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Perceptions of environmental health surveillance workers of the independent monitoring of water fluoridation in Espírito Santo, Brazil

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ABSTRACT

This study examines the perception of environmental health surveillance workers regarding the independent monitoring of water fluoridation in Espírito Santo, Brazil. Using a qualitative approach, ten environmental health surveillance workers from nine municipalities of varying population sizes in Espírito Santo were individually interviewed based on a semi-structured script. The interviews were recorded and fully transcribed. Thematic Content Analysis was performed following Bardin. In total, eight respondents reported that independent monitoring of water fluoridation was not being carried out. Training and state support were identified as facilitators of water quality surveillance, whereas the lack of supplies and transportation, work overload, staff turnover, and lack of training on fluoridation and independent monitoring were cited as barriers. Positive perceptions predominated toward water surveillance activities due to their social relevance. Negative perceptions were mainly related to work overload and lack of training, the latter being the most frequent suggestion for improvement. It is concluded that the effectiveness of water fluoridation surveillance depends on the provision of adequate and safe working conditions for monitoring fluoride levels, ensured by health managers, including the implementation of continuing education programs.

Keywords: environmental surveillance, independent monitoring, water fluoridation.

Percepção dos trabalhadores da vigilância sobre o monitoramento independente da fluoretação da água no estado do Espírito Santo, Brasil

RESUMO

A pesquisa objetivou verificar a percepção dos trabalhadores da vigilância em saúde ambiental sobre o heterocontrole da fluoretação da água de abastecimento público no estado do Espírito Santo, Brasil. Neste estudo com abordagem qualitativa, dez trabalhadores da vigilância em saúde ambiental de nove municípios de diferentes portes populacionais do estado do Espírito Santo (Brasil) concederam entrevistas individuais, seguindo um roteiro

semiestruturado, que foram gravadas e transcritas na íntegra. A Análise de Conteúdo Temática foi realizada segundo Bardin. O heterocontrole da fluoretação da água não era realizado por oito entrevistados. As capacitações e o apoio do estado foram facilitadores da vigilância da qualidade da água, enquanto a falta de insumos e transporte, sobrecarga de trabalho, rotatividade de cargo, falta de capacitação sobre fluoretação e seu monitoramento foram dificultadores. Percepções positivas sobre o trabalho de vigilância da água predominaram, dado o seu papel social. Percepções negativas surgiram por sobrecarga de trabalho e falta de capacitação, sendo este a principal sugestão de melhoria no trabalho. Conclui-se que o trabalho de vigilância da fluoretação da água depende de disponibilização de condições laborais adequadas e seguras para desempenhar o monitoramento do parâmetro fluoreto, viabilizadas pelos gestores em saúde, incluindo programas de educação permanente.

Palavras-chave: fluoretação da água, heterocontrole, vigilância ambiental.

1. INTRODUCTION

Water fluoridation in public supply systems is the most important public oral health measure implemented in Brazil (Souza Neto and Frazão, 2020). It is widely recommended by respected health organizations such as the World Health Organization (WHO) and the International Association for Dental Research (IADR) (Frazão and Narvai, 2017) for its role in controlling dental caries and promoting equity in health access, as people from all socioeconomic backgrounds can benefit. Moreover, water fluoridation enables efficient use of financial resources, offering a higher cost-benefit ratio in oral health outcomes for the population (Mariño and Zaror, 2020).

Environmental health surveillance plays an essential role in monitoring public water fluoridation through the process of independent monitoring, defined as "*the principle according to which, if any good or service entails risk or represents a protective factor for public health, then, in addition to the producer's control over production, distribution, and consumption, there must also be control by State institutions*" (Narvai, 2000, p. 388; our translation). Thus, surveillance ensures adequate and safe fluoride levels in drinking water, providing maximum benefit in caries prevention and minimal risk of dental fluorosis (Frazão *et al*., 2018).

In response to the challenges faced by surveillance systems, important legislation and programs have been developed, such as VIGIÁGUA (Brazilian National Program for Surveillance of Drinking Water Quality for Human Consumption) which standardized public supply services and water quality procedures (Frazão *et al*., 2018). To record water quality monitoring data, the Water Quality Surveillance Information System (SISÁGUA) was established (Oliveira Junior *et al*., 2019). Subsequently, the Brazilian National Guidelines for Drinking Water Sampling organized the work of the environmental health surveillance sector, providing guidance on surveillance procedures in accordance with drinking water standards (BRASIL, 2016). More recently, Consolidation Ordinance No. 5 of 2017, Annex XXI, established the "Standards and Guidelines on the Fluoridation of Public Water Supply Systems for Human Consumption" (BRASIL, 2017), later reaffirmed by Ministry of Health Ordinance No. 888 of 2021 (BRASIL, 2021).

Despite these policy efforts, several shortcomings persist in the independent monitoring of water fluoridation. Studies have reported fluoride levels outside the acceptable range (Rosário et al., 2021), long periods without analysis or record of fluoride levels (Campos et al., 2015), the absence of many municipalities from the national registry, and data inconsistencies in SISÁGUA (Frazão et al., 2013). These findings highlight the pressing need to implement or strengthen independent monitoring practices. The lack of prior training for those working in the VIGIÁGUA program, limited knowledge among technical staff regarding the importance of

fluoridation and its independent monitoring, and insufficient familiarity with current legislation (Campos et al., 2015; Kenupp et al., 2025) add to the difficulties faced by surveillance professionals, such as resource shortages and work overload. Together, these factors hinder the effective independent monitoring of water fluoridation.

In this context, the objective of this study was to assess the perceptions of environmental health surveillance workers regarding the independent monitoring of public water supply fluoridation in the state of Espírito Santo, Brazil, in order to reveal local realities and challenges that cannot be captured solely via quantitative data.

2. MATERIAL AND METHODS

This qualitative study investigated the perceptions of environmental health surveillance workers regarding their daily work, technical knowledge, and views on their practices related to the independent monitoring of public water supply fluoridation.

The study population consisted of environmental health surveillance workers who served as technical references for the VIGIÁGUA program in municipalities belonging to the three Health Regions of the State of Espírito Santo—metropolitan, central-northern, and southern (as defined during the methodological planning stage in 2023) (Espírito Santo, 2020). In total, three technical references were selected from each Health Region—one from a small municipality (Category I), one from a small-to-medium municipality (Category II), and one from a large municipality—totaling nine municipalities. The municipalities were randomly selected using the "Sorteio.com" website. In addition, one technician from the Regional VIGIÁGUA Laboratory was included to provide a more comprehensive understanding of water fluoridation surveillance, resulting in a total of ten participants. This initial sampling strategy sought to ensure greater heterogeneity among participants by encompassing the diverse population contexts of the municipalities. However, during the interviews, an adequate level of information saturation was achieved, as evidenced by the recurrence of similar statements among participants. Therefore, the inclusion of additional participants was deemed unnecessary.

Inclusion criteria involved municipalities with environmental health surveillance workers participating in the VIGIÁGUA program and available for interview. Workers who declined to discuss their work routines or refused to sign the informed consent form would have been excluded; however, no exclusions occurred among the selected municipalities. To recruit participants, the municipal secretary of environmental surveillance in each municipality was contacted using information available online on municipal websites. Subsequently, the technical references of the Vigiágua Program in the selected municipalities were contacted.

Interviews were conducted from September 2024 to January 2025, in the local language, Brazilian Portuguese, and, after the completion of data collection, all statements were translated using a certified official translation service. Individual interviews were held via the Google Meet online platform or in person (according to each participant's convenience and availability), using a semi-structured interview script. The interview guide was developed based on a pilot study conducted in a previous investigation, in which an interview was carried out with a technical reference for the VIGIÁGUA program from a large municipality in the State of Espírito Santo, demonstrating adequate understanding of the questions used. The script included open-ended questions addressing topics such as entry into the surveillance sector; length of participation in the VIGIÁGUA program; prior and subsequent training; knowledge of the VIGIÁGUA program; understanding of water fluoridation, its risks, and benefits; existence and importance of independent monitoring of water fluoridation in the municipality; facilitators and barriers to independent monitoring; experiences of working in the program; and suggestions for program improvement. Interviews were recorded using the "Voice Memos" app on an *iPhone X* and fully transcribed via the high-quality transcription platform "Turboscribe."

A single interviewer conducted all interviews, having received methodological training

during the academic master's program and being guided by qualitative research methods reported in the scientific literature. To this end, the interviewer conducted the interviews using clear and accessible language, following a basic itinerary: presentation of the researcher, explanation of the study's object of interest and the motivations for conducting it, justification for the selection of participants, assurance of confidentiality and anonymity, and the interview itself. The conversation was conducted in a manner that did not involve expressing opinions or inducing responses. All support provided to participants was clarified in the informed consent form and, accordingly, one participant requested a review of their interview, which was granted, and part of the interview transcript was subsequently excluded.

Data analysis followed the Thematic Content Analysis approach proposed by Laurence Bardin (Bardin, 1977), carried out in three stages: pre-analysis; exploration of the material; and treatment of results, inference, and interpretation. In the pre-analysis stage, an initial understanding of the collected material was achieved through exhaustive reading, aiming to obtain an overall view of the content and its particularities. At this stage, the theoretical concepts guiding the analysis were defined, along with the forms of message classification (excerpts or phrases from the discourses) and the assumptions for their interpretation. During the exploration of the material, the analysis itself was conducted, in which the messages were classified using the MAXQDA software. In this phase, the messages were organized according to the classification developed in the previous stage, and their core meanings were identified through inference. Broader thematic axes were then established based on the relationships among these core meanings, and text segments were grouped around these themes during the writing process. Additionally, the analytical process was subjected to peer debriefing conducted by two academic supervisors with experience in qualitative research, during the coding and thematic development phases, contributing to the refinement of analytical categories and achieving consensus on the final analytical framework. Thematic analysis concluded with an interpretive synthesis connecting the emergent themes to the study's objectives and assumptions (Minayo *et al.*, 2007). This qualitative approach enabled an in-depth understanding of the topic within the Brazilian context.

To ensure the methodological rigor and trustworthiness of this study, criteria widely recognized in qualitative research were adopted, including credibility, transferability, confirmability, and dependability (Lincoln and Guba, 1985). Credibility was achieved through systematic analysis of the empirical material, with exhaustive reading of the interviews and the application of previously defined criteria for data extraction and interpretation. Consistency was also maintained between the research objectives, the theoretical framework, and the methodological procedures employed. To enhance transferability, a detailed description of the research context, participants, and analytical procedures was provided, allowing other researchers to assess the applicability of the findings to similar contexts. Regarding confirmability, systematic records of the analytical process were maintained, as well as documentation of the criteria used for data categorization and interpretation, ensuring transparency and enabling the traceability of the evidence supporting the findings. Dependability was ensured using a previously defined analytical protocol, which guided all stages of data collection and analysis, contributing to the consistency, stability, and coherence of the research process.

The study received authorization from the Espírito Santo State Health Department (SESA) (approval code 2024-P386X7) and ethical approval from the Research Ethics Committee of the Health Sciences Center of the Federal University of Espírito Santo (UFES) (CAAE 81246824.1.0000.5060). All participants signed an informed consent form.

3. RESULTS AND DISCUSSION

We found that nine participants were municipal employees, and one was a state employee from the Regional VIGIÁGUA Laboratory. All had joined the Environmental Health Surveillance Division through public examinations or selective recruitment processes. A total of six participants held undergraduate degrees, two of whom also had postgraduate qualifications, whereas the remaining participants had technical training. In total, five professionals reported working in the VIGIÁGUA program for up to two years, four had between seven and twelve years of experience, and one had served as the municipality's technical reference for more than twenty years. For confidentiality, participants are referred to by letters A through J instead of their names.

From the thematic content analysis of the interviews, two main themes emerged, corresponding to the study's objectives: "The practice of independent monitoring of water fluoridation" and "Qualification for the work".

3.1. The practice of independent monitoring of water fluoridation

The main finding of this study was the absence of independent monitoring of public water supply fluoridation, reported by eight of the ten technical references of the VIGIÁGUA program, who also demonstrated limited awareness of the mandatory nature of this procedure within drinking water quality surveillance.

> "(...) This analysis is not currently performed within the VIGIÁGUA program." (Participant A)

> "(...) Fluoride? Well, in our municipality we're only conducting microbiological and turbidity tests, as the regional laboratory provides those." (Participant D)

> "(...) No, not by me—only by [the water supply company]." (Participant F)

The indication that independent monitoring of water fluoridation is not being performed in municipalities in the state of Espírito Santo was also observed by Mendonça *et al.* (2021), who reported the absence of recorded fluoride levels in the SISÁGUA database for 79.5% of municipalities in 2017. Similarly, a documentary review of technical reports from the Brazilian Ministry of Health from 1997 to 2017 revealed that fluoride was not among the parameters prioritized for the surveillance of drinking water quality during that period (Sanchez *et al*., 2021).

These findings suggest that technical guidelines provided to workers in the VIGIÁGUA program may still follow outdated standards. However, Ministry of Health Ordinance No. 888 of 2021 clarifies that all fluoridation standards set forth in Consolidation Ordinance No. 5 of 2017, Annex XXI, must be followed by surveillance authorities (BRASIL, 2021).

Only two municipalities reported monitoring the fluoride parameter and mentioned all stages of planning, material selection, and operational procedures established by the Brazilian National Guidelines for Drinking Water Sampling (BRASIL, 2016). One of these municipalities, although aware of the existence of these procedures, did not carry out the actions following the verification of the test reports, failing to continue with activities such as the inspection of unsatisfactory results, guidance for corrective measures, and recollection of samples to obtain adequate results. Therefore, the assurance of optimal fluoride levels in drinking water may not be ensured through the practice of independent monitoring of fluoridation due to a lack of adjustments to inconsistent data.

> "(…) So, when it comes, for example, to a system that has treatment, due to lack of training, I don't know what to do. (…) We went through a period (…) when

> the turbidity of the samples was high. And then I didn't know what to do (…), and in those samples in which turbidity, you know, was high, fluoride was too." (Participant B)

Although the technical representatives of these two municipalities monitored the fluoride parameter in treated water, they did not do so for springs or artesian wells located in rural areas of the municipality, as in the Alternative Collective Solution for the Supply of Drinking Water (SAC) and the Alternative Individual Solution for the Supply of Drinking Water (SAI) (BRASIL, 2021).

> "(…) Yes, we do analyses, but not for fluoride. (…) Because there's no water treatment. It's raw water. The way it's captured, it's distributed." (Participant B)

The interviewees were unaware that fluoride is a chemical component naturally present in surface or groundwater sources (Narvai, 2000), and therefore did not assume that fluoride could naturally occur at a preexisting concentration or even in excess in the water. When the concentration exceeds 1.5 mg/L, the excess fluoride should be removed, as in some localities the naturally occurring concentration may be very high, posing a risk of dental fluorosis in children (Frazão *et al*., 2013).

Some environmental health surveillance workers demonstrated a lack of understanding of the surveillance duties, stating that the independent monitoring of fluoridation might not be carried out by the municipalities since the water supplier itself provides its analysis data, or that it should instead be conducted by the sanitary surveillance sector (outside the scope of the VIGIÁGUA program).

The lack of distinction between "control" and "surveillance" of water quality was observed among some surveillance professionals. Water quality control (conducted by the water supply service providers) differs from surveillance in terms of institutional responsibility, operational approach, geographical coverage, sampling frequency and number, and use of results, although both share similarities in planning and implementation (BRASIL, 2018).

In the text of Consolidation Ordinance No. 5 of 2017, Annex XX, which addresses water potability, the information on the surveillance of fluoride levels in water is not clearly stated. It mostly used the term "control" for this parameter, giving the impression of a regulation aimed at the water producer, and only cited the maximum allowable fluoride concentration of 1.5 mg/L (BRASIL, 2017). According to one interviewee, the water production company always claimed compliance with this regulation, even when questioned by the surveillance sector. However, Ministry of Health Ordinance No. 888 of 2021 amended Consolidation Ordinance No. 5, assigning to the municipal health departments the responsibility for water quality surveillance as established in Annex XXI of the latter ordinance, in line with the VIGIÁGUA program and the Brazilian National Guidelines for Drinking Water Sampling, emphasizing surveillance actions, including independent monitoring of water fluoridation, which may have previously been secondary (BRASIL, 2021).

Although most surveillance workers reported not performing the independent monitoring of fluoride, they showed commitment to the VIGIÁGUA program, and many recognized the importance of monitoring this parameter, pointing out various facilitating and hindering factors.

State support was among the most frequently mentioned facilitators for water quality monitoring. Seven interviewees expressed strong perceptions of support from the other Health Regions for any need or question during their daily work routine, as well as easy access to state technical references.

> "(…) So, every time a new demand arises, they're always there with us; the

> superintendency, the lab staff." (Participant A)

The Laboratory Environment Management System (GAL) and the Information System for the Surveillance of Drinking Water Quality for Human Consumption (SISÁGUA) platforms were mentioned as easy and efficient tools in the work process. Only one interviewee considered that "SISÁGUA itself is a very complex program," although it did not pose a difficulty to their work.

> "(…) The system is easy. It's not difficult. It's very good. It gives all the right information." (Participant C)

> "(…) And even the systems we use, like GAL. I think it works very well. It's a program that works very well." (Participant G)

Through these platforms, workers can enter data from their work at all stages, establishing continuity from the planning phase of water collection to the final dissemination of independent monitoring results. The reported complexity may be related to the volume of data involved. The systematization of information seems to favor water surveillance work and communication among VIGIÁGUA program representatives, regional laboratories, and the population served by the public water supply. Moreover, such information is used to manage health risks, support the development of public policies in environmental health related to drinking water consumption, and characterize water quality to identify vulnerabilities and guide decision-making by managers (Oliveira Júnior *et al*., 2019).

Another facilitating factor for water surveillance was familiarity with local residents in smaller municipalities, reported by two interviewees. This familiarity made access to the designated sampling locations easier.

> "(…) Because we already know things here; the local businesses, the neighborhoods." (Participant H)

On the other hand, several barriers were identified in the independent monitoring of water fluoridation. Structural difficulties were cited, such as the lack of laboratory space, shortages of supplies (equipment operation, reagents), and inadequate transport of samples. Short timeframes, long distances, and high in-vehicle temperatures for transporting water samples to laboratories were also mentioned, reinforcing these logistical barriers. The lack of logistical and transportation resources has commonly been identified as a hindrance in the work processes of the Brazilian Unified Health System (SUS) (Cunha *et al*., 2023). Overall, the precarious infrastructure for conducting independent monitoring of fluoridation by surveillance workers may reflect the absence of a more effective state-level work plan prioritizing the surveillance of fluoride in public water supplies to ensure the adequacy of this public health measure in preventing dental caries.

> "(…) It's happened that I've done all the collections and then, on that day, there was no car to take them, and I lost all the samples that had been collected." (Participant D)

In addition, seven participants reported lack of personnel and work overload.

> "(…) So, as a small municipality, we do a bit of everything, you know? In my case, I'm currently partly in coordination, and I also do fieldwork. There are other types of work at certain times, not only VIGIÁGUA. VIGIÁGUA is usually once a month, plus other related activities when needed. We do everything here." (Participant E)

The working relationships established between municipal technical reference professionals, their regional managers, and laboratory technical supervisors—especially for obtaining more technical information—although contributing to the work, may not be sufficient for it to be effective at the municipal level. The shortage of staff in environmental health surveillance teams leads to the development of multitasking professionals who end up taking responsibility for monitoring a wide range of health hazards. This situation may hinder activities related to water surveillance, as workers in some municipalities may experience work overload within the surveillance sector (Mendonça et al., 2021).

Job turnover was also mentioned in one interview, attributing the loss of institutional knowledge within the sector to the dismissal of surveillance employees. This issue may be associated with a lack of job stability, stemming from the precarization of health work. Following the decentralization of the SUS, as defined in the 1988 Brazilian Constitution, surveillance practices were transferred from the state to the municipal level. Consequently, the organization of health work became subject to low professional qualification, high job turnover, work overload, and unprotected contractual arrangements (Viana *et al.*, 2018; Silva *et al*., 2021). These factors directly interfere with the disorganization of water surveillance activities, as workers lack adequate and safe conditions to perform monitoring of the fluoride parameter.

Considering that all Health Regions were included in our study, the absence of independent monitoring of public water supply fluoridation was predominantly reported in municipalities outside the Metropolitan Health Region. Mendonça *et al.* (2021) found that municipalities in Espírito Santo with larger populations and higher Gross Domestic Product (GDP) per capita had greater availability of information on fluoride, which may be related to better infrastructure and organization within water surveillance. Smaller or less urbanized municipalities throughout Brazil are more impacted by underinvestment in public policies (Sanchez *et al*., 2021), and the profile of municipalities in the state of Espírito Santo is predominantly small, comprising about 84% of all municipalities (IBGE, 2022).

A study analyzing the degree of implementation of water quality surveillance activities regarding the fluoride parameter across different Brazilian states classified Espírito Santo as being at an advanced level of implementation, ranking higher than 20 other federative states. This classification was based on data from semi-structured interviews conducted during the national research project Vigifluor ("Coverage and Surveillance of Public Water Supply Fluoridation in Brazil"), conducted from 2010 to 2015 (Sanchez *et al.*, 2021). However, this finding does not reflect the reality of many municipalities in the state, suggesting the need for more coordinated actions by environmental health surveillance managers, particularly in smaller and lower-income municipalities.

Even amid numerous barriers to independent monitoring of water fluoridation, workers' perceptions—understood as processes of extracting information through the reception, assimilation, and use of knowledge (Rodrigues *et al*., 2012)—were predominantly positive regarding water surveillance work. According to Nunes *et al*. (2019), the meanings and significance of work arise from workers' understanding of their professional activity through experience and perception. Nevertheless, fluoridation is still not widely perceived as a factor of oral health protection for the population or as an element that enhances water quality.

3.2. Qualification for the work

Technical knowledge is an essential tool for water surveillance work, being closely linked to compliance with various regulations and the execution of specific operational procedures (Belotti *et al*., 2019). Initial training for participation in the VIGIÁGUA program was mentioned by eight interviewees, lasting from one to five days. Two other participants reported receiving no initial technical training, having only been instructed by previous employees or having sought information independently in the legislation. Moreover, seven interviewees

stated that they had participated in training sessions for the VIGIÁGUA program during their time in the surveillance sector.

> "(…) Well, they usually hold, on average, three or four training sessions a year. (…) Just like the one that's about to happen now—how to operate the GAL system, how to use the SISÁGUA program, how to collect water samples, you know, how to use the colorimeter to measure chlorine." (Participant F)

In total, three other workers reported receiving no subsequent training. A professional stated: "(...) No, there wasn't; only that initial training. We've actually been requesting other training sessions." (Participant E). Although the training programs mentioned by workers positively contribute to water surveillance, these educational processes proved insufficient, as they did not cover several aspects related to the independent monitoring of water fluoridation.

Professional qualification via continuing education programs tends to focus on individual professional development, in which standards and concepts are presented for workers' assimilation, leading to work that is disconnected from management and social participation, failing to enhance performance within the public institution (Oliveira *et al*., 2024). In many cases, technical reference professionals were found to perform only the tasks immediately available to them, remaining alienated from the work process. This fragmentation prevents professionals from perceiving how their individual contributions fit into the broader system of water quality surveillance. Several studies describe worker participation in work processes as "the only way to improve the quality of health work" (Viana *et al.*, 2018; our translation).

Although most municipalities offered some form of training (either initial or continuing education), in none of the interviews did initial training address the fluoride parameter as part of the process of monitoring water quality for human consumption. Training generally focused on the use of data recording systems, fieldwork, and water sample collection, revealing a mechanistic and minimally participatory approach.

> "(…) Specific to fluoridation? No, not specific to fluoridation." (Participant G)

> "(…) So, I was only shown how to collect samples; the rest I had to learn by myself. Since then, no professional courses or training have been offered. (...) Out of curiosity, I went looking for information myself. I found some inspection guides that address fluoridation. But, like, if the level is too high or too low, I don't know what to do because of the lack of training." (Participant B)

A study on work process management within the SUS linked the absence of specific training and professional gaps to lower work effectiveness, associating the technical capacity of health professionals to operate, systematize, and analyze data with the effective use of information for planning and monitoring activities in the work process (Cunha *et al*., 2023). Due to the lack of technical training, deficiencies in knowledge among water surveillance workers regarding fluoridation and its independent monitoring were observed in municipalities of various sizes across all Health Regions. This reflects limited public sector concern for water fluoridation surveillance and, consequently, a general neglect of this public oral health measure with the greatest preventive potential against dental caries. Previous studies conducted in Espírito Santo have also reported the same knowledge gaps among water surveillance workers in municipalities of the metropolitan region (Campos *et al*., 2015; Kenupp *et al*., 2025).

Only two interviewees demonstrated knowledge of legislation related to the fluoride parameter—one mentioned the ideal concentration for their municipality, and the other mentioned the maximum allowable concentration. All others were unable to specify the fluoride ion concentration that should be present in public water supplies.

> "(…) There's the ordinance that says it should vary from 0.6 to 0.8 milligrams per liter. (...) Consolidation No. 5, of September 28, 2017." (Participant B)

> "(…) Our ordinance—that's what we follow. It comes from the Ministry of Health, from LACEN with the results, and most of the time, since fluoride can't exceed 1.5, it's always low, it's okay, it's satisfactory." (Participant G)

Lack of awareness of legislative updates regarding fluoride levels in public water supplies may directly affect the quality of the water provided to the population, as adjustment of this parameter's concentration is essential. Very low fluoride levels in water (below 0.6 mg/L) are insufficient to provide anticary benefits (Sanchez *et al*., 2021), and therefore surveillance should not focus solely on compliance with the maximum allowable value. Conversely, a maximum fluoride concentration of 1.5 mg/L is acceptable primarily for naturally fluoridated water. However, in the case of fluoride added during water treatment processes, it is unnecessary to exceed the optimal concentration of 0.9 mg F/L (Frazão *et al*., 2013), as recommended by Ordinance No. 888/2021 of the Brazilian Ministry of Health, which establishes fluoride concentration limits based on the average maximum daily temperatures of Brazilian municipalities (BRASIL, 2021).

The interviewees also demonstrated superficial or limited knowledge of the benefits and risks associated with water fluoridation, and all expressed a desire to receive more information on the topic. The benefit of consuming fluoridated water was most frequently described as "tooth protection." Regarding the risks of excessive fluoride intake, one participant mentioned the appearance of "stains" on teeth. Several statements, however, revealed conceptual misunderstandings, citing risks such as "tooth weakening" and "tooth loss."

> "(…) So, I only know superficially that it can cause problems related to bones, right? And to teeth, right? Their structure. It can make them weak, fragile, and even lead to tooth loss when fluoride is absent, right? And when it's excessive, it can cause those little white stains. Also superficial." (Participant A)

> "(…) because it prevents cavities. So, it's this dosage that we have to monitor, which I think is also important to avoid that whole issue of weakening the teeth." (Participant G)

> "(…) They said it was to prevent cavities, but I know it's not that effective." (Participant I)

The lack of training on water fluoridation is reflected in the limited understanding of its importance as a preventive health measure, reinforcing the technical nature of water surveillance practices (Kenupp *et al*., 2025). The workers are unaware of the substantial public health benefits that can be achieved through their professional actions by ensuring proper fluoride levels that prevent oral health problems and reduce public expenditures (Mariño and Zaror, 2020). A study analyzing the cost-effectiveness of removing fluoride from public water supplies in the United States developed a model simulating oral health data for individuals aged 0–19 years included in the US National Health and Nutrition Examination Survey. The study demonstrated that discontinuing water fluoridation would result in a 7.5% increase in cases of decayed teeth—equivalent to 25.4 million cases—at a cost of 9.8 billion dollars over five years, leading to a significant rise in public spending and primarily affecting the oral health of children without access to private dental care (Choi and Simon, 2025).

Fluoridated water was also described as "not that effective" in preventing dental caries, a view associated with media reports of alleged "health harms," which have increased significantly due to their rapid spread in digital environments. Many cross-sectional studies

have been cited to support claims about the harmful effects of fluoride ingestion on human health, based on associations that do not establish causal relationships (Cury et al., 2019). However, a large-scale population study estimated lifetime exposure to fluoridated water during participants' first five years of life to assess potential effects on cognitive neurodevelopment. The study provided strong evidence against a cause–effect relationship and reaffirmed the reliability of water fluoridation as a preventive oral health measure (Do et al., 2025).

Given this context, in which more consistent professional training is needed, Continuing Education in Health constitutes the most appropriate strategy for developing and strengthening health professionals' skills (BRASIL, 2004) via collaborative practices across sectors and among health managers (BRASIL, 2014). Learning for work takes place in and through work, fostering collective reflection on the surveillance process, which can be transformed based on the real needs of workers (Rodrigues *et al*., 2021).

Continuing education programs can aid raise issues relevant to surveillance professionals according to their work routines, differing from the training sessions typical of traditional continuing education, in which the topics addressed do not always reflect the municipalities' actual needs (Pantoja *et al.*, 2020). The problematization of the complex reality of work takes place via active methodologies, enabling workers to gain a deeper understanding of their professional experiences and fostering awareness of the importance of commitment to their work (Campos *et al.*, 2017). Thus, knowledge, skills, and attitudes interact, enabling individuals to become protagonists of their work and agents of institutional transformation (Oliveira *et al*., 2024).

Moreover, the responsibility for educational processes related to surveillance work has often been attributed to the state level, while municipalities have not taken part in meeting workers' training needs. This reveals a lack of professional development programs at the municipal level, which would be better aligned with the realities faced by water surveillance professionals (Silva *et al*., 2021).

Negative perceptions were reported regarding the lack of training. The absence of information about the independent monitoring of fluoridation led to a sense of disorientation, as participants were unable to provide any information on the topic when asked during the interview. On the other hand, the interview process encouraged participants to raise questions about the subject, which had previously gone unnoticed in their daily work.

> "(…) So, I don't know how that would be done, right, because it depends on that, how it would be done. (…) I have no idea how this process of [independent monitoring of] fluoridation by the city government would work." (Participant F)

Given the importance of access to education for health work, this was identified by workers as the main suggestion for improving the VIGIÁGUA program, reinforcing their interest in professional development, including training, education, and participation in work processes (Viana *et al.*, 2018).

> "(…) Ah, I'd like to have more training, you know? A lot more." (Participant H)

As a result of the lack of training, one participant suggested reducing the frequency of water quality monitoring to every two months, which raises questions about the role of surveillance as a public health-promoting body.

As a limitation of this study, since most interviews were conducted remotely after participants signed an informed consent form, it is possible that they had searched for information about water fluoridation or about their work in the VIGIÁGUA program beforehand. In addition, the lack of in-person interaction may have limited the collection of

more detailed information from participants. On the other hand, this study is original in that it investigated the reality of independent monitoring surveillance of public water supply fluoridation in municipalities of different population sizes across all Health Regions of the state, revealing diverse contexts and encouraging improvements and the implementation of water fluoridation monitoring processes.

4. CONCLUSIONS

This study concludes that, although the absence of independent monitoring of water fluoridation predominates among the participating municipalities, environmental health surveillance workers demonstrated commitment to the VIGIÁGUA program. However, these workers lack the adequate and safe conditions necessary to monitor fluoride levels, which could be overcome via better coordinated actions by environmental health surveillance managers. The absence of independent monitoring of public water fluoridation can deeply impact the population's oral health, increasing the risk of dental caries when appropriate fluoride levels cannot be ensured, especially among socially vulnerable individuals without regular access to dental services.

The need for independent monitoring of water fluoridation was recognized by workers as being closely related to the availability of training and education. Our findings highlight the importance of professional development through continuing education programs as an effective alternative to address the educational deficiencies identified in this study. In this way, water surveillance can become more effective, ensuring that fluoridation remains a key component of water quality.

5. DATA AVAILABILITY STATEMENT

Data availability not informed.

6. REFERENCES

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