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Potential For Dietary Calcium to Prevent Fluoride Uptake in Children in Halaba Special District, Southern Ethiopia: Knowledge, Attitudes, and Practices of Mothers

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Abstract

Fluorosis is a public health problem in Ethiopia. Fluoride (F) absorption can be decreased by dietary calcium (Ca) which forms insoluble complexes with the fluoride ion F-. The aim of this study was to assess maternal knowledge, attitudes, and practice (KAP) towards calcium in an area with high water F (9.7± 0.27mg/L) in Halaba, Southern Ethiopia. A cross-sectional study was conducted in 254 child-mother pairs randomly chosen from two kebeles of the district, and a questionnaire was used to obtain KAP. Teff, maize, millet were the major cereals in the study area and milk followed from the animal source food. The majority (96.5%) of respondents had never heard about fluoride. More than two-thirds reported that they did not know about the causes of teeth decay and skeletal fluorosis, and just 2% were aware that calcium could mitigate fluorosis symptoms. As a follow-up, nutrition education was provided that included sources of calcium stressing locally available foods. This study suggests that future research should focus on behavior communication for enhancing the community's knowledge, attitude, and practices towards fluorosis including improving calcium intake.

Keywords: Calcium; Fluoride; Fluorosis; Knowledge; Attitude; Practices; Intake; Ethiopia

Abbreviations: KAP: knowledge, attitudes, and practice; F: Fluoride; Ca: Calcium

Introduction

A recent systemic review [1] reported that in Ethiopia the mean fluoride (F) level in drinking water is greater than the WHO standard value of 1.5 mg/L and that in the Ethiopian rift valley, groundwater F varies from 0.1 to 75 mg/L. In SNNPR, the prevalence in drinking water sources of F concentration exceeding the WHO level of 1.5 mg/L was 57.1%, 25.9 %, and 50 % for well, spring, and tap water sources [2]. Thus, F is a major health concern throughout Ethiopia but particularly in the southern areas where groundwater fluoride is prevalent. Fluorosis can be categorized as dental, skeletal, and non-skeletal. All of these arise from high, continuous exposure to F in foods and water throughout the lifespan. The risk of dental fluorosis is of greatest concern for children below 8 years of age because enamel can no longer be repaired once pre-eruptive maturation has occurred [3,4]. In Halaba Kobochobare kebele of Ethiopia, previous research showed that drinking water sources contain fluoride above the WHO guideline value (1.5mg/L), and the fluoride content of most of the prepared foods was 1.3-3.2 mg/kg [5]. The prevalence of severe and moderate dental fluorosis was 20% in children. Skeletal fluorosis symptoms were found in 12-14% of children, and some nonskeletal fluorosis signs such as gastrointestinal symptoms were seen in 1-3 % of children [5].

The adverse effects of fluoride have been linked to poor calcium intake. With a low calcium diet, the ability of calcium to bind fluoride and prevent its absorption does not occur and fluorosis proceeds more quickly [6]. Fluoride, when ingested as sodium fluoride on an empty stomach, has a bioavailability of almost 100% but when taken concomitantly with a glass of milk or with a calcium-rich breakfast its bioavailability decreases to 70% and 60%, respectively [7,8]. Thus, it has been postulated by researchers studying fluorosis in Ethiopia that an increased intake of dietary calcium may reduce fluorosis progression [5,9]. Recently we tested this hypothesis by conducting an intervention with calcium in women living in a high fluoride area of Ethiopia, using eggshell powder as a supplemental source of calcium, and this provided support for calcium mitigating fluorosis signs and symptoms [10]. Further, our recent epidemiological studies show an association between calcium intake from foods and fluorosis signs and symptoms in adults [10] and in school-age children Tefera et al. [11]. However, knowledge of fluorosis and of the role calcium might play remains sparse in Ethiopia despite efforts to improve knowledge, attitudes, and practice (KAP) (Kebede – AJFAND). Hence, more information is needed on preventing fluorosis as young children are still growing and have erupting teeth. We, therefore, report our study of maternal KAP towards fluoride and calcium in an area where signs and symptoms of fluorosis are prevalent in children, with the aim to assess gaps in KAP. A secondary aim was to gather information on fluoride and calcium-containing foods in order to design appropriate nutrition education materials.

Materials and Methods

Study area

Halaba district is located 315 km south of Addis Ababa and is geographically located at 7017’ N latitude and 38006’ E longitude. It is a special district where the administration directly reports to the regional state. The altitude of the district ranges from 1554 to 2149 m but most of the areas in the district are found at about 1800 m. Rainfall has been a major limiting factor in agricultural production in the area, and as a result, it is one of the districts in SNNPR where drought is observed [12]. Two kebeles were selected purposively. A list of households with children 3-8 years were identified. 127 study participants were selected by the simple random method from each kebele.

Study participants

This cross-sectional survey, study participants were randomly selected mothers who have children from the age of 3-8 years. The sample size was determined by G*power version 3.0.10. For a two-tailed t-test with an effect size of 0.5, based on Cohen’s d effect size calculation ranges from 0.2 to 0.5 [13], for α equal to 0.05, and for a power 80. The total sample size for the cross-sectional study was 254 with equal numbers from two kebeles. 127 mother-child pairs per kebele were selected by the simple random method. Water and staple foods were selected purposively from each area determine the fluoride levels.

Measurement and data collection procedures

The method of data collection was by using an interviewer administrated questionnaire containing the demographic and socioeconomic characteristics, KAP questions, and a multiple-choice checklist on calcium intake. All interviewers also completed a 24-hour dietary recall with mothers of each child’s intake, using photographs, food models, household measurements (spoons, cups) and food weighing scale to help subjects accurately estimate amounts of food consumed. Liquids were recorded quantities as volumes, preferably using the respondents’ own household utensils calibrated with graduated cylinders plastic. A 24-hour recall, KAP questionnaire, drinking water sample, staple food sample, in households where there is more than one child, the index child was selected by tossing a random number.

Calcium and Fluoride Intakes

The amount of calcium and fluoride were calculated manually using two stages [14]. In the first stage, the nutrient intake data were recorded separately for each respondent. Portion sizes and quantities were converted into weight equivalents. In the second stage, for each respondent, the weight equivalent was computed manually using the Ethiopian Food Composition tables Part III and Part IV (EPHI, 1998) for calcium and laboratory analysis results for fluoride.

Follow-up Nutrition Education

Sessions of nutrition education were delivered on sources of fluoride, calcium-rich food, and its benefit to minimize fluoride toxicity. For nutrition education, copies of a poster showing the key messages about food groups, sources of fluoride and calcium-rich food, and their role to mitigate fluorosis was made and shared with the community. Images of children fetching water, how fluoride affects teeth, as well as locally available foods with an emphasis on those making a calcium-rich diet were included. Nutrition education sessions were delivered by the investigator and two research assistants in both kebeles.

Data management and analysis

All data were entered, cleaned, and analyzed using statistical software SPSS version [15]. All continuous data were checked for normality using the Kolmogorov Smirnov test. Fluoride and calcium contents were calculated for mean intake, percent of recommended daily allowance, and upper tolerable intake, and descriptive statistics (mean ±SD), frequency and percentage) were used to display the study findings.

Ethical considerations

The study approval was obtained from the Institutional Review Board of the College of medicine and health science at Hawassa University. Informed written consent was taken from the study participant mothers.

Results

(Table 1) A total of 254 children aged 3-6 years were included in the study. The median age of the study subjects was 4 (IQR: 3-6) years. The male to female ratio of participant children was 1.2 and all respondents were from Halaba ethnic group and Muslim by religion.

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Table 1: Socio-demographic characteristics and assets of study subjects' households in Halaba special district, SNNPR Ethiopia, June 2017.

Socio-demographic variable	Frequency(n=254)	Percent (%)
Maternal education		
No formal education	227	89.4
Primary	14	5.5
Read and/or write	13	5.1
Head of households		
Father	228	89.7
Mother	6	2.4
Both	20	7.9
Occupation		
Housewife	247	97.2
Petty trader	7	2.8
Family size		
1-5	82	32.3
>5	172	67.7
Agricultural land		
Yes	246	96.9
No	8	3.1
Animal owned		
Ox	193	93
Cow	174	65.3
Sheep	28	11
Goat	40	15.7
Donkey	96	37.8
Reported household assets		
Mobile	73	28.7
Radio	55	21.7
Hand torch	154	60.6
Bicycle	5	2
Water source		
Pond water	146	57.48
Public borehole	254	100

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Table 2: Dietary intakes of calcium (Ca) and fluoride (F) of Study children, Halaba special district, (n=254), Ethiopia, June 2017.

Age	Mean ±SD Ca intake(mg)	RDA	% below Ca RDA
1-3y (n=77)	277.4 ±189.1	500	87
>4 y (n=177)	362.9±234.3	800	75.1
	Mean ±SD F intake(mg)	UL	**% above F UL**
1-3y (n=77)	3.05 ±.50	1.5	100
>4 y (n=177)	3.77±1.26	2.5	100

Table 3: Knowledge and practices of mothers towards fluoride and calcium intake for fluorosis mitigation by their children in Halaba special district, (n=254), Ethiopia, June 2017.

Variable	Frequency	Percentage
Ever heard/aware of fluoride		
Yes	9	3.5
No	245	96.5
Ever heard/aware of calcium		
Yes	7	2.8
No	247	97.2
Knowledge about the sources of fluoride		
Yes	5	2
No	249	98
Knowledge about the consequences of excess fluoride intake		
Yes	8	3.1
No	246	96.1
Knowledge about the benefits of calcium mitigating excess fluoride intake		
Yes	6	2.4
No	248	97.6
Ever heard about teeth decay		
Yes	84	33.4
No	170	66.6
Ever heard about skeletal fluorosis		
Yes	35	13.8
No	219	86.2
Knowledge about the cause of teeth decay		
Evil eye/evil spirit	14	5.5
Not eating enough food	48	18.9
Drinking dirty water	22	8.6
Do not know	170	66.6
Knowledge about the cause of skeletal fluorosis		
Evil spirit/ God's punishment	19	7.4
Not eating enough food	11	4.3
Drinking dirty water	5	1.9
Do not know	219	86.2
Do you have a method of treating fluoride removal?		
Yes	0	0
No	254	100

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Subject Characteristics

Table 1 shows the characteristics of the families in which the target children were selected. Details are found in the table, but the additional discussion was given for the source of drinking water. As the finding of this study as participant mothers responded 146(57.48%) of them use pond water. In comparison to spring water, dams and open pans, and stream water; pond water contains high mean concentration of fluoride [16].

Children's Calcium and fluoride Intakes

Table 2 shows the concentration of Calcium and fluoride in collected food samples from the study households. Mean (±SD) of Calcium of 1-3 years children were 277.4±189.1 and 87% of them below recommended daily allowance (500). For age 4 and above years, mean (±SD) of calcium concentration was 362.9±234.3 and 75.1% of the participants' calcium level below the recommended daily allowance which is 800.

Mothers' knowledge and practices about fluoride and fluorosis

Almost no one knew the link between fluoride intake and fluorosis, as shown in Table 3. Few were familiar with calcium and its connection to fluorosis. More know about tooth decay. As, a study conducted among 4852 Ethiopian rift valley residences, the prevalence of dental fluorosis was estimated to be 28% ranging from 24 to 32% and Studies reported a high prevalence of dental fluorosis in the Rift Valley region of Ethiopia where the level of fluoride, especially in groundwater is significantly high [17-19].

Mothers' Attitudes about calcium and fluoride intake

The respondents were interviewed to grasp their attitude about calcium and fluoride with the lens of reducing fluoride toxicity. Behavior-related attitudes were categorized as the risk of excessive fluoride consumption, negative consequences of excess fluoride intake, social norms for who approves calcium consumption, self-efficacy of the mother to add calcium-rich foods for their children, costs, and health beliefs of calcium consumption. Only small segments of respondents (5.9%) strongly agree that excessive fluoride intake would be a risk of fluorosis. Almost one-third (33.46%) perceive that excessive fluoride intake and a low level of calcium intake would not be advantageous. More than half (56.7%) disagree that the costs of calcium-rich food including finger millet require too much money. A Poster showing calcium-containing foods in the community and how these might be used to reduce fluorosis was prepared and presented to the community (Table 4) (Figure 1). Maternal awareness of calcium-rich food and fluorosis reduction was improved due to education by showing of the poster.

Table 4: Fluoride and calcium composition (Mean± SD) of selected staple foods from Halaba special district, Ethiopia, June 2017.

Food type	Fluoride(mg/kg)[1]	Calcium (mg/kg)[2]
Injera, maize (n=3)	2.4± 2.1	40.6±14.6
Injera, teff (n=3)	1.8± 0.4	57.0±17.9
Flat Bread maize(n=3)	1.3± 0.2	39.0±11.1
Flat bread millet(n=3)	1.8± 0.3	245.2±25.6
Milk (mg/L) (n=3)	0.4 ± 0.1	890
Kale (n =3)	4.9 ± 1.0	1863
Potable water (n = 4)	9.7 ± 1.5	2.0 ± 0.9

[1]Fluoride values were measured.

[2]Calcium values were calculated from food composition data.

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Figure 1: Poster showing calcium-rich foods and healthy diet.

Discussion

The findings of this study show that maternal knowledge, attitudes, and practices towards exposure to fluoride by their children is low in Halaba special district, Southern Ethiopia, which is a concern in an area of Ethiopia where fluorosis is prevalent. There is growing evidence that calcium intake can mitigate fluorosis symptoms [6,9,10] yet mothers in this area were not aware, and calcium intakes of children are low. The main finding of this study shows very few mothers were aware of fluoride and the consequences of excess intake, yet dental and skeletal fluorosis are visibility prevalent in the Rift Valley [5,20-22]. In the current study, only 5.9% of respondents strongly agreed that excessive fluoride intake would be a risk for fluorosis. Surprisingly, respondents did not perceive excessive fluoride consumption as a risk for fluorosis. An earlier study of KAP done on fluorosis and its mitigation in three endemic areas of Ethiopia also showed there is a knowledge gap about fluoride and its health consequences [6]. Thus, in the intervening time there remains a knowledge gap about the consequences of fluoride.

Studies show fluorosis mitigation is mainly addressed through defluoridation of water in most cases. There are suggestions that nutritional supplements can also be used as a part of curative measures, such as focusing on adequate intake of foods rich in calcium, vitamins C and E, and antioxidants, along with consuming safe drinking water [23]. Others have focused many on calcium which as a divalent cation can bind the fluoride ion and prevent its absorption [10]. Hence, diets poor in calcium facilitate an increase in the body's retention of fluoride leading to excessive accumulation of fluoride in the body that can interfere with the normal growth and development of bones during childhood.

In the current study, very few participants (2.4%) indicated calcium ingestion had benefits for mitigating excess fluoride intake, and no one used calcium foods for this reason. Calcium intakes are low in many areas of Ethiopia [34] but data on calcium intakes are sparse, especially for children. In our study, children aged 1 to 3 years had intakes of 277 [38].4 ±189.1 mg per day. This is lower than that reported in Dale district where [37] showed for children 1-2 years old, calcium intake was 426 ± 238 mg/day. This is an area where enset, a high calcium food, was often part of the diet). In our study children 4-8 years of age had calcium intakes of 362.9±234.3 mg per day which is lower than that of children aged 6-8 years measured in a different area of Halaba, 544 ± 203 [24]. In the latter study, children were older and so may have had a high overall food intake. The majority

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of the respondents believe that they will try to increase child's diet rich in calcium if the health approves it. Interestingly, more than half (56.7%) disagree that the costs of calcium-rich food including finger millet and milk require too much money. This shows that the costs for calcium-rich foods might not be a matter.

In the current study, and that of Tefera et al. [11], estimated fluoride intakes of children using actual fluoride levels of local foods. We found fluoride intakes to be approximately 3 mg per day from foods alone while Tefera et al. [11] reported over 10 mg per day and Kebede et al. [5] found 7.9 mg. Differences may be due to different food patterns. Foods grown in parts of the country not afflicted with high F would be lower than foods grown locally. Urine F excretion is a rough reflection of F intake as there is a high percentage of ingested F that is absorption, especially in growing children. Urinary F reflects dietary intake and Kebede et al. [5] reported F excretion of 3.3 ± 2.2 mg/L for children in Halaba while it was close to 9 mg/L in other parts of Ethiopia.

Knowledge and awareness of dental fluorosis are important factors to self-prevention and control of dental fluorosis. Increasing knowledge of fluorosis and mitigating thought calcium reach food and antioxidants among parents and the general population could be one of the approaches to help reduce the fluorosis prevalence in this community [25]. The simple interventions to reduce fluorosis include the provision of surface water, rainwater, and consumption of Low-fluoride groundwater and other interventions are defluoridation of water through flocculation and adsorption [26]. Similarly, health education and better nutrition are some of the cost-effective intervention measures [27]. The education delivered should incorporate information about the overall health consequences of excessive fluoride intake and sources of fluoride, along with preventive methods that need to be taken [28].

Two major interventions are suggested to prevent fluorosis: a) withdrawal of fluoride sources by which the progression of the disease would be arrested and b) promotion of a nutritive diet with adequate intake of calcium, iron, folic acid, vitamins C and E, and other antioxidants through dairy products, vegetables, and fruits. Nutritional intervention requires counseling of fluorosis and education of the female members of the households who are responsible for cooking and serving food for the family. They are educated about the locally grown/available food, or agricultural crops that are high in calcium, vitamin C, and other antioxidants, and that need to be consumed on a daily basis through breakfast, lunch, and dinner [29]. Creating awareness about the sources of fluoride can help make informed choices regarding water and other items of consumption, enabling potential victims to be engaged in need-based preventive measures in the affected areas [30]. Health and nutrition education will help to reduce the effect of ingested fluoride until either defluoridation techniques are employed or the water source is changed [6]. In addition, fluoride-reducing treatments may be key to addressing widespread dental health problems faced by millions of rural residents in Ethiopia's remote, poverty-stricken Main Rift Valley [31-37].

Conclusion

The evidence from this study reveals that the majority of respondents in a high fluorosis area had never heard about fluoride at the time of the study. Only a small number of the respondents knew the sources of fluoride and the consequences of excessive fluoride ingestion. Similarly, very few respondents indicated calcium ingestion benefits to mitigate excess fluoride intake. Treating for fluoride removal/ fluorosis mitigation was not being practiced by many respondents. The majority of respondents did not perceive as fluorosis as risky. Children's dietary calcium intakes were very low. With nutrition education, the majority of the respondents would consider trying to make their child's diet higher in calcium if this would improve their child's health.

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Conflict of interests

The authors declare no conflicts of interest. The sponsors had no role in the design, execution, interpretation, or writing of the study.

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