

A comparative study of dental fluorosis and non-skeletal manifestations of fluorosis in areas with different water fluoride concentrations in rural Kolar

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ABSTRACT

Background: Fluorosis is an endemic disease which results due to excess exposure to high fluoride from different sources. The climatic factors and dependency on ground water add to the risk of fluorosis in Kolar. In addition to it, the epidemiological studies conducted on fluorosis in Kolar are very few. **Aims:** (1) To estimate age-specific prevalence of dental fluorosis in the study population. (2) To determine the proportion of study subjects with non-skeletal manifestations of fluorosis (3) To assess and compare the influence of various socio-epidemiological factors in the occurrence of dental fluorosis among the study population in areas with high and normal fluoride. **Methodology:** A cross-sectional study was conducted among the residents of three randomly selected villages, Thimmasandra and Batwarahalli (high fluoride) and Maddinayakanahalli (normal fluoride) belonging to Bangarpet taluk, Kolar for 1 year. Dental fluorosis was assessed by the Dean's grading. Non-skeletal manifestations were elicited based on clinical features. Fluoride levels of drinking water sources were estimated by ion-electrode method. The Chi-square and Fisher's exact tests were used to see the difference in proportions and a *P* value of <0.05 was considered for statistical significance. **Results:** The prevalence of dental and non-skeletal fluorosis in the study groups with high and normal fluoride groups were 13.17%, 5.5%, 3.84%, 1.9%, respectively. The prevalence of dental fluorosis was significantly higher among the children and adolescents compared to adults (*P* < 0.05). **Conclusion:** Dental fluorosis is a public health problem mainly affecting children and adolescents in Bangarpet.

Keywords: Dean's index, fluoride, fluorosis, ion-electrode method, non-skeletal fluorosis

Introduction

Fluoride is an important element of concern to the medical society as the deficiency leads to defective enamel formation in teeth and the excess leads to dental, skeletal, and non-skeletal fluorosis in the form of muscle weakness, tiredness, fatigue, anemia, dyspepsia, male infertility, polyuria, polydipsia, repeated stillbirths, abortions, and so on. Hence, it is essential to keep the fluoride consumption at an optimum level. The Bureau of Indian Standards (BIS) has set the standards for

fluoride levels in drinking water with maximum desirable limit as 1.0 mg/L and permissible limit in the absence of alternate source as 1.5 mg/L. Fluorosis has its impact on 21 states of India. Kolar, a drought prone area, with its semi-arid climate, the dependency on ground water for drinking and domestic purpose, makes it susceptible to be one of the 16 fluorosis endemic districts of Karnataka. The literatures on fluorosis in Kolar are minimal and hence the present study was taken up.^[1-6]

Objectives

1. To estimate age-specific prevalence of dental fluorosis in the study population

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- To determine the proportion of study subjects with non-skeletal manifestations of fluorosis
- To assess and compare the influence of various socio-epidemiological factors in the occurrence of dental fluorosis among the study population in areas with high and normal fluoride.

Methodology

As per the report of fluoride estimation being routinely done in Kolar district by the office of the executive engineer, Panchayat Raj Engineering Division Kolar, Bangarpet taluk was selected as the primary sampling unit as it recorded the highest number of villages i.e., 79 with high fluoride level. The areas with fluoride >1.5 mg/L and <1.0 mg/L were grouped as high and normal water fluoride areas. Among two randomly selected study groups with high water fluoride (Batavarahalli and Thimmasandra) (Group 1) and with normal fluoride levels (Maddinayakanahalli) (Group 2) belonging to Bangarpet taluk, Kolar district, a community based cross-sectional study was conducted for a period of 1 year. Public borewell was the only source in all the above villages. Ethical clearance was obtained from the institutional ethical committee. Sample size was calculated using the formula $n = z^2(pq/L^2)$, where, $z = 1.96$ at 95% confidence interval, $p =$ estimated prevalence (30%),^[7] $q = 100 - p$, and $L =$ permissible error (10% of p). The total sample size of $896 \approx 900$ was considered for the study.

House-to-house survey was conducted to estimate the prevalence of dental fluorosis among all the household residents aged >8 years.^[6] After obtaining informed consent in local verbatim, the data were recorded in a pre-tested, semi-structured, validated questionnaire about the socio-demographic profile and certain risk factors of dental fluorosis i.e., source of water for drinking, cooking, and other domestic purposes, type of foods consumed and use of fluoride-containing products. Persons with no teeth, artificial teeth, pregnant women, bedridden, and the persons who were not available even after two visits were excluded from the study. Dental fluorosis was assessed after obtaining hands-on training from the dental department by using Dean's index.^[8] The community fluorosis index (CFI) was computed to know the public health importance.^[8,9] The fluoride exposure dose through drinking water was calculated by the equation, fluoride exposure dose = $FC \times WI/BW$, where FC is the fluoride concentration in milligrams per liter (mg/L), WI is the water intake in liters per day (L/day), and BW is the body weight in kilograms (kgs).^[8] Non-skeletal manifestations of fluorosis were assessed based on clinical history for dyspepsia with nausea/vomiting/pain abdomen/constipation/diarrhea, muscle weakness, tiredness, fatigue, polyuria, polydipsia, repeated abortions/still births.^[6]

The data were analyzed using standard statistical package. Proportion of fluorosis and the association of fluorosis with selected individual risk factor were analyzed using appropriate tests i.e., Chi-square and Fisher's exact test. Logistic regression

was used to find the association of the predictor variables with the dependent variable in terms of adjusted odds ratios and their 95% confidence intervals. A P value of <0.05 was taken as statistically significant.

Results

Sociodemographic profile of the study participants

The median age of the participants was 30 years with an interquartile range (IQR) ranging between 18 years to 45 years in the high fluoride group, and in the normal fluoride group median age was 33 years with an IQR ranging between 20 years to 45 years. Females predominated in both high (52.6%) and low fluoride groups (52.1%). Among the different castes, highest proportion i.e., 56.9% of the participants in the high fluoride group belonged to scheduled caste/tribe and 87.5% in the normal fluoride group belonged to other backward classes. Only 2 out of 486 i.e., 0.41% in the high fluoride group used aquaguard before drinking water. Mean consumption of drinking water was almost same in both the fluoride groups. Majority among the illiterates i.e., 52.4% were in normal fluoride group. Major chunk i.e., 60.1% of unemployed and 53.4% of poor socio-economic status belonged to high fluoride group. Among those who used fluoride-containing materials for dental cleaning, majority i.e., 51.7% of the study participants were in high fluoride group. Fluoride-containing medications like antipsychotics were used equally in both the study groups. Among those who were malnourished, majority i.e., 51.7% of the study participants belonged to normal fluoride group [Table 1].

Prevalence of dental fluorosis

The prevalence of dental fluorosis in the study group with high fluoride level was 13.17% and in the study group with low fluoride was 3.84%. The age specific prevalence in both the high and normal fluoride groups decreased as the age increased [Table 2].

The prevalence of dental fluorosis among the children and adolescents (8–19 years) was 31.83% and among adults (>19 years) was 1.32%. Among the children and adolescents, the prevalence of dental fluorosis in the study group with high and normal fluoride groups were 46.88% and 11.58%, respectively. Among the adults, the prevalence of dental fluorosis in the study group with high and normal fluoride groups were 1.11% and 1.55%, respectively.

Among children and adolescents in high fluoride area, maximum number i.e., 21 (16.4%) had moderate grade and 20 (15.6%) had very mild grade of dental fluorosis, whereas in the study group with normal fluoride, 5 (5.3%) and 4 (4.3%) had questionable and moderate grades of fluorosis, respectively. Among the adults with high fluoride level, 3 (0.8%) and 1 (0.3%) had moderate and questionable grades of dental fluorosis and in the other group, 4 (1.3%) and 1 (0.3%) had moderate and mild grades of dental fluorosis, respectively.

CFI was 0.8, suggesting slight public health significance among children and adolescents in the high fluoride group and among the other group it was negative and suggested no public health importance.

Factors associated with dental fluorosis

The occurrence of dental fluorosis among children and adolescents in the group with high fluoride was significantly higher compared to the other group ($P < 0.05$). Among the study population with dental fluorosis, we observed that statistically significant association was seen between high fluoride levels in water and occurrence of dental fluorosis and majority of them with dental fluorosis were males ($P < 0.05$). In the normal fluoride group, occurrence of dental fluorosis was higher on exposure to lower dose of fluoride; however, dental fluorosis was not seen on exposure to higher dose of fluoride in water. In the high fluoride group, the occurrence of dental fluorosis was not seen at the lower dose of fluoride exposure but dental fluorosis prevailed constantly at higher fluoride exposure with intermittent rise

and fall indicating highest prevalence of dental fluorosis at the peak points [Figure 1]. It was also noted that there was statistically significant association between socio-economic status and occurrence of dental fluorosis and majority of them with dental fluorosis belonged to poor socio-economic status ($P < 0.05$). The use of fluoridated dental products for dental cleaning was also significantly associated with occurrence of dental fluorosis and majority of them with dental fluorosis used fluoridated dental products for dental cleaning ($P < 0.05$). There was no influence of castes, occupation, and educational status observed in the prevalence of dental fluorosis ($P > 0.05$). The other socio-demographic factor i.e. the occurrence of dental fluorosis was not associated with other risk factors like quantity of water consumed, clinically suspected anemia, and nutritional status of dental fluorosis ($P > 0.05$). After applying logistic regression for the significant factors affecting the prevalence of dental fluorosis in two areas with high and low fluoride, the risk of occurrence of dental fluorosis was significantly seven times higher among the children and adolescents compared to adults in the high fluoride group ($P > 0.05$) [Table 3].

Table 1: Baseline characteristics of the study population

Particulars of the study subjects	High fluoride group (n=486)	Normal fluoride group (n=417)
Median age (IQR) in years	30 (18.75-45)	33 (20-45)
Gender (%)		
Females	241 (52.6)	217 (47.4)
Males	245 (55.1)	200 (44.9)
Caste (%)		
Scheduled caste/scheduled tribe	277 (91.4)	26 (8.6)
Other backward castes	189 (34.1)	365 (65.9)
General	20 (43.5)	26 (56.5)
Utility from the public borewell (%)		
Direct	484 (53.7)	417 (46.3)
Use of aquaguard	2 (100.0)	0 (0.0)
Mean consumption of drinking water [§]	1.94±0.55	2.07±0.50
Illiterates (%)	161 (47.6)	177 (52.4)
Unemployed (%)	140 (60.1)	93 (39.9)
Poor/very poor (%)	444 (53.4)	387 (46.6)
Fluoridated tooth paste (%)	404 (51.7)	378 (48.3)
Fluoride-containing medications (%)	1 (50.0)	1 (50.0)
Malnourished [underweight + overweight + obese] (%)	139 (48.3)	149 (51.7)

[§]Mean Consumption of drinking water in Litres (Mean±SD). IQR: Interquartile range

Clinical manifestations of non-skeletal fluorosis

The manifestations of non-skeletal fluorosis were higher among high fluoride group (32/486, 6.58%) compared to normal fluoride group (18/417, 4.32%). Among the study participants with non-skeletal manifestations of fluorosis, majority

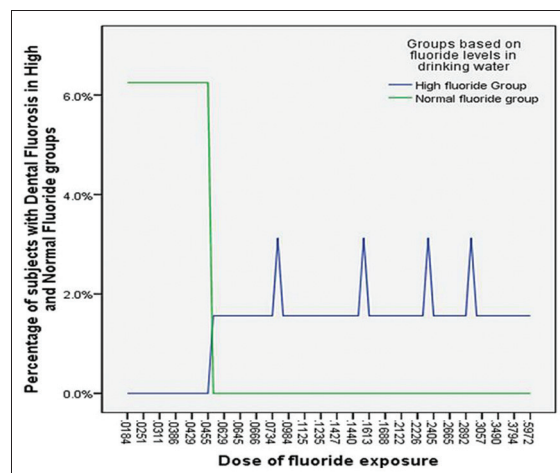


Figure 1: Dental fluorosis with dose of fluoride exposure in both high and normal fluoride groups

Table 2: Age-specific prevalence of dental fluorosis in both high and normal fluoride groups

Age (years)	High fluoride group (%)	Age-specific prevalence in high fluoride group (%)	Normal fluoride group (%)	Age-specific prevalence in normal fluoride group (%)
≤10	34 (100.0)	18 (52.94)	14 (100.0)	3 (21.42)
11-15	60 (100.0)	29 (48.34)	36 (100.0)	5 (13.89)
16-20	53 (100.0)	14 (26.42)	63 (100.0)	5 (7.94)
21-25	59 (100.0)	2 (3.38)	43 (100.0)	2 (4.65)
>25	280 (100.0)	1 (0.36)	261 (100.0)	1 (0.38)
Total	486 (100.0)	64 (13.17)	417 (100.0)	16 (3.84)

i.e., 24 (75.0%) with dyspepsia, 19 (59.38%) with complaints of fatigue, and 9 (69.23%) with muscle weakness belonged to high fluoride group. None of the study participants had complaints of polyuria, polydipsia, repeated abortions, and repeated stillbirths [Table 4].

The study subjects with clinical manifestations of non-skeletal fluorosis were higher compared to those without clinical manifestations of non-skeletal fluorosis at nearly same doses of fluoride exposure in both high and normal fluoride groups [Figure 2a and b].

Discussion

“Fluoride”, a double-edged sword, causes dental fluorosis when consumed in excess. Dental fluorosis has become a common esthetic problem faced by the individuals residing in endemic areas of fluorosis.

Prevalence of dental fluorosis

According to Gopalakrishnan *et al.*, the prevalence of dental fluorosis among school going children in the age group of 10–15 years in the endemic districts of Kerala was 38.3% and in

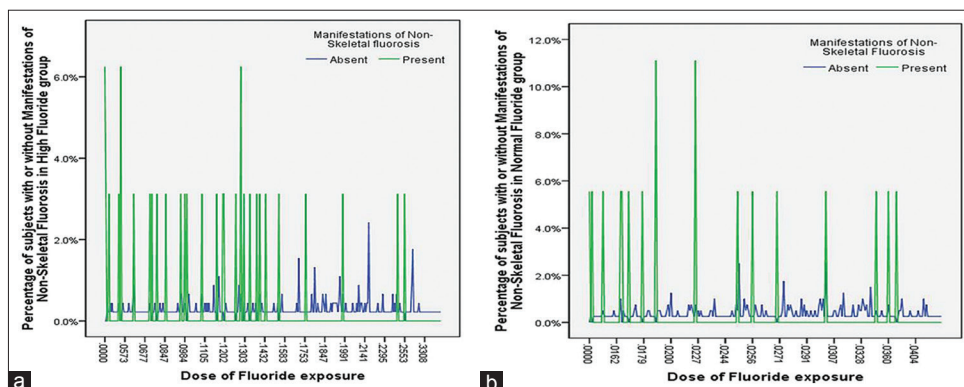


Figure 2: Clinical manifestations of non-skeletal fluorosis among (a) High fluoride group. (b) Normal fluoride group

Table 3: Relationship between various socioepidemiological factors with dental fluorosis in two areas with differential water fluoride levels

Particulars	High fluoride group (%)	Normal fluoride group (%)	Total (%)	Adjusted OR (CI)
Age group*				
Children and adolescents	60 (84.51)	11 (15.49)	71 (100.0)	7.05 (1.43-34.87)*
Adults	4 (44.45)	5 (55.55)	9 (100.0)	
Gender [§] *				
Males	12 (63.15)	7 (36.85)	19 (100.0)	
Females	15 (93.75)	1 (6.25)	16 (100.0)	
Educational Status				
Literates	63 (80.77)	15 (19.23)	78 (100.0)	
Illiterates	1 (50.0)	1 (50.0)	2 (100.0)	
Socioeconomic status ^{*,*}				
Middle (upper/lower)	27 (100.0)	0 (0.0)	27 (100.0)	
Poor	37 (69.81)	16 (30.19)	53 (100.0)	
Caste [§]				
Scheduled caste/other backward castes	61 (82.43)	13 (17.57)	74 (100.0)	
General category	3 (50.0)	3 (50.0)	6 (100.0)	
Quantity of drinking water consumed per day in liters [§]				
≤2	51 (83.61)	10 (16.39)	61 (100.0)	
>2	13 (72.23)	5 (27.77)	18 (100.0)	
Items used for dental cleaning [§] *				
With fluoride	57 (83.82)	11 (16.18)	68 (100.0)	
Without fluoride	7 (58.34)	5 (41.66)	12 (100.0)	
Clinically suspected anaemia [§]				
With dental fluorosis	18 (90.0)	2 (10.0)	20 (100.0)	
Without dental fluorosis	46 (76.67)	14 (23.33)	60 (100.0)	
Malnourished [§]				
Yes	29 (82.86)	6 (17.14)	35 (100.0)	
No	35 (77.78)	10 (22.22)	45 (100.0)	

*P<0.05; [†]Fisher's exact test; [§]Chi-square test

Table 4: Non-skeletal manifestations of fluorosis

Non-skeletal manifestations of fluorosis	High fluoride group (%)	Normal fluoride group (%)	Total (%)
Dyspepsia	24 (75.0)	8 (25.0)	32 (100.0)
Muscle weakness	9 (69.23)	4 (30.77)	13 (100.0)
Fatigue	19 (59.38)	13 (40.62)	32 (100.0)

Each individual had either one or more than one manifestations

the non-endemic districts was 3.3%; however, in our study the age-specific prevalence (11–15 years) in high and normal fluoride groups were 48.3% and 13.9%, respectively, which are relatively higher. The prevalence of dental fluorosis in endemic areas of Alappuzha and Palakkad in different age groups were as follows: 10–11 years – 25.2% and 41.9%, 12–13 years – 36.8% and 38.6%, 14–15 years – 41.2% and 60%, and >15 years – 26.8% and 34.5%, respectively; in non-endemic areas of Kollam and Thrissur in different age groups were as follows: 10–11 years – 5.1% and 11.1%, 12–13 years – 5.4% and 3.0%, 14–15 years – 3.7% and 1.9%, and >15 years – 0.0% and 1.6%, respectively; however, in our study the age-specific prevalence among ≤10 years in high and normal fluoride groups were 52.9% and 21.4% and 11–15 years in high and normal fluoride groups were 48.3% and 13.9%, respectively, which are relatively higher. The difference may be due to the different comparative age groups and different study settings.^[10]

The prevalence of dental fluorosis was significantly higher among the children and adolescents compared to adults ($P < 0.05$) in the present study. Golgire *et al.*, have recorded similar findings wherein, most affected age groups were 11–20 years followed by 1–10 years and prevalence has decreased with increase in age which corresponds to the current study.^[11] Similarly, data from the the National Health and Nutrition Examination Survey, 1999–2004 and the 1986–1987 the National Survey of Oral Health in U.S. school children also showed that the prevalence of dental fluorosis was higher among younger persons and ranged from 41% among adolescents aged 12–15 years to 9% among adults aged 40–49 years.^[12]

The findings of prevalence of dental fluorosis and CFI among adults in the groups with fluoride >1.5 mg/L and <1.0 mg/L in the current study were in contrast to the findings by Karthikeyan *et al.*, in Tamilnadu and Garg S in Sahara village.^[13,14] The reason may be that the exposure for higher fluoride content among the residents of Batwarahalli, Thimmasandra, and Maddinayakanahalli might have been within 25–30 years and people who are exposed to high fluoride level during 0–6 years develop signs of dental fluorosis. In addition to that the exact duration of stay in that area was not accounted for in the study which is one of the limitations of the study hence there may be a difference in the exposure statuses.

Our study reported maximum moderate grades of fluorosis among high fluoride (4.9%) and (1.9%) among normal fluoride and are in line with findings by Verma *et al.*, where majority had

moderate grade of fluorosis.^[15] Arya *et al.*, in Doda, Jammu and Kashmir with fluoride level ranging from 0.04 to 4.9 mg/L also found most (33.5%) of the affected population under moderate category similar to our study.^[16]

Factors associated with dental fluorosis

Higher prevalence of dental fluorosis was observed in high fluoride group compared to normal fluoride. Prevalence of dental fluorosis is high at low fluoride exposure in normal fluoride group, though the fluoride exposure through water is less in that area. The reason may be due to the fluoride ingestion through food which needs further in-depth analysis, another added limitation.

As mentioned earlier, even after adjusting for the significant confounders, the risk of occurrence of dental fluorosis was significantly seven times higher among the children and adolescents compared to adults in the high fluoride group and the similar findings has been discussed earlier as per the findings of Golgire *et al.*^[11]

Though majority of the individuals affected with dental fluorosis were males, literates, subjects with poor socio-economic status, and those who used items with fluoride for dental cleaning were initially associated significantly with fluoride levels, after adjusting for the effect of confounding, they did not significantly differ among the high and normal fluoride groups. Similarly Verma *et al.*, found that majority were males, with no significant association.^[15] In a study conducted by Nirgude *et al.*, in Nalgonda in 2008–2009, has got more cases of dental fluorosis among illiterates (47.3%) and lower socio-economic status (69.1%) and the finding with respect to literacy status is not in concordance with the current study findings and this may be due to the fact that majority of the study subjects in the current study were literates.^[17] Though use of fluoridated toothpaste has been identified as a potential risk factor for dental fluorosis, it was not an independent predictor in the current study which implicates the need for conducting an in-depth study.^[18] In a study by Gopalakrishnan *et al.*, the gender and the quantity of consumption of drinking water were not significant in endemic and non-endemic districts of Kerala except for Palakkad where the quantity of consumption of drinking water was significantly associated with occurrence of dental fluorosis.^[10] Mahantesha *et al.*, in Bagalkot on evaluation for risk factors of dental fluorosis, the prevalence of fluorosis was not associated significantly with nutritional status and water consumption on applying multiple logistic regressions and are in line with the current study.^[19]

Manifestations of non-skeletal fluorosis

Higher proportion of study subjects with clinical manifestations of non-skeletal fluorosis compared to those without clinical manifestations of non-skeletal fluorosis at nearly same doses of fluoride exposure in both high and normal fluoride groups indicates that these manifestations may be due to fluoride exposure through water or other sources like food.

Limitations

1. The major risk factor in the development of dental fluorosis is drinking water. Fluorosis develops in an individual during the time of calcification of teeth, which takes place from early infancy. The fluoride content of the water which was consumed during that period is of critical importance, which is not feasible to assess. The exact duration of stay in that area was not accounted for in the study due to feasibility factors. It was presumed that the children have been drinking water from the same source since their childhood (during the time of their teeth calcification)
2. The fluoride concentration in the ground water can fluctuate with the seasons and seasonal changes (sunshine, rainfall, humidity, and temperature) and hence an annual average is a better indicator of fluoride levels in sources of drinking water
3. Urinary fluoride and serum fluoride levels, for the confirmation of consumption of fluoride rich water/food could not be analyzed as we could not procure the instrument for the fluoride ion analysis due to constraints of time and logistics, as it was one person investigation
4. Fluoride could not be established as a causative factor for manifestations of non-skeletal fluorosis as elicited in the study. For the causation to be established, it needs an intervention wherein, the affected individuals needs to be diverted for the safe source of water and reassessment after 2–3 weeks for the same manifestations and if the manifestations have disappeared, then it can be confirmed that the manifestations were due to fluoride levels.^[20] Establishing causation was beyond the objectives of the study
5. Although we have taken history of use of fluoridated tooth paste, fluoridated mouth rinse, infant milk formulas, it needs an in-depth analysis of fluoride levels in the foods consumed in addition to detailed diet survey to confirm the cause of fluorosis which could not be performed due to operational feasibility.

Conclusion

Dental fluorosis is a public health problem among the children and adolescents of Bangarpet taluk, Kolar. Hence, there is an urgent need to tackle the problem. This study acts as a pointer to public health physicians and other various sectors concerned in addressing the current issue. The scenario depicted also warns a serious consideration in taking up further interventions through the inter-sectorial efforts including a primary care physician i.e., setting up community de-fluoridation units, improving the awareness about this current scenario among the residents of Bangarpet.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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