Assessing the Effect of Fluoride on Oral Health Status among the General Population Residing in High and Low Fluoride Blocks in Namakkal District, Tamilnadu, India: A Cross-Sectional Study

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Abstract:

Aim: The aim of this study is to assess the effect of fluoride on oral health status among the general population residing in high and low levels of fluoride blocks in Namakkal district of Tamilnadu, India.

Materials and method:A cross-sectional study was conducted to assess the impact of fluoride on oral health among people of WHO index age groups residing in the Namakkal district of Tamilnadu, India. The sample size was estimated to be 600based on the multistage random sampling method. A pre-tested structured questionnaire was used to collect the demographic data and oral hygiene practices of the people. Oral Health Assessment form, WHO proforma 2013 (Adult and children) was used for assessing Dental caries and Enamel fluorosis.

Results: The prevalence of enamel fluorosis in high fluoride block Paramathi is 77.0%, and Kabilar malai is 75.0%. The prevalence of dental caries in high fluoride block Paramathi is 58.0%, and high fluoride block Kabilar malai is 58.0%. The prevalence of enamel fluorosis in low fluoride block Mohanur is 68.0%, and low fluoride block Sendamangalam is 62.0%. The prevalence of dental caries in low fluoride block Mohanur is 87.0%, and low fluoride block Sendamangalam is 89.0%.As per the study results, the prevalence of enamel fluorosis is high in high fluoride blocks, and the dental caries prevalence is high in low fluoride blocks.

Conclusion: Public health awareness should be given by the public health officials of the community to the people about the harmful and beneficial effects of Fluoride.
Keywords: Fluoride, oral health, dental caries, Namakkal, Tamilnadu and water.

Introduction:

Oral health is one of the most imperative parts for the maintenance of general health. Improper oral hygiene may affect the oral health of people in many ways such as dental caries, gingivitis, clinical attachment loss, periodontal diseases, etc[1]. Dental caries, periodontitis and oral cancer are the most prevalent public health issue in worldwide especially in developing countries like India the oral health problems still continues to be a major burden among the population. There is no existing proper evidence was available for the rapid increase of epidemiology of oral diseases among the people in India since the available studies were not performed based on the generalization of the population [2].

The etiology of oral diseases is multifactorial; to maintain good oral hygiene, the daily nourishment of dietary intake in the form of proteins, carbohydrates and minerals are essential. The oral health in general has a strong association between diet, nutritional intake and overall health with many correlating factors. The deficiency of adequate nutrition intake can have a great impact on the oral health of people. The oral health problems such as alteration of taste includes bitter and metallic taste, increased salivation, difficulty in swallowing and mastication are the major symptoms occurs due to nutritional deficiencies. the reduction secretion of saliva can cause pain and difficulty during swallowing and mastication [3,4].

The micronutrient plays an essential role in maintaining the structural integrity of the oral tissues. Water is the major source for the supply of essential micronutrients into the human body. The fluoride was found to be effective against dental caries by various mechanism. The fluoride reacts with saliva and dental plaque by reducing the process of demineralization and enhancing the remineralization cycle which thereby acts as a healing process in inhibiting the formation of dental caries. Moreover, fluoride interferes with the glycolysis, the factor which is responsible for the cariogenic bacteria to produce the formation of acid. Various studies suggested that ingestion of fluoride during the tooth development period makes the tooth more resistant to dental caries formation [5].

Tamilnadu is one of the states in India which had the highest prevalence of many oral diseases, especially dental caries and periodontal diseases. The overall prevalence of dental caries in Tamilnadu was found to be 63.9% [6], and 50% of them had gingivitis, whereas 36% of the people in Tamilnadu had a prevalence of periodontal diseases [7,8]. According to Central groundwater board Ministry of water resources Government of India, Namakkal district of Tamilnadu has the highest fluoride content which was above the permissible limit in water [9]. The World Health Organization reported that the permissible limit of fluoride should be 1.5 mg/l was considered to be optimal.

The two parent articles taken for this study, among that one study conducted by Karunakaran et al. in the year 2008 [10] as per this article, the Mohanur block is considered a low fluoride block in the Namakkal district, and similar to that also the study conducted by Samson et al. in the year 2011[11] Sendamangalam block considered a low fluoride block in the Namakkal district.

The fluoride is also a compound that naturally occurs in the water when it is present in optimal level; it has a protective action against dental caries; if it was beyond the optimal level it can lead to dental fluorosis and makes the tooth more prone for demineralization. The objective of this study was to evaluate the concentration of fluoride in groundwater residing in high and low-fluoride blocks in the Namakkal district and also to assess the impact on oral health status among the general population residing in high and low-level blocks in the Namakkal district.

Materials and method:

A cross-sectional study was conducted to assess the impact of fluoride on oral health among people residing in the Namakkal district of Tamilnadu, India. The objective of this study was

to evaluate the concentration of fluoride in groundwater residing in high and low-fluoride blocks in the Namakkal district and also to assess the impact on oral health status among the general population residing in high and low-level blocks in the Namakkal district. The duration of study was conducted for a period of Sixteen months from May 2021- September 2022 until the desired samples of subjects were obtained for the study. The study was done among the general public of index age groups 5, 12, 15, 35-44, and 65-74 years who reside in high and low levels of fluoride content areas in the Namakkal district of Tamilnadu, India. The ethical permission was obtained with ethical approval number SRMDC/IRB/2020/MDS/No.702 from the institutional review board of SRM Dental College, Ramapuram, Chennai. The aim and methodology of the study were explained to the patients, and the written informed consent form was obtained from the subjects who participated in the study.

1.Inclusion criteria:

- Those who were permanent residents from birth.
- Those who were present on that day of examination.
- Those who fall under index age groups, i.e., 5 years, 12 years, 15 years, 35-44 years, 65-74 years.
- Those who were using primary sources of water from well, tap and borewell.

2.Exclusion criteria:

- The source of drinking water is not from primary sources.
- Those had migrated from other places.
- The teeth which were not fully erupted and fractured teeth.
- Those who were wearing orthodontic brackets.
- Those who have a consumption of fluoride tablets.

The sample size was calculated using G*power, a study done by Alireza Heidari et al. 2019 [12], which was taken as the parent article for sample size calculation. The alpha error was 0.05 and the power (1- β err prob)- 0.95. The final sample size obtained was 600, which were equally divided into two groups based on the high and low levels of fluoride (300 samples) content of water in the Namakkal district. The subjects of index age groups residing in high and low fluoride water content areas of Namakkal district were recruited based on a multistage random sampling method using the table of random numbers. The armamentarium used for the examination is a mouth mirror, explorer, cotton rolls, cotton holder, kidney trays, disposable gloves and masks. The investigator was adequately trained to record the oral health status among people residing in the Namakkal district of Tamil Nadu, India. Intra-examiner reliability was evaluated using kappa statistics in which the outcome was satisfied (0.84). The study protocol and the purpose of the study were properly explained to the study participants, and then the written informed consent form was distributed to the participants. The patients who were willing to participate in the study and fulfilled the consent form were recruited for the study. The water samples were collected from various sources, such as well, bore well and tap water in the Namakkal district. The water samples were randomly collected from the people residing in high and low fluoride blocks in the Namakkal district. In each block, 20 water samples were collected from house to house. The 250ml of water was stored in a polyethylene bottle from each source, and the concentration of fluoride content in the water was estimated.A pre-tested structured questionnaire obtained from Shanthi et al. in the year 2014 [13] was used to record the demographic data and oral hygiene practices of the people. The first part of the questionnaire consists of demographic data such as age, sex, socio-economic status and source of drinking water. The second part of the questionnaire consists of data regarding oral hygiene practices, which includes materials used for brushing, duration and frequency of brushing, type of device used for brushing. The third part of the questionnaire consists of lifestyle and dietary habits such as intake of fluoride tablets, usage of fluoride toothpaste, family history of dental fluorosis. The dataset was subdivided, distributed and presented as tables. To analyse the data SPSS (IBM SPSS Statistics for Windows, Version 26.0, Armonk, NY: IBM Corp. Released 2019) is used. The Normality tests, Kolmogorov-Smirnov and Shapiro-Wilks tests results revealed that the data

follows normal distribution. Chi-square test was applied to find the statistical significance between high and low iron-fluoride blocks, gender differences, and prevalence of dental caries and enamel fluorosis in the fluoride blocks. Significance level is fixed as 5% ($\alpha = 0.05$). P-value <0.05 is considered to be statistically significant.

Results:

Table 1: Water quality analysis of high fluoride blocks in the drinking water according to the central ground water board (CGWB) ministry of water resources and the mean value of the fluoride levels obtained from this study analysis

According to CGWB - High Fluoride blocks	Fluoride levels based on Central ground water board Ministry of water resources (ppm)	Fluoride levels obtained from the current study analysis Mean (ppm) and SD
Paramathi	1.54	1.04 (0.323)
Kabilar Malai	1.80	0.89 (0.404)

Table 1 represents the presence of High Fluoride in the drinking water according to the Central Ground Water Board Ministry of Water Resources and the fluoride levels obtained from the present study analysis of fluoride blocks, i.e., Paramathi (1.04) and Kabilar malai (0.89). There is a decline in the fluoride levels of present study analysis compared to the Central Ground Water Board Ministry of Water Resources.

Table 2: Water quality analysis of low fluoride blocks in the drinking water according to the Karunakaran et al in the year 2009 and Samson et al in the year 2011; and the mean value of the fluoride levels obtained from this study analysis

According to Karunakaran et al (2009) and Samson et al (2011) – Low Fluoride blocks	Fluoride levels based on the Karunakaran et al in the year 2009 and Samson et al in the year 2011 (ppm)	Fluoride levels obtained from the current study analysis Mean (ppm) and SD
Mohanur	0.5	1.03(0.403)
Sendamangalam	0.6	0.59(0.159)

Table 2 represents the fluoride levels of low fluoride blocks according to the Karunakaran et al in the year 2009 and Samson et al in the year 2011; and the fluoride levels obtained from the present study analysis. There is an increase in the fluoride level in the present study (i.e., Mohanur block) but there were no changes in fluoride level in the present study (i.e., Sendamangalam block).

Table 3: Prevalence of dental caries in high fluoride blocks according to current study finding

According to CGWB - High Fluoride blocks	Dental caries present % (n)	Optimum fluoride levels obtained from the current study analysis mean (ppm)
Paramathi	38.7(58)	1.04
Kabilar Malai	38.7(58)	0.89

Table 3 depicts the prevalence of dental caries in the current finding fluoride blocks in which Paramathi has 38.7%, and Kabilar malai has 38.7% of dental caries prevalence.

Table 4: Prevalence of dental caries in low fluoride blocks according to current study finding

According to Karunakaran et al (2009) and Samson et al (2011) – Low Fluoride blocks	Dental caries present %(n)	Optimum fluoride levels obtained from the current study analysis mean (ppm)
Mohanur	58.0 (87)	1.03
Sendamangalam	59.3 (89)	0.59

Table 4 depicts the prevalence of dental caries in the current finding fluoride blocks, whereas Mohanur has 58.0% and Sendamangalam has 59.3% of dental caries prevalence.

Table 5: Prevalence of enamel fluorosis in high fluoride blocks according to current study finding

According to CGWB - High Fluoride blocks	No abnormal condition %(n)	Questionable %(n)	Very mild %(n)	Mild %(n)	Moderate %(n)	Severe %(n)
Paramathi	**48.7(73)**	**0.0(0)**	**10.0(15)**	**16.7(25)**	**13.3(20)**	**11.3(17)**
Kabilar Malai	**50.0(75)**	**0.0(0)**	**11.3(17)**	**14.0(21)**	**12.7(19)**	**12.0(18)**

Table 5 represents the prevalence of enamel fluorosis in high-fluoride blocks. A severe form of fluorosis in the current finding of Paramathi and Mohanur block is 11.3% and 12.0%, respectively.

Table 6: Prevalence of enamel fluorosis in low fluoride blocks according to current study finding

According to Karunakaran et al (2009) and Samson et al (2011) – Low Fluoride blocks	No abnormal condition%(n)	Questionable %(n)	Very mild %(n)	Mild %(n)	Moderate %(n)	Severe %(n)
Mohanur	54.7(82)	10.7(16)	22.0(33)	10.0(15)	2.7(4)	0.0(0)
Sendamangalam	56.7(85)	14.0(21)	16.7(25)	10.7(16)	0.0(0)	0.0(0)

Table 6 represents the prevalence of enamel fluorosis in the current finding of fluoride blocks. The high prevalence was found in very mild fluorosis, whereas Mohanur has 33% and Sendamangalam has 25%

Table 7: Gender differences in the prevalence of dental caries

Gender	Dental caries present %(n)	p-value
Male	46.7 (140)	**0.184**
Female	50.7 (152)	

Table 7 represents the prevalence of dental caries in males and females, whereas the female has the highest prevalence of dental caries (50.7%). There is no statistically significant difference (p-value=0.184) was found between males and females for the prevalence of dental caries.

Table 8: Gender differences in the prevalence of enamel fluorosis

Gender	Normal % (n)	Questionable % (n)	Very Mild % (n)	Mild % (n)	Moderate % (n)	Severe % (n)	P-value
Male	54.3 (163)	6.0 (18)	14.7 (44)	12.0 (36)	7.3 (22)	5.7 (17)	**0.971**
Female	50.7 (152)	6.3 (19)	15.3 (46)	13.7 (41)	8.0 (24)	6.0 (18)	

Table 8 represents the frequency and percentage of Enamel fluorosis in both genders. There is no statistically significant difference was found between males and females for the prevalence of enamel fluorosis (p= 0.971)

Table 9: Comparison of prevalence of dental caries and enamel fluorosis in fluoride blocks according to current study finding

Blocks		Dental caries % (n)	P value	Enamel fluorosis %(n)	P value
			0.001*		**0.001***
According to CGWB - High Fluoride blocks	**Paramathi**	38.7 (58)		51.3 (77)	
	Kabilar Malai	38.7 (58)		50.0 (75)	
According to Karunakaran et al (2009) and Samson et al (2011) – Low Fluoride blocks	**Mohanur**	58.0 (87)		45.4 (68)	
	Sendamangalam	59.3 (89)		41.4 (62)	

Table 9 represents the prevalence of dental caries and enamel fluorosis in fluoride blocks. A statistically significant difference was found between the current finding of fluoride blocks for dental caries and enamel fluorosis with a p-value of 0.001* and 0.001*, respectively.

Table 10: Prevalence of dental caries according to index age groups of the study participants

Index age groups	Dental caries present %(n)	P-value
5 years	48.3 (58)	**0.924**
12 years	50.0 (60)	
15 years	50.0 (60)	
35-44 years	50.0 (60)	
65-74 years	45.0 (54)	

Table 10 depicts the frequency and percentage of study participants of dental caries according to 5 years, 12 years, 15 years, 35-44 years and 65-74 years in fluoride blocks of Namakkal district. There is no statistically significant relation was found between the age groups for the prevalence of dental caries (p=0.924)

Table 11: Severity of enamel fluorosis according to index age groups of the study participants

Index age groups	Normal % (n)	Questionable % (n)	Very Mild % (n)	Mild % (n)	Moderate % (n)	Severe % (n)	Overall prevalence of fluorosis % (n)	P-value
5 years	100 (120)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0(0)	**0.001***
12 years	35.0 (42)	10.8 (13)	17.5 (21)	17.5 (21)	8.3 (10)	10.8 (13)	64.9(78)	
15 years	27.5 (33)	12.5 (15)	20.8 (25)	18.3 (22)	7.5 (9)	13.3 (16)	72.4(87)	
35-44 years	36.7 (44)	7.5 (9)	17.5 (21)	17.5 (21)	15.8 (19)	5.0 (6)	63.3(76)	
65-74 years	63.3 (76)	0 (0)	19.2 (23)	10.8 (13)	6.7 (8)	0 (0)	36.7(44)	

Table 11 depicts the frequency and percentage of study participants of Enamel fluorosis according to the index age groups 5 years, 12 years, 15 years, 35-44 years and 65-74 years in fluoride blocks of Namakkal district. There was a statistically significant relationship found between the index age groups for the prevalence of enamel fluorosis (P value <0.001*)

Discussion:

The oral health gets affected in numerous ways and the aetiology responsible for the oral diseases is multifactorial. The environmental factors such as air, water, diet and lifestyle habits play a pivotal role in determining the healthy oral cavity of the people. The intake of adequate quality of water with good mineral content within permissible limits also have a significant effect on the oral and general health. Hence this present study focused on the impact of the high and low fluoride blocks on oral health status among population residing in Namakkal district of Tamilnadu according to CGWB. On the water quality analysis of high fluoride blocks according to CGWB in present study there is a decline in the fluoride level in drinking water. Similarly in the low fluoride blocks (classified according to the Karunakaran et al in the year 2009 and Samson et al in the year 2011), there is a contrary increase in the fluoride levels of Mohanur block and obtained same value in Sendamangalam block from the current study results in the drinking water. This groundwork study was initiated to compare the oral health status based on the iron and fluoride level data obtained from the CGWB and the Karunakaran et al in the year 2009 and Samson et al in the year 2011. However, the current study results vary from the CGWB, and the Karunakaran et al in the year 2009 and Samson et al in the year 2011 values of the fluoride level in present study were within the range of optimum level. Hence this study suggests the CGWB and the Karunakaran et al in the year

2009 and Samson et al in the year 2011 to update the current data to the current year because there is more flaws when compared with the present study and CGWB.

In the presentfinding, the prevalence of dental caries in high fluoride blocks i.e., Paramathi was 38.7%, and Kabilar malai was 38.7%. In the both fluoride high blocks the prevalence of dental caries obtained was same. This was contrast with John JB et al in the year 2015 had reported that the prevalence was 77% in Namakkal district [14]. This might be due to optimum fluoride level in the drinking water which was the extraordinary finding of present study which deny with the CGWB data. In the present finding, the prevalence of dental caries in low fluoride block Mohanur was 58.0% and Sendamangalam was 59.3%. However, there is no big variation in the prevalence of dental caries between high Fluoride and low-fluoride blocks. This might be due to the extraordinary findings because optimum fluoride levels was obtained in present study which was deny to the fluoride levels in the low fluoride blocks according to the Karunakaran et al in the year 2009 and Samson et al in the year 2011.A statistically significant difference was found between the current finding of high and low fluoride blocks on the prevalence of dental caries (p-value 0.001).

In this current study the prevalence of dental caries in male was 46.7% and female was 50.7%. Among male and female, the prevalence of dental caries was found to be highest in female (50.7%) when compared to male (46.7%). This was contrast to Karunakaran et al in the year 2014 had reported that the prevalence of dental caries was found high in male (69.6%) when compared to females (61.5%) [9]. In the current study, the dental caries was not found to be significant with gender. This was in line with the study conducted by Guracho et al in the year 2021 [15] had reported that the dental caries was not statistically significant with gender. This was in contrast with the study conducted by Mulu et al in the year 2014 [16] had reported that the dental caries was found to be statistically significant with age. They might be due to change in lifestyle habits and dietary modifications among the people in different environmental conditions might increase the people more prone to the development of dental caries.

Another study conducted by Parasuraman et al in the year 2017[6] had reported that there is an similar finding found that the prevalence of dental caries was high among female (54%) when compared to male (46%) and it was not significant (p=0.075). In the current study finding also states that there is no statistically significant difference (p-value=0.184) was found between males and females for the prevalence of dental caries.

In the current finding analysis of enamel fluorosis in comparison with the fluoride levels in drinking water prevalence of enamel fluorosis according to CGWB high fluoride block and the current finding of Paramathi was 51.3%, and in Kabilar malai was 50.0%. The prevalence of enamel fluorosis according to Karunakaran et al on the year 2009 and samson et al in the year 2011 low fluoride block and the current finding of Mohanur is 45.4%, and Sendamangalam is 41.4 %. There was a significant difference between the high and low fluoride blocks and enamel fluorosis (p-value 0.001*). Enamel fluorosis was more in the high fluoride blocks than in low fluoride blocks. The similar study conducted by Yadav et al in the year 2009 [17] had reported that the 30-94.85% in high fluoride villages is high when compared to the low fluoride villages (8.80-28.20%). This concludes that the high fluoride block has a greater incidence of enamel fluorosis This result is contrast to the study Sukhabogi et al in the year 2014 [18] had reported that the Low fluoride area (60.5%) was high when compared to high fluoride area (32.4).

In the current study finding the prevalence of dental fluorosis in male (54.3%) and female was 50.7% and it was found to be highest among male (54.3%) when compared to female. This was similar with the study conducted by Ravikumar and Khan in the year 2015 [19] had reported that the prevalence of dental fluorosis was more prevalent among male when compared to female. Another study conducted by Ramesh et al in the year 2016 [20] also reported that the prevalence of dental fluorosis was more common in male which was also similar finding with the present study. This reason might be that the intake of water was more in males due to their excessive physical activity and working environment compared to the

female population. Another study conducted by Kumar et al in the year 2022 [21] had reported that the prevalence of dental fluorosis was high in female (54.9%) when compared to male (45.1%) which is found contrast with the present study. There is no statistically significant difference found between male and female for the prevalence of enamel fluorosis (p= 0.971).

The current study also reported that the prevalence of dental fluorosis was more among 15 years (72.4%) when compared to other index age groups. This was in Similar to the Kumar et al in the year 2022 [21] with the current study that the dental fluorosis prevalence was highest in the index age group of 15 years and it was also significant. Another study conducted by Ravikumar and khan in the year 2015 [19] had reported that the more prevalence of dental fluorosis was high in the index age group of 13-14 years when compared to 11-12 years. There was a statistically significant relationship found between the index age groups for the prevalence of enamel fluorosis (P value <0.001*). Another study conducted by Nataraj et al in the year 2019 [22] had reported that the prevalence of dental fluorosis was high in 9-12 years age group when compared to 12-15 years which is contrast to the present finding.

Limitations of the study:

The primary limitations of the study are confounding variables should be considered into an account to get more appropriate outcome. Further, the equal sampling of females and males were not the priority which might pave way for gender bias.

Conclusion and recommendations:

As per the study results, the prevalence of enamel fluorosis is high in high fluoride blocks, and the dental caries prevalence is high in low fluoride blocks. Indian government should take proper measures in regulating the permissible limits of fluoride content, but also to evaluate all the mineral content in drinking water to improve oral health for the maximum beneficiaries of the people. This study's contradictory finding emphasises the importance of drinking water and CGWB should plan and organize a team for the upgradation of the water quality in India. Such lacunae might be due to the unqualified manpower, such ground work can be done efficiently by Public Health dentist alone but they are not recruited for the Central, State and District level Officials. Hence the Public Health Dentist should be recruited as a District Oral Health Officer for formulating a meticulous plan to solve the community dental problem. National Program on Prevention and control of dental diseases should look on to the endemic areas for the prevention of dental fluorosis which should be assessed, implemented and monitored by the Public health Dentist who should be recruited as oral health program officers in both central and state governments.

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