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DENTAL FLUOROSIS PREVALENCE IN NIGERIAN SCHOOL-AGED CHILDREN LINKED WITH FOOD TYPES.

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Author's note: The information and original data used in this study are partly from the author's previous research work. 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 fluorosis is a global public health problem. In Nigeria, 11.4% of the population is impacted by this disorder. Dental fluorosis caused by consistent exposures to high fluoride during tooth development, is linked to the development of a variety of psychological and physiological problems. These include dental aesthetics, reduction in intelligence and skeletal changes. The purpose of this quantitative, cross-sectional study was to examine the prevalence of dental fluorosis in rural Nigerian children and its association with common food types. A multilevel theoretical model was used to develop possible fluoride exposure pathways, such as food habits, family SES, and dental care, as well as factors in the environment. The study focused on 2 main research questions: What is the prevalence rate of fluorosis in school children in Nigeria? Is it associated with the fluoride content of common food types in the community? Data was collected through the administration of two surveys; on children aged 5 to15 years, and their parent/guardian. Chi-square and regression analysis 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, and children fluorosis was significantly associated with the family SES. This study's possible impact includes raising awareness to the problem and the possible ways to resolve it, such as through, information on possible food types with high fluoride content and the provision of a supportive social environment like improved dental care services.

Keywords: Children, fluorosis, food types.

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Introduction

Dental fluorosis, commonly called mottled enamel, is a term that describes the hypoplasia of tooth enamel due to excess intake of fluorine. It has been reported that fluorosis in humans arises mainly from intake of drinking water than from other sources such as vegetable consumption or from anthropogenic contamination of the environment e.g. volcanic eruptions or from phosphate producing plants (Ando et al., 2001). However, a number of practices and natural occurrences are known to predispose to fluorosis. These are; geographical location, economic factors, and food culture of the people (Kloos & Haimont, 1999; Qian, Susheela, Mudgal & Keast, 1999) thereby affecting the quality of life (Allen, 2003).

While we know of the many risk factors involved in dental discoloration in general, we have limited understanding as how some cultural practices can lead to the development of dental fluorosis in children thereby leaving a gap in the literature.

Concerning the development of bones and teeth, fluorine is an essential element in the mineralization process through the formation of fluoroapatite an important constituent in tooth development (World Health Organization [WHO], 2002). It is known that permanent dentition and mineralization starts in utero and continues up to 4 or 5 years after birth, root development on the other hand continues up to 2 to 3 years after eruption (Kumar et al., 2012). Teeth are prone to developmental disturbances during mineralization and thus are susceptible to drugs and environmental toxicants (Billings, Berkowitz, & Watson, 2004). Such disturbances also include high levels of fluorine especially above those recommended by WHO; maximum limit 1.5mg/l in drinking water in normal conditions and , 1.0 mg/l in hotter, dryer climates with tendency of higher intake of water (WHO, 2002).

The negative health impact of fluorosis highlights the importance of this study in order to find ways of reducing this impact. These effects include; aesthetic, psychological, decreased intelligence, skeletal fluorosis and, overall poor quality of life (Aguilar-Diaz, Irigoyen-Camacho, & Borges-Yanez, 2011). All these concerns are of immense importance when dealing with the health status of a population in endemic fluorosis regions so that steps can be taken to address the problem (Cao et al., 1996). Thus the social change impact of this study should focus at raising awareness to the associated disabilities, disease and loss of resources (dollars) that are related with the problem of fluorosis. Fluorosis itself does not cause death, but the accompanying disabilities such as reduction in intelligence, the psychological effects of the aesthetics of the teeth, as well as the limitations in mobility due to skeletal fluorosis, may lead to lost hours in human resources and finances and these lower the quality of life.

The prevalence of dental fluorosis across the world children varies according to the influences earlier highlighted. For example, a study in Nigeria put the rate at 11.4% in the urban settlement of Ibadan (Ajayi, Arigbede, Dosunmu, & Ufomata, 2012), while another in rural India, put the prevalence rate at 31.4% (Saravanan et al., 2008). In china however, the rate was higher i.e. between 52 and 84% in the Mongol, Kazak, and Yugu areas of the Gansu Province (Cao et al., 1997). The rate is yet 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, here the prevalence rate was as high as 95. 9%(Kahama et al., 1997) and 61% to 91% (Allibone et al., 2012) respectively.

Study Objectives

The purpose of this quantitative, cross-sectional study was to determine the prevalence of fluorosis in children in the Zing local government area, a rural settlement in northern Nigeria and to examine if it is linked to the common food types eaten by them. The people of this area are commonly associated with discolored teeth right from childhood (Ambinkanme, Sale, Ahmed, Peters & Magaji, 2014). Some of the common foods types consume in the community include dawa (form of millet), bambara nuts, vegetables and the yam tuber as staples (Ambinkanne et al., 2014). As stated above, this study's intention was to ascertain the extent that the exposure to certain food types in the environment contribute to the development of dental fluorosis in children ages 5 to 15 years.

The independent variables examined in the study were the fluoride content of common foods. These were studied to see how they were associated with dental fluorosis in children as the dependent variable. The possible co-variables examined in the study included SES.

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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 dawa consumption by these children?
   $H_0^{\ 1}$ Null hypothesis: There is no association between dental fluorosis in children and consumption of dawa by these children.
   H_A^1Alternative hypothesis: There is an association between dental fluorosis and dawa consumption in these children.
3. Is there an association between the presence of fluorosis among children in the Zing community and bambara consumption by these children?
   H_0^1Null hypothesis: There is no association between dental fluorosis in the children and their bambara consumption.
   H_A^1Alternative hypothesis: There is an association between dental fluorosis and bambara consumption in these children.
4. Are the children's families SES potential confounders in the study outcome?
   H_0^1Null hypothesis: The children's families SES are confounders to the study outcome.
   H_A^1Alternative hypothesis: The children's families' SES statuses are not confounders to the study outcome.

Method

Study Participants

The study participants for the first survey were children aged 5 -15 years, both male and female, of Mumuye ethnicity drawn from eight regular public primary schools selected from existing primary schools by systematic random selection. These public schools had sizable student population of an average of 360 students per school and were located in either the rural or urban part of Zing local government area.

The students sample was selected by a systematic random selection of every third pupil whose parents provided 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 second survey was administered to parent/guardian of each child enrolled in the survey preferably the parent who was able to communicate clearly with the researcher. In this way, family-level influences on childhood fluorosis were explored.

All surveys were administered in English with help from a capable community leader.

Inclusion and Exclusion Criteria

Participants were school children aged 5 to15 years, who had been born and raised in the community. The inclusion criteria for the selection of parents/guardian, was 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 seeking and obtaining approval from the State Ministry of Education to conduct the study following which the individual head teachers of the participating schools in the study zone were contacted and briefed about the study. The PTA (parent teachers' pupils association) of the participating schools was also briefed about the study and ethical concerns addressed.

A systematic random selection of every third pupil from each of the grades during class roll call (i.e., from the class register) was carried out and these together with their parents were met with in the school assembly hall in order to orientate them on what the study was about and to agree on the timing for the conduct of study. Ethical issues involved in the study were pointed out to them 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 used for the study was determined for a statistical power of 80% and an alpha level of .05 (95% CI) for an effect size of 0.3 for a small to medium effect (Cohen, 1998) as 176. An additional 25% was added to make up for attrition, bringing the number 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) as basis.
2. WHO/FAO, NIOSH (National Institute for Occupational Safety and Health), and EPA -procedure for analyzing chemicals, and estimating fluoride in biological materials and environmental samples (ATSDR, 2013). These organizations recognize the use of ion selective and the colorimetric (spectrophotometric) methods for detecting fluoride levels in both biological and environmental samples.
3. 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 (Appendix A).

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.

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Data Collection

The survey was administered face to face to the participants in English. To help collect data, four research assistants were used and include a dentist, a laboratory scientist, 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, and the second sought to understand family and neighborhood influences on childhood fluorosis. The purpose of these surveys was to help answer the four 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 operating at the child, family, and community levels (such as the fluoride content of common food types in the community) were the independent variables. Dental caries and SES were looked at as covariates

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

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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 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 the plan 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, eats dawa, eats bambara, 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).

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For the descriptive statistics, the characteristics of the study population were presented in frequency tables and graphs. 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 and 3: There is a positive association between dental fluorosis and the variables of dawa consumption and bambara consumption by children, as well as Hypothesis 4: There is an association between family SES and fluorosis in children, 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, and correlations 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 was 136 (50.6%) male, and, 133 (49.4%) 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 ages of 14 and 15 years. These age-related percentages were comparable across gender, the mean age for male was 10.6 ± SD 2.90 and that of female was 9.8 ± SD 2.60 (Figure 1, Appendix B). 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). 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 and D). Regarding diet, 228 (84.8%) of the respondents ate dawa, while 41 (15.2%) did not, and 252 (93.7%) of the respondents ate bambara, while 17 (6.3%) did not. Regarding the frequency of eating dawa, 59 (21.9%) of the respondents ate dawa daily, 33 (12.3%) ate dawa weekly, 136 (50.6%) ate dawa, two to three times weekly, and 41 (15.2%) did not eat dawa at all. Also, 43 (16.0%) of the respondents ate bambara daily, 45 (16.7%) ate bambara weekly, 164 (61.0%) ate bambara two to three times weekly, and 17 (6.3%) respondents did not eat bambara at all. This implies that most people ate dawa and bambara two to three times weekly.

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Table 1
Children Characteristics

	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
Eats breakfast, lunch, dinner daily		
No	83	31.0
Yes	186	69.0
Total	269	100.0
Eats dawa		
No	41	15.2
Yes	228	84.8
Total	269	100.0
Eats bambara		
No	17	6.3
Yes	252	93.7
Total	269	100.0

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Frequency of eating		
dawa	59	21.9
Daily	33	12.3
Weekly	136	50.6
2 - 3 times weekly	41	15.2
None	269	100.0
Total		
Frequency of eating		
bambara	43	16.0 *(table continues)*
Daily	45	16.7
Weekly	164	61.0
2 - 3 times weekly	17	6.3
None	269	100.0
Total		
Diagnosis of		
Fluorosis?	233	86.6
Yes	36	13.4
No	269	100.0
Total		
SES		
High	3	1.10
Middle	57	21.20
Low	209	77.70
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 B), Class grade-related proportions across gender were similar for male and female p value 0.10 (Figure 2, Appendix C), and there was no difference in percentage among gender for who eats breakfast, lunch, and dinner daily, p value 0.817 (Figure 3, Appendix D).

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

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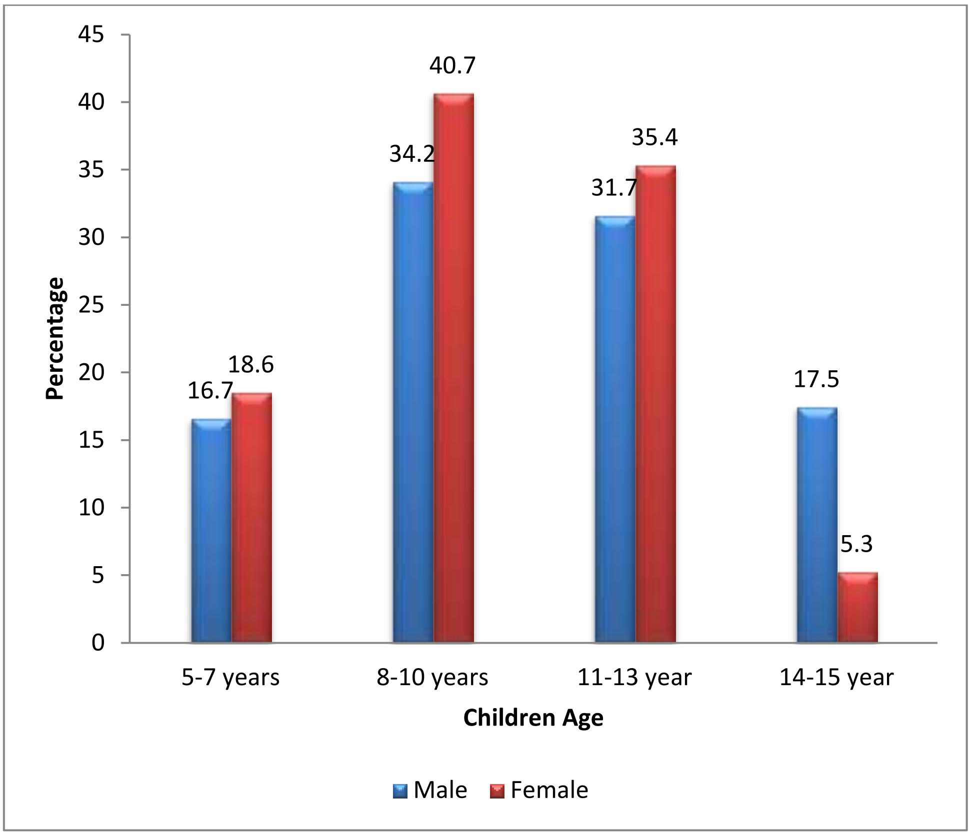

Figure 1. Age profile of participants by gender.

Figure 1 shows that the percentage distribution 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 while 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.

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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 B) and indicates that the male students were slightly older than the female students.

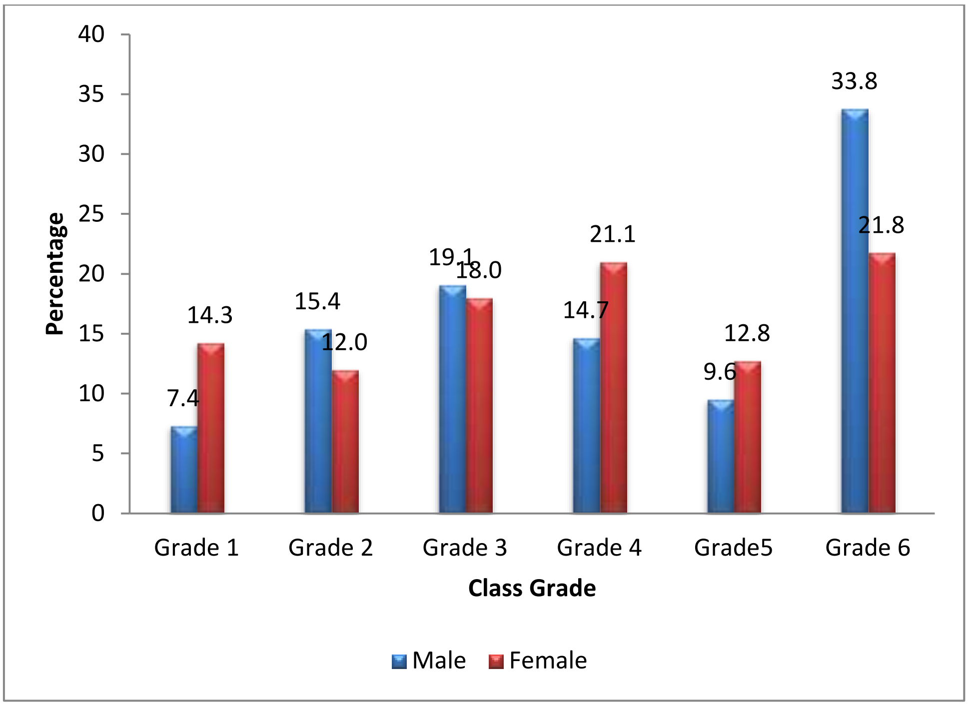

Figure 2. Gender characteristics according to class grade.

Figure 2, shows 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 C) 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.

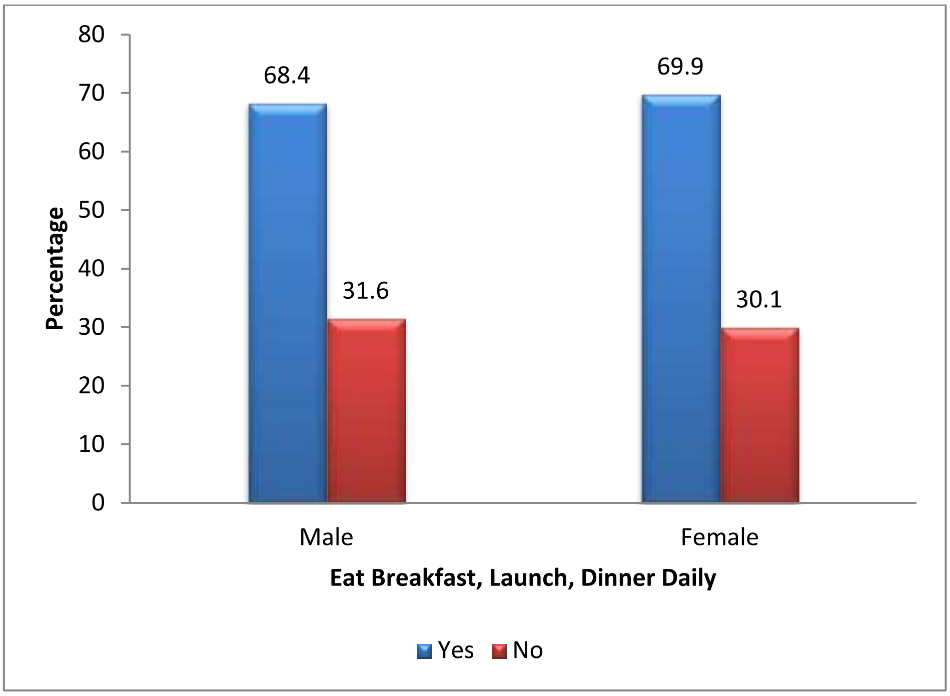

Figure 3. Gender ratio for students feeding.

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 D), indicating that there was no significant difference between the students as regards feeding.

Figure 4, presents the diagnosis rate of fluorosis in the study population.

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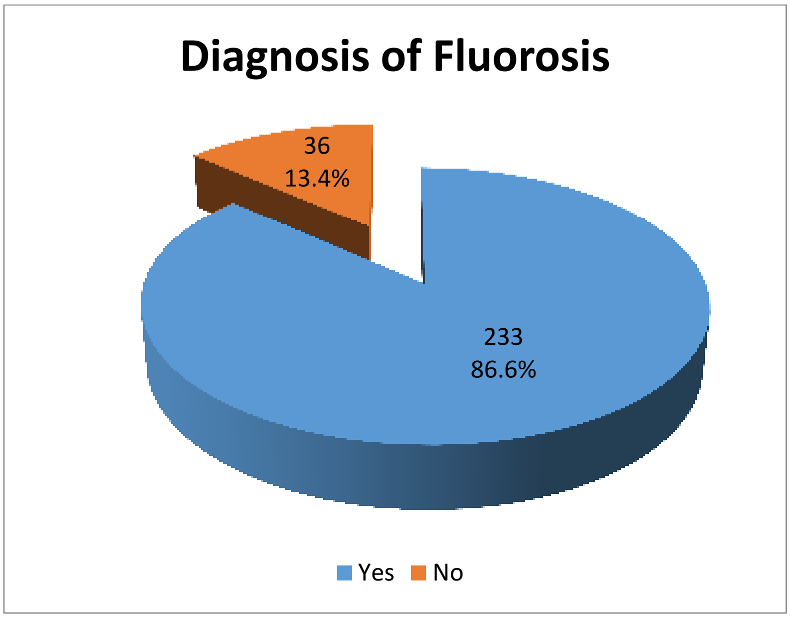

Figure 4. Diagnosis rate of fluorosis in the study population.

From this figure, the fluorosis prevalence in the students in the study area was 86.6% and, those without fluorosis was 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 E), 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 was related to family SES, and the student's knowledge of illness, *p* value 0.027, and <0.001 (Table 4 and Appendix F).

Figure 5 below, demonstrates the fluorosis diagnosis rate by gender.

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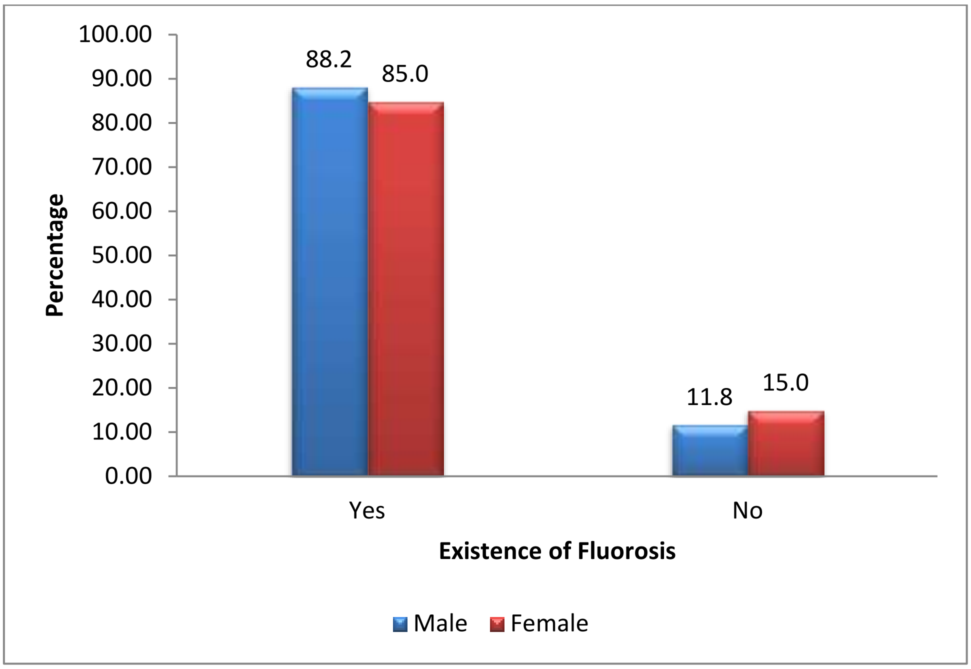

Figure 5. Fluorosis diagnosis rate by gender.

Figure 5 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 genders in the diagnosis of fluorosis, p=0.432 (Appendix G), indicating that both gender were similarly affected.

Similarly, Figure 6 presents the proportion of fluorosis among children by age group and gender.

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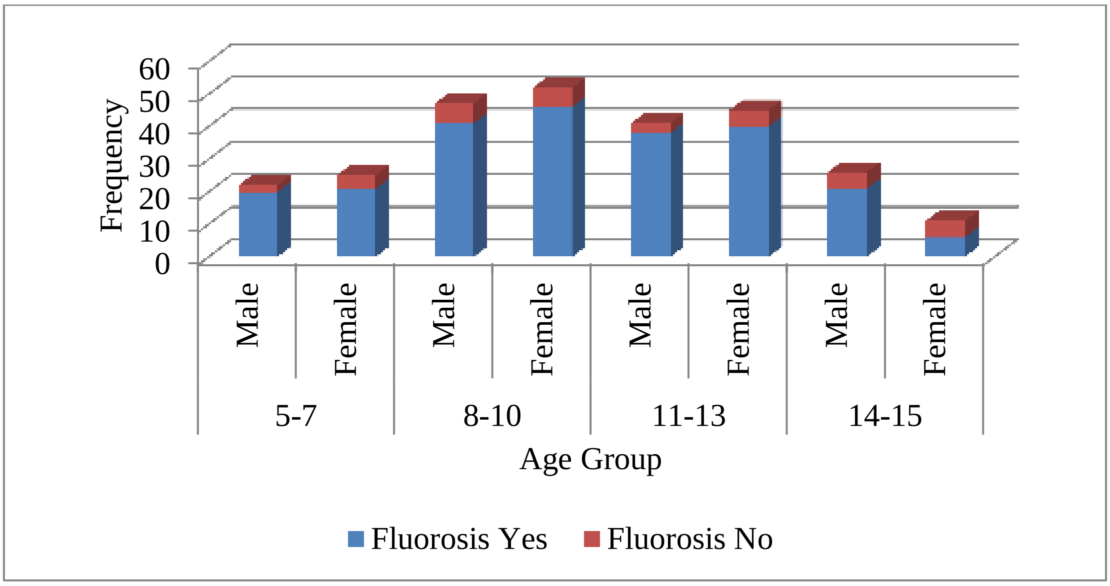

Figure 6. Proportion of fluorosis by age group and gender.

Figure 6 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 E).

The Figure further shows that fluorosis was similarly distributed across genders, although there was a slight increase among the female (i.e. female 107, and male 99) in the 5 to13 year-old age range and a slight male increase (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 G).

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Inferential Statistics

Chi Square Results

Hypothesis 2

H_0: There is no association between the presence of fluorosis among children and dawa consumption.

H_1: There is an association between the presence of fluorosis among children and dawa consumption.

Table 2 presents the chi-square test result of dental fluorosis and the consumption of dawa by children in the study population. The results show that no cell had an expected count of less than 5, the minimum expected count was 5.49." This shows that the sample size requirement for the use of chi-square test of was satisfied. Here the Pearson chi-square statistic ($X^2 = 0.568$ and $p > 0.10$) suggests the acceptance of the null hypothesis, that there is no significant association between dawa consumption and the presence of fluorosis in children in the study population. Also, the data show that, of the 228 children who stated that they eat dawa 199 had fluorosis (87.28%) while 34 of the 41 children who did not eat dawa had fluorosis (82.92%).

Table 2

A 2x2 Contingency Chi-Square Test of the Association Between Dawa Consumption and the Presence of Fluorosis.

Diagnosis of Fluorosis	Consumption of Dawa			df	X2	Sig.
	No	Yes	Total			
Yes	34(35.5)	199(197.5)	233(233)			
No	7(5.5)	29(30.5)	36(36)	1	0.568	0.451
Total	41(41)	228(228)	269(269)			

* The minimum expected count (in parenthesis) was 5.49. Chi-square requirements satisfied. Person chi-square statistic is not significant at 95% C.I.

Hypothesis 3

H_0: There is no association between the presence of fluorosis among children in the Zing community and bambara consumption.

H_1: There is an association between the presence of fluorosis among children in the Zing community and bambara consumption.

Table 3 presents the chi-square test result of the presence of fluorosis in children and bambara consumption. The result shows that

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the sample size requirement for the use of chi-square test of independence was not met; and, Fisher's exact test was used. This test showed a *p value* of 0.06 thereby suggesting a rejection of the research hypothesis. This means that there is no significant association between bambara consumption and the presence of fluorosis in children in the study population. However, based on these results, 87.70% of the children who ate bambara (221 out of 252 children) had fluorosis while, 70.59% of those that did not eat bambara had fluorosis (12 out of 17 children).

Table 3

A 2x2 Contingency Chi-Square Test of the Association Between Bambara Consumption and the Presence of Fluorosis.

	Consumption of Bambara			Sig
Diagnosis of Fluorosis	No	Yes	Total	
Yes	12(14.7)	221(218.3)	233(233)	
No	5(2.3)	31(33.7)	36(36)	0.06
Total	17(17)	252(252)	269(269)	

*1 cell (25.0%) had an expected count (in parenthesis) of less than 5. The minimum expected count was 2.28. Chi-square conditions not met. Fisher's *p* value used. *P* = 0.06 not significant at 95% C.I.

Hypothesis 4

H_0: There is no association between family SES and fluorosis in children.

H_1: There is an association between family SES and fluorosis in children.

Table 4 presents the chi-square test's result of SES and a diagnosis of fluorosis in the children. The results show that the chi-square test of independence was not satisfied, necessitating the use of Fisher's exact test. The results show that the two-sided exact significance is 0.027. Since the significance value is less than 0.05, the null hypothesis is rejected and shows that there is a significant association between family SES and fluorosis among children in the Zing community. This was more significant in the lower and middle SES (*P* = 0.009 and 0.014) than in the high SES (*P* = 0.494).

Table 4

A 2x3 Contingency Chi-Square Test of the Association Between Family SES and the Presence of Fluorosis.

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-square conditions not met. Fisher's exact test used, p = 0.027 significant at 95% C.I. Cell by cell analyses p = 0.009, 0.014(low and middle SES) and p = 0.494(high SES).

Discussion/Study Findings

This was a field survey of children participants aged 5 to 15 years, and their parents/guardians. The sample size used for the study was 269 children (Survey 1) and 269 parents (Survey 2). The surveys were designed to determine possible influences on children's oral health at the child, and parent/household levels.

The child participants were made up of approximately 30 pupils from each of the 8 participating schools and were all drawn from the six grades of these primary schools. The demographic characteristics of the children according to person, place and time were as follows; they were all between the ages of 5 and 15 years old, 68.7% of them were between the ages of 8 to 13 years, 50.6% of them were male, while 49.4% were female. The mean age of the children were, male (10.63 ± SD 2.86), and female (9.88 ± SD 2.60). An Independent sample t - test was significant at a p value of 0.025 (Appendix A) indicating that the male students were slightly older than the female students.

The class grades of the children ranged from Grade 1 to Grade 6 and, the gender ratios across these grades were comparable. A Pearson chi-square test of these class gender characteristics was not statistically significant at p value of 0.10 (Appendix C) showing no significant difference between gender distributions across the grades. There was also, no significant difference between the gender on who eats breakfast, lunch and dinner daily (p = 0.817, Appendix D).

The results of the study show the following: The length of time that the majority of the children (68.7%) had lived in the study area was

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8 to 13 years (Table 1). 84.4% of the children ate dawa (Table 1), while 93.7% of them ate bambara (Table 1). The percentage of children in the study diagnosed with fluorosis was 86.6%, indicating a high prevalence rate (Figure 4). 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 5). There was no significant difference between the gender in the diagnosis of fluorosis (*p* = 0.432, Appendix G). 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 6).

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 E), 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 family SES, and the student's knowledge of illness, *p* value 0.027, and <0.001 (Table 4 and Appendix F).

On test of hypotheses, the association of the presence of fluorosis with dawa consumption in Research Question 2 was not significant. The test of significance for the association with dawa was $X^2 = 0.568$, $p = 0.451$ (Table 2). The test of association between the presence of fluorosis and bambara consumption in Research Question 3 was also not significant, with the Fisher's exact test two-sided significance value of $p = 0.06$ (Table 3). However, the test of association between SES and fluorosis was significant at p=0.027(Table 4).

Arising from these results, it can be concluded that two of the four RQ were satisfied, thus linking fluorosis to SES. Although the test of association in RQ2 and 3 was not significant (*p* = 0.451 and 0.06 respectively), we must not rush to conclude that these food types were not linked to fluorosis. Because, based on the results of this study, the proportion of those children who ate dawa and bambara and had fluorosis was very high. In particular, however, the association with eating bambara (*p* = 0.06) was of great interest which require further research. This finding is similar to the findings by Cao et al., (1996), who found that brick tea and zanba were food items with high fluoride levels that were linked with fluorosis in Tibetan children. In the present study, the mean fluoride concentration in dawa was 7.2 mg/l, and in bambara, it was 6.6 mg/l (Appendix I). These levels are high when compared with the concentrations in brick tea (2.59±1.73mg/l) and zanba (5.12±2.80mg/l) and the WHO recommended levels of fluorine in water which is 1mg/l. Thus, the food types of the population of the present study may also be linked with dental fluorosis. However, further research need to be done here.

Post hoc Measures.

The study utilized many measures in order to ensure validity of the study findings, such as; examining the questionnaire for content, empirical and construct validity; this was done by ensuring that all relevant variables of interest were covered, and also aligning the variables to the research questions. Also, the questionnaire was checked to see if the content could identify the intended variables and was capable of measuring these variables (Yaghmaie, 2003). To ensure empirical validity, it was important to assess how the instrument will be capable of measuring the outcome correctly; this was achieved by ensuring that the dentist using the TSIF repeated the dental examinations of some participants without the knowledge of the dentist and thereafter comparing the scores. In this way the Cronbach's alpha test of validity was 0.948, indicating good reliability of the measurement (Bulsara & Priya, 2014). Also, the reliability of the questionnaire was assessed by conducting a pilot test of the questionnaire in a similar population (a group of pupils aged 5 to 15 years) to ascertain if they understood and could respond to the questions. Teachers in the schools were ask to provide feedback on the appropriateness of the survey instrument and if the pupils answered the items on the questionnaire correctly.

Furthermore, the reliability and validity of measurement instruments (i.e., the spectrophotometric method for measuring fluoride levels in foods, and the TSIF scale for grading fluorosis) have been tested by previous researchers in similar environments (Cao et al., 1997; Horowitz, 1986; Kahama et al., 1997; Paul et al., 2011). Generally, the spectrophotometric method can detect fluoride levels up to 0.1mg/dl in water (EPA 1998) and up to 1µg in tea, cocoa, tobacco, food beverages (Kakabadse, 1971).

To address the challenge of selection bias which would have occurred because of the extent of the condition in the study area and the likelihood of children and parents volunteering to participate with the hope of getting treatment, thereby causing a bias in participant selection in favor of the problem, a systematic random selection was done following the criteria described in the method section. Furthermore, the potential non-response error arising from the survey process where inadequate responses on some questions leading to missing data were control for by, a large sample size in order to prevent it from affecting the validity of the findings.

Limitations of the Study

As this was a cross-sectional study design, the weakness of inadequate control over rival explanations, such as covariables that could be confused with fluorosis, may impinged on the cases of fluorosis diagnosed. To be able to control this, the dentist made definite diagnosis of the cases presented as; dental fluorosis, dental caries, or other dental conditions. This made the diagnoses more specific, thereby ruling out other causes of dental discoloration.

The reliability estimate of the questionnaires as a measurement instrument was assessed to be 92% to 95%, indicating that the questionnaires could accurately elicit correct responses from over 90% of the respondents.

The validity of the measure for grading the severity of fluorosis by the dentist was assessed using the test-retest method. Cronbach's alpha test of validity was 0.948, indicating good reliability; however, the reliability of the measurement instrument cannot always be 100%, and this could affect the diagnosis of the severity of fluorosis. Also, the estimations of fluoride content in the vegetables, dawa, and bambara utilized the spectrophotometric method, whose accuracy is 80% to 92%. This may have affected the validity of the findings and therefore impact their generalizability.

Recommendations

Many interesting findings resulted from this study that can contribute to the current knowledge on fluorosis, such as the link to food types consume which may need further research to focus on the extent of fluoride contamination of the food pathways and the development of fluorosis in the study area. Again, it will be interesting to further look at the close relationship between fluorosis and the consumption of bambara food in this community.

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Appendix

Appendix A: Descriptive Criteria and Scoring System for the Tooth Surface Index of Fluorosis

Numeric Score	Descriptive Criteria
(0)	Enamel shows no evidence of fluorosis.
(1)	Enamel shows definite evidence of fluorosis, namely areas with parchments-white color that total less than one-third of the visible enamel surface. This category includes fluorosis confined only to incisal edges of anterior teeth and cusp tips of posterior teeth ("snow capping").
(2)	Parchment-white fluorosis totals at least one-third of the visible surface, but less than two-thirds.
(3)	Parchment-white fluorosis totals at least two-thirds of the visible surface.
(4)	Enamel shows staining in conjunction with any of the preceding levels of fluorosis.Staining is defined as an area of definite discolouration that may range from light to very dark brown.
(6)	Both discrete pitting and staining of the intact enamel exist.
(7)	Confluent pitting of the enamel surface exists. Large areas of enamel may be missing and the anatomy of the tooth may be altered. Dark-brown stains is usually present.

Note: From Indexes for Measuring Dental Fluorosis by H.S. Horowitz, 1986. *Journal of Public health Dentistry*, *46*, 179 – 183.

Appendix B: 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).

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Appendix C: Table of Gender Characteristics According by Classgrade.

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 D: 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 E: 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)

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

Diagnosis of fluorosis	Noticed color change on teeth: 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.

Appendix G: Table Showing Diagnosis of Fluorosis and Gender.

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

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

Appendix H: A 2 x 2 Contingency Chi-Square Test of the Severity of Fluorosis and Gender.

Severity of Flourosis	Gender: 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.

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Appendix I: Descriptive Results of Fluoride in Dawa and Bambara Sampled in the Zing Community

	N	Min	Max	Mean	SD
Fluoride content in dawa	242	6.5	8.4	7.194	.733
Fluoride content in bambara	275	5.6	8.2	6.606	1.151

Table presents the mean fluoride content in dawa and bambara sampled in the study area. The table shows that the mean fluoride content in both dawa and bambara are high (above 1 mg/l).