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LACK OF DIETARY SOURCES OF IODINE AND THE PREVALENCE OF IODINE DEFICIENCY IN RURAL WOMEN FROM SIDAMA ZONE, SOUTHERN ETHIOPIA

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ABSTRACT

Iodine deficiency has been reported to affect a large number of people in Ethiopia. Although significant progress against iodine deficiency disorders (IDD) has been reported worldwide, millions of people remain with insufficient iodine intake. Multiple factors may contribute to iodine deficiency. Hence, the objective of this study was to investigate iodine deficiency and dietary intake of iodine. A cross-sectional survey design was used to assess urinary iodine concentration (UIC), goiter and dietary intake of iodine in a sample of 202 non-pregnant women living in three rural communities of Sidama Zone, southern Ethiopia. Urinary iodine concentration was analyzed using the Sandell-Kolthoff reaction, goiter was assessed using palpation and dietary source of iodine was assessed using a food frequency questionnaire. Data were analyzed using selected descriptive and analytical statistical measures with SAS software. Mean (SD) age, mid upper arm circumference (MUAC) and body mass index [BMI - $Wt_{(kg)}/(Ht_{(m)})^2$] were 30.8 (7.9) y, 24.8(2.5) cm and 20 (2.2) respectively. Median UIC was 37.2 µg/L. Participants with UIC <20 µg/L, classified as severely iodine deficient were 22.8%; 46.5% had UIC between 20 to <50 µg/L, classified as moderately iodine deficient, and 27.2 % had UIC in the mild deficiency range of 50 to <100 µg/L. Only 3.5% of the women had UIC ≥ 100 µg/L. The total goiter rate was 15.9%, which was 1.5% visible and 14.4% palpable goiter. A majority of the participants consumed Enset (*E. ventricosum*), corn and kale frequently and meat was consumed rarely. None of the participants reported ever consuming iodized salt or ever having heard about use of iodized salt. Adjacent communities (Alamura, Tullo and Finchawa) showed significant differences in UIC, goiter rate and frequency of fish and dairy consumption. The findings of the present study revealed that iodine status of the population is a significant public health problem. Hence, there is a need to supply iodized salt in order to achieve the goal of elimination of iodine deficiency disorders in the community.

Key words: urinary iodine, goiter, food frequency ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 13 No. 5 December 2013 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Iodine deficiency is one of the most common nutritional problems of the world. More than two billion people, most of them in developing countries, suffer from inadequate intake of iodine [1]. Despite the significant progress against iodine deficiency disorders (IDD), according to the 2007 survey report by WHO, there were about 312.9 million (41.5%) of Africa's population who had insufficient iodine intake [2].

In Ethiopia, IDD affects a large proportion of the population. In 2007, Cherinet and Yemane [3] surveyed goiter status and found goiter rate among 15 to 49 year old women to be 35.8%, which included 24.3% palpable and 11.5% visible goiter. In the southern region of Ethiopia out of 1702 women examined for goiter, 43.2% had palpable and 17.7% had visible goiter, which is a total goiter rate of 60.9% [3]. Subsistence populations living in areas where the soil has been depleted of iodine are at great risk of iodine deficiency. Iodine deficiency in the soil affects all forms of plant life, and crops grown on iodine-depleted soil will have low iodine content. Thus, populations who rely on subsistence agriculture for a living are likely to be exposed to iodine deficiency if the soil iodine content is low [2].

In population studies, iodine status is usually assessed by measuring iodine concentration in spot urine samples. Median urinary iodine concentration (UIC) of 100 µg/L and above defines a population without significant iodine deficiency; in other words, at least 50% of the sample should be above 100µg/L. In addition, not more than 20% of samples should be below 50µg/L [2]. Intake of sources of iodine can be estimated by using a food-frequency questionnaire (FFQ) [4]. The objective of the present study was to assess dietary sources of iodine and the prevalence of iodine deficiency in the study population.

MATERIALS AND METHODS

Design

A cross-sectional survey design was used to assess UIC, goiter and dietary sources of iodine in a convenience sample of 202 non-pregnant women living in three rural communities of southern Ethiopia in July, 2009. A questionnaire was used to assess socio-economic status and food frequency. Anthropometric measurements were taken and UIC and goiter were used to estimate iodine status.

Subject selection and ethical consideration

Ethical clearances were obtained from Oklahoma State University (OSU), Hawassa University, Southern Nations, Nationalities and Peoples Regional Health Bureau, and the Ministry of Science and Technology, Ethiopia. Detailed explanation about the research was given to the health workers at the wereda (an administrative unit equivalent to district) level. Thereafter, a thorough discussion was done in each community with the local health workers and potential participants, from which 202 women volunteered to participate in the study and were registered. An informed consent was read for each woman and signed by fingerprint before data collection was started. All study participants were women aged 18 and above, non-pregnant and inhabitants of three adjacent villages named as Finchawa, Tullo and Alamura.

Data collection

Research assistants were given training prior to data collection on the questionnaire and anthropometric measurements. The questionnaire also was pretested in 10 women from the communities who were not involved in the study. Demographic characteristics and socioeconomic status were assessed using questions adapted from the Ethiopia Demographic and Health Survey 2005 report [5]. Food consumption patterns of respondents were assessed using a standardized food frequency questionnaire [6].

Each woman's weight was measured on a solar digital scale (Uniscale, UNICEF, NY) and recorded to the nearest 100 grams. Height was measured to the nearest 0.1 cm using a calibrated board (Adult Board, Schorr Productions, Olney, MD). Mid upper arm circumference (MUAC) was measured using a plastic tape. Anthropometric measurement methods were according to Gibson [6].

Urine was collected in a cup out of which samples were taken to fill tightly sealed vials. Samples were placed on ice, refrigerated at Hawassa University, and transported to Oklahoma State University for analysis. Urinary iodine was analyzed in duplicate using the Sandell-Kolthoff reaction and categorized for severity of iodine deficiency per WHO/UNICEF/ICCIDD recommendations [2].

Total goiter was determined by palpation based on the following grades: grade 0, no palpable or visible goiter; grade 1, goiter palpable but not visible when neck is in the normal position; grade 2, goiter visible when neck is in the normal position [2].
Data were analyzed using descriptive and analytical statistical measures. Percentages, frequency distributions, means and standard deviations were used to describe the socio-economic and demographic characteristics of the respondents and their iodine status. Analysis of variance and chi-square analyses were used to examine differences between villages. Pearson's correlations were used to identify associations between variables. All the analyses were performed with SAS software, version 9.3 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Demographic, socioeconomic and anthropometric characteristics of women

Characteristics of the study participants are shown in Table 1. The self – reported age (Mean (SD)) of the 202 participants was 30.8 (7.8) years. Approximately 50% of the participants were between 18 and 30 years old and the rest were between 30 and 49 with only 2 participants above 49 years. The mean height and weight were 157.3 (6.0) cm and 50 (6.5) kg respectively.

Most of the women (92.1%) were married whereas 6.4%, 1% and 0.5% were widowed, single or divorced respectively. More than 90% of the participants responded that the husband is the household head. The household size and number of children were 6.1 (2.4) and 4.2 (2.2) respectively. Of the participants, 63.5% had no formal education and the remaining (36.5%) had limited education. Out of those who had education, there was only one who completed 2 years of college after high school and one other who completed high school.

Of the participants, 26% owned mature enset (local indicator of wealth) and 85% owned livestock. The average size of land was 0.4 (0.2) hectares and there was only one participant who had as much as 1.5 hectare of land.

A majority of the participants (63.7%) had a house with roof made of grass or straw whereas the rest had houses with roofs made of corrugated iron. The walls of the house were built with wood and mud, dry mud blocks or wood and grass. Most had floors made of mud or smeared cow dung, but 10% had cement floors. Socio-demographic characteristics were not significantly different between women who had goiter versus those who did not, the same holds true in women who had UIC above or below the median.

Food consumption patterns

As indicated in Table 2 all participants reported that they had never consumed iodized salt. Despite living close to Lake Awassa that is the source of fish for the surrounding and nearby villages, only 24.3% consumed tilapia as often as 3-6 times per week. The rest either never or rarely consumed fish. No one reported consuming tilapia or catfish as often as once per day and correlation between UIC and fish consumption was not significant ($p = 0.075$). None of the participants had consumed meats as often as once a week. Some of the participants, 5.9% and 17.3%, consumed milk 3 to 6 times a week or once per day respectively. Almost all of the participants had consumed corn, enset (*E. ventricosum*) and kale (staple foods in the community) frequently (more than once per day) to 3 to 6 times a week. Among the legumes, kidney bean was consumed frequently by 77% of the participants. Of the participants, very few people had eaten the most popular grain (teff) in the country, but consumption of this grain had significant positive association with wealth ($p < 0.003$). Avocado, papaya and banana are the most commonly consumed fruits in the area, but 45% of women had never consumed papaya. None of the participants had ever consumed cassava or yam except those 8% who consumed yam rarely.

Assessment of urinary iodine

Assessment of urinary iodine concentration (UIC) showed that 96.5% of participants had UIC below 100 µg/L, which is an indicator of iodine deficiency. Among these, 22.8% were severely iodine deficient, 46.5% were moderately iodine deficient, and 27.2% were mildly iodine deficient based on the classification recommended by WHO [2]. Women who had adequate iodine concentration (UIC >100 µg/L) were only 3.5% and median UIC was only 37.2 µg/L. Moreover, the maximum UIC obtained among the participants was 146.5 µg/L. The palpation-based goiter assessment showed that 16% had goiter, with 14.4% palpable and 1.5% visible goiter. In this study UIC was significantly correlated with plasma selenium ($r = 0.16$, $p =$

0.023). A significant correlation also was observed between goiter rate and transferrin receptor (r = 0.20, p = 0.005) which indicates goiter was more common in women with functional iron deficiency (data not shown).

Differences in variables by village

Three adjacent village communities who shared the same market and had very similar socio-economic resources differed in the rate of goiter, UIC and frequent consumption of some foods. Village Alamura had the lowest mean UIC (26.5 µg/L) and Finchawa showed the highest (27.9%) rate of goiter compared to the other two villages. The food consumption pattern seemed to be different in the villages. A higher percentage (42.2%) of Tullo participants had consumed fish (tilapia and catfish) frequently and Tullo had a goiter rate of only 6.1%. However, a lower percentage (11.5%) of participants in this village had consumed dairy products frequently (Table 4).

DISCUSSION

Several studies have reported the public health significance of iodine deficiency in Ethiopia as a whole, as well as in the study region. According to Cherinet *et al*. [7], prevalence of goiter in school children in southern Ethiopia was 56.2% and median UIC was 10 µg/L. In Wondo Genet, which is approximately 50 km from our study area, 99% of the rural women participating in the study had UIC less than 20 µg/L which indicated severe iodine deficiency [8]. A study from Hawassa town reported 82% of school children had UIC below 50 µg/L [9]. Thus, although sampling in the present study does not allow extrapolation to the population, the finding that iodine deficiency would be classed as a serious public health problem was consistent with other reports from southern Ethiopia.

The study participants had poor dietary iodine intake; all women reported they had never consumed iodized salt, and surprisingly none of the women recalled ever hearing about iodized salt. Supporting our findings, even in an urban area (Hawassa town), Meron *et al*. [9] found that more than half of the participants did not know the importance of iodized salt and no households were using adequately iodized salt.

The recommended nutrient intake (RNI) for an adult woman is 150 µg/day [10] and the recommendations increase for pregnancy and lactation [11]. The staple foods frequently consumed in the area such as enset, corn and kidney bean are not high in iodine. Cherinet and Kelbessa [12] reported that iodine concentration of enset, corn and kidney bean could be as low as 24.0, 22.9 and 10.9 µg/kg (dry weight), respectively, illustrating the difficulty in attaining recommended intakes without the use of iodized salt.

None of the participants reported consuming other important dietary sources of iodine except limited amounts of fresh water fish. Milk would usually have been considered a source of iodine but the quantity matters. In this study population, milk is usually consumed in coffee but only in small amounts. Moreover, in some regions of Ethiopia, iodine concentration of cow's milk was found to vary from 15.5 (2.2) to

22.2 µg/L [12]. And, two studies from the south of Ethiopia have reported iodine concentrations of the primary water sources to be ≤ 7.5 µg/L [8, 9].

The iodine content of plants depends on the iodine content of the soil, and iodine in soil also affects the content of the water [2]. In China, adding potassium iodate into irrigation canals significantly improved soil iodine concentration, plant iodine uptake, iodine content of meat, milk and eggs and human iodine status which illustrates the movement of iodine through the food chain[13].

Because the majority of the women in the present study depend on their own production for their daily consumption, differences in elevation and occurrence of runoff may require further study because runoff can be a cause for iodine depletion of the soil [2]. Village Alamura has higher elevation and significantly lower UIC. Thus, geographic, as well as dietary, factors may contribute to the significant differences in rate of goiter and in UIC observed in these adjacent communities. Source of drinking water also requires attention. Cherinet and Kelbessa [12] found that goiter prevalence was higher among subjects whose major drinking water source was contaminated with bacteria. Significant differences in consumption of foods such as milk and fish were also observed among the villages.

Thyroid hormone synthesis can be inhibited by dietary factors, such as goitrogenic compounds from millet and thiocyanate from cassava. The frequent consumption of maize and sweet potato can also be detrimental because they contain small amounts of cyanogenic glycosides, thiocyanate precursors which have antithyroid effects [14]. Other micronutrient deficiencies, including vitamin A, selenium, and iron, can contribute to iodine deficiency by affecting thyroid hormone production and metabolism. Thus the interaction of multiple nutrient deficiencies and determinant compounds in foods requires in depth investigation [15, 16].

To estimate prevalence of iodine deficiency, urinary iodine concentration (UIC) is an important biomarker to assess recent iodine intake because most iodine absorbed in the body eventually appears in the urine [17]. However UIC reflects iodine status only at the time of measurement, not longer than a few days, whereas thyroid size reflects iodine nutrition over months and years and represents a chronic situation of iodine deficiency [2].

Based on the criteria for monitoring progress towards sustainable elimination of IDD as a public health problem, the proportion of households using adequately iodized salts should be > 90% and median urinary iodine in the general population should be 100 to 199 µg/L [2]. Thus IDD was a serious public health problem in the present study population, based on the fact that none of the participants reported consuming iodized salt and the median UIC of 37.2 µg/L is far below the desirable value. The palpation-based goiter assessment (16%) also indicated chronic iodine deficiency. Although goiter rate criteria are not set for adults, for school-age children a goiter rate of 5% or more indicates the presence of a public health problem [2].

Ethiopia has required salt iodization since March, 2012, which is important progress towards eliminating iodine deficiency disorders. However, in order to bring about the desired change in iodine status, there is a need to focus on creating awareness regarding the benefits of iodized salt, and of the need for proper utilization, storage, and overall handling. A recent article by Andersson and colleagues noted that although global iodine status is improving, Ethiopia is among the few countries where moderate iodine deficiency remains [18]. Ethiopia's reputation for iodine deficiency is not surprising given that qualitative research conducted in December of 2010 indicated that only 3 to 5% of salt in the country was iodized at that time [19]. However, the full implementation of the salt iodization program accompanied by increased community awareness should do much to alleviate the problem.

CONCLUSION

Iodine deficiency is a severe public health problem in the study area. None of the rural women participating in the study reported consuming iodized salt, and other dietary sources of iodine were minimal. Differences in iodine deficiency observed among adjacent villages require further investigation to identify root causes, but none of the villages actually had adequate iodine status. Moreover, although there is still a need for further analysis regarding the interaction of micronutrient deficiencies and the effect of goitrogenic compounds on iodine status in these communities, it is apparent that consumption of iodized salt will be of great benefit in improving IDD in the study population.

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Table 1: Demographic, socioeconomic and anthropometric characteristics of rural women from Sidama zone (n = 202)

	Frequency	Percent	Mean (SD)
Age			30.8(7.8)
Household size			6.1(2.4)
Number of children			4.2(2.2)
Marital status			
- Single	2	1.0	
- Married	186	92.1	
- Divorced	1	0.5	
- Widowed	13	6.4	
Education level			
- No education	127	63.5	
- Some education	73	36.5	
Size of land (ha)			0.4 (0.2)
Livestock ownership			
- Yes	172	85.2	
- No	30	14.8	
Owning mature enset			
- Yes	52	25.7	
- No	150	74.3	
Type of roof of house			
- Grass/straw	132	63.7	
- Corrugated iron	70	36.3	
Body mass index			20 (2.2)
Mid upper arm circumference			24.8 (2.5)

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Table 2: Frequency (%) of reported consumption of selected food types by rural women from Sidama zone

Food type	Frequently (>3/wk)	Once/wk	Very rarely	Never
Iodized salt	0	0	0	100
Fish				
- Catfish	0	11.9	29.7	58.4
- Tilapia	24.3	23.8	27.2	24.7
Meat				
- Beef	0	0	96.0	4.0
- Chicken	0	0	59.4	40.6
- Sheep	0	0	27.7	72.3
- Goat	0	0	42.1	57.9
Eggs	3.0	11.9	41.1	44.0
Dairy products				
- Milk	23.2	18.8	29.7	28.3
- Butter	13.8	26.2	42.7	17.3
Cereals				
- Corn	100.0	0	0	0
- Wheat	7.4	13.9	51.5	27.2
- Teff	0.5	3.5	43.5	52.5
Legumes				
- Pea	21.3	22.3	38.6	17.8
- Kidney bean	77.2	8.4	11.4	3.0
- Lentil	15.4	27.7	36.6	20.3
- Peanut	0	0.5	3.5	96.0
Vegetables & root crops				
- Kale	95.0	1.0	2.0	2.0
- Cabbage	19.8	23.3	39.6	17.3
- S. potato	7.9	21.8	55.5	14.8
- Potato	29.1	29.7	32.8	8.4
- Enset	94	3.0	0.5	2.5
- Yam	0	0	7.5	92.5
- Cassava	0	0	0	100
Fruits				
- Avocado	41.1	29.7	21.3	7.9
- Papaya	13.9	10.4	30.2	45.5
- Banana	26.7	28.2	30.7	14.4

Table 3: Urinary iodine concentration and goiter rate of rural women from Sidama zone (n = 202)

	n	Percent	Median
UIC (µg/L)			
- < 20	46	22.8	
- 20 to < 50	94	46.5	
- 50 to100	55	27.2	
- > 100	7	3.5	
Median			37.2 µg/L
Goiter rate			
- No goiter	170	84.1	
- Palpable goiter	29	14.4	
- Visible goiter	3	1.5	
Total Goiter Rate (TGR) (%)	32	15.9	

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Table 4: Median urinary iodine concentration (UIC), frequency of goiter, and food consumption of rural women from Sidama zone by village

Variables*	Finchawa (n = 67)	Tullo (n = 65)	Alamura (n = 70)
UIC (µg/L)	40.7[a]	44.1[a]	26.5[b]
Goiter (%)	27.9[a]	6.1[b]	12.9[b]
Frequent consumption of fish (%)	20.9[b]	42.2[a]	12.9[c]
Frequent consumption of dairy products (%)	21.4[a]	11.5[b]	21.0[a]

*Only variables that are significantly different by village are included
- Values in a row that share a superscript are not significantly different from each other

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