Utilization of Community-Level Fluoride-Filtered Water and its Associated Factors in Dugda Woreda of East Shewa Zone, Oromia Region, Ethiopia

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ABSTRACT

BACKGROUND: Long-term consumption of water containing an excessive amount of fluoride causes dental and skeletal fluorosis. De-fluoridation options differ in terms of scale, efficacy, long-term viability, and user acceptance. Therefore, this study aimed to identify the challenges of using fluoride-filtered water and its associated factors among households.

METHODS: A cross-sectional study was conducted from April to May, 2018 among 405 randomly selected households in Dugda Woreda of Ethiopia Rift Valley East Shewa Zone, Oromia Region. A structured interviewer-administered questionnaire was used to collect the data. SPSS version 20 was used to enter and analyze the collected data. Logistic regression analysis was used to identify association between dependent and independent factors and explained by odds ratio with 95%CI.

RESULTS: A total of 228 (56.3%) households were found to utilize fluoride filtered water from community water supply schemes for drinking and cooking purposes. No family history of fluorosis (AOR = 44.4, 95%CI: 18.8, 104.74), monthly income of less than 1000 ETB (AOR = 0.03, 95%CI: 0.004, 0.23), good knowledge of community fluoride filter schemes (AOR = 5.93, 95%CI: 1.30, 26.9), and not afford to pay bill of ⩾0.50 ETB [AOR = 0.4, 95%CI: 0.20, 0.91] were factors significantly associated with utilization of community-level fluoride-filtered water.

CONCLUSION: In this study, more than half of the households used fluoride filtered water. Family monthly income, affordability, presence of family members with the history of fluoride exposure, and knowledge about community fluoride filter schemes were factors significantly associated with utilization of community-level fluoride-filtered water.

KEYWORDS: De-fluoridation, drinking water, Ethiopia Rift Valley, fluorides, Nalgonda, utilization

Background

Water purity is threatened, as it is constantly contaminated by a variety of pollutants. Fluoride is an example of a pollutant that can be found in water all throughout the universe. It is useful for the development of enamel when detected in small concentrations of about 0.7 mg/l in drinking water, but it causes serious health concerns when discovered in concentrations of more than 1.5 mg/l. In 2015, fluorosis affected 200 million people from more than 30 countries.[1] Fluoride is a fluorine anion with a small radius, a high proclivity for acting as a ligand, and the ability to produce a wide range of organic and inorganic compounds in soil, rocks, air, plants, and animals. Fluoride ion can be found in both surface and groundwater due to its compounds solubility.[2]

Due to its geological and climatic characteristics, Ethiopia's Central Rift Valley (ECRV) has the highest fluoride concentrations (above 5 mg/l) in the world, particularly in deep wells in the semi-arid portions of the region.[3] The ECRV's acid volcanic rocks, which have both high fluoride and low soluble calcium concentrations, are the principal source of fluoride. Fluoride concentrations of up to 26 mg/l have been found in more than 40% of deep and shallow wells. Fluoride distribution in deep wells, on the other hand, varies, even between wells that are close together.[4] The majority of ECRV residents rely on fluoride-rich water sources.[5]

De-fluoridation of drinking water is accomplished through the use of various technologies. However, multiple factors must be considered when selecting the appropriate fluoride removal technologies, such as material cost and availability, capital investment and operating costs, simplicity in design and operation, by-products during treatment, removal capacity, community acceptance, and willingness to pay.[6,7] The social difficulties
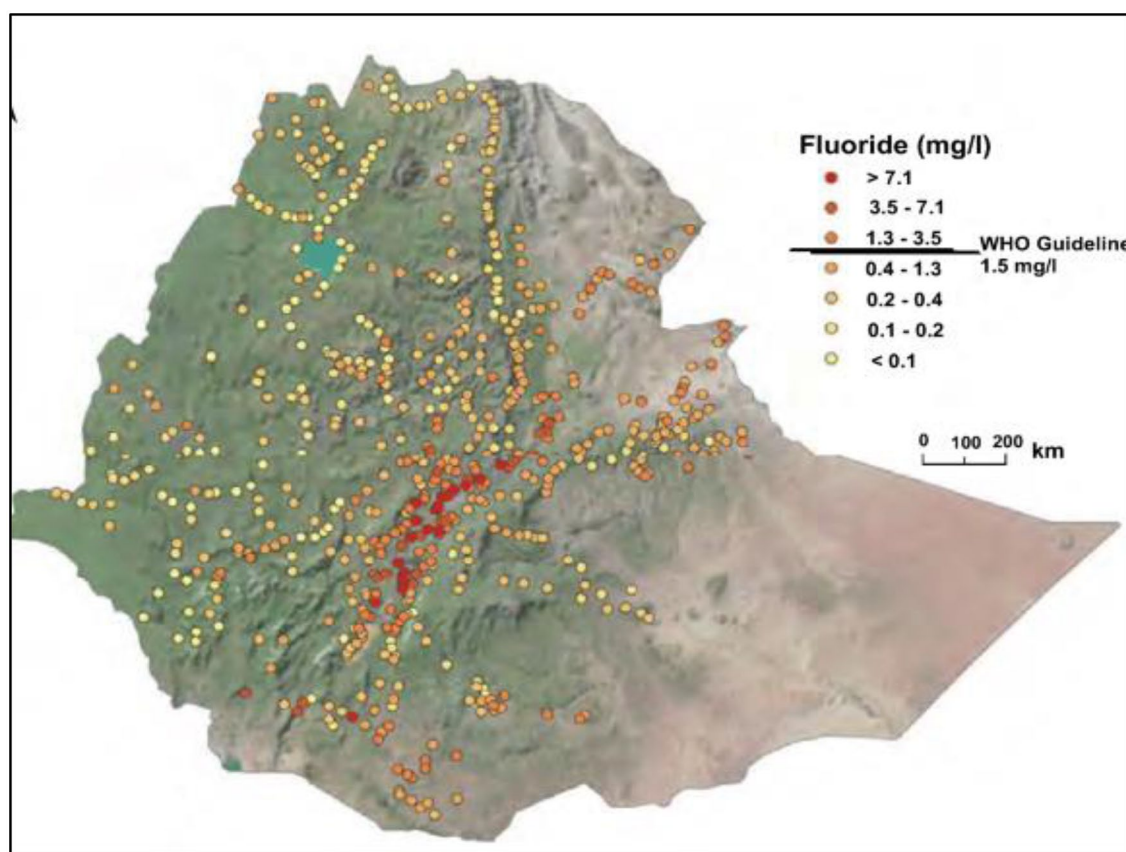
Figure 1. Fluoride concentration distribution in ground water across Ethiopia.
Source: MacDonald et al.[10]

caused by fluorosis, as well as local beliefs, influence technology acceptance, and experience has shown that public awareness initiatives can help determine acceptance.[4]

Study done in Northern Rift Valley of Ethiopia showed that 45% of households were preferred community-level fluoride-filtered water.[8] According to this study, 89.9% of the respondents were got water for drinking and cooking from community filters. Each household purchases 4.9 jerry cans (98l) of filtered water. This implies that 1 person uses 2.9l/day, but in practice, 1 person consumes 4.4l/day in this village, indicating that nearly half of the water used by each house is used.[8]

It is critical to identify and assess the utilization problem of deployed technological solutions for community benefit in order to keep the fluoride mitigation technology in place. There is insufficient data on the current status of fluoride mitigation projects in the ECRV, particularly in Dugda Woreda. Therefore, this study aimed to identify level of utilization of community-level fluoride-filtered water, and its associated factors in Dugda Woreda of Ethiopia Rift Valley East Shewa Zone, Oromia Region, Ethiopia.

Materials and Methods
Study design and setting

A community-based cross-sectional study was conducted in April, 11 to 30, 2018 in Dugda district of Ethiopia Rift Valley East Shewa Zone, Oromia Region. The district has 1 town administration and 34 rural kebeles (the smallest administrative structure in Ethiopia) with a total population of 164,394. From 34 rural kebeles, only 8 them have implemented community fluoride filter water schemes. Starting from 2005, there were 9 Nalgonda filter and 8 bone-char filter schemes so far piloted in that 8 kebeles by Oromia Self-Help Organization (OSHO) and Ethiopian Catholic Church. For this study, 3 kebeles who have Nalgonda and bone-char filter water schemes were included in namely; Tuchi Giragona, Dodota Denbel, and Jawwa Bofoo. These selected kebeles were one of the fluoride mitigation intervention project areas in the ECRV.

Fluoride distribution in Ethiopia

Reports showed that the distribution of fluoride in Ethiopia ranges from 0.1 to 75 mg/l.[9] The highest fluoride concentrations were found in the Ethiopian Rift Valley, while the lowest concentrations were found in the Ethiopian highlands (Figure 1).[10]

As shown in Figure 2, if a community has been exposed for a long time to fluoride concentrations of up to 24 mg/l in groundwater, the symptoms must have manifested in severe fluorosis (dental fluorosis).[11] The severe form begins with focal pitting, then progresses to confluent pitting on the white opaque enamel, and finally total enamel loss and tooth deformation.

Figure 2. Severe enamel fluorosis in Ethiopian Rift Valley area.
Source: Rango et al.[11]

Sample size determination

The sample size was calculated using Epi Info Version 7.2 software, based on a single population proportion formula, with the following assumptions: 50% of households using community fluoride filter schemes, a 5% margin of error at a 95% confidence level, and a 10% non-response rate. Then, the final sample size was 422 households.

Sampling procedure

Three kebeles were selected from 8 kebeles of Dugda Woreda that have a fluoride mitigation implementation (Nalgonda and bone-char fluoride filter water schemes) by using purposive sampling technique. The selected kebeles were Tuchi Giragona (820 households), Dodota Denbel (843 households), and Jawwa Bofoo (582 households). The kebeles had a total of 2245 households and the calculated sample size was proportionally allocated to the randomly selected kebeles and households were selected by a using systematic sampling technique.

Study variables

Dependent variable. Fluoride-filtered water utilization.

Independent variables. Sociodemographic factors (gender, age, marital status, educational status, religion, average monthly income, and family size), water source, traveled distance, water storage containers, water bill, knowledge, water supply line brake, and acceptance of community-level fluoride-filtered water.

Operational definitions

Good knowledge. If those community members who participated in and were interviewed about their water schemes gave correct answers to the 5 knowledge questions, they were considered to have good knowledge.

Good attitude. If the interviewed participants who were asked about their water schemes had answers that were above the mean of the 5 attitude questions given, they were considered to have a positive attitude.

The accessibility of community filtered schemes. If any household was measured by calculating the accessibility of water supply schemes as if it took a walking distance greater than 1.5 km or 30 minutes and a waiting time of more than 15 minutes, it was considered as an inaccessible.

Data collection procedure

A structured interviewer-administered questionnaire was used to collect data. The questionnaire was adapted from various relevant literature on community fluoride filter water utilization, with necessary changes based on the research objectives. The questionnaire was written in English, translated into Amharic and Afaan Oromo, and then re-translated back into English to ensure consistency. Interviews were conducted by trained data collectors under the supervision of environmental health professionals, with the overall data collection processes being checked by the authors of this study.

Data quality control

The data quality was maintained by performing a pre-test with 5% of the sample questions in 1 kebele outside of the actual data collection area of Dugda Woreda and modifying accordingly. During the pre-test, interviewers and supervisors evaluated the clarity and understandability of the questionnaire, and some corrections and changes were made to the questionnaire before it was duplicated.

Data process and analysis

The collected data were entered, cleaned, coded, and analyzed by using SPSS version 20. Descriptive statistics were used to summarize categorical data. Logistic regression analysis was used to identify association between dependent and independent factors and explained by odds ratio with 95%CI. The *P*-value of <.05 was considered as statistically significant.

Ethical consideration

Ethical clearance was obtained from Institutional Review Board (IRB) of Hawassa University, Medicine and Health Science College and legal written letter for the study area was obtained from Department of Environmental Health and final permission for conducting the study was also obtained from Dugda Woreda, Water, Mining, and Energy Office. All the study respondents were informed about the objective and the purpose of the study, and their verbal consent was obtained before conducting data collection. The names of participants were not included in the questionnaires, and participants were given the option to withdraw from the study at any time during the interview.

Table 1. Socio-demographic characteristics of the study participants in Dugda Woreda, East Showa, Oromia Region, Ethiopia, 2018 (n = 405).

VARIABLES	CATEGORIES	FREQUENCY	PERCENTAGE (%)
Gender	Male	156	38.5
	Female	249	61.5
Age	<45 y	321	79.3
	≥45 y	84	20.7
Educational status	No formal education	183	45.2
	Read and write	97	23.9
	Primary	125	30.9
Marital status	Married	275	67.9
	Single	28	6.9
	Divorced	42	10.3
	Widowed	60	14.8
Religion	Orthodox	211	52.1
	Protestant	53	13.1
	Muslim	141	34.8
Average monthly income	<1000 ETB	89	22
	1000-2000 ETB	280	69.1
	2001-3000 ETB	36	8.9
Family size	<5	270	66.7
	≥5	135	33.3

Results

Socio–demographic characteristics of respondents

This study had a total of 405 participants, with a response rate of 95.9%, and the majority of the participants 249 (61.5%) were females. The mean age of the respondents was 38.58 years (SD = 7.98). More than half of the respondents, 275 (67.5%) were married. One hundred eighty-three (45.2%) of the respondents were have no formal education and 211 (52.1%) were orthodox religion followers. The majority of participants 280 (69.1%) earn between 1000 and 2000 ETB (Ethiopian currency) monthly (Table 1).

Community–level fluoride–filtered water schemes utilization

Two hundred twenty-eight (56.3%) of the interviewed households were used fluoride-filtered water from community-level fluoride-filtered water schemes for drinking and cooking and the reaming 177 (43.7%) were utilized water from non-fluoride filter water schemes. Three hundred twenty-five (80.2%) of interviewed households were traveled a distance less than 1.5 km for collecting water. Two hundred eleven (52.1%) were

regularly getting filtered water and 177 (43.7%) not get filtered water at all. The minimum and maximum water bill 258 (63.7%) pay 0.50 ETB and 80 (19.8) pay 0.75 ETB for 201 respectively. Three hundred sixty-one (89.1%) of the interviewed households used jerry cans for water storage in their home. Three hundred forty-eight (85.9%) of the interviewed households had good knowledge about community-level fluoride-filtered water schemes. One hundred eighty-one, 44.7% of households prefer to utilize water from the newly established filtering techniques Hydroxyapatite (HAP) filter (Table 2).

Factors associated with community–level fluoride–filtered water utilization

A binary logistic regression analysis result showed that, no family history of fluorosis (AOR = 44.4, 95%CI: 18.8, 104.74) were 44 times more likely utilize community-level fluoride-filtered water, as compared to who have affected family member. The households with a monthly income below 1000 ETB had 97% reduced odds of utilization of fluoride filtered water, as compared to the households with a monthly income between 2001 and 3000 ETB. Households that had good knowledge

Table 2. Community-level fluoride-filtered water schemes utilization in Dugda Woreda of East Shewa Zone, Oromia Region, Ethiopia, 2018 (n = 405).

VARIABLES	CATEGORIES	FREQUENCY	PERCENTAGE (%)
Water source	Community-level fluoride-filtered water schemes	228	56.3
	Non-fluoride-filter water schemes	177	43.7
Traveled distance	<1.5 km	325	80.2
	≥1.5 km	80	19.8
Household get filtered water	Regularly	211	52.1
	Get irregularly	17	4.2
	Not get at all	177	43.7
Water storage containers	Jerry cans	361	89.1
	Clay pot	44	10.9
Water bill/20 l	0.50 ETB	258	63.7
	0.60 ETB	67	16.5
	0.75 ETB	80	19.8
Knowledge of community toward fluoride-filter schemes	Good knowledge	348	85.9
	Poor knowledge	57	14.1
Water source regularly face a supply brake	Nalgonda filter schemes	46	11.4
	Bone-char filter	40	9.9
Acceptance of community-level fluoride-filtered water schemes	Nalgonda filter	14	3.5
	Bone-char filter	70	17.3
	Hydroxyapatite filter	181	44.7
	Non-filter source	140	34.6

about community fluoride-filter schemes were 5.93 times (AOR = 5.93, 95%CI: 1.30, 26.95) more likely utilized community fluoride filter compared to their counterparts. Households that were able to afford to pay bill of 0.50 ETB [AOR = 0.4, 95%CI:0.20, 0.91] were 60% less likely used fluoride filtered water compared to those who paid a bill of ≤0.50 ETB (Table 3).

Discussion

The aim of this study was to determine the utilization of community level fluoride filtered water and associated factors in Ethiopia's Rift Valley East Shewa Zone, Oromia Region, in the Dugda Woreda. According to the findings of this study, 56.3% used community-level fluoride-filtered water at the time of the survey. This study's finding was consistent with a study conducted in the northern Ethiopian Rift Valley, which found that 60% of people consumed fluoride filtered water.[12] However, it were lower as compared to studies done at Weyo Gabriel kebele, Oromia Region an average of 65% of the total water consumption was filtered water.[13] Our study showed that 44.5% prefer to use hydroxyapatite filtered water. Our study findings were better than those of a study conducted in the Oromia Region's East Showa, with 18% of the study community preferring for hydroxyapatite filtered water.[13]

The study's findings revealed that half of the interviewed families were orthodox religion followers in the area, and they believe that bone-char filters interfere with their religion's fasting day, making it unacceptable to the majority of the local community for religious reasons. The majority of protestant religion followers, on the other hand, were not opposed to bone-char filter technologies; as a result, protestant religion followers were more likely to use filtered water than their orthodox counterparts. The findings of this study matched those of a study conducted in India, which found that Hindus are culturally opposed to the Taboo limitations, notably the bone-char method. Bone-char generated from pigs may be viewed with suspicion by Muslims. The stench of burnt bones has often been regarded as repulsive.[14]

In this study, 22% of the families interviewed could not afford to pay the water bill. To cover the high operational costs, water fees have also been raised. A water bill of up to 14 ETB/m³ is in place in Arsi Negelle, according to a study.[15] The cost

Table 3. Summary of logistic regression factors associated with utilizing community-level fluoride-filtered water among in Dugda Woreda of East Shewa Zone, Oromia Region, Ethiopia, 2018 (n = 405).

VARIABLES	CATEGORIES	FLUORIDE FILTERED WATER UTILIZATION		COR (95%CI)	AOR (95%CI)
		YES	NO		
Age of participants	<45 y	201	120	1.00	1.00
	≥45 y	26	58	0.3 (0.2-0.5)	0.8 (0.29-2.3)
Educational status	No formal education	91	92	0.6 (0.4-1.0)	1.5 (0.5-4.1)
	Read and write	60	37	1.0 (0.6-1.7)	1.3 (0.5-3.6)
	Primary	77	48	1.00	1.00
Monthly income	<1000 ETB	21	68	0.7 (0.3-1.7)	0.03 (0.04-0.3)**
	1000-2000 ETB	196	84	5.3 (2.5-11.3)	0.6 (0.1-2.5)
	2001-3000 ETB	11	25	1.00	1.00
Households get water regularly	Yes	165	46	7.5 (4.5-11.6)	2.7 (0.9-8.0)
	No	63	131	1.00	1.00
Distance traveled to water collection	≤1.5 km	193	132	1.9 (1.6-3.1)	1.3 (0.6-3.0)
	>1.5 km	35	45	1.00	1.00
Water bill	≥0.50 ETB	158	100	1.7 (1.1-2.6)	0.4 (0.20-0.91)**
	<0.50 ETB	70	77	1.00	1.00
Households afforded to pay for water bill	Yes	207	109	6.2 (3.6-10)	0.3 (0.04-0.3)
	No	21	68	1.00	1.00
No family history of fluorosis	Yes	189	23	1.00	1.00
	No	39	154	32.4 (18.6-58.6)	44.4 (18.8-104.7)**
Household's knowledge about community fluoride filter	Good	21	36	0.4 (0.2-0.7)	5.9 (1.30-26.95)*
	Poor	207	141	1.00	1.00
No. of times supply brace per wk	≤3 times	223	154	1.00	1.00
	>3 times	5	23	6.7 (0.02-4.0)	0.3 (0.02-4.0)

1.0 = reference value.
*$P < .05$. **$P < .01$.

of replenishing Nalgonda filtering material, which this local population in the research area cannot afford, is 1 probable cause for the increase.

Households with a good understanding of community fluoride filter technologies were 5.93 times more likely to use the community's fluoride filtered water. The findings of this study exceed those of studies conducted in Ethiopia's Fantale, Adami Tulu, and Halaba areas.[16,17] This disparity could be explained by the fact that receiving training on the importance of community fluoride filtration technologies has a greater impact on improving community awareness. In addition, health extension workers also educate the public about fluoride and its health effects.

In some parts of Ethiopia's rift valley, most households perceive the presence of water as a blessing, regardless of its chemical content.[16] In practice, however, according to this study, the prevalence of fluorosis among households that used filtered water for the last 10 years was only 1.9%, whereas households that did not use fluoride-filtered drinking water had a 7.7% prevalence of fluoride history. This means that households that

used filtered water were nearly as safe as those that did not use community filters; even if daily fluoride intake comes not only from drinking water but also from foods and beverages that contain at least trace amounts of fluoride.[18,19]

In terms of water quality, the findings revealed that people were aware that their water might need to be filtered and that this was done in order to reduce health impacts and water-borne diseases. They were also aware of the causes and effects of non-fluoride filtered water quality; however, some members of the community are forced to use the household level fluoride filter water they own or the one that is easily accessible.

Our study also revealed that religious beliefs were the most major barrier to the acceptance of bone-char filters in those rural villages. This finding was in agreement to another study that found that more than half of the study households were orthodox religion followers and were completely opposed to using filtered water by bone-char filter in those Kebeles. This is primarily due to the belief that drinking water filtered by a bone-char filter will cause them to break their fast day, so no orthodox religion followers are permitted to use water from bone-char filter schemes, and those Protestants and Muslims who practice fluoridation have also complained about a change in test results in bone-char filtered water.

With the exception of 1 scheme near Dugda Woreda, Catholic Church, the Nalgonda filtration approaches were almost non-functional, according to key informant interview results. Even if the majority of the people in the area didn't like it, the 3 Kebele had 7 operational bone-char filter schemes. Only 47 (11.6%) of the 405 households interviewed decided to utilize filtered water from bone-char systems. This indicates how religious beliefs have an impact on the local community's acceptance of the bone-char filtration procedure. Similarly, the results of the key informant interviews confirmed the survey findings, with the majority of participants complaining about the use of bone-char filter techniques during the key informant interview.

Even if they buy a 1 kg hydroxyapatite filter for 120 ETB and a 1 kg bone-char filter for 27 ETB and regenerate it twice a year without knowing why or when, according to key informant interviews. Despite the fact that most local households prefer filtered water from hydroxyapatite filtering schemes, more than 80% of the community accepts filtered water from newly constructed HAP filtering schemes without considering the cost difference between the 2 filtering options (120 ETB for 1 kg hydroxyapatite and 0.75 ETB for 201 filtered water by HAP).

Limitations

This study has limitations, such as response and community desirability bias in the use of bone-char water fluoride filters. This study was not supported by laboratory-based results. Furthermore, seasonal variation was not observed because the study was cross-sectional.

Conclusions

More than half of the households used fluoride-filtered water from community-level fluoride-filtered water schemes. Monthly income, not afford to pay bill of ⩾0.50 ETB, no family history of fluorosis, and households' knowledge of community fluoride filter schemes were factors that were significantly associated with the use of community-level fluoride-filtered water in this study.

Therefore, before implementing any type of filtering technology for the community, the affordability and ease of that provided filtering technology must be informed to the local community; the best cost-effective and locally acceptable fluoride filter technology will be required; and a future study should be conducted in order to know more about fluoride filter technology.

Author Contributions

AA conceptualizes the study, collects the data, and conducts the analysis. The manuscript was written by AA, ZA, NES, and BN. The manuscript was critically examined and reviewed by NES, ZA, BN, MBA, HBM, GGK, AEM, and AEA. The final manuscript was read and approved by all of the authors.

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Availability of Data and Materials

The data that support the findings of this study has a sort of identifier of individual participants and researcher reserved to send it.

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