

SYSTEMATIC REVIEW AND META-ANALYSIS

Iodine concentration level of iodized dietary salt and its associated factors: a systematic review and meta-analysis

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Abstract

Background: Iodine deficiency disorder (IDD) is a major public health problem in Ethiopia. The availability of adequate iodized dietary salt at the household level is immensely important. Hence, this review aimed to estimate the pooled prevalence of adequate iodine concentration level of iodized dietary salt at the household level and its associated factors in Ethiopia.

Methods: We searched the literature using electronic databases (PubMed/Medline, Google Scholar, Science Direct, and Embase) and gray literature from January 9, 2022, to February 25, 2022. The rapid test kit was used to measure the adequacy of iodine level of dietary salt. The quality of studies was assessed using Joanna Briggs Institute critical appraisal tool. Heterogeneity between studies was checked using I^2 test statistics and publication bias was checked using funnel plot and Egger's statistical test at a 5% significance level. A random-effects model was employed to estimate the pooled prevalence of the outcome variable and its determinants in Ethiopia.

Results: The search identified 149 studies of which 18 studies were included with a total of 10,556 participants. The pooled prevalence of adequate iodine levels of iodized salt in Ethiopia was 44.37% (95% CI: 35.85–52.88). Women who had formal education (adjusted odds ratio (AOR) = 1.99 (95% CI: 1.47–2.48)), good knowledge of women (AOR = 2.14, 95% CI: 1.36–3.36), packed iodized salt (AOR = 3.85 (95% CI: 1.88–7.87)) and storage of iodized salt at home for less than 2 months (AOR = 2.66 (95% CI: 2.11–3.35)) were the significant factors.

Conclusion: This review suggests that the pooled prevalence of adequate iodine levels was low. Our finding highlights the need for considering the educational status, knowledge, and duration of salt storage to enhance the prevalence of adequate levels of iodized salt at the national level.

Key Words

- ▶ iodine concentration level
- ▶ iodized
- ▶ salt
- ▶ systematic review and meta-analysis
- ▶ Ethiopia

Introduction

Iodine is present in the body in scarce amounts (1) and is an essential micronutrient that is required for the production of thyroid hormone which is vital for immune response, growth, and brain development of the fetus, infants, and young children (1, 2, 3). Also, it has an important role in a wide range of functions including academic performance (4, 5), physical development of child and women's health, quality of human life, and the economic productivity of adults (6, 7, 8). However, inadequate intake of iodine leads to insufficient production of thyroid hormone which causes stillbirth, abortion, impaired growth, cretinism, and stunting (3, 9). These adverse effects are collectively known as iodine deficiency disorders (IDD) (1, 6, 10).

According to World Health Organization (WHO) report, approximately one-third of the world's population lives in areas where sources of iodine are insufficient, and around 29.8% (241 million) school-age children, are among the vulnerable groups and are estimated to have insufficient intake of iodine from the total school-age children, 58 million of them are living in African (11). The global control of iodine deficiency through a universal salt iodization program has been introduced in many countries over the past 30 years (1, 12). Despite this and ongoing interventions, many populations in the world remain at risk of iodine deficiency (4, 13).

In Ethiopia, great progress has been made toward the elimination of iodine deficiency through the provision of household iodized salt (14). However, many potential barriers have been identified that reduce the iodine content of iodized salt and some of them include educational status, salt washing, sunlight, heat, packing, knowledge, and poor handling practices (15, 16). Adequate data are not available about coverage of the adequacy of iodine content in household iodized salt and its associated factors at the national level in Ethiopia. Therefore, this systematic review and meta-analysis aimed to estimate the pooled prevalence of adequate iodine content in household iodized salt and its associated factors in Ethiopia.

Methods

Search strategy and selection criteria

The authors did a systematic review and meta-analysis using the Preferred Reporting Items for Systematic Reviews

and Meta-Analyses (PRISMA) guidelines (17). We searched exhaustively different databases like PubMed/Medline, Google Scholar, Science Direct, Embase, and unpublished literatures from January 9, 2022, to February 25, 2022. All studies were searched using the keywords (Prevalence) OR (magnitude) OR (epidemiology) OR (level) AND (associated factors) OR (determinants) AND (iodine concentration) AND (iodized salt) AND (household) AND (Ethiopia).

Eligibility criteria

Inclusion criteria

The two investigators (T M E and R H K) independently reviewed the retrieved articles carefully. Those studies conducted in Ethiopia, published in English, and original researches containing the prevalence and associated factors of the adequate iodine content of iodized salt in the household were included in this study. In addition, articles that used a rapid test kit (RTK) to assess the iodine content of iodized salt were considered as inclusion criteria.

Exclusion criteria

Studies with incomplete data on the outcome variable were excluded in this review. Moreover, studies that used measures other than the WHO, United Nations Children's Fund (UNICEF), and International Council for Control of Iodine Deficiency Disorders (ICCIDD) recommendation for adequacy of iodine concentration were excluded from the analysis.

Outcome measures

The primary outcome of this study was dichotomized as adequate or inadequate iodine level of iodized salt. The WHO, UNICEF, and ICCIDD joint recommendation was used to measure the outcome variable if the RTK result of iodine level of dietary salt of 15 ppm and above was considered as adequate and inadequate if the iodine level of dietary salt was less than 15 ppm. Furthermore, the secondary outcomes considered in this review were the associated factors that related to reducing the level of iodine in iodized dietary salt.

Data extraction

Data extraction from studies was done by two independent reviewers (T M and R H). Disagreements between reviewers were resolved through discussion. We used a standardized data extraction form, Microsoft excel

Table 1 Summary of included studies to assess the iodine concentration level of iodized salt at household level in Ethiopia, 2021.

Author	Publication		Setting	Sample		Outcome	Response rate	Prevalence	JBI-Score
	year	Regions		size	Included				
Bazezew <i>et al.</i> (3)	2018	Addis Ababa	Urban	549	544	184	99.1	33.8	Low risk
Fereja <i>et al.</i> (32)	2018	Oromia	Rural	356	351	138	98.6	64.8	Low risk
Tariku & Mazengia (33)	2019	Amhara	Both	714	700	443	98	63.3	Low risk
Ajema <i>et al.</i> (20)	2020	SNNPR	Urban	875	875	509	100	58.2	Low risk
Mesele <i>et al.</i> (34)	2014	Amhara	Rural	698	694	694	99.4	29.7	Low risk
Hailu <i>et al.</i> (35)	2016	Oromia	Urban	422	393	114	93.1	29	Low risk
Abebe <i>et al.</i> (22)	2017	Amhara	Both	714	705	234	98.7	33.2	Low risk
Anteneh <i>et al.</i> (15)	2017	Amhara	Rural	1194	1194	683	100	57.4	low risk
Mekonnen <i>et al.</i> (23)	2018	Amhara	Urban	500	492	341	98.4	69.3	Low risk
Gebremariam <i>et al.</i> (21)	2013	Amhara	Urban	848	810	234	95.5	28.9	Low risk
Gebremichael <i>et al.</i> (36)	2020	Amhara	Both	596	576	162	96.6	28.1	Low risk
Desta <i>et al.</i> (19)	2019	Tigray	Both	318	292	51	91.8	17.5	Low risk
Kumma <i>et al.</i> (16)	2018	SNNPR	Urban	441	440	166	99.8	37.7	Low risk
Teka (25)	2020	Addis Ababa	Urban	423	415	266	98.1	63.8	Low risk
Bulli <i>et al.</i> (37)	2020	Oromia	Rural	603	596	364	98.8	61.1	Low risk
Gebriel <i>et al.</i> (38)	2014	Benishangul	Urban	395	395	79	100	20	Low risk
Dinka <i>et al.</i> (26)	2021	Oromia	Both	476	470	140	98.7	29.8	Low risk
Mesfin <i>et al.</i> (20)	2020	Amhara	Both	620	614	448	99.03	73	Low risk

sheet format, to collect the information from all the eligible studies. All the selected studies were summarized and recorded with the following domains: name of the first author, publication year, region, study setting and design, sample size, response rate, prevalence rate, and quality score (Table 1).

Quality assessment

The Joanna Briggs Institute (JBI) checklist (18) was used as a guideline to assess the quality of each articles reviewed. The JBI scores assigned to each reviewed article that range from 0 if none of the criteria were met to 8 if all criteria were met,

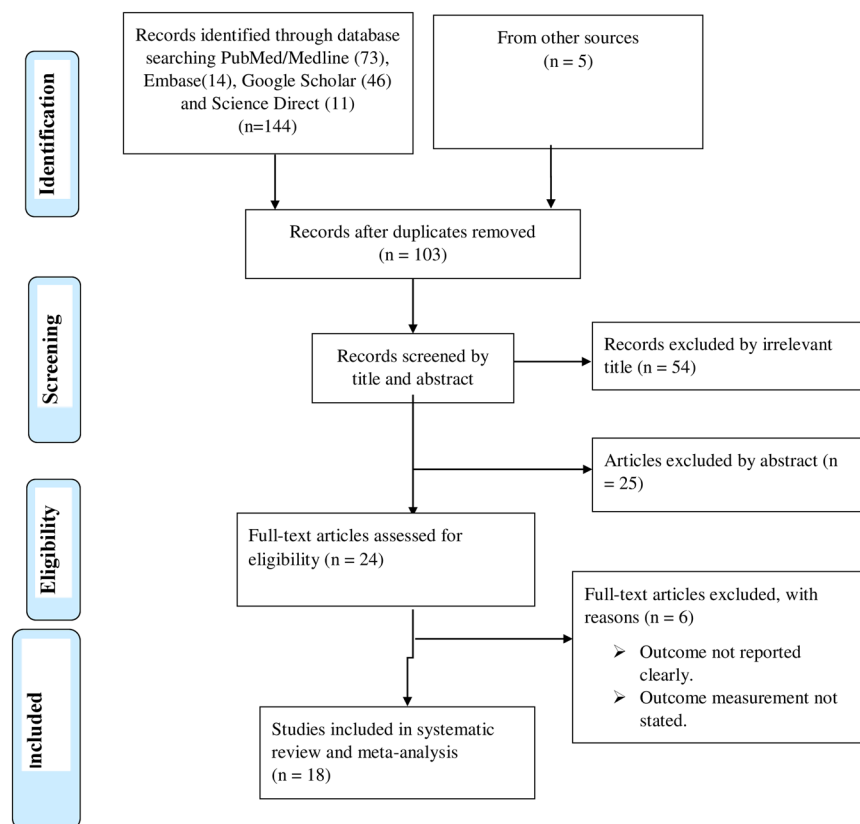


Figure 1 A PRISMA flow chart explaining the selection of primary studies for systematic review and meta-analysis.

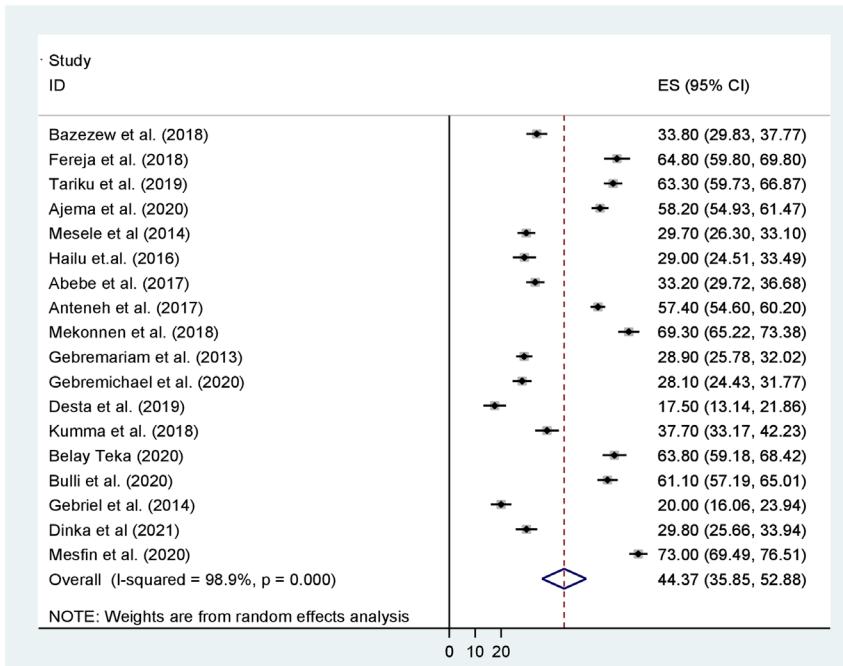


Figure 2

Forest plot revealing the pooled prevalence of adequate iodine concentration in dietary iodized salt at the household level in Ethiopia.

then the sum of the study represented the overall quality of a study. Then studies were rated as low risk or good quality when it scored 4 and above included in the analysis.

Statistical analysis

Meta-analysis was performed using STATA version-14.0 software after importing the prepared data from the Microsoft Excel sheet. Meta-analysis of the pooled prevalence of adequate iodine concentration level was carried out using a random effect model with a 95% CI.

Heterogeneity among the reported prevalence of studies was checked by using the I² test. Publication bias was also assessed objectively by performing Egger's correlation and Begg's regression intercept tests at a 5% significance level and subjectively by funnel plot through visual assessment for its asymmetry. Subgroup analysis was carried out using study setting (categorized as urban, rural, and both), study period, and sample size. Moreover, sensitivity analysis was performed to see the influence of each study on the overall effect size.

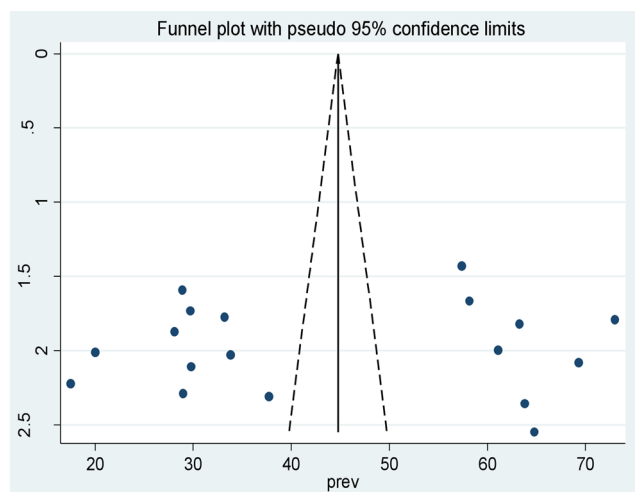


Figure 3

Funnel plot of 95% CI for publication bias to assess the pooled prevalence of adequate concentration of dietary iodized salt.

Results

We identified 149 studies from different databases and other sources. After we removed the duplicate studies, 79 studies were excluded because they were irrelevant for this study. Then, the remaining 24 full-text studies were assessed for eligibility and 6 studies were excluded after reading the full article because they did not use WHO definition for adequacy of iodine level for iodized dietary salt. Finally, 18 studies were eligible and included for computing the pooled prevalence of the outcome of variable with a total of 10,556 study participants. The flow diagram of the study search and selection process are depicted in Fig. 1. The distribution of the studies in the regional states of Ethiopia were Amhara (8), Oromia (4), SNNPR (2), Addis Ababa (2), Benishangule Gumz (1), and Tigray (1). The detailed characteristics of the studies are shown in Table 1.

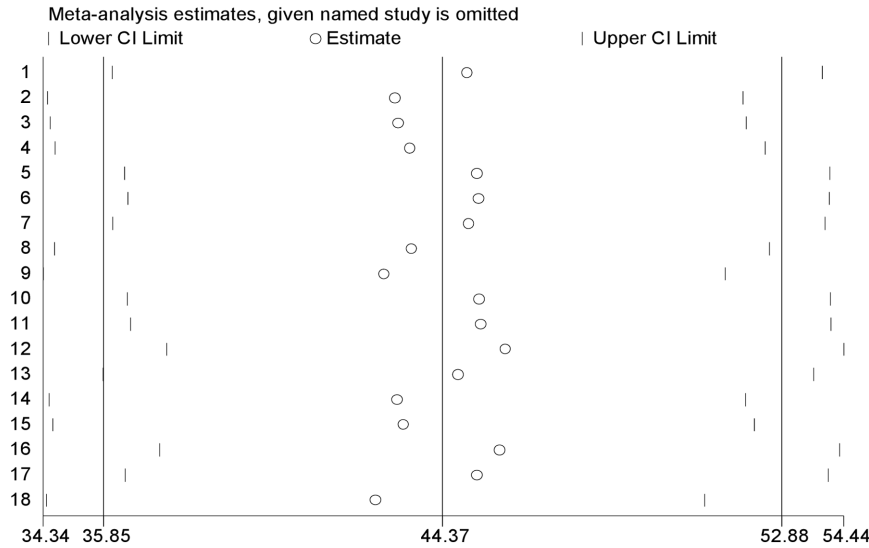


Figure 4
Output of sensitivity analysis of included studies for this review.

Meta-analysis

In this review, the overall pooled prevalence of adequate iodine level of iodized dietary salt in households in Ethiopia was 44.37% (95% CI: 35.85–52.88) and the prevalence ranges from 17.5 (19) to 73% (20) (Fig. 2). A random effect model was used and the result of the heterogeneity test was $I^2=98.9%$ ($P < 0.0001$). Publication bias was assessed subjectively by observing the funnel plot which was found to be a symmetrical distribution of included studies (Fig. 3) and objectively by applying the Egger test ($P=0.71$). Both methods revealed the absence of publication bias among studies. In addition, subgroup analysis was done by study setting (categorized as urban, rural, and both), study period, and sample size. Furthermore, the result of sensitivity analysis revealed that there is no single study that affects the pooled prevalence of adequate iodine level of dietary iodized salt in the household (Fig. 4).

Subgroup analysis

Subgroup analysis was conducted based on study setting, study period, and sample size. Based on study design, the prevalence of adequate iodine concentration in household iodized salt of rural part of the country was found to be 45.79%. Using the study period, the prevalence of adequate iodine concentration in household iodized salt among studies conducted in 2017 and before was 39.17 (Table 2).

Factors associated with iodine level of iodized dietary salt

All authors have analyzed the potential determinants of iodine concentration level of iodized salt in household

in Ethiopia from eight studies (15, 16, 21, 22, 23, 24, 25, 26). Knowledge and educational status of the women, home storage duration of iodized dietary salt at home, and packed iodized salt were the significant associated factors.

Knowledge of women

The result of five articles (15, 21, 22, 24, 26) showed that women who had good knowledge for iodine were 2.14 times more likely to have adequate iodine level of iodized dietary salt at the household than those women having poor knowledge (AOR=2.14, 95% CI: 1.36–3.36) (Fig. 5).

Table 2 Summary of subgroup analysis of the prevalence of adequate iodine concentration iodized dietary salt in household in Ethiopia.

Variables	Number of articles	Prevalence of adequate iodine ES (95% CI)	I^2 (P-value)
	Number of studies		
Study setting			
Urban	8	42.58 (29.86–55.30)	98.8% (<0.001)
Rural	4	53.21 (37.42–68.99)	98.7% (<0.001)
Both	6	40.84 (23.09–58.57)	93.3% (<0.001)
Study period			
≤2017	13	39.17 (30.06–48.28)	98.7% (<0.001)
>2017	5	57.85 (42.07–73.64)	98.8% (<0.001)
Sample size			
≤600	10	39.35 (27.66–51.05)	98.7% (<0.001)
>600	8	73.00 (69.48–76.51)	99.0% (<0.001)
Overall	18	44.36 (35.85–52.88)	98.9% (<0.001)

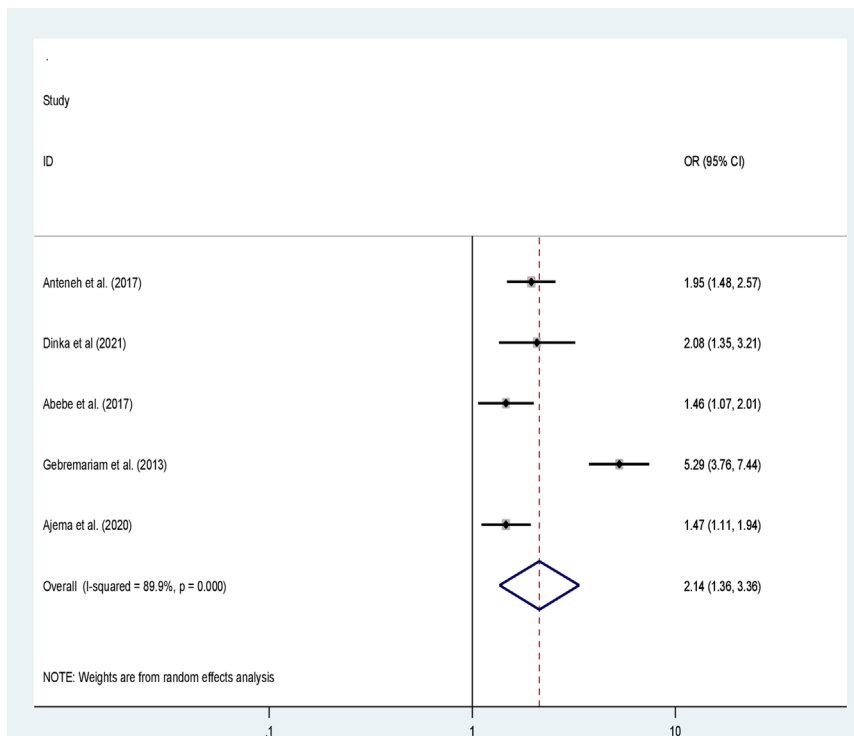


Figure 5

Forest plot depicting the association of adequate iodine concentration in dietary iodized salt with knowledge of women.

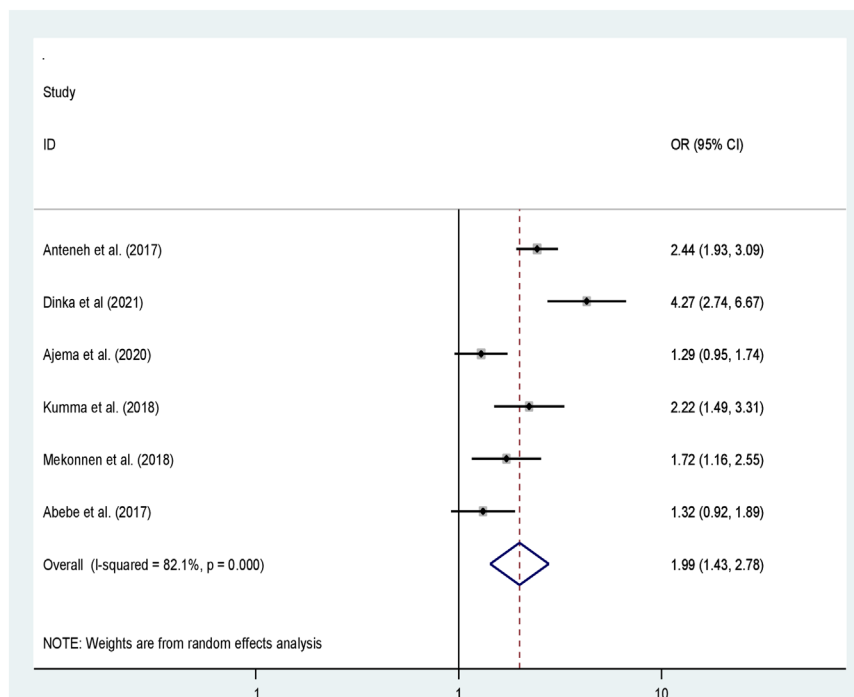


Figure 6

Forest plot revealing the association of adequate iodine concentration in dietary iodized salt with educational status of women.

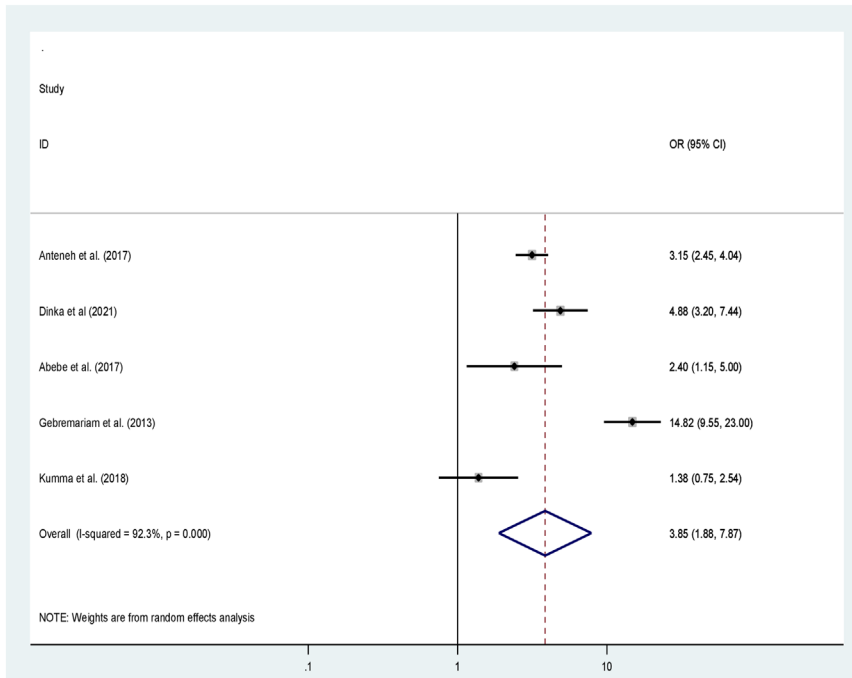


Figure 7

Forest plot showing the association of adequate iodine concentration in dietary iodized salt with packed iodized salt.

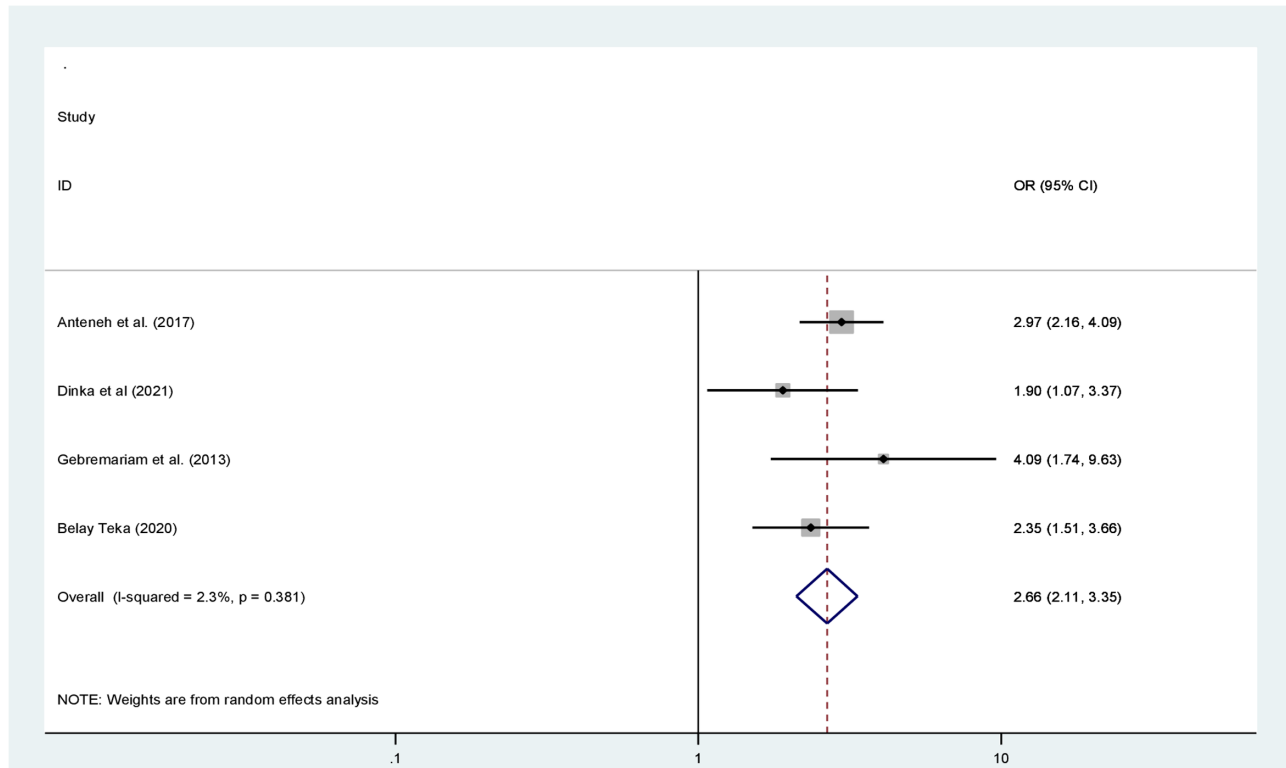


Figure 8

Forest plot revealing the association of adequate iodine concentration in dietary iodized salt with duration of iodized salt storage at home.

Educational status of women

The pooled result of six included articles (15, 16, 22, 23, 24, 26) revealed that women who had formal education were 1.99 times more likely to have adequate iodine concentration level in the iodized salt at their own home than those women who had no formal education (Fig. 6).

Packed/covered iodized salt

Regarding the availability of packed iodized dietary salt, the pooled result of five studies (15, 16, 21, 22, 26) showed that the level of adequate iodine in the iodized salt with cover/packing was 3.85 times higher than unpacked/uncovered iodized salt (Fig. 7).

Storage duration of iodized salt at home

Moreover, the result from four studies (15, 21, 25, 26) revealed that storage duration was the other significant factor that affects the adequacy of iodine level. The odds of storage of iodized salt for less than 2 months at home was 2.66 times more likely to have adequate iodine concentration in iodized salt than iodized salt kept for 2 months and beyond at home (Fig. 8).

Discussion

Universal salt iodization is the major approach to eliminate IDD especially in developing countries like Ethiopia (11). This systematic review and meta-analysis reviewed the prevalence of adequate iodine level in iodized salt and associated factors in Ethiopia. This review revealed that the pooled prevalence of adequate level of iodine in household iodized salt was low at 44.37% (95% CI: 35.85–52.88). To eliminate iodine deficiency disorder, the WHO recommended that the prevalence of adequate iodine content in dietary salt in the household must be equal to or greater than 90% (27). This shows that Ethiopia is still far from reaching achieving world health recommendations of dietary salt with adequate iodine levels at the national level.

Regarding subgroup analysis, in this review, the prevalence of adequate levels of iodine in dietary salt in 2017 and before was 39.17 % (95% CI: 30.06–48.28) lower than studies conducted after 2017 (57.85 (95% CI: 42.07–73.64)). This could be the presence of continuous community awareness creation on the importance of iodized salt. Moreover, the prevalence of adequate iodine

level in dietary salt at the household level was higher in rural settings (53.21% (95% CI: 37.42–68.99)) than in urban settings (42.58% (95% CI: 29.86–55.30)). This might be due to great efforts that were made for the rural communities through health extension packages by the government of Ethiopia.

Besides, having formal educational status and good knowledge of women were the significant factors that affect the level of iodine content in dietary salt in line with the study conducted in India (28), this might be because educated and knowledgeable women may have the culture of practicing proper storage and utilization of iodized dietary salt at the household.

This review showed that using packed/covered salt was significantly associated with an adequate level of iodine in dietary salt than using unpacked salt in the household. This finding is consistent with the studies conducted in Poland (29) and Iran (30). This might be due to the fact that unpacked iodized salt may lose the iodine content because of different environmental factors. And according to our study, finding the content of iodine in iodized salt storage of iodized salt at the home beyond 2 months increase the loss of iodine content of dietary salt. This finding is in line with the studies conducted in Iran (30) and China (31), and this might be due to the increment of the loss of iodine content in iodized salt over time. In conclusion, continuous monitoring of the quality of iodized salt, proper utilization of iodized salt, and creating community awareness on how to use and the benefits of iodized dietary salt would have a better impact on achieving WHO standards and the elimination of IDD. Finally, the government of Ethiopia and stakeholders should increase the coverage and access for iodized dietary salt with adequate iodine concentration at the household level and strengthen salt legislation enforcement.

Supplementary materials

This is linked to the online version of the paper at <https://doi.org/10.1530/ETJ-22-0066>.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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Availability of data and materials

The data set used for this review is available upon reasonable request from the corresponding author.

Author contribution statement

T M E has contributed to the conceptualization and design. T M E and R H K performed the literature search, data extraction, analysis, and interpretation of the data. T M E wrote the first draft of the manuscript. T M E, R H K, S H, M M, T M, D S and G A revised the paper. All authors have read and approved the final manuscript.

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