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Risk factors associated with dental fluorosis in Central Plateau State, Nigeria

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Abstract – *Objectives:* Dental fluorosis is known to occur in some parts of Plateau State, but the factors responsible for its occurrence are unknown. The purpose of this study, therefore, was to determine the factors associated with the occurrence of dental fluorosis in Central Plateau. *Methods:* The study was cross-sectional and comparative in design. Subjects were selected using the multi-stage sampling technique. One Local Government Area each was randomly selected from the high and low altitude parts of the district, and from each selected Local Government Area two health districts were randomly selected with probability proportional to size. From each of the selected health districts two major settlements were selected again with probability proportional to size. Twelve- to fifteen-year-old lifelong residents of the selected settlements were then selected for study. Each respondent completed an interviewer-administered questionnaire after which he/she was clinically examined to ascertain his/her fluorosis status. Samples of water were collected from water sources consumed by the respondents in each settlement. *Results:* One thousand one hundred children aged 12–15 years were studied, 554 (50.4%) of which lived in the high altitude part of the district and 546 (49.6%) in the low altitude part of the district. Fluorosis prevalence was significantly associated with altitude and the fluoride level of water. The prevalence of fluorosis was significantly associated with altitude ($\chi^2 = 85.735$, d.f. $= 1$, $P < 0.0001$) and the fluoride level of water (χ^2 for trend $= 8.009$, d.f. $= 1$, $P < 0.05$) in the low altitude parts of the district. None of the respondents had used fluoride-containing toothpaste before 4 years of age and none used fluoride supplements. *Conclusion:* The occurrence of dental fluorosis in Central Plateau could be because of the high altitude of the area and the fluoride concentration of the waters consumed in the district.

Key words: Central Plateau; dental fluorosis; risk factors

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In the past, it was believed that dental fluorosis occurred, almost exclusively, in individuals who have resided in areas with optimal or high fluoride in the drinking water. However, in recent times, fluorosis occurrence has become more widespread and its prevalence has increased even in areas with fluoride-deficient water supplies (1). The increased use of fluoride in preventive dentistry has been suggested as the possible explanation (2).

Although drinking water is by far the greatest source of fluoride ingestion by man, other sources like beverages, toothpastes, infant formula, fluoride supplements, food tenderizers/condiments and sea foods have contributed to increased background fluoride exposure in many countries (3–5). These other sources may be responsible for the occurrence and high prevalence of dental fluorosis in areas with fluoride-deficient water supplies. In addition, high altitude has been shown to be a risk factor for fluorosis in East Africa (6, 7).

Apart from the high fluoride intake from the food tenderizing 'magadi', a condiment that is consumed in East Africa and which has much higher fluoride than the drinking water consumed

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there, no sources of fluoride, other than drinking water, appears to have been reported in African countries. In addition, the use of fluoride in preventive dentistry is rather uncommon to many African communities, even where endemic dental fluorosis is prevalent (8). In Plateau State, Nigeria, dental fluorosis is known to occur in several communities in Langtang North, Langtang South, Wase and Pankshin Local Government Areas, but the factors responsible for its occurrence in the region are unknown although drinking stream water has been reported to be associated with the occurrence of the condition in Langtang town (9).

The purpose of this study was to determine the prevalence of dental fluorosis among 12- to 15-year-old children in Central Plateau and the risk factors associated with its occurrence.

Materials and methods

The Central Plateau Senatorial District is composed of five administrative councils (Local Government Areas): Bokkos, Kanam and Mangu which have relatively low altitude (about 1000 m above sea level), and Kanke and Pankshin which have relatively high altitude (about 1700 m above sea level). From the high altitude part of the district, Pankshin Local Government Area was randomly selected. Two health districts, Chip and Pankshin township, were randomly selected from the six health districts in the Local Government Area by sampling with probability proportional to size. From each of the selected health districts, two major settlements, Pankshin central and Dokfai in Pankshin health district, and Chip village and Shoro in Chip health district were selected, again by sampling with probability proportional to size. From the low altitude part of the district, Mangu Local Government Area was randomly selected and the same procedure was followed to select Ampang West and Kerang from Kerang health district, and Sabon-layi and Mangu central from Mangu health district. In each settlement, selection of households was performed using the expanded programme on immunization's modified cluster sampling technique (10). In each selected household, all the 12- to 15-year-old children who were lifelong residents of the communities and who gave their consent were examined. One hundred and thirty-eight children were required from each cluster (selected settlement), totalling 1100.

Ethical clearance and informed consent

Approval for the conduct of the study was obtained from the ethical committee of Jos University Teaching Hospital. Approval was also obtained from the traditional rulers (Mai-Angwa) of the various villages after an explanation of the aims and benefits of the project. Consent for participation of our subjects was obtained verbally from their parents/guardians and the subjects themselves. This was necessary because they were minors.

Selection of subjects

Eligibility criteria included lifelong residence in the selected communities and age of 12–15 years old. This information was obtained from the parents/guardian, and was confirmed with the child. An interviewer-administered structured pretested questionnaire, which enquired about the socio-demographic characteristics of the subjects, their sources of water supply, diet, use of fluoride toothpaste before 6 years of age and use of fluoride supplements, was completed by each subject before he/she was clinically examined.

Clinical examination

One trained dentist examined the children under field conditions. During the examination, the child was seated on a chair in a shade. Indirect natural light was used for illumination. The surfaces of the teeth were not specially cleaned. Presence and severity of dental fluorosis was assessed on the buccal/labial surfaces using the Thylstrup and Fejerskov (TF) index. Efforts were made during the history and oral examination to rule out other enamel abnormalities apart from fluorosis. About 10% of the children were re-examined for reliability tests. The intra-examiner reliability was 0.9 (Kappa statistic).

Fluoride exposure from water

Drinking water samples were collected in polyethylene bottles from water sources consumed by the study subjects and analysed for fluoride concentration using the SPADNS reagent solution method, a spectrophotometric method that is as sensitive and specific as the ion selective electrode method. All water samples were collected during one season (at the height of the dry season, in April). Statistical analyses were carried out using the Statistical Package for Social Sciences. Chi-square test for trend was used to test for the existence of association between fluorosis prevalence and fluoride levels of drinking water.

Results

Fluoride exposure

Fluoride supplements

None of the study subjects had used fluoride supplements.

Fluoride toothpaste

None of the children used fluoride-containing toothpaste before 6 years of age.

Diet

The diets of all the children were basically the same types of foods that were grown in similar soil. The condiments were also the same. The fluoride content of the different foods was not determined.

Fluoride exposure from water

Water for drinking and domestic purposes in this district is obtained from four major sources: well, stream, bore hole and pipe borne. The pipe borne water is available only in one community in the entire district; even here the supply is so erratic that no household depends entirely on it for their drinking and domestic water supply. However, most of the subjects obtained their drinking water from one major source and for the majority of them; this was the well or stream. Only 11.3% got their drinking water from more than one source. The fluoride exposure from drinking water for those who obtained their drinking water from more than one source was estimated by taking the mean of the fluoride concentration of the different sources. The mean fluoride concentration of water consumed in the high altitude part of the district was significantly lower than that consumed in the low altitude part ($t = 2.70$, d.f. = 21, $P < 0.05$) (Table 1). However, the difference is clinically insignificant.

Altitude

Five hundred and fifty-four (50.4%) study subjects lived at high altitude (mean height above sea level = 1700 m) while five hundred and forty-six (49.6%) lived at low altitude (mean height above sea level = 1000 m).

Dental fluorosis

Dental fluorosis was present in 12.9% of the children examined, most of them had TF score 1 (7.7%). The highest TF score was TF 5. The prevalence of fluorosis was significantly associated with altitude ($\chi^2 = 85.74$, d.f. = 1, $P < 0.0001$) and the fluoride level of water (χ^2 for trend = 8.009, d.f. = 1, $P < 0.05$) (Tables 2 and 3). To be sure that fluorosis prevalence is actually associated with the fluoride level of drinking water; the confounding effect of altitude was controlled by stratification. When this was carried out, the prevalence of fluorosis was found to be significantly associated with the fluoride level of water only in the low altitude areas (χ^2 for trend = 6.275, d.f. = 1, $P < 0.05$) but not in the high altitude areas ($\chi^2 = 1.719$, d.f. = 1, $P > 0.05$) (Tables 4 and 5).

Table 1. Comparison of the mean fluoride levels of water in the high and low altitude parts of the Central Plateau Senatorial District

	Fluoride concentration (ppm)				
Water source	high altitude	low altitude	*T*-value	d.f.	*P*-value
Well	0.69 ± 0.09	0.70 ± 0.16	−1.31	10	>0.05
Stream	0.67 ± 0.03	0.76 ± 0.04	3.68	6	<0.05
Borehole	0.59 ± 0.00	0.65 ± 0.05	−1.56	2	>0.05
Total	0.68 ± 0.004	0.71 ± 0.018	2.70	21	<0.05

Table 2. Comparison of the prevalence of fluorosis in the high and low altitude parts of the Central Plateau Senatorial District

	High altitude			Low altitude		
	Presence of fluorosis	Absence of fluorosis	Total	Presence of fluorosis	Absence of fluorosis	Total
Tooth 11	123 (22.2%)	431 (77.8%)	554 (100%)	19 (3.5%)	527 (96.5%)	546 (100%)
Tooth 14	132 (23.8%)	422 (76.2%)	554 (100%)	21 (3.8%)	525 (96.2%)	546 (100%)

$\chi^2 = 85.735$; d.f. = 1; $P < 0.0001$.

Table 3. Prevalence of fluorosis according to fluoride levels in the Central Plateau Senatorial District

Fluoride level (ppm)	Absence of fluorosis	Presence of fluorosis	Total
Very low	38 (3.7%)	–	38 (3.7%)
Low	27 (2.6%)	5 (0.5%)	38 (3.1%)
Moderate	733 (71.7%)	114 (11.2%)	847 (82.9%)
High	100 (9.8%)	5 (0.5%)	105 (10.3%)
Total	898 (87.9%)	124 (12.1%)	1022 (100.0%)

χ^2 for trend = 8.009; d.f. = 1; $P < 0.05$.

Table 4. Prevalence of fluorosis according to fluoride levels in the high altitude parts of the Central Plateau Senatorial District (stratified analysis)

Fluoride level (ppm)	Absence of fluorosis	Presence of fluorosis	Total
Very low	–	–	–
Low	23 (4.8%)	3 (0.6%)	26 (5.4%)
Moderate	352 (73.3%)	102 (21.3%)	454 (94.6%)
High	–	–	–
Total	375 (78.1%)	105 (21.9%)	480 (100.0%)

There is no significant relationship between fluoride levels and prevalence of fluorosis in this part of the district.
χ^2 = 1.719; d.f. = 1; P = 0.190.

Table 5. Prevalence of fluorosis according to fluoride levels in the low altitude parts of the Central Plateau Senatorial District showing trend relationship between fluoride levels and prevalence of fluorosis

Fluoride level (ppm)	Absence of fluorosis	Presence of fluorosis	Total
Very low	37 (6.8%)	1 (0.2%)	38 (7.0%)
Low	4 (0.7%)	2 (0.4%)	6 (1.1%)
Moderate	381 (70.3%)	9 (1.7%)	390 (72.0%)
High	101 (18.6%)	7 (1.3%)	108 (19.9%)
Total	523 (96.5%)	19 (3.5%)	542 (100.0%)

χ^2 for trend = 6.275; d.f. = 1; $P < 0.05$.

Discussion

The main findings of this cross-sectional study are that altitude and the fluoride levels of water are risk factors for the occurrence of dental fluorosis in Central Plateau. Fluorosis prevalence was significantly higher in the high altitude parts of the district than the low altitude parts whose waters contained higher levels of fluoride. Although fluorosis prevalence was found to be significantly associated with the fluoride level of water as shown in Table 3, this relationship could not be linear because stratified analysis to control for the confounding effect of altitude revealed that fluorosis prevalence is not significantly associated with the fluoride level of water in the high altitude part of the district which account for most of the fluorosis in the district (Tables 4 and 5). This suggests that other risk factors apart from fluoride exposure from water may be responsible for the occurrence of dental fluorosis in those areas. As the use of fluoride supplements is rare in African communities such as this and none of the study subjects used fluoride-containing toothpaste at an early age when they would have swallowed a significant amount of it to have systemic effect, it is likely that the high altitude of the areas may be responsible for the occurrence of fluorosis there. Moreover, altitude was found to be significantly associated with the prevalence of fluorosis in the area.

Although the fluoride content of foods and condiments used by this population was not determined, the food types are the same and are grown in similar soil and as such, their fluoride content is not expected to differ significantly. Whitford, while discussing the mechanism of dental fluorosis, maintained that fluoride balance and its tissue concentration, and hence the risk of fluorosis, are increased by factors such as residence at high altitude (11). This may be the mechanism by which high altitude causes fluorosis. It has also been reported that in the absence of fluoride exposure residence at high altitude *per se* can have profound disruptive effects on amelogenesis that could be confused with dental fluorosis (12). In this study, however, efforts were made using history and clinical examination to rule out other enamel changes apart from fluorosis before classifying the teeth as fluorotic, as such enamel hypoplasia may not explain the results obtained. The increased prevalence of fluorosis found in the high altitude part of the district (when compared with the low altitude one) could be better explained by the added risk for fluorosis caused by residence at high altitude since this is known to increase the risk (odds) of fluorosis.

The findings of this study are in agreement with those of previous works including that of Akpata and colleagues in North-Central Nigeria (13), and Yoder and colleagues in Tanzania (14), both of which found a significant association between altitude and the prevalence of dental fluorosis.

Although several other studies have reported significant association between altitude and the prevalence and severity of dental fluorosis, there is none in which altitude was found to be the sole risk factor. In this study, the fluoride level of water is also significantly associated with the prevalence of fluorosis in the low altitude parts of the district although this area accounts for a small proportion of the fluorosis burden of the district. This also agrees with the finding of other workers including that of MC Kay and Dean in 1934, Tsutsui et al. in Japan in1987 and Riordan in 1993 (15–20).

The reproducibility test of the clinical examination showed substantial agreement and no evidence of systematic error. We were not able to carry out any reliability tests of the interviews and cannot rule out recall bias, but systematic bias in the different altitude areas is unlikely. We were also not able to determine the fluoride content of the different foods and condiments consumed in the area; and if this is substantial, it might contribute to the occurrence of fluorosis.

Water samples for fluoride analysis were collected at the same period, at the height of the dry season. The fluoride level of water sources could vary with the season, but as water samples were collected from the different sources in the different parts of the district at the same period this is not expected to introduce any systematic error (21).

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