (WHO), who considers it an indispensable method of oral health prevention strategies[2].

According to the U.S. Centers for Disease Control and Prevention (CDC), fluoridated water is one of the ten significant public health gains of the 20th century, since it prevents 40 to 70% of caries in children and reduces 40% to 60% tooth loss in adults. It is a comprehensive, inexpensive method that benefits all social groups[3].

According to Frazão et al.[4], access to fluoridated water is the most effective, efficient, inexpensive and recommended method for the prevention of caries, besides being one of the National Oral Health Policy guidelines (PNSB), concerning consolidation of health surveillance. According to the Ministry of Health, more than 100 million people throughout the country are benefited by this measure[5].

In Brazil, public water supply fluoridation was mandated by Federal Law Nº 6.050, dated May 24, 1974[6], regulated by Decree Nº 76.872, dated December 22, 1975[7], and its values were determined by Ordinance Nº 635, of December 26, 1975[8], ranging from 0.6 ppm to 0.8 ppm nationwide.

Although fluoridation has become mandatory, the Ministry of Health admits coverage of around 60%, with inequalities among regions. In the South and Southeast, more than 70% of people benefit from fluoridation while in the North, it is less than 30%[5].

According to Frazão et al.[9], of the 139 municipalities of Tocantins, only five report and regularly feed Sisagua, 127 are not registered, and seven are registered but do not report data regularly. Therefore, these systems are underfed by municipalities and additional control is required by the state, municipal or private institutions whenever any product evidences a risk to the health of the population, besides the implementation of a reliable and complete information system.

Water fluoridation's effectiveness in Brazilian capitals has been evaluated in the early 21st century[10] and a statistically significant difference was found in the cities studied, with a declining DMFT mean in the locations with fluoridated water, but Palmas was not the object of the research. In 2010, SB Brasil conducted an epidemiological survey in the country, and the DMFT at 12 years found in the capital of the state of Tocantins was 2.83. This value is in line with WHO's recommendation that, as from 2000, the worldwide mean value should be less than 3 at 12 years of age[11].

The availability of fluoridated treated water has increased in Brazil, producing health benefits and, at the same time, contributing to declining inequalities. This was demonstrated by Frazão and Narvai[12], when evaluating the coverage of public water supply fluoridation in Brazilian municipalities, by demographic size and level of municipal human development index (IDH-M). They showed that, in the 2000-2008 period, 8.6% of the Brazilian population started to receive the benefit, raising the coverage level rate from 67.7% to 76.3%, one of the highest coverage among the ten most populous countries of the planet. However, this growth was more pronounced in the South, Southeast and Midwest, with a more discrete, slow and uncoordinated growth in the North and Northeast regions.

In recent years, a definite higher exposure of the population to various sources of fluoride, such as dentifrices, food, medicines, mouthwashes and public water supply has been reported. This fluoride can play a vital role in the prevention and control of dental caries in kids and adults. However, depending on the exact dose and time of exposure, it may lead to chronic intoxication, and dental fluorosis is the most common toxic effect caused by fluoride. Its prevalence has manifested mainly in mild and very mild forms and was observed in communities with fluoridated water[13-15].

Several studies point to the wide variation of fluoride levels in public water supply and reinforce the need to implement effective and continuous surveillance systems[14,16-18].

This research aimed to collect data on the existence of heterocontrol in the ten largest municipalities in the state of Tocantins, analyze the fluoride concentration found in the public water supply of these cities, and to propose discussions with local authorities and institutions responsible for drinking water to highlight the relevance of the proper implementation and inspection of public water supply fluoridation.

Ciência & Saúde Coletiva, 25(4):1507-1518, 2020

Methods

The theoretical-methodological framework of this study is a quantitative, descriptive and cross-sectional analysis. This is a field survey that conducted the visits to the water treatment plants (WTP), the collection and analysis, which focused on finding out the current situation of fluoridation, the existence and effectiveness of heterocontrol performed by the competent authorities regarding the quality and quantity of fluoride used in these cities and verifying the constancy of fluoride ion values in the water supplied to the population. Collections were performed in three different months.

Work was conducted in the cities of Palmas, Araguaína, Gurupi, Porto Nacional, Paraiso do Tocantins, Araguatins, Colinas, Guaraí, Tocantinópolis and Dianópolis.

Initially, the public supply company of the state, known as BRK Ambiental, was visited to obtain specific information on how fluoridation is performed. Two questionnaires were also applied to the State Health Secretariat of Tocantins; the first was conducted in 2014 and the second in 2017, to know some aspects of the fluoridation process and highlight the current situation and changes in the supply system in these three years. The questionnaires provided data that were not available on websites or publications since no other work related to this subject was found in Tocantins.

Sample collection points were the same places where the agents of the State Water Surveillance Program carried out monthly samples for analysis of apparent color, turbidity, total coliforms, free residual chlorine and the presence or absence of Escherichia coli., taking into account the division of the urban area of the municipalities and the amount of Water Treatment Plants (WTP) of each of the locations surveyed.

Samples were collected directly from the faucet coupled to the hydrometer, preferably in public places such as schools, nurseries and hospitals and conditioned in polyethylene bottles with adequately identified lid.

All collections were carried out by the State or Municipal Health Secretariat in the ten municipalities, between May and August of 2017, by the environmental surveillance agent responsible for each location surveyed. The norms and standards established by the Manual of Collection for the Analysis of Human Consumption Water of the State of Tocantins[19] and by the National Guideline of the Sampling Plan of the Human Consumption Water Quality Monitoring of the Ministry of Health[20] were observed, following the same parameters for chlorine, turbidity and coliforms, ensuring that no regions were excluded from the analysis.

A script was used to carry out the monitoring of water quality with the following steps: elaboration of the sampling plan, with the parameters to be monitored, collection frequency and number of samples to be analyzed; definition of a schedule of forwarding the samples to the public health laboratory, according to the installed capacity in the state laboratory, selected for sending the samples; selection of the collection points (collection addresses) and completion of the analysis request sheets in the laboratory environment management system.

Once the planning part was finalized, we followed with water collection in the selected municipalities, and the municipal environmental surveillance agent was responsible for the following steps: identification of the water collection spot; verification of the existence of a faucet next to the easel; opening the tap for three minutes, or enough time to eliminate stagnant water in the pipeline, ensuring that the water comes from the distribution network and not from internal boxes or reservoirs; wearing gloves for the procedures to make the collections; washing the bottle three times with the water to be collected; filling the flask with water, discarding a small portion of the sample, leaving an empty space to allow a good homogenization before the onset of the analysis; labeling the bottles and filling the request form, including the data measured in the field and starting time of the collection procedure.

In total, 516 samples were collected according to water sampling VigiFluor guidelines[21]. The places chosen took into account the amount of existing WTPs, so they were carried out at various points in the cities. This justified the difference between the number of samples, since some cities have only one WTP, such as Porto Nacional (12 monthly collections / totaling 36), Colinas do Tocantins (18/54), Guaraí (17/51), Dianópolis (12/36), Araguatins (14/42), Paraíso do Tocantins (10/30) and Gurupi (13/39). While others such as Palmas (18/54), Araguaína (40/120) and Tocantinópolis (18/54) had a more significant number of samples because they have several WTPs.

Laboratory analysis was carried out in the biochemistry laboratory of Piracicaba Dental School, University of Campinas (Unicamp) and was made according to Vigifluor protocol[22].

Next, a descriptive analysis was performed involving calculations and tables for better vi-

sualization of the results. Two parameters were established for the criterion of the values, the first being the precursor document for fluorine concentration standardization, Ordinance GM/MS Nº 635/1975[8], which approves the norms and standards for the fluoridation of human consumption water from public supply systems, establishing recommended limits for the concentration of the fluoride ion by the average maximum daily temperatures throughout Brazil, where the ideal concentration of fluorine for the cities surveyed is of 0,7 mg F/L (ppm F), and can vary between 0.6 and 0.8 mg F/L for cities with temperature ranging from 26.4ºC to 32.5ºC. The second parameter used was the Brazilian Fluoridation Technical Consensus[23], which takes into account the local temperature, and admits that between 26.3ºC and 32.5º C, the ideal fluorine variation varies from 0.55 mg F/L to 0.84 mg F/L, assigning the maximum benefit of prevention of dental caries and minimum risk of developing dental fluorosis.

Two interdisciplinary and multidisciplinary debates were held, named First and Second Fluoridation Symposium ITPAC PORTO NACIONAL, the first held in October 2016 and the second in October 2017, with the aim of discussing the fluoridation of public water supply, its characteristics and consequences.

Results

From the analyses performed, it can be observed that the mean concentration of fluoride varied considerably in the ten cities surveyed (Table 1), with a minimum value of 0.03 ppm (low fluoridation) and a maximum value of 1.07 ppm (high fluoridation).

In Table 1, we also observed that there was no continuity of the fluoride ion concentration in the water samples, since the city of Colinas do Tocantins recorded a standard deviation of 0.40, ranging from 1.07 ppm to 0.83 ppm, followed by Tocantinópolis, which ranged from 0.31 ppm to 0.46 ppm, Paraíso do Tocantins ranged from 0.91 ppm to 0.84 ppm, Porto Nacional had values ranging from 0.68 ppm to 0.91 ppm and, finally, the city of Dianópolis, with an amount of fluorine ranging from 0.07 ppm to 0.77 ppm.

The following parameters can be observed in Table 2: insignificant, when there is no anticaries protection; minimum, when protection exists, but is inexpressive; maximum benefit, when anticaries protection is adequate and ideal; moderate, when protection exists, but also the risk to cause fluorosis and harm when fluoride concentration is so high that the risk of harm outweighs the benefits of anticaries protection.

Table 2 shows that the city of Araguatins had 100% of the collections with insignificant dental anticaries protection; Araguaína came in second, with 70.8% of the unprotected samples, both with almost no fluoride index; followed by Tocantinópolis, which had 59.3% of the samples without fulfilling their anticaries role.

Of the 516 samples analyzed, only 31.6% fulfilled the role of the primary indication of fluoride use, with maximum anticaries benefit, but the other 68.4% showed values below or null concerning this benefit. Table 2 also evidences that cities such as Dianópolis (58.3%) and Guaraí (68.6%) are covered by more than 50% of the samples concerning dental caries prevention.

Regarding the risk of producing fluorosis, Table 3 also uses five parameters. However, they are different from those used to classify the benefits of dental anticaries protection, since they comply with the Brazilian Fluoridation Technical Consensus[23], where the parameters of fluorosis were: negligible for the risk of causing dental fluorosis, low for a small probability of developing questionable fluorosis, moderate for a quantity of fluoride capable of producing very mild and mild fluorosis, high risk where the ion concentration would cause moderate fluorosis and very high risk of triggering severe fluorosis.

Table 3 also shows a situation of concern. Colinas has 77.8% of samples with a high risk of producing mild or very mild fluorosis, followed by Porto Nacional with 72.2%, Paraíso do Tocantins 66, 7%, Palms 53.7% and finally Gurupi with 51.3% of the samples with values above the standards with respect to the quantity recommended by the two fluoride evaluation criteria.

Table 4 shows the best risk-benefit combination, i.e., the optimal concentration of fluoride so that the population can benefit from anticaries protection, without risking to develop another condition, which would be dental fluorosis. We noticed that 9 out of 10 municipalities have their analyses out of the ideal standard, i.e., only 19.8% of the samples surveyed were in the best combination, with the maximum benefit of preventing dental caries and the minimum risk of producing dental fluorosis. Only the city of Guaraí had most of the analyses with the best index, 66.7% of the ideal samples collected, followed by Dianópolis, which recorded 36.1%, Tocantinópolis with 29.6% and Araguaína with 24.2% of the samples

Ciência & Saúde Coletiva, 25(4):1507-1518, 2020

Table 1. Fluoride concentration values in the public water supply samples according to the municipality and collection period. Tocantins, Brazil, 2017.

Municipality	Collection	N	Mean	Standard Deviation
Araguaína	1º month	40	0.14	0,21
	2º month	40	0.25	0,25
	3º month	40	0.33	0,30
	Municipality	120	0.24	0,27
Araguatins	1º month	14	0.05	0,01
	2º month	14	0.04	0,00
	3º month	14	*0.03	0,00
	Municipality	42	0.04	0,01
Colinas	1º month	18	**1.07	0,47
	2º month	18	0.83	0,41
	3º month	18	1.05	0,26
	Municipality	54	0.98	0,40
Dianópolis	1º month	12	0.17	0,01
	2º month	12	0.44	0,23
	3º month	12	0.77	0,04
	Municipality	36	0.46	0,28
Guaraí	1º month	17	0.42	0,15
	2º month	17	0.55	0,23
	3º month	17	0.63	0,09
	Municipality	51	0.54	0,18
Gurupi	1º month	13	0.86	0,09
	2º month	13	0.87	0,04
	3º month	13	0.80	0,03
	Municipality	39	0.84	0,07
Palmas	1º month	18	0.77	0,27
	2º month	18	0.83	0,19
	3º month	18	0.75	0,25
	Municipality	54	0.78	0,24
Paraíso	1º month	10	0.91	0,19
	2º month	10	0.85	0,37
	3º month	10	0.84	0,32
	Municipality	30	0.86	0,29
Porto Nacional	1º month	12	0.91	0,12
	2º month	12	0.68	0,39
	3º month	12	0.95	0,06
	Municipality	36	0.85	0,26
Tocantinópolis	1º month	18	0.31	0,31
	2º month	18	0.36	0,29
	3º month	18	0.46	0,29
	Municipality	54	0.38	0,30
Total	1º month	172	0.49	0,43
	2º month	172	0.52	0,38
	3º month	172	0.61	0,37
Total		516	0,54	0.40

*Minimum limit of fluoride found in samples; **Maximum limit of fluoride found in samples.
Source: Pinheiro et al., 201723.

with an ideal percentage. The other cities, that is, the vast majority (80.2% of the collected samples) are outside this ideal proportion, all recording below 10%, namely, Paraiso with 6.7%, Porto Nacional 5.6%, Gurupi 5.1%, Colinas and Palmas tied with 3.7%, and, finally, with Araguatins,

Table 2. Absolute and relative frequencies of caries prevention benefit classifications of public water supply samples by municipality. Tocantins, Brazil, 2017.

Municipalities	Benefit											
	Negligible		Minimum		Maximum		Moderate		Harm		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Araguaína	85	70.8	2	1.7	31	25.8	1	0.8	1	0.8	120	100.0
Araguatins	42	100	0	0.0	0	0.0	0	0.0	0	0.0	42	100.0
Colinas	7	13.0	0	0.0	4	7.4	42	77.8	1	1.9	54	100.0
Dianópolis	15	41.7	0	0.0	21	58.3	0	0.0	0	0.0	36	100.0
Guaraí	6	11.8	9	17.6	35	68.6	1	2.0	0	0.0	51	100.0
Gurupi	0	0.0	0	0.0	19	48.7	20	51.3	0	0.0	39	100.0
Palmas	6	11.1	1	1.9	18	33.3	29	53.7	0	0.0	54	100.0
Paraíso	3	10.0	0	0.0	6	20.0	20	66.7	1	3.3	30	100.0
Porto Nacional	3	8.3	0	0.0	7	19.4	26	72.2	0	0.0	36	100.0
Tocantinópolis	32	59.3	0	0.0	22	40.7	0	0.0	0	0.0	54	100.0
Total	199	38.6	12	2.3	163	31.6	139	26.9	3	0.6	516	100.0

Source: Pinheiro et al., 2017[3].

with 0.0% of the ideal collections, all with levels of fluorides very close to zero, which characterizes that the city of Araguatins does not have natural fluorine, nor does it receive an addition.

Questionnaires were applied to the State Environmental Surveillance and the Vigiagua Program in an attempt to collect specific data about the water monitoring and fluoridation system of the State, such as functioning, composition and actions taken. The first questionnaire was applied during the execution of the multicenter project Vigiflúor in 2014, a project that culminated in this research, and the second was applied in 2017, the results of which are shown in Box 1.

When the first stage of the multicenter Vigiflúor project was started in 2014, no heterocontrol was performed in any city in the state of Tocantins[24] regarding the amount of fluoride. However, in Palmas, according to the Municipal Health Secretariat, heterocontrol has been carried out since 2016. It was also observed that both the analysis of the Sisagua data on fluorine and the integration and actions with other sectors that are also interested in fluoridation quality were not carried out in 2014, noting that they are carried out in 2017.

Discussion

Although the fluoridation policy is mandatory and extremely efficient, what has happened is that public water supply fluoridation is not yet a reality in Tocantins, and as an aggravating circumstance, it does not yet have reliable information to evaluate the level of coverage of this measure in the state, and it is the first time that this heterocontrol is performed in the cities of Tocantins. This situation becomes more evident when we analyze data provided by the public water supply company of Tocantins reporting that of the 139 municipalities of Tocantins, only 29 have fluoridated water, resulting in 110 municipalities without fluoridation.

Frazão et al.[9] had already announced this situation when they stated that of the 139 municipalities of Tocantins, only 5 regularly reported to the SISAGUA systems in 2013, showing that the available data were insufficient and partial.

Several authors have shown through epidemiological surveys and research that the administration of post-eruptive fluoride in constant and safe dosages with efficient and reliable fluoridation of public water supply and within the ideal fluoride levels will provide a significant benefit and, thus, decrease 30%-50% the dental caries index in the population[18,25-29].

Only the city of Guaraí had most of the analyses with a better index for greater anticaries protection and lower risk of fluorosis, with 66.7% of the ideal samples collected, but remaining outside the first parameter used by this research (Ordinance GM/MS Nº 635/1975[8]), since the general mean (0.54 ppm) of the fluorine values found in the collections of this city is below that recommended.

Table 3. Absolute and relative frequencies of risk classifications in producing dental fluorosis of public water supply samples by municipality. Tocantins, Brazil, 2017.

Municipalities	Risk											
	Negligible		Low		Moderate		High		Very High		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Araguaína	85	70.8	31	25.8	2	1.7	1	0.8	1	0.8	120	100.0
Araguatins	42	100.0	0	0.0	0	0.0	0	0.0	0	0.0	42	100.0
Colinas	7	13.0	2	3.7	2	3.7	42	77.8	1	1.9	54	100.0
Dianópolis	15	41.7	13	36.1	8	22.2	0	0.0	0	0.0	36	100.0
Guaraí	6	11.8	43	84.3	1	2.0	1	2.0	0	0.0	51	100.0
Gurupi	0	0.0	2	5.1	17	43.6	20	51.3	0	0.0	39	100.0
Palmas	6	11.1	3	5.6	16	29.6	29	53.7	0	0.0	54	100.0
Paraíso	3	10.0	2	6.7	4	13.3	20	66.7	1	3.3	30	100.0
Porto Nacional	3	8.3	2	5.6	5	13.9	26	72.2	0	0.0	36	100.0
Tocantinópolis	32	59.3	16	29.6	6	11.1	0	0.0	0	0.0	54	100.0
Total	199	38.6	114	22.1	61	11.8	139	26.9	3	0.6	516	100.0

Source: Pinheiro et al., 2017[23].

Table 4. Absolute and relative frequencies of the best combination between the maximum benefit of dental caries prevention and the minimum risk of producing dental fluorosis in public water supply samples by municipality. Tocantins, Brazil, 2017.

Municipalities	Best benefit-risk combination					
	Yes		No		Total	
	N	%	N	%	N	%
Araguaína	29	24.2	91	75.8	120	100.0
Araguatins	0	0.0	42	100.0	42	100.0
Colinas	2	3.7	52	96.3	54	100.0
Dianópolis	13	36.1	23	63.9	36	100.0
Guaraí	34	66.7	17	33.3	51	100.0
Gurupi	2	5.1	37	94.9	39	100.0
Palmas	2	3.7	52	96.3	54	100.0
Paraíso	2	6.7	28	93.3	30	100.0
Porto Nacional	2	5.6	34	94.4	36	100.0
Tocantinópolis	16	29.6	38	70.4	54	100.0
Total	102	19.8	414	80.2	516	100.0

Source: Pinheiro et al., 2017[23].

Of the 10 municipalities surveyed, only the capital Palmas remained within the two parameters established by this study, with an average fluoride of 0.78 ppm, but 96.3% of the analyzed samples do not show a better combination of the maximum benefit of the prevention of dental caries and the minimum risk of producing dental fluorosis, since a large part of the analyzed samples were above the acceptable values and others with ideal values, which resulted in a mean at almost the maximum tolerated limit, increasing the risk of dental fluorosis to the population.

The municipalities of Araguaína, Araguatins, Tocantinópolis, Dianópolis and Guaraí are below the values recommended by the specific ordinance and by the technical consensus of fluoride, and these cities are without coverage against dental caries, but with no risk of fluorosis. On the other hand, the municipalities of Colinas do Tocantins, Paraíso do Tocantins and Porto Nacional have a concentration of fluoride higher than recommended, taking into account the two criteria. In this case, the population of these three cities is exposed to moderate and high risk of devel-

Box 1. Comparison between data provided by the Vigiagua Program, concerning water quality in the state of Tocantins, Brazil, at two different times, 2014 and 2017.

Questions asked	2014	2017
Does the State monitor Vigiagua's water quality? Coordinated by the Ministry of Health?	Yes	Yes
Technical composition of the Vigiagua team	02 biologists,	01 biólogo, 01 engenheiro alimentos, 02 engenheiros ambiental
01 food engineer,	08	08
01 environmental manager	01 biologist,	Sim
01 food engineer,	Não	Sim
02 environmental engineers	Não	Não
Regional administrations involved	08	08
Identification, registration, permanent inspection, monitoring and follow-up of the water quality program	Yes	Yes
Analysis of the Sisagua data on fluorine	No	Yes
Conducting surveys and investigations on fluoridation	No	No
Integration and actions with other sectors that are also interested in the quality of fluoridation.	No	Yes
Operational control by supply companies	Yes. Monthly reports	Yes. Daily and weekly reports
Heterocontrol by the State	No	No
Heterocontrol by the Municipalities	No	Yes, only in Palmas. Weekly report.
Type of laboratory/method that performs heterocontrol	Does not perform	Own laboratory LACEN
Is there specific legislation in the State relating to the fluoridation of public water supply?	No	No

oping mild or very mild dental fluorosis, with maximum benefit against caries. Gurupi, on the other hand, is within the second criterion, but is above the first established standard, with a low risk to the development of dental fluorosis and maximum protection against dental caries.

Two evaluation parameters were purposely chosen for this research, and the first parameter were Ordinances GM/MS Nº 635/1975[8] and MS 2.914/2011[30], which complement each other and are the legislation used by the water inspection bodies in all states that do not have a specific Ordinance, classifying the fluoride values up to the maximum temperature of 32.5ºC, which partially fits the reality of the state of Tocantins.

For that reason, a second evaluation parameter was added in 2011, namely, the CECOL Technical Consensus on Fluorides as a suggestion to overcome this limitation of old ordinances, both of values and ways of evaluating the consequences of fluoride application, where the researchers recommend that the evaluation of the water fluoride content should be made considering the realms related to the benefit and risk, to assess, in each analysis, the intensities of both the preventive benefit of dental caries and the inherent risk of dental caries and the risk inherent to the exposure to fluoride (natural or added).

The values of the two criteria are very similar concerning the adequate quantity and mean of fluorides, but are entirely different concerning the maximum allowed limit (1st criterion =1.5 ppm or mgF/L; 2nd criterion = 0.84 ppm or mgF/L). However, in the whole country, considering the averages of maximum annual temperatures, the concentration determined for maximum caries prevention and limitation of occurrence of enamel fluorosis is between 0.6 and 0.8 mg/L[1].

The results of this research corroborate several other studies that have also alerted to the great diversity of fluoride levels in public water supply. This reinforces the need for implementation of surveillance systems, evidencing the relevance of heterocontrol that is carried out efficiently and continuously, to maintain adequate standards to ensure fluoridation quality[14,16-18,31-33].

Ciência & Saúde Coletiva, 25(4):1507-1518, 2020

Ideal fluoride values change from region to region, depending on the average local temperature, based on the idea that higher temperatures trigger more drinking water consumption, so less fluoride is required. Alvares et al.[34] found that the minimum temperature of the state would range from 20ºC to a maximum of above 32ºC, reaching as high as 40ºC, showing a high mean temperature swing, justifying that the values of fluorides in the state of Tocantins should not exceed the values of 0.84 mgF/L or ppm[23].

Frazão et al.[4] concluded in their research that the daily intake of water with fluoride concentration > 0.9 mgF/L is a risk to the dentition in children under eight years of age, and according to scientific evidence, the risk is the possibility of dental fluorosis occurring, to varying degrees, with predominance of the "very mild" and "mild" levels, so that consumers should be expressly informed of this risk. Thus, considering the expanded national fluoridation program for regions with a typically tropical climate, and the differences between data and values regarding the use of fluoride at different temperatures, we reiterate the authors' suggestion on the need to revise Ordinance GM/MS Nº 635/1975[8].

The applied questionnaires showed the changes that occurred in these three years regarding water surveillance, observing a growing to the implementation of heterocontrol, since, in the first questionnaire, no city in the state performed the measurement, while in the second, the city of Palmas started this procedure in 2016, and the other cities, according to the State Health Secretariat, are organizing to carry out this additional control.

There is a greater concern and care of environmental surveillance regarding the amount of fluoride ion in the water supplied to the Tocantins' population, and a movement towards equipping the state reference laboratory and training technicians to perform heterocontrol.

Another change perceived by the questionnaires was the integration of actions with other sectors that are also interested in the quality of fluoridation, such as the academy, where this project is a real example, which has been researching the quality of water fluoridation in Tocantins since 2014, in partnership with State Health Secretariat of Tocantins, in an attempt to benefit society in general and generate changes in this effective health public policy necessary to a state with a poor socioeconomic situation.

It was found that there is still no specific legislation in the State regarding public water supply fluoridation, and Tocantins is regulated by the generalized and old national ordinances, which do not take into account the peculiarity of the State concerning climate, socioeconomic conditions and individual fluoride consumption. Thus, the need to establish a State ordinance on the use of fluoride in public water supply was noted.

According to the Tocantins water supply company, lack of financial and human resources for the installation of fluoride reservoirs are impediments to the implementation of fluoridation systems in the 110 cities of Tocantins who do not yet have fluoride in the public water supply.

Frias et al.[35] estimated the cost of public water supply fluoridation. For this study, they took into account the costs with initial installation capital; chemicals (fluorosilicic acid); system operation (system maintenance, electricity and human resources); and control of fluoride levels. They found that the average cost per capita/year in the city of São Paulo was R$ 0.08 (US$ 0.03) in 2003. The accumulated cost in 18 years of implementation of the fluoridation system was R$ 1.44 (US$ 0.97) per capita, indicating that these costs were so comparatively negligible that their inclusion in the tariff calculations did not change the final amount to the consumer, compared to the set of water treatment expenses, highlighting the fluoride cost-benefit efficiency.

Also, the partial or total ignorance of the current technical regulations and consensuses on public water supply fluoridation was identified, observing the need for continuous training of health professionals, including among water potability-related professionals, which evidences the need to discuss this issue more with health professionals in general. The same results were also found by Ferreira[18,36], where we also verified the lack of information among the general population and managers of the health councils concerning water fluoridation.

The limitations of this research were access to the municipal and state information system on water quality, besides the difficulty of direct contact with the managers of the cities surveyed and of the impossibility to access water treatment plants of the cities, and the collections were held at other strategic points in the ten municipalities.

Conclusion

We concluded that 80.2% of the analyzed samples were not adequate concerning the number

of fluorides, where eight municipalities have fluoride added to water. However, 9 out of 10 samples are not in the appropriate standard of least risk of dental fluorosis and greater protection against dental caries.

Heterocontrol in the inland Tocantins is not carried out, only in the capital Palmas, and there is an imminent need of a state ordinance on fluoridation, within the local precepts.

We also reiterate the need for further discussions with local authorities, the general population and institutions responsible for drinking water to discuss and highlight the issue, raising awareness of the importance of social control.

Collaborations

APAG Lacerda contributed in the design, research, methodology and final writing. NA Oliveira contributed as research advisor in all stages. HHC Pinheiro as research co-supervisor in all stages. KML Assis contributed to the articulation for data collection, methodology and final writing. JA Cury contributed in laboratory analysis of the water samples and revised the final draft of the manuscript.

Acknowledgments

To CNPq for funding the Vigiflúor project, and to the coordinator of the referred project, Paulo Frazão, Full Professor at the Faculty of Public Health of the University of São Paulo, for conducting the multicenter study prior to this study.

References

1. Brasil. Fundação Nacional de Saúde (Funasa). *Manual de fluoretação da água para consumo humano*. Brasília: Funasa; 2012.
2. Brasil. Ministério da Saúde (MS), Coordenação Nacional de Saúde Bucal. *Guia de recomendações para o uso de fluoretos no Brasil*. Brasília: MS; 2009.
3. Horowitz H. The 2001 CDC Recommendations for Using Fluoride to Prevent and Control Dental Caries in the United States. *Journal of Public Health Dentistry* 2003; 63(1):3-8.
4. Frazão P, Peres MA, Cury JA. Qualidade da água para consumo humano e concentração de fluoreto. *Rev Saude Publica* 2011; 45(5):964-973.
5. 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.
6. Brasil. Congresso Nacional. Lei 6.050, de 24 de maio de 1974. Dispõe sobre a fluoretação da água em sistemas de abastecimento quando existir estação de tratamento. *Diário Oficial da União* 1974; 27 maio.
7. Brasil. Decreto nº 76.872, de 22 de dezembro de 1975. Regulamenta a lei 6.050/74, que dispõe sobre a fluoretação da água em sistemas públicos de abastecimento. *Diário Oficial da União* 1975; 23 dez.
8. Brasil. Ministério da Saúde (MS). Portaria nº 635, de 26 de dezembro de 1975. Aprova normas e padrões sobre fluoretação da água dos sistemas públicos de abastecimento, destinada ao consumo humano. Brasília: MS; 2011. *Diário Oficial da União* 1975; 26 dez.
9. Frazão P, Soares CCS, Fernandes GF, Marques RAA, Narvai PC. Fluoretação da água e insuficiências no sistema de informação da política de vigilância à saúde. *Rev Assoc Paul Cir Dent.* 2013; 67(2):94-100.
10. Narvai PC, Frias A C, Fratucci MVB, Antunes JLF, Carnut L, Frazão P. Fluoretação da água em capitais brasileiras no início do século XXI: a efetividade em questão. *Saude Debate* 2014; 38(102):562-571.
11. Petersen, P. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century - the approach of the WHO Global Oral Health Programme. *Community Dentistry and Oral Epidemiology* 2003; 31(Supl. 1):3-24.
12. Frazão P, Narvai PC. Fluoretação da água em cidades brasileiras na primeira década do século XXI. *Rev Saude Publica* 2017; 51:47.
13. Carvalho RB, Medeiros UV, Santos K, 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.
14. Cangussu MCT, Narvai PC, Castellanos FR, Djehizian V. A fluorose dentária no Brasil: uma revisão crítica. *Cad Saude Publica* 2002; 18(1):7-15.
15. Santiago MR, Silva JLS. O flúor em águas subterrâneas: um problema social. In: *Anais do XVIII Simpósio Brasileiro de Recursos Hídricos*; Cuiabá; 2004.
16. Cesa K, Abegg C, Aerts D. A Vigilância da fluoretação de águas nas capitais brasileiras. *Epidemiol Serv Saude* 2011; 20(4):547-555.
17. Freitas CHSM, Sampaio FC, Roncalli AG, Moysés SJ. Reflexões metodológicas sobre prevalência da fluorose dentária nos inquéritos de saúde bucal. *Rev Saude Publica* 2013; 47(Supl. 3):138-147.
18. Ferreira RGLA, Marques RAA, Menezes LMB, Narvai PC. Múltiplos aspectos do uso do flúor em saúde pública na visão de lideranças da área de saúde. *Cien Saude Colet* 2013; 18(7):2139-2146.
19. Tocantins. Secretaria de Estado da Saúde, Superintendência de Vigilância e proteção à Saúde. *Manual de coleta para análises de água de consumo humano*. Palmas: Secretaria de Estado de Saúde; 2016.
20. Brasil. Ministério da Saúde (MS). Secretária de Vigilância em Saúde. *Diretriz nacional do plano de amostragem de vigilância em saúde ambiental relacionada a qualidade da água para consumo humano.* Brasilia: MS; 2006.
21. Ely HC, Frazão P, Faquim JPS, Neves M, Cesa K, Toassi RFC, Cury JA, Narvai PC. Guia de amostragem para vigilância da concentração do fluoreto na água de abastecimento público. In: Frazão P, Narvai PC, organizadores. *Cobertura e vigilância da fluoretação da água no Brasil: municípios com mais de 50 mil habitantes.* São Paulo: FSP-USP; 2017. p. 87-101.
22. Cury JA, Tabchoury COM, Tenuta LMA, Frazão P, Narvai PC. Protocolo de coleta e análise da amostra de água para o fluoreto. In: Frazão P, Narvai PC, organizadores. *A Cobertura e vigilância da fluoretação da água no Brasil: municípios com mais de 50 mil habitantes*. São Paulo: FSP-USP; 2017. p. 102-111.
23. Centro Colaborador do Ministério da Saúde em Vigilância da Saúde Bucal (CECOL/USP). *Consenso técnico sobre classificação de águas de abastecimento público segundo o teor de flúor*. São Paulo: Faculdade de Saúde Pública da Universidade de São Paulo; 2011.
24. Pinheiro HHC, Rebelo MABR, Vieira JMR, Castro VPHDF, Lacerda APAG, Souza MS, Cury JÁ, Narvai PC. Cobertura e vigilância da fluoretação das águas nos municípios com mais de 50 mil habitantes da região Norte. In: Frazão P, Narvai PC, organizadores. *Cobertura e vigilância da fluoretação da água no Brasil: municípios com mais de 50 mil habitantes*. São Paulo: FSP-USP; 2017. p. 113-130.
25. Narvai PC. Cárie dentária e flúor: uma relação do século XX. *Cien Saude Colet* 2000; 5(2):381-392.
26. Narvai PC, Castellanos RA, Frazão P. Prevalência de cárie em dentes permanentes de escolares do Município de São Paulo, SP, 1970-1996. *Rev Saude Publica* 2000; 34(2):196-200.
27. Cury JA. Uso de flúor e controle da cárie como doença. In: Baratieri LN, organizador. *Odontologia Restauradora: fundamentos e possibilidades*. São Paulo: Santos; 2001. p. 31-68.
28. Centers for Disease Control and Prevention (CDC). Achievements in Public Health, 1900-1999: fluoridation of drinking water to prevent dental caries. *MMW Morb Mortal Wkly Rep* 1999; 48(41):933-940.
29. Ramires I, Buzalaf MAR. A fluoretação da água de abastecimento público e seus benefícios no controle da cárie dentária: cinqüenta anos no Brasil. *Cien Saude Colet* 2007; 12(4):1057-1065.
30. Brasil. Ministério da Saúde (MS). Portaria nº 2.914, de 12 de dezembro de 2011. Dispõe sobre os procedimentos de controle de vigilância da qualidade da água para o consumo humano e seu padrão de potabilidade. *Diário Oficial da União*; 2011.

31. Peixoto DF. Heterocontrole da Fluoretação da Água de Abastecimento Público no Município de Jaguarabiraba, Ceará, Brasil. *Rev Bras Promo Saude* 2012; 25(3):271-277.
32. Panizzi M, Peres MA. Dez anos de heterocontrole da fluoretação de águas em Chapecó, Estado de Santa Catarina, Brasil. *Cad Saude Publica* 2008; 24(9):2021-2031.
33. Ramires I, Maia LP, Rigolizzo DS, Lauris JRP, Buzalaf MAR. Heterocontrole da fluoretação da água de abastecimento público em Bauru, SP, Brasil. *Rev Saude Publica* 2006; 40(5):883-889.
34. Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM. Modeling monthly mean air temperature for Brazil. *Theoretical Applied Climatology* 2013; 113(3-4):407-427.
35. Frias AC, Narvai PC, Araújo ME, Zilbovicius C, Antunes JLF. Custo da fluoretação das águas de abastecimento público, estudo de caso Município de São Paulo, Brasil, período de 1985-2003. *Cad Saúde Publica* 2006; 22(6):1237-1246.
36. Ferreira RGLA, Bógus CM, Marques RAA, Menezes LMB, Narvai PC. Fluoretação das águas de abastecimento público no Brasil: o olhar de lideranças de saúde. *Cad Saude Publica* 2014; 30(9):1884-1890.

Article submitted 04/03/2018
Approved 15/08/2018
Final version submitted 17/08/2018