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GENETIC AND ENVIRONMENTAL INFLUENCES ON FLUOROSIS PREVALENCE IN NIGERIA CHILDREN

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Author's note: The information and original data used in this study are adapted from the author's previous research work published as cultural and environmental determinants of dental discoloration amongst school-aged children in Nigeria. The work was self-funded and there is no conflict of interest to declare as it relates to the findings of this study which needed wider dissemination.

Abstract

Dental discoloration from fluorosis is an over looked public health problem. In Nigeria, 11.4% of the population is impacted by this disorder. Dental fluorosis caused by successive exposures to high fluoride concentrations during tooth development in utero is linked to the development of a variety of psychological and physiological problems: from dental aesthetics to a reduction in intelligence and skeletal changes. The purpose of this quantitative, cross-sectional study was to examine the influences of biological make up and environment in the development of dental fluorosis in children in a rural community in Nigeria. A multilevel theoretical model was used to develop possible fluoride exposure pathways, in order to identify such factors. The study was guided by 2 main research questions: What is the prevalence of fluorosis among Nigerian school-aged children? What is its association with the prevailing influences of age, gender, duration of residence and health behavior? Data was collected by administering surveys, on children aged 5 to15 years. 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. The severity of children fluorosis was associated with the length of stay in the study area and not gender. This study's possible impact on social change include raising awareness to this problem which is more environmental and identify possible ways to resolve it, such as through, improved dental care services and a supportive social environment like flocculation of community water sources.

Keywords: Fluorosis, Genetics, and Environment.

Introduction

Dental fluorosis presents as hypoplasia of tooth enamel. Various practices and occurrences have been associated with the development of fluorosis in humans such as from intake of fluorine through drinking water, Ando et al. (2001), geographical location, fluoride concentration of naturally fluoridated waters, contamination of surface waters by magnetic fluorine, some cultural practices, and economic factors - such as poverty, inaccessibility to municipal water supplies and lack of knowledge.

This study seeks to establish an association between biological factors such as gender, age, and, environmental factors such as length of residence, and health behavior as they relate to the development of fluorosis. This will help to give direction on how to address the damage caused by the adverse health effects of fluorosis in the population. Such health effects include disabilities such as the aesthetics of teeth and associated psychological effects; decreased intelligence; skeletal changes and, overall poor quality of life (Aguilar-Diaz, Irigoyen-Camacho, & Borges-Yanez, 2011). Aesthetic concerns from dental fluorosis was shown as 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). Of greater concern however, is the effect of fluorosis on the mental development of children as, children in endemic areas of fluorosis are at risk for impaired development of intelligence, Saxena, Sahay and Goel (2012).

Furthermore, early exposure to fluorosis leads to the development of skeletal fluorosis and the detectable rate of skeletal fluorosis has been found to increase with age, especially after age 30 (Cao et al., 1996). All these concerns are of immense significance in relation to the health status of a population in endemic fluorosis regions

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and it is important that steps should be taken to address this problem (Cao, Zhao, & Liu, 1996).

On the prevalence of dental fluorosis, this varies across the world depending on the factors highlighted. For example, in Nigeria the rate is 11.4% in the urban settlement of Ibadan (Ajayi, Arigbede, Dosunmu, & Ufomata, 2012), in rural India, the rate is 31.4% (Saravanan et al., 2008), in china, the rate was 52 and 84% in the Mongol, Kazak, and Yugu areas of the Gansu Province (Cao et al., 1997). This rate was still higher in those areas of the world with high volcanic activity such as Lake Elementaita in Kenya and Ambrym Island in the Vanuatu archipelago, with 95. 9%(Kahama, Kariuki, Kariuki, & Njenga, 1997) and 61% to 91% (Allibone et al., 2012) respectively.

The social change implications of this study involves designing programs that can help reduce the problem of fluorosis. To do so requires a systematic approach to identifying the predisposing factors in the community in order to address them. This can be achieved through the use of a tested health model. For this purpose, the children oral health model was used as foundation (see Fisher-Owens et al., 2007). This model comprises 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 age, gender, health behavior, and duration of stay of child in the environment This was done to assess the extent that genetic and environmental factors contribute to the development of fluorosis.

The testable independent variables examined were the following: for genetic and biologic endowment (age and sex of children), for development (length of stay), physical and demographic attributes (child's SES), health behaviors and practices (health seeking behavior and knowledge of disease), use of dental and dental insurance.

Research Question(s) and Hypotheses.

Research Questions

The research questions for the study were as follows:

1. 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.
2. Is there an association between the presence of fluorosis among children in the Zing community and the age of the children?
   H_0^1 Null hypothesis: There is no association between dental fluorosis in children and their age.
   H_A^1Alternative hypothesis: There is an association between dental fluorosis and their age.
3. Is there an association between the presence of fluorosis among children in the Zing community and the duration of residence of the children?
   H_0^1 Null hypothesis: There is no association between dental fluorosis in children and duration of residence.
   H_A^1Alternative hypothesis: There is an association between dental fluorosis and duration of residence.
4. Is there an association between the presence of fluorosis among children in the Zing community and their gender?
   H_0^1Null hypothesis: There is no association between dental fluorosis in the children and their gender.
   H_A^1Alternative hypothesis: There is an association between dental fluorosis and their gender.
5. Is there an association between the presence of fluorosis among children in the Zing community and health behavior?
   H_0^1Null hypothesis: There is no association between dental fluorosis in the children and their health behavior.
   H_A^1Alternative hypothesis: There is an association between dental fluorosis and their health behavior.

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Method

Study Participants

The study participants were children aged 5 -15 years, both male and female, and their parents. The children were drawn from eight public primary schools by systematic random selection of every third pupil whose parents gave consent and who met the selection criteria in each of the six grade levels at each of the schools. In this way, at least four pupils were selected from each grade level across the eight schools in the study area. This ensured that at least 24 pupils were selected from each school for 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

Participants were school children within the ages of 5 to15 years, born and raised in the community. The parents/guardian were selected, based on their children being selected as participants for the study.

Sampling procedures

The procedure for recruitment of participants was conducted through several steps and began by obtaining approval to conduct the study from the State Ministry of Education. This was followed by contacting the individual head teachers and the PTA (parent teachers' association) of the participating schools and briefing them about the study and ethical issues involved.

A systematic random selection of every third pupil from each of the grades during class roll call (from the class register) was carried out and these together with their parents were orientated on the study and agreement on the timing for the conduct established. Ethical issues involved in the study were pointed out and resolved, these were; that participation was voluntary, that it was not going to affect 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). Furthermore, 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 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) was 176 (using a "*t* test" for two independent samples). However, an additional 25% was added to make up for attrition, bringing the sample size to 220. In conducting the study, 281children participants and their parents were enrolled and administered questionnaires. Of this number, 269 participated, thereby bringing the total sample size used to 269. This implies that 12(4.3%) of the enrolled participants were lost to attrition.

Measures and Covariates

The study used the following measurement tools:

1. A validated survey questionnaire using the 22 domains of influences on childhood oral health model (Fischer-Owen et al., 2007) with particular focus on the five childhood domains i.e. genetic and biology, development, physical and demographic attributes, health behavior, use of dental facilities etc.
2. The TSIF. This clinical scale was used by the dentist (research assistant) to grade the severity of the dental fluorosis. This scale had been used successfully in past surveys (Horowitz, 1986). The scale ranges from 0 to 6.

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 administered face to face to the participants in English and data was collected by three research assistants and include a dentist, and two assistants for the administering of the questionnaire. All 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

This was a quantitative, cross-sectional survey involving the administration of 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 five research questions listed above.

A quantitative cross-sectional survey design was adopted to enable the assessment of an association between the variables. As this study was an exploratory one which looked at associations between variables that had occurred, there was no need for any manipulation of variables. Therefore, this study design allowed 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 factors associated with oral health at the childhood level were the independent variables. Dental caries was looked at as a covariate.

Results

This section presents the study findings as they address each of the research questions and hypothesis.

Participant flow

A total of 281 pupils and parents gave consent to participate in the study. Of this number, 273 of the children and, 263 parents responded to the questions, accounting for 97% and 93.6% participation respectively. During the data sorting and analysis stage, 23 parents/guardians were re-contacted to provide information on missing data. This second field visit held from January 10 to January 15, 2018. Thereafter, the criteria for the sample selection such as age and duration of residence in the community

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and the matching parent/guardian for each student were applied. In this way, 4 students were dropped from the study for not meeting the criteria. Arising from this, analysis of the results was conducted on 269 children and their parents/guardian, for a total of 538 participants.

Recruitment

This was a field survey that involved the generation of primary data. It lasted from the beginning of May 2017 to the end of June 2017 in the first instance and from January 10 to 15, 2018, in the second instance. The first week was focused on the recruitment processes (i.e., explaining to the parents, teachers, and pupils that a study was being held and further addressing the selected participants). Then, consent and assent forms were administered to selected participants as outlined in the methods.

There were no major discrepancies in the data collection plan from that presented in the method section, however, to elicit the correct responses from the parents/guardians, the parent who could communicate freely and clearly with the researcher was preferred for the administration of the questionnaire. This was different from my earlier plan, where mothers would have had first preference. In this way, 36% of responses were provided by the mothers and 63.6% by the fathers which may bias the responses. Furthermore, due to the interest shown in the study, more participants were enrolled in the study than the sample size initially anticipated. This markup was used to help address the problem of attrition.

Data Analysis

The data analysis process involved collating, sorting, and coding the data points generated from the survey questionnaire. I used the excel spread sheet for entering the data points of all participants. In this way, all the variables in the study were entered for each participant, such as age, sex, period of residence in the community, where do you seek treatment when sick, how do you care for your teeth daily, water source, occupation of parents, household size, and severity of dental fluorosis. I thereafter used the following software; SPSS, Epi info, and Winpepi software as statistical tools for analysis (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.

Hypothesis 2, 3, 4 and 5: There is an association between dental fluorosis and the variables of age, duration of residence, gender, and health behavior as childhood level influences, 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 characteristics; and (b) examination of the research questions and testing of hypothesis focusing on the inferential analysis using chi-square test.

Description of Sample

Frequency and Percentages

Student characteristics. Table 1 presents the demographic information for the student participants. The gender distribution shows that 136 (50.6%) of the respondents were male, while 133 (49.4%) were female. Based on age in years, 47 (17.5%) of the children were between the ages of 5 to 7 years, 99 (36.8%) between the ages of 8 to 10 years, 86 (31.9%) between the ages of 11 to 13 years, and 37 (13.8%) between the

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ages of 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 (Figure 1, Appendix A). Regarding class levels, 29 (10.8%) of the respondents were in Grade 1, 37 (13.8%) were in Grade 2, 50 (18.6%) were in Grade 3, 48 (17.8%) were in Grade 4, 31 (11.2%) were in Grade 5, and 75 (27.9%) were in Grade 6 (Figure 2, Appendix B). On feeding, 185 (69%) of the respondents ate breakfast, lunch, and dinner daily, while 83 (31%) did not. These percentages were also comparable across gender (Figure 3, Appendix C).

Furthermore, the table indicates that more of the children 99 (37.9) had lived in the community for 8 to 10 years.

Table 1
Children Characteristics

Variable	Frequency	Percentage
Gender		
Male	136	50.6
Female	133	49.4
Total	269	100
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
SES		

High	3	1.10
Middle	57	21.20
Low	209	77.70
Total	269	100.0
Eats breakfast, lunch, dinner daily		
No	83	31.0
Yes	186	69.0
Total	269	100.0
Duration of Residence		
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
How do you clean your		
teeth?	197	73.2
Toothpaste on brush	62	23.0
Chewing stick	2	0.7
Charcoal		
Toothpaste on	6	2.2
brush/chewing stick	2	0.7
None	269	100.0
Total		
Taught oral hygiene in		
school	26	9.7
No	243	90.3
Yes	269	100.0
Total		
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 (Figure 1, Appendix A), Class grade-related proportions across gender were similar for male and female *p* value 0.10 (Figure 2, Appendix B), and there was no difference in percentage among gender for who eats breakfast, lunch, and dinner daily, *p* value 0.817 (Figure 3, Appendix C).

Figure 1 below presents a chart of the age profiles of the participants by gender

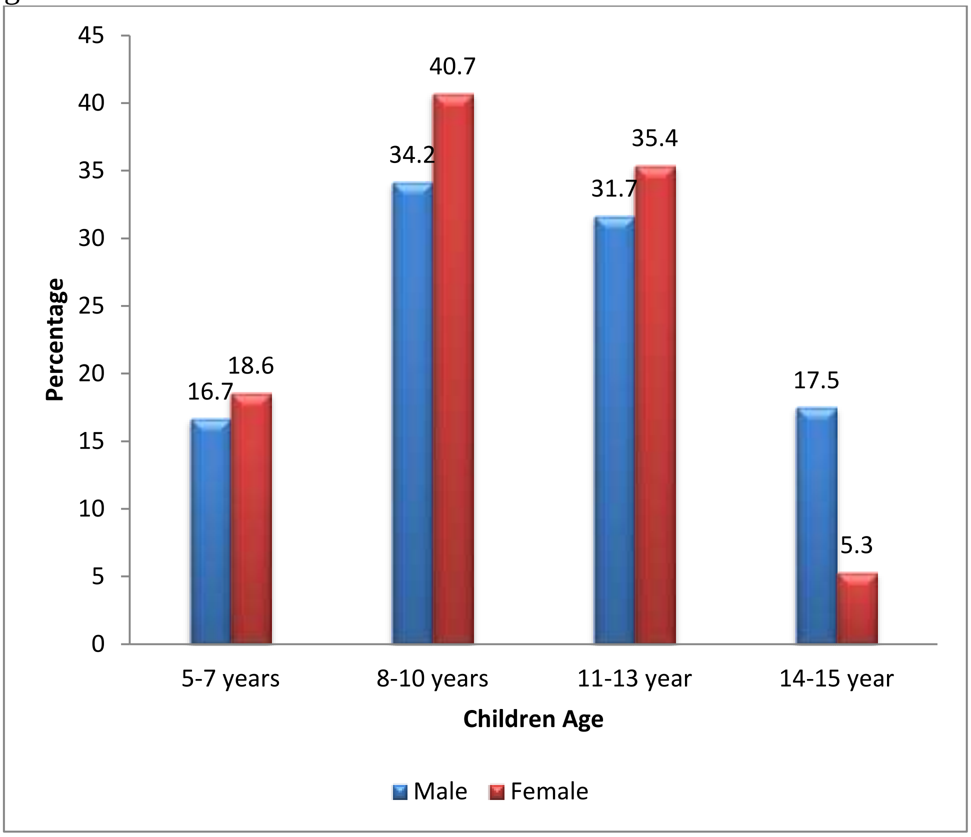

Figure 1. Age profile of participants by gender.

In Figure 1, it can be seen that the percentage across the various age groups were 16.7% male to 18.6% female in the 5 to 7 age group, 34.2% male to 40.7% female in the 8 to 10 age group, and 31.7% male to 35.4% female in the 11 to 13 age group but for the 14 to 15 age group, there were more males (17.5%) than females (5.3%). The fall in the proportion of females in the 14 to 15 age group can be explained by the custom of early marriage of the girl child. As for the very young 5 to7years old, there is still poor educational policy, and structural system that support the early education of this age group. However, the majority of the children were in the 8 to 10, and 11 to 13 age groups, and the percentages of both genders in these groups were 65.7% male to 76.1% female.

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.

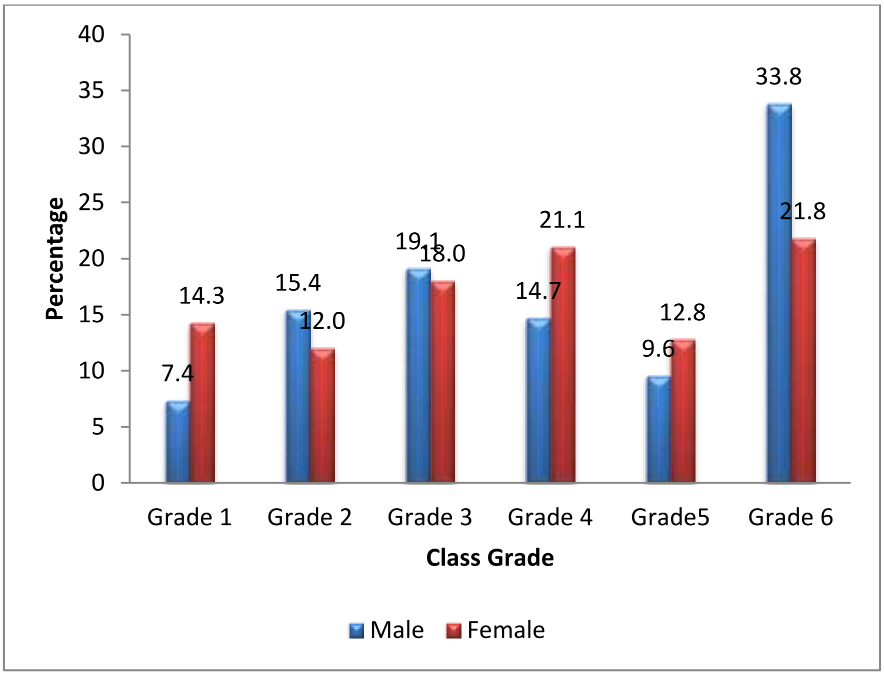

Figure 2. Gender characteristics according to class grade.

In Figure 2, it can be seen that the gender gap across Grades 1 to 6 is the same as it is complimentary. This is because the sum of the proportions for males across grades 1 to 6 is the same with that of the females. The sum of proportions for males across grades 1 to 5 is 66.2%, while the sum for the proportions of the females across grades 1 to 5 is 78.2%. The difference between females and males (ie 78.2% minus 66.2% which is 12.0%) is the same with the gender gap of 12% found in grade 6. However, 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.

Figure 3, presents the gender ratio for which students eat breakfast, lunch, and dinner daily.

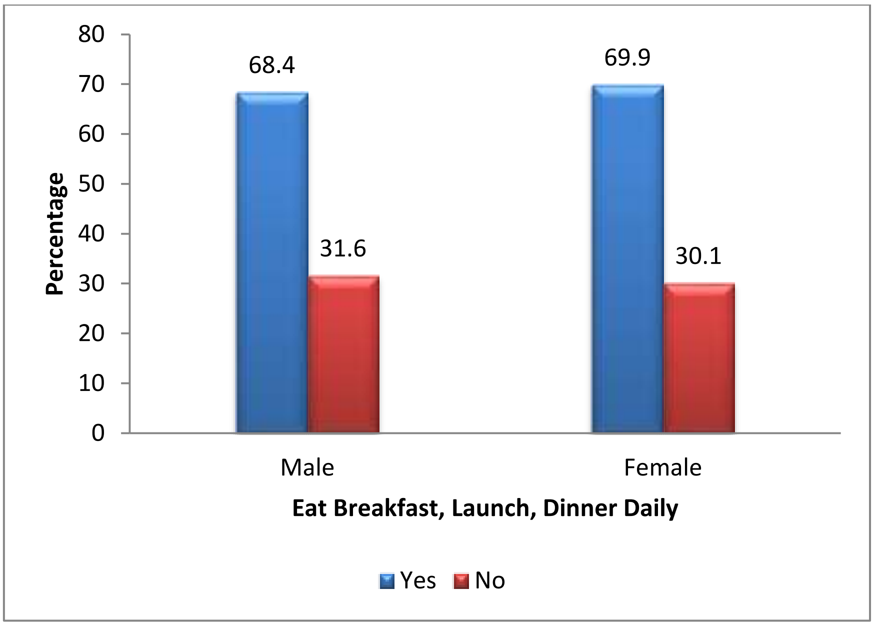

Figure 3. Gender ratio for students feeding.

This figure shows a similarity among the two genders regarding which students eat breakfast, lunch, and dinner daily and also those who do not. The independent t – test mean of children who ate breakfast, lunch and dinner daily was male 1.482 ± SD 0.50 and female 1.497 ± SD 0.50. This was however not significant at a p=0.817 (Appendix C), indicating that there was no significant difference between the students as regards feeding.

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Figure 4 below, presents the relation of gender characteristics with choice of treatment by the students.

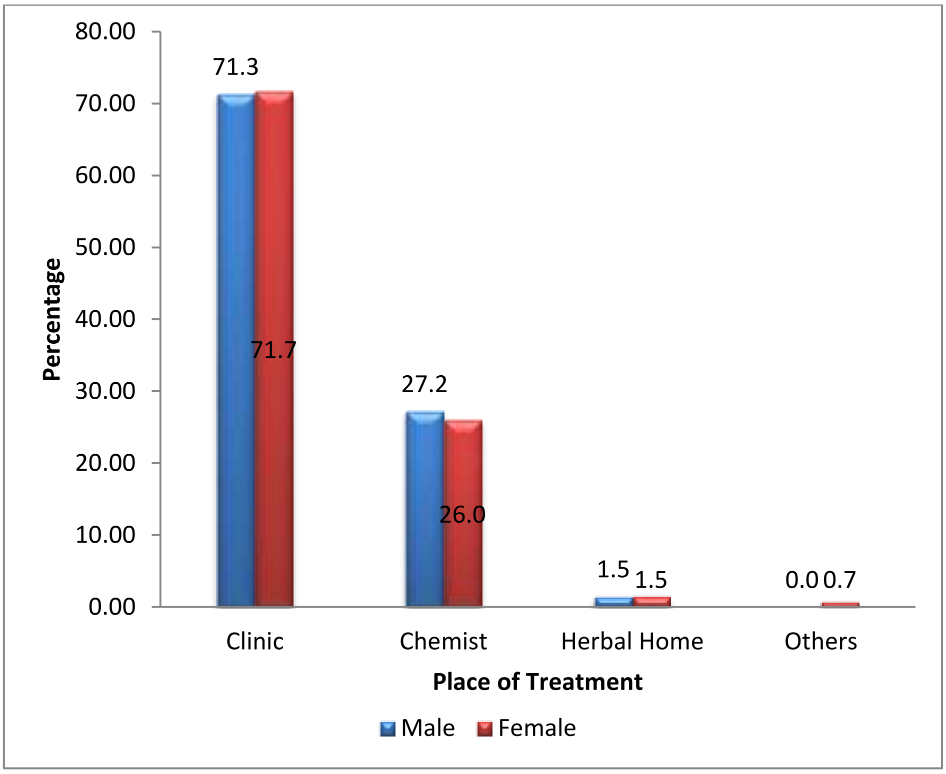

Figure 4. Gender characteristics with choice of treatment.

In Figure 4, the percentage of male that used health clinic was 71.3%, and that of female was 71.7%. The percentage of students who used health clinic was more when compared with those using the chemist (27.2% male, 26.0% female), herbal home (1.5% male, 1.5% female) and others (0.0% male, 0.7% female). Their choices were however, not statistically significant with exact fisher test value of *p* 0.683 (Appendix D) which indicates that there was no significant difference between males, and females in the methods they choose when seeking for treatment. This may be explained by the fact that their choices were limited by the methods available in the community.

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Figure 5, summarizes student's preferred mode of cleaning teeth.

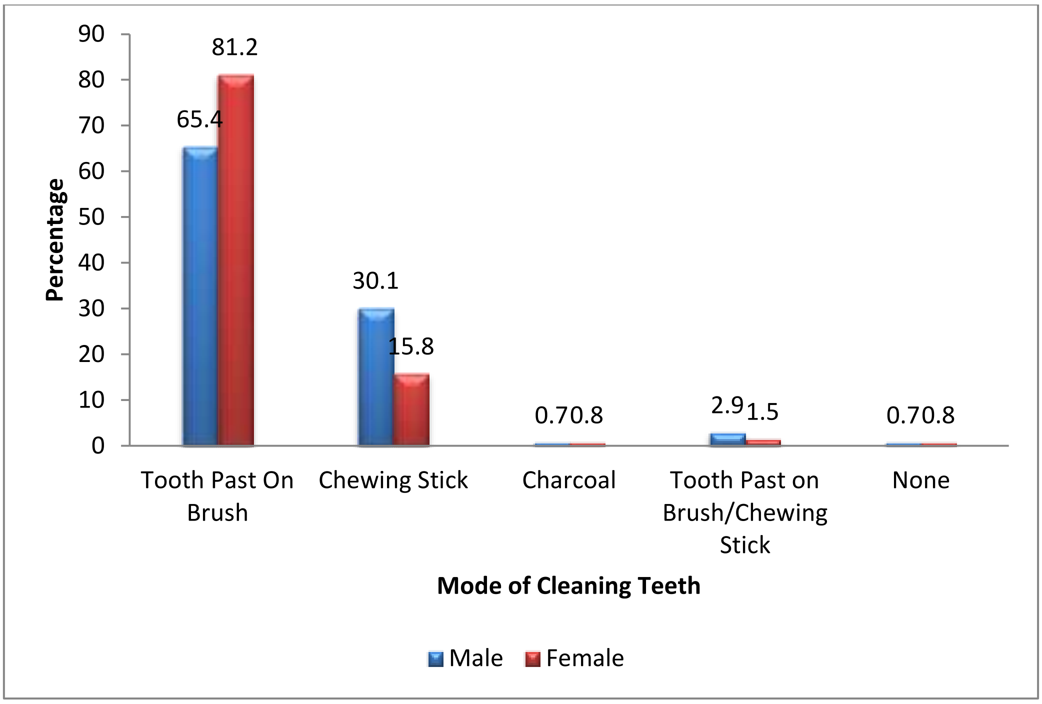

Figure 5. Student's preferred mode of cleaning teeth

In Figure 5, it can be seen that 65.4% of the male children, and 81.2% of the female children used toothpaste and a brush. This was followed by 30.1% male, and 15.8% female who preferred using chewing stick to care for their teeth. These student's choices for cleaning teeth was significant with exact fisher test of p= 0.0239(Appendix E), indicating that there was significant difference between the gender in the methods used in cleaning teeth.

Figure 6 below, shows whether children were taught hygiene in school.

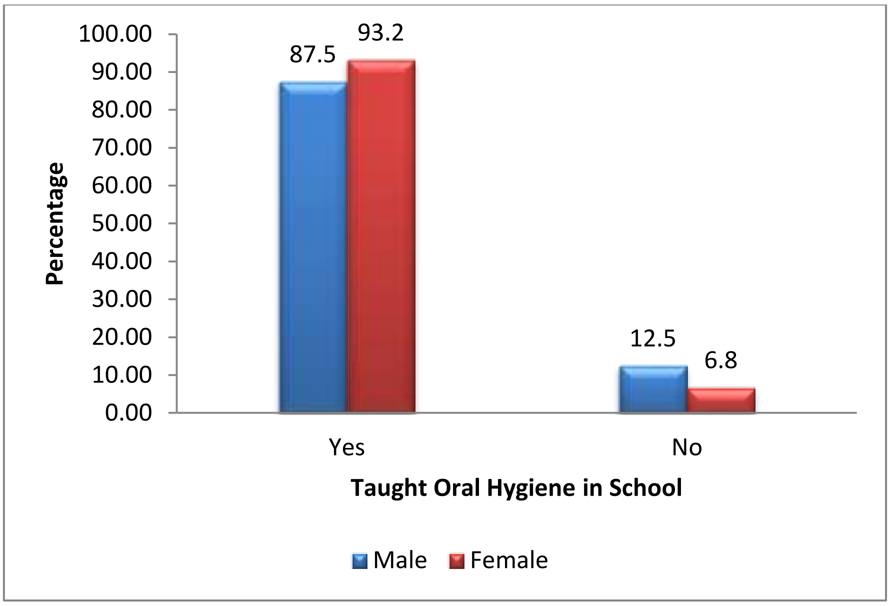

Figure 6. Children taught oral hygiene in school.

In this figure, it can be seen that 87.5% of the male children and 93.2% of the female children indicated that they were taught oral hygiene in school. While 12.5% of the male and 6.8% of the female children indicated that they were not taught oral hygiene. An independent *t* – test mean of children taught oral hygiene was 1.132 ± SD 0.34, while the mean of children not taught oral hygiene was 1.182 ± SD 0.39. The *p* value was 0.517, indicating that there was no significant difference between the gender on being taught oral health in school (Appendix F).

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Figure 7, presents the diagnosis rate of fluorosis in the study population.

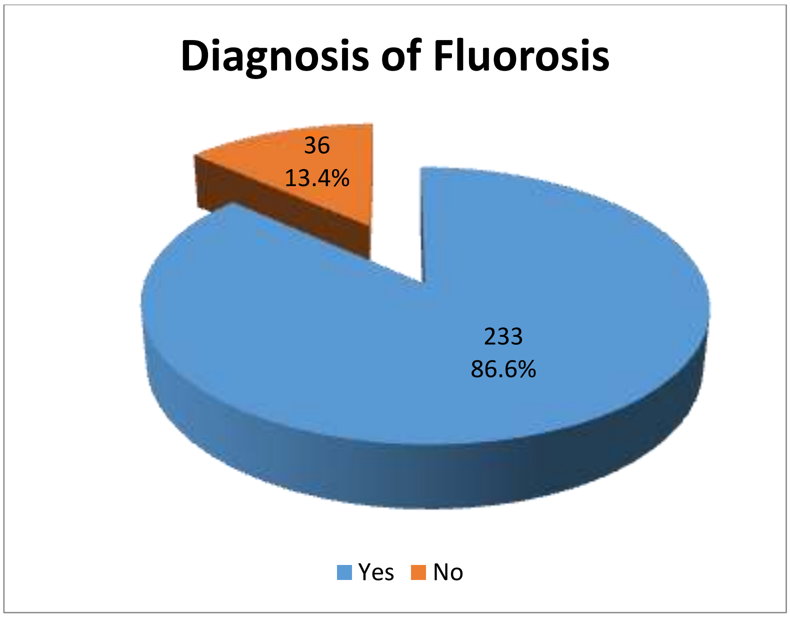

Figure 7. Diagnosis rate of fluorosis in the study population.

From this figure, it can be seen that the prevalence of fluorosis in the students in the study area was 86.6% and, those without fluorosis accounted for 13.4%. 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 0.181 (Appendix G), indicating that there was no significant difference in the age of those children with fluorosis and those without fluorosis. However, the difference between children having fluorosis and those without fluorosis may be caused by the length of stay in the community, the age of the student, student's attitude to health, the student's knowledge of illness and family SES; *p*= 0.031, <0.001, <0.001 and 0.027 respectively (Tables 2, 5, 6, and Appendix I).

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Figure 8 below, demonstrates the fluorosis diagnosis rate by gender.

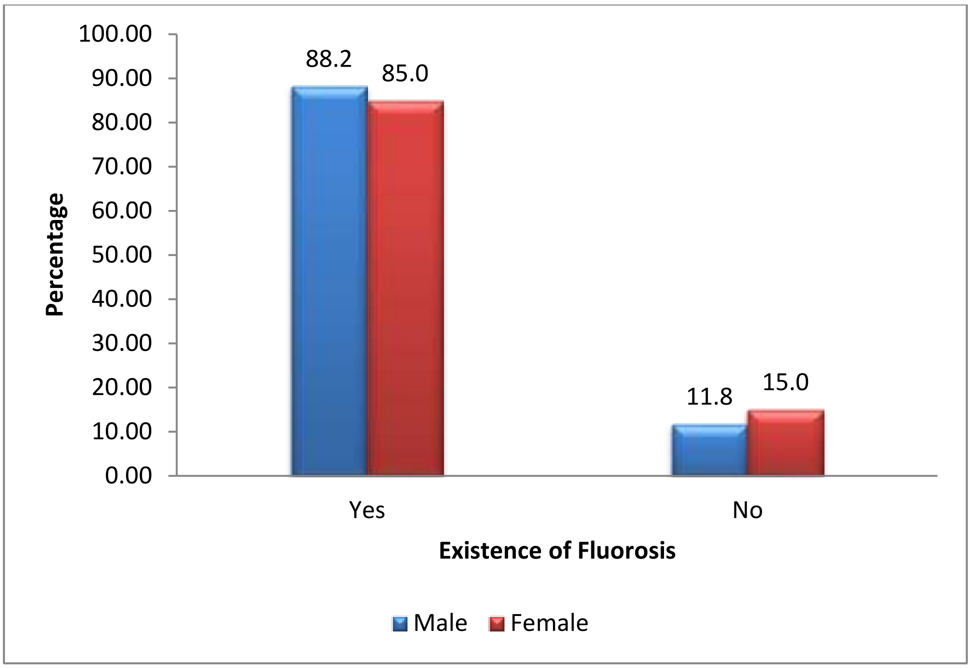

Figure 9. Fluorosis diagnosis rate by gender.

Figure 8 shows that majority of both males and females were found to have fluorosis. The proportion of diagnosis of fluorosis and gender from the figure is male with fluorosis 88.2% (without fluorosis 11.8%) and female with fluorosis 85.0% (without fluorosis 15.0%). The independent *t* –test of the mean of fluorosis diagnosis was male 1.118 ± SD 0.3234, and for female 1.150 ± SD 0.3588. However, there was no statistical difference between the gender in the diagnosis of fluorosis, *p*=0.432 (Appendix H), indicating that both gender was similarly affected.

Similarly, Figure 9 presents the proportion of fluorosis among children by age group and gender.

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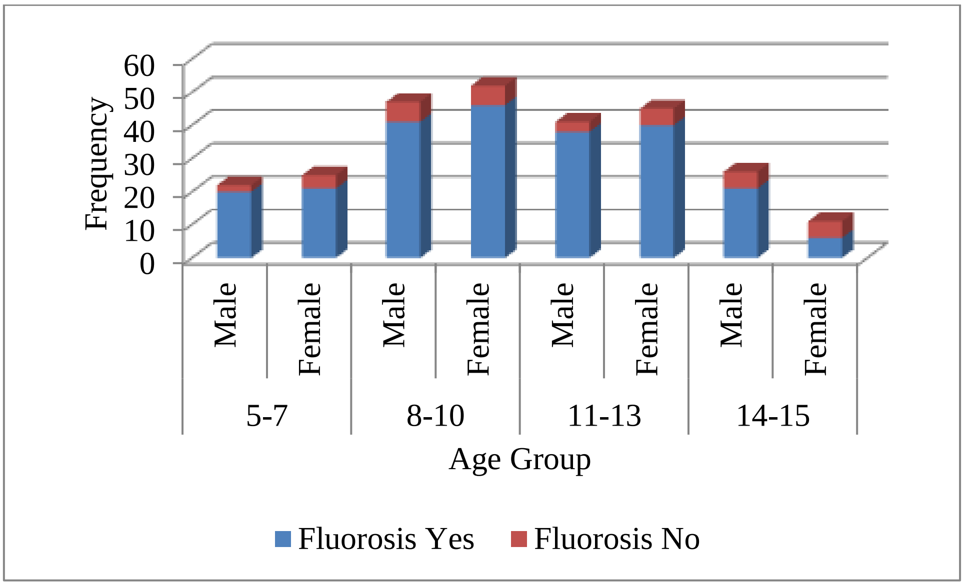

Figure 9. Proportion of fluorosis by age group and gender.

Figure 9 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. There is no statistically significant difference between the mean age of children with fluorosis (10.20 ± SD 2.68), and those without fluorosis (10.80 ± SD 3.22) with p value 0.181 (Appendix G).

The Figure further shows that fluorosis was similarly distributed across genders, although there was a slight female preponderance (i.e. female 107, and male 99) in the 5 to13 year-old age range and a slight male preponderance (male 21, and female 6) in the 14 to15 year-old range. The mean of fluorosis diagnosis was 1.118 ± SD 0.3234 for male, 1.150 ± SD 0.3588 for female, and there was no significant statistical difference between the gender in the diagnosis of fluorosis, p=0.432 (Appendix H).

Inferential Statistics

Chi Square Results

The hypothesis tests of childhood level influences associated with fluorosis, showed considerable significance with the number of years the

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children had lived in the area, their age, their health behaviors and knowledge of illness, as well as their SES. However, the gender of the child did not significantly influence the severity of fluorosis in the children.

Hypothesis 2 and Hypothesis 3
H_0: There is no association between fluorosis in children and their age/duration of residence.
H_1: There is an association between fluorosis in children and their age/duration of residence.

Table 2: *2x2 Contingency Table Between Diagnosis of Fluorosis and Years Lived in the Area*

Diagnosis of fluorosis	Age/Years Stayed 5-7 years	8-10 years	11-13 years	14-15 years	Total	df	X2	Sig.
Yes	42(41.6	89(88.3)	77(72.8)	25(30.3)	233(233)			
No	6(6.4)	13(13.7)	7(11.2)	10(4.7)	36(36)	3	8.881	0.031
Total	48(48)	102(102)	84(84)	35(35)	269(269)			

*1 cell (12.5%) had expected count (in parenthesis) of less than 5. The minimum expected was 4.68. Chi-square conditions met. *P* = 0.031; 0.005(14 - 15 age group). Significant at 95% CI.

The results show that "1 cell (12.5%) had an expected count of less than 5, and the minimum expected was 4.68," which implies that the sample size requirement for the chi-square test of independence is satisfied. The probability of the chi-square test statistic (X^2 = 8.881, *p*=0.031) was less than the alpha level of significance of 0.05 and implies that the length of time the child had lived in the area significantly influenced a diagnosis of fluorosis. This was similarly affected by the age of the child since the children had lived in the area since birth. Thus hypothesis 2 and 3 were similarly portrayed.

Hypothesis 4
H_0^1Null hypothesis: There is no association between dental fluorosis in the children and their gender.
H_A^1Alternative hypothesis: There is an association between dental fluorosis and their gender

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Table 3: *A 2x2 Contingency Chi-Square Test of the Presence of Fluorosis and Gender.*

	Gender					
Diagnosis of Fluorosis	Male	Female	Total	df	X2	Sig
Yes	120(117.8)	113(115.2)	233(233)			
No	16(18.2)	20(17.8)	36(36)	1	0.621	0.431
Total	136(136)	133(133)	269(269)			

* The minimum expected count (in parenthesis) was 17.80. Chi-square conditions met. Not significant at alpha level 0.05.

Table 3 shows a 2 x 2 contingency table of gender and the diagnosis of fluorosis. The result shows that "0 cell (0.0%) had expected count of less than 5, and the minimum expected was 17.80" which implies that the sample size requirement for the chi-square test of independence was satisfied. The probability of the chi-square test statistic (X^2 = 0.621, *p*=0.431) was more than the alpha level of significance of 0.05 and implies that there is no statistical difference between gender and the development of fluorosis. Furthermore, the severity of fluorosis across the gender was not significant thus showing no difference amongst the gender.

Table 4: *A 2 x 2 Contingency Chi-Square Test of the Severity of Fluorosis and Gender*.

	Gender					
Severity of Flourosis	Male	Female	Total	df	X2	Sig
Mild	48(41)	33(40)	81(81)			
Normal	17(17.2)	17(16.8)	34(34)			
Moderate	35(41)	46(40)	81(81)	3	4.252	0.235
Severe	36(36.9)	37(36.1)	73(73)			
Total	136(136)	133(133)	269(269)			

* The minimum expected count (in parenthesis) was 16.81.Chi-square conditions met. Not significant at alpha level of 0.05.

In Table 4, the results of the 2x2 contingency test are presented. They show that "0 cells (0.0%) had an expected count of less than 5, and the minimum expected was 16.81," which implies that the sample size requirement for chi-square test of independence was satisfied. The probability of the chi-square test statistic (X^2 = 4.252, p=0.235) was more than the alpha level of significance of 0.05 and implies that there is no statistical difference between the sexes on the severity of fluorosis. From the foregoing hypothesis 2, 3 and 4, tested above, significant association for children fluorosis was more related to the factors of environment than biology or genetics.

Hypothesis 5

H_0^1Null hypothesis: There is no association between dental fluorosis in the children and their health behavior.

H_A^1Alternative hypothesis: There is an association between dental fluorosis and their health behavior.

Regarding the children's attitude to health (judged by the appearance of their teeth), the results in Table 5 show that "0 cells (0.0%) had an expected count of less than 5, and the minimum expected count was 15.26." This implies that the sample size requirement for the chi-square test of independence was satisfied. The Pearson chi-square statistic (X^2 = 18.112 and p = <0.001) of the observed data suggest a significant association between the influence of a child's attitude to health and the presence of fluorosis. This shows that their attitude regarding the appearance of their teeth significantly influenced the diagnosis of fluorosis among the children. Hence, there was a significant association between attitude regarding the appearance of their teeth and the presence of fluorosis among the children in the Zing community.

Similarly, Table 6 shows that children knowledge of the disease also significantly affected diagnosis of fluorosis. This implies the general poor knowledge of the disease in children of the community.

Table 5

2 x 2 Contingency Table Between Presence of Fluorosis and the Child's Attitude to Health (Appearance of Teeth)

Diagnosis of Fluorosis	Like appearance of teeth Yes	No	Total	df	X^2	*P*-value
Yes	87(98.7)	143(134.3)	233(233)			
No	27(15.3)	9(20.7)	36(36)	1	18.112	<0.001
Total	114(114)	155(155)	269			

* The minimum expected count (in parenthesis) was 15.26. Chi-square conditions are met. Significant at 95% CI.

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Table 6: *2x2 Contingency Table Between the Presence of Fluorosis and Child's Knowledge of Illness (Can Describe Color of Their Teeth)*

	Noticed color change on teeth					
Diagnosis of fluorosis	Yes	No	Total	df	X2	Sig.
Yes	173(161.1)	60(71.9)	233(233)			
No	13(24.9)	23(11.1)	36(36)	1	21.258	<0.001
Total	186(186)	83(83)	269(269)			

* The minimum expected count (in parenthesis) was 11.11. Chi-square conditions are met. 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 child 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. 77.7% of the children were from low-SES families (Table 1), and 68.7% of the children had lived in the study area for 8 to13 years (Table 1).

71% of the children involved in the study preferred to seek medical treatment at a clinic (Table 1). This student's characteristic was comparable across genders (p = 0.683, Appendix D). Furthermore, a great majority of the children used toothpaste on a brush to clean their

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teeth, and this characteristic differed significantly between the gender ($p = 0.0239$) with more female using toothpaste on brush than male (Appendix E). However, there was no significant difference between the gender on being taught oral hygiene in school ($p = 0.517$, Appendix F). There was also, no significant difference between the gender on who eats breakfast, lunch and dinner daily (p = 0.817, Appendix C).

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 length of time that the majority of the children (68.7%) had lived in the study area was 8 to 13 years (Table 1). The percentage of children in the study diagnosed with fluorosis was 86.6%, indicating a high prevalence rate (Figure 7). Those without fluorosis accounted for 13.6%. The prevalence of fluorosis according to gender was 88.2% for males, and 85.0% for females (Figure 8). There was no significant difference between the gender in the diagnosis of fluorosis ($p = 0.432$, Appendix H). 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 (Figure 9).

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 G), indicating that there was no significant difference in the age of children with fluorosis and those without fluorosis. The difference between the children with fluorosis and those without fluorosis was accounted for by the length of stay in the community, the age of the student, student's attitude to health and the student's knowledge of illness, family SES, *p* value 0.031, <0.001, <0.001, and 0.027 respectively (Tables 2, 5, 6 and Appendix I).

Further exploratory findings in the study showed a statistical significant association between the development of fluorosis with age and length of stay of student in the area (X^2 8.881, $p = 0.031$) in favor of higher age and length of stay, family SES (Fisher's $p = 0.027$) in favor of low and mid SES, children's attitude to health ($X^2 = 18.112$, $p = < 0.001$) in favor of children that did not like the appearance of teeth, and children's knowledge of illness (could describe the color of their teeth) ($X^2 = 21.258$, $p = < 0.001$) in favor of those who noticed color change.

Conclusion and Recommendations for Policy Guide

The study threw up many interesting findings concerning its goal i.e. whether, fluorosis in this region is associated with biological endowments or the environment. The study findings clearly showed significant association with duration of residence and age of child, the children's attitude to health and knowledge of the disease. All these are seen as environmental factors. The genetic variables tested was age and gender. Concerning gender, there was no significant association with the development of fluorosis nor was it associated with its severity. Other influences found to be associated with fluorosis such as the family SES are all environmental factors. Therefore, in this study many more of the environmental factors are shown to be linked with the development of fluorosis in this population.

In designing program for fluorosis control in this population, focus should be directed at improving knowledge of the children about the disease, teaching the children on good oral hygiene practices, teaching the community various ways on how to improve their SES, identifying and addressing the environmental source of high fluoride in which the children are exposed as they reside in this community. Such efforts will 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 of Children that Eat Breakfast, Lunch and Dinner Daily by Gender**.**

	Eats breakfast, lunch, dinner daily	N	Mean	Std. Deviation	Std. Error Mean
Gender	Male	83	1.482	0.5027	.0552
	Female	185	1.497	0.5013	.0369

Note: N = 268, p = 0.817 (independent t – test).

Appendix D:

Table of Seeking Treatment When Ill

Gender	Chemist	Health clinic	Herbal home	Others	Total
Male	37(35.4)	97(97.6)	2(2.0)	0(1.0)	136(136.0)
Female	33(34.6)	96(95.4)	2(2.0)	2(1.0)	133(136.0)
Total	70(70.0)	193(193.0)	4(4.0)	2(2.0)	269(269.0)

Note: N = 269, p = 0.532, expected count in parentheses. As conditions for use of chi square were not met, *Winpepi* was used for exact fisher test p = 0.6829.

Appendix E:

Table of Student's Preferred Method of Cleaning Teeth.

Gender	Charcoal	Chewing Stick	Chewing Stick/Toothpaste on brush.	None	Toothpaste on brush	Total
Male	1(1.0)	41(31.3)	4(3.0)	1(1.0)	89(99.1)	136(136.0)
Female	1(1.0)	21(30.7)	2(3.0)	1(1.0)	108(97.9)	133(133.0)
Total	2(2.0)	62(62.0)	6(6.0)	2(2.0)	197(197.0)	269(269.0)

Note: N = 269, X^2 = 9.739, p = 0.083, expected count in parentheses. However, as conditions for chi-square were not met, exact fisher's test was used, p = 0.0239. Cell by cell p value = 0.004 significant for toothpaste on brush in favor of female (+0.02) to male (-0.02).

Appendix F:

Table Showing Mean of Children Taught Oral Hygiene and Fluorosis.

	Taught Oral Hygiene	N	Mean	Std. Deviation	Std. Error Mean
Fluorosis	Yes	243	1.132	0.3388	.0217
	No	22	1.182	0.3948	.0842

Note: N = 267, p = 0.517(independent t – test)

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Appendix G:

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 H:

Table Showing Diagnosis of Fluorosis and Gender.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Diagnosis Fluorosis	Male	136	1.118	.3234	.0277
	Female	133	1.150	.3588	.0311

Note: *N* = 269, *p* = 0.432 (independent *t* – test).

Appendix I:

A 2x2 Contingency Table Between Diagnosis of Fluorosis and Family SES

Diagnosis of Fluorosis	Family SES Low	Middle	High	Total	Sig.
Yes	175(181)	55(49.4)	3(2.6)	233(233)	0.027
No	34(28)	2(7.6)	0(0.4)	36(36)	
Total	209(209)	57(57)	3(3)	269(269)	

*2 cells (33.3%) had expected count (in parenthesis) of less than 5. The minimum expected count was 0.40. Chi-sqaure conditions were not met. Fisher test used.