ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 15, Issue, 08, pp.25577-25584, August, 2023
DOI: https://doi.org/10.24941/ijcr.44781.08.2023

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

EXPLORING THE INFLUENCES OF ALTITUDE AND FERTILIZERS ON FLUOROSIS PREVALENCE IN NIGERIAN CHILDREN

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ARTICLE INFO

Article History:
Received 19th May, 2023
Received in revised form
15th June, 2023
Accepted 17th July, 2023
Published online 30th August, 2023

Key words:

Fluorosis, Altitude, and Fertilizers.

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ABSTRACT

Dental fluorosis, an under reported public health problem the world over impacts 11.4% of the population in Nigeria. It is caused by successive exposure to high fluoride concentrations during tooth development and is linked to the development of a variety of psychological and physiological problems: dental aesthetics, reduction in intelligence and skeletal changes. The purpose of this quantitative, cross-sectional study was to explore the influences of altitude and use of fertilizers in cropping in the development of dental fluorosis in children in a rural community in Nigeria. A multilevel theoretical model was used to identify possible fluoride exposure pathways that impact childhood oral health. The study was guided by 2 main research questions: What is the prevalence of fluorosis among Nigerian school-aged children? What is the association of this prevalence with the prevailing influences of altitude and use of fertilizers in cropping? Data was collected by administering surveys, on children aged 5 to15 years and their parents/guardians. Chi-square tests were used to test for possible associations. The study findings showed a fluorosis prevalence rate of 86.6% in the 269 school children surveyed, with majority of these children between the ages of 8 to 13 years. There was no significant association of fluorosis prevalence with altitude in the population, however the association with the use of fertilizers requires further research. This study's possible impact on social change include raising awareness to this problem as well encouraging the cautious use of fertilizers in cropping.

Citation: ***Ogbudu Gabriel Ada, MB BCH, MPH, PhD.* 2023.** "Exploring the Influences of Altitude and Fertilizers on Fluorosis Prevalence in Nigerian Children*". International Journal of Current Research*, 15, (08), 25577-25584.

INTRODUCTION

The impact of heights and use of fertilizers have been suggested as other pathways for fluoride absorption and thus associated with the development of dental fluorosis in children (Fejerskov, Manji & Baelum, 1990; Pandey & Pandey, 2011). Dental fluorosis which presents as hypoplasia of tooth enamel is caused by absorption of fluoride during mineralization of teeth under formation (Fejerskov *et al*., 1990). Thus any exposure to fluoride, whether systemic or topical, can result in dental fluorosis. The exposure pathway of fluorosis may be due to accidental exposure or from endemic sources. The various exposure pathways for fluoride absorption into the body include water, food, soil, air, topical application, and climate. High altitude and weather have been identified as pathways because of increased ingestion of fluoride caused by variations in daily water consumption due to the effect of temperature (Fejerskov *et al*. 1990). Fluoride contamination of the environment and food chain has been reported from agricultural application of pesticides and fertilizers (Pandey and Pandey, 2011). Furthermore, it has been stated that industrial activities, such as those of phosphate fertilizer factories, aluminum factories and glass fiber factories tend to produce air borne fluoride in their vicinities leading to its inhalation and consequent enhanced human exposure (Pandey & Pandey, 2011). These authors linked such industrial activities to the higher prevalence of fluorosis in the rural areas where these activities were taking place. The present study area is hilly and mountainous, and the weather is usually hot except during the short period of rain lasting about 4 months (Ambinkanme, Sale, Ahmed, Peters & Magaji, 2014). Since no other studies on fluorosis have been conducted in this area, this study sought to examine whether the high altitude and temperature may favor the development of fluorosis, as noted by Fejerskov and colleagues (1990). In addition, as majority of the population are subsistent farmers who more likely apply fertilizers in their farms to improve the yield, the study sought to establish an association between farming practices such as the use of fertilizers in cropping, and the development of fluorosis. This will help guide the institution of programmes that can ameliorate the damage caused by the adverse health effects of fluorosis in the population.

Such health effects include disabilities such as psychological effects from the aesthetics of teeth, lowered intelligence, skeletal changes and, overall poor quality of life. Psychological disabilities as a result of aesthetic concerns has been shown to be a cause for concern in 2.1% to 3.3% of children with mild fluorosis (Saravanan *et al*., 2008; Laurence, Lewis, Dixon, Redmayne & Blinkhorn, 2012). Even of greater concern, is the effect of fluorosis on the mental development of children as, children in endemic areas are at risk of impaired development of intelligence, Saxena, Sahay and Goel (2012). Furthermore, exposure to fluorosis is linked to the development of skeletal fluorosis which is known to increase with age (Cao *et al*., 1996). These health concerns require concerted efforts to mitigate the effect in fluorosis endemic population as in the study area. The prevalence of dental fluorosis varies across the different regions of the world depending on the prevailing factors favoring the absorption of fluoride. For example, the rate in Nigeria is 11.4% in the urban settlement of Ibadan (Ajayi, Arigbede, Dosunmu, & Ufomata, 2012), while in rural India, the rate is 31.4% (Saravanan *et al*., 2008). Also in china, the rate was 52% and 84% in the Mongol, Kazak, and Yugu areas of the Gansu Province (Cao *et al*., 1997). The prevalence is even higher in those areas of the world with high volcanic activity such as Lake Elementaita in Kenya and Ambrym Island in the Vanuatu archipelago (Kahama, Kariuki, Kariuki, & Njenga, 1997; Allibone *et al*., 2012). The social change implications of this study involves designing programmes that can help mitigate the problem of fluorosis. In doing this, a systematic approach in identifying the various pathways of fluoride absorption in the community is required. This is achieved by utilizing the children oral health model as foundation (see Fisher-Owens *et al*., 2007). This model comprises of 22 domains of influences that can be used to assess children's oral health.

Study Objectives: The purpose of this quantitative, cross-sectional study was to examine how children fluorosis in the Zing local government area, a rural settlement in northern Nigeria is influenced by altitude and the use of fertilizers in farms. This was done to assess the extent that environmental factors can contribute to the development of fluorosis.

The testable independent variables examined were the following: for altitude (farming locations of valley, low land, hilly site) and use of fertilizers for cropping.

Research Question(s) and Hypotheses

Research Questions

The research questions for the study were as follows:

- What is the prevalence of dental fluorosis in children ages 5 to 15 years in the Zing community?

H_0^1 **Null hypothesis:** The prevalence of dental fluorosis in children ages 5 to 15 years in the Zing community is negligible.

H_A^1 **Alternative hypothesis:** The prevalence of dental fluorosis in children ages 5 to 15 years in the Zing community is significantly high.

- Is there an association between the presence of fluorosis among children in the Zing community and the location of farming sites?

H_0^1 **Null hypothesis:** There is no association between the presence of fluorosis among children in the Zing community and the location of farming sites.

H_A^1 **Alternative hypothesis:** There is an association between dental fluorosis and the location of farming sites.

- Is there an association between the presence of fluorosis among children in the Zing community and use of fertilizers in cropping?

H_0^1 **Null hypothesis:** There is no association between dental fluorosis in children and use of fertilizers in farms.

H_A^1 **Alternative hypothesis:** There is an association between dental fluorosis and use of fertilizers in farms.

Method

Study Participants: The study participants were children 5 -15 years of age, both male and female, and their parents. The children were selected by systematic random selection of every third child from eight public primary schools whose parents gave consent to participate in the study, and who met the selection criteria across the six grade levels at each of the schools. At minimum, four pupils were selected from each grade level in each of the eight schools in the study area, thereby ensuring that at least 24 pupils were selected from each school to make a total sample population of not less than 192. The surveys were administered in English with help from a capable community leader.

Inclusion and Exclusion Criteria: The inclusion criteria were, school children within the age bracket of 5 to15 years, and who were born and raised in the community. The inclusion of parents/guardian was based on their children selected to participate in the study.

Sampling procedures: The procedure for recruitment of participants followed the under listed steps: obtaining approval to conduct the study from the State Ministry of Education; contacting the individual head teachers and the PTA (parent teachers' association) of the participating schools and briefing them about the study and ethical issues. The selection of participants was through a systematic random selection of every third pupil from each of the grades during class roll call (from the class register) , orientation of both children and their parents on the study and agreement on the timing for the conduct established; resolution of ethical issues involved in the study such as participation was voluntary, study not affecting school day activities, the procedure for selecting participants, how the study would be conducted, and some aspects of the study that were to be repeated (i.e., dentist inspection of teeth). Consent to participate was given by both parents/guardians and children through signing the consent and assent forms. Of the 281 pupils and parents who gave consent to participate in the study, 269 participated in the study representing 95.7%. To encourage the participants, each pupil was rewarded with a biro worth#100(about $1) for participating.

The Sample Size: The sample size for the study was determined using a statistical power of 80% and an alpha level of .05 (95% CI) with an effect size of 0.3 for a small to medium effect (Cohen, 1998). This was 176 (using a "*t* test" for two independent samples), which with an additional 25% to make up for attrition, brought the sample size to 220. However, 281children and their parents were enrolled for the study. Of this, 269 participated, bringing the total sample size used to 269. In this way 12(4.3%) of the enrolled participants were lost to attrition.

Measures and Covariates

The study used the following measurement tools:

- A survey questionnaire validated by utilizing the 22 domains of influences on childhood oral health model (Fischer-Owen *et al.*, 2007) with particular focus on the community level domains i.e. physical environment such as altitude and weather, and community cultural norms and practices such as the use of fertilizers in cropping.
- The TSIF scale. This clinical scale was used by the dentist (research assistant) to grade the severity of the dental fluorosis and ranges from scale 0 to 6 (Horowitz, 1986).

The questionnaire was checked for content, empirical and constructs validity and the reliability was assessed by conducting a pilot test of the questionnaire in a similar population.

Data Collection: The survey was conducted by a face to face administration of the questionnaire to the participants in English and data collected using three research assistants: a dentist, and two assistants for the administration of the questionnaire. The helpers were oriented on study procedures, data collection procedures, eligibility to participate, administration of the consent form, and proper administration of the survey questionnaire.

The Study Design: The study design was a quantitative, cross-sectional survey that involved administering two separate surveys. The first assessed the presence of dental fluorosis in children in the study area, the second sought to understand family and neighborhood influences on childhood fluorosis. The purpose of these surveys was to help answer the three research questions listed above. The study was exploratory as it looked at associations between variables that had occurred thereby allowing an establishment of an association between the variables under study. The study variables were the presence of dental fluorosis as a dependent variable; while the community factors associated with oral health at the childhood level were the independent variables.

RESULTS

The study findings as they address each of the research questions and hypothesis are presented below.

Participant flow: Of the 281 pupils and parents who gave consent to participate in the study, 273 of the children and, 263 parents responded to the questions, which translate to 97% and 93.6% of participation respectively. 23 parents/guardians were re-contacted at the data sorting and analysis stage, in order to provide information on missing data, thereby necessitating a second field visit. Following from above, the criteria for the sample selection for each student were applied which resulted in the exclusion of 4 students from the study for not meeting the criteria. Therefore, analysis of the results was conducted on 269 children and their parents/guardian.

Recruitment: It was a field survey that lasted from May 2017 to June 2017 and in January 2018. It involved the generation of primary data. Some of the activities in the recruitment processes include: explaining to the parents, teachers, and pupils that a study was being held and further addressing the selected participants. Thereafter, consent and assent forms were administered to selected participants as stated in the methods. To correctly elicit responses, the parent that could communicate freely and clearly with the researcher was preferred for the administration of the questionnaire. Although this was different from the earlier plan, where mothers would have had the first preference. Administering this way allowed for better capturing of the parent's responses. In this way, 36% of responses were provided by the mothers and 63.6% by the fathers which may bias the responses. Also, following the interest shown in the study, more participants were enrolled than initially anticipated. This markup helped in addressing the problem of attrition.

Data Analysis: For data analysis process of collating, sorting, and coding of the data points from the questionnaire, I utilized the excel spread sheet in entering all the data points of the participants. In this way, all the variables in the study were entered for each participant, such as age, sex, occupation of parents, farming site, do you use fertilizer in cropping, and severity of dental fluorosis. I thereafter used the following software; SPSS, and Winpepi software as statistical tools for analysis of the data (Green & Salkind, 2011). For the descriptive statistics, the characteristics of the study population were presented in frequency tables. Considering that this study involved mostly categorical variables, frequency count, percentages, and charts were used to present the data. For measures of association, a chi-square statistic was used for tests of association. To answer the research questions and related hypotheses, the following statistical tests were carried out.

Hypothesis 1: The prevalence of dental fluorosis in children 5 to 15 years of age in the Zing community is high when compared with the standard TSIF scale developed by Horowitz in conjunction with Dean's fluorosis scale, a frequency count of the fluorosis in children was taken.

Hypothesis 2, and 3: There is an association between dental fluorosis and the variables of altitude, and the use of fertilizers in farms, a chi-square test was used to analyze if there were statistical associations in order to make inferences.

The assumptions for testing the hypotheses were (1) the two variables should be measured at an ordinal or nominal level (i.e., categorical data) and (2) the variables should consist of two or more categorical independent groups. To comply with the underlying assumptions, I ensured that both the dependent and independent variables were measured at a nominal level. I made sure that the value in the cell expected was not less than 5 in at least 80 % of the cells and that no cell had expected of less than 1.

Study Findings: The study findings are presented below according to the research questions and hypothesis. It begins with (a) description of the sample using frequency, percentages, charts, means, to examine the children and parents'/guardian characteristics; and (b) examination of the research questions and testing of hypothesis focusing on the inferential analysis using chi-square test.

Student characteristics: Table 1, shows the demographic information of the children participants. The gender frequency is 136 (50.6%) as male and133 (49.4%) as female. In terms of their ages, 47 (17.5%) of the children were aged 5 to 7 years, 99 (36.8%) were aged 8 to 10 years, 86 (31.9%) were aged 11 to 13 years, and 37 (13.8%) were aged 14 and 15 years. These age-related percentages are comparable across gender; mean age for male 10.6 ± SD 2.90 and for female 9.8 ± SD 2.60, $p = 0.025$ showing that the male children were slightly older than the female (Appendix A). Regarding class grades, 29 (10.8%) of the children were in Grade 1, 37 (13.8%) in Grade 2, 50 (18.6%) in Grade 3, 48 (17.8%) in Grade 4, 31 (11.2%) in Grade 5, and 75 (27.9%) in Grade 6. These grades related percentages are comparable across gender and there was no significant difference between the gender distribution across the grades, $p = 0.10$ (Appendix B). Table 1 also, shows a fluorosis prevalence rate of 86.6%. and, those without fluorosis 13.4%. The mean age of children with fluorosis was 10.20 ± SD 2.68, and those without fluorosis was10.80 ± SD 3.22. The test of significance was *p* value 0.181 (Appendix C), indicating that there was no significant difference in the age of those children with fluorosis and those without fluorosis. Furthermore, the Table, shows that the age group with the highest proportion of fluorosis was the 8 to10 years-old followed by the 11 to13 years-old. This means that 70.8% of the children diagnosed with fluorosis were between the ages of 8 to13 years (Figure 1)

Table 1. Children Characteristics

Variable	Frequency	Percentage
Gender		
Male	136	50.6
Female	133	49.4
Total	269	100.0
Age in years		
5-7 years	47	17.5
8-10 years	99	36.8
11-13 years	86	31.9
14-15 years	37	13.8
Total	269	100.0
Class grade		
Grade 1	29	10.8
Grade 2	37	13.8
Grade 3	50	18.6
Grade 4	48	17.8
Grade 5	30	11.2
Grade 6	75	27.9
Total	269	100.0
Diagnosis of Fluorosis?		
Yes	233	86.6
No	36	13.4
Total	269	100.0

Note: 4 students in class grades 1 and 5 were dropped during data sorting for not meeting criteria. Age-related percentages across gender differed significantly, mean (male, 10.63 ± 2.86; female, 9.88 ± 2.60), *p* value of 0.025 (Appendix A), Class grade-related proportions across gender were similar for male and female *p* value 0.10 (Appendix B).

Figure 1 shows that the age group with the highest proportion of fluorosis was the 8 to10 years-old followed by the 11 to13 years-old. This means that 70.8% of the children diagnosed with fluorosis were between the ages of 8 to13 years.

Parents/guardians characteristics*:* Table 2 presents the information on the parents of the sampled children. The gender distribution shows that 171 (63.6%) respondents were male, while 98 (36.4%) were female. 1 (0.4%) respondent was less than 11 years of age, 6 (2.2%) respondents were between 11 to 20 years of age, 63 (23.4%) respondents were between 21 to 30 years of age, 88 (32.7%) respondents were between 31 to 40 years of age, 81 (30.1%) respondents were between 41 to 50 years of age, 24 (8.9%) respondents were between 51 to 60 years of age and 6 (2.2%) were above 60 years of age. As regard the highest educational status in the household, the table shows that 56 (21.9%) respondents had degrees, 3 (1.1%) had a diploma or NCE, 138 (51.3%) had completed secondary education, 32 (11.9%) had completed primary education, and 3 (1.1%) had no formal education. It was also observed that 228 (84.8%) practiced farming as their occupation while 41 (15.2%) did not; and 210 (78.1%) used fertilizers in farming, while 59 (21.9%) did not. This implies that most of the participants practiced farming as an occupation, and used fertilizers in farming. The use of fertilizers in farms did not significantly affect fluorosis in their children (Pearson's chi-square p = 0.179, Appendix D). However, whether parents were employed or not, significantly affected children fluorosis (p = 0.050, Appendix E).

Table 2. Parent or Guardian Characteristics

	Frequency	Percentage	Children with Fluorosis	Children without Fluorosis
Gender				
Male	171	63.6	149	22
Female	98	36.4	84	14
Total	269	100	233	36
Age				
Less than 11years plus				
11- 20 years	7	2.6	5	2
21 - 30 years	63	23.4	56	7
31 - 40 years	88	32.7	78	10
41 - 50 years	81	30.1	67	14
51 - 60 years	24	8.9	23	1
Above 60years	6	2.2	4	2
Total	269	100	233	36
Household highest education				
Degree	59	21.9	54	4
Diploma/NCE	3	1.1	2	1
Secondary	138	51.3	118	20
Primary	32	11.9	26	6
No formal education	3	1.1	2	1
No response	34	12.6	31	3
Total	269	100	233	36
Employed				
Yes	123	45.7	111	12
No	146	54.3	122	24
Total	269	100	233	36
Practice farming as occupation				
Yes	228	84.8	197	31
No	41	15.2	36	5
Total	269	100	233	36
Use fertilizers in farming				
Yes	210	78.1	185	25
No	59	21.9	48	11
Total	269	100	233	36

Note: Age < 11 years was 0.4%.

Inferential Statistics

Chi Square Results

The hypothesis tests of community level influences i.e. altitude and use of fertilizers in cropping as associated with fluorosis, showed no significant association with both, however, the level of significance with fertilizer use requires further research as can be seen in the test of hypothesis below.

Hypothesis 2

H_0: There is no association between the presence of fluorosis among children in the Zing community and cropping on hilly sites.

H_1: There is an association between the presence of fluorosis among children in the Zing community and cropping on hilly sites.

Table 3 presents the association (Survey 2) between the farm location and the presence of fluorosis among the children in the Zing Community. The results show that "1 cell (12.5%) had an expected count of less than 5 and the minimum expected was 2.28," which implies that the sample size requirement for chi-square test of independence is satisfied. The probability of the chi-square test statistic (chi-square =4.62, *p*=0.202) was greater than alpha level of significance of 0.10, which implies that there is no association between the presence of fluorosis among children and farm location. Of the 39 children who helped with cultivating land in the valley, 30 had fluorosis (76.9%); of the 169 children who helped with cultivating land on a low area, 147 had fluorosis (86.9%) and of the 22 who helped in cultivating land on hilly site, 20 had fluorosis (90.9%).

Table 3. A 2x2 Contingency Chi-Square Test of the Association Between Farm Location and the Presence of Fluorosis.

Diagnosis of fluorosis		Farm	location					
	Valley	Low land	Hilly site	None	Total	Df	X2	Sig.
Yes	30(33.8)	147(146.4)	20(19.1)	36(33.8)	233(233)			
No	9(5.2)	22(22.6)	2(2.9)	3(5.2)	36(36)	3	4.62	0.202
Total	39(39)	169(169)	22(22)	39(39)	269(269)			

*1 cell (12.5%) had an expected count (in parenthesis) of less than 5. The minimum expected count was 2.94. Chi-square conditions met. *P* > 0.05, not significant.

Hypothesis 3

H_0: There is no association between the use of fertilizers in farming and a diagnosis of fluorosis in children.

H_1: There is an association between the use of fertilizers in farming and a diagnosis of fluorosis in children.

Table 4 presents the results of the test of the relationship (Survey 2) between the use of fertilizers in farming and dental fluorosis among children. The result shows that "0 cells (0.0%) had an expected count of less than 5, and the minimum expected count was 7.90." This implies that the sample size requirement for chi-square test of independence was satisfied. The probability of the chi-square test statistic (X^2 = 3.155 and *p*=0.076) is more than the alpha level of significance of 0.05. Thus, the null hypothesis that there is no association between the use of fertilizers in farming and the diagnosis of fluorosis in children is supported. Hence, there is no significant association between the use of fertilizers in farming and fluorosis among children in the Zing community. Furthermore, of the 210 participants who used fertilizers in farming, 186 had fluorosis (88.6%) while of the 59 participants who did not use fertilizers in farming, 47 had fluorosis (79.7%).

Table 4. A 2x2 Contingency Chi-Square Test of the Association Between the Use of Fertilizers in Farming and the Presence of Fluorosis

Diagnosis of Fluorosis	The Use of Fertilizer in farming			df	X_2	Sig.
	Yes	No	Total			
Yes	156(181.9)	47(51.1)	233(233)			
No	22(28.1)	12(7.9)	36(36)	1	3.155	0.076
Total	210(210)	59(59)	269(269)			

*The minimum expected count (in parenthesis) was 7.90. Chi-square conditions met. *P* > 0.05, not significant at 95% CI.

Study Findings: This study involved a field survey of children participants aged 5 to 15 years, as well as their parents/guardians. The sample used for the study was 269 participant children. The surveys were designed to determine possible influences on children's oral health at the community level. The child participants were comprised of approximately 30 pupils from each of the 8 participating schools involved in the study and were drawn from all six grades of these primary schools. The socio demographic characteristics of the population included the following; the children were all between 5 to 15 years of age, with 68.7% of them between the ages of 8 to 13 years. 50.6% of the children were male, while 49.4% were female and the gender ratios across the various age groups were comparable. An Independent sample *t* - test shows that the mean age of children in the study was male (10.63 ± SD 2.86), and female (9.88 ± SD 2.60). This was significant at a *p* value of 0.025 (Appendix A) and indicates that the male students were slightly older than the female students.

The grades of the children involved in the study ranged from Grade 1 to Grade 6. The gender ratios across the grades were comparable, a Pearson chi-square test of these class gender characteristics were not statistically significant at *p* value of 0.10 (Appendix B) indicating that there was no significant difference between gender distributions across the grades.

The results of the study show the following: the age range of the sample was 5 to 15 years, and 50.6% of them were male and 49.4% were female. The percentage of children in the study diagnosed with fluorosis was 86.6%, indicating a high prevalence rate (Table 1). Those without fluorosis accounted for 13.6%. The age group with the highest prevalence of fluorosis was 8 to10 years (37.3%), followed by 11 to13 years (33.5%). Thus, 70.8% of children with fluorosis were between the ages of 8 to 13years (Figure1). The mean age of children with fluorosis was 10.20 ± SD 2.68, and those without fluorosis was10.80 ± SD 3.22. This was not statistically significant at *p* value of 0.181 (Appendix C), indicating that there was no significant difference in the age of children with fluorosis and those without fluorosis. Further exploratory findings in the study showed no statistical significant association between the development of fluorosis and the altitude that children work and farm (X^2 =4.62, *p*=0.202) and also the use of fertilizers in farms (X^2 = 3.155 and *p*=0.076). Although, there was no statistically significant association between fluorosis in children and the altitude and use of fertilizers, this does not rule out an association as it can be seen from various percentages of the children with fluorosis in Table 3 and 4. In addition, because of the close association of the statistical result of p=0.076 in respect of the use of fertilizers in farms and children fluorosis, caution should be exercised in interpreting the result as not significant. In this regards, further research need to be carried out.

Conclusion and Recommendations for Policy Guide: The exploratory findings in the study as it concerns its goal i.e. whether, fluorosis in this region is associated with farming locations or the use of fertilizers in farms, the findings showed no significant association with these variables in this location. However, the close association of children fluorosis with all the sites of farming i.e low land, valley or hilly sites is a cause for concern which necessitate further research. On the other hand, the close association of statistical significance established with the use of fluorosis indicates that further research should be carried out in this region. It also requires a cautious advice on the use of fertilizers in farms in this region. In designing program for fluorosis control in this population therefore, attempts should be directed at improving knowledge of farmers on exploring other methods in improving farm yield. Such efforts could also require examining the fluoride composition of common exposure agents such as foods, soil, water etc in order to identify the route of exposure. In that way, targeted measures at controlling fluorosis in the community can be instituted.

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Appendix A: Table of Mean Age of Participating Children by Gender.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Age in years	Male	136	10.632	2.8644	.2456
	Female	133	9.880	2.6084	.2262

Note: $N = 269$, $p = 0.025$ (Independent sample test).

Appendix B: Table of Gender Characteristics According by Class grade.

Gender	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Total
Male	10(14.7)	21(18.7)	26(25.3)	20(24.3)	13(15.2)	46(37.9)	136(136.0)
Female	19(14.3)	16(18.3)	24(24.7)	28(23.7)	17(14.8)	29(37.1)	133(136.0)
Total	29(29.0)	37(37.0)	50(50.0)	48(48.0)	30(30.0)	75(75.0)	269(269.0)

Note: N = 269, $X^2 = 9.236$, $p = 0.10$, expected count in parentheses.

Appendix C: Table Showing Mean Age of Fluorosis in Children.

	Diagnosis of Fluorosis	N	Mean	Std. Deviation	Std. Error Mean
Age in years	Yes	233	10.172	2.6807	.1756
	No	36	10.833	3.2205	.5367

Note: N = 269, *p* = 0.181(independent *t* – test)

Appendix D: Table of Use of Fertilizers (parents' survey) and Fluorosis in Children

Use of fertilizers	Fluorosis in children		Total
	Yes	No	
Yes	185	25	210
No	48	11	59
Total	233	36	269
Note: N=269, *p*=0.179.			

Appendix E: Table of Parents Employed and Fluorosis in Children

Employed	Fluorosis in children		Total
	Yes	No	
Yes	111	12	123
No	124	24	148
Total	233	36	269

Note: N = 269, Pearson *p* = 0.037(chi-square conditions not met), fisher exact *p* = 0.050 mid p = 0.037 (from Epi info statistical software).

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