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# USING FISHER-OWEN'S CONCEPTUAL-MODEL IN DESIGNING PROGRAM FOR FLUOROSIS CONTROL 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 is a public health problem with 11.4% of the population in Nigeria, impacted by this disorder. Dental fluorosis one of such discoloration is caused by exposures to high fluoride during tooth development. It is linked to the development of a variety of physiological and psychological problems, such as dental aesthetics, reduction in intelligence and skeletal changes. The purpose of this quantitative, cross-sectional study was to examine how the children oral health model can be used to design programs for the control of fluorosis in children in a rural community in Nigeria. The theoretical model utilized a twenty- two domain of influences to develop possible fluoride exposure pathways. The study was guided by the following research questions: What is the prevalence of fluorosis among Nigerian school-aged children? What are the prevailing influences at children, parental and community levels that can impact on children fluorosis? Data was collected by administering three surveys, on children aged 5 to15 years, their parent/guardian, and on community leaders. 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. Children fluorosis was associated with the length of stay in the study area, knowledge and the fluoride content in water, soil, and food. This study's possible impact on social change

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include raising awareness, and identifying many possible ways that can be used to control it; such ways as improved dental care services and flocculation of community water sources.

**Keywords:** Children, fluorosis, parental and community level influences, environment.

## Introduction

Dental discoloration due to fluorosis presents as hypoplasia of tooth enamel. Ando et al., (2001) reported that fluorosis in humans arises from the intake of fluorine through drinking water. However, various practices and occurrences have been associated with the development of fluorosis such as 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 ameliorate the damage caused by the adverse health effects of fluorosis by examining factors that promote its development. The health effects of fluorosis include such disabilities as aesthetics 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 and it is important that steps should be taken to address this problem (Cao et al., 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 et al., 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. In this study, at least 17 of the domains were explored to find any association with children fluorosis. At the child level, the domains explored were, genetic and biologic endowment, healthy development, physical and demographic attributes, health behaviors and practices, and use of dental care and dental insurance. At the parental level, the domains explored were family composition, SES, family function, health behaviors and coping skills, social support, and food culture. At the community level, the domains included health care system characteristics, dental care system characteristics, social environment, physical environment, and community oral environment such as availability of programs that promote oral care in the community.

Easily identifiable community-level influences that relate to fluorosis could be the type of social environment that exist in the community such as, whether there is a good water supply, whether there are good dental care services, and whether there are peculiar cultural norms observed in the community. Some parental influences could include single-parent family household that might poorly be affected by its SES status and thus health-seeking behaviors. For the child level influences, such interesting attributes as, whether the child utilizes dental care services or is enrolled in dental care insurance? Children's oral health problems, such as dental fluorosis, could be impacted by various factors that are related to all three levels of influences thus, a model that correlates these influences is appropriate to this assessment. As previously stated, the multilevel conceptual model developed by Fisher-Owen et al. (2007) provides such a framework.

**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 assess how it is associated with childhood, parental, and community level influences. This was done by identifying the influences in the oral health childhood model, and potential inferences drawn between dental fluorosis and the influences at these levels thereby testing, and evaluating hypotheses.

The testable independent variables examined were the following: children level; 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 dental and dental insurance; for the family level; family composition, family function, SES, health behaviors, and social support; at community level; good water supply, dental care services, community dental program etc. These were studied to see how they are associated with dental fluorosis in children as the dependent variable. The possible co-variables examined in the study included dental caries.

**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 childhood level influences in the model?

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$H_0^{1}$ Null hypothesis: There is no association between dental fluorosis in children and childhood level influences

$H_A^{1}$Alternative hypothesis: There is an association between dental fluorosis and childhood level influences.

3. Is there an association between the presence of fluorosis among children in the Zing community and parental level influences in the model?

   $H_0^{1}$Null hypothesis: There is no association between dental fluorosis in the children and parents level influences.

   $H_A^{1}$Alternative hypothesis: There is an association between dental fluorosis and parent level influences.

4. Is there an association between the presence of fluorosis among children in the Zing community and community level influences in the model?

   $H_0^{1}$Null hypothesis: There is no association between dental fluorosis in the children and community level influences.

   $H_A^{1}$Alternative hypothesis: There is an association between dental fluorosis and community level influences.

## 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 participants for the community sociodemographic factors were the local government council chairman, the traditional council leader, and all the school heads.

All three 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. The criteria for inclusion in the third survey was that the participant was either a chairman of the local government council, head of a traditional institution, or the head of a participating school.

**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).
2. The colorimetric (spectrophotometric) methods for detecting fluoride levels in both biological and environmental samples. This method is recognized by the WHO/FAO, NIOSH (National Institute for Occupational Safety and Health), and EPA for analyzing chemicals, and estimating fluoride in biological materials and environmental samples (ATSDR, 2013).
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.

## Data Collection

The survey was administered face to face to the participants in English and data was collected by four research assistants 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 three 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, and the third community level influences and demographic characteristics. 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

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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 child, family, and community levels 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 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. However, concerning community demographic characteristics, all of 18 eligible participants consented and responded to the administered questionnaires.

**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.

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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, eats breakfast, lunch and dinner, 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 and 4: There is an association between dental fluorosis and the variables grouped as influences under child level, parent level and community level, a chi-square test was used to analyze if there were statistical associations in order to make inferences. For clarity, the variables under child level influences were age and sex of child, length

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of residence in the community, SES, health behavior and practice, use of dental care services; those under parent level influences were family composition, family function, SES, health behaviors, and social support, for community influences, availability of dental services, community dental care program, availability of good water supply, fluoride content of common water supply and food substances.

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, parents and community 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**

Children characteristics. Table 1 presents the demographic information for the children participants. The gender distribution shows that 136 (50.6%) of the respondents were male, while 133 (49.4%) were female, 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 are comparable across gender, as the mean age for male was 10.6 ± SD 2.90 and for female 9.8 ± SD 2.60 (Figure 1, Appendix B). As regard their 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). Concerning feeding, 185 (69%) of the respondents ate breakfast, lunch, and dinner daily, while 83

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(31%) did not. These percentages were also comparable across gender (Figure 6, Appendix C and D).

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*

| | 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 |
| | | |
| SES | | |
| High | 3 | 1.10 |
| Middle | 57 | 21.20 |
| Low | 209 | 77.70 |
| Total | 269 | 100.0 |
| | | |
| Eats breakfast, lunch, dinner | | |

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| | | |
|---|---|---|
| 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 |
| Farm location | | |
| Valley | 39 | 14.5 |
| Low land | 169 | 62.8 |
| Hilly site | 22 | 8.2 |
| None | 39 | 14.5 |
| Total | 269 | 100.0 |
| How do you clean your teeth? | | |
| Toothpaste on brush | 197 | 73.2 |
| Chewing stick | 62 | 23.0 |
| Charcoal | 2 | 0.7 |
| Toothpaste on brush/chewing stick | 6 | 2.2 |
| None | 2 | 0.7 |
| Total | 269 | 100.0 |
| Taught oral hygiene in school | | |
| No | 26 | 9.7 |
| Yes | 243 | 90.3 |
| Total | 269 | 100.0 |
| Diagnosis of | | |
| Fluorosis? | 233 | 86.6 |
| Yes | 36 | 13.4 |
| No | 269 | 100.0 |
| Total | | |

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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 6, Appendix D).

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

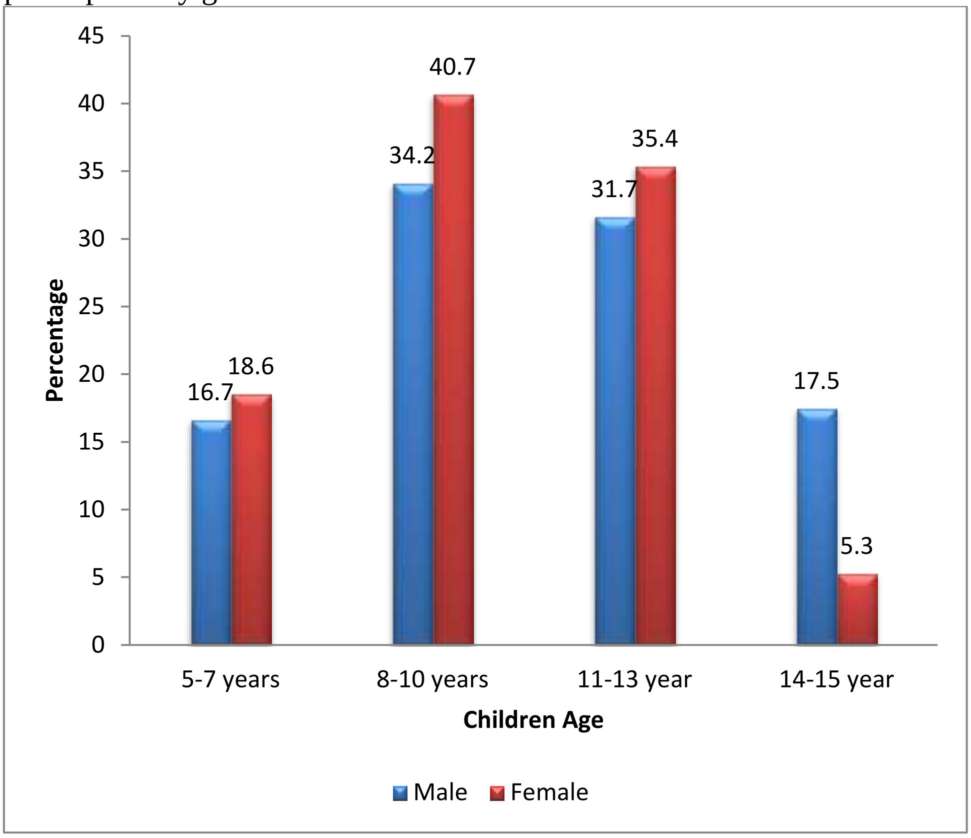


*Figure 1.* Age profile of participants by gender.

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

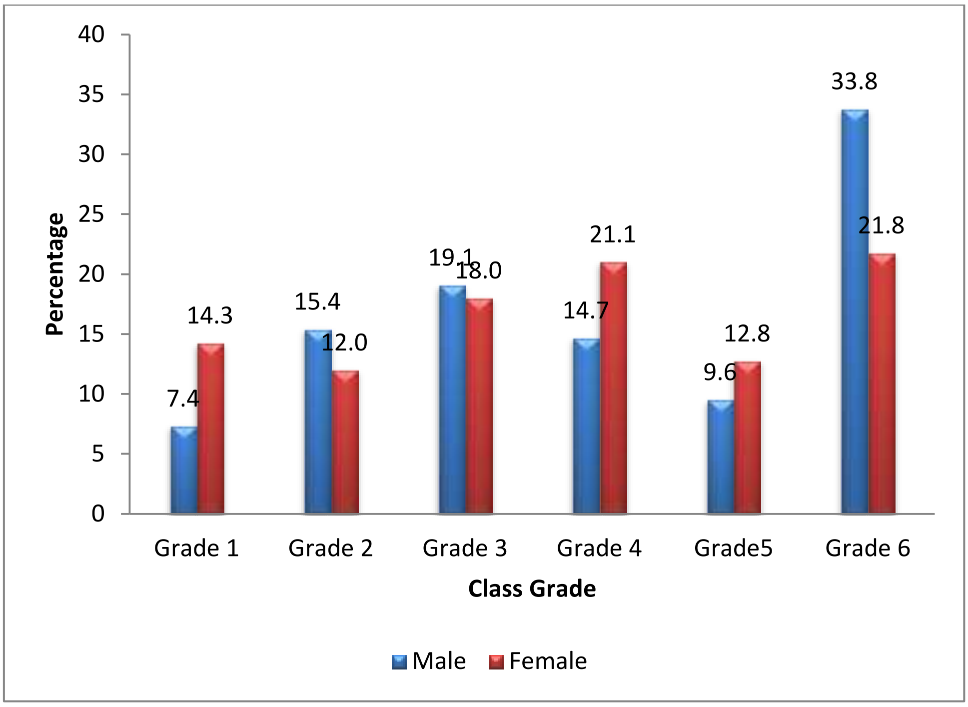

*Figure 2*. Gender characteristics according to class grade.

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 C) indicating that there was no significant difference between gender distributions across the grades.

Figure 3 below, presents the relation of gender characteristics with choice of treatment by the students.

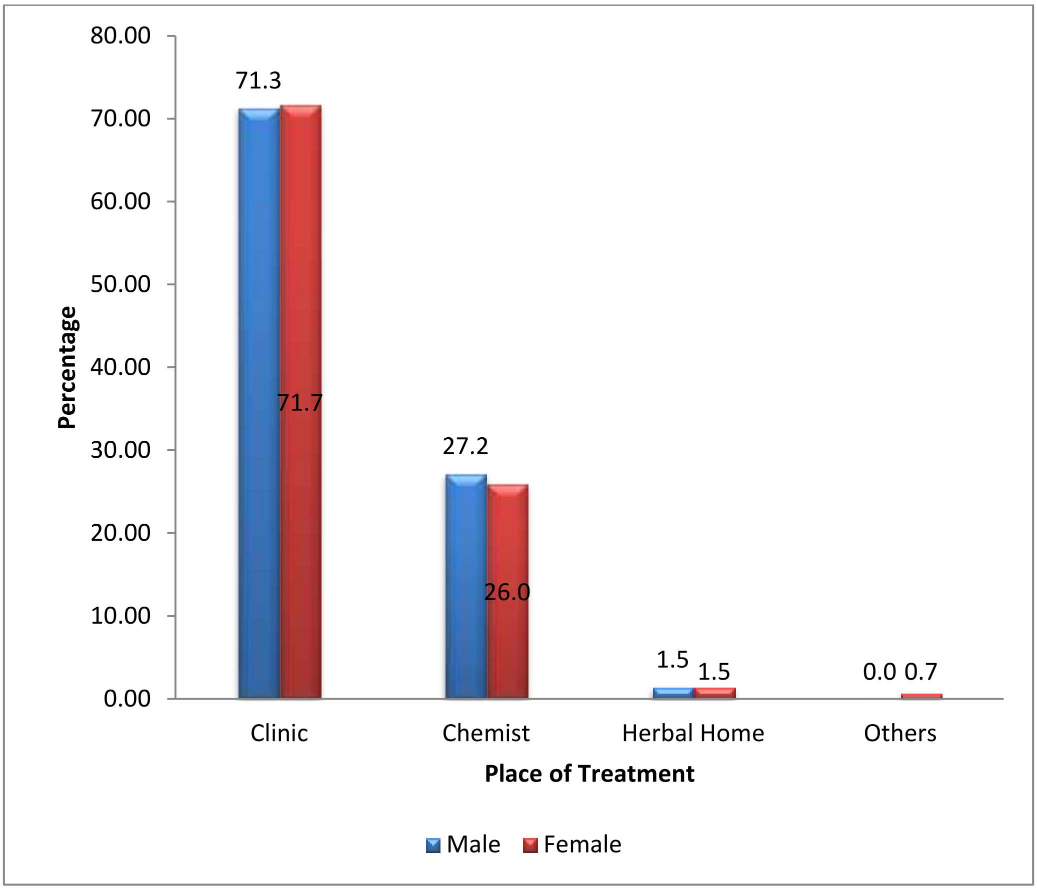


*Figure 3*. Gender characteristics with choice of treatment.

In Figure 3, 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 was however, not statistically significant with exact fisher test value of *p* 0.683 (Appendix E) 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 4, summarizes student's preferred mode of cleaning teeth.

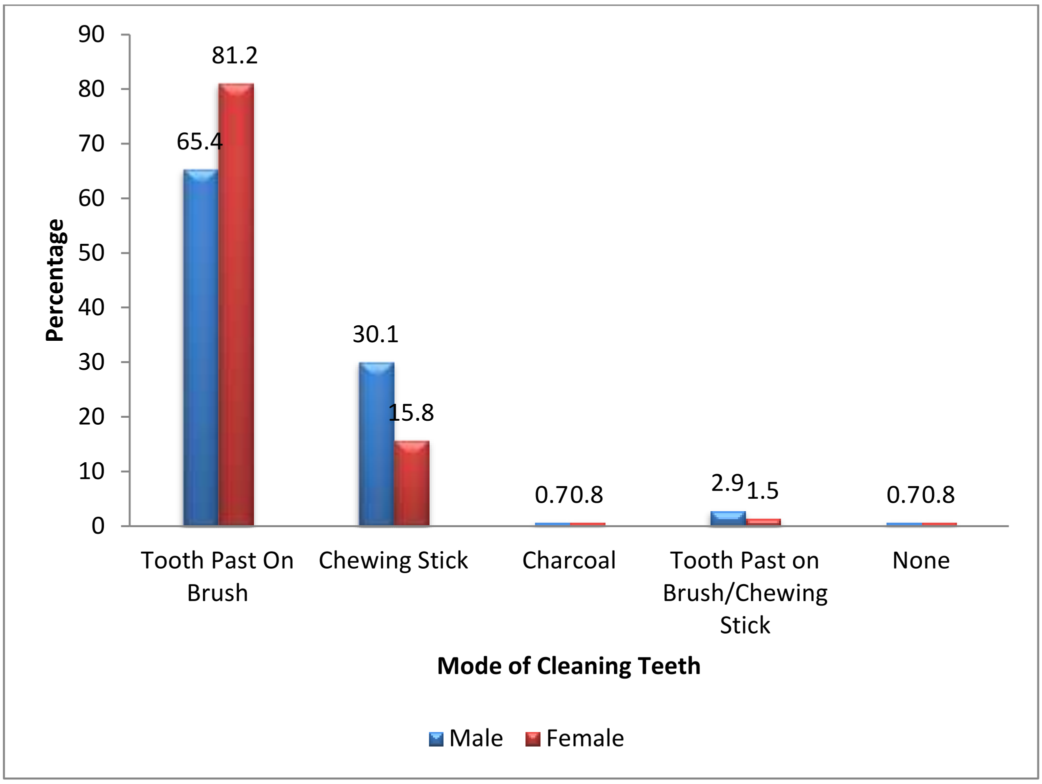


*Figure 4.* Student's preferred mode of cleaning teeth

In Figure 4, 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 F), indicating that there was significant difference between the gender in the methods used in cleaning teeth.

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Figure 5 below, shows whether children were taught hygiene in school.

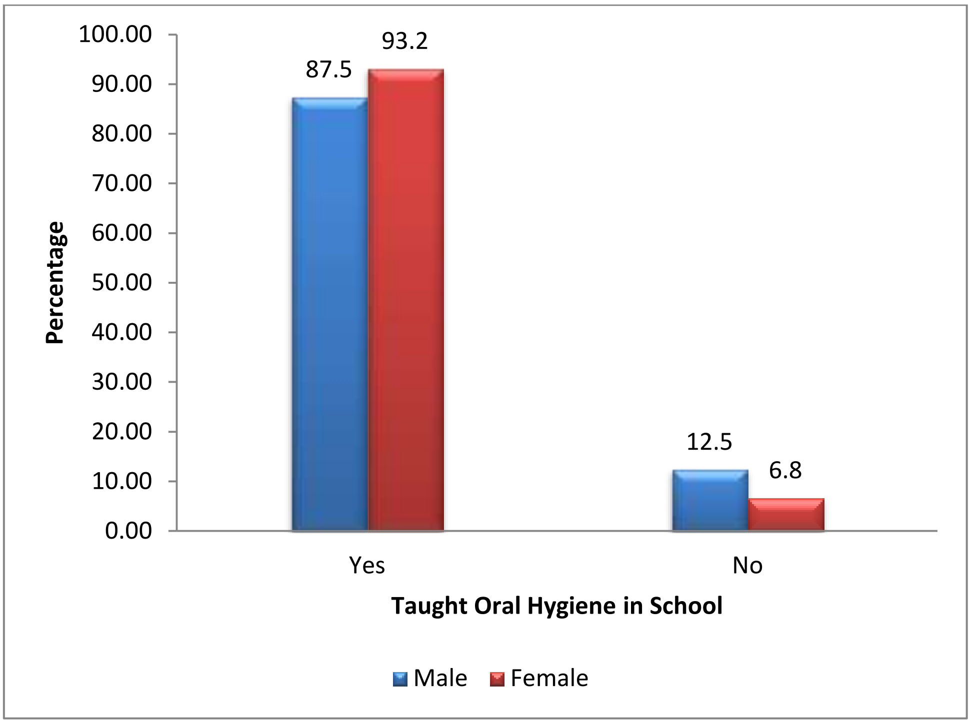


*Figure 5*. Children taught oral hygiene in school.

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 G).

Figure 6, presents the gender ratio for which students eat breakfast, lunch, and dinner daily.

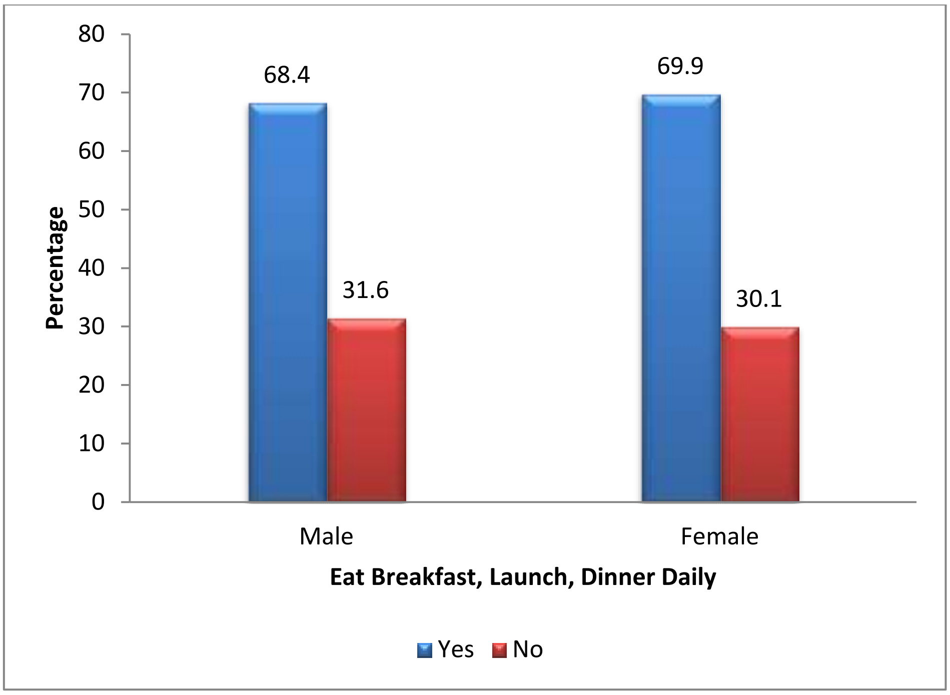


*Figure 6*. Gender ratio for students feeding.

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

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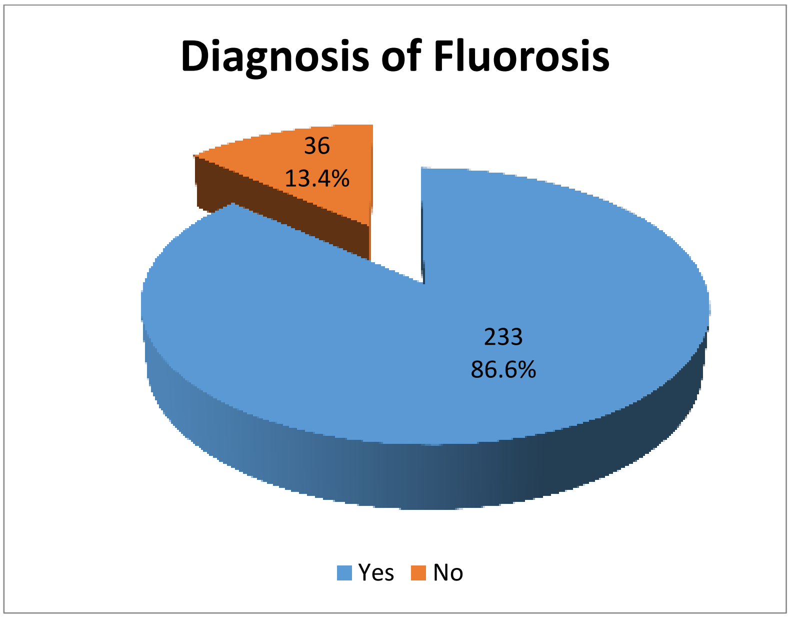


*Figure 7.* Diagnosis rate of fluorosis in the study population.

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 H), 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, family SES, student's attitude to health, and the student's knowledge of illness; $p$= 0.031, 0.027, <0.001, and <0.001 respectively (Tables 4, 5, 6, and 7 below).

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

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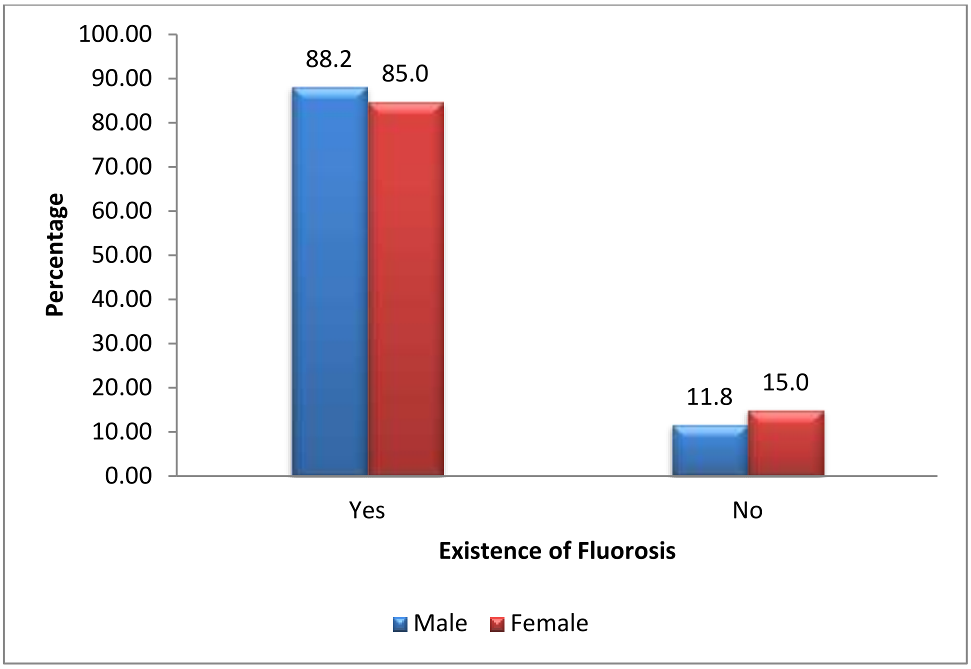


*Figure 8*. Fluorosis diagnosis rate by gender.

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

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

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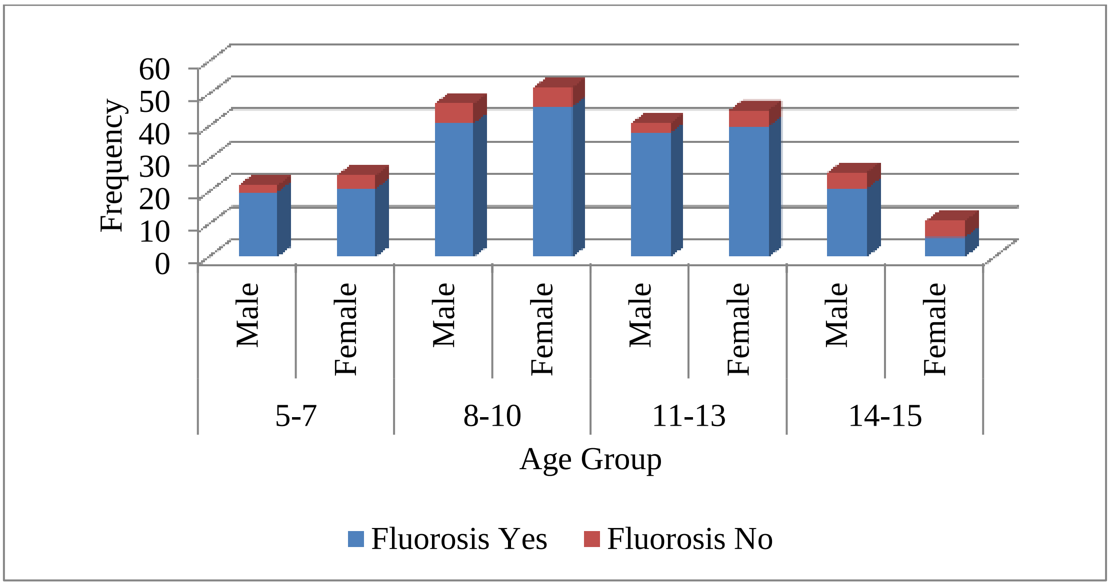


*Figure 9.* Proportion of fluorosis by age group and gender.

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 H).

The Figure further shows that fluorosis was similarly distributed across genders, 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, $p$=0.432 (Appendix I).

**Parents/guardians characteristics.** Information on the parents of the sampled children is presented in Table 2. The gender distribution shows that 171 (63.6%) of the respondents were male, and 98 (36.4%) were female. 1 (0.4%) was less than 11 years of age, 6 (2.2%) respondents were between 11 to 20 years of age, 63 (23.4%) respondents were between 21 to 30 years of age, 88 (32.7%) respondents were between 31 to 40 years of age, 81 (30.1%) respondents were between 41 to 50 years of age, 24 (8.9%) respondents were between 51 to 60 years of age and 6 (2.2%) were above 60 years of age. The family composition showed both parents living together in 230 (85.5%), 4 (1.5%) were reconstituted parents, while 30 (11.2%) were single parents and 5 (1.9%) did not respond.

The household size, showed 63 (23.4%) respondents with less than 6 people, 148 (55.0%) respondents with between 6 to 10 people, 30 (11.2%) respondents had between 11 to 15 people, 12 (4.5%) respondents had 16 to 20 people, 7 (2.6%) respondents had between 21 to 25 people, 3 (1.1%) had between 26 to 30 people, while 6 (2.2%) were above 30.

This table also reveals that 239 (82.9%) respondents ate family meals together, while 30 (11.2%) did not eat family meals together. Based on household highest level of education, the table shows that 56 (21.9%) respondents had degrees, 3 (1.1%) had a diploma or NCE, 138 (51.3%) had completed secondary education, 32 (11.9%) had completed primary education, and 3 (1.1%) had no formal education. It was also observed that 228 (84.8%) practiced farming as their occupation while 41 (15.2%) did not. Similarly, 24 (8.6%) students were enrolled in dental care, while 245 (91.1%) were not. Based on source of water, the table shows that the majority of the parents or guardians (52.8%) had borehole as their primary source of water.

As regards the characteristics of the parents whose children had fluorosis, it was observed that 97.4% of them were 21 to 50 years old, 87.1% lived together, and 89.2% ate family meals together. 50.6% of them had secondary education, 52.3% were unemployed, and 92.3% of them did not enroll their children in dental care program. Again, 53% of them were from households with 6 to 10 family size.

The characteristics of parents whose children had fluorosis showed that the household size with the most children having fluorosis was 5 to 10(Appendix J) and these accounted for 61.4% of the children fluorosis. The type of family composition, did not significantly affect fluorosis in their children (fisher's $p = 0.1021$, Appendix K). However, whether parents were employed or not significantly affected children fluorosis ($p = 0.050$, Appendix L).

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**Table 2**
*Parent or Guardian Characteristics*

| | Frequency | Percentage | Children with Yes | Fluorosis No |
|---|---|---|---|---|
| Gender | | | | |
| Male | 171 | 63.6 | 149 | 22 |
| Female | 98 | 36.4 | 84 | 14 |
| Total | 269 | 100 | 233 | 36 |
| Age | | | | |
| Less than 11years plus | 7 | 2.6 | 5 | 2 |
| 11- 20 years | 63 | 23.4 | 56 | 7 |
| 21 - 30 years | 88 | 32.7 | 78 | 10 |
| 31 - 40 years | 81 | 30.1 | 67 | 14 |
| 41 - 50 years | 24 | 8.9 | 23 | 1 |
| 51 - 60 years | 6 | 2.2 | 4 | 2 |
| Above 60years | 269 | 100 | 233 | 36 |
| Total | | | | |
| Family composition | | | | |
| Both parents together | 230 | 85.5 | 203 | 27 |
| Reconstituted parents | 4 | 1.5 | 4 | 0 |
| Single parent | 30 | 11.2 | 23 | 7 |
| No response | 5 | 1.9 | 3 | 2 |
| Total | 269 | 100 | 233 | 36 |
| Household size | | | | |
| Below 6 | 63 | 23.4 | 50 | 9 |
| 6 - 10 | 148 | 55.0 | 123 | 19 |
| 11 – 15 | 30 | 11.2 | 25 | 4 |
| 16 – 20 | 12 | 4.5 | 12 | 0 |
| 21 – 25 | 7 | 2.6 | 6 | 2 |
| 26 – 30 | 3 | 1.1 | 3 | 0 |
| Above 30 | 6 | 2.1 | 14 | 2 |
| Total | 269 | 100 | 233 | 36 |

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| | | | | |
|---|---|---|---|---|
| Eat family meals together | | | | |
| Yes | 239 | 82.9 | 208 | 31 |
| No | 30 | 16.7 | 25 | 5 |
| Total | 269 | 100 | 233 | 36 |
| Household highest | | | | |
| education | 59 | 21.9 | 54 | 4 |
| Degree | 3 | 1.1 | 2 | 1 |
| Diploma/NCE | 138 | 51.3 | 118 | 20 |
| Secondary | 32 | 11.9 | 26 | 6 |
| Primary | | | | |
| No formal | 3 | 1.1 | 2 | 1 |
| education | 34 | 12.6 | 31 | 3 |
| No response | 269 | 100 | 233 | 36 |
| Total | | | | |
| Employed | | | | |
| Yes | 123 | 45.7 | 111 | 12 |
| No | 146 | 54.3 | 122 | 24 |
| Total | 269 | 100 | 233 | 36 |
| Practice farming as | | | | |
| occupation | 228 | 84.8 | 197 | 31 |
| Yes | 41 | 15.2 | 36 | 5 |
| No | 269 | 100 | 233 | 36 |
| Total | | | | |
| Children enrolled in dental care | | | | |
| program | 24 | 8.9 | 18 | 6 |
| Yes | 245 | 91.1 | 215 | 30 |
| No | | | | |

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| | | | | |
|---|---|---|---|---|
| Total | 269 | 100 | 233 | 36 |
| Source of water Borehole | 142 | 52.8 | 128 | 14 |
| Borehole and other sources | 58 | 21.5 | 46 | 12 |
| Public tap and other sources | 21 | 7.8 | 18 | 3 |
| Stream and other sources | 48 | 17.9 | 41 | 7 |
| Total | 269 | 100 | 233 | 36 |

Note: Age < 11 years was 0.4%, other water sources include well, river.

**Community demographic characteristics.** The socio demographic characteristics of the community is presented in Table 3. The responses provided by the community leaders who were university graduates (50%) or had at least secondary education (72.2%) provided insight into the socio demographic characteristics of the community. The table indicates that, the most frequently used sources of water supply were boreholes and streams (77.8%), and there was no dental care program or access of the community to a dentist in the local government area. Additionally, water sources were not fluoridated in the community. The leaders also indicated that the most common health facilities used in the community were the primary health centers.

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**Table 3**
*Community Demographic Characteristics.*

| | Frequency | Percent |
|---|---|---|
| Qualification of community leaders. | | |
| Graduates | 9 | 50.0 |
| Secondary/technical | 4 | 22.2 |
| Primary school | 4 | 22.2 |
| No school | 1 | 5.6 |
| Total | 18 | 100 |
| Water sources: | | |
| Borehole | 7 | 38.9 |
| Stream | 7 | 38.9 |
| Stream, borehole, municipal | 1 | 5.6 |
| Stream, borehole | 3 | 16.7 |
| Total | 18 | 100 |
| Availability of dental program: | | |
| No | 14 | 77.8 |
| Yes | 4 | 22.2 |
| Total | 18 | 100 |
| Access to dentist | | |
| No | 16 | 88.9 |
| Yes | 2 | 11.1 |
| Total | 18 | 100 |
| Types of health facilities | | |
| Hospitals | | |
| Primary care centers | 1 | 5.6 |
| Primary care centers, | 15 | 83.3 |
| hospitals | 2 | 11.1 |
| Total | 18 | 100 |
| Fluoridation of water sources: | | |
| No | | |
| Yes | 14 | 77.8 |
| Total | 4 | 22.2 |
| | 18 | 100 |

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## Inferential Statistics

### *Chi Square Results*

**Research Question 2, child level influences;** Is there an association between the presence of fluorosis among children in the Zing community and childhood level influences in the model?

At the child level, some of the influences tested to find an association with fluorosis were; the number of years lived in the area, age, health behavior and knowledge of illness, as well as their SES. Also, the gender of the child if it significantly affected the severity of fluorosis in children was explored.

The exploratory test of these variables (Tables 4, 5, 6, 7, 8, 9) showed the following; length of stay and age of child had chi-square ($X^2$ 8.881, $p$ =0.031), Child's SES (fisher exact $P = 0.027$), child's attitude to health ($X^2 = 18.112$, $p < 0.001$), knowledge of illness ($X^2$ 21.258, $p < 0.001$), child's gender (($X^2$ 0.621, $p = 0.431$), severity by gender ($X^2$ 4.252, $p = 0.235$). This implies that age and length of stay, child's attitude to, and knowledge of health, as well as the child's SES significantly affected the development of fluorosis in children in this community, while the gender did not affect both the development of fluorosis or it's severity.

**Research Question 2: Parent level influences**: Is there an association between the presence of fluorosis among children in the Zing community and parent level influences in the model?

The exploratory tests of family composition, household size, household highest education, and enrollment in a dental care program were not significant in relation to the children having dental fluorosis. The *p* values for these variables were 0.1021, 0.516, 0.994, and 0.109, respectively (Appendix K, L, N and Table 10). There was no significant association between how parents maintained their children's oral hygiene. Here, the two-sided Fisher exact value was $p = 0.083$. However, there was a significant association between parent's employment status and fluorosis in their children ($p = 0.050$, Appendix L). This implies that parent's employment status more significantly is associated with children's fluorosis status in this community.

**Research Question 4: Community level influences;** Is there an association between the presence of fluorosis among children in the Zing community and community level influences in the model?

Although not tested for significance, the community-level influences highlighted in the demographic characteristics revealed the following: (a) there is no dental care program provided by the local government, (b) there is no access to a dentist in the community, (c) water sources are not fluoridated, and (d) the most frequently used sources of water in the community are the boreholes and streams (77.8%).

However, a regression analysis of the community variables water, foods, and soil, and the severity of fluorosis (Table 11) showed that the average level of the severity of fluorosis (Sfl) was 3.40 with a SD (Standard deviation) of 2.00. Fluoride content in water (Fcwmgl) had a minimum value of 1.00 mg/l and a maximum value of 6.80 mg/l, with an average value of 3.47 mg/l and an SD of 1.96mg/l. The fluoride content in the soil (Fcsmgl) had an average value of 0.39 mg/l with an SD of 0.96 mg/l. The estimated average value of fluoride content in food, including dawa, and bambara (Fcvmgl), was 6.49mg/l with an SD of 0.89 mg/l. The minimum and maximum values were 5.75 mg/l and 8.20 mg/l, respectively. This indicates considerably high fluoride content in water and food substances than the WHO recommended value.

## Study Findings

This study involved a field survey of children participants aged 5 to 15 years, as well as their parents/guardians and community leaders. The sample used for the study was 556 participants including 269 children (Survey 1), 269 parents (Survey 2) and 18 community leaders (Survey 3). The surveys were designed to determine possible influences on children's oral health at the child, parent/household, and the community levels using the child health model devised by Fischer Owen et al 2007.

The socio demographic characteristics of the participants 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. 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) at a *p* value of 0.025 (Appendix

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

The grades of the children involved in the study was from Grade 1 to Grade 6. The gender ratios across the grades showed a Pearson chi-square test *p* value of 0.10 (Appendix C) 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).

A great majority of the children used toothpaste on a brush to clean their teeth, and this characteristic differed significantly between the gender ($p = 0.0239$) with more female using toothpaste on brush than male (Appendix F). However, there was no significant difference between the gender on being taught oral hygiene in school ($p = 0.517$, Appendix G). 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 percentage of children diagnosed with fluorosis was 86.6%, indicating a high prevalence rate (Figure 7). Those without fluorosis was 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 I). 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 H), indicating that there was no significant difference in the age of children with fluorosis and those without fluorosis.

Further exploratory findings in the study showed 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.

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The age structure of their parents and guardians ranged from 11 to 75 years, with majority of them between the ages of 21 to50 years (86.2%, Table 2). On parents whose children had fluorosis, 97.4% of them were between 21 to 50 years old, 87.1% of them lived together as parents, and 89.2% of them ate family meals together. 50.6% of them had secondary education, 52.3% were unemployed, and 92.3% of them did not enroll their children in dental care program. Furthermore, 55% used water from boreholes, while 53% of them had household size of between 6 to 10 persons (Table 2).

The type of family composition, and source of water used by the family did not significantly affect children fluorosis ($p$ = 0.1021, 0.2214; Appendix K, and O). However, parent's employment status significantly affected diagnosis of fluorosis in children ($p$ = 0.050, Appendix L).

The demographic characteristics of the community include the following: the most frequent sources of water used in the community were boreholes and streams (77.8%, Table 3). 77.8% of the people had no access to a dental care program in the local government area (Table 3), while 88.9% of them had no access to a dentist (Table 3). 77.8% of water sources were not fluoridated (Table 3), and the most available health facilities in the community were primary health centers (Table 3).

On test of hypotheses, the association of the presence of fluorosis with childhood level influences in Research Question 2 showed that six of the influences identified was significantly associated with fluorosis. On the test of hypothesis in Research Question 3, the results showed that childhood fluorosis was significantly associated with the family SES and whether the parents were employed or unemployed. However, on Research Question 4, concerning community level influences, although direct statistical tests were not established; the descriptive analysis of the various variables examined (Table 11) indicated that there are contributory factors in the development of fluorosis.

## Discussion

The usefulness of the theoretical model used in this study to identify factors contributing to the development of fluorosis in children was highlighted. Of the 22 domains of influences in this model, 17 were tested. The result section clearly shows that they were significant findings at the child, parent and community levels. This indicates that designing programs to control the high prevalence of childhood fluorosis

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in this community will require addressing these factors. For clarity, the findings were as follows; the prevalence of fluorosis was 86% and this was significantly associated by the following factors at the childhood level; age and length of stay of child in the community, the child's attitude and knowledge of health, the family SES. The prevalence was not however associated with gender of child and this was the same for severity of fluorosis which was not affected by the gender of the child. In this regard, we can accept the research hypothesis in RQ2 of the study which states that childhood dental fluorosis is influenced by childhood factors. In this study, those influences have been identified. Thus, of the six child-level influences explored in this theory as possible contributors to the development of fluorosis, four (4) were found to contribute substantially namely, length of stay in the area, age of child, SES, and health behavior and practices.

Concerning the parent level influences in RQ3; five were explored and include family composition, family function, SES, health behaviors, and social support. The results indicate that family SES, and whether the parents were employed or unemployed significantly influenced childhood fluorosis. However, family composition, family function, health behaviors and social support did not significantly influence childhood fluorosis. Although the statistical test of significance may be unsubstantial, yet we may not rule out the influences; for example, as regards family function, where the family size was also seen as an important factor, only 23.4% of the households surveyed had an average family size of 1 to 5. The majority had household sizes of 6 or more people which is large considering the low SES of most families, and this must exert enormous pressure on family resources which is scarce, thereby exerting an influence.

Regarding health behavior, practices, and coping skills, this influence was assessed to highlight how parents maintained their children's oral hygiene although their responses showed no statistically significant association between the method used for maintaining oral hygiene and fluorosis (Table 12), their answers still indicated that there were no dental programs for their children (Table 2), this in itself is, a poor -level health behavior that might contribute to childhood fluorosis.

Regarding social support, the study also found that there is minimal support for dental health in the community. For example, there is no access to a dentist and there is no dental insurance scheme in the community (Table 3). All these may influence dental care in the community. Thus at the minimum, of the five parental influences explored, four contributed substantially to the development of poor oral health of children in this community. Regarding the hypothesis in RQ3, the study findings support the research hypothesis that parent level influences significantly affect the development of children fluorosis.

Regarding community level-influences as outlined in RQ4, although not statistically tested, the descriptive analysis of the various variables examined (Table 11) indicated that there are contributory factors in the development of fluorosis as the fluoride content in these samples were all higher than the WHO recommended level of 1mg/l. In addition, the study found that there is no dental care system or community dental program available. The only program taking place involves oral hygiene lessons taught in the primary schools. The social and physical environment for dental care is therefore poor, and there are no programs for ameliorating or mitigating the effect of high fluorine content in the available common sources of water in the community. Thus at the minimum, four of the community level influences were found to contribute substantially to the development of fluorosis in this community.

The findings in this study are in agreement with the domains of influences proposed in Fisher-Owen's model for children's oral health. In it, at least 12 of the 22 influences were found to contribute to the development of dental fluorosis in the study area. The influences identified can lead to guided measures for fluorosis control among children in the community.

## Recommendations

Based on the study findings above, the current body of knowledge regarding fluorosis control can be improved by adopting targeted measures aimed at its control. Such appropriate measures shall focus at the individual, family, and community levels. Thus in designing control program for fluorosis control, the aim is to adopt measures targeted at the substantial findings at the various levels examined.

At the individual level, children need to be educated about appropriate health behaviors, including good oral hygiene, practical ways to care for their teeth (e.g., showing them how to use toothpaste and a toothbrush, the need to brush twice a day, how to detect early signs of abnormality in teeth color, and how to determine what is normal dental growth and what should be reported to the dentist), the importance of regular dental check-ups as well as regular medical-check and the need to avoid sweet foods and drinks before bed time to discourage the proliferation of oral micro-organisms.

At the family level, there is need for parents to improve parent-child interaction through such opportunities as family meals for instance. This will help them to check their children's dental growth in order to identify issues that may require help and may necessitate the institution of strict family dental care measures. There is also need to try to improve their family SES by finding ways of engaging in resourceful ventures and to improve the family's level of education. They should learn to enroll their children in dental care programs and address family food habits that promote the development of fluorosis such as a reduction in those foods identified as having high fluoride content

At the community level, measures should involve the provision of essential services to improve dental care such as, monthly dental examinations of school pupils by a dentist and treatment of any identified issues; the institution of dental insurance for children aged 2 to 15 years. It should also improve the social environment by instituting community health programs such as the flocculation of commonly available water sources (e.g., boreholes), to remove excess fluorine thereby providing safe water for community use. The local government could also improve the general health care services in the community through manpower development and the provision of essential facilities, and they should perform routine/regular checks of the fluorine content in water sources in order to keep them within allowable limits.

At the State/national levels, there should be adequate regulatory measures on the control of fluorine contamination of water sources and trained manpower to safeguard these measures. Policies should also be implemented to control these disorders on a general scale, and resources should be provided to carry out these measures at the community level. If addressed, these changes will bring about positive social change and improve the quality of life in this community.

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## List of Additional In-text Tables.

**Table 4**

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

| | Years Stayed | | | | | df | X2 | Sig. |
|---|---|---|---|---|---|---|---|---|
| Diagnosis of fluorosis | 5-7 years | 8-10 years | 11-13 years | 14-15 years | Total | | | |
| 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.

**Table 5**

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

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

**Table 6**

*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.

**Table 7**

*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.

**Table 8**

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

| Diagnosis of Fluorosis | Gender 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.

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**Table 9**

*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.

**Table 10**

*2 x 2 Contingency Table Between Presence of Fluorosis and Enrollment in Dental Care Program*

| | Children enrolled in dental care program | | | |
|---|---|---|---|---|
| Diagnosis of fluorosis | Yes | No | Total | Sig. |
| Yes | 18(20.8) | 215(212.2) | 233(233) | |
| No | 6(3.2) | 30(32.8) | 36(36) | 0.109 |
| Total | 24(24) | 245(245) | 269(269) | |

* 1 cell (25.0%) had expected count (in parenthesis) of less than 5. The minimum expected count was 3.21. Chi-square conditions not met. Fisher's test used. Not significant at 95% CI.

**Table 11.**

*Descriptive Results of Fluoride in Water, Soil, and Food, and the Severity of Fluorosis.*

| | N | Min | Max | Mean | SD |
|---|---|---|---|---|---|
| Severity of fluorosis | 269 | 0.00 | 6.00 | 3.40 | 2.00 |
| Fluoride content in water | 269 | 1.00 | 6.80 | 3.47 | 1.96 |
| Fluoride content in soil | 269 | 0.00 | 3.00 | 0.39 | 0.96 |
| Fluoride content in food | 269 | 5.75 | 8.20 | 6.49 | 0.89 |

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**Table 12**

*2 x 2 Contingency Table between the Presence of Fluorosis and Chosen Method for Maintaining Oral Hygiene.*

| | Tooth paste, Chewing stick, Other | | | | | | Sig. |
|---|---|---|---|---|---|---|---|
| Diagnosis of fluorosis | Chewing stick | Tooth-paste | Other | Tooth-paste and other | Chewing stick and other | Total | |
| Yes | 18(19.1) | 211 (208.7) | 1(1.7) | 0(0.9) | 3(2.6) | 233(233) | 0.083 |
| No | 4(2.9) | 30(32.3) | 1(0.3) | 1(0.1) | 0(0.4) | 36(36) | |
| Total | 22(22) | 241(241) | 2(2) | 1(1) | 3(3) | 269(269) | |

* 7 cells (70.0%) had expected count (in parenthesis) of less than 5. The minimum expected count was 0.13. Conditions for use of chi-square test statistic were not met, hence fisher test was used. Not significant at 95%CI.

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# Appendix

**Appendix A:** Dentist Record of Observations Using TSIF Scale

| | | Description of severity | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Participant number | Does participant have dental fluorosis? Yes/No | 0. Normal enamel shows no evidence of fluorosis | 1. Enamel shows areas with parchments white color less than 1/3 of visible enamel surface | 2. Parchment white fluorosis totals at least 1/3 of visible surface | 3. Parchment white fluorosis on at least 2/3 of surface | 4. Enamel shows staining in conjunction with preceding levels; stains range from light to very dark brown | 5. Both discrete pitting and staining of enamel exist | 6. Confluent pitting of enamel surfaces; large areas of enamel may be missing; dark brown stains present | Level of severity |

**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).

**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 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.

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**Appendix F:** 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 G:** 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)

**Appendix H:** 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 I:** 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)

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Appendix J: Table Showing Frequency of Fluorosis in Children and Household Size

| Household size | Fluorosis Yes | Fluorosis No | Total |
|---|---|---|---|
| 2 | 2 | 1 | 3 |
| 3 | 12 | 1 | 13 |
| 4 | 16 | 6 | 22 |
| 5 | 20 | 1 | 21 |
| 6 | 31 | 6 | 37 |
| 7 | 28 | 4 | 32 |
| 8 | 26 | 6 | 32 |
| 9 | 14 | 1 | 15 |
| 10 | 24 | 2 | 26 |
| 11 | 7 | 2 | 9 |
| 12 | 7 | 1 | 8 |
| 13 | 1 | 1 | 2 |
| 14 | 4 | 0 | 4 |
| 15 | 6 | 0 | 6 |
| 16 | 2 | 0 | 2 |
| 18 | 6 | 0 | 6 |
| 20 | 4 | 0 | 4 |
| 21 | 1 | 1 | 2 |
| 22 | 1 | 0 | 1 |
| 23 | 1 | 0 | 1 |
| 25 | 3 | 1 | 4 |
| 28 | 1 | 0 | 1 |
| 30 | 2 | 0 | 2 |
| 40 | 0 | 1 | 1 |
| 50 | 2 | 0 | 2 |
| 70 | 1 | 0 | 1 |
| 100 | 1 | 0 | 1 |
| 130 | 1 | 0 | 1 |
| NA | 9 | 1 | 9 |
| Total | 233 | 36 | 269 |

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**Appendix K:** Table of Family composition and Fluorosis in Children

| Family composition | Fluorosis in children | Total |
|---|---|---|
| | Yes | |
| | No | |
| Both parents together | 203 | 230 |
| Reconstituted parents | 27 | 4 |
| Single parent | 40 | 30 |
| No response | 22 | 5 |
| | 8 | |
| | 41 | |
| Total | 233 | 269 |
| | 36 | |

Note: N=269, $X^2 = 6.108$, $p = 0.106$. Chi-square conditions not met, fisher $p$ value = 0.1021

**Appendix L:** Table of Parents Employed and Fluorosis in Children

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

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

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**Appendix M:** Table Household Family Size and Fluorosis in Children.

| Household size | Households Freq. | Fluorosis freq. |
|---|---|---|
| Below 6 | 63 | 50 |
| 6 – 10 | 148 | 123 |
| 11 – 15 | 30 | 23 |
| 16 - 20 | 12 | 12 |
| 21 – 25 | 7 | 6 |
| 26 and above | 9 | 17 |
| Total | 269 | 233 |

*Note:* fisher's $p$ = 0.517, $X^2$ = 4.235, $p$ = 0.516(computed using winpepi statistical software).

**Appendix N:** Table Household Highest Education and Fluorosis in Children.

| Household highest education | Education Freq. | Fluorosis Freq. |
|---|---|---|
| Degree | 59 | 54 |
| Diploma/NCE | 3 | 2 |
| Secondary | 138 | 118 |
| Primary | 32 | 26 |
| No formal education | 3 | 2 |
| No response | 34 | 31 |
| Total | 269 | 233 |

*Note*: fisher's $p$ = 0.997, chi-square conditions not met (computed using winpepi statistical software).

**Appendix O:** Table of Water Sources and Fluorosis in Children.

| Water sources | Yes | No |
|---|---|---|
| Borehole | 128 | 14 |
| Borehole and other sources | 46 | 12 |
| Public tap and other sources | 18 | 3 |
| Streams and other sources | 41 | 7 |
| Total | 233 | 36 |

*Note*: Other sources include river, well, etc. fisher's $p$ = 0.2214, $X^2$ = 4.267, $p$ = 0.254(computed using winpepi statistical software).