Advances in Biological Research 11 (5): 250-257, 2017
ISSN 1992-0067

DOI: 10.5829/idosi.abr.2017.250.257

Risk Factors of Iodine Deficiency Disorder and Prevalence among Primary School Children in Kutaber District, South Wollo Zone, Ethiopia

Asamnew Ahmed, Sisay Menkir and Fethu Lemma

Haramaya University College of Natural and Computational; and Veterinary Medicine, Ethiopia

Abstract: This cross-sectional study was conducted from October 2014 to October 2015. The aim of this study was to determine prevalence and risk factors of iodine deficiency disorder among primary school children in Kutaber District, South Wollo Zone, Ethiopia. From each study participant, urine sample was taken to measure urine iodine level. In addition, salt samples to estimate iodine content using Iodometric titration method. Data were analyzed using SPSS version 20.0 and MS-Excel spread sheet 2007. A total of 67 (17.44%) females and 46 (11.97%) males were in iodine deficiency related goiter problem. Significant (p = 0.00) association between the frequency of cabbage intake and development of goiter was observed. A total of 279 (72.6%) of the urine samples showed iodine deficiency below the normal level, 100µg/l. The total goiter rate among school children was 113 (29.41%). The consumption of granulated non-iodinated salt in the study area was found to be 313 (81.5%). Subnormal iodine content in daily taken salt and elevated consumption of cabbage were main causes of iodine deficiency disorder. The result showed the need to minimize loss of iodine while cooking by adding salt on cooked food and reduced consumption of cabbage. Therefore, awareness creation on detrimental effects of iodine deficiency disorder and better distribution of iodized salt are highly recommended to the study population.

Key words: Iodine Deficiency Disorders · Kutaber Children · Prevalence

INTRODUCTION

Iodine is a trace mineral, which is essential for the development and growth of the human body. Iodine deficiency disorders (IDD) affect people and change children's and adults lives. One of the most important and well-known global nutritional problems is iodine deficiency (goiter) and its deficiency is the most common preventable cause of mental disability in the world. It is estimated that more than one billion people, reside primarily in less-developed countries, are unable to consume adequate levels of iodine. Only during almost the last three decade, it has been realized that IDDs are the leading cause of intellectual impairment [1]. Iodine deficiency causes reduced production of thyroid hormones (T3/T4). A decrease in the serum level of T3/T4 triggers the secretion of high amount of pituitary thyroid stimulating hormone, which stimulates thyroid glandular activities that results in enlargement of the gland [2]. Nearly two billion (28%) of the world's population, of whom more than 321 million (39%) Africans are at risk of insufficient iodine intake [3]. Based on the global data of iodine nutrition, Ethiopia is one of the African countries with the highest prevalence of (IDD) and with the weakest program to prevent IDD [4]. In Ethiopia, IDD has been recognized as a serious public health problem for the past six decades. Today, it still remains a major threat to national health and development programs [5]. The most recent data on coverage of iodized salt in Ethiopia indicated that only between 15 and 20 % of the participants used adequate iodized salt nationally [6]. Goitrogenic food is cheaply available in the community that may contribute to the development of goiter and the quality of salt distributed to the community is not well inspected for the presence of adequate amount of iodine [7]. There are a number of potential risk factors that may lead to iodine deficiency including low dietary iodine, selenium deficiency, pregnancy and exposure to radiation, increased intake of goitrogenic food, sex, smoking tobacco, alcohols, oral contraceptives and age [8]. Several studies on the prevalence of iodine deficiency in Ethiopia have been done but there are still many localities in the

Corresponding Author: Asamnew Ahmed, Haramaya University College of Natural and Computational and Veterinary Medicine, Ethiopia.

country including the present study area was not cover up. Although the disorders are the marked health constraints in a country, the status of the disease in children in the study areas have not been yet studied to full extent and not well documented. Therefore, the objectives of this study were to determine prevalence and risk factors of iodine deficiency disorder among school children in study area.

MATERIALS AND METHODS

Description of the Study Area: This study was conducted in Kutaber Primary School located in Kutaber district. It is found 421 kms away from Addis Ababa. Its geographical coordinates are 11° 16' 0" North, 39° 32' 0" East and its elevation is 800m-3200m above sea level. It is divided into 21 rural kebeles. Kutaber is bordered on the south by Dessie Zuria, on the west by Adila river that separates it from Tenta, on the north by Walano, which separates it from Ambasel and on the east by Tehuledere [9]. This woreda had a total human population of 95,410, of whom 47,341 were males and 48,069 were females. The main cash crops for the population are wheat, teff, red sorghum, barley and pulses along with this potato and cabbage supplemented by sheep and cattle [10].

Study Design: The design of the study was cross sectional survey involving primary school children to determine the prevalence of iodine deficiency disorder and its risk factors in the study population. The study was conducted on school children from 6-15 years of age at kutaber district from October 2014 to October 2015.

Urine samples were collected from study participants and were subjected to laboratory investigation for determination of urinary iodine concentration in the Ethiopian public health institute (EPHI). Physical examination and palpation of each study participant was carried out in Kutaber Primary School compound by a physician to see the presence and absence of goiter manifestation. In addition, salt samples were collected from the house of each study participant and subjected to laboratory investigation at EPHI to determine the iodine concentration in the salt.

Study Population and Sampling Techniques: The study was carried out in Kutaber primary school from October 2014 to October 2015. A total of 384 school children participated in this study, of these, 244 and 140 were males and females, respectively. 231 belonged to the age group of 6-10 years old and the remaining 153 were in the age category of 11-15 years. The age distribution of the study subjects varied from 6 years to 15 years. Mean age of the study population was 10 years. The proportion of males was greater than females within the study area.

Sample Size Determination: Since there was no previous investigation conducted on the same title in the study area, the sample size was determined by the statistical formula for single population [11]. The number of children in the school was based on the estimated prevalence of 50%, with 95% confidence interval, 5% absolute precision, based on this, a total of 384 primary school children aged 6 -15 years constituted the sample of the study

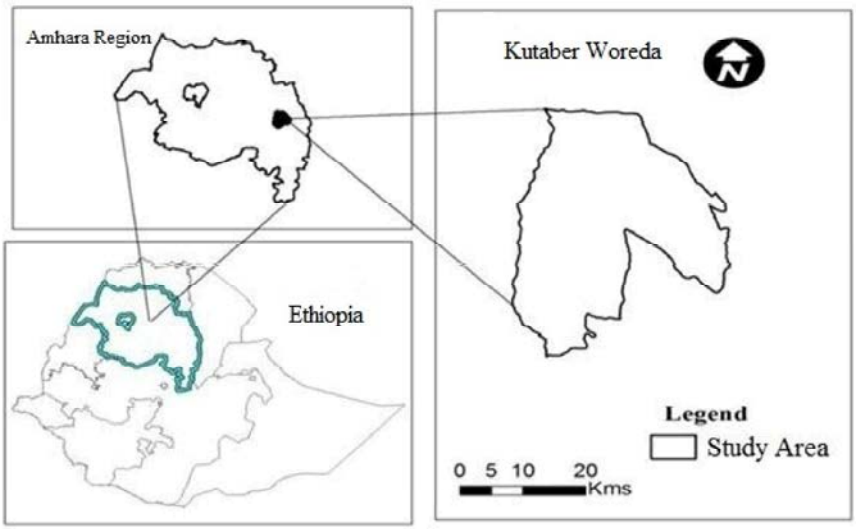

Fig. 1: Map of the study area, adapted from Arc GIS version 10.1

$$n = \frac{Z^2 P_{\exp}(1 - P\exp)}{d^2}$$

where: n = sample size
Z = level of confidence
d = precision
p = expected prevalence or proportion. Accordingly, a total sample size of 384 was obtained using the above stated formula to conduct this study in the study area.

Methods of Data Collection

Physical Examination of Goiter: According to the criteria of WHO/UNICEF/ICCIDD [12], each study participant was physically examined through palpation by a physician to check the presence of goiter manifestation. Iodine deficiency disorder manifested as goiter was palpated and graded by a physician using standard procedures as per the criteria of WHO/UNICEF/ICCIDD [12]. According to these criteria, goiter was graded as follows: Grade 0**:** no palpable or visible goiter; Grade 1**:** a goiter that is palpable but not visible and Grade 2**:** a swelling in the neck. Based on severity, goiter was categorized a**s** mild if total goiter prevalence (TGP) = 5.0-19.9%, moderate if TGP = 20-29.9% and severe if TGP ≥30%.

Collection of Urine and Salt Samples: About 10 ml spot urine samples were collected in clean tightly sealed and properly labeled sterile plastic vials. The urine samples were immediately transferred to the thermo cool box at -4^{0}c containing ice bags and stayed for a week until analysis before transported to EPHI [13]. The sex, grade level, age and code number given for each child were labeled on every plastic vial of the urine sample. In addition, from each house of study participant, 10 mg of salt sample was collected and transported to EPHI laboratory for iodometric titration analysis.

Laboratory Analysis

Determination of Urinary Iodine Concentration: In manuals of WHO [14], analysis of urinary iodine was done using the spectrophotometric procedure. This involves the spectrophotometric analysis, measuring the Optical density (OD) value of a reaction medium, which utilizes iodine as a catalyst. During this reaction, one of the reactants, ceric ammonium sulfate (yellow in color) is reduced to cerrous (colorless) form which uses iodine as a catalyst. The OD value at 420 nm gives a clue about the iodine content of urine sample. It indicated that the more the OD value, the lesser is the iodine content.

Determination of Iodine Concentration from Salt Samples: The samples were kept in desiccators at room temperature until iodine content was analyzed. Salt samples were grouped based on criteria such as powdered or crystal, iodized or non-iodized and based on the method of packing. Type I**:** Ordinary, non- iodinated, granulated. Type II**:** Ordinary, non-iodized, packed. Type III**:** Processed iodized and packed. A salt sample from each category was analyzed for iodine content using standard Iodometric titration method suggested by WHO [14]. This method involves the titration of a solution of salt and standard Sodium thiosulphate ($Na_2S_2O_3$ $5H_2O$) solution to find out the end point [15].

Data Analysis: Observation of the correlation between iodine concentrations against OD, data were analyzed by using Microsoft Excel spread sheet 2007 and SPSS version 20.0 for using mean comparing option, multinomial logistic regression and descriptive statistics analysis. P-values = 0.05 were considered statistically significant. The absorbance readings and iodine concentration was vitally important to construct a standard curve on graph paper by plotting iodine concentration of each standard on the abscissa against its optical density OD at 420 nm on the ordinate. Results were calculated from the linear regression equation of the graph.

RESULTS AND DISCUSSION

Prevalence of Goiter among the Study Participants: As shown in Table 1, the total goiter rate (TGR) was 113 (29.41%). Of these, the prevalence of Grade 1 and Grade 2 goiter rate was 26.29 and 3.12%, respectively. This indicated that IDD was a moderately severe public health problem according to recommendations of WHO [12].

In all age groups, the TGR in females (17.44%) was greater than that of males (11.97%). There were higher significant differences ($P < 0.05$) in TGR between sexes in both age groups of 6-10 and 11-15 years old. The data on iodine nutrition status of women and school aged children in Ethiopia showed that the prevalence of goiter in school age children was greater than 30% that was indication of severe iodine deficiency, in goiter endemic regions [16].

In the present study, iodine deficiency was found to be more prevalent in females compared to males. This is in agreement with studies conducted by Abuye *et al.* [17] in Tigray region, Berhanu *et al.* [18] has also reported that goiter is more common in females than in males as it was reported from Oromia region. Chandra *et al.* [19] and Furlanetto *et al.* [20] reported that the TGRs were higher

Table 1: Prevalence of goiter among the Study Participants by age and sex wise

Age (years) and sex	Nº examined	Grade 1 prevalence (%)	Grade 2 prevalence (%)	(TGR) (%)	X^2	P-value
6-10 years					16.737	0.000
Male	145	25(6.51)	3(0.78)	28(7.29)		
Female	86	32(8.33)	6(1.56)	38(9.89)		
Sub-total	231	57(14.84)	9(2.34)	66(17.18)		
11-15 years					20.160	0.000
Male	99	17(4.42)	1(0.26)	18(4.68)		
Female	54	27(7.03)	2(0.52)	29(7.55)		
Sub-total	153	44(11.45)	3(0.78)	47(12.23)		
All age groups						
Male	244	42(10.93)	4(1.04)	46(11.97)		
Female	140	59(15.36)	8(2.08)	67(17.44)		
Total	384	101(26.29)	12(3.12)	113(29.41)		

Table 2: Some Socio-demographic characteristics of parents of selected school children

Factors	No. (%)	Factors	Nº (%)
Sex of children		Monthly income level(birr)	
Male	244(63.5)	<500	36(9.4)
Female	140(36.5)	500-1000	69(18.0)
Educational level		1001-2000	100(26.0)
Illiterate	107(27.9)	2001-3000	73(19.0)
Primary education	174(45.3)	3001-5000	59(15.4)
Secondary education	65(16.9)	>5000	47(12.2)
Diploma and above	38(9.9)	Frequency of household cabbage consumption	
Occupation		Never	30(7.8)
Farmer	278 (72.4)	2x a week	162(42.2)
Merchant	47 (12.2)	3x a week	192(50.0)
Employee	59 (15.4)	Type of salt purchased	
Other	-	granulated	313(81.5)
		packed in plastic	51(13.28)
		packed in plastic bottle	19(4.94)
		Time of salt addition	
		Before cooking	94(24.5)
		During cooking	143(37.2)
		After cooking	147(38.3)

in females than in males in Kefa Zone, south west Ethiopia. A report from Tarai region of India showed females had higher TGR (34.4%) compared to males (26.9%) [21]. The possible explanation is that females are more vulnerable than males because of physiological reasons such as early puberty, which starts about 2 years earlier than males [22]. As a result, their iodine demand is higher than males. In addition, estrogen, which is a female hormone, has a well-known inhibitory effect on iodine uptake by thyroid follicular cells [22].

Socio-Demographic Characteristics of Parents of School Children: Regarding the monthly income level of the parents of the school children, 36(9.4%), 69(18%), 100 (26%), 73(19%) and 59(15.4%) of them had a range of *Birr* 500, 501-1000, 1001-2000, 2001-3000 and 3001-5000 per month, respectively. Only 47 (12.2%) of the respondents had monthly income level of above *Birr* 5000. Regarding the household cabbage consumption frequency indicated that 30 (7.8%) of the respondents had never consumed cabbage, while 162 (42.2%) and 192 (50%) of the respondents consumed cabbage twice and three times a week, respectively (Table 2).

With respect to their educational background, the majority of the study participants, 174 (45.3%) had completed primary education, 107 (27.9%) were uneducated, 65(16.9%) had Completed secondary education and the rest 38 (9.9%) were diploma holders. Most of the study participants were farmers 278 (72.4%) followed by government employees 59 (15.4%) and the remaining 47(12.2%) were merchants. In the study area the majority of the participants were using only granulated salt 313 (81.5%) and 51(13.28%) were using salt packed in plastic and 19(4.94%) of the participants were using salt packed in plastic bottle.

Table 3: Association of Socio-demographic features of the parents with manifestation of goiter

Factors				95%CI			
Sex of children	Nº. ofexamined	Nº of Positive (%)	OR	Lower Bound	Upper bound	P-value	
Male	244	46(11.97)					
Female	140	67(17.44)	0.265	0.160	0.442	0.000	
Educational level							
Illiterate	107	31(8.07)	1.024	0.397	2.644	0.960	
Primary education	174	53(13.80)	0.764	0.313	1.867	0.555	
Secondary education	65	18(4.68)	0.939	0.336	2.626	0.905	
Diploma and above	38	11(2.86)	-	-	-	-	
Monthly income (*Br*)							
<500	36	11(2.86)	0.848	0.361	1.994	0.706	
500-1000	69	24(6.25)	0.770	0.315	1.881	0.566	
1000-2000	100	27(7.02)	-	-	-	-	
2000-3000	73	19(4.94)	-	-	-	-	
3000-5000	59	21(5.46)	-	-	-	-	
>5000	47	11(2.86)	-	-	-	-	
Frequency of cabbage consumption							
Never	30	2(0.52)	28	14.81	3.316	66.167	.000
2x a week	162	16(4.16)	146	8.444	4.573	15.591	.000
3x a week	192	95(24.73)	97	-	-	-	-

Out of the total 384 study participants under investigation, 237 (61.7%) used salt before and during cooking which might reduce the amount of iodine content in the diet. Iodine is volatile in nature and can escape when exposed to even little temperature changes. Thus, risk minimization of iodine deficiency would be possible by the addition of salt just after cooking (Table 2).

Association of Socio Demographic Features of the Parents with Manifestation of Goiter in School Children: The highest prevalence of goiter 95 (24.73%), was observed among school children who consumed cabbage three days per week. The lowest prevalence of goiter 2 (0.52%) was observed among those who had never included cabbage in their diet. The result clearly indicated that significant association existed between the frequency of cabbage intake and development of goiter (p=0.000). Thus, this finding agrees with the findings of Yinebeb *et al.* [7] concerning Shebesenbo district, Jimma Zone, South west Ethiopia. Sex difference was also found to be significantly associated (p= 0.000) with prevalence of goiter. This indicated that females have the probability of being 0.265 times more vulnerable to goiter than males (OR= 0.265) and this value lied between 0.160 (lower) and 0.442 (upper) limit at 95% CI (Table 3).

This finding of Table 3 disagrees with the result reported by WHO, UNICEF, ICCIDD [23] which indicated the presence of correlation between the income of the household and prevalence of iodine deficiency [23]. Based on Abuye's report, children who belonged to the parents earning monthly income > 1500 *Birr* had the least IDD (23%) compared to those who earn <1000 *Birr*. The higher TGR in low-income category could be because of low food security, including cruciferous vegetables examples all types of cabbage are containing chemical isothiocyanates, which block the enzyme that allows thyroid to use iodine, use of non-iodized salt and lack of medical attention. Related study results reported that the prevalence of goiter is common in economically low families. This suggests that living standard may have direct relationship with iodine nutritional status and thereby with prevalence of IDDs in a population [23].

A direct correlation (p=0.000) was seen between the frequency of cabbage intake and prevalence of goiter. Children who consumed more cabbage per week were more exposed to goiter than those never ate cabbage. Abuye *et al.* [24] reported that consumptions cassava, kale cabbage and sweet potato have been shown as a risk factor for the development of goiter. The present finding is supported by the experimental work done on goitrogens reported that rabbits that were fed cabbage regularly developed goiter [25]. In addition to this, in Oromia region, including Shebesenbo District, mothers who take cassava regularly showed higher prevalence of goiter compared to non-users [23]. Cabbage contains thiocyanate and isothiocyanate that inhibit iodine uptake by the thyroid follicular cells and also blocks the thyroid peroxidase enzyme [26]. In the presence of goitrogens, iodination of thyroglobulin protein might be impaired, resulting in poor thyroxin production and enlargement of the thyroid gland. Goitrogenic foods can block the absorption and utilization of the available iodine from the diet [27].

Table 4: Mean urinary iodine concentration by sex and age of study participants

Age(years) and Sex	Nº of urine samples examined	Mean	SD(µg/l)	x^2	P-value
6-10 years		0.29	0.453	7.643	0.004
Males	145	0.25	0.434		
Females	86	0.39	0.490		
Sub-total	231				
11-15 years		0.31	0.463	5.295	0.017
Males	99	0.21	0.413		
Females	54	0.26	0.421		
Sub-total	153				
All age groups					
Males	244	0.19	0.392		
Females	140	0.48	0.501		
Total	384	0.29	0.456		

Table 5: Mean iodine concentration by type of Salt Samples

Types of Salt Samples	Nº of examined Samples	Mean	SD(µg/l)	x^2	P-value
Non-Iodinated				9.339	0.025
Type I	249	0.31	0.465		
Type II	102	0.25	0.438		
Sub-total	351	0.28	0.451		
Iodinated					
Type III	29	0.31	0.471		
Type IV	4	0.00	0.000		
Sub-total	33	0.31	0.471		

SD=Standard deviation

Assessment of Urinary Iodine Concentration: In age group 6-10 and 11-15 years the mean urinary iodine excreted (UIE) value by (µg/l) for male and female children were (0.25±0.434 and 0.39±0.490) and (0.21±0.413 and 0.26±0.421) respectively. Thus, there were significant difference ($p<0.05$) in UIE values between each sex of these age group observed. This finding agrees with the work of Takele *et al.* [28] who indicated that significance levels of UIE between 1996 (P=0.43) and 1999 (P=0.017) and significant difference also observed between 2000 (P=0.008) and 2003 (P=0.002) for sex with repeated measurements in all 384 children. This study clearly showed that in all age groups the standard deviation value of examined urine sample was found to be higher in females than males which indicated that the data points spread far from the mean and there were a great variation appeared among females (Table 4).

Assessment of Salt Iodine Concentration: As per the result of salt samples collected from children's participants 351(91.4%) of the participants were using non-iodized salt (type I and type II) (Table 5). This could be one of the main reasons for the high prevalence of iodine deficiency in the population and the remaining 33 (8.6%) of salt samples were iodized either with recommended iodine level should be 15 parts per million (ppm) at consumer level and 30 ppm at production level which is not recommended to consume, since it causes iodine-induced hyperthyroidism, thyroiditis and thyroid papillary carcinoma [29]. Besides this, the consumption of non-iodized salt was directly correlated (x^2=9.339, P=0.025) with the amount of urinary iodine being excreted) (Table 5).

The magnitude of severity in the result of this study was lower than earlier study reports who reported that 81% of household salt samples of the study area had iodine level below the minimum standard set by the quality and standard authority of Ethiopia [30].

Assessment of Categorical Urinary Iodine Concentration: Among a total of 384 urine samples tested males from the age group of 6-10 years and 11-15 were 96 (25%) and 58 (15.10%) showing sub-normal urinary Iodine Concentration, respectively. On the other hand, females from the age groups of 6-10 years and 11-15 years were 77 (20.05%) and 48 (12.5%) indicating urinary iodine level below the normal, respectively. As a whole, 279 (72. 6%) of the urine samples showed iodine deficiency below the normal level (100 µg/l) in both sexes (Table 6).

Table 6: Age and sex association of school children based on category of urinary Iodine Concentration

Age & Sex	Nº of Examined		Nº of positive (%)		Category of urinary Iodine Concentration (µg/l)			
			<20	20-49.9	50-99.9	100-199.9	200-299.9	>300
6-10 years								
Males	145	96(25)	3	12	81	46	3	-
Females	86	77(20.0)	7	8	62	9	0	-
11-15years								
Males	99	58(15.1)	2	13	43	30	9	2
Females	54	48(12.5)	12	8	28	6	0	0
Total(%)	384	279(72.6)	24(6.2)	41(10.6)	214(55.7)	91(23.)	12(3.1)	2(0.5)

Urinary iodine < 20 µg/L= severe, 20-49.99 µg/L= moderate, 50-99.99 µg/L= mild, 100-199.99 µg/L = adequate, 200-299.99 µg/L= above requirement,>300 µg/L=excessive. Excessive urinary Iodine concentration indicated adverse health consequences such as iodine-induced hyperthyroidism, autoimmune thyroid diseases. Median urinary iodine (MUI) level is also important indicator of iodine deficiency of the entire population. According to the current finding, the MUI (Median urinary iodine concentration) was found to be 74.76 µg/l, for both sexes while 79.81 µg/l and 61.58 µg/l in males and females, respectively. This result was below 100 µg/l which indicates that the study area is moderately affected by iodine deficiency compared with what Berhanu *et al.* [18] reported a MUI level of 25 µg/l in Oromia region, suggesting a very severe case of iodine deficiency in the population.

ACKNOWLEDGMENTS

The authors would like to thank Kutaber Primary School members for their unreserved helps during the research work.

REFERENCES

1. Hetzel, B.S., 1989. An overview of the prevention and control of iodine deficiency disorders, in: The Prevention and Control of Iodine Deficiency Disorders, ed. by Amsterdam, Netherland, pp: 17.
2. Hetzel, B.S., G.F. Maberly and W. Mertz, 1986. Trace Elements in Human and Animal Nutrition.5th Edition. Academic Press, New York, 2: 139-208.
3. Andersson, M., V. Karumbunathan and M.B. Zimmermann, 2011. Global iodine status in 2011 and trends over the past decade. Journal of Nutrition, 142(4): 744-750.
4. B. Hussein and V. Assey, 2012. Elimination of Iodine Deficiency through Salt Iodization in Ethiopia, ICCIDD, Addis Ababa, Ethiopia.
5. Cherinet, A., B. Yemane, A. Girma, G. Zewditu and E. Tesema, 2007. Prevalence of goiter in children 6 to 12 years of age in Ethiopia. Food and Nutrition Bulletin, 8(4): 391-98.
6. Central Statistics Authority (CSA), 2011. Ethiopia Demographic and Health survey, Addis Ababa, Ethiopia.
7. Yinebeb, M., M. Andualem, P.N. Rajesh and B. Getnet, 2012. Prevalence and severity of iodine deficiency disorder among children 6-12 years of age in Shebesenbo district, Jimma Zone, South west Ethiopia. Ethiopian Journal of Health Science, 22: 196-204.
8. Venturi, S. and M. Venturi, 2009. "Iodine in evolution of salivary glands and in oral health." Nutrition and health, 20(2): 119-134.
9. Svein, E. and South Wollo, 2004.1:100,000 Topographic and administrative map of South Wollo Zone, Amhara Region, Ethiopia.
10. Central Statistics Authority (CSA), 2007.Ethiopia Demographic and Health survey, Addis Ababa, Ethiopia.
11. Lwanga, S.K. and S. Lemeshow, 1991. Sample size determination in health studies: a practical manual, WHO Geneva.
12. WHO/UNICEF/ICCIDD, 2007. Assessment of Iodine Deficiency Disorders and monitoring their elimination: A guide for programme managers, 3rd ed. Geneva.
13. World Health Organization (WHO), 2007. Technical consultation for the prevention and control of Iodine Deficiency in pregnant and lactating women and in children less than two years old, Geneva.
14. WHO/ CCIDD/ UNICEF, 1990. A Practical guide to the correction of IDD. In: Dunn JT, Vander Harr F. Netherlands: International Council for Control for Iodine Deficiency Disorders.
15. Sullivan, KM., E. Houston, J. Gorestein and C. ervinskas, 1995.Titration methods for salt iodine analysis: Monitoring Universal Salt Iodization program. Atlanta, Georgia, USA.

16. Kidane, T. and A. Wolde gebriel, 2006. Prevalence of Iodine deficiency disorder in a highland district in Tigray. Ethiopian Journal of. Health Development, 20(1): 58-59.
17. Abuye, C., Y. Berhane, G. Akalu, Z. Getahun and T. Ersumo, 2007. Prevalence of goiter in children 6 to 12 years of age in Ethiopia. Food and Nutrition Bulletin, 28(4): 391.
18. Berhanu, N., K. Wolde Michael and M. Bezabih, 2004. Endemic goiter in School Children in Southwestern Ethiopia." Ethiopian Journal of Health Development, 18(3).
19. Chandra, A.K., A. Bhattacharjee, T. Malik and S. Ghosh, 2008. Goiter Prevalence and Iodine Nutritional status of Shool Children in a Sub Himalayan Tarai Region of EsternUttra Pradesh, Indian Pediatrics, 45(28): 469-474.
20. Furlanetto, T.W., R.B. NunesJr, A.M.I. Sopelsa and R.M.B. Maciel, 2001. Estradiol decreases iodine uptake by rat thyroid follicular FRTL-5 cells. Brazil Journal of Medical Biology Research, 34: 259-263.
21. Abuye, C. and Y. Berhane, 2007. The Goiter rate, its association with reproductive failure and the knowledge of iodine deficiency disorders (IDDs) among women in Ethiopia: Cross-sectional community based study. BMC Public Health, 7: 316.
22. Meron, G., L. Eskndir, B. Alemtsehay, T. Nega, A. Chernet and J. Barbara, 2012. Iodine deficiency in primary school children and knowledge of Iodine deficiency and iodised salt among caretakers in Hawasa town, Southern Ethiopia. Ethiopian Journal of Health Development, 26(1): 30-35.
23. WHO, UNICEF, ICCIDD, 1994. Indicators for assessing Iodine Deficiency Disorders and their control through salt iodization. World Health Organization; WHO Document, Geneva, WHO/NUT/94.6.
24. Abuye, C., Y. Berhane and T. Ersumo, 2008. The role of changing diet and altitude on goiter prevalence in five regional states in Ethiopia. East African Journal of Public Health, 5(3): 163-168.
25. weather, F., S. Talit and R.F. Hurrel, 1996. Bioavailability of minerals and trace elements, Nutrition Research Reviews, 9: 295-324.
26. Thomas, R., F. Nadine, A. Ute and B. Shoma, 2006. Longitudinal examination of 24-h urinary iodine excretion in schoolchildren as a sensitive, hydration status: independent research tool for studying iodine status. American Journal of Clinical Nutrition, 83:639-46. Printed in USA.
27. Azizi, F., A. Duffiel, H. Bürgi, J. Dunn, B. Hetzel and F. Delange, 2001. Assessment of iodine deficiency disorders and monitoring their elimination: A guide for programme managers, 2nd edition. World Health Organization, Geneva.
28. Takele, L., T. Belachew and T. Bekele, 2000. Iodine concentration in salt at household and retail shop levels in Shebe town, Southwest Ethiopia. East African Medical Journal, 80(10): 532.
29. World health organization (WHO),1996. Recommended iodine levels in salts and guidances for monitoring their adequacy and effectiveness Geneva, 8-9 July.
30. Takele, L., T. Belachew and T. Bekele, 2003. Iodine concentration in salt at household and retail shop levels in Shebe town, south west Ethiopia. East African Medical Journal, 80(10).