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Heterocontrol of fluoridation of the public water supply in the Municipality of Cascavel, in the state of Paraná

Heterocontrole da fluoretação das águas de abastecimento público no Município de Cascavel, Paraná

Heterocontrol de la fluoración del agua de abastecimiento público en el municipio de Cascavel, Paraná

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This is a quantitative and descriptive research-extension, carried out between October 2017 and September 2018, with the objective of evaluating the fluoride concentration by the principles of heterocontrol, in the public water supply of the municipality of Cascavel, in the state of Paraná, Brazil. Six Basic Health Units were considered for the collection of samples, considering some close and others distant from the treatment stations, with monthly and duplicate collections. The average maximum temperatures were around 19.5 ° C; therefore, the fluoride content in the water should be between 0.65 and 0.94 ppm. 144 samples were analyzed, of which 46 (31.9%) samples were above the 0.94 ppm limit and 6 (4.2%) samples were below the 0.65 ppm limit. In the months of April and June, there was the largest number of samples with levels above the limit 0.94 ppm F, and the months of July and August presented the minimum values. Despite the majority (63.9%) of the samples being within the standards, there is a need to perform heterocontrol to subsidize the city and the Companhia de Saneamento do Paraná.
Descriptors: Fluoridation; Fluorine; Public Health Surveillance.

Esta é uma pesquisa-extensão, quantitativa e descritiva, realizada entre outubro de 2017 a setembro de 2018, com o objetivo de avaliar a concentração de flúor pelos princípios do heterocontrole, nas águas de abastecimento público do município de Cascavel - PR. Considerou-se para a coleta de amostras seis Unidades Básicas de Saúde, considerando algumas próximas e outras distantes das estações de tratamento, com coletas mensais e em duplicata. As médias de temperaturas máximas se situaram em torno de 19.5°C; sendo assim, os teores de fluoretos na água deveriam ficar entre 0,65 e 0,94 ppm. Foram analisadas 144 amostras, sendo que 46 (31,9%) amostras estavam acima do limite 0,94 ppm e 6 (4,2%) amostras estavam abaixo do limite de 0,65 ppm. Nos meses de abril e junho, houve o maior número de amostras com teores acima do limite 0,94 ppm F, e os meses de julho e agosto apresentaram os valores mínimos. Apesar da maioria (63,9%) das amostras estarem dentro dos padrões, há necessidade de se realizar o heterocontrole para subsidiar a cidade e a Companhia de Saneamento do Paraná.
Descritores: Fluoretação; Flúor; Vigilância em Saúde Pública.

Esta es una investigación-extensión cuantitativa y descriptiva, realizada entre octubre de 2017 y septiembre de 2018, con el objetivo de evaluar la concentración de flúor por los principios de heterocontrol, en los suministros públicos de agua del municipio de Cascavel – PR, Brasil. Se consideraron seis Unidades Básicas de Salud para la toma de muestras, considerando algunas cercanas y otras lejanas a las plantas de tratamiento, con tomas mensuales y por duplicado. Las temperaturas máximas medias se situaron en torno a los 19,5°C; por lo tanto, el contenido de fluoruro en el agua debería estar entre 0,65 y 0,94 ppm. Se analizaron un total de 144 muestras; 46 (31,9%) muestras estaban por encima del límite de 0,94 ppm y 6 (4,2%) muestras estaban por debajo del límite de 0,65 ppm. En los meses de abril y junio se registró el mayor número de muestras con contenidos superiores al límite de 0,94 ppm F, y los meses de julio y agosto presentaron los valores mínimos. A pesar de que la mayoría (63,9%) de las muestras estaban dentro de las normas, es necesario realizar el heterocontrol para subsidiar a la ciudad y a la *Companhia de Saneamento do Paraná*.
Descriptores: Fluoruración; Flúor; Vigilancia en Salud Pública.

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INTRODUCTION

The benefits of fluoride for the control of dental caries have been verified. In a systematic review carried out by the Oral Health Group of Cochrane, the benefit of fluoride added to the public water supply is observed in the reduction of cavities, both in primary and permanent dentition[1].

In Brazil, fluoridation started in 1954 in the city of Baixo Guandu - ES, and, since then, the coverage of water fluoridation has been increasing, increasing the coverage rate from 67.7% (2000) to 76.3 % (2008), one of the highest coverage among the 10 most populous countries on the planet[2]. Despite the advances, the Brazilian states with the lowest socioeconomic indices are those that also have low percentages of coverage of water fluoridation3.

Controlling the fluoridation process in order to maintain adequate fluoride levels is as important as the continuity of the measurement, and it is very important to ensure continuity and adequate fluoride levels in the waters, through the operational control in the water treatment plants, carried out by the responsible companies by the fluoridation process[4].

In addition to this operational control in water treatment plants, heterocontrol must be implemented, which means the health surveillance of fluoride concentrations carried out by any body or institution, public or private, other than the company responsible for the treatment and addition of fluoride. in water, since it is a good or service that implies risk or represents a protective factor for public health[2].

Law No. 6.0505, Federal Decree No. 76.8726 and Ordinance GM/MS No. 6357 are the legal instruments still in force that determine the obligation to fluoride water throughout the country, in public supply systems equipped with a Water Treatment Station (ETA).

The ideal fluoride concentrations in water are determined according to the average annual maximum temperatures in each region, with the fluoride limit established between 0.6 to 1.7 ppm by Ordinance GM/MS No. 6357. Currently, Ordinance No. 2,914/20118 determines that the maximum allowed concentration of fluoride in water must not exceed 1.5 ppm. This fluoride content would not be recommended for any region of the country, according to the Collaborating Center of the Ministry of Health in Oral Health Surveillance9 (CECOL), which proposed a criterion for the classification of waters according to the fluoride content and according to the variation of the region's temperature, with the lowest fluoride content in the waters at 0.45 ppm and the highest content at 0.94 ppm. In this document, there was a detail related to the dimensions of the benefit of dental caries control, as well as the risk of dental fluorosis caused by the fluoridation of the water supply, going beyond the "adequate/inadequate" dichotomous categories 9.

In a study[10] carried out based on the average of the maximum daily temperatures recorded, carried out in Brazilian capitals for the year 2008, it was possible to calculate the optimal fluoride concentration values, according to the formula recommended in Ordinance GM/MS No. 6357, and verify that the variation of fluoride levels in the water supply would be around 0.6 ppm (for Boa Vista - RR) and 0.8 ppm (in Curitiba - PR).

The fluoride concentration is a relevant parameter to assess the quality of drinking water, either because of the possibility of controlling tooth decay, when present at adequate levels, or because of the potential to cause dental fluorosis, when at high levels. Establishing safety levels for fluoride in drinking water is an essential measure to protect human health[9].

Heterocontrol should serve as a tool to ensure the efficacy and safety of fluoridation, and its results should be forwarded to the sectors responsible for providing water for human consumption in the municipality so that, if necessary, measures are adopted, as there are studies that show results heterocontrol with significant variations in fluoride concentration, in some Brazilian locations[11-14].

Given the importance of fluoridation for public health and the importance of monitoring adequate fluoride concentrations in public water supplies, this study aimed to evaluate the

fluoride concentration by the principles of heterocontrol in public water supplies in the municipality of Cascavel - PR.

METHODS

This is a quantitative and descriptive research-extension, which performed fluoride heterocontrol by sampling regions connected to Water Treatment Plants (ETA), carried out in the city of Cascavel - PR. Also, information from the Companhia de Saneamento do Paraná (SANEPAR) was used to find out about the municipality's water distribution network, through ETA and its spatial coverage in the municipality; and the Atlas website of the National Water Agency (http://atlas.ana.gov.br/Atlas/forms/Home.aspx), which contains a sketch of all supply networks in Brazilian cities.

For the definition of sampling points for water collection during the execution of the study, the Sampling Guide for Surveillance of Fluoride Concentration in Public Supply Water prepared by CECOL15 was used.

The treated water supply network of the Companhia de Saneamento do Paraná (SANEPAR) is available to 100% of the urban population of Cascavel.

The municipality of Cascavel has three WTPs with reservoirs for fluoride application, so that six Basic Health Units (UBS) were determined as collection points, closer and more distant from the three water treatment plants. The UBS were defined as collection points, due to their geographic distribution, so that it covered all regions of the city. The collection was carried out monthly during the period of one year, from October 2017 to September 2018. The samples were collected directly from taps, at the point of entry of the network, in 50 ml polyethylene bottles, previously rinsed with water from the tap, identified and labeled.

The samples collected were analyzed, in duplicate, in the biochemistry laboratory of the Dentistry Course of the State University of West Paraná (UNIOESTE), using an ion analyzer coupled to a fluoride ion measuring electrode, Analyser® model 18AF, having as reference value the average of the two readings.

Prior to analysis, the instrument was calibrated in standard solutions of 0.1 ppm F and 1 ppm F. These solutions were created from the standard 100 ppm solution of Fluoride Analyzer®. For calibration, the electrode was partially immersed, until the reading stabilized for the 0.1 ppm and 1 ppm solution parameters. The collected samples were prepared and the TISSAB III Analyser® ionic strength adjusting solution was added to them.

The value of the average maximum temperature in the municipality was used as a parameter for the analysis of the fluoride concentration in the water supply, and this information was requested, via email (faleconosco@simepar.br), from the Meteorological System of Paraná - SIMEPAR. For the municipality surveyed, in the period from October 2017 to September 2018, the average maximum temperatures were around 19.5°C.

According to the Collaborating Center of the Ministry of Health in Oral Health Surveillance (CECOL)[9], for locations where average annual maximum temperatures are below 26.3 ° C, the best benefit-risk combination occurs in the range of 0, 65 ppm F to 0.94 ppm F (Chart 1), this being the parameter adopted for this study.

Chart 1. Criteria proposed by the Collaborating Center of the Ministry of Health in Oral Health Surveillance, University of São Paulo, 2011[8,9].

Fluoride content in water (ppm)	Benefit (caries control)	Risk (producing fluorosis)
0,00 to 0,44	Insignificant	Insignificant
0,45 to 0,54	Minimun	Low
0,55 to 0,64	Moderate	Low
0,65 to 0,94	**Maximum**	**Low**
0,95 to 1,24	Maximum	Morerate
1,25 to 1,44	Questionable	High
1,45 or more	Harmful	Very High

Considering the average maximum temperatures and the best benefit-risk combination proposed by CECOL, the results of the analyzes were entered into a Microsoft Excel spreadsheet. Descriptive statistics (mean, minimum, maximum, standard deviation, variation coefficient and amplitude) were performed with the aid of the Bioestat® 5.0 software.

As previously mentioned, this is a university research and extension project and does not involve human beings. Thus, the project could be carried out after consulting the Ethics Committee, which informed that there is no need for evaluation (According to Resolution 466/12).

RESULTS

72 samples were collected in duplicate, or 144 analyzes. It can be seen that 46 (31.94%) samples were above the 0.94 ppm F limit and 6 (4.16%) samples were below the 0.65 ppm limit (Table 1).

The fluoride concentration range between 0.65 to 0.94 ppm F, which is considered to be the best benefit-risk combination, was found in 63.9% of the total samples collected. Among the collection points, the Morumbi Unit had the largest number of samples, 83.3%, with fluoride concentration between 0.65 and 0.94 ppm F, however, two collection points presented half (50%) of your samples outside this standard (Table 1).

Table 1. Fluoride concentration according to technical criteria of the Collaborating Center of the Ministry of Health in Oral Health Surveillance (CECOL) by location. Cascavel/PR, 2019.

Local da coleta	BHU Los Angeles		BHU Floresta		BHU XIV de Novembro		BHUParque São Paulo		BHU Parque Verde		BHU Morumbi		Total	
Fluorite in water (in *ppm)*	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0.00 to 0.44	0	0	0	0	0	0	0	0	4	16.7	0	0	4	2.8
0.45 to 0.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.55 to 0.64	0	0	2	8.4	0	0	0	0	0	0	0	0	2	1.4
0.65 to 0.94 *	17	70.8	18	75	12	50	13	54.1	12	50	20	83.3	92	63.9
0.95 to 1.24	7	29.2	4	16.6	12	50	11	45.9	8	33.3	4	16.7	46	31.9
1.25 to 1.44	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.45 or more	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total of samples	24	100	24	100	24	100	24	100	24	100	24	100	144	100

Note: * Best combination benefit-risk.

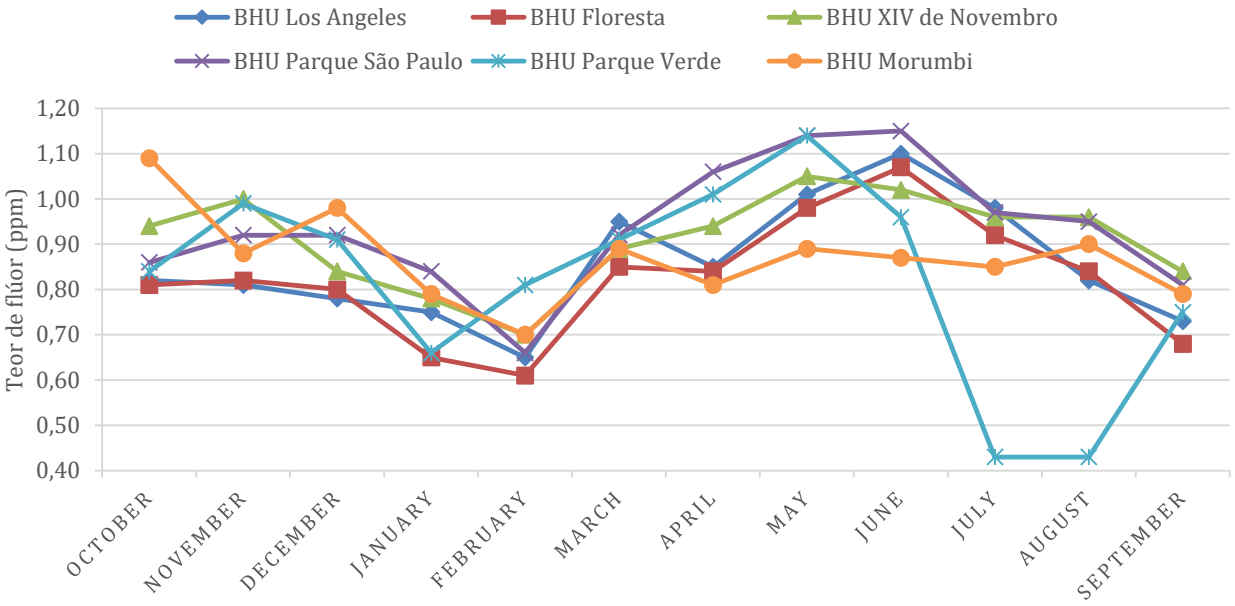
The highest variation coefficient occurred at UBS Parque Verde with 26.96%, with a minimum value of 0.43 ppm F and a maximum value of 1.14 ppm F, followed by UBS Parque São Paulo, which presented the variation coefficient 14.87% with a minimum value of 0.66 ppm F and a maximum value of 1.15 ppm F (Table 2).

In Graph 1, it was possible to observe, between the months of April and June, the largest number of samples with levels above the limit 0.94 ppm F. Regarding the minimum value, this was observed for two consecutive months (July/August), at one of the collection points (Parque Verde Unit), and in the following month (September), the fluoride content returned to the standard 0.65 to 0.94 ppm F.

Table 2. Measures of central tendency and dispersion of fluoride concentrations by location. Cascavel, PR, 2019.

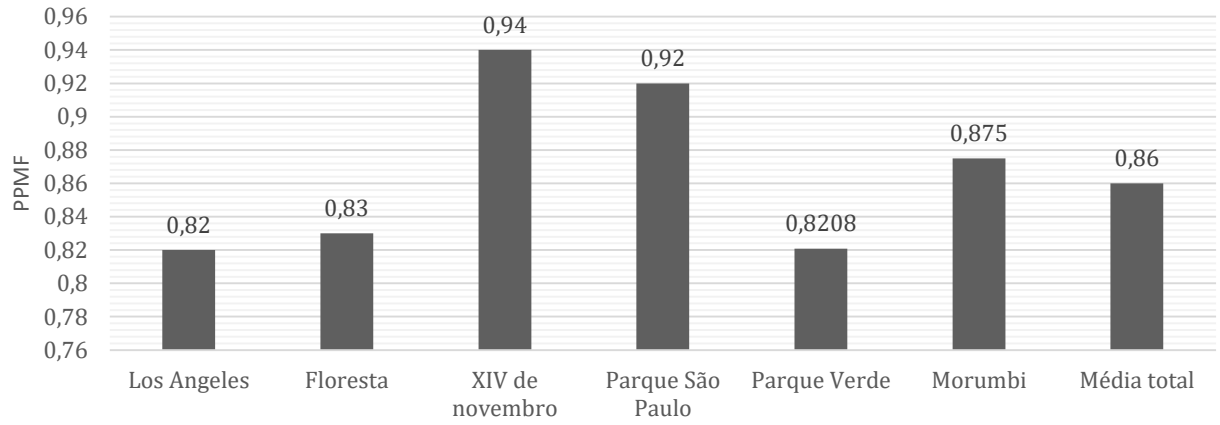
BHU of sample	Mean ppm	Standard Deviation	Coeficient Variation	Minimum Value	Maximum Value	Amplitude
Los Angeles	0.82	0.13	15.2%	0.65	1.10	0.45
Floresta	0.83	0.12	16.1%	0.61	1.07	0.46
XIV de Novembro	0.94	0.10	11.3%	0.70	1.05	0.35
Parque São Paulo	0.92	0.13	14.8%	0.66	1.15	0.49
Parque Verde	0.82	0.22	26.9%	0.43	1.14	0.71
Morumbi	0.87	0.09	11.3%	0.70	1.09	0.39

Graph 1. Average fluoride levels (ppm) found in the collected water samples, by month of follow-up. Cascavel, PR, 2019.



The average of the 144 samples analyzed were distributed by collection points and the total average between the collection points was 0.86 ppm (Graph 2).

Graph 2. Average fluoride concentration in the water samples during the 12 months analyzed, according to the different locations studied. Cascavel, PR, 2019.



DISCUSSION

The fluoridation of public water supplies is an essential element in preventing health problems, being one of the priority actions of health policy in the area that transcends the merely technical dimension of the dental sector and must be monitored throughout its development.

This policy is encouraged by Brazilian legislation, and, at the same time, recommended by several institutions that support it and contribute, through their guidance manuals, to the fluoridation of public water supply and its control, highlighting the Collaborating Center from the Ministry of Health in Oral Health Surveillance (CECOL) of the Universidade de São Paulo (USP)[9,15].

It is up to the municipal level, through the Municipal Health Secretariats, to carry out water quality surveillance in conjunction with operators, keeping the information system of the Water Quality Surveillance Information System for Human Consumption (SISAGUA) up to date[15].

A multicenter study[16] on coverage and surveillance of water fluoridation carried out, with data from the period 2010 to 2015, in municipalities with more than 50 thousand inhabitants, found that, in the state of Paraná, fluoridation and food surveillance in SISAGUA was carried out by supply system operator, SANEPAR. There were no systematic records of analyzes for the fluoride parameter by the State Surveillance, with an action developed in 2010, specific for sample collection and analysis of fluoride contents, making it possible to validate fluoridated municipalities, however without continuity[16].

In 2014, it is already possible to observe the presence of Health Surveillance services in municipalities in Paraná, acting in hetero-control, as well as hetero-control initiatives in certain locations in Paraná, carried out by higher education institutions[14,17-19].

The heterocontrol in the municipality of Cascavel allowed us to confirm that fluoride is present in water for human consumption, however, with monthly variations in the fluoride content identified between the water collection points and at the same point over the analyzed period. None of the analyzes performed showed a peak that would alert the chronic exposure of the fluoride concentration above the recommended, exposing the target population to the possible development of fluorosis, similar to the study of heterocontrol in the city of Uberlândia[20].

The decision to implement and maintain at optimal levels the fluoride content of water in Brazilian municipalities should be based on an understanding of social factors such as work and income, generating greater or lesser availability and frequency in the use of fluoridated toothpaste, as well as access to other caries prevention strategies.

Water fluoridation is associated with a higher proportion of children without caries and a reduction in the number of teeth affected by the disease[2]; in addition, it enables the redirection of oral health activities, carried out by higher education professionals, towards other population groups[21]. It is always worth remembering that lifetime exposure to fluoridated water has also been associated with a reduction in dental caries in adults[22].

It was found that 63.9% of fluoridated water samples were in the best risk-benefit range, 0.65 to 0.94 ppm F, according to the classification proposed by CECOL. In turn, even though most samples are in the best risk-benefit range, heterocontrol should have a continuity line. Longitudinal studies of heterocontrol of fluoridation[13,23] indicate the need for interventions by the company responsible for water treatment in the city, help to maintain optimal fluoride levels in public water supply, and present a better pattern of maintenance of adequate fluoride levels.

In a review study[24], failures in water fluoridation were observed due to problems such as: manual metering pump, variation in water flow, complex distribution network, technical operational difficulty, different analytical technique between internal and external control, failures in public administration, distance between reservoirs and ETA, source of supply artesian well, low HDI of the municipality, lack of equipment, laboratory and technical infrastructure and naturally fluoridated sources.

Surveys[14,17-19] of heterocontrol, in the state of Paraná, show diversity. In an analysis of the waters of 23 municipalities belonging to the 15th Regional Health Region of Paraná, they showed that 79.5% of the fluoridated water samples were in the best risk-benefit range[17]. In municipalities with a population of over 50 thousand inhabitants in the Metropolitan Region of Curitiba - PR, of the total of 2,797 water samples analyzed, only 51.5% were in the best benefit-risk range for the concentration of fluoride, presenting an unsatisfactory result[14].

In Paraná, the best result in heterocontrol studies was in the city of Maringá, in 2010, which showed that 86% of the samples collected from the water supply system and water were in accordance with the best benefit-risk combination[18]. On the other hand, in the city of Ponta Grossa - PR, two thirds of the samples were outside the ideal standard of 0.55 ppm F to 0.84 ppm F, with a predominance of overdosed samples, reaching 13.4% the percentage of samples with fluoride levels above 1.1 ppm[19].

In this study, the results of the analyzes showed that 31.9% of the samples in the fluoride concentration range between 0.95 ppm F and 1.24 ppm F, which represents a moderate risk of fluorosis, in accordance with CECOL parameters. However, the highest concentrations found did not exceed 1.16 ppm F, being very close to the acceptable limit. The mean of the 144 samples was 0.86 ppm F, an adequate value with the analysis criteria used in this study; however, the average should be viewed with caution as it would end up hiding variations that may occur over the period at the same or at different collection points.

Difficulty in maintaining adequate fluoride in the drinking water was also visible, which could serve as a warning for possible problems arising from this inadequacy, mainly the probability of an increase in the incidence of fluorosis, despite the fact that the present study was not designed to assess a causal relationship. effect between consumption of fluoridated water and risk of fluorosis in the population.

Considering that most of the dosages (63.9%) are within the limits, and the samples (31.9%) with overdoses are very close to the appropriate limit, the results are not alarming, as degrees of dental fluorosis are very light and light (normally found in Brazil) does not affect the self-perception and quality of life of adolescents[25].

On the other hand, levels below the recommended level could substantially alter the effectiveness of this preventive maneuver in terms of reducing dental caries, especially in individuals deprived of access to other fluoride delivery media. This fact highlights the importance of studies aimed at periodic monitoring of fluoride levels in the water supply, as well as the effect of the adequacy of these levels on the incidence of caries and fluorosis in the population. Also, educational institutions, even as a contribution, can act permanent way in the control of this measure by exercising its social role, especially in the analysis of fluoride levels and in the expansion of the social debate on the quality of water consumed by populations[26].

CONCLUSION

Although most concentrations (63.9%) were within the limits, there were fluctuations in fluoride levels, with a predominance of overdose, found in the public water supply in Cascavel during the 12 months of evaluation. These results suggest the continuity of external monitoring of water fluoridation, in order to provide support for appropriate adjustments with SANEPAR.

To date, there are no published data in relation to the presence or absence of fluorosis in schoolchildren in the municipality and, in view of this, a study that seeks to describe fluorosis in this population is relevant.

Observation time is identified as a limitation of this study, which is why a longer period of longitudinal follow-up for future works is suggested.

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CONTRIBUTION
Amanda Naelly Voinaski Dall Agnoll, **Ana Luiza Amadori**, **André Luiz Marçcal Terreri**, **Anna Kallyne Eberts Sebastiany** and **Daniela Pereira Lima** contributed to the study design, data collection and analysis, writing and reviewing. **Danielle Portinho** collaborated in the design, collection and analysis of data and reviewing.

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