RESEARCH ARTICLE

Individual and community level factors associated with use of iodized salt in sub-Saharan Africa: A multilevel analysis of demographic health surveys

Yigizie Yeshaw1,2*, Alemneh Mekuriaw Liyew2, Achamyelah Birhanu Teshale2, Tesfa Sewunet Alamneh2, Misganaw Gebrie Worku3, Zemenu Tadesse Tessema2, Adugnah Zeleke Alem2, Getayeneh Antehunegn Tesema2

1 Department of Physiology, School of Medicine, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia, 2 Department of Epidemiology and Biostatistics, Institute of Public Health, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia, 3 Department of Human Anatomy, School of Medicine, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia

* yigizieyeshaw29@gmail.com

Abstract

Introduction

Iodine deficiency disorder a common problem in sub-Saharan Africa (SSA). It affects not only the health of the affected individual but also the economic development of the country. However, to the best of our knowledge, there is a scarcity in literature about the associated factors of iodized salt utilization in sub-Saharan Africa. Therefore, this study aimed to identify both individual and community level determinants of iodized salt utilization in sub-Saharan Africa.

Methods

This study used the appended datasets of the most recent demographic and health survey from 31 sub-Saharan countries. A total weighted sample of 391,463 households was included in the study. Both bivariable and multivariable multilevel logistic regression were done to determine the associated factors of iodized salt utilization in sub-Saharan Africa. Therefore, this study aimed to identify both individual and community level determinants of iodized salt utilization in sub-Saharan Africa.

Results

Those households with primary (AOR = 1.53, 95% CI = 1.50–1.57), secondary (AOR = 1.81, 95% CI = 1.76–1.86) and higher education level (AOR = 2.28, 95% CI = 2.17–2.40) had higher odds of iodized salt utilization. Households with middle (AOR = 1.05, 95% CI = 1.02–1.08), richer (AOR = 1.13, 95% CI = 1.09–1.17) and richest wealth index (AOR = 1.23, 95% CI = 1.18–1.28) also had an increased chance of using iodized salt. Households from high community media exposure (AOR = 2.07, 95% CI = 1.71–2.51), high community education level (AOR = 3.78, 95% CI = 3.14–4.56), and low community poverty level (AOR = 1.29, CI = 1.07–1.56) had higher odds of using salt containing iodine.
Introduction

Iodine is an essential trace mineral that is needed for the synthesis of thyroid hormones from the thyroid gland that aid in the development, growth and control of metabolic processes [1, 2]. When the intake of iodine is inadequate due to different reasons, the thyroid gland fails to synthesize sufficient amounts of thyroid hormones which in turn lead to the development of iodine deficiency disorders [3]. Iodine deficiency disorder (IDD) is associated with stillbirth, spontaneous abortion, congenital anomalies, perinatal mortality, cretinism, short stature, infant mortality, impaired mental functioning, delayed physical and psychomotor development [4–10]. It also affects quality of life the affected individual and economic productivity [11, 12].

Though the use of iodized salt can prevent iodine deficiency disorder, many parts of the world do not have enough iodine available through their diet and hence, iodine deficiency continues to be an important public health problem globally, making 30% of the world’s population at risk of iodine deficiency disorder [2]. This problem is more pronounced in sub-Saharan Africa [9]. To minimize the impact of IDD, the adoption of universal salt iodization (USI) program is recommend in all countries and there has been major global progress to the elimination of IDDs [13]. For instance, the global prevalence of clinical IDDs fell from 13.1% in 1993 to 3.2% in 2019, and 720 million cases of clinical IDDs have been prevented by USI (a reduction of 75.9%) [14] and the proportion of households consuming iodized salt increased from 70% in 2000 to 88% in 2019 low-income countries [13]. Although this substantial progress has been made over the last several decades towards iodized salt consumption, still it is under the recommendation of the World Health Organization (at least 90% of households should consume iodized salt) [8] and hence, iodine deficiency remains a significant health problem in developing countries [15].

Some previous research works conducted revealed that the use of iodized salt is associated with wealth index [16–19], age [16, 17], education status [16–20], community media exposure [18], knowledge of respondents on IDD and the importance of using iodized salt [20, 21]. Despite the use of iodized salt is a cost-effective universal strategy to combat IDD [22], IDD is still a problem in SSA [23]. However, to the best of our knowledge, there is no study that identifies the individual and community level determinants of iodized salt utilization in SSA. Identifying these factors that are associated with iodized salt utilization will be crucial for policy makers and other concerned bodies to take intervention measures and minimize the burden of IDD in the region.

Methods

Data source

The appended most recent demographic and health survey (DHS) datasets of 31 sub-Saharan countries (conducted from 2010 to 2018) were used for this study. The DHS is a nationally...
representative survey, collected every five years, to provide population and health indicators at the national and regional levels. A pretested standard Demographic and Health Survey questionnaires were used for data collection of the DHS surveys. The questionnaire was conceptualized to the different countries context and the data were collected by trained data collectors. The datasets of each sub Saharan country were obtained at https://dhsprogram.com/data/dataset_admin/index.cfm. Only those countries with data on iodized salt utilization were included for the analysis. Hence, a total weighted sample of 391,463 households were included in the analysis (Table 1).

Variables of the study

**Dependent variable.** Iodized salt utilization was the dependent variable. To ascertain the use of iodized salt, households were asked by the interviewers to bring a salt used for cooking purpose and they tested it using the iodine rapid test kits (RTKs) for presence or absence of iodine. So in this study, we only determined how much percentages of households were using

### Table 1. List of countries sub-Saharan countries, their demographic and health survey year and sample size included in the analysis.

| Country name            | Weighted sample size | Survey year |
|-------------------------|----------------------|-------------|
| Angola                  | 14,269               | 2015/16     |
| Burkina                 | 13,714               | 2010        |
| Benin                   | 13,288               | 2017/18     |
| Burundi                 | 14,389               | 2016/17     |
| Central Democratic Congo| 16,076               | 2013/14     |
| Congo                   | 10,453               | 2011/12     |
| Cote d’Ivoire           | 8,511                | 2011/12     |
| Ethiopia                | 15,939               | 2016        |
| Gabon                   | 8,716                | 2012        |
| Ghana                   | 10,237               | 2014        |
| Gambia                  | 5,210                | 2013        |
| Guinea                  | 7,496                | 2018        |
| Kenya                   | 34,139               | 2014        |
| Comoros                 | 3,902                | 2012        |
| Liberia                 | 8,589                | 2013        |
| Lesotho                 | 6,583                | 2014        |
| Mali                    | 9,106                | 2018        |
| Malawi                  | 22,489               | 2015/16     |
| Mozambique              | 13,140               | 2011        |
| Nigeria                 | 37,780               | 2018        |
| Niger                   | 9,010                | 2012        |
| Namibia                 | 9,205                | 2013        |
| Rwanda                  | 11,478               | 2014/15     |
| Sierra Leone            | 11,322               | 2013        |
| Chad                    | 15,892               | 2014/15     |
| Togo                    | 8,958                | 2013        |
| Tanzania                | 11,737               | 2015/16     |
| Uganda                  | 17,851               | 2016        |
| South Africa            | 2,443                | 2016        |
| Zambia                  | 11,485               | 2018        |
| Zimbabwe                | 8,056                | 2015        |

https://doi.org/10.1371/journal.pone.0251854.t001
salt that contains iodine irrespective of the amount of iodine content. And hence we dichotimized our dependent variable household iodized salt utilization into yes (households are using salt that has iodine) and no (households were not using salt that has iodine).

**Independent variables.** In this study, both individual and community level variables were included. The individual level factors included in this study were marital status, wealth index, education level, age of household head, and media exposure (a composite variable of having radio and television, in which households were said to have media exposure “if they have exposed to either of radio or television” and no “if did not have exposure to all of the above media sources”). The community level variables included in this study were residence, community poverty level (a composite variable generated from wealth index and defined as the proportion of households in the community with low wealth status (lowest and second quantiles), community education level and community media exposure (the proportion of households who had at least one of the medias sources (television or radio) and dichotomized as low (< 50% of households had one of these media sources) and high (≥ 50% of households had one of these media sources) based on median value)). With the exception of residence, the above mentioned community level variables were not directly found in the DHS data and hence they were created by aggregating their corresponding individual level variables at the cluster level. Then after, these generated community level variables were categorized as high and low based on their median value (their value were skewed).

**Data analysis procedure.** We used STATA 14 software to extract, recode and analyze the data. The data were weighted before doing any statistical analysis to restore the representativeness of the sample and get a reliable estimate and standard error. The procedure of weighting and its rationale is found on the guide of DHS statistics [24].

Due to the correlated nature of DHS data, measures of community variation/random-effects such as Intraclass Correlation Coefficient (ICC), Median Odds Ratio (MOR) and Proportional Change in Variance (PCV) were calculated. Accordingly, the values of these measures were found to be significant, and hence the use of multilevel logistic regression model is more appropriate than using ordinary logistic regression. To choose the best fitted model, first we developed four models and compared them with Deviance. These were: the null-model; a model with no independent variable, model I; a model that have individual-level factors only, model II; a model with community-level factors only and model III; a model that contain both individual and community level independent variables. Of the four models fitted, model III was the best fitted model, had the lowest Deviance.

After selecting the best fitted model, bivariable and multivariable multilevel logistic regression was done to determine the associated factors of iodized salt utilization in SSA. All variables with a p value < 0.25 at bi-variable analysis were entered into the multivariable multilevel logistic regression model. In the final model, we used p value ≤ 0.05 to declare statistically significant variables.

**Ethics consideration**

We used a secondary analysis of DHS data. Therefore, obtaining ethical approval was not needed. However, we have received a permission letter to download and use the data files from DHS Program.

**Results**

**Individual and community level characteristics of study participants**

A total weighted samples of 391,463 households were included in this study. Of these, majority, 248,265 (63.42%) and 292,145 (74.63%) of them were living rural area and currently married, respectively. Regarding educational level, 133,352(34.06%) of the participants had not received
formal education. Most of the study participants, 241,677 (71.74%) had media exposure. More than half of the study participants were from high community education (50.82%), and high community media exposure (51.14%) (Table 2).

**Random effect analysis**

According to the result of the random-effects model, there is significant clustering of iodized salt utilization across the communities (OR of community level variance = 2.75, 95%)

| Table 2. Socio demographic characteristics of respondents. |
|------------------------------------------------------------|
| **Variables**                                               | **Weighted frequency** | **Percentage** |
| Residence                                                  |                           |               |
| Urban                                                      | 143,198                   | 36.58         |
| Rural                                                      | 248,265                   | 63.42         |
| Marital status                                             |                           |               |
| Never married                                              | 28,318                    | 7.23          |
| Married                                                    | 292,145                   | 74.63         |
| Formerly married                                           | 71,000                    | 18.14         |
| Education level of household head                          |                           |               |
| No education                                               | 133,352                   | 34.06         |
| Primary education                                          | 125,493                   | 32.06         |
| Secondary education                                        | 100,546                   | 25.68         |
| Higher education                                           | 32,072                    | 8.19          |
| Community education                                        |                           |               |
| Low                                                        | 192,533                   | 49.18         |
| High                                                       | 198,930                   | 50.82         |
| Wealth index                                               |                           |               |
| Poorest                                                    | 75,353                    | 19.25         |
| Poorer                                                     | 76,352                    | 19.50         |
| Middle                                                     | 77,364                    | 19.76         |
| Richer                                                     | 80,028                    | 20.44         |
| Richest                                                    | 82,366                    | 21.04         |
| Community poverty level                                    |                           |               |
| Low                                                        | 190,463                   | 48.65         |
| High                                                       | 201,000                   | 51.35         |
| Sex of household head                                      |                           |               |
| Male                                                       | 284,605                   | 72.70         |
| Female                                                     | 106,858                   | 27.30         |
| Age of household head (years)                              |                           |               |
| < 25                                                       | 24,996                    | 6.39          |
| 25–34                                                      | 95,714                    | 24.45         |
| 35–44                                                      | 97,213                    | 24.83         |
| 45–54                                                      | 72,550                    | 18.53         |
| 55–64                                                      | 52,613                    | 13.44         |
| ≥ 65                                                       | 48,377                    | 12.36         |
| Media exposure                                             |                           |               |
| Yes                                                        | 241,677                   | 61.74         |
| No                                                         | 149,786                   | 38.26         |
| Community media exposure                                   |                           |               |
| Low                                                        | 191,286                   | 48.86         |
| High                                                       | 200,177                   | 51.14         |

https://doi.org/10.1371/journal.pone.0251854.t002
CI = 2.43–3.11). The value of ICC in the null model revealed that 45.49% of the overall variation of iodized salt utilization was attributed to cluster variability. The 4.83 MOR value of the null model also indicates the presence of variation in iodized salt utilization between clusters. It means if we randomly select households from different clusters, those households at the cluster with higher household iodized salt utilization had 4.83 times higher chance of using iodized salt use compared to their counterparts.

As you can see in the Table 3 below, the PCV increases from 12.64% (model I) to 31.97% (model III), indicating that model III best explains the variability of iodized salt utilization. Moreover, model III has the lowest Deviance value. Hence, it was selected as best fitted model (Table 3).

**Associated factors of iodized salt utilization in sub-Saharan Africa.** To identify associated factors of iodized salt utilization, both bivariable and multivariable multilevel logistic regression analyses were performed. Accordingly, on bivariable analysis, education level, marital status, media exposure, community media exposure, wealth index, community poverty and community education level were associated with iodized salt use in SSA ($p < 0.25$). In the final model, community poverty level, wealth index, community education, education level, and community media exposure were found to be significantly associated with iodized salt utilization ($p \leq 0.05$).

Households who were from high community media exposure had 2.1 times higher odds of iodized salt utilization compared to those households of low community media exposure (AOR = 2.07, 95% CI = 1.71–2.51). Household heads with primary, secondary and higher education level had 1.5 (AOR = 1.53, 95% CI = 1.50–1.57), 1.8 (AOR = 1.81, 95% CI = 1.76–1.86) and 2.3 (AOR = 2.28, 95% CI = 2.17–2.40) times higher chance of using iodized salt compared to those with no education. Those households from high community education level had 3.8 (AOR = 3.78, 95% CI = 3.14–4.56) times higher chance of iodized salt utilization compared to those households came from low community education level. Household with middle, richer and richest wealth status had 1.05 (AOR = 1.05, 95% CI = 1.02–1.08), 1.1 (AOR = 1.13, 95% CI = 1.09–1.17) and 1.2 (AOR = 1.23, 95% CI = 1.18–1.28) times higher odds of iodized salt utilization compared to households with poorest wealth index. Those households from low community poverty level had 1.3 (AOR = 1.29, CI = 1.07–1.56) times higher odds of using salt containing iodine compared to their counterparts (Table 4).

**Discussion**

Though salt iodization is the preferred affordable strategy for prevention of iodine deficiency disorders [25], iodine deficiency disorders still continue to be a serious public health problem in low income countries [23, 26]. Therefore, this study was conducted to identify the associated factors of iodized salt utilization in SSA. This study found that education level, media exposure, residence, community poverty level, wealth index, community education, and community media exposure were associated with iodized salt utilization in SSA.
Similar to a study done in Ethiopia [18], in this study, those households from high community media exposure had an increased chance of using iodized salt compared to their counterparts. This is because media exposure is one effective way of increasing people’s level of awareness and use of iodized salt [27, 28]. This finding highlighted the need to continual and effective use of media to improve the utilization of iodized salt in the region.

Another factor which is significantly associated with use of iodized salt is level of education. Those household with primary, secondary and higher education level had higher odds of using iodized salt compared to uneducated once. Similarly, households from high community education level had higher chance of using iodized salt compared to those households came from low community education level. The finding of this study is consistent with other studies conducted elsewhere [16–19]. This higher chance of using iodized salt among educated participants might be due an increased knowledge and awareness about the importance of using iodized salt [27, 29].
Consistent with previous studies conducted in low income countries [16–19, 30], in this study, wealth index is associated with use of iodized salt. Those households with middle, richer and richest wealth status had an increased chance of iodized salt utilization compared to households with poorest wealth status. Moreover, households who were from low community poverty level had higher odds of using iodized salt compared to their counterparts. This is because households’ access to use iodized salt is commonly dependent on awareness, availability and price [31]. Households with high economic status can afford to purchase salt from appropriate sources which contains iodine compared to poor households [32, 33].

This study has two major strengths. The first one is the use of very huge and representative datasets of 31 sub-Saharan countries, which are collected by well-trained data collectors using standard and validated questioner that makes the finding of this study to be generalizable for the region. The second strength of this study is the use of multilevel modeling, a model that accounts the nested/hierarchical nature the demographic and health survey to get reliable estimates. However, our study is not free from limitations. This study uses rapid test kits (RTKs) to identify weather the households are using salt that contains any levels of iodine or not. Therefore, we are unable to quantify the amount of iodine in the salt and hence, we failed to categorize the use of iodized salt as adequate or inadequate. Due to the secondary nature of the study, we are also unable to assess knowledge of individuals and some food sources of iodine with the use of iodized salt.

Conclusion

Both individual and community level factors were found to be associated with use of salt containing iodine in sub-Saharan Africa. Education level, media exposure, community poverty level, wealth index, community education, and community media exposure were found to be associated with use of salt containing iodine in SSA. Therefore, to improve the use of iodized salt in the region, there is a need to increase access to media sources and develop the socioeconomic status of the community.

Acknowledgments

We authors would like to thank the MEAUSRE DHS Program for giving the permission to access and use the dataset for the study.

Author Contributions

Conceptualization: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyel Birhanu Teshale, Tesfa Sewunet Alamneh, Misganaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Data curation: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyel Birhanu Teshale, Tesfa Sewunet Alamneh, Misganaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Formal analysis: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyel Birhanu Teshale, Tesfa Sewunet Alamneh, Misganaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Funding acquisition: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyel Birhanu Teshale, Tesfa Sewunet Alamneh, Misganaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.
Investigation: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Methodology: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Project administration: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Resources: Yigizie Yeshaw, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Software: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Supervision: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Validation: Yigizie Yeshaw, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Visualization: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Writing – original draft: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

Writing – review & editing: Yigizie Yeshaw, Alemneh Mekuriaw Liyew, Achamyeleh Birhanu Teshale, Tesfa Sewunet Alamneh, Misanaw Gebrie Worku, Zemenu Tadesse Tessema, Adugnaw Zeleke Alem, Getayeneh Antehunegn Tesema.

References
1. Zimmermann MB. Iodine deficiency. Endocrine reviews. 2009; 30(4):376–408. https://doi.org/10.1210/er.2009-0011 PMID: 19460960
2. Association AT. Iodine Deficiency 2018. Available from: https://www.thyroid.org/wp-content/uploads/patients/brochures/IodineDeficiency_brochure.pdf.
3. Organization WH. Iodine deficiency in Europe: a continuing public health problem: World Health Organization; 2007.
4. Gowachirapant S, Jaiswal N, Melse-Boonstra A, Galetti V, Stinca S, Mackenzie I, et al. Effect of iodine supplementation in pregnant women on child neurodevelopment: a randomised, double-blind, placebo-controlled trial. The lancet Diabetes & endocrinology. 2017; 5(11):853–63. https://doi.org/10.1016/S2213-8587(17)30332-7 PMID: 29039199
5. John CC, Black MM, Nelson CA. Neurodevelopment: the impact of nutrition and inflammation during early to middle childhood in low-resource settings. Pediatrics. 2017; 139(Supplement 1):S59–S71. https://doi.org/10.1542/peds.2016-2828H PMID: 28562249
6. Velasco I, Bath SC, Rayman MP. Iodine as essential nutrient during the first 1000 days of life. Nutrients. 2018; 10(3):290. https://doi.org/10.3390/nu10030290 PMID: 29494508
7. Rohner F, Zimmermann M, Jooste P, Pandav C, Caldwell K, Raghavan R, et al. Biomarkers of nutrition for development—iodine review. J Nutr. 2014; 144(8):1322s–42s. https://doi.org/10.3945/jn.113.181974 PMID: 24966410

8. Organization WH. Assessment of iodine deficiency disorders and monitoring their elimination: a guide for programme managers. 2007.

9. Zimmermann MB, Jooste PL, Pandav CS. Iodine-deficiency disorders. The Lancet. 2008; 372(9645):248–52. https://doi.org/10.1016/S0140-6736(08)61005-3 PMID: 18676011

10. Caron P. Neurocognitive outcomes of children secondary to mild iodine deficiency in pregnant women. Annales d’endocrinologie. 2015; 76(3):248–52. https://doi.org/10.1016/j.anndoc.2015.01.001 PMID: 25934357

11. WHO. Iodization of salt for the prevention and control of iodine deficiency disorders 2019. Available from: https://www.who.int/elena/titles/salt_iodization/en/.

12. De Benoist B, Andersson M, Egli I, Takkouche B, Allen H. Iodine status worldwide. WHO Global Database on Iodine Deficiency Geneva: World Health Organization. 2004.

13. UNICEF. Global Database on Household Iodized Salt 2019 2019. Available from: https://data.unicef.org/topic/nutrition/iodine-deficiency.

14. Gorstein JL, Bagriansky J, Pearce EN, Kupka R, Zimmermann MB. Estimating the Health and Economic Benefits of Universal Salt Iodization Programs to Correct Iodine Deficiency Disorders. Thyroid: official journal of the American Thyroid Association. 2020. https://doi.org/10.1089/thy.2019.0719 PMID: 32458745

15. Pearce EN, Andersson M, Zimmermann MB. Global iodine nutrition: Where do we stand in 2013? Thyroid: official journal of the American Thyroid Association. 2013; 23(5):523–8. https://doi.org/10.1089/thy.2013.0128 PMID: 23472655

16. Ba DM, Ssentongo P, Liao D, Du P, Kjerulff KH. Non-iodized salt consumption among women of reproductive age in sub-Saharan Africa: a population-based study. Public Health Nutr. 2020; 23(15):2759–69. https://doi.org/10.1017/S1368980019003616 PMID: 31915084

17. Gewa CA, Leslie TF, Pawloski LR. Geographic distribution and socio-economic determinants of women’s nutritional status in Mali households. Public Health Nutr. 2013; 16(9):1575–85. https://doi.org/10.1017/S136898001200451X PMID: 23072839

18. Yeshaw Y, Alem AZ, Tesema GA, Teshale AB, Liyew AM, Tesema AK. Spatial distribution and determinants of household iodized salt utilization in Ethiopia: a spatial and multilevel analysis of Ethiopian demographic and Health survey. BMC Public Health. 2020; 20(1):1421. https://doi.org/10.1186/s12889-020-09538-z PMID: 32943046

19. Bazezew MM, Yallew WW, Belew AK. Knowledge and practice of iodized salt utilization among reproductive women in Addis Ababa City. BMC Res Notes. 2018; 11(1):734. https://doi.org/10.1186/s13104-018-3847-y PMID: 30326961

20. Tariku WB, Mazenqia AL. Knowledge and Utilization of Iodized Salt and Its Associated Factors at Household Level in Mecha District, Northwest Ethiopia. 2019; 2019:9763830.

21. Hino DE, Roba KT. Utilization of Iodized salt and Associated Factor in Zuway Dugda District, Arsi Zone, Oromia Regional State, South East Ethiopia. East African Journal of Sciences. 2019; 13(1):75–80.

22. Bryce J, Coitinho D, Darnton-Hill I, Pelletier D, Pinstrup-Andersen P. Maternal and child undernutrition: effective action at national level. Lancet (London, England). 2008; 371(9611):510–26. https://doi.org/10.1016/S0140-6736(07)61694-8 PMID: 18206224

23. WHO. Guideline: fortification of food-grade salt with iodine for the prevention and control of iodine deficiency disorders. Geneva: 2014.

24. Croft TN, Marshall AM, Allen CK, Arnold F, Assaf S, Balian S. Guide to DHS statistics. Rockville: ICF. 2018.

25. UNICEF. Sustainable elimination of iodine deficiency: Progress since the 1990 World Summit for Children: UNICEF; 2008.

26. International N. Salt Iodization: A Global Health Success Story 2020. Available from: https://www.nutritionint.org/what-we-do/by-programs/salt-iodization/.

27. Buxton C, Baguune B. Knowledge and practices of people in Bia District, Ghana, with regard to iodine deficiency disorders and intake of iodized salt. Arch Public Health. 2012; 70(1):5. https://doi.org/10.1080/0778-7367-70(1-5) PMID: 22958618

28. Çan G, Ökten A, Green J. The role of local mass media in promoting the consumption of iodized table salt. Health Education Research. 2001; 16(5):603–7. https://doi.org/10.1093/her/16.5.603 PMID: 11675807
29. Lowe N, Westaway E, Munir A, Tahir S, Dykes F, Lhussier M, et al. Increasing Awareness and Use of Iodised Salt in a Marginalised Community Setting in North-West Pakistan. Nutrients. 2015; 7(11):9672–82. https://doi.org/10.3390/nu7115490 PMID: 26610563

30. Habiel B, Luvanda EP, Yusuf Patrick Marwa, Abdalla Hussein, Erick Mbogoro. Socio-economic and Spatial Correlates of Iodized Salt Usage among Tanzanian Households. 2018.

31. Nahar B. Report of the National Salt Iodization Survey, Bangladesh 2015. [Internet]. Dhaka, Bangladesh: Icddr, b, GAIN. 2015.

32. Khan JR, Biswas RK, Sheikh MT, Huq M. Factors associated with the availability of iodized salt at household level: a case study in Bangladesh. Public Health Nutr. 2019; 22(10):1815–23. https://doi.org/10.1017/S1368980018003907 PMID: 30755282

33. Sen TK, Das DK, Biswas AB, Chakrabarty I, Mukhopadhyay S, Roy R. Limited access to iodized salt among the poor and disadvantaged in North 24 Parganas district of West Bengal, India. Journal of health, population, and nutrition. 2010; 28(4):369–74. https://doi.org/10.3329/jhpn.v28i4.6043 PMID: 20824980