

## Prevalence of dental fluorosis & dental caries in association with high levels of drinking water fluoride content in a district of Gujarat, India

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**Background & objectives:** Endemic fluorosis resulting from high fluoride concentration in groundwater is a major public health problem in India. This study was carried out to measure and compare the prevalence of dental fluorosis and dental caries in the population residing in high and normal level of fluoride in their drinking water in Vadodara district, Gujarat, India.

**Methods:** A cross-sectional study was conducted in Vadodara district, six of the 261 villages with high fluoride level and five of 1490 with normal fluoride level in drinking water were selected. The data collection was made by house-to-house visits twice during the study period.

**Results:** The dental fluorosis prevalence in high fluoride area was 59.31 per cent while in normal fluoride area it was 39.21 per cent. The prevalence of dental caries in high fluoride area was 39.53 per cent and in normal fluoride area was 48.21 per cent with CI 6.16 to 11.18. Dental fluorosis prevalence was more among males as compared to females. Highest prevalence of dental fluorosis was seen in 12-24 yr age group.

**Interpretation & conclusions:** The risk of dental fluorosis was higher in the areas showing more fluoride content in drinking water and to a lesser degree of dental caries in the same area. High fluoride content is a risk factor for dental fluorosis and problem of dental fluorosis increased with passage of time suggesting that the fluoride content in the water has perhaps increased over time. Longitudinal studies should be conducted to confirm the findings.

**Key words** Cross sectional study - dental caries - dental fluorosis - fluoride water - India - prevalence rate

Endemic fluorosis resulting from high fluoride concentration in groundwater is a public health problem in India. The available data suggest that 15 States in India are endemic for fluorosis (fluoride level in

drinking water >1.5 mg/l), five of these have category III (>50% of the districts affected) which includes Gujarat<sup>1</sup>. The Assam region of North East India has also been recognized as a fluoride-affected area<sup>2</sup>.

World Health Organization (WHO) has set the upper limit of fluoride concentration in drinking water at 1.5 mg/l<sup>3</sup>. The Bureau of Indian Standards, has therefore, laid down Indian standards as 1.0 mg/l as maximum permissible limit of fluoride with further remarks as "lesser the better"<sup>4</sup>. The WHO in Oral Health Report (2003)<sup>5</sup> has stated fluoride as most effective agent in dental caries prevention.

Gujarat Water Supply and Sewerage Board (GWSSB) has surveyed all the villages in Gujarat and reported 15.8 per cent of the villages having fluoride level more than 1.5 mg/l (personal communication, GWSSB).

This study was aimed to test the hypothesis whether high fluoride level in drinking water is more a risk factor leading to fluorosis than its protective role in the prevention of dental caries.

The objectives were to measure the prevalence of dental fluorosis and dental caries in the population residing in areas with high and normal level of fluoride in the drinking water, and to find out whether high fluoride level in drinking water is more protective for dental caries or a risk factor for dental fluorosis.

### Material & Methods

This cross-sectional prevalence study was conducted by the Department of Preventive and Social Medicine, Medical College, Vadodara, Gujarat, for a period of six months. Vadodara district has total 7794 sq. kilometer area spread in 12 talukas and 1651

villages<sup>6</sup>. Ethical approval for the study was obtained from institutional review board of Medical College, Vadodara. Under assumption of detecting a difference of 3 per cent prevalence in dental fluorosis in the areas having high and normal fluoride in the drinking water, the sample size required was 2500. Of the 1651 villages, 261 (15.81%) have been detected to have drinking water fluoride level of more than 1.5 mg/l (personal communication, GWSSB). Eleven of these 261 villages having high fluoride content in the drinking water and 11 villages of the remaining 1490 having normal fluoride in drinking water were randomly selected for water sampling. Water samples were collected from all the water sources (maximum 5) from all these selected villages. The analysis for the fluoride level was made by auto analyzer using a spectrophotometric method<sup>7</sup>. The results of these 22 villages were compared with GWSSB reports (personal communication, GWSSB). Eleven of the 22 villages showed similar findings and these 11 villages were selected for further study (Table I). Of these 11 villages, five had fluoride level <1.5 mg/l. All the houses in each village were visited for data collection by trained tutors and assistant professors of Preventive and Social Medicine Department, Medical College, Vadodara. All age groups were included in the study after taking informed consent. Those who could not be studied in the second visit were excluded from the study.

Dental caries care was counted when any of the teeth falls into the category of decayed, decayed and filled or missing due to caries (grade 2, 3, or 4)<sup>8</sup> and

**Table I.** Study population and fluoride level in the different sources of water

Name of village	Fluoride level (mg/l) in water					Total population	Population studied
	Sample I	Sample II	Sample III	Sample IV	Sample V		
Karsan	3.43	2.49	1.54	2.20	1.80	1819	1371
Rajavant	4.10	—	—	—	—	346	214
Soikuva	0.02	0.02	—	—	—	242	161
Ajod	0.11	—	—	—	—	1646	1499
Fatepura	1.92	1.83	—	—	—	286	157
Ghantiyal	0.38	0.39	0.50	0.38	—	1131	844
Kharakuva	3.19	0.98	0.58	0.17	0.02	269	154
Kolaba	0.35	0.50	—	—	—	712	594
Kundi-UK	2.99	2.79	3.01	—	—	355	224
Titod	2.43	2.18	2.23	2.32	—	1094	802
Totarmata	1.84	1.06	2.02	2.79	3.09	136	73
Total						8036	6093 (75.8%)

**Table II.** Distribution of dental caries and fluorosis in the studied population

Cases	High fluoride areas (6 villages)			Normal fluoride areas (5 villages)		
	Male (n=1437)	Female (n=1404)	Total (n=2841)	Male (n=1521)	Female (n=1731)	Total (n=3252)
Dental fluorosis	881 (61.31)	804 (57.26)	1685 (59.31)	623 (40.95)	652 (37.67)	1275 (39.21)
Dental caries	556 (38.69)	567 (40.38)	1123 (39.53)	681 (44.77)	887 (51.24)	1568 (48.21)

Values in parentheses are percentages

dental fluorosis when tooth was not normal. The grading for dental fluorosis was done as: questionable (grade 1), very mild fluorosis (grade 2), mild fluorosis (grade 3), moderate fluorosis (grade 4), and severe fluorosis (grade 5)<sup>9</sup>.

For subsequent analysis all the grades of fluorosis were dichotomized as fluorosis (grade 1 to grade 5) or no fluorosis (grade 0) and area was also dichotomized as high fluoride villages (water fluoride level >1.5 mg/l, villages Karsan, Rajavant, Fathepura, Kundi-U.K., Titod & Totarmata) and normal fluoride level (water fluoride level ≤ 1.5 mg/l, villages Ajod, Ghantial, Kharakuva, Kolaba & Soikuva). Data were analyzed by Chi-square and Mental Hensel Chi-square tests.

### Results

The prevalence of dental fluorosis in high fluoride area was 59.31 per cent while in normal fluoride

area it was 39.21 per cent (Table II). The difference was statistically significant (CI 17.59-22.57% with RR=1.51). Also the prevalence of dental caries in high fluoride area was 39.53 per cent and in normal fluoride area was 48.21 per cent with a difference of 8.68 per cent (CI 6.16 to 11.18%), RR=0.82 indicating protective effect of fluoride for dental caries.

The prevalence of dental fluorosis in high fluoride area was 61.30 per cent in males and 57.26 per cent in females while in normal fluoride area was 40.96 per cent in males and 37.67 per cent in females (Table III). Age and sex adjusted R.R. was 1.56 with CI 1.48-1.64 per cent. The prevalence of dental fluorosis was highest in 12 to 24 yr age group.

### Discussion

Of the total population under study (n=8036), 6093 persons (response rate of 75.8%) were studied. The

**Table III.** Age cohort & sex-wise distribution of dental fluorosis in the studied population

Age (yr)	High fluoride area				Normal fluoride area				R.R.
	Male		Female		Male		Female		
	No.	%	No.	%	No.	%	No.	%	
<5	13/173	7.55	10/142	7.04	9/135	6.67	5/109	4.58	1.02
5-11	170/300	56.67	149/233	63.94	130/342	38.01	118/321	36.76	1.56
12-24	237/283	83.74	227/316	71.83	174/356	48.87	156/388	40.20	2.47
25-34	162/224	72.32	165/256	64.45	98/216	45.37	127/300	42.33	1.77
35-44	105/156	67.30	88/146	60.27	87/186	46.77	104/256	40.62	1.57
45-64	147/213	69.01	122/217	56.22	101/222	45.49	117/265	44.15	1.48
>65	47/89	52.80	43/94	45.74	24/64	37.50	25/92	27.17	1.35
Total	881/1437	61.30	804/1404	57.26	623/1521	40.96	652/1731	37.67	1.49

Age and sex adjusted R.R. = 1.56 (95% CI = 1.48 - 1.64),  $P < 0.01$

non-response rate was more (28.91%) (1203/4161) for men while for women it was only 19.1 per cent (740/3875). This was due to their non-availability for various reasons including being out of station for work or sickness, *etc.* The prevalence of dental fluorosis in the study population was 49.26 per cent. Choubisa<sup>9</sup> reported the prevalence of dental fluorosis as 45 per cent among 21 different villages in southern Rajasthan. Another study conducted in a village in Maharashtra also found the prevalence of dental fluorosis as 43 per cent<sup>10</sup>. In Turkey, the dental fluorosis prevalence was reported as 29 per cent in normal fluoride area and 77 per cent in high fluoride area among 12 to 14 yr old school children<sup>11</sup>. A study conducted on Mexican school going children showed the prevalence of dental fluorosis as 60 per cent<sup>12</sup>. In Tanzania, Vuhahula *et al*<sup>13</sup> observed the prevalence of dental fluorosis as 96.3 per cent.

Our findings do not tell us about the period of fluoride ingestion in the studied population. Dental fluorosis develops only when one is exposed to high fluoride level during 0-6 yr of age when dentition develops. Once fluorosis develops, it is permanent<sup>14</sup>.

Dental caries being lower in high fluoride area is suggestive of its protective effect. Similar findings were observed earlier by Tsutsui *et al*<sup>15</sup> in Japanese communities, and also by others<sup>16</sup>. There is no alternative but to reduce exposure to fluoride level for prevention of fluorosis while dental caries can be prevented by the improved oral hygiene and ensuring the reduced bacterial growth and less production of acid<sup>17</sup>. One study conducted in Namibia on fluorosis, caries and oral hygiene in school children observed that high concentrations of fluoride in drinking water alone did not result in acceptable caries levels<sup>18</sup>.

The relative risk of having dental fluorosis increased with decrease in age up to 12 yr and age and sex adjusted relative risk was 1.56 with the 95 per cent confidence interval of 1.48 to 1.64. The analysis suggested to interpret the age-wise data separately as the relative risk differed by the stratum. The crude R.R. was 1.49.

While discussing effect of fluoride in drinking water on dental fluorosis, one major confounder may be for those who stay currently in high or normal fluoride areas but at the time of the permanent dentition (first 6 years of their life) may not be staying there and, therefore, would be misleading the analysis. To

correctly interpret the data, we need to have the exact information of their stay at the time of dentition. Alternatively, we restricted the analysis to those who were staying in the same villages since birth. For re-analysis, the study population was excluded for those who have not been staying in the respective villages from the birth. The difference in dental caries decreased while difference in dental fluorosis increased justifying the need for removing the confounder in the analysis. The crude, and age and sex adjusted relative risk also increased for dental fluorosis for high fluoride area. Further, it also indicates that fluoride in water is more a risk factor for fluorosis than a protective factor for dental caries.

In conclusion, our findings showed that the risk of dental fluorosis was significantly higher in the areas showing more fluoride content in drinking water and to a lesser degree of dental caries in the same area. There was also an increased problem of dental fluorosis with the passage of time. It is recommended to reduce the fluoride content of drinking water in the high fluoride area by making either alternative sources available or providing water with reduced fluoride content.

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