Analysis of Fluoride Content in a Health Macro Region in the State of Pernambuco, Brazil *

Análisis del contenido de flúor en un macrorregión de salud en el estado de Pernambuco, Brasil

Análise de teores de flúor em uma Macrorregião de saúde do estado de Pernambuco, Brasil

Polyana Matos Alcântara
Secretaria de Saúde da Cidade do Recife, Brasil
polyanalcantara@gmail.com
ORCID: https://orcid.org/0000-0001-7586-7053

Tereza Maciel Lyra
Instituto Aggeu Magalhães. Graças, Brasil
Universidade de Pernambuco, Brasil
tereza.lyra@fiocruz.br
ORCID: https://orcid.org/0000-0002-3600-7250

Juliana Loiola da Silveira
Universidade Federal de Pernambuco, Brasil
juliana.loiola@ufpe.br
ORCID: https://orcid.org/0000-0001-6610-4273

Petrônio José de Lima Martelli
Universidade Federal de Pernambuco, Brasil
petroniocarla@uol.com.br
ORCID: https://orcid.org/0000-0001-6920-6435

DOI: https://doi.org/10.11144/Javeriana.uo41.afch

Received: 07 october 2022
Accepted: 08 november 2022
Published: 29 december 2022

Abstract:

Background: Despite the fluoridation of public water supply being recognized as an excellent preventive measure for the control of dental caries, it is known that the state of Pernambuco does not perform systematic monitoring of the fluoride (F) levels in its waters. Purpose: To describe and analyze F levels in the water sources and public water supply in municipalities of the first health macro-region of Pernambuco, with 50,000 inhabitants or more. Methods: This was a descriptive study that combined data from the Brazilian Institute of Geography and Statistics and the National Sanitation Information System with data from Companhia Pernambucana de Saneamento, the VIGIFLUOR project and the Water Quality Surveillance Information System for Human consumption. Results: The analysis of the data indicated the presence of natural F in insignificant or minimal contents in most of the studied municipalities. In addition, three levels of maximum benefit for caries prevention were found, but this concentration does not reach the population via public supply. Conclusion: The results show that the F levels of the public supply network of 13 municipalities analyzed do not contribute to the protection of the population. This approach stresses the need for the water supply to the municipalities of the first macro-region of health to be fluoridated artificially. It may also be good to assure the population have access to quality treated and fluoridated water with a surveillance mechanism established through hetero-control programs.

Keywords: dental caries, dental fluorosis, dentistry, fluoridation, oral health, Pernambuco, Brazil, public health, water quality, water supply.

Resumen:

Antecedentes: A pesar de que la fluoración del agua de abastecimiento público sea reconocida como una excelente medida preventiva para el control de la caries dental, se sabe que el estado de Pernambuco no realiza monitoreo sistemático de los niveles de fluoruro en sus aguas. Objetivo: Describir y analizar los niveles de fluoruro (F) en las fuentes de agua y suministro público de agua en municipios del primer macrorregión de salud de Pernambuco con 50.000 habitantes o más. Métodos: Este fue un estudio descriptivo que combinó información del Instituto Brasileño de Geografía y Estadística y el Sistema Nacional de Información de Saneamiento con datos de Compañía Pernambucana de Saneamiento, el proyecto VIGIFLUOR y el Sistema de Información de Vigilancia de la Calidad del Agua para el consumo Humano. Resultados: El análisis de los datos indicó la presencia de F natural en contenidos insignificantes o mínimos en la mayoría de los municipios estudiados. Además, se encontraron tres niveles de máximo beneficio para la prevención de caries, pero esta concentración no llega a la población vía abastecimiento público. Conclusión:

Los resultados muestran que los niveles F de la red pública de abastecimiento de los 13 municipios analizados no contribuyen a la protección de la población. Este enfoque destaca la necesidad de que el suministro de agua a los municipios de la primera macrorregión de salud sea fluorado artificialmente. También puede ser bueno para asegurar a la población el acceso a agua tratada y fluorada de calidad y que se establezca un mecanismo de vigilancia a través de programas de heterocontrol.

Palabras clave: calidad del agua, caries dental, fluorosis dental, fluoración, odontología, Pernambuco, Brasil, salud bucal, salud pública, suministro de agua.

Resumo:

Antecedentes: Apesar da fluoretação das águas de abastecimento público ser reconhecida como uma excelente medida preventiva para o controle da cárie dentária, sabe-se que o estado de Pernambuco não realiza um monitoramento sistemático dos níveis de fluoreto das suas águas. Objetivo: Descrever e analisar teores de flúor (F) nos mananciais e águas de abastecimento público dos municípios da primeira macrorregião de saúde de Pernambuco que tenham 50.000 habitantes ou mais. Métodos: Trata-se de um estudo descritivo que une as informações do Instituto Brasileiro de Geografia e Estatística e do Sistema Nacional de Informação sobre Saneamento com os dados da Companhia Pernambucana de Saneamento, do projeto VIGIFLUOR e do Sistema de Informação de Vigilância da Qualidade da Água para Consumo Humano.Resultados: A análise dos dados apontou a presença de F natural em teores insignificantes ou mínimos na maioria dos municípios estudados. Ademais, até foram encontrados níveis de benefício máximo para a prevenção da cárie em três mananciais, entretanto, tal concentração não alcança a população via abastecimento público. Conclusões: Os resultados demonstraram que os teores de F na rede de abastecimento público dos 13 municípios analisados não contribuem para a proteção da população. Esse estudo enfatiza a necessidade de que a água de abastecimento dos municípios da primeira macrorregião de saúde seja fluoretada artificialmente; podendo ainda, para de fato assegurar à população o acesso à água tratada e fluoretada de qualidade, que seja instituído mecanismos de vigilâncias através de programas de heterocontrole.

Palavras-chave: abastecimento de água, cárie dentária, fluoretação, fluorose dentária, odontologia, Pernambuco, Brasil, qualidade da água, saúde bucal, saúde pública.

INTRODUCTION

Currently, in terms of oral health, dental caries remains the main health problem of the Brazilian population, according to the results of the last national epidemiological survey (1,2). This pathology affects people of different age groups and socioeconomic levels unevenly, precisely because of the social differences that characterize these people and the context in which they are inserted (3).

Despite its persistent prevalence, caries rates have shown a significant reduction from the implementation of preventive measures and promotion in public health (4). Among these measures, the fluoridation of public water supply is considered the closest to the ideal with regard to disease control; since the benefits of its use can reach all people, without any distinction of economic, social or educational nature. In addition, water fluoridation is an important tool for achieving equity in oral health, as it mainly benefits population segments in the worst socioeconomic conditions, which often do not have access to other preventive methods and, therefore, are the who most need efficient fluoridation (5,6).

Fluoridation has proven to be safe, effective, and inexpensive and is recommended by the World Health Organization (WHO) (7,8). The effectiveness of this measure in the decline of caries is a scientifically verified fact and widely accepted by specialists in public health and by the dental community (9). This process has been supported and encouraged by deliberations approved both at the Health and Oral Health Conferences, as well as by the Ministry of Health (MS) and by the main professional entities in Dentistry and Public Health (10).

In Brazil, increasing the coverage of the method and due compliance with Law No. 6050/1974, which makes water fluoridation (FA) mandatory where there is a water treatment plant, were recommended in the three National Conferences on Oral Health (CNSB) held so far: first CNSB 1986, second CNSB 1993, and third CNSB 2004 (11). In such meetings, the strategic importance of FA was reiterated to face dental caries, which is undeniably a public health problem in the country (12).

From the point of view of health surveillance, it is imperative to ensure maximum benefit and minimum risk to consumers. This presupposes knowing and controlling the fluorine content of water used for consumption, making such information available to the population. The effects of fluoride (F) on human health highlight the importance of its study, after all, both the addition of insufficient amounts and the addition of excessive amounts of F are undesirable (13). Insufficient water fluoridation does not prevent caries, and excessive F concentration can cause fluorosis (14, 15). To avoid these situations, permanent surveillance of the AF is essential, at the highest quality level, considering whether the F present in the water is naturally present in it or if it was added in the treatment process (14).

Studies show that some regions of Brazil have natural sources of F in their water supply, making it important to identify and map these areas (14,15). It is essential to know the natural levels of fluorine in springs before making them available for human consumption, preferably evaluating them prior to the implementation of artificial fluoridation systems (14).

In this sense, sanitation companies periodically carry out studies of water for human consumption, providing reports on their quality. However, according to studies conducted in the country, the information passed on by the companies is considered unreliable, which makes the analyzes performed on the levels of F inaccurate (16). Considering this fragility, the external control emerged, which is described as: "[...] the principle that any good or service that involves risk or represents a protective factor for public health requires, in addition to control by the producer, the control of State institutions over the process of its development, being its implantation means to effectively contribute to the improvement of the quality of artificial fluoridation" (17).

The VIGIFLUOR Project can be considered as one of the tools for external control of the levels of F present in public water supply in the country. VIGIFLUOR was a multicenter study aimed at describing the surveillance and population coverage of fluoridation of public water supply in Brazilian municipalities with a population greater than or equal to 50,000 inhabitants. The project had the participation of researchers from different Brazilian states and had financial support from the National Council for Scientific and Technological Development (CNPq) (18).

Until now, the state of Pernambuco has not carried out systematic surveillance of F levels in its waters and there are no scientific publications that discuss the levels of F present in public water supplies in the state. Thus, the aim of this study was to describe and subsequently analyze F levels in springs and public supply waters in municipalities with 50,000 inhabitants or more, located in the first health macro-region of the state of Pernambuco, comparing data provided by the Sanitation Company Pernambuco (COMPESA) with data obtained by VIGIFLUOR (18).

MATERIALS AND METHODS

This was a descriptive study with an observational design based on secondary data. It was conducted based on the study of COMPESA data, primary data collected from the municipalities participating in the VIGIFLUOR PROJECT, and data recorded in the Information System for Surveillance of Water Quality for Human Consumption (SISAGUA). These data indicated the levels of F in water from sources for human consumption and in the water supply network of municipalities in the first Health Macro Region of Pernambuco that have a population greater than 50,000 inhabitants. Furthermore, demographic data released by the Brazilian Institute of Geography and Statistics (IBGE) and the National Sanitation Information System (SNIS) related to access to treated water were also used.

The state of Pernambuco through the Regionalization Master Plan (PDR) 2011 has its territory divided into four health macro-regions. Considering the availability of reports on F levels from COMPESA and VIGIFLUOR, as well as the project by the State Coordination of Oral Health to implement the artificial

fluoridation process, which points to the first Health Macro-Region as the first beneficiary, we chose to study the latter in the present study.

FIGURE 1
Map of the Four Macro-Regions of the State of Pernambuco - Source: Secretary of Health of the state of PE. Regional Master Plan, 2011

With regard to the inclusion criteria, municipalities with regular water supply that had data available from both COMPESA and VIGIFLUOR were included, excluding those that do not fit these conditions. Therefore, the universe of this research comprises the municipalities belonging to the I, II, III and XII Regional Health Managements (GERES), members of the first Macro Region of the state of Pernambuco, provided that they had a population equal to or greater than 50,000 inhabitants in 2017 and respected the inclusion criteria. Thus, the following municipalities were part of the sample: Abreu e Lima, Cabo de Santo Agostinho, Camaragibe, Carpina, Ipojuca, Jaboatão dos Guararapes, Moreno, Olinda, Palmares, Recife, São Lourenço da Mata, and Vitória de Santo Antão.

Data collection for the VIGIFLUOR project was performed by public servants linked to the Unified Health System (SUS), working in the health surveillance sector, who were previously calibrated. To collect the data, we established two main water samples per treatment station (ETA) or alternative supply solution (SAA) existing in each municipality. Those two samples were located in different units. The collection also included two control samples in different units, one for each main sample. The collection points for the main samples were preferably chosen at a point in the network that were the closest to the water treatment unit. Likewise, in public units in the area of education or health, we chose the collection point in the network that was farthest from the ETA.

The data collection happened monthly for three consecutive months with all collections conducted on the same day of the month. After collected, data were sent to the biochemistry laboratory of the Piracicaba Dental School of the State University of Campinas (FOP-UNICAMP), so that the F content could be measured using an electrometric method. From the levels obtained, the researchers built and managed a database in Microsoft Excel® spreadsheets.

Secondary data from COMPESA's reports came from source control reports, which are executed and made available in digital format regularly by the company. Such data provided information referring to the amount of natural F detected in spring water. In turn, secondary data related to demographics and access to treated water came from a study and surveys conducted by IBGE and SNIS, respectively. Such values were obtained through consultation of public databases available on the Internet during the study period.

The data collected were organized in Microsoft Excel® spreadsheets and analyzed regarding F levels. It is important to point out that the relationship between F concentration and average variation of maximum daily air temperatures in each region was also considered. At the end of the process, as shown in Table 1, the concentration of F present in the water, which offers maximum benefit for dental caries and minimum risk for fluorosis, was identified for the locations selected for the study (whose average temperatures range from 26.3 °C to 32.5 °C). The analysis was conducted considering the new classification, proposed by the Collaborating Center of the Ministry of Health on Oral Health Surveillance of the University of São Paulo (CECOL/

USP), for concentrations of F present in the public water supply, which was approved by the community of academics, specialists, and professionals in the field (19).

In addition, this multicenter study is part of the project "Coverage and surveillance of fluoridation of public water supply in Brazil" that is linked to the CECOL/USP. Given this scenario, we carried put the study in accordance with the Resolution of the National Health Council/CNS No. 466/12 and approved by the Research Ethics Committee of the University of São Paulo's School of Public Health, concept No. 2,517,890.

TABLE 1
Consensus on Maximum Benefit and Minimum Risk for F Contents in Public Water Supply at Mean Annual Temperatures Between 26.3 °C and 32.5 °C

Fluoride content in water (in ppm or mg F/L)	**Benefit (prevent caries)**	**Risk (produce dental fluorosis)**
0,00 a 0,44	Insignificant	Insignificant
0,45 a 0,54	Minimum	Low
0,55 a 0,84	**Maximum**	**Low**
0,85 a 1,14	Maximum	Moderate
1,15 a 1,44	Questionable	High
1,45 or more	Harm	Very high

Source: Vigifluor Project

RESULTS

Regarding access to treated water, Table 2 shows that the municipalities of Carpina and Olinda had the highest proportion of urban population with access to treated water (95 %). On the other hand, at the lower end was the municipality of Ipojuca, which provided treated water to just over half of its population (57 %). Considering all the municipalities studied, 3,022,991 people had access to treated water, which corresponds to a coverage of 81 % of the population of the first health macro-region in the state of Pernambuco.

In addition, Table 3 shows that the minimum and maximum values of F content found in each municipality, based on COMPESA reports and the VIGIFLUOR database, were not adequate and there was a significant discrepancy between them.

In most municipalities, F levels were considered insignificant or minimal for the desired effect of reducing dental caries. It is also emphasized that the levels of F, which is considered to be of maximum benefit for the prevention of caries, were found in the municipalities of Olinda, Palmares, and Recife. However, such measures were already at a level considered to be of moderate risk for the production of dental fluorosis (0.86 mg F / L).

Likewise, when evaluating the data from COMPESA separately, all the water samples were outside the range for best benefit for caries and lowest risk for fluorosis, considering the classification proposed by CECOL/USP (0.55 to 0, 84 mg F / L).

TABLE 2

Population Coverage and Urban Population with Access to Treated Water in Municipalities with more than 50,000 Inhabitants in the First Health Macro-Region, State of Pernambuco

County	Population[1]	Urban population served with water supply (inhabitant) [2]	Population with access to water supply (%)
Abreu e Lima	**99,364**	83,807	84
Cabo de Santo Agostinho	**204,653**	160,008	78
Camaragibe	**156,361**	118,949	76
Carpina	**82,685**	78,819	95
Ipojuca	**94,533**	54,348	57
Jaboatão dos Guararapes	**695,956**	512,606	74
Moreno	**62,119**	49,592	80
Olinda	**390,771**	370,589	95
Palmares	**62,832**	49,172	78
Recife	**1,633,697**	1,362,452	83
São Lourenço da Mata	**112,099**	78,690	70
Vitória de Santo Antão	**137,578**	103,959	76
Total	**3,732,648**	3,022,991	81

Source: 1 BGE. Research Directorate - DPE - Coordination of Population and Social Indicators - COPIS. [2] National Sanitation Information System - SNIS 2016

TABLE 3

Minimum and Maximum Values of Natural F Content in Water Sources and in the Public Water Supply Network for Human Consumption in the First Macro-Region of Health in the State of Pernambuco

County	COMPENSA[1] (Fountains) F levels		VIGIFLUOR[2] (Supply network) F levels	
Abreu e Lima	0	0.27	0.03	0.09
Cabo de Santo Agostinho	0	0.48	0.03	0.08
Camaragibe	0	0.49	0.01	0.18
Carpina	0	0.17	0.07	0.20
Ipojuca	0	0.48	0.03	0.11
Jaboatão dos Guararapes	0	0.49	0.04	0.24
Moreno	0	0	0.07	0.14
Olinda	**0**	**0.86**	**0.01**	**0.17**
Palmares	**0**	**0.96**	**0.42**	**0.84**
Recife	**0**	**0.86**	**0.01**	**0.14**
São Lourenço da Mata	0	0.49	0.05	0.21
Vitória de Santo Antão	0	0.17	0.11	0.61

Source: [1] COMPENSATE. SGCQ – Quality Control Management System. Sample reports by element [2] Vigifluor Project database, collected under supervision of the research group in Pernambuco

DISCUSSION

Before presenting the analysis of the data, we consider it important to emphasize the value of water fluoridation for society. Such a relevance relates to the fact that F modifies the processes of demineralization and remineralization of the tooth. Demineralization decreases when F is present in the oral cavity in low and constant concentrations, which halts mineral loss and, consequently, reduces the progression rate of caries. The addition of F to public water supply is scientifically proven to be effective in preventing the disease and is considered socially fair as its scope is collective with the potential to improve the oral health of the entire population. Furthermore, the F is still a measure of considerable impact in communities in socioeconomic disadvantage. In such communities, the prevalence of dental caries contributes to the persistence of social segregation, which is characterized by the precarious living conditions of affected populations (20).

Despite the fact that public water supply fluoridation in systems equipped with ETA has been mandatory in Brazil since 1974, the state of Pernambuco, through its sanitation authority, does not perform artificial fluoridation of supply waters (11). This situation meaningfully complicates the fight against caries in the state, as shown by indicators obtained through oral health epidemiological surveys in Brazil. Those surveys that were conducted between 2003 and 2010 show an average decline of 8.6 % in the DMFT Index (decayed, missing teeth, and/or filled due to caries) scores in capital cities with fluoridated water, when compared to those without fluoridation. The latter show an average increase of around 12.8 % (12) of the DMFT Index. Investment in fluoridation as a preventive method is a priority since the state has coverage through oral health teams in primary care of 63.34 %. It means that, in theory, just over half of the dependent SUS population is covered with dental care in the public sphere, which does not necessarily indicate timely and comprehensive access to dental services (21).

In this context, it is worth noting that coverage of supply water does not imply regular access. This situation is commonly critical in Pernambuco, which is battered by irregular rainfalls. When the water supply is lacking, the population resorts to water trucks, water bottles, wells, water tanks, and other unrelated forms to public supply, which happen without any type of monitoring.

Furthermore, the data relating to access to public water supply (Table 2) show the impact that fluoridation would have if municipalities received fluoridated water in their homes. Moreover, the scientific literature points out that the greater the access to fluoridated water, the smaller the magnitude and prevalence of oral caries in populations (19). According to national studies, there are significant differences between 10 % and 30 % in the DMFT Index rates among children and young people when comparing cities with and without F addition to water for human consumption (1).

Table 3 shows a significant discrepancy between the values measured by COMPESA and VIGIFLUOR, which confirms what is described in the literature: external control is priority to verify whether the results from the internal control performed by operators of sanitation agencies are adequate. Likewise, they help detect the possibility of occurrence of technical or methodological issues (22).

Therefore, the results presented here prove, at first sight, the occurrence of two undesirable extremes. After all, while part of the population assisted by COMPESA receives water with insignificant levels of F for anti-caries action, another considerable portion may be consuming water with high levels of natural F, putting themselves at risk of developing dental fluorosis. However, in a deeper analysis, comparing COMPESA and VIGIFLUOR data, we found out that, despite the considerable presence of natural F in the water sources of these municipalities. These concentrations do not necessarily reach the population via the public supply network. Despite not reaching the population who consume water available from public supply, they may be consuming it because it is common among users to drill and use water from wells, mines, and other sources without the supervision of competent entities (23).

The data collected by VIGIFLUOR show the levels of F found in samples obtained from the populations who consume water from the supply network. This is supported by the fact that F levels are below the

minimum standard (0.55 mg F/L), that is, there is no apparent caries preventive benefit in the municipalities studied. An exception is the municipality of Palmares with a concentration of 0.84 mg F/L, which is considered within the optimum range; therefore, there could be a benefit from artificial fluoridation that is subsidized by the National Health Foundation (24).

The data collected from SISAGUA suggests an important underutilization of the system. None of the municipalities studied have records on the control and surveillance of F content in their water supplies. This finding is of particularly important because it indicates that municipalities are not routinely monitoring F levels in their treated water supply networks. A lack of such monitoring prevents municipalities with eventually high levels of natural F from detecting such a situation, which represents an imminent risk of fluorosis for the population that consumes water from springs. This type of evidence supports the arguments and actions for an external control process.

CONCLUSIONS

The study identified in the secondary data reviewed that there are varying concentrations of F in natural springs and public supply water in the municipalities of the first health macro-region of Pernambuco. The region has a population of more than 50,000 inhabitants. Individual cases, such as Palmares showed fluoride in the water, which is contrary to other municipalities inspected. Some high levels of F were also observed in the records that support the argument for the urgency to implement control mechanisms so that fluoridation occurs in a safe manner, providing the maximum benefit to citizens.

RECOMMENDATIONS

There is still much to be studied on the topic of water fluoridation and its monitoring in regions and municipalities. Furthermore, since there will be new updated data to support decision making on public measures on the topic, new studies and assessments will be appropriate. In that regard, any new questions arising will require a systematic research approaches to be addressed.

ACKNOWLEDGMENTS

This reports is part of a multicenter project titled, "Coverage and surveillance of fluoridation of public water supply in Brazil," which is linked to the Collaborating Center of the Ministry of Health of the University of São Paulo (CECOL/USP). The project received approval of the Research Ethics Committee of the FSP-USP under research protocol No. 22186513.8.0000.542. In the state of Pernambuco, the coordination was in charge of Professor Petrônio J. de L. Martelli from UFPE. The Ministry of Health and the National Research Council (CNPq) funded this project.

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Notes

* Original research.

How to cite this article: Alcântara PM, Lyra MT, da Silveira JL, Martelli PJL. Analysis of Fluoride Content in a Health Macro Region in the State of Pernambuco, Brazil. Univ Odontol. 2022; 41. https://doi.org/10.11144/Javeriana.uo41.afch