RISK FACTORS ASSOCIATED WITH THE PREVALENCE OF FLUOROSIS INTHE ENDEMIC AREA OF PUNJAB (BATHINDA DISTRICT)

ABSTRACT

Aim: To assess the risk factors associated with the prevalence of fluorosis in the endemic area of Punjab.

Study design: The fluorosis endemic area of Punjab state was purposively selected for assessment of risk factors associated with it**.**

Place and duration of study: The study was conducted in rural and urban areas of Bathinda district during January 2021 to March 2021

Methodology: A sample of 140 subjects were selected randomly consisting of 70 males and 70 females each from both the rural and urban area of Bathinda district. An interview schedule cum questionnaire was designed to collect general, dietary and clinical information of the respondents. The degree of dental fluorosis was assessed using ICMR index [1].

Results: It was revealed that among the rural subjects, majority of respondents were suffering from grade 1 fluorosis (38.57%) followed by grade 0 (37.14%), grade 2 (18.57%) and grade 3 (5.71%). Whereas among urban subjects, majority of respondents were free from fluorosis (58.57%) followed by grade 2(34.28%), grade 1 (21.42%) and grade 3 (5.71%). Age and the duration of stay in the endemic area were found to be positively correlated with the incidence of fluorosis. The higher number of subjects having heavy or moderate lifestyle were suffering from grade 2 and grade 3 of fluorosis, whereas majority of sedentary respondents were free from fluorosis and suffering from grade 1 of fluorosis. A negative correlation was observed with the per capita income of the selected subjects, i.e., with the increasing income the prevalence of fluorosis decreased. Excessive intake of tea and alcohol was also associated with the severity of fluorosis. Among various micro nutrients, the intake of Calcium, phosphorus, magnesium and ascorbic acid was found to be significantly ($P<0.05$) different in the subjects with various grades of fluorosis.

Conclusion: Water is the primary source of fluorine intake by humans, but there are many predisposing factors that aggravate the condition for fluorosis, which can be avoided by taking diet rich in calcium and anti-oxidants in addition to water with permissible level of fluorine. The higher prevalence in the rural area as compared to urban area might be due to more consumption of tea and alcohol by respondents belonging to rural area.

Key words:*Endemic, Fluorosis, Prevalence, Risk factors, Co-relation, Bathinda*

INTRODUCTION

Fluoride is an element naturally occurring in soil and mostly found in water becauseof its geological origin and is released into the water due to weathering or volcanic activity. The amount of fluoride in soil that occurs naturally depends mainly on climate, composition,host rock and hydrology. Several human activities increase fluoride in the atmosphere including chemical manufacturing plant, waste pits, aluminum, steel, glass, enamel, concrete,tile, pottery and cement production and chemical containing fluoride production. Fluorine isbeneficial to one as it avoids dental caries and is purposely added to water in certain parts of USA.

Excessive ingestion of Fluorine compounds can result in major health disorders like dental fluorosis, skeletal fluorosis and non-skeletal fluorosis. The dental effects are shown much earlier than the skeletal effects. Skeletal fluorosis affects the bones and major joints of the body like neck, back bone, shoulder, hip and knee joints resulting in to severe pain, rigidity or stiffness in joints. Non-skeletal forms of fluorosis are earlier manifestations, which develop long before the onset of typical changes in teeth and skeletal bones, these are seen as gastro-intestinal symptoms and sometimes might be misdiagnosed due to overlapping with other diseases.

Fluorosis is caused by excessive intake of fluorides from multiple sources such as food, water, air and excessive use of toothpaste. However, drinking water is the most significant source. Moderatelevelof chronic exposure (above 1.5 mg/liter of water) is more common. Acute high-level exposure to fluoride is rare and usually occurs due to accidental contamination of drinkingwater or due to fires or explosions. Water with high levels of fluoride content are mostly found at the foot of high mountains and in areas where geological deposits are collected in sea. Once fluoride enters the body either through the blood vessels in the mouth or through the gastrointestinal route, it reaches the various organs and tissues in the body [2]. Fluoride toxicity results in dental and skeletal fluorosis. It also damages nervous system causes gastro-intestinal problems, anemia and pregnancy defects. Considering the seriousness of this national problem, the study of precipitating factors that causes fluorosis is of paramount importance. Bathinda was chosen as the area for study as it lies in the endemic belt of Punjab.

Fluorosis is a significant public health issue in twenty-four countries, including India, which is situated in the geographical fluoride belt that stretches from Turkey to China and Japan across Iraq, Iran, and Afghanistan [3]. In today's world, more than 200 million people are under the terrible fate of fluorosis [4].In context of India, this problem of fluorosis is now spread in twenty provinces affecting more than six crore sixty lakh people. As a consequence of fluoride toxicity 6 lakh people might develop a neurological disorder [5]. In India fluorosis is mainly due to excessive fluoride in water except in parts of Gujarat and Uttar Pradesh where industrial fluorosis is also seen. The desirable limit of fluoride as per Bureau of Indian Standards (BIS) is 1ppm. Rajasthan, Gujarat and Andhra Pradesh are worst affected states.

Punjab, Haryana, Madhya Pradesh and Maharashtra are moderately affected states while Tamil Nadu, West Bengal, Uttar Pradesh, Bihar and Assam are mildly affected states.

The prevalence of fluorosis has been found to be associated with some other risk factors including calcium deficiency, fluoridated toothpastes, beverages. fluoride-rich foods such as tea, foods contaminated with post-harvest fumigants and pesticides. Fluorosis has also been found more prevalent in males than females as most of the males are involved in field jobs and labour, which lead to more consumption of water. The late stages of skeletal and dental fluorosis are permanent and irreversible in nature and are detrimental to the health of an individual and the community, which in turn has adverse effects on growth, development & economy of the country.

Considering the seriousness of this national problem, the present study was conducted to investigate the precipitating factors that causes fluorosis particularly in the endemic areas.

MATERIALS AND METHODS

The study was conducted in Bathinda district from which four areas were randomly selected namely Jassi Baghwali, Gehri Bhagi, Model town and Dhobiana Basti. It was selected because of reported prevalence of fluorosis in this district in the literature. A total of 140 respondents compromising of 70 adults (35 males and 35 females) in the age group of 30-50 years were selected by random sampling method from rural and urban area each of Bathinda district. An interview schedule cum questionnaire was developed to elicit data pertaining to general information, dietary information, clinical symptoms etc. The data was collected by personally interviewing the respondents who were willing to give information after explaining them the purpose of the study. Dietary intake of subjects was recorded for three consecutive days by “24-hour recall method” to assess the food intake of the subjects. The average daily nutrient intake was calculated by using Indian nutritive software DietCal [6]. Prevalence of dental fluorosis was recorded using ICMR Index [1]. Data collected was used to analyze relationship of various factors like age, occupation, sex, socio-economic status, tea, alcohol and nutrients with the prevalence of fluorosis.

RESULTS AND DISCUSSION

Prevalence of fluorosis

Dental fluorosis is an enamel hypo-mineralization characterized by high porosity of the surface and sub-surface than normal enamel due to excess fluoride intake.On comparison of the data from rural and urban area, it was observed that in the urban area, more subjects were free from fluorosis (Table 1) with a statistically significant(P<0.05) difference. The similar trend of higher number of respondents suffering from various grades of fluorosis was also observed among those belonging to rural area. In rural area 11.42% male respondents and in the urban area 5.71%. male respondents were affected by grade 3 of dental fluorosis and no

female respondent was reported to be affected by severe grade of fluorosis. The prevalence rate of fluorosis in the present investigation wasfound to be in the range as reported indifferent states of India. A prevalence of dental fluorosis ranging from 30-94.85%in the Jhajjar district of Haryana state has been reported by Yadav *et al* (2009) [7]. Similarly, a prevalence of 59.31% of dental fluorosis has been reported by Kotecha *et al* (2012) [8] in the high fluoride area of Gujarat state.Further, various predisposing factors chiefly age, occupation, duration of stay in endemic area etc. affecting the prevalence of fluorosis were also investigated and their correlations with the incidence of fluorosis were also determined.

Table 1 : Prevalence of various grades of fluorosis among the selected subjects from rural and urban areas. (N=140)

Grading	Rural (n=70)				Urban (n=70)				
	Males	**Females**	**z-value**	**Total**	**Males**	**Females**	**z-value**	**Total**	**z-value**
Grade 0	10 (28.50)	16 (45.71)	-1.304^{ns}	26 (37.14)	18 (51.42)	23 (65.71)	-0.928^{ns}	41 (58.57)	-2.537*
Grade 1	15 (42.85)	12 (34.28)	0.642^{ns}	27 (38.57)	8 (22.85)	7 (20)	0.273^{ns}	15 (21.42)	2.13*
Grade 2	6 (17.14)	7 (20)	-0.291^{ns}	13 (18.57)	7 (20)	5 (14.28)	0.603^{ns}	12 (34.28)	0.220
Grade 3	4 (11.42)	0	2.029*	4 (5.71)	2 (5.71)	0	1.424^{ns}	2 (5.71)	0.834

Figures in parenthesis represents percentages

*Significant at 5% level

NS - non significant

Age

The prevalence and severity of dental fluorosis was found to be higher with the increase in the age, asthe majority of the respondents who were free from fluorosis and suffering from Grade 1 fell in the age group of 30-35 years. Furthermore, it was observed that the respondents suffering from severe form of fluorosis i.e., grade 2 and grade 3 were significantly higher in the age group of 46-50 years. (Table 2). Akuno *et al* (2019) [9] had also stated that the prevalence and severity of dental fluorosis increases with age and health deterioration in the people above 35 years of age tends to be faster towards the skeletal fluorosis.

Table 2: Age-wise distribution of prevalence of various grades of dental fluorosis.

Age	Grade 0	Grade 1	Grade 2	Grade 3
30-35	26 (38.80)	17 (38.09)	-	-
36-40	19 (28.35)	13 (30.09)	7 (28)	

41-45	12 (17.91)	5 (11.90)	7 (28)	1 (16.66)
46-50	10 (14.92)	7 (19.04)	11 (44)	5 (83.33)
χ^2 Value	9.477*	8.66*	10.44*	11.33*

*Significant at 5% level

Figures in parenthesis represents percentages.

Occupation:

The incidence of fluorosis has also been to be affected by the type of occupation.The data presented in Table 3 depicts that the maximum numberi.e., 73.13% of subjects who were free from dental fluorosis (Grade 0) and grade 1 of fluorosis (69.04%) were in the category of sedentary workers. However, majority of the heavy workers i.e 72% and 83.33% were suffering from grade 2 and grade 3 of the dental fluorosis. The reason for which might be higher level of water consumption among heavy and moderate workers due to strenuous activities in the sun in comparison to sedentary workers. Raj and Umayorubhagan (2013) [10] had reported that the percent distribution of dental fluorosis varied significantly according to the profession of the selected subjects in Agastheeswaram Union (Tamil Nadu, India). Sharma et al (2013) [11] reported that farm laborers were more prone to develop fluorosis than those engaged in sedentary occupations. Similar findings had been reported by Choubisa et al (2009) [12] that the highest incident of dental and skeletal fluorosis was observed among laborers followed by farmers, housewives, businessmen, students and servicemen. The higher prevalence among heavy and moderate workers might be due to more work in the sun and more consumption of water (that has fluorine content above the permissible limit). However, a study conducted by Shruthi and Anil (2018) [13] reported no influence of caste, occupation and education on the prevalence of dental fluorosis.

Table 3: Prevalence of dental fluorosis among selected subjects according to their occupation

Occupation	Grade 0	Grade 1	Grade 2	Grade 3
Heavy	6 (8.95)	3 (7.14)	18 (72)	5 (83.33)
Moderate	12 (17.91)	10 (22.80)	5 (20)	1 (16.66)
Sedentary	49 (73.13)	29 (69.04)	2 (8)	-
χ^2 Value	48.56*	25.85*	17.36*	7*

* Significant at 5% value

Figures in parenthesis represents percentages

Duration of exposure:

One of the important factors in prevalence of dental fluorosis is the duration of stay in the endemic area. The residents of the fluorosis endemic area continuously consuming fluorinated water are most likely to develop mottled enamel. The results of the present study were in concordance with the

above stated facts. As evident from Table 4 significant number of respondents free from fluorosis (44.77%) had been staying in the endemic area for less than 10 years, whereas the majority of the respondents suffering from grade 2 (72%) and grade 3 (83.33%) had been the residents of endemic area from more than 20 years.Bharati and Rao (2003) [14] reported that a minimum period of 6 years of stay was predisposing for dental fluorosis to manifest and 11 years for skeletal fluorosis. Similarly, degree of fluorosis was associated with duration of stay in the endemic area in a study conducted by Kloos and Haimanot (2019) [15]. Gupta et al (2008) [16] observed that progressive evolution of clinical features correlates with the duration of stay in the endemic fluorosis villages.

Table 4:Duration of stay and prevalence of fluorosis in the endemic area

Length Of Stay	Grade 0	Grade 1	Grade 2	Grade 3
Below 10 Years	30 (44.77%)	13 (31.77%)	1 (4%)	0
11-20 Years	11 (16.41%)	8 (17.07%)	6 (24%)	1 (16.66%)
Above 20 Years	26 (38.80%)	21 (51.21%)	18 (72%)	5 (83.33%)
χ^2 Value	8.98*	6.14*	18.32*	8.66*

*Significant at 5% level

Figures in parenthesis represents percentages

Economic status:

The economic status of a family/individual isone of the majordeterminants of quantity and quality of diet. The expenditure on the protective and luxurious food increases as the income increases. Fluorosis has been found to be more common in low economic group because of the reason that diets of these people are deficit in many nutrients. More than 90% of the people who were suffering from severe fluorosis belonged to low socio-economic status as reported by Teotia and Teotia (1984) [17]. In the present study also similar kind of trends was observed as evident from Table 5.Maximum number of the subjects who were suffering from grade 3 of dental fluorosis had monthly income below USD 128. However, among the subjects having monthly income above USD 256 majority of them were either free from fluorosis or suffering from grade 1. Shruthi and Anil (2018) [13] reported a statistically significant association between socio-economic status and occurrence of dental fluorosis.

Table 5: Income wise distribution of the various grades of fluorosis among selected subjects.

INCOME	GRADE 0	GRADE 1	GRADE 2	GRADE 3
BELOW 10,000	9 (13.43)	4 (9.52)	19 (76)	5 (83.33)
11000-20000	26 (38.80)	18 (42.85)	6 (24)	1 (16.66)
ABOVE 20000	32 (47.76)	20 (47.61)	0	0
χ^2 Value	12.74*	10.85*	22.64*	8.66*

*Significant at 5% level

Figures in parenthesis represents percentages

Source of water:

Consumption of water containing large amount of fluoride has been reported to be primary cause of fluorosis as reported several years ago. The data collected in present study revealed that significantly higher percentage of respondents free from fluorosis were drinking RO (reverse osmosis) water followed by respondents drinking water-works water. Grade 1 of fluorosis was significantly higher in respondents drinking RO water (80.95%) followed by respondents drinking waterworks water (11.90%) and tube-well water (7.14%). A significantly higher percentage of respondents suffering from grade 2 (68%) and grade 3 (100%) of fluorosis were drinking tube-well water.

Table 6: Prevalence of various grades of dental fluorosis according to the source of drinking water

SOURCEOF DRINKING WATER	GRADE 0	GRADE 1	GRADE 2	GRADE 3
RO	58 (86.56)	34 (80.95)	4 (16)	0
TUBEWELL	0	3 (7.14)	17 (68.00)	6 (100)
WATERWORKS	9 (13.43)	5 (11.90)	4 (16)	0
χ^2 Value	87.25*	43*	13.52*	18*

*Significant at 5% level

Figures in parenthesis represents percentages

Apart from the above stated general factors, some of the dietary factors such as tea and alcohol consumption along with some of the micro nutrients has been found to be associated with the prevalence of fluorosis.

Tea and Alcohol:

A significant association was found between intake of tea and fluorosis as out of all the commonly consumed foods, the highest fluoride content was in the tea (59.72±0.05 μg/g). As the daily tea intake increased, a significant progression in the grade of fluorosis was also observed as depicted in Table 7 and 8. A significant difference (p,0.05) in the intake of tea by the respondents having different grades of fluorosis was recorded. The data was collected during the months of winter, which might account to more consumption of tea. Plaka *et al* (2017) [18] had also observed a statistically significant association of fluorosis with consumption of tea. Similarly, intake of alcohol and fluorosis were also found to be significantly ($p<0.05$) associated. A significant difference ($p<0.05$) was observed in the intake of alcohol by respondents having different grades of fluorosis.

Table 7: Mean daily intake of tea and alcohol among selected males (n=70)

Food groups	Rural				Mean ± SD	Urban				Mean ± SD
	Grade 0	Grade 1	Grade 2	Grade 3		Grade 0	Grade 1	Grade 2	Grade 3	

Tea	450[a] ±155.99	750.57[b] ±115.54	983.33[c] ±68.31	1325[d] ±95.74	749.4 ±384.35	208.88[a] ±160.37	594.44[b] ±88.19	850[c] ±91.28	1275[d] ±106.06	497.14 ±347.88
Alcohol	120.50[a] ±22.04	182.85[b] ±35.23	375.17[c] ±8.01	550.25[d] ±11.81	239.7 ±94.97	26.47[a] ±26.32	92.77[b] ±7.94	177.14[c] ±18.22	307.5[d] ±24.74	89.71 ±82.36

a, b, c, d represents significant difference at 5% level

Values represent Mean± SD

Table 8: Mean daily intake of tea and alcohol among selected females (n=70)

Food groups	Rural				Mean ± SD	Urban				Mean ± SD
	Grade 0	Grade 1	Grade 2	Grade 3		Grade 0	Grade 1	Grade 2	Grade 3	
Tea	350.14[a] ±79.92	640.9[b] ±104.44	914.29[c] ±110.73	-	405.29 ±328.85	175[a] ±145.36	625[b] ±116.49	787.5[c] ±47.87	-	352.42 ±192.34

a, b, c, d represents significant difference at 5% level

Values represent Mean± SD

Nutrient	Rural	Mean ±	Urban	Mean ±

Consumption of nutrients:

The minerals viz calcium, phosphorus and magnesium play an important role in bone development. Ascorbic acid acts as an antioxidant which protects against the oxidative damage caused by fluoride compounds. From the findings of the study as depicted in Table 9 and 10 and Fig. 1,2,3 and 4 it was observed that there was a significant difference in the intake of calcium, phosphorus, magnesium and ascorbic acid among the subjects suffering from various grades of fluorosis. Flourine being an electronegative element, gets attracted by positively charged ions like calcium. Bone and teeth contain the highest amount of calcium in the body, which attract the maximum amount of fluoride and is deposited as calcium fluorapatite crystals. At the same time, from certain areas in the bone and tooth, the unbound calcium is lost.

	Grade 0	Grade 1	Grade 2	Grade 3		Grade 0	Grade 1	Grade 2	Grade 3	
Calcium	1081.11[a] ±205.59	705.94[b] ±40.26	468.37[c] ±14.47	237.37[d] ±10.38	718.86 ±298.18	941.87[a] ±83.64	678.76[b] ±101.29	486.37[c] ±86.12	281.63[d] ±69.11	745.38 ±232.588
Phosphorus	871.1[a] ±161.97	569.3[b] ±46.33	378.5[c] ±40.26	193.7[c] ±51.76	579.6 ±337.38	759.1[a] ±191.5	546.7[b] ±164.05	393.5[bc] ±198.20	226[c] ±144.09	600.1 ±334.60
Magnesium	541.69[a] ±98.81	352.57[b] ±42.59	234.99[c] ±17.10	124.26[c] ±40.07	354.24 ±147.48	421.04[a] ±23.65	334.09[b] ±18.734	243.95[c] ±13.298	140.59[d] ±13.51	365.2 ±46.60
Ascorbic acid	209.41[a] ±10.49	167.27[b] ±8.09	129.48[c] ±8.95	102.10[c] ±8.20	165.38 ±36.66	242.05[a] ±19.13	192.63[bc] ±10.52	158.6[bc] ±13.25	125.58[c] ±18.46	206 ±42.18

Table 9: Mean Daily nutrient intake among selected males (n=70).

a, b, c, d represents significant difference at 5% level

Values represent Mean± SD

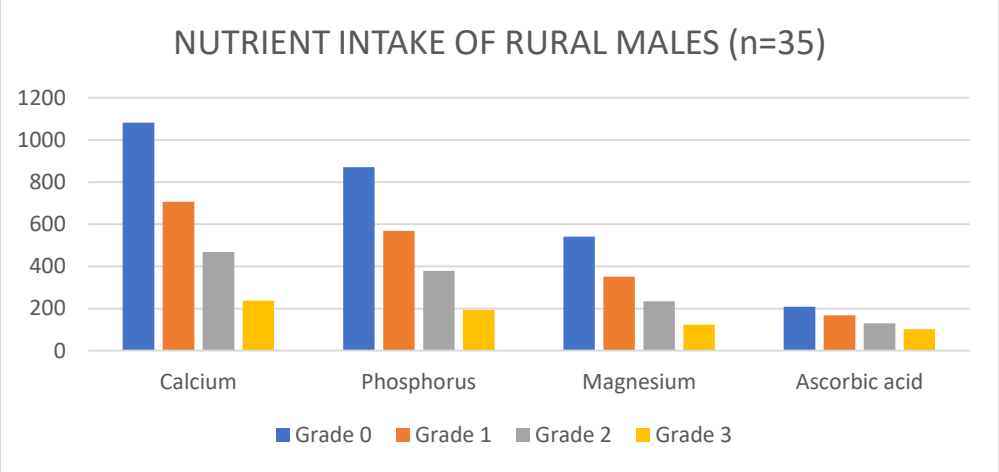

Fig. 1: The nutrient intake of the selected rural male subjects (n=35)

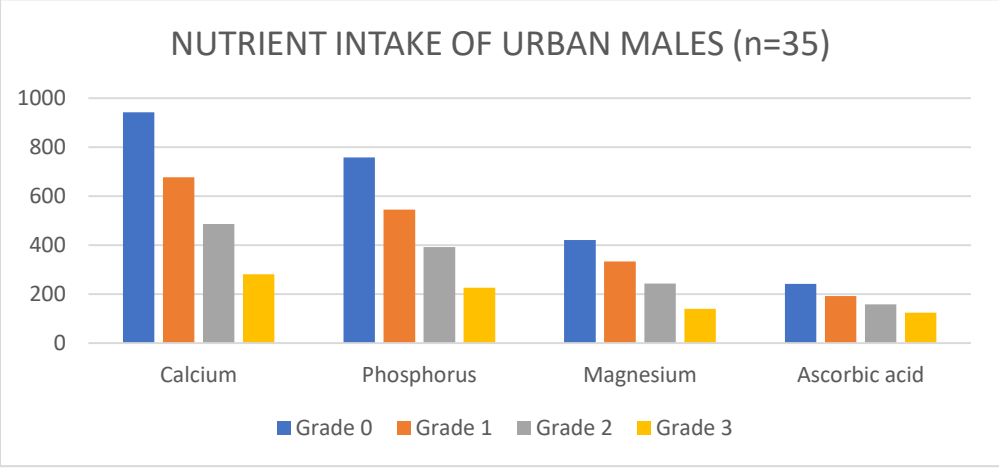

Fig. 2: The nutrient intake of the selected urban male subjects (n=35)

Table 10: Mean daily intake of micro nutrients among selected females (n=70)

Nutrient	Rural				Mean± SD	Urban				Mean± SD
	Grade 0	Grade 1	Grade 2	Grade 3		Grade 0	Grade 1	Grade 2	Grade 3	
Calcium	778[a] ±91.20	691.55[b] ±79.54	310.57[c] ±11.33	-	669.26 ±187.62	770.91[a] ±10.38	590.24[b] ±58.73	270.68[c] ±42.93	-	663.4.26 ±180.16
Phosphorus	627.3[a] ±431.39	562.1[b] ±172.75	250.7[c] ±158.24	-	540.9 ±605.99	623.4[a] ±53.26	475.2[b] ±78.85	218.8[c] ±40.39	-	534.6 ±337.34
Magnesium	389.41[a] ±15.08	340.12[b] ±9.66	150.02[c] ±10.95	-	339.5 ±38.47	370.74[a] ±33.05	270.84[b] ±16.95	135.28[c] ±18.34	-	331.28 ±144.52
Ascorbic acid	162.67[a] ±18.54	132.0[b] ±10.32	83.33[c] ±10.97	-	128.1 ±39.27	225.26[a] ±22.74	196.15[b] ±10.91	137.71[c] ±6.52	-	206.90 ±36.16

a, b, c, d represents significant difference at 5% level

Values represent Mean± SD

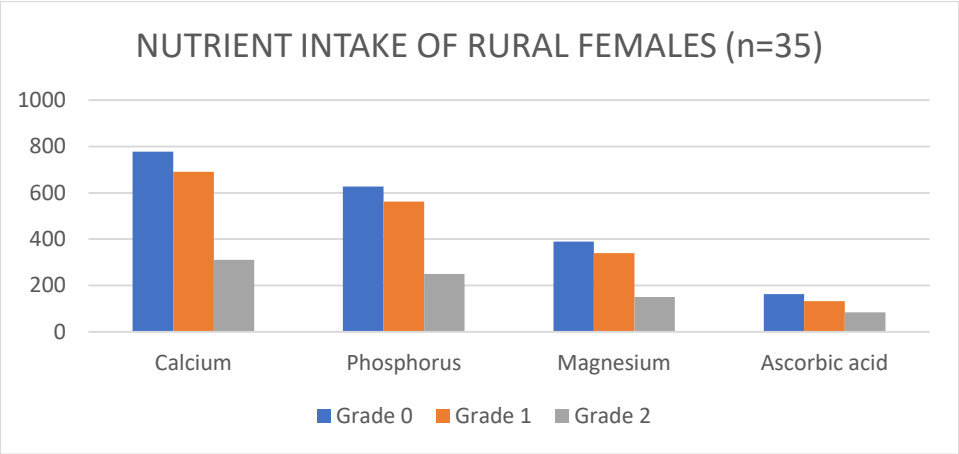

Fig. 3: The nutrient intake of the selected rural female subjects (n=35)

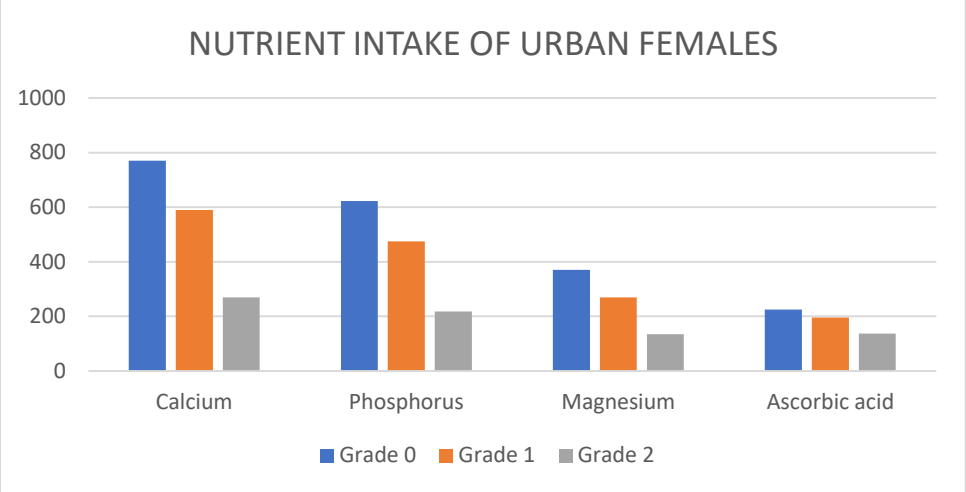

Fig. 4: The nutrient intake of the selected urbanfemale subjects (n=35)

It is the excessive intake of fluorine that results in fluorosis combined with other secondary factorsand Fig.5 depicts the fluorine intake of respondents. The intake of fluorine increased significantly with the increase in the severity of fluorosis. The minimum intake was observed in respondents who were free from fluorosis i.e. 5.17 and 5.04 mg/day for rural male and female respectively. The maximum intake was observed in the rural males (15.28 mg/day) followed by urban males (14.25 mg/day) suffering from grade 3 fluorosis.It has been reported by Lennon *et al* (2004) [19] that there was clear evidence from India and China that skeletal fluorosis and an increased risk of bone fractures occurred as a result of long-term excessive exposure to total fluoride intake of 14 mg/day and evidence is suggestive of an increased risk of bone effects at total intake above about 6 mg fluoride per day.

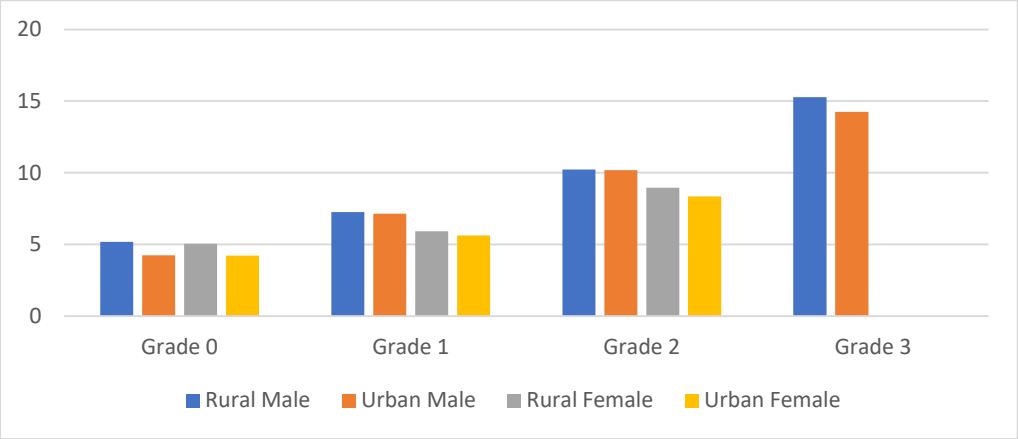

Fig 5: Fluorine intake by the selected subjects according to the various grades of fluorosis

Conclusion

Fluorosis still continues to be a challenging problem in the endemic areas. However, population living in these areas are not aware of the factors causing fluorosis. So, there is a need to pay attention towards imparting nutrition education in the endemic areas. The population in these areas should be made aware about the protective role of foods against fluoride toxicity such as fruits, vegetables (rich in ascorbic acid) and milk and milk products (rich source of calcium and magnesium).

Consent

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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