

# Characteristics of sanitation companies associated to water fluoridation of the supply systems of Brazilian municipalities, 2008\*

*Características das empresas de saneamento associadas à fluoretação da água dos sistemas de abastecimento de municípios do Brasil, 2008*

Franklin Barbosa da Silva<sup>1</sup> , Paulo Frazão<sup>1</sup> 

**ABSTRACT: Introduction:** The adjusted effect of the characteristics of sanitation companies on the provision of fluoridation into public water supply in Brazilian municipalities was evaluated. **Methods:** Cross-sectional and ecological study based on the 2010 Demographic Census, 2008 National Survey on Basic Sanitation (PNSB), and 2010 Atlas of Human Development. The independent variables were the characteristics of utilities and municipalities, and the outcome was the lack of provision of fluoridation. Prevalence ratio was estimated with Poisson regression with robust variance. **Results:** 5,565 Brazilian municipalities were included. In the adjusted analysis, the outcome was independently and positively associated to municipalities in the North, Northeast, Central-West and Southeast macro-regions, with coverage rates for water and sewage services below the median value, with less than 10,000 inhabitants, medium and low / very low in human development. Regarding the independent effect of the utilities' characteristics, they were more likely not to provide fluoridation, all the companies that were not classified as indirect administration of the government or mixed-capital company or mixed-capital company of public character; municipal and intermunicipal (PR=1.21; 95%CI 1.19–1.23); and when the municipal government is the only provider (PR=1.22; 95%CI 1.20–1.25). **Conclusion:** The lack of provision of water fluoridation was greater when the service was mainly provided by municipal administrations and private companies associated or not to public entities, regardless of the characteristics of the municipalities.

**Keywords:** Fluoridation. Sewerage enterprises. Multivariate analysis. Ecological studies. Environmental health.

\*Article derived from a doctoral thesis entitled *Contextual characteristics associated to the fluoridation of public water supply in Brazil in 2008*, presented by Franklin Barbosa da Silva to the Graduate Program in Public Health at Universidade de São Paulo, in 2019.

<sup>1</sup>Department of Politics, Management and Health, Faculty of Public Health, Universidade de São Paulo – São Paulo (SP), Brazil.

**Corresponding author:** Franklin Barbosa da Silva. Rua 3, 81, Conjunto Castelo Branco, Parque 10 de Novembro, CEP: 69055-210, Manaus, AM, Brazil. E-mail: frank\_barbosa@usp.br

**Conflict of interests:** nothing to declare – **Financial support:** Amazonas State Research Support Foundation (*Fundação de Amparo à Pesquisa do Estado do Amazonas - FAPEAM*), process No. 062.03159.2014, and Brazilian Council for Scientific and Technological Development (CNPq), process No. 303681/2016-0. The last author is a researcher of the Brazilian Council for Scientific and Technological Development (CNPq 305132/2019-9).

**RESUMO:** *Introdução:* Avaliou-se o efeito ajustado das características das empresas de saneamento na provisão da fluoretação da água de abastecimento público nos municípios brasileiros. *Métodos:* Estudo ecológico transversal com base no Censo Demográfico 2010, Pesquisa Nacional de Saneamento Básico 2008 e Atlas de Desenvolvimento Humano 2010. As variáveis independentes foram as características das empresas e dos municípios e o desfecho foi a falta de provisão da fluoretação. Estimou-se a razão de prevalência por meio de regressão de Poisson com variância robusta. *Resultados:* Incluíram-se 5.565 municípios brasileiros. Na análise ajustada, o desfecho foi independente e positivamente associado com municípios das macrorregiões Norte, Nordeste, Centro-Oeste e Sudeste, que tinham taxas de cobertura de serviços de água e esgoto abaixo do valor mediano, menos de 10 mil habitantes e índice médio e baixo/muito baixo de desenvolvimento humano. Quanto ao efeito independente das características das empresas, tiveram maior probabilidade de não ofertar fluoretação todas as empresas classificadas como de administração indireta do poder público, ou sociedade de economia mista, ou economia mista de caráter público; as municipais e intermunicipais (razão de prevalência — RP = 1,21; intervalo de confiança de 95% — IC95% 1,19 – 1,23); e a prefeitura, quando única executora (RP = 1,22; IC95% 1,20 – 1,25). *Conclusão:* A falta de provisão da fluoretação da água foi maior quando o serviço era prestado preponderantemente por administrações municipais e empresas privadas, associadas ou não a entidades públicas, independentemente das características dos municípios. *Palavras-chave:* Fluoretação. Empresas de saneamento básico. Análise multivariada. Estudos ecológicos. Saúde ambiental.

## INTRODUCTION

Access to fluorides through public water and toothpaste has been considered an important determinant to explain the decline in dental caries since the 1970s in several developed countries<sup>1</sup>.

Data from 2012 indicated that water fluoridation was present in 25 countries, with more than 377 million people affected<sup>2</sup>. The United States of America, Brazil and Australia are federative republics in which the measure's coverage, although high, is not homogeneous among states<sup>3-5</sup>. It can be assumed that these differences between regions of the same country are linked to the political-administrative complexity that the relative autonomy of national subunits brings to the provision of sanitation services. Characteristics of municipalities, such as human development index, geographic location between macro-regions and population size seem to be linked to the benefit<sup>4,6,7</sup>. However, there is no scientific information on the independent effect of other variables, such as the characteristics of sanitation companies in the provision of public health technology.

The environmental conditions for capturing and treating water and the characteristics of the provision of water supply services as a semi-public good, among other aspects, make the activity quite complex<sup>8,9</sup>. As a result of the strong market pressure, since the 1980s<sup>10,11</sup>, there has been a gradual investment opening by the private sector in sanitary activities in several countries, based on the promise to increase investment capacity and the efficiency of the sector<sup>12</sup>.

In Brazil, the sanitation sector has undergone several changes throughout its history, and the ownership in the provision of services to the municipal level has been recently defined, which can establish partnerships with public and private entities, relationships in which

responsibility can be delegated<sup>13</sup>. Management characteristics may be distinct and specific to each location in the country, with the possibility of direct involvement in the provision of services. Although Law No. 6.050, approved by the National Congress in 1974 in Brazil, made fluoridation mandatory everywhere a water treatment plant exists, creating conditions to universalize access to fluorides, studies have shown that the provision of water fluoridation is extremely unequal, both among macro-regions<sup>14</sup> and among municipalities in the country<sup>15</sup>. Nonetheless, the significance of the effect of specific variables linked to the concessionaire on the provision of public policy in the presence of characteristics linked to the municipalities, including the Brazilian macro-region to which it belongs, was not further investigated.

Considering the aforementioned aspects, the objective of the present study was to evaluate the adjusted effect of the characteristics of sanitation companies in the provision of fluoridation of public water supply in Brazilian municipalities.

## **METHODS**

### **STUDY DESIGN**

This is a cross-sectional and ecological study, which encompassed all Brazilian municipalities.

### **DATA SOURCE**

The 2010 Demographic Census, 2008 National Survey on Basic Sanitation (PNSB), and 2010 Atlas of Human Development grounded the study.

The Demographic Census is a statistical operation that constitutes a source of information about the population's life condition in the municipalities<sup>16</sup>. PNSB provides data on basic sanitation conditions in all Brazilian municipalities with the work of public agencies and private companies<sup>17</sup>. The Atlas of Human Development is an initiative of the United Nations Development Program (UNDP) that offers human development indicators for Brazilian municipalities and states<sup>18</sup>.

### **STUDY VARIABLES**

The situation of fluoridation in all municipalities in the country was extracted from PNSB 2008, that is, the existence or not of the service in water destined for public supply, regardless of coverage. The outcome was defined by the rate of municipalities without the benefit. The main independent variables were characteristics linked to the sanitation companies, such as the legal nature of companies providing water supply services, the administrative

sphere, and the way in which the service is performed<sup>16</sup>. The legal nature variable was broken down into six categories: direct administration of public authority, autarchy, public company, mixed-capital company, public consortium, private company, foundation, and association. Given that 1,848 municipalities had two, three and even four classifications, and to avoid categories with low frequency, the data were organized into six categories:

- indirect administration of the exclusive public authority (autarchy, public company and public consortium); only mixed-capital company; public-limited liability company (combination of two categories, one of which is a mixed-capital company and the other is a direct public administration, public company, autarchy or public consortium);
- private-mixed company (combination of two categories, one of which is a mixed-capital company and the other is a foundation, private company or association);
- direct administration of exclusive public authority;
- direct administration of public power authority with any type of indirect administration of public authority (adding two or three categories); direct administration of public power combined with private administration (adding two or three categories);
- mixed-capital company combined with direct or indirect administration of public authority and private administration (adding three or four categories);
- only private administration (private company, foundation and association).

The administrative sphere variable, originally classified as federal, state, municipal, private, inter-federative and intermunicipal, was also recategorized into five categories:

- sum of state or federal exclusive classification;
- sum of municipal or intermunicipal exclusive classification;
- only private;
- associations between public entities (two or three categories combined, between federal, state, municipal or intermunicipal);
- associations between public and private entities (two, three or four categories combined, between private entities and the federal, state, municipal, intermunicipal or inter-federative sphere).

The service performance form variable indicates who actually works in the provision of the service, maintaining the original classification:

- the city council is the only service performer;
- other entities perform the service;
- the city council and other entities perform the service.

The following characteristics related to the municipalities, from the census, were included: macro-region; demographic size; coverage of the general water distribution network; coverage of the general sewage / rainwater distribution network. The Municipal Human Development Index (MHDI), present in the 2010 Atlas of Human Development, was also used.

The macro-region concerns a political division that has already been used as a relevant variable in a study related to the provision of sanitation services<sup>19</sup>. It was categorized according to the division of the Brazilian Institute of Geography and Statistics (IBGE):

- South;
- Southeast;
- Central-West;
- Northeast;
- North<sup>16</sup>.

The demographic size refers to the total number of residents in the municipality at the time of the Census survey. To describe it, the 2010 population estimates were separated into:

- municipalities with up to 10,000 inhabitants;
- more than 10,000 inhabitants, up to 50,000;
- more than 50,000 inhabitants, according to the criteria used in another study<sup>4</sup>.

Variables included the coverage of both the general water distribution network and the general sewage/rainwater distribution network because they express the quality of the sanitation service with fluoridation. Both were calculated using the proportion between the number of permanent private households supplied by the general distribution network and the total number of permanent private households in the municipality. For analytical purposes, the classification was made according to the median of the percentage coverage values. The MHDI was inserted as a variable in the study, which is a measure composed of three dimensions (longevity, education, and income) to characterize the degree of development of the municipalities that did not provide fluoridation. The data for 2010 were divided into three categories: very low and low (between 0 and 0.499 and between 0.500 and 0.599); medium (between 0.600 and 0.699); and high and very high (between 0.700 and 0.799 and between 0.800 and 1).

## DATA ANALYSIS

The values of the prevalence ratios (PR) and respective 95% confidence intervals (95% CI) were estimated between the outcome and the independent variables with Poisson regression analysis, with robust variance. The hypothesis of the study that guided the multiple analysis was to verify whether the characteristics of the sanitation companies (legal nature, administrative sphere and service performance form) remained or not associated to the outcome, regardless of the characteristics related to the municipalities (coverage of the general distribution network) of water, coverage of the general sewage/rainwater distribution network, demographic size, macro-region and 2010 MHDI. For that, four multiple models were built. In model 1, only variables related to the municipalities were included. In model 2, in addition to those related to the municipalities, the legal nature variable was included in

the analysis. In model 3, the legal nature variable was replaced by the administrative sphere and, in model 4, by the service performance form. They were included in the model separately because some categories of variables related to the characteristics of the utilities were associated to each other and the outcome. Stata 12 statistical software was used<sup>20</sup>.

Due to the fact that research uses only census information, of public access, there was no mandatory evaluation by the system of Research Ethics Committees/National Research Ethics Commission, according to the Resolution of the National Health Council (CNS) No. 510, of April 7, 2016.

## RESULTS

Among the 5,565 municipalities included in the study, data were missing for the following variables: general water distribution network (n=5), general sewage/rainwater distribution network (n=111), and legal nature, administrative sphere and service performance form (n=4). Table 1 shows the distribution of municipalities according to the characteristics investigated. Among them, 60.2% had fluoridation services, and those belonging to the South and Southeast macro-regions had greater provision of the service. The presence of fluoridation was higher in the upper medians of the variables: coverage of the general water distribution network and sewage coverage. It was also higher in municipalities with a population of over 50,000 inhabitants and in those with very high/high MHD. The public sector's role in providing the benefit was noted. State companies, largely represented in the category that included entities characterized as indirectly managed by the public authorities/mixed-capital companies/mixed-capital public entities, and which operate by the association between public entities from different spheres and mixed-capital companies, were responsible for providing water supply services to more than 60% of the municipalities and had higher rates of service provision: 74.9 versus 27.8%, when the concessionaire was a private company. State entities, when added to federal ones in administering the service, also proportionally performed better. On the other hand, when the city council was the only performer, the worst performance was noted.

Table 1 also shows the values of the gross and adjusted effects of the independent variables on the rate of municipalities lacking the benefit. The values of the simple analysis indicate that all categories of variables showed an association with the outcome, except for the Southeast category of the macro-region variable (PR=1.02; 95%CI 0.99–1.04). In the first model of multiple analysis, in which only variables related to the municipalities were included, the associations remained present in all categories, especially municipalities belonging to the Northern macro-region, with a high probability of absence of public policy (PR=1.62; 95%CI 1.58–1.67). Municipalities in the Southeast macro-region, in the presence of the other variables, became significantly associated to the outcome (PR=1.06; 95%CI 1.04–1.09). In Model 2, in which, in addition to the characteristics of the municipalities, the legal nature variable was added, all categories were associated to the outcome, with

Table 1. Total frequency of Brazilian municipalities and 95% confidence interval (95%CI) of the gross and adjusted prevalence ratios (PR) of the Poisson regression models for municipalities without fluoridated water, according to the characteristics investigated.

Variables	Municipalities			Simple	Model 1	Model 2	Model 3	Model 4
	Total	No provision						
	n	n	(%)	95%CI	95%CI	95%CI	95%CI	95%CI
<b>Region</b>								
South	1,188	145	12.2	1.00	1.00	1.00	1.00	1.00
Southeast	1,668	235	14.1	0.99 – 1.04	1.04 – 1.09*	1.03 – 1.07*	1.03 – 1.07*	1.02 – 1.06**
Central-West	466	212	45.5	1.25 – 1.34*	1.23 – 1.32*	1.21 – 1.29*	1.22 – 1.30*	1.21 – 1.29*
Northeast	1,794	1,218	67.9	1.46 – 1.53*	1.42 – 1.50*	1.42 – 1.50*	1.43 – 1.50*	1.45 – 1.53*
North	449	404	90.0	1.66 – 1.73*	1.58 – 1.67*	1.46 – 1.59*	1.50 – 1.60*	1.54 – 1.64*
<b>Water supply</b>								
≥ 72.6%	2,780	765	27.5	1.00	1.00	1.00	1.00	1.00
< 72.6%	2,780	1,444	51.9	1.17 – 1.21*	1.02 – 1.06*	1.03 – 1.06*	1.03 – 1.07*	1.02 – 1.06*
<b>Sewage coverage</b>								
≥ 17.5%	2,727	654	24.0	1.00	1.00	1.00	1.00	1.00
< 17.5%	2,727	1,484	54.4	1.22 – 1.27*	1.03 – 1.08*	1.01 – 1.05**	1.01 – 1.05*	1.02 – 1.06*
<b>Demographic size (inhabitants)</b>								
More than 50,000	608	156	25.7	1.00	1.00	1.00	1.00	1.00
From 10,000 to 50,000	2,444	1,003	41.0	1.09 – 1.16*	1.00 – 1.05***	0.98 – 1.04	1.00 – 1.06***	0.99 – 1.04
Less than 10,000	2,513	1,055	39.8	1.10 – 1.17*	1.07 – 1.13*	1.03 – 1.09*	1.07 – 1.13*	1.04 – 1.10*
<b>2010 MHDl</b>								
Very high/high	1,933	240	12.4	1.00	1.00	1.00	1.00	1.00
Medium	2,233	985	44.1	1.26 – 1.31*	1.04 – 1.09*	1.04 – 1.09*	1.05 – 1.09*	1.05 – 1.09*
Low/Very low	1,399	989	70.7	1.49 – 1.55*	1.03 – 1.10*	1.03 – 1.10*	1.04 – 1.10*	1.02 – 1.08*
<b>Legal nature</b>								
Indirect public administration/ Mixed-capital company of public character	3,524	977	27.7	1.00		1.00		

Continue...

Table 1. Continuation.

Variables	Municipalities			Simple	Model 1	Model 2	Model 3	Model 4
	Total	No provision						
	n	n	(%)	95%CI	95%CI	95%CI	95%CI	95%CI
Mixed-capital company of private character	309	128	41.4	1.06 – 1.15*		1.07 – 1.13*		
Direct public administration	924	571	61.8	1.24 – 1.30*		1.22 – 1.28*		
Direct public administration + indirect/ Direct public administration + private entity	299	186	62.2	1.23 – 1.32*		1.09 – 1.16*		
Mixed-capital company + public entity + private entity	266	167	62.8	1.23 – 1.32*		1.10 – 1.17*		
Private entity	209	151	72.2	1.30 – 1.39*		1.11 – 1.20*		
Administrative sphere								
State + Federal	2,125	550	25.9	1.00			1.00	
Association of only public entities	1,067	362	33.9	1.04 – 1.09*			0.98 – 1.02	
Municipal + Intermunicipal	1,383	712	51.5	1.18 – 1.23*			1.19 – 1.23*	
Association between public and private entities	748	405	54.1	1.19 – 1.26*			1.11 – 1.16*	
Private	208	151	72.6	1.32 – 1.42*			1.11 – 1.21*	
Service performance form								
Other entities perform the service	3,220	1,033	32.1	1.00				1.00
The city council and other entities perform the service	1,368	580	42.4	1.05 – 1.10*				0.99 – 1.02
The city council is the only service performer	943	567	60.1	1.18 – 1.24*				1.20 – 1.25*

\*p<0.000; \*\*p<0.01; \*\*\*p<0.05; MHD: Municipal Human Development Index.



the exception of “between 10,000 and 50,000 inhabitants” for the demographic size variable (PR=1.01; CI95 % 0.98–1.04), which did not differ in terms of the reference category. Companies classified as “directly managed by public authorities” were more likely not to provide fluoridation (PR=1.25; 95% CI 1.22–1.28), followed by private companies (RP=1.16; 95%CI 1.11–1.20). In the following model, three categories of administrative sphere showed significant associations with the outcome in the presence of covariates linked to the municipalities. Only the category that combined public entities did not differ from the reference category (PR=1; 95%CI 0.98–1.02). Comparing the Simple model and Models 2 and 3, it was observed that the net effect corresponding to the private nature of the legal nature and the administrative sphere, although significant, has lost its magnitude. In the last model, which included the service performance form variable, the category “city council was the only service performer” had a high probability of not providing fluoridation (PR=1.22; 95%CI 1.20–1.25). Just like in Model 2, the category “between 10,000 and 50,000 inhabitants” lost statistical significance. Observing the data of all the adjusted models, the variables related to the sanitation companies and the macro-region variable showed the highest probabilities of not providing fluoridation when compared to the reference categories.

## DISCUSSION

This is the first study in a federative republic of three political-administrative levels, which evaluated the net effect of specific variables linked to the concessionaire responsible for water supply on the lack of provision of public fluoridation policy, in the presence of characteristics linked to the municipalities, including the macro-region to which they belong. The study hypothesis was confirmed, that is, the characteristics of the sanitation companies remained positively associated to the provision of fluoridation, regardless of those related to the municipalities.

The process of multiple modeling of the variables verified that, in the comparison with the Brazilian municipalities of the South macro-region, all those belonging to the other macro-regions had a significant probability of not ensuring the population's access to the benefit, with magnitudes varying between 2 and 9% for the Southeast macro-region, 21 and 32% for the Central-West, 42 and 53% for the Northeast, and 46 and 67% for the North, indicating markedly different patterns of public policy implementation.

Previous studies point out these interregional differences<sup>7,14</sup>. The contribution of the present investigation was to show the strength of the macro-region in the presence of other variables linked to municipalities and concessionaires. The regional inequality of public fluoridation policy seems to follow the history of implementation of essential public services in the Federative Republic of Brazil, such as access to the general water network and the electricity network. This access was marked by an expansion process with clear territorial inequality, in which the North and Northeast macro-regions were only reached by expressive coverage as of the 2000s<sup>21</sup>. This uneven expansion seems to be primarily linked to the

concentration of economic growth in the South and Southeast macro-regions, which was reflected in higher revenue from local governments and investment capacity. The country's development was marked by inequality in the distribution of wealth and the construction of citizenship rights was unevenly distributed according to the insertion in the formal labor market, with the social benefits linked to the contributions and earnings of workers. The reported inequalities only found political definition for their reduction with the formulation of the Constitution of the Federative Republic of Brazil of 1988 and its resulting fiscal structure, which can be considered recent from the point of view of the universalization of public sanitation services<sup>22</sup>.

Factors such as coverage of water and sewage services remained significantly associated, showing that the lack of access to the benefit was linked to coverage rates for these services below the median value. Nonetheless, the magnitude of the association did not exceed the probability of 10% in any of the models. Given that the economic cost of maintaining water fluoridation in treatment plants would not affect the efficiency of sanitation services provided by companies<sup>23</sup>, it is legitimate to consider maintaining optimal concentration standards for preventing dental caries as an indication of the quality of treatment services and water distribution under the responsibility of companies<sup>24,25</sup>.

Even in the presence of variables linked to municipalities and sanitation companies, medium and low/very low levels of human development remained positively associated to the outcome. As to demographic size, very small municipalities, defined as those with less than 10,000 inhabitants, showed a significant probability of not having the fluoridation service provision. An ecological study that investigated the association between social and economic indicators at the municipal level and the presence of water fluoridation in 252 municipalities in the state of Santa Catarina, Brazil, in 2000, showed that the municipalities that did not offer fluoridation had a lower number of inhabitants and lowest child development rates<sup>6</sup>.

Research involving 5,558 Brazilian municipalities found that fluoridation provision rates were lower in municipalities with less than 10,000 inhabitants and with low/very low MHDI<sup>4</sup>. The present study corroborates the data in the literature, reinforcing that the service expansion policy should include the specificities of small municipalities and those with medium and low/very low MHDI.

Considering the recent changes in the sector's regulatory framework in Brazil<sup>26</sup>, which expand the possibilities of participation by private companies and give municipalities the right to provide services, the results seem to suggest a complex environment for the expansion of fluoridation in the country. In the present study, the municipalities that had the best results in the provision of fluoridation had its water supply provided by state companies that concentrated greater investment capacity and historical experience in the sector, whereas the lack of access was associated to municipal direct administration and private administration, whether or not combined with public entities. In addition, the economic return that the provision of the service can bring to private companies can make small, low-income municipalities unattractive for private investments<sup>27,28</sup>. Thus, in the same way

that the universalization of water and sewage services will depend, to a large extent, on the satisfactory performance of the regulatory authority<sup>29</sup>, in view of the results presented, the universalization of access to fluorides through the supply water will depend on the presence of this theme on the political agenda of the sector's regulatory activities. For this to be achieved, establishing lines of horizontal and vertical coordination of public policy on the fluoridation of water supply systems is of utmost importance.

The data for present research dates to 2008 and 2010. However, information concerns an activity sector (sanitation) whose changes occur in the medium and long term. The fluoridation situation was obtained with a questionnaire applied by IBGE in the entities that provide sanitation services. Such information does not have another source of data to check its validity. There are data missing from some variables in a very small number of municipalities, which does not imply changes in the observed associations. Regardless of the present limitations, the study stands out for covering practically all the municipalities in Brazil, and for including in the analysis important characteristics of the sanitation companies never investigated before.

## CONCLUSION

The lack of fluoridation provision was independent and positively associated to municipalities in the North, Northeast, Midwest and Southeast macro regions, with coverage rates for water and sewage services below the median value, with less than 10,000 inhabitants and low and medium level/very low human development. It was higher when the service was mainly provided by municipal administrations and private companies, whether or not associated to public entities, regardless of the characteristics of the municipalities.

## REFERENCES

1. Bratthall D, Hänsel-Petersson G, Sundberg H. Reasons for the caries decline: what do the experts believe? *Eur J Oral Sci* 1996; 104(4 Pt 2): 416-22. <https://doi.org/10.1111/j.1600-0722.1996.tb00104.x>
2. British Fluoridation Society. One in a million - the facts about water fluoridation [Internet]. Manchester: British Fluoridation Society; 2012 [acessado em 1º fev. 2019]. Disponível em: <https://www.bfsweb.org/one-in-a-million>
3. Centers for Disease Control and Prevention. Fluoridation Statistics: 2014 [Internet]. U.S. Department of Health & Human Services, National Water Fluoridation Statistics; 2016 [acessado em 1º fev. 2019]. Disponível em: <https://www.cdc.gov/fluoridation/statistics/2014stats.htm>
4. Frazão P, Narvai PC. Water fluoridation in Brazilian cities at the first decade of the 21st century. *Rev Saúde Pública* 2017; 51(47). <https://doi.org/10.1590/s1518-8787.2017051006372>
5. Australian Health Policy Collaboration, Australian Dental Association. Australia's Oral Health Tracker Technical Paper [Internet]. 2018 [acessado em 1º fev. 2019]. Disponível em: <https://www.vu.edu.au/sites/default/files/australias-oral-health-tracker-technical-paper.pdf>
6. Peres MA, Fernandes LS, Peres KG. Inequality of water fluoridation in Southern Brazil — the inverse equity hypothesis revisited. *Soc Sci Med* 2004; 58(6): 1181-9. [https://doi.org/10.1016/s0277-9536\(03\)00289-2](https://doi.org/10.1016/s0277-9536(03)00289-2)
7. Gabardo MC, da Silva WJ, Olandoski M, Moysés ST, Moysés SJ. Inequalities in public water supply fluoridation in Brazil: an ecological study. *BMC Oral Health* 2008; 8: 9. <https://doi.org/10.1186/1472-6831-8-9>
8. Abbott M, Cohen B. Productivity and efficiency in the water industry. *Util Policy* 2009; 17(3-4): 233-44. <https://doi.org/10.1016/j.jup.2009.05.001>

9. Barbosa A, De Lima SC, Brusca I. Governance and efficiency in the Brazilian water utilities: A dynamic analysis in the process of universal access. *Util Policy* 2016; 43(Part A): 82-96. <https://doi.org/10.1016/j.jup.2016.06.013>
10. Beveridge R, Hüesker F, Naumann M. From post-politics to a politics of possibility? Unravelling the privatization of the Berlin Water Company. *Geoforum* 2014; 51: 66-74. <https://doi.org/10.1016/j.geoforum.2013.09.021>
11. Swyngedouw E. Privatising H2O Turning Local Water Into Global Money. *JEP* 2003; 19(4): 10-33. <https://doi.org/10.20446/JEP-2414-3197-19-4-10>
12. Ouda OKM, Al-Waked RF, Alshehri AA. Privatization of water-supply services in Saudi Arabia: A unique experience. *Util Policy* 2014; 31: 107-13. <https://doi.org/10.1016/j.jup.2014.10.003>
13. Brasil. Lei nº 11.445, de 5 de janeiro de 2007. Estabelece diretrizes nacionais para o saneamento básico; e dá outras providências. *Diário Oficial da União* 2007.
14. Antunes JLF, Narvai PC. Políticas de saúde bucal no Brasil e seu impacto sobre as desigualdades em saúde. *Rev Saúde Pública* 2010; 44(2): 360-5. <https://doi.org/10.1590/S0034-89102010005000002>
15. Silva FB, Frazão P. Sanitation utilities and fluoridation of water supply systems: an ecological study in Brazilian municipalities, 2008-2010. *Epidemiol Serv Saúde* 2018; 27(4). <https://doi.org/10.5123/s1679-49742018000400003>
16. Instituto Brasileiro de Geografia e Estatística. Censo Demográfico 2010 [Internet]. Rio de Janeiro: IBGE; 2010 [acessado em 1º fev. 2019]. Disponível em: <https://ww2.ibge.gov.br/home/estatistica/populacao/censo2010/>
17. Instituto Brasileiro de Geografia e Estatística. Pesquisa Nacional de Saneamento Básico: 2008 [Internet]. Rio de Janeiro: IBGE; 2010 [acessado em 1º fev. 2019]. Disponível em: <https://sidra.ibge.gov.br/pesquisa/pnsb/pnsb-2008>
18. Programa das Nações Unidas para o Desenvolvimento. Atlas de Desenvolvimento Humano [Internet]. Programa das Nações Unidas para o Desenvolvimento; 2013 [acessado em 1º fev. 2019]. Disponível em: <http://atlasbrasil.org.br/2013/>
19. Rezende S, Wajnman S, De Carvalho JAM, Heller L. Integrando oferta e demanda de serviços de saneamento: análise hierárquica do panorama urbano brasileiro no ano 2000. *Eng Sanit Ambient* 2007; 12(1): 90-101.
20. StataCorp. Stata Statistical Software: Release 12. College Station: StataCorp LP; 2011.
21. Arretche M. Trajetórias das desigualdades: como o Brasil mudou nos últimos cinquenta anos. São Paulo: Editora Unesp; 2015.
22. Arretche M. Federalismo e igualdade territorial: uma contradição em termos? *Dados* 2010; 53(3): 587-620. <https://doi.org/10.1590/S0011-52582010000300003>
23. Sabbioni G. Efficiency in the Brazilian sanitation sector. *Util Policy* 2008; 16(1): 11-20. <https://doi.org/10.1016/j.jup.2007.06.003>
24. Frazão P, Peres MA, Cury JA. Qualidade da água para consumo humano e concentração de fluoreto. *Rev Saúde Pública* 2011; 45(5): 964-73. <https://doi.org/10.1590/S0034-89102011005000046>
25. Batabyal AK, Chakraborty S. Hydrogeochemistry and water quality index in the assessment of groundwater quality for drinking uses. *WER* 2015; 87(7): 607-17. <https://doi.org/10.2175/106143015X14212658613956>
26. Scriptore JS, Toneto Júnior R. A estrutura de provisão dos serviços de saneamento básico no Brasil: uma análise comparativa do desempenho dos provedores públicos e privados. *Rev Adm Pública* 2012; 46(6): 1479-504. <https://doi.org/10.1590/S0034-76122012000600004>
27. Bakker K. Neoliberal versus postneoliberal water: geographies of privatization and resistance. *Ann Am Assoc Geogr* 2013; 103(2): 253-60. <https://doi.org/10.1080/00045608.2013.756246>
28. Greiner PT. Social drivers of water utility privatization in the United States: An examination of the presence of variegated neoliberal strategies in the water utility sector. *Rur Sociol* 2016; 81(3): 387-406. <https://doi.org/10.1111/ruso.12099>
29. Carvalho AEC, Sampaio LMB. Paths to universalize water and sewage services in Brazil: The role of regulatory authorities in promoting efficient service. *Util Policy* 2015; 34: 1-10. <https://doi.org/10.1016/j.jup.2015.03.001>

Received on: 05/24/2019

Reviewed on: 07/26/2019

Approved on: 08/09/2019

**Contribution of authors:** Silva F. B. e Frazão P. participated in the study's conception and design, in the analysis and interpretation of data, in the writing and critical review of the content, and in the final approval of the version to be published. Both authors declare that they are responsible for all aspects of the work, in order to ensure that issues related to the accuracy or integrity of any of its parts are properly investigated and resolved.

