

Diego Antônio Menegasse Velásquez

**Dental fluorosis: a review of a multidisciplinary project
performed in Northern Minas Gerais, Brazil**

Universidade Fernando Pessoa

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Trabalho apresentado à Universidade Fernando Pessoa como parte dos requisitos para
obtenção do grau de Mestre em Medicina Dentária.

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Abstract

The objective of this dissertation is to describe and critically evaluate the multidisciplinary scientific work developed in Northern Minas Gerais with regards to diagnosis, treatment and prevention of endemic dental fluorosis. This bibliographic review was based on the research of scientific articles from the following platforms: MEDLINE, PubMed and BIREME. In the mentioned zone, dental fluorosis was detected, and geological investigations on the possible causes were performed. Immediate solutions like dental restorations were undertaken, improving people's social lives. From a preventive perspective, informative actions were undertaken and a defluoridation methodology was created and tested in order to improve water treatment and reduce dental fluorosis incidence. The interdisciplinary methodology between dentistry and geology was crucial to improve life quality on communities affected by dental fluorosis in Northern Minas Gerais. This project is an example of how the scientific investigation contributes to the community development.

Keywords: fluorosis, fluoride, endemic fluorosis, dental fluorosis.

Resumo

O objetivo desta dissertação é descrever e avaliar criticamente o trabalho científico multidisciplinar desenvolvido no norte de Minas Gerais em relação ao diagnóstico, tratamento e prevenção da fluorose dentária endêmica. Esta revisão bibliográfica baseou-se numa pesquisa de artigos científicos nas seguintes plataformas: MEDLINE, PubMed e BIREME. Na região referida foi detectada fluorose dentária e realizaram-se investigações geológicas sobre suas possíveis causas. Foram tomadas resoluções imediatas, como restaurações dentárias, melhorando aspetos da vida social dos locais. De uma perspectiva preventiva, ações informativas foram efetuadas e uma técnica de defluoretação foi criada e testada para melhorar o tratamento da água e diminuir a incidência de fluorose dentária. A metodologia interdisciplinar entre a medicina dentária e a geologia foi crucial para melhorar a qualidade de vida nas comunidades afetadas pela fluorose dentária no Norte de Minas Gerais. Este projeto é um exemplo de como a investigação científica contribui para o desenvolvimento comunitário.

Palavras-chave: fluorose, flúor, fluorose endêmica, fluorose dentária.

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I. Introduction

Fluoride can be found in many different places in the environment such as water, soil and volcanic ashes (Ferreira et al., 2010; Linhares et al., 2018). It may cause either positive or negative impact in humans' life depending on the amount ingested. In lower concentrations, up to 1.5 mg/L, it is known as an anticariogenic factor (Santa-Rosa et al., 2014), and for this reason countries such as United States, Brazil, Australia and United Kingdom add artificial fluoride in the water treatment. On the other hand, epidemiological studies have shown the negative impact in the health of populations that overconsume this mineral, namely dental, skeleton and non-skeleton fluorosis (Shruthi and Anil, 2018).

Dental fluorosis (DF) is characterised by hypomineralised enamel lesions caused by continuous ingestion of high fluoride doses during dental formation, which in severe cases can lead to consequences as anatomical deformities (Castilho et al., 2015). Therefore, and also considering that dental formation begins in prenatal period, it is expected that children would be more vulnerable to DF (Jheon et al., 2013).

The recommended limits of fluoride for human consumption vary according to its source and the climate. The World Health Organization (WHO) states that the maximum concentration of fluoride for drinking water should be 1.5 mg/L for natural fluoride occurrence and 0.5 mg/L to 1.0 mg/L for artificial fluoridation. Maximum daily temperature of the air also plays an important role in fluoride intake, because it is related to the average volume of water taken by the respective population (WHO, 2017).

When fluorosis manifests endemically, the main source of fluoride is usually the groundwater supply, which is affected by dissolution of fluoride minerals present in the aquifer framework. That may be caused by dissolution of fluorite present on calcareous rocks (Ferreira et al., 2010) or volcanic rocks rich in fluorides (Dehbandi et al., 2018).

DF is one of the most important signs of ingestion of a high fluoride quantity, even though it's a late measure. Therefore, places with high prevalence of DF indicate a high and prolonged fluoride intake through water or nourishment (Idon and Enabulele, 2018). This fact is exemplified by studies that have pointed out a significant association between a high fluoride concentration in water for human consumption and the prevalence of the disease (Wang et al., 2012). A prevalence of 11.3 to 100% of DF is observed in areas where fluoride concentration exceeds the value recommended by the WHO (Rango et al., 2012; Dehbandi et

al., 2018; Idon and Enabulele, 2018).

Endemic fluorosis is a public health and a global eco-toxicological problem reported in many different countries in the world such as Brazil, Argentina, Mexico, India, and China. Worldwide, it is estimated that 200 million people consume drinking water with a fluoride level above WHO guidelines (Dehbandi et al., 2018). In Brazil, since this issue was detected in the northern region of Minas Gerais state, research groups from School of Dentistry and Department of Geology from *Universidade Federal de Minas Gerais* (UFMG – Federal University of Minas Gerais) have developed several scientific studies in the region, to reduce the damage caused to the affected people and try to point out preventive solutions.

1.1. Objective

The aim of this dissertation is to review, describe and critically evaluate a multidisciplinary scientific project developed in the northern region of Minas Gerais state with regards to diagnosis, treatment and prevention of endemic fluorosis.

1.2. Method

This review was based on the research of scientific articles from the following platforms: MEDLINE, PubMed and BIREME. Articles in Portuguese, Spanish and English were selected, and the keywords used were fluorosis, fluoride, endemic fluorosis, dental fluorosis, aesthetic restorative treatment, direct veneers, microabrasion, water treatment, defluoridation, psychological impairment. Additionally, sites of public institutions were consulted in the internet. All the articles related to the above-mentioned project were also included.

II. Dental fluorosis

2.1. Aspects and severity of dental fluorosis

Clinically, mild to moderate DF manifests as thin and white opaque lines distributed in different levels over enamel surface. On the other hand, more severe presentations of the disease manifest as complete enamel opacification, presenting porous black and brownish stains (Idon and Enabulele, 2018) (figure 1, annex). From the pathologic aspect, even though

DF is more commonly associated with aesthetic implications rather than functional, it may cause the teeth to become more likely to suffer from pitting, leading to dentine exposure and consequently hypersensitivity, in more severe cases (Tonguc, 2011).

DF has different clinical manifestations, and its severity varies according to factors such as quantity and duration of fluoride consumption, diet, age, nutritional status and use of substances containing fluoride. Thus, similar doses of fluoride intake may cause different clinical aspects in individuals (Dehbandi et al., 2018).

One of most often employed DF measures is the Thylstrup and Fejerskov (TF) Index (Thylstrup and Fejerskov, 1978), very useful for epidemiological studies of endemic DF. It is a rating system based on the clinical appearance of the disease with scores ranging from 0 to 9, allowing classification from the mildest to the most severe clinical presentation. The score 0 represents normal enamel translucency, while the scores 1 to 4 denote increasing degrees of opacity and 5 to 9 loss of outermost enamel (Adelário, 2010) (figure 1, annex).

2.2. Fluorosis worldwide

Endemic fluorosis is a public health problem that can be found in many countries and alarms the respective national authorities for its negative impact on people's life. China and India, the two most populous countries in the world, have serious problems with fluorosis (Dai et al., 2007). For instance, in Rajasthan, India, the prevalence of skeleton fluorosis is considerably high (32.8-39%) (Choubisa, 2001). In China, a national cross-sectional study with large representative samples indicates that prevalence of DF rates 50.44% in children aged 8-12 years old in drinking-water supply areas that are no fluoride-safe (Wang et al., 2012). In USA, it is estimated that about 23% of children have mild or severe fluorosis (Kravchenko et al., 2014). In Africa, this issue can be found throughout the east side of the Rift Valley, including Tanzania (Jarvis et al., 2013) and Ethiopian districts of Fentale, Alaba and Adamitulu, with DF prevalences in school age children of 70%, 93% and 93.7%, respectively (Kebede et al., 2016). Furthermore, in Latin America this disorder was largely described too. In Mexico, many regions such as Aguascalientes, Chihuahua, Salamanca and Durango are reported to have excess of fluoride in potable water (Hurtado-Jimenez and Gardea-Torresdey, 2005). In those high-risk areas, prevalence of DF is about 60% (García-Pérez, 2013). In Sampacho, Argentina, an epidemiological survey was performed that detected a DF prevalence of 52% for deciduous dentition and 78% in permanent teeth in scholars (Azcurra, et al., 1995). In Brazil, this problem is also well described. In Cocal district, Santa Catarina state, an

epidemiologic survey was carried out which indicates that 87% of scholar children who consume water with high fluoride concentration present moderate to severe DF (Castilho et al., 2015). In Nova Venécia, Espírito Santo state, it was found a prevalence of 100% for DF (with a predominance of TF index score 2) among examined schoolchildren that live in the area (n=27) (Carvalho et al., 2011).

III. Dental fluorosis in Northern Minas Gerais, Brazil

The municipalities of São Francisco and Verdelândia, located in the northern region of Minas Gerais (figure 2, annex), are between the poorest zones of this state and their socioeconomic context is aggravated by the lack of surface water availability and water resources management. In São Francisco there are approximately 54,000 inhabitants, 36.5% of which live in rural area, and Human Development Index (HDI) is 0.68, lower than the state average (Santa-Rosa et al., 2014). At the municipality headquarters, water supply is carried out by *Companhia de Saneamento de Minas Gerais* (COPASA – Sanitation Company of Minas Gerais) through surface water sources. On the other hand, in the rural area water supply comes from the underground and the municipality is responsible for its distribution. In Verdelândia municipality there are approximately 8,000 inhabitants (IBGE, 2007) and HDI is 0.60 (PNUD Brasil, 2000).

The whole zone is affected by long periods of droughts due to semi-arid to sub-humid climate, and from the 1970's deep tubular wells were opened to improve water supply to rural areas. From this period, cases of DF began to be reported, however, without gaining much repercussion by the political authorities. The first organ to detect endemic fluorosis and assess water fluoride content in the area was *Fundação Nacional da Saúde* (FUNASA – National Health Foundation). The local Secretary of Health even declared they were making an effort in educating population to only use well's water for cleaning purposes rather than drinking, but nothing much else was done (Castilho et al., 2010).

Thus, research groups in the fields of dentistry and geology from UFMG started to perform an investigation in the municipalities of São Francisco and Verdelândia to study endemic DF occurrence and assess fluoride concentrations in the groundwater in the area. In São Francisco municipality, epidemiological oral health surveys were performed in the rural communities of Mocambo, Vaqueta and Novo Horizonte in 2002, and Barreiro dos Anjicos, Brejo dos

Anjicos and Furado Grande in 2007. In 2005, the same study was carried out in Amargoso district, located in Verdelândia municipality. The control district was Retiro, in which COPASA was in charge of water treatment (Velásquez et al., 2010). Lifelong residents between 6 and 22 years old constituted the selected sample. These age limits were chosen because of the change in dentition, which starts to occur around 6 years old, and because individuals above 22 may not have been exposed to excessive fluoride ingestion from deep wells during dental formation. As a result, it was found a prevalence of 80.4% of DF in the examined people. In order to evaluate the severity of the disease, it was used the TF Index and 48.9% of individuals presented what is considered severe DF ($TF \geq 5$) (Velásquez et al., 2010). Moreover, it was excluded any other alternative source of fluorides that could possibly increase prevalence or severity of DF. In the control district, DF was not found (Ferreira et al., 2010, Velásquez et al., 2010).

A hydrogeological study was also performed concomitantly to the epidemiological survey. A sampling campaign of deep wells water in the area was carried out and mineralogical identification of the aquiferous calcareous rocks was performed. The average for fluoride concentration in the districts studied is approximately 3 mg/L. Furado Grande presents the lowest fluoride content (1.4 mg/L) and Amargoso the highest (4.8 mg/L). In the control district of Retiro, concentration is low (0.2 mg/L), and this is probably the reason why no DF has been found in this area (Ferreira et al., 2010).

3.1. Psychosocial implications

Oral health problems may cause significant psychosocial well-being impact on population (WHO, 2017). DF not only affects dental health but also results in constraints due to the damage on the smile aesthetics. Thus, it is crucial to measure the effects of this disease and its treatment in the social and psychological aspects, and how it may alter children's life quality (Cunha and Tomita, 2006).

Castilho et al. (2009) performed a qualitative study on perception towards endemic DF in which 23 adolescents and 14 schoolteachers of the city of São Francisco, Minas Gerais, were interviewed face-to-face. The objective of this study was to describe how severe fluorosis affects self-esteem of adolescents and young people of São Francisco area. Adolescents reported feeling embarrassed to smile as they were usually mistreated and suffered from bullying and guilt. DF causes embarrassment because it is wrongly associated with lack of hygiene, and consequently some interviewees reported problems with early romantic

relationships. Their opinions were similar, and no relevant differences were found with regards to age and gender. Schoolteachers enhanced this social behaviour, pointing out problems like lack of spontaneity, shyness, inhibition, quietness, sadness and embarrassment. According to them, students with DF covered face with hands and smiled with lips closed, avoided smiling, didn't like to get their picture taken and avoided school activities and speaking with classmates. One child even declared, "... *I think I missed out on moments of happiness because I couldn't smile more joyfully*" (Castilho et al., 2009).

3.2. Care measures

i. Educational approach

Misperception of DF causes is widespread among locals in Northern Minas Gerais, including teachers and those responsible for formal education of children and young people. They showed themselves confused about the role of fluoride in the anomaly, indicating lack of scientific knowledge about this subject. The population identified water rich in carbonates (which can be seen and tasted due to turbidity and salinity) as causers of DF, teeth damage, kidney stones and even cancer, rather than fluorides in underground water (Castilho et al., 2010).

Therefore, the first measure undertaken in order to deal with the problem was to develop an extension project responsible for spreading scientific knowledge about the issue. Researchers from the Dentistry School and the Department of Geology of UFMG carried out a multidisciplinary educational approach in Brejo dos Anjicos, one of the districts highly affected by endemic fluorosis in Northern Minas Gerais. The goals of community education were to provide scientific based information to the population carrying the disease, educators and health managers about DF associations with the area's geo-environmental context and consequences of the disease. In addition, they also aimed contribute to the teaching process in schools, making people aware that DF can be prevented. Geologic knowledge was not part of basic education in the area, so when the population had to face a problem related to a geological factor, they did not understand what they were dealing with. Fantinel and Colleagues (2013) developed ludic educational activities and workshops such as interactive exposition in schools using several didactic materials about local environment and health. This community educational approach was a crucial step to bring to locals the notion that DF in Northern Minas Gerais is an endemic rather than a personal problem and to get the population to work actively as a community against DF. Furthermore, it brought researchers

closer to the social and cultural reality of the affected community and provided mutual establishment of trust and collaboration. All these factors cooperated to disseminate the project goals and to obtain local access (Fantinel et al., 2013).

ii. Preventive solution

As a prophylactic solution, the prefecture of São Francisco municipality, in collaboration with FUNASA, the first group to assess fluorides and DF in the area, built an alternative water distribution network in Mocambo district, with water captured from a nearby dam. However, this water was untreated and presented turbid appearance, especially on rainy days. Due to this aspect, the change on the water supply source did not solve the problem for local residents as they refused to consume this water. Even with an alternative water supply, residents still used the old wells with high fluoride content, until 2006, when wells from Mocambo district were finally sealed (Castilho et al., 2009).

iii. Direct aesthetic restorative treatment

In 2009, dentists from Dentistry School of UFMG attempted to soften the negative impact of DF by performing aesthetic restorative treatment on locals, recovering their smile and consequently improving their social lives (Santa-Rosa et al., 2014). The target population was constituted by residents of the districts from municipality of São Francisco affected by moderate to severe DF with aesthetic impairment. The dental treatment included direct resin veneers (figure 3, annex) and/or microabrasion of only anterior teeth, as they constitute the most significant elements of the smile aesthetic. Besides that, posterior teeth would require a much more complex treatment, which was not practical for the proposed work due to time, travel and resources needed. The restorative treatments were performed by a dental surgeon trained according to adequate protocols for direct resin veneers (Iório, 1999) and microabrasion (Mondelli et al., 1995). The greater the damage on teeth and aesthetic impairment, the greater indications for direct veneers (Santa-Rosa et al., 2014).

After the restorative intervention, Santa-Rosa and colleagues (2014) carried out a study on the effects of the dental treatments. In total, 57 subjects were interviewed, with a median age of 16 years old, and most of them were students (77.2%). Two trained researchers performed the interviews in two different occasions: the first (baseline) was carried out before the dental intervention and the second (follow-up) 24 months later. To assess functional and psychosocial impacts of DF, it was used the short version of the Oral Health Impact Profile (OHIP) questionnaire, which evaluates seven conceptual dimensions: functional limitation,

pain, psychological discomfort, physical inability, psychological inability, social inability and disability (Slade, 1997).

As a result, two years after performing the aesthetic procedures significant improvement was achieved in prevalence, severity and extent of functional and psychological impairment caused by DF. The prevalence of functional and psychosocial impact reduced from 43.9% at baseline, to 11.9% at follow-up.

iv. Water treatment

Water quality is a subject of major concern once humanity depends on it to exist. Water for human consumption must be free of chemical and biological contamination. In zones like the Northern Minas Gerais, scarce of water resources, the main alternative to prevent fluorosis is to treat the available water, removing the excess of fluoride by a process named defluoridation. Currently, there are different defluoridation techniques, which can be broadly classified as precipitation, adsorption, ion exchange and miscellaneous (Ingle et al., 2014).

In an attempt to reduce fluoride concentration from water of deep wells in Northern Minas Gerais as propose sanitation alternatives to improve drinking water quality, the *Centro de Desenvolvimento de Tecnologia Nuclear de Minas Gerais* (CDTN - Center of Nuclear Technology Development of Minas Gerais) developed a new defluoridation method: the Domestic Defluoridation Filter System (DDFS). The DDFS consists in adsorbent microspheres of activated alumina-coal composite, sized for domestic use and it is composed by 3 units: on the top there is a 30 L container for water with high fluoride content, and on the bottom one smaller container inside a larger one. The inner 8 L recipient holds the adsorbent spheres and the bigger one, with a capacity of 55 L, contains the filtered water. Drummond and colleagues (2014) performed an experimental study to test the system effectiveness. The filters were installed in 4 residences with a total of 20 individuals of different ages (from 2 to 59 years old), all from the same rural community of São Francisco. Samples of tap (control) and filtered water were collected for 22 weeks, along with urine of the subjects (urine is the major excretion route for ingested fluoride), aiming to assess human exposure to fluoride. As a result, DDFS reduced significantly fluoride concentration from 2.56 mg/L (initial fluoride concentration) to 1.5 mg/L or less for a period from 5 to 9 weeks, during the 22 weeks of the study. After this period, saturation of activated alumina-coal composite spheres occurred, meaning that they must be frequently replaced to maintain optimum fluoride level. Therefore, it was concluded that DDFS system is efficient in reducing high fluoride content from wells'

water for approximately 30 days (Drummond et al., 2014).

IV. Discussion

Long periods of droughts and depletion of surface water sources in a disadvantaged socioeconomic context lead to an increased demand of alternative water resources, usually from deep wells. Underground water is one of the most abundant sources of fluoride, once the bedrocks are the prime source of this mineral (Dehbandi et al., 2018). Thus, the districts located in the North of Minas Gerais, affected by all of these factors, became a target for scientific investigation due to emergence of endemic DF.

As a result of the hydrogeological research to quantify fluoride content in well's water, Velásquez and colleagues (2010) have found fluoride concentrations higher than 1.5 mg/L in most of the studied districts in Northern Minas Gerais. Amargoso, which is the studied place with highest fluoride content (4.8 mg/L), presents a concentration 6 times higher than the maximum recommended level for this area.

Furado Grande is the only exception, presenting a concentration lower than the limit proposed by the WHO (WHO, 2017). However, the concentration in this zone is still above the defined value on Brazilian legislation (0.8 mg/L) (Brasil, Ministério da Saúde, 1975), considering climatic characteristics. Limits are variable according to the climate because it is assumed that warmer and drier places increase water consumption needs, and then locals would consume more water than who live in a cooler environment.

DF has different clinical presentations depending on its severity and most of the studies on the disease have found a positive statistical association between water's fluoride concentration and DF severity (Acharya, 2005; Carvalho et al., 2011 and Majumdar and Sundarraj, 2013). The studies mentioned concluded that the prevalence and severity of DF are directly related to the quantity of ingested fluoride, age of exposure and duration of consumption. This reinforces WHO's guidelines for drinking-water quality, which point out that skeleton fluorosis (a more severe presentation of the disease) is highly associated with the consumption of water with a fluoride content above 6 mg/L (WHO, 2017).

On the other hand, Ferreira and his colleagues (2010) did not find an association between fluoride concentration and DF severity. This might have occurred because many individuals have heterogeneous exposures to distinct wells throughout life, as fluoride in the water supply

is highly variable in this region and they could have had access to uncontaminated water during dental formation. As an example, in 1995, one of the wells of Mocambo (São Francisco municipality) was sealed and then people in this rural community stopped consuming water with a high fluoride level, which reduced exposure for those living there (Ferreira et al., 2010).

DF severity may also be an aggravating factor for dental cavities prevalence. Costa and colleagues (2013) performed a study in Northern Minas Gerais with those who consumed water with high fluoride content during dental formation, in order to study association between prevalence of dental caries and DF severity. In total, 511 individuals between 7 and 22 years old were examined and they were classified according to the Decayed/Missing/Filled Teeth (DMFT) and TF index. It was found a statistically significant positive association ($p < 0.01$) between the prevalence of dental caries and more severe DF among those up to 12 years old. Thus, the authors concluded that severe fluorosis is likely to increase susceptibility to dental caries, probably due to pores on dental surface, which causes erosion of friable enamel. Likewise, Carvalho et al. (2011) and Taghipour et al. (2016) also have found a positive association between DMFT and severe DF.

Considering the psychological disturbances that DF may cause on those carrying the disease, Castilho and colleagues (2009) interviewed adolescents with DF in São Francisco, Minas Gerais, and identified high self-esteem impairment on them. Another study with similar results on the aesthetic self-perception of schoolchildren regarding DF was performed in Pereira Barreto, Brazil (Silva et al., 2001), where it was found a fluoride content of up to 20 mg/L in the water and the mean fluoride concentration was 1.3 mg/L (Uchoa and Saliba, 1971). Among interviewed children with DF, 70% of them reported relationship problems because of the disease, which highlights its negative impact on young people.

In contrast, Lima and his colleagues (2014) have found an unexpected result. Their study, performed in Teresina, Brazil, has shown a very little or no impact of DF on oral health, and consequently it did not affect children's quality of life. However, this probably occurred because DF on 80.3% of the children in this study was mild or very mild (80.3%), whilst most of the interviewed children in Castilho and colleagues' study (2009) presented severe DF. In fact, Michel-Crosato et al. (2005) and Chankanka et al. (2010) concluded that mild DF has a very little effect on people's life quality, which explains the differences in these outcomes.

In parallel to psychosocial disturbances, DF is also associated to dental caries, as suggested by Costa and colleagues (2013). They found a positive statistical association between DF

severity and susceptibility to dental caries in children up to 12 years old. The study from Taghipour and colleagues (2016) corroborates this result, showing a correlation between the DF severity and the number of dental cavities in children. This association between severe DF and caries is probably because DF makes the teeth more porous, which increases the capability of the biofilm to adhere onto dental surface, hindering its removal (Costa et al. 2013). However, it is important to point out that caries is a multifactorial chronic disease that presents many influencing factors such as nutritional habits, socioeconomic status and culture, so DF should not be taken as the only factor for dental caries.

To prevent people from drinking fluoride-contaminated water, it was built an alternative water distribution network in Mocambo district (Castilho et al., 2009). This was a convenient attempt to change water consumption habits, but it was not effective because the water of the alternative network did not have a satisfactory physical appearance, once it did not go through any treatment process. Castilho and colleagues (2009) identified a misperception on causes and consequences of DF among students and local educators and then it was foreseeable that residents would deny drinking from this water source. A treatment of this water, such as a chemical one, would precipitate solid particles in suspension, improving water's appearance (FUNASA, 2014), and then population would consume water from this better quality alternative source rather than fluoride rich water.

The correct knowledge is essential to fight endemic fluorosis through preventive actions and then promote health. Skills' development, services' reorientation and adoption of new public health policies are important for health promotion (Sheiham and Moysés, 2000), and prevention of diseases includes actions undertaken towards the population in order to avoid disease emergence and reduce its prevalence (Czeresnia, 2003). Piranha and Carneiro (2009) even suggest a better education on Earth Sciences as an important strategy to form informed citizens. Thus, the formative measure undertaken by Fantinel and colleagues (2013) had a great importance to Brejo dos Anjicos. They elucidated and provided scientific knowledge on endemic fluorosis to the population through an interdisciplinary method, using an appropriated language for each group (schoolchildren and adults). Therefore, this educational approach undertaken in Northern Minas Gerais also contributed to a change in the educational process in schools of this community, contributing to the community development and improving life quality.

When fluorosis affects teeth during dental formation, it leads to lifelong sequels because teeth enamel cannot be healed. Therefore, the most appropriate alternative to soften the

impairments caused by DF is through a restorative treatment. When a restorative dental treatment needs to be performed, the kind of procedure carried out must be chosen very carefully by the professional, based on factors such as available work time, severity of the disease, material quality, durability and patient's socioeconomic condition. The main treatment options for DF are direct composite resins veneers, indirect ceramic veneers and microabrasion (for mild severity cases). Direct composite resin restorations can be performed in a single appointment, using few materials, and can provide an appropriate natural look, usually resulting in satisfied patients (Mesko et al., 2016). On the other hand, indirect restorations such as ceramic veneers also present a very satisfactory result, but require a higher level of secondary attention, especially for prosthetic procedures. Ceramic veneers require laboratorial steps, which increase considerably the treatment cost, more appointments, and a higher technological density when compared to resin veneers. Studies have shown that there seem to be a little difference between direct and indirect restorations for DF treatment in terms of aspect and longevity when they are performed with high quality material and by an experienced professional (Muts et al., 2014). However, it is important to emphasize that both procedures have its specific indications and contraindications, and they must be taken into consideration before choosing the best treatment alternative.

According to Korkut (2018), direct composite veneer restoration is one of the most preferred treatments for aesthetic restorations of anterior teeth because of its long-lasting functional aspect and aesthetic success, especially in young patients. Considering these factors and the main purpose of the project developed in Northern Minas Gerais, the direct resins veneers and microabrasion performed by Santa-Rosa and colleagues (2014) was convenient in terms of costs and benefits, meeting directly the need of the population: restoration of the smile aesthetics. This choice was practical because these techniques could be executed outside the dental office using mobile equipment and in one single appointment. These treatments presented a satisfactory and immediate result with a relatively low cost, considering the socioeconomic context of the area. As a complement, it would be interesting to carry out a follow-up study to assess the longevity and long-term quality of the veneers made in 2009, 10 years after the procedures.

Santa-Rosa and her colleagues (2014) also assessed the psychological improvements due to the treatment on those who received it. A significant reduction on the impairments were observed after 2 years and this result corroborates the findings of Cangussu et al. (2002) and Castilho et al. (2009) that moderate to severe DF causes dissatisfaction with self-appearance,

social exclusion and low self-esteem. Severe DF in Northern Minas Gerais contributed to the exclusion of a whole generation of young people by damaging their health and life quality. This clinical approach had a great social importance due to its contribution in reducing the disease negative impact, giving to the benefited the opportunity of social inclusion. Santa-Rosa and colleagues' study (2014) also proved that direct dental restoration and microabrasion are an appropriate and low-cost alternatives to reestablish smile aesthetics, leading to an improvement on people's social life. This fact contrasts with the idea that associates more expensive and complex treatments to a higher quality, which contributes to financial barriers to dental treatments' access for those who have a poorer economic context. Furthermore, from a broader aspect, this clinical approach has also enabled the training of community health workers with regards to dealing with consequences of DF. Thereby, they can act as multipliers of information and clarify population on how to deal with fluorosis peculiarities.

In United Kingdom, Rodd and his colleagues (2011) also performed a study on implications of aesthetic procedures using microabrasion and composite restoration in children with enamel defects. Likewise, it was given a questionnaire about how they felt before and after the procedure. In the enquiry performed previous to the treatment, more than a half, out of 63 subjects, reported being a target of unkind remarks about their teeth by their peers, results that are similar with the obtained in young people affected by DF in São Francisco, Minas Gerais (Castilho et al., 2009). Following the treatment, children felt generally more positive, happier and confident. This study, together with the Santa-Rosa and colleagues (2014) one, highlights the life changing power of a restorative aesthetic dental treatment and how it can provide a better life quality.

On the other hand, preventing fluorosis is the best alternative, especially because there is no cure for the most severe form of the disease, which is the skeleton fluorosis. Thus, offering fluoride safe water to the population is the most appropriate action to fight fluorosis. Considering the extensive number of different methodologies available in the market, Fernandes and colleagues (2006) developed a study aiming to determine the most appropriate and efficient low-cost domestic technique, and they tested different defluoridation agents such as activated alumina, bone charcoal, resins of ion exchange, aluminium sulphate and calcined silica. The authors concluded that most of the methods present a satisfactory result and bone charcoal offers the best cost-performance ratio. This study approved the usage of all the tested materials for water defluoridation in terms of effectivity and affordability (Fernandes et al.,

2006).

Taking into consideration the low socioeconomic level of the population and the water shortage in São Francisco rural area, defluoridation of the water in a residential setting was a very convenient alternative in Northern Minas Gerais to prevent the disease. Likewise, in a population of rural India, inserted in a similar environmental and social context to the one of the Northern Minas Gerais, activated alumina is also used in a domestic setting to remove fluoride from drinking water, a project supported by UNICEF (Renuka and Pushpanjali, 2013). Fernandes et al. (2006) and Ingle et al. (2014) described the advantages of the traditional adsorption technique using activated alumina, such as its low cost and capacity for removal of up to 90% of the fluoride content, but also pointed out its limitations, including exhaustion of activated alumina, need of skilled operative personnel and high dependence on a specific pH range (5.0 to 6.0). The residential method developed by CDTN to control fluoride content in Minas Gerais (Drummond et al., 2014) overcame some of these limitations by simplifying the technical process, making it more practical, but there is still space for improvement. Therefore, more studies are necessary to delay the saturation of alumina microspheres, making longer-lasting filters, which will benefit regions inserted in a context similar to São Francisco.

It has been observed the existence of many different and effective methods for water defluoridation, and each one with their advantages and disadvantages, as pointed out by Fernandes et al. (2006) and Ingle et al. (2014). Therefore, it does not exist a best alternative, but the most suitable for each context, local conditions, financial resources and available materials. Some systems can be particular to a certain zone, which means that the method used in one place may not meet the requirements for another.

V. Conclusion

Even though it does not increase mortality, fluorosis is a major public health issue with functional, social and psychological negative implications. The interdisciplinary methodology applied in the described project performed in Northern Minas Gerais was crucial to improve life quality in the districts affected by DF, once knowledge in both dentistry and geology is essential to fight this endemic. This multidisciplinary project is a great example of how scientific development may contribute to a community development and promotes health,

taking into consideration economic and social factors. Briefly, DF was detected, immediate solutions were pointed out and restorations were performed on those with DF, improving their social lives. In long-term, from a preventive aspect, informative actions about DF were undertaken and defluoridation methodology tested in order to diminish DF incidence and improve water management for future generations. Besides improving life quality for locals, the research work also contributed to the educational process in the area, which is one of the most important aspects to be successful in actions to fight this endemic.

To conclude, much has been done so far through this pioneering project, but there is still much to do in order to eradicate this endemic in Minas Gerais. There is a great range of available and affordable alternatives to correct water fluoride content, thus the existence of this anomaly has no further justification. Therefore, it is suggested a political, financial and scientific movement to apply what was studied so far and promote health for current and future generations, both in Brazil and other countries, through prophylactic actions and treatment of the existing cases. In addition, it is also suggested an improvement in education concerning fluorosis, especially in areas where it occurs, and an encouragement of the population to actively participate in the preventive measures against this disease.

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VII. Annex

7.1. Figures



Figure 1. Dental fluorosis in a child in Mocambo district - TF index 7. (Reproduced with permission from Velásquez et al., 2010).

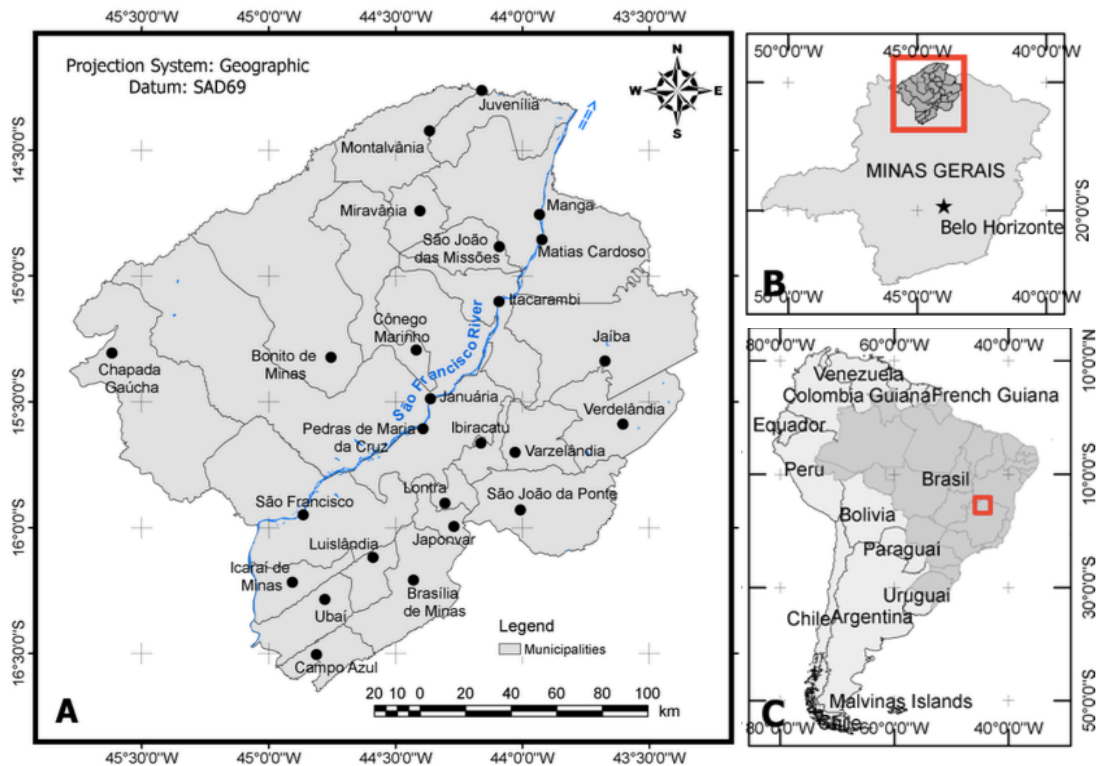


Figure 2. Maps showing (A) São Francisco and Verdelândia municipalities; (B) the North region of Minas Gerais, where the referred municipalities are located; (C) the location of Minas Gerais in Brazil. (Reproduced and adapted with permission from Ferreira et al., 2010).

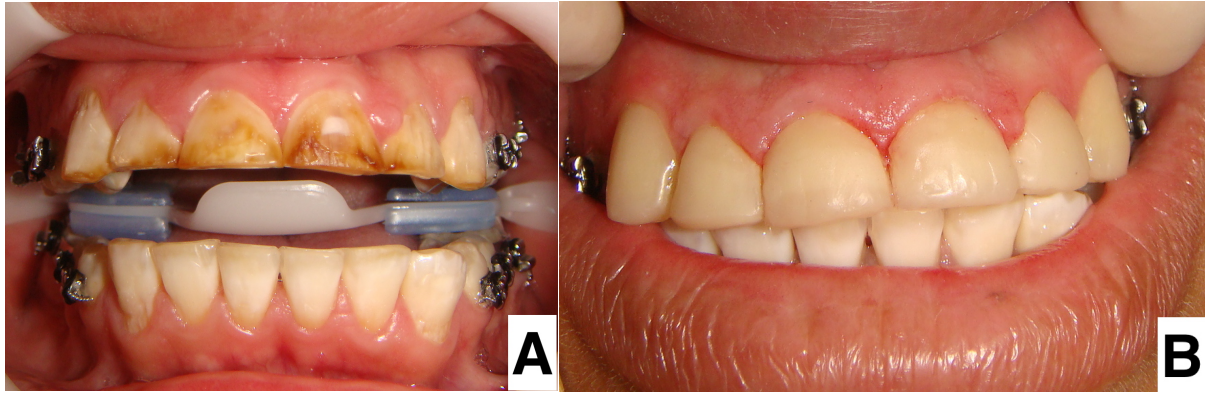
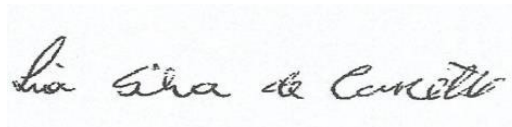


Figure 3. Teeth with severe fluorosis treated with direct resin aesthetic veneers: A – before procedure; B – immediately after procedure. (Courtesy of Prof. Dr. Cláudia S. Magalhães).

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Belo Horizonte, 24 de Junho de 2019

Prof.^a Dr.^a Lia Silva de Castilho

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