Household Salt Iodine Level and Associated Factors in Dire Dawa City Administration, Eastern Ethiopia

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Abstract

Background: Iodine is the commonest, but not the only, cause for the low level of thyroid hormones. Salt iodization is the preferred strategy to control this Deficiency Disorder. However, there is limited information on the level of iodine on household salt and the associated factors in Dire Dawa city administration. The main aim of this study was to assess the level of iodine in the household salt and associated factors in Dire Dawa City Aadministration.

Methods: Community based cross-sectional study was conducted in Dire Dawa City Administration among randomly selected 402 households. The level of iodine was determined by using rapid test kit and iodometric titration test. Data were collected by structured questionnaire using face to face interview on socio-demographic, economic dietary diversity, salt storage and utilization. The data were entered in to EpiData Version 3.1 and exported to SPSS Version 20.0 for analysis. All the variables that had P<0.25 with outcome variable in the bivariate analysis were included in the multivariate regression model, and P-value ≤ 0.05 was declared as statistically significant.

Results: Inadequate amount of iodized salt (<15 parts per million) was found among 51% of the households and 49.5% of the households' salt had inadequate (less than 20 mg/kg) iodine concentration using Iodometric titration test. Using non-packed salt (AOR=1.3; 95% CI: 1.1-4.73), knowledge about the importance of iodized salt (AOR=2.3; 95% CI: 1.05-4.90), storing the salt for more than two months (AOR=2.1;5% CI: 1.14-4.61), purchasing salt from open market (AOR=2.3; 95% CI: 1.1-6.5) and retail shop (AOR=1.6;95% CI:1.1-5.1), and divorced, widowed and separated (AOR=2.93; 95% CI: 1.56-6.59) were significantly associated with the availability of inadequate iodized salt at the households.

Conclusions: In the study area, many of the households did not have access to adequately iodized salt at the household level. Hence, the concerned stakeholders should sensitize the community about the importance of iodized salt and its proper handling at the household level.

Keywords: *Iodometric Titration, Rapid Test, Iodine, Dire Dawa*

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Introduction

Iodine is a trace element that is essential for the synthesis of thyroid hormones by the thyroid gland. Thyroid hormones are involved in growth, development and control of metabolic processes in the body. The erosion of soils in riverine areas due to loss of vegetation from clearing for agricultural production, overgrazing by livestock, and tree-cutting for firewood results in a continued and increasing loss of iodine from the soil. Ground water and foods that are grown locally in these areas lack iodine (Venkatesh *et al.,*1995; WHO, 2007).

Failure to have adequate iodine leads to insufficient production of thyroid hormones, and this results in Iodine Deficiency Disorders (IDD) that leads to mental retardation, physical sluggishness (growth retardation), and other defects in the development of the nervous

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system, goiter (enlarged thyroid), reproductive failure, increased childhood mortality, and economic stagnation. The most devastating effect of these is on the developing human brain (Venkatesh *et al*., 1995).

Iodine deficiency disorders (IDD) is a major global public health concern, affecting an estimated two billion people worldwide in over 50 countries. Globally, 30% of the world's population is affected by IDD and more than 150,000 million people are affected in Africa alone (WHO, 2007; ICCIDD, 2011). The global database of the World Health Organization (WHO) shows that from 1993 to 2003 iodine deficiency was still a public-health problem in 54 countries, and an estimated two billion individuals had an insufficient dietary iodine intake (WHO, 2007; ICCIDD, 2011). WHO recommends a daily intake of 90 µg of iodine for preschool children, 120µg for schoolchildren, 150µg for adolescents and adults, and 250µg for pregnant and lactating women (WHO, 2007).

To control IDD, salt iodization is the preferred strategy and is implemented in more than 120 countries around the globe. After the implementation of this strategy, many countries in the world have successfully eliminated IDD or made substantial progress in their control, largely as a result of salt iodization. The regional burden of iodine deficiency in Africa compared to other regions showed that seven of the top 10 iodine-deficient countries with the greatest number of Salt Iodine Concentration (SAC) with insufficient iodine intake in 2011 were from Africa (ICCIDD, 2014).

In Ethiopia, one out of 1000 children has a cretin and are mentally handicapped, due to a congenital thyroid deficiency, and more than 50,000 prenatal deaths are occurring annually due to iodine deficiency disorders. Of the total population, 26% have goiter and 62% are at risk of IDD, according to national survey made by the previous Ethiopian Health Nutrition and Research Institute (Takele *et al*., 2003).

A study conducted in Gondar town indicated that 28.9% of the household salts had iodine (Gebremariam *et al.,* 2013), 62.9% in Assela town (Hawas *et al.,* 2016), 30% in Goba (Abdurahman *et al.,* 2016), and 26.1% in Assosa town (Gebriel *et al.,* 2014). However, the recent studies in Ethiopia indicated that the coverage of iodated salt at national level seen as 88.8% and 94.4% by Rapid Test Kit (RTK) and iodometric titration, respectively; but adequacy (20 ppm to 40 ppm) was reported only in 23.20% (Zerfu, 2014). Ethiopian Demographic and Health Survey (EDHS) 2016 also indicated 89.3% of the households use iodized salt, with 91.9% in urban (CSA, 2016). However, there is limited information on the level of iodine on household salt in our study area. The EDHS data indicated 83.5% the household has adequate iodine. However, no study was done using Iodometric titration test in Dire Dawa to the best knowledge of these researchers. Therefore, the objective of this study was to assess the level of iodine in the household salt and its associated factors in Dire Dawa city Administration, Eastern Ethiopia.

Materials and Methods

Study Area and Period

This study was conducted in Dire Dawa City Administration, which is located 515 km from Addis Ababa on the East Ethiopia and 311 km to the west of Djibouti port. The city administration has a population of 342,827, of whom 233,224 (67.93%) live in urban. The city has six hospitals (2 public, 3 private and 1 Ethio-Djibouti), 9 health centers and 3 health posts (UN, 2008).This research was conducted in four *Kebeles* (smallest administrative unit of Ethiopia) of Dire Dawa city from February to March 2017.

Study Design and Population

A community based cross-sectional study was employed on the residents living in the selected kebeles. Household members who usually purchased food item and prepared food in the selected households were interviewed, but those who were serious ill and those could not communicate were excluded from the study.

Sample Size Determination and sampling procedure

The required sample size for this study was determined using a single population proportion formula with proportion of 50% as there are no other studies published in the same context in the area, 95% confidence interval and 5% of margin of error. After adding five percent of non-response rate, the sample size was 404 households. From the total nine kebeles in the city, four kebeles (Kebele 02, 03, 07 and 09) were selected using a simple random sampling technique and then the total sample size was allocated to the selected kebeles proportional to the number of households in each kebele. Data on number of household in each kebele were obtained from health extension workers working in the kebele. Kebele 02, 03, 07 and 09 had

total household of 13,366, 5,540, 4,147 and 8,250, respectively. From these, after the first household had been selected using a lottery method, the remaining samples of households were selected using systematic a random sampling technique every 70th household. If the selected household had no eligible participants, the next household was selected. Finally 172 household data from kebele 02, 71 data from kebele 03, 53 data from 07 and 106 household data were collected from Kebele 09.

Data Collection Methods

Data were collected by face-to-face interview using a structured questionnaire. The questionnaire included information on socio-demographic and economic characteristics, knowledge about salt storage, storage status, availability and accessibility of iodized salt. The study participants' knowledge about the importance of iodized salt was categorized as good if the respondents had answered correctly more than half of the seven knowledge questions on the importance of using iodized salt. The questions were: What are the ill effects of iodine deficiency? How can we prevent iodine deficiency? Do you know how goiter can be prevented? Why is the intake of iodized salt important? Can we prevent IDD by regularly consuming iodized salt? What are the major causes of goiter? What foods are rich sources of iodine?

To determine the level of iodine in the household salt, the salt samples were tested using Rapid Test Kit (MBI Kits International). Each of the households asked provide a teaspoon of salt. Then the data collectors took sample from it and fill on small cup and spread it to flat level of the cup. Finally they added two drop of test solution on surface of salt rom the white ampule. Rapid test kits are used as semi quantitative estimations of iodine content (Sullivan *et al.* 1995). This test kits are rapid, simple and easily applied in a field setting, and need no training of a chemistry laboratory personnel. Compare color on salt with color chart with one minute and determine the iodine level (intense color). If no color change appeared on the salt (after one minute, on a fresh sample add up to 5 drop of recheck solution in red ampule and the two drops of test solution on same spot and compare the color with color chart and determine iodine content. If the iodine content is ≥ 15ppm iodized salt when it is tested with rapid test kits, it is categorized as adequate and below this 15 ppm is inadequate (Sullivan et al., 1995). Nonetheless, this rapid testing kits technique must be supported by titration because rapid testing kits alone cannot provide reliable estimates of iodine content in salts (WHO, 2007). To determine level of iodine in the salt using iodiometric titration, 10 gm of salt was collected from the selected 100 households of each selected kebele to verify the RTK test. This method is recommended at various levels of a distribution system over rapid testing kits (WHO, 2007). The salt sample was packed in to plastic bag and sealed in order to make airtight. The samples were coded and stored at room temperature and protected from light and moisture until the time of analysis. They were transported to and analyzed at the laboratory of Ethiopia Food, Medicine and Healthcare Administration and Control Authority (EFMHACA), Dire Dawa branch. The samples were analyzed to find out the iodine content by titration method. The principle was that iodine was liberating by adding sulphuric (orthophosphoric) acid to a solution of iodate salt. Potassium iodide solution was added to keep the iodine in dissolved state.

Iodine liberate was titrate with sodium thiosulphate solution to form sodium iodide and sodium tetrathionate. Starch was used as an external indicator. Briefly, 10gm of salt sample was weighed and transferred to a clean conical flask with 50ml of distilled water. Two ml of sulfuric acid (2N) was added followed by addition of 5ml of potassium iodide (10% solution) and shaken to mix. The color of the solution turned deep yellow. The conical flask was covered with watch glass and kept in dark for 10 minutes. The sodium thiosulfate solution was placed in burette and the salt solution was titrated with sodium thiosulfate until the color turned pale yellow. One ml starch solution was added to the mixture. The color of the mixture turned purple. The titration was continued until the deep blue color completely disappeared. The volume of sodium thiosulfate solution needed for the titration was noted before (MI *et al.,* 1995). All these procedures were done in laboratory with trained laboratory technicians all the samples using iodiometric titration method. The iodine level in the salt samples is accurate for laboratory detection of the potassium iodate concentration, which can be categorized as Adequate (20–40 mg/kg) inadequate (<20 mg/kg) and tested with iodometric titration (WHO, 2007). >40mg/kg is considered overdose when it was tested with iodometric titration (WHO, 2007).

Data Quality Control

The questionnaire was first developed in English and translated in to local languages (Amharic, Oromiffa and Somali) and then translated back to English to check consistency. A two-day training was given to the data collectors and supervisors on the data collection tool and the data collection procedure. Then the questionnaire was pretested on 5% of the sample size out of the study area to ensure its validity. The supervisors and the first investigator supervised the data collectors closely. The first investigator and the supervisors checked for the completeness of each questionnaire on daily basis. Two data clerks did the data entry and consistency of the entered data was crosschecked by comparing the two separately entered data on EpiData.

Data Processing and Analysis

The collected data were entered into EpiData 3.1 and exported to SPSS statistical software Version 20.0 for analysis. Before the analysis, the data were checked for completeness and then cleaned. The descriptive statistics were presented using frequencies, percentages, tables and graphs. Binary logistic regression was used to identify the factors associated to the level of iodine in the household salt. All the independent variables with p-value <0.25 in the bivariate analysis were the candidates for multivariate logistic regression analysis. In addition to this, model goodness of fit was checked by Hosmer-Lemeshow test. P-value less than 0.05 were considered statistically significant. The degree of association between dependent and independent variables was reported using Adjusted Odds Ratio (AOR) and 95% CI.

Ethical Considerations

The study was carried out after obtaining ethical clearance from Haramaya University, College of Health and Medical Sciences Institutional Health Research Ethical Review Committee. Official letter of cooperation were written to Dire Dawa City health bureau and letter of cooperation was obtain from health bureau. Information of the study was given to the participants' including purpose and procedures, potential risk, benefit and ensure the right of participants can withdraw from the study at any time. Informed, voluntary written consent was obtained from each participant and confirmed by signature of the participant. In order to protect the confidentiality of information name and other identification not included in questioners and to maximum effort was made to maintain privacy of the respondent during the interview.

Results

Socio demographic Characteristics of the Study Participants

Out of the 404 samples, 402 participants involved in the study, with a response rate of 99.5%. Of the study subjects, 347 (78.5%) were female, 222 (55.2%) were married, 123 (32.8%) attended at least primary school, and 35.6% were housewives. The mean age of the participants was 30.81(±SD 11.551) years, with a range of 14-70 years. Many of the study households had family size of ≤ 5 (71.6%), and 169 (42.3%) had an average monthly income of ≥2000 Ethiopian Birr (ETB) (Table 1).

Level of Iodine in the Household Salt

Using rapid testing kit, adequate amount of iodized salt was found in 49% of the households. The rest 51% do not contain adequate iodine in it (43.3% had inadequate (<15ppm) and 7.7% had no iodine at all (0 PPM)) (Figure1).

From 100 samples tested using titration method, 42 (41.5%) samples were in the range of 20-40 mg/kg, and 49.5% were below the minimum requirement (20 mg/kg) (Figure 2).

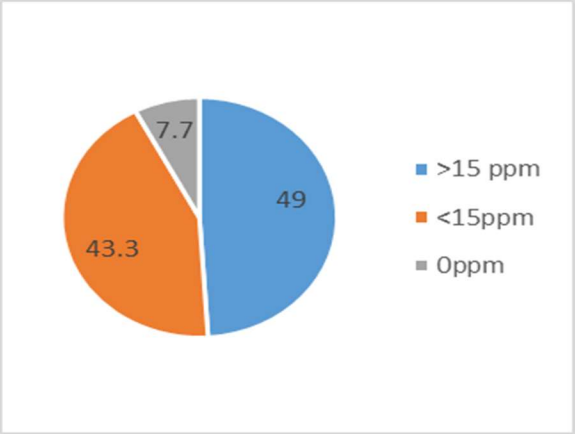

Figure 1: level of Iodine in the household salt testing by Rapid Test Kit at Dire Dawa City administration, East Ethiopia, 2017.

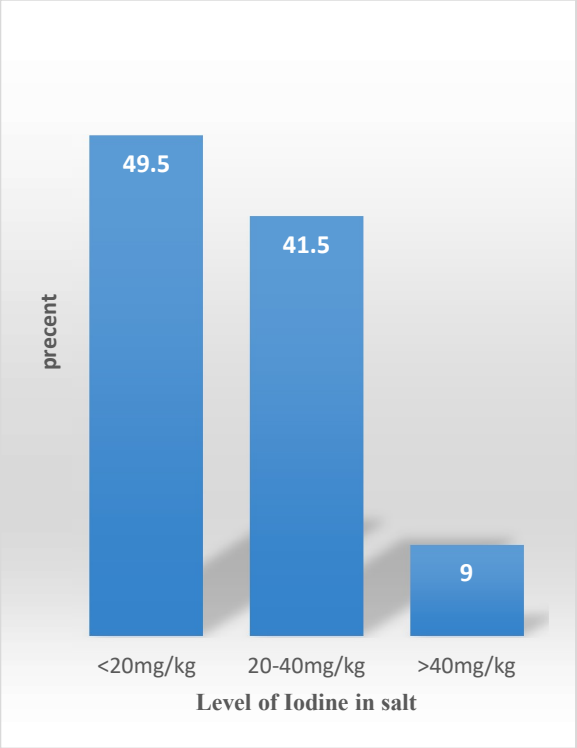

Figure 2: level of Iodine in the household salt tested by Titration, Dire Dawa city administration, East Ethiopia, 2017.

Characteristics of the Household Salt

The study participants reported that they stored their salt in a dry place (94.0%), in a covered/sealed container (88.6%), and for less than two months (78.1%). Some used packed salt (68.2%), and many purchased their salt from retail shop (79.6%) (Table 2).

Factors associated with inadequacy of iodine in the household salt

In the bivariate logistic regression analysis, the participants' age, sex, educational and marital status, salt storing practice, and knowledge about storing iodized salt were removed from the model, because they had p-values greater than 0.25. In the bivariate analysis, marital status, duration of storing salt, place of purchasing salt, knowledge about iodized salt, type of salt used, and washing salt before cooking were the factors associated with the level of iodine in the household salt (Table 3).

In the multivariate logistic regression analysis, marital status, duration of storing salt, knowledge about iodized salt, place of purchasing salt and utilization of packed salt were associated with the inadequacy of iodine in the household salt. Women not in marriage (widowed, divorced and separated) were 2.93 times more likely to have salts with inadequate iodine than those who were single (AOR=2.93; 95% CI: 1.56-6.59). Households who used non-packed salt were 1.3 times more likely to have inadequately iodized salt than those who used packed salt (AOR=1.3; 95% CI: 1.08-4.73). Those who had poor knowledge about iodized salt (AOR 2.3; 95% CI: 1.05-4.9) and who stored salt for more than two months (AOR=2.1; 95% CI: 1.14-4.61) were 2.3 and 2.1 times more likely to use salt with inadequate iodine compared to their counterparts, respectively. The households who purchased salt from open market or retail shops were 2.3 and 1.6 times more likely to use salts with inadequate iodine compared to the households who purchased their salt from supermarket (AOR=2.3; 95% CI: 1.1-6.5) and (AOR=1.6; 95% CI: 1.1-5.1) respectively (Table 3).

Table 1: Socio demographic characteristics of study participants at Dire Dawa city administration, East Ethiopia, 2017 (n=402).

Variables	Label	**Frequency**	**Percent (%)**
Sex	Male	55	21.5%
	Female	347	78.5%
Age (years)	14-29	242	60.2%
	30–44	113	28.1%
	≥45	47	11.7%
Educational status	Cannot read and write	33	8.2%
	Only read and write	20	5%
	Primary school (1-8th)	132	32.8%
	Secondary school (9th-12th)	126	31.3%
	Diploma and above	91	22.6%
Marital status	Single	135	33.6%
	Married	222	55.2%
	Others*	45	11.1%
Occupation	Governmental employee	43	10.7%
	Private sector employee	40	10%
	Daily laborer	14	3.5%
	House wife	143	35.6%
	Merchant	39	9.7%
	Others	123	30.6%
Family size	≤5	288	71.6%
	>5	114	28.4%
Average family income(Birr)	< 1000	110	27.4%
	1000–2000	123	30.5%
	>2000	169	42.3%

**Divorced, widowed, and separated.*

Table 2: Practice of participants about iodized salt in Dire Dawa city administration, East Ethiopia, 2017 (n=402)

Variables	**Label**	**Frequency**	**Percent (%)**
Duration of salt storage	≤2 months	314	78.1%
	>2 months	88	21.9%
Type of salt during purchasing	packed-salt	274	68.2%
	Non packed-salt	128	31.8%
Type of salt used to store	With cover	356	88.6%
	Without cover	46	11.4%
Storage place of salt	In dry place	378	94%
	In moist area	24	6%
Place of purchasing salt	Open Market	46	11.4%
	Retail shop	320	79.6%
	Super market	36	9.0%
Exposed to sun light	Yes	42	10.4%
	No	360	89.6%
Washing salt before cooking	Yes	27	6.7%
	No	375	93.3%
Time of adding salt during cooking	Early and during cooking	84	21%
	At the end of cooking	300	74.6%
	Late after end of cooking	18	4.4%

Discussion

This study revealed that 51.0% and 49.5% of the household were using salts with inadequate iodine using Rapid test kit and iodometric titration test respectively. Marital status, duration of storing salt, knowledge about iodized salt, place of purchasing salt and utilization of packed salt were significantly associated with the inadequacy of iodine in the household salt.

The availability and consumption of adequately iodized salt must be granted for sustainable elimination of IDD. According to WHO, UNICEF and ICCIDD, the elimination of IDD is possible when the proportion of households using iodized salt reaches 90%, (WHO, 2007) and Ethiopia also set target to reach 90% in 2014/2015 (GAIN *et al.,* 2013). According to WHO, UNICEF, and ICCIDD about 20% of iodine lost from salt while transporting from the production site to households and another 20% lost during cooking process (Andersson *et al*., 2012).

In this study, the proportion of households with adequate iodized salt was 49%. The finding is higher than the ones found in studies done in Benishangul-Gumuz of Assosa town (26.1%) (Gebriel *et al.,* 2014), in Laelay Maychew, 33% (Gidey *et al*., 2015), in Sidama zone Bensa woreda, 39.6% (Tsegaye *et al.,* 2016), in Lalo Asabi 8.7% (Meselech *et al.,* 2016), in Bale Goba 30% (Abdurahman *et al.,* 2016). Nevertheless, it is very low compared to EDHS 2016 of Dire Dawa City (83.5%) (CSA, 2016).This difference might be due to study period because recently Ethiopian government is working on the universal salt iodization to the standard. However, this figure is far below the WHO recommendation of covering 90% (WHO, 2007).

This study indicated that 62.4% of the households had good knowledge on the importance of using iodized salt. A study conducted in Shebe town of South West Ethiopia showed that 78.5% of the household had poor knowledge on iodized salt (Takele *et al.,* 2003). Another study in Assosa, South west Ethiopia, also indicated that lack of knowledge of iodized salt and not aware about the advantage of using iodized salt were the main factors related to the utilization of non-iodized salt in the households (Gebriel *et al.,* 2014).

This study showed that using packed salt was associated with level of iodine in the household salt. The finding was in agreement with study finding in Gondar and Laelay Maychew, in which using packed salt was associated with the availability of adequately iodized salt (Gebremariam *et al.,* 2013, Gidey *et al.,* 2015). Another study done in Iraq showed that packed salt is adequately iodized compared with non-packed salt (Ebrahim, 2012). This might be due to good transportation system, storage, and keeping it in a suitable environmental condition. In addition to this, this study also found that there were good storage practices of iodized salt at the household level; 89.6% the households stored their salt in a dry place, 88.6% stored it in covered container, and this is higher compared to the findings from similar studies conducted in Ghana, 62.6% (Buxton, 2012) but is similar to the one in Basra City of South Iraq, 89.3% (Ebrahim, 2012).

Storing salt in the household after purchase for long time increases loss of up to 20% of iodine (Andersson *et al.,* 2012). Previous studies in Gondar town and Laelay Maychew indicated a similar finding (Gebremariam *et al.,* 2013; Gidey *et al.,* 2015). A study from Canada (Diosady *et al.,* 1997) demonstrated that iodate salt losses 28–51% of its iodine after three months, 35-52% after 6 months and up to 66% after 12 months. High humidity resulted in rapid loss of iodine from iodized salt, ranging from 30–98 percentage of the original iodine content. Likewise, an experimental study in London (Kelly, 1953) showed that loss of iodine was 24–90% during 63 weeks storage when exposed to different environmental factors, whereas the loss was only 5.6% after 13 months of storage, where salt was stored in a glass jar.

Strength and Limitation of the study

The strength of this study is the concentration of iodine in salt previous study was measured using RTK method which is semi-quantitative method. But this study tested the concentration of iodine titration using quantitative method to verify the rapid test. The limitation of this study was only one fourth of the sample of salt was tested using titration method and the iodine level was determined by taking a sample only from the salt, which did not include urinary testing of iodine.

Table 3: Variables associated with Level of iodine in the household salt in Dire Dawa city administration, East Ethiopia 2017 (n=402)

Variables	Iodine adequacy		COR(95% CI)	AOR(95% CI)
	Inadequate	Adequate		
Marital status				
Single	51(24.9)	84(42.6)	1	
Married	122(59.5)	100(50.8)	2.01(1.26-3.18)	1.70(0.91- 3.01)
Others+	32(15.6)	13(6.6)	4.10(1.90-9.22)	2.93(1.56-6.59)*
Duration of storing salt				
Less than two months	134(65.4)	180(91.4)	1	1
More than two months	71(34.6)	17(8.6)	5.61(3.08-10.60)	2.1(1.14-4.61)*
Knowledge about iodized salt				
Poor	155(74.6)	109(55.3)	2.52(1.61-3.94)	2.30(1.05-4.9)*
Good	50(32.0)	88(44.7)	1	1
Purchasing place				
Open Market	30(14.6)	14(7.1)	5.70(2.2-15.7)	2.3(1.11-6.52)*
Retail shop	160(78.0)	148(75.1)	2.90(1.43-6.21)	1.6(1.10- 5.10)*
Supermarket	13(6.4)	35(17.8)	1	1
Is salt packed				
No	78(38.0)	50(25.4)	1.60(1.03-2.58)	1.3(1.08-4.73)*
Yes	127(62.0)	147(74.6)	1	1
Wash salt before use				
No	185(90.2)	190(96.4)	1	1
Yes	20(9.8)	7(3.6)	2.9(1.15-8.40)	0.70(0.50 -1.50)

**P-value is significant at α < 0.05; COR-Crude Odds Ratio; AOR- Adjusted Odd Ratio; CI- Confidence Interval.*
+ others include: divorced and widowed.

Conclusion

Based on the finding of this study, we can conclude that about half of the households were using salt with low level of iodine in the household. This is very low compared to the WHO recommendation to prevent IDD and against the universal salt iodization policy of the country. This needs strong interventions by different stakeholders to increase the availability of iodized salt for the community. Nutrition education on storage of iodized salt and the importance of using iodized salt in the households should be stressed. The households should be sensitized to the importance of iodized salt and its proper handling at the household level. All samples were collected from the households, so there is a need to testing of salts from household and retailers to estimate how many percentage of iodine is lost in between retailer and the households.

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Competing interest

The authors declare that they have no competing interests.

Author's contribution

GF, BM and KTR involved in conceiving the idea, developing methods and data analysis. GF Participated in data collection, analysis. MA and KTR involved in

manuscript writing, reanalyzing the data and reviewing the comments of the manuscript. All Authors critically reviewed and approved the final version for publication.

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