OSTEO-DENTAL FLUOROSIS IN RELATION TO NUTRITIONAL STATUS, LIVING HABITS, AND OCCUPATION IN RURAL TRIBAL AREAS OF RAJASTHAN, INDIA

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SUMMARY: A cross-sectional survey of 18,621 adults of both sexes living in rural tribal areas of the Dungarpur and Udaipur districts of Rajasthan, India was conducted to correlate the prevalence of osteo-dental fluorosis with nutritional status, living habits, and occupation. The mean fluoride (F) concentration in drinking water sources ranged from 1.0 to 6.1 ppm. Among subjects with poor nutrition, the prevalence of dental fluorosis rose to 61.6% and skeletal fluorosis to 23.9%. A high incidence of fluorosis was also observed in subjects using substances such as alcohol, betel nuts, citrus fruits, edible ghee or fat, tea, and tobacco. The highest incidence of dental (90.1%) and skeletal (60.8%) fluorosis was observed in alcohol or beverage users and the lowest (30.8% and 8.9%) in the citrus fruits users, respectively. Subjects with different occupations exhibited a variable incidence of dental and skeletal fluorosis. Labourers showed the highest incidence of dental and skeletal fluorosis (63.1% and 26.2%), followed by farmers (61.2% and 21.8%), housewives (57.1% and 13.2%), businessmen (54.2% and 14.4%), students (54.2% and 9.5%), and servicemen (51.5% and 15.9%), respectively. These data pertaining to the relationship of osteo-dental fluorosis with nutritional status, living habits, and occupation were statistically analysed and found to exhibit highly positive correlations. Possible causes for differences in the incidence of fluorosis in relation to nutritional status, habits, and occupation are discussed.

Keywords: Fluoride water; Fluorosis and occupation; Fluorosis in Rajasthan, India; Living habits; Nutritional status; Osteo-dental fluorosis.

INTRODUCTION

Dental and skeletal fluorosis have been widely reported in areas where the fluoride (F) content in drinking water is high.[1] In India this problem is endemic in several states.[2-3] In Rajasthan, people in almost all the districts, especially in rural areas, are adversely affected with fluorosis.[4-7] In these areas domestic animals are also affected with fluorosis.[8-11] Although the prevalence of fluorosis in relation to the concentration of F in drinking water has been widely reported, studies on the occurrence of fluorosis in relation to other variables such as age, sex, and certain dietary components are also of interest.[12-17] Because the incidence of fluorosis in relation to nutritional status, use of certain foodstuffs, and occupation of subjects has had only limited study, the present survey-type investigation was undertaken to determine the relationship of dental and skeletal fluorosis to nutritional status, living habits, and occupation in two F endemic districts of Rajasthan.

MATERIALS AND METHODS

Our study was conducted in 73 villages (Table 1) of the Dungarpur and Udaipur districts in Rajasthan, India, which are predominantly inhabited by tribal

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populations using dug wells and hand pumps and a few seasonal ponds as the main sources of their drinking water.

Table 1. Villages surveyed in Dungarpur and Udaipur districts of Rajasthan, India

District	Panchayat Samiti	Number of villages	Names of villages (Mean F level in the drinking water source)
Dungarpur	Aspur	10	Jogiwara (1.1), Munged (1.5), Jhariyana (1.8), Bodigam (2.4), Punjpur (2.9), Mal (3.3), Dhundha (3.5), Kabja (3.7), Pindawal (4.0) and Ghunta (4.4)
	Bichhiwara	4	Rampur (1.1), Buvela (1.2), Vagdari (1.8) and Vadepal (3.2)
	Dungarpur	10	Navatapra (1.2), Lolakpur (1.5), Faloz (2.7), Dovada (2.8), Vikaspur (3.0), Ragunathpura (3.2), Mandavpal (3.8), Naraniya (5.2), Genhuwara (5.8) and Samota (6.1).
	Sagwara	18	Thakarda (1.0), Akhepur (1.3), Gamda (1.4), Bhimdadi (1.7), Bhasaur (2.0), Jethana (2.2), Bhachadiya (2.3), Mavita (2.5), Virsingpur (2.6), Padra (2.6), Kariyana (2.7), Padampura (2.9), Samaliya (3.1), Kahela (3.4), Padava (3.5), Saroda (4.2), Bhavanpura (4.8), and Karada (5.0)
	Simalwara	2	Sithal (1.0) and Bhemai (1.5).
Udaipur	Kherwara	4	Banjaria (1.4), Kalyanpur (1.6), Hodi (2.4) and Bhalunguda (4.4).
	Salumbar	13	Kheda (1.0), Manpur (1.2), Matasula (1.5), Randela (1.9), Seriya (2.3), Noli (2.9), Alpur (3.1), Kalyakala (3.2), Salumber (1.9), Jhalara (4.0), Tharoda (4.0), Mandli (4.2), and Kalutada (5.4).
	Sarada	12	Pipla (1.1), Kunda (1.2), Bori (1.4), Kejad (1.5), Chavand (1.6), Karadia (1.8), Sagatara (2.3), Surkand Kheda (2.8), Pandar (3.1), Dhakarda (3.5), Dekali (4.7), and Khajuria (5.8).
	Total	73	

The mean F concentration in these drinking water sources, estimated spectrophotometrically by the alizarin method,[18] varied from 1.0 to 6.1 ppm compared to the recommended maximum permissible limit of 1–1.5 ppm.[19-20] For the collection of data pertaining to the incidence and severity of fluorosis, a cross-sectional survey was made covering 18,621 individuals (both sexes) residing in these villages. A questionnaire was designed to collect information regarding names, sex, age, occupation, nutritional status (good, fair, and poor), dietary habits, and clinical symptoms of dental and skeletal fluorosis.[1,3] For skeletal fluorosis, adults over the age of 21 who had lived in one of the villages for at least 15 years were included in the study.

RESULTS

Fluorosis in relation to nutritional status and habits: Villagers with "poor" nutritional status showed the highest incidence of dental and skeletal fluorosis, whereas those with good and fair nutritional status had the lowest (Table 2). The correlations were analysed statistically and found to be highly positive (r = +1). As seen in Table 3, a high incidence of dental and skeletal fluorosis was observed for habitual users of tea, tobacco, betel nuts, and/or alcoholic drinks, whereas a relatively a very low incidence of fluorosis was observed among users of citrus fruits and ghee. The statistical correlation between the incidence of dental and skeletal fluorosis in users (r = +1) and non-users (r = +0.7857) were also found to be highly positive.

In relation to occupation: Although subjects of the studied areas have a variety of occupations, but on the basis of the types of work, they have been divided into six groups, viz., businessmen, farmers, housewives, labourers, servicemen, and students. From the data in Tables 4 and 5, it is clearly evident that labourers of both districts showed the highest incidence of dental fluorosis and servicemen the

lowest. However, the percentage of subjects with severe dental fluorosis (Table 5) was in the order: labourers > farmers > businessmen > servicemen > housewives > students.

Table 2. Incidence (%) of fluorosis in relation to nutritional status

Nutritional status	Dental fluorosis (D.F.)			Skeletal fluorosis (S.F.)		
	District		Total	District		Total
	Dungarpur	Udaipur		Dungarpur	Udaipur	
Good	571/986 (57.9)	204/678 (30.1)	775/1664 (46.6)	52/498 (10.4)	14/260 (5.4)	66/758 (8.7)
Fair	940/1406 (66.9)	405/1118 (36.2)	1345/2524 (53.3)	134/693 (19.3)	58/533 (10.9)	192/1226 (15.7)
Poor	6579/8813 (74.7)	2305/5620 (41.0)	8884/14433 (61.6)	1278/4105 (31.1)	352/2716 (13.0)	1630/6821 (23.9)
Total	8090/11205 (72.2)	2914/7416 (39.3)	11004/18621 (59.1)	1464/5296 (27.6)	424/3509 (12.1)	1888/8805 (21.4)

Figures in parentheses indicate percentage. Correlation coefficient between prevalence of dental and skeletal fluorosis, r = +1 (highly positive).

Table 3. Incidence (%) of fluorosis in relation to certain dietary substances

Dietary substance	Dental fluorosis (D.F.)		Skeletal fluorosis (S.F.)	
	Users	Non-users	Users	Non-users
Alcoholic drinks	3114/3456 (90.1)	7890/15165 (52.0)	1292/2125 (60.8)	596/6680 (8.9)
Betel nuts	5486/7319 (75.0)	5518/11302 (48.8)	1119/3679 (30.4)	769/5126 (15.0)
Citrus fruits	617/2003 (30.8)	10387/16618 (62.5)	84/947 (8.9)	1804/7858 (23.0)
Ghee (Fat)	2742/5714 (48.0)	8262/12907 (64.0)	266/2701 (9.8)	1622/6104 (26.6)
Tea	9597/13928 (68.9)	1407/4693 (30.0)	1716/6885 (24.9)	172/1920 (9.0)
Tobacco	3491/4364 (80.0)	7513/14257 (52.7)	1170/3618 (32.3)	718/5187 (13.8)

Figures in parentheses indicate percentage. Correlation coefficient between prevalence of dental and skeletal fluorosis in users r = +1 (highly positive) and in non-users r = + 0.7875 (highly positive).

Similarly, a high incidence of skeletal fluorosis (Table 4) was also observed in labourers followed by farmers, servicemen, businessmen, housewives, and students. The severity of skeletal fluorosis was proportional to the incidence, i.e., higher the incidence, higher the severity (Table 5). Grade III skeletal fluorosis was highest among labourers and farmers, whereas grade I was more common among businessmen, housewives, and students. These data when analysed statistically showed a weak positive correlation (r = 0.4857 to 0.6). However, the correlation

between the incidence of dental (r = +0.7) and skeletal fluorosis (r = +1.0) was found to be highly positive (Table 5).

Table 4. Incidence (%) of fluorosis in relation to various occupations

Occupation Group	Dental fluorosis (D.F.)			Skeletal fluorosis (S.F.)		
	District		Total	District		Total
	Dungarpur	Udaipur		Dungarpur	Udaipur	
Businessmen	180/276 (65.2)	58/163 (35.6)	238/439 (54.2)	50/276 (18.1)	13/163 (8.0)	63/439 (14.4)
Farmers	1761/2362 (74.6)	599/1496 (40.0)	2360/3858 (61.2)	462/1678 (27.5)	124/1006 (12.3)	586/2684 (21.8)
House wives	698/996 (70.1)	242/649 (37.3)	940/1645 (57.1)	112/671 (16.7)	34/438 (7.8)	146/1109 (13.2)
Labourers	3076/3971 (77.5)	1252/2885 (43.4)	4328/6856 (63.1)	743/2125 (35.0)	221/1548 (14.2)	964/3673 (26.2)
Servicemen	258/406 (63.5)	91/272 (33.5)	349/678 (51.5)	81/406 (20.0)	27/272 (9.9)	108/678 (15.9)
Students	2117/3194 (66.3)	672/1951 (34.4)	2789/5145 (54.2)	16/140 (11.4)	5/82 (6.1)	21/222 (9.5)
Total	8090/11205 (72.2)	2914/7416 (39.3)	11004/18621 (59.1)	1464/5296 (27.6)	424/3509 (12.1)	1888/8805 (21.4)

Figures in parentheses indicate percentage. Correlation coefficient between incidence of dental and skeletal fluorosis in relation to occupations in Dungarpur district r = + 0.4857 (less positive); Udaipur district r = + 0.6 (Positive); total r = + 0.5571 (Positive).

Table 5. Severity (%) of fluorosis in relation to occupations

Occupation Groups	Dental fluorosis (D.F.)						Skeletal fluorosis (S.F.)			
	D.F.$^{+ve}$ Subjects	Questionable	Very-mild	Mild	Moderate	Severe	S.F.$^{+ve}$ Subjects	Grade I	Grade II	Grade III
Labourers	4328/6856 (63.1)	164 (3.8)	468 (10.8)	972 (22.5)	1126 (26.0)	1568 (36.2)	964/3673 (26.2)	152 (15.8)	253 (26.2)	559 (58.0)
Farmers	2360/3858 (61.2)	176 (7.5)	341 (14.4)	376 (16.0)	830 (35.2)	634 (26.9)	586/2684 (21.8)	152 (25.9)	138 (23.5)	296 (50.5)
Servicemen	349/678 (51.5)	50 (14.3)	58 (16.6)	89 (25.5)	80 (22.9)	72 (20.6)	108/678 (15.9)	33 (30.6)	35 (32.4)	40 (37.0)
Businessmen	238/439 (54.2)	30 (12.6)	48 (20.2)	74 (31.1)	36 (15.1)	50 (21.0)	63/439 (14.4)	24 (38.0)	17 (27.0)	22 (34.9)
Housewives	940/1645 (57.1)	167 (17.8)	174 (18.5)	350 (37.2)	113 (12.0)	136 (14.5)	146/1109 (13.2)	59 (40.4)	48 (32.9)	39 (26.7)
Students	2789/5145 (54.2)	862 (30.9)	685 (24.6)	496 (17.8)	371 (13.3)	375 (13.4)	21/222 (9.5)	14 (66.7)	7 (33.3)	-
Total	11004/18621 (59.1)	1449 (13.2)	1774 (16.1)	2360 (21.4)	2556 (23.2)	2865 (26.0)	1888/8805 (21.4)	434 (23.0)	498 (26.4)	956 (50.6)

Figures in parentheses indicate percentage. Correlation coefficient between incidence and severity of dental fluorosis r = 0.7 (highly positive); skeletal fluorosis r = +1.0 (highly positive).

DISCUSSION

In the rural areas of the present study, dominated by tribal populations with smaller numbers of scheduled castes (SC) and general castes (GC) populations. Tribals are mostly illiterate and socio-economically backward and poor in the society as well as are genetically different from non-tribal SC and GC subjects. The tribals are predominantly farmers and labourers and generally drink more water, thereby maximizing their F intake.[8] In addition, the tribals are genetically different from the SC and GC caste groups, and therefore may be relatively more susceptible to F toxicosis.[21] Secondly they also ingest locally made wines and tea that are additional sources of fluoride toxicity.[22-25] Subjects belonging to other occupation groups also drink wine, beverages, and tea, but the nutrient value of their diets and socio-economic status vary greatly. Hence, variation in the incidence and severity of F toxicosis (fluorosis) is likely. In farmers and labourers, the nutritional value of their food is generally very poor and therefore deficiency of vitamins and other dietary components is possible which can decrease or increase F absorption/intoxication.[1] It is well known that milk, curd, and some vegetables are rich in calcium, whereas citrus fruits and leafy vegetables contain vitamin C. Both these nutrients and fat (ghee and domestic oils) reduce F absorption.[1] Subjects having these food stuffs in their diet (good nutritional status), the incidence and severity of fluorosis are less than in subjects having only fair and poor nutritional status (Tables 2 and 3). This indicates that poor nutrition exacerbates F toxicity.

The incidence and severity of fluorosis varied greatly among different occupation groups. Such differences have been observed in different castes having their own kinds of professions; Kumhars are severely affected by dental fluorosis followed by Muslims, Brahmins, Jat, Harijans, and Barbers.[26] These variations are probably due mainly to differences in nutrition. But other factors, depending on the type of occupation, can have a significant role in the aggravation of fluorosis. In labourers and farmers the severity of fluorosis is much greater than in servicemen and businessmen (Table 5) and is less in housewives and students. Other investigators[8,26] have observed and reported a maximum incidence and severity of skeletal fluorosis in farmers and hardworking subjects. Those studies indicate that, in addition to nutrition and physical work, intrinsic individual genetic differences contribute to the degree of F intoxication. The present study significantly expands this area of our knowledge of F toxicosis.

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