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Prevalence of Goiter Among School-Aged Children in Ethiopia: Update of Systematic Review and Meta-analysis

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Abstract

Background: Iodine deficiency is a major public health concern throughout the world. Goiter is the most visible sign of iodine deficiency. In Ethiopia, a study finding regarding the prevalence of goiter among school-age children is inconsistent and highly variable.

Objectives: To estimate the pooled prevalence of goiter among school-age children in Ethiopia.

Methods: Three international databases (MEDLINE/Pub-Med, Google Scholar and Science Direct) were systematically searched. Besides, the reference sections of identified articles were searched to increase the chance of detecting missed articles in gray literature. STATA Version 14 statistical software was used to conduct a meta-analysis. The pooled prevalence with a 95% confidence interval was displayed using the forest plot. A random-effect meta-analysis model was used to compute the pooled prevalence, and The Cochrane Q test statistics and I^2 test were used to assess the heterogeneity of the studies.

Results: A total of 14 studies fulfilled the inclusion criteria and included in this systematic review and Meta-analysis, with a total sample size of 26,282. The finding of this systematic review revealed that the pooled prevalence of goiter among school-age children was 42.9% (95% CI: 38.8–46.9). The highest prevalence of goiter (46.7%) was observed in Oromia region and the lowest (26.3%) was observed in Benishangul-Gumuz region.

Conclusions: This review finding revealed that more than two in five of the school children in Ethiopia suffer from iodine deficiency disorder as manifested by the goiter rate.

Keywords

goiter, iodine, iodine deficiency disorders, school-age, children, Ethiopia

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Introduction

Iodine deficiency disorders (IDDs) refer to the ill effect iodine deficiency in a population.[1–3] Iodine deficiency is a major public health concern throughout the world. The main factor responsible for iodine deficiency is a low dietary supply of iodine.[4] IDD can result in a spectrum of health problems in children ranging from Goiter, impaired mental function, retarded physical development, irreversible mental retardation and cretinism in children, increased susceptibility of the thyroid gland to nuclear radiation.[2,5–11] Under severe conditions, iodine deficiency is responsible for a mean IQ loss of 13.5 points in children.[2,11–13] At a population level, iodine deficiency hurts a country's overall health and productivity and hinders its socioeconomic development.[14] Globally, about 2 billion people are affected by iodine deficiency.[15–18] In developing countries, 38 million newborn babies per year are not

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protected from the devastating consequences of iodine deficiency.[19] Elimination of iodine deficiency disorders improves children's cognitive development, reduces stillbirths and stunting. Moreover, this will contribute to improvement in the quality of primary education, reduce under nutrition, child morbidity, miscarriages and improve maternal health.[1,3,7,11,20]

Goiter is the most visible sign of iodine deficiency. It is defined when "each of the lateral lobes of the thyroid gland is larger than the terminal phalanges of the thumb of the person examined.[1] Goiter can be used as a baseline assessment of a region's iodine status and it is a sensitive long-term indicator for the success of an iodine program.[1] According to the WHO guideline, a total goiter rate of greater than 5% or more among school-age children (6-12years) indicate the presence of public health problem. The World health organization recommends the assessment and reporting of the iodine status of the population every 3 years.[1]

In Ethiopia, a national survey of goiter prevalence among school-age children was conducted in 2005 and reported a prevalence of 40%.[21] Several cross-sectional studies were also conducted in different regions of the country to estimate the iodine status of the population. The goiter rate varies from region to region and between the years of the studies.

Despite the Ethiopian goal of IDD elimination through universal salt iodization by the year 2015,[22] the recent cross-section study conducted in 2017 reported a goiter prevalence of 52%.[23] A recent systematic review in Ethiopia reported a 40.5% prevalence of goiter among people aged 6–18 years old.[24] This systematic review and meta-analysis aimed to estimate the pooled prevalence of goiter among school-aged children (6-12 years) in Ethiopia. The prevalence of goiter among school children is used as a key indicator of population-level of iodine deficiency both due to their physiologic vulnerability and ease of accessibility through schools.[1] The result of this study will indicate the burden of iodine deficiency disorder in Ethiopia using the total goiter rate as an indicator. This study will also give some insight to highlight the progress and effectiveness of programs towards the elimination of iodine deficiency disorders.

Methods

Search Strategies

This systematic review and meta-analysis was conducted to estimate the pooled prevalence of goiter among school-age children in Ethiopia. The protocol for this review was registered in the International Prospective Register of Systematic Reviews (PROSPERO), the University of York Centre for Reviews and Dissemination (Registration Number: CRD42019 129418) on the 3rd June 2019. To adhere to the scientific standard, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were used (Table S1).[25] Three international databases: MEDLINE/Pub-Med, Google Scholar and Science Direct were systematically searched. Also, references of identified articles were searched to increase the chance of detecting missed articles in gray literature. To search relevant articles for this study, we used the following keywords: "prevalence", "Goiter", "Child", and "Ethiopia". We used the following MeSH terms to search MEDLINE/Pub-med database: Goiter [Mesh], Child [Mesh], and Ethiopia [Mesh]. The key terms were used separately and/or in combination using Boolean operators like: "OR" or "AND". The literature search from those databases was done from March 21 to April 20, 2019. All papers published until April 20, 2019, were included in this systematic review.

Eligibility Criteria

Participants. We included studies examining the prevalence of goiter among school-age children in Ethiopia.

Study designs. For this review, we included all observational studies reporting the prevalence of goiter among school-age children in Ethiopia.

Language. We included all articles reported in the English.

Setting. There was no restriction by type of setting.

The Outcome of Interest

Primarily, this study aimed to estimate the pooled prevalence of goiter among school-age children. The prevalence of goiter was calculated by dividing the number of children who have goiter to the total number of study participants (sample size) in each study multiplied by 100.

Operational Definition

Goiter was examined using standard techniques recommended by WHO/UNICEF/ICCIDD. Finally, goiter is graded as follows. Grade 0: no palpable or visible goiter, grade 1: A goiter that is palpable but not visible when the neck is in the normal position, grade 2: A swelling in the neck that is clearly visible when the neck is in a normal position and is consistent with an enlarged thyroid when the neck is palpated. Goiter rate is reported as the number of children with goiters of grades 1 and 2 divided by a total number of examined children.[26]

Data Extraction

Two authors (YT and KB) independently extract all necessary data using a standardized data extraction format. The data extraction format includes primary author, year of publication, study period, country, regional state, study design, sample size, response rate and prevalence of goiter.

Quality Assessment

Newcastle-Ottawa Scale (NOS) quality assessment tool for cross-sectional studies was adapted to assess the quality of each independent study.[27] The tool has three main sections. The first component of the tool graded out of five stars and mainly focuses on the methodological quality of each original study. The second section of the tool graded out of two stars and mainly concerns about the comparability of each study. The last section of the tool graded out of three stars and used to assess the outcomes and statistical analysis of each original study. Two authors (YT and KB) independently assessed the quality of included research articles using the stated tool. Differences in the scoring of articles between the two reviewers were addressed by taking the mean score of the two authors. After reviewing various literatures, we declared that articles scored ≥ 7 points out of 10 stars were considered to be high-quality hence included in this study.

Data Management and Analysis

We used Microsoft Excel spreadsheets for data extraction and STATA Version 14 statistical software for data analysis. The descriptive data were presented using a table to describe the characteristics of each primary study. The magnitude of each original studies as well as the overall magnitude is described using a forest plot graph. The horizontal line of the forest plot shows the 95% CI and the black box represents the Weight of each study. Q-statistics and I^2 test is conducted to assess the random variations between each original study.[28] Heterogeneity will be interpreted as an I^2 value = 0% no heterogeneity, 25% = low, 50% = moderate, and 75% = high.[29]

Publication bias was assessed using a funnel plot. In the absence of publication bias, the plot resembles a symmetrical large inverted funnel. The two main statistical methods (Egger's and Begg's tests) used to test the funnel plot asymmetry.[30,31]

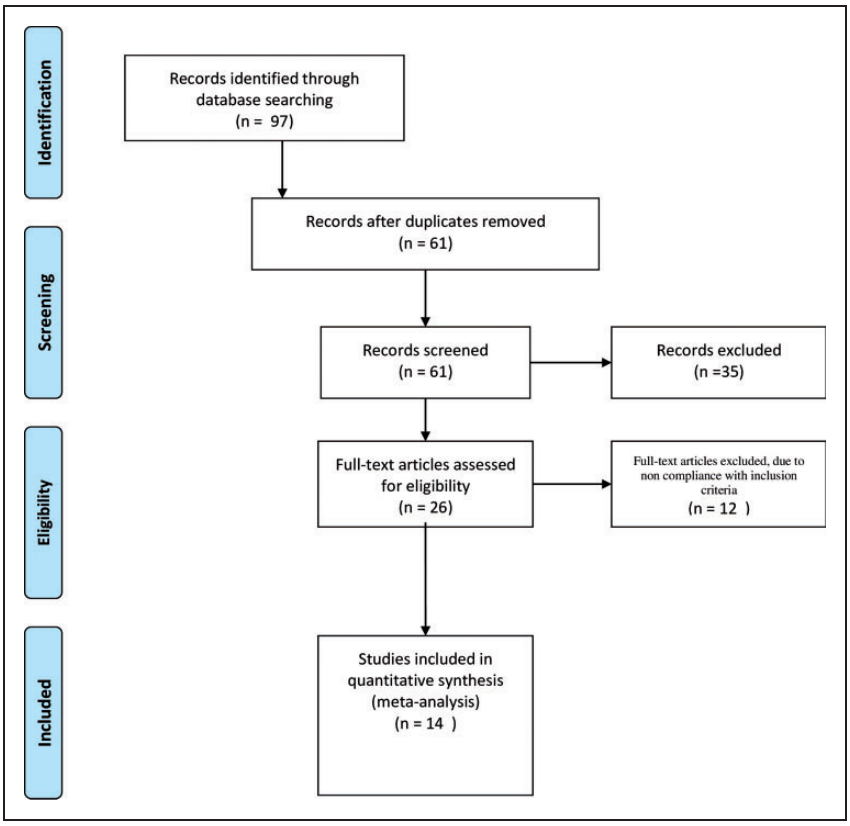

Figure 1. Flow Chart of the Study Selection Process for Systematic Review and Meta-analysis of the Prevalence of Goiter Among School-Age Children in Ethiopia.

Results

Characteristics of the Primary Studies

A systematic search of the electronic databases yielded a total of 97 articles. Out of this, there were 36 duplicate articles found across all databases. After the removal of duplicates articles were screened by title and abstract. A total of 35 articles were excluded based on non-compliance with their titles and abstracts. As described in the Figure 1, a total of 26 full articles were accessed and screened based on compliance with the inclusion and exclusion criteria. Finally, 14 research articles fulfilled the inclusion criteria and all of them were checked and fulfilled the optimal quality standard evaluated by New Castle Ottawa quality assessment tool (Table S2). A total of 14 studies published between 2000 and 20019 were used to estimate the pooled prevalence of goiter in this systematic review and meta-analysis. A total of 26,282 samples of school-age children were included in the study. All original studies estimated the prevalence of goiter using a cross-sectional study design. The sample size of each original study ranges from 358 to 10965. The lowest prevalence (26.3%) of goiter was reported by a study conducted in Benishangul-Gumuz region[32] and the highest (62.1%) was reported in Amhara region (Table 1).[33]

Meta-analysis

As presented in Figure 2, this meta-analysis found that the pooled prevalence of goiter among school-age children in Ethiopia was found to be 42.9% (95% CI: 38.8–46.9). Degree of heterogeneity between included studies was high ($I^2 = 97.3\%$, Cochrane Q-statistics P-value < 0.0001) due to this we used a random-effect meta-analysis model to estimate pooled prevalence. To identify possible sources of random variation, we conducted meta-regression using publication year and sample size as covariates. However, these variables were not found to be a significant source of variation (Table 2). Additionally, we statistically tested the presence of publication bias using Egger's and Begg's tests. Both tests found that there is no statistically significant publication bias ($p = 0.39$ & $p = 0.44$ respectively) in the undertaking of this study (Figure 3).

Subgroup Analysis

We performed a subgroup analysis of the prevalence of goiter using the study areas within Ethiopia and by sample sizes of the original studies. Based on this we observed the highest prevalence of goiter (46.7%) in Oromia region and the lowest (26.3%) in Benishangul-Gumuz region. Based on the sample size, studies with sample size less than 600 exhibited relatively higher

Table 1. Descriptive Summary of Original Studies Included in Systematic Review and Meta-analysis of the Prevalence of Goiter Among School-Age Children in Ethiopia.

Primary Author	Year of Publication	Study Period	Country	Study Regional State	Woreda	Study Design	Sample Size	Prevalence With 95% CI
Abebe et al.[34]	2017	February 21–march 31 2016	Ethiopia	Amhara	Dabat	Cross-sectional	735	29.1 (25.9–32.6)
Tigabu et al.[33]	2017	April 8–25, 2015	Ethiopia	Amhara	Gasgibla	Cross-sectional	443	62.1 (57.5–66.5)
Mesele et al.[35]	2014	July–December, 2012	Ethiopia	Amhara	Lay- Armacho	Cross-sectional	694	37.6 (34–41.2)
Gebriel et al.[32]	2014	May 10–20, 2012	Ethiopia	Benishangul –Gumuz	Asosa	Cross-sectional	395	26.3 (22–30.6)
Cherinet et al.[36]	2000	NR**	Ethiopia	National study	-	Cross-sectional	2485	53.3(51.3–55.3)
Cherinet et al.[21]	2007	May, 2005	Ethiopia	National study	-	Cross-sectional	10965	39.9 (38.6–41.2)
Cherinet et al.[37]	2008	NR**	Ethiopia	National study	-	Cross-sectional	6960	37.1 (36–38.2)
Bekele et al.[38]	2019	Feb 5–25, 2019	Ethiopia	Oromia	Chole	Cross-sectional	407	36.6 (31.6–40.8)
Mezgebu et al.[39]	2012	Jan 2011	Ethiopia	Oromia	Shebe-senbo	Cross-sectional	389	59.1 (54.2–64)
Mezgebu et al.[40]	2017	Oct 1–30, 2010	Ethiopia	Oromia	Jimma town	Cross-sectional	1254	39.1 (36.4–41.8)
Enyew et al.[41]	2015	April–May, 2012	Ethiopia	Oromia	Goba	Cross-sectional	397	50.6 (46.6–60.5)
Hailu et al.[42]	2016	February–June, 2015	Ethiopia	Oromia	Robe	Cross-sectional	393	43.5 (33.9–53.1)
Muktar et al.[23]	2019	February 13–30, 2017	Ethiopia	Oromia	Anchar	Cross-sectional	407	51.8 (46.9–56.8)
Hibstu et al.[43]	2017	July 15–30, 2017	Ethiopia	SNNPR*	Leku	Cross-sectional	358	35.2 (30.4–40.5)

*South nations, nationalities, and peoples' region.
**Not reported.

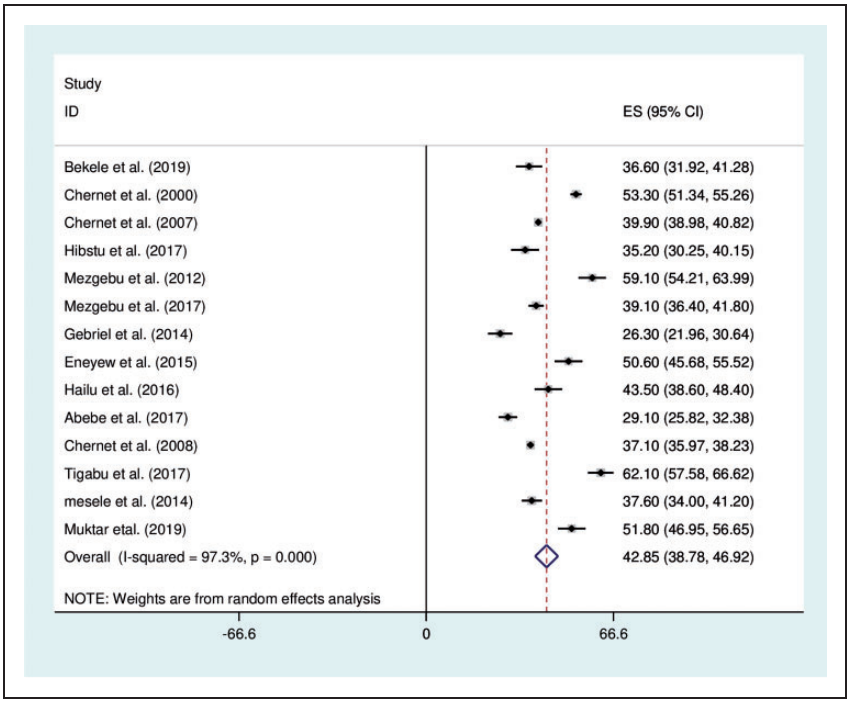

Figure 2. Forest Plot of Pooled Prevalence of Goiter Among School-Age Children in Ethiopia.

Table 2. Meta-Regression of Factors Related to the Heterogeneity of the Studies Included in Estimating the Pooled Prevalence of Goiter Among School-Age Children in Ethiopia.

Variables	Coefficient	P-Value
Year of publication	−.031	0.59
Sample size	−.00043	0.66

(45.6%) prevalence, when compared to those with a sample size greater than 600, had slightly lower (39.7%) prevalence (Table 3).

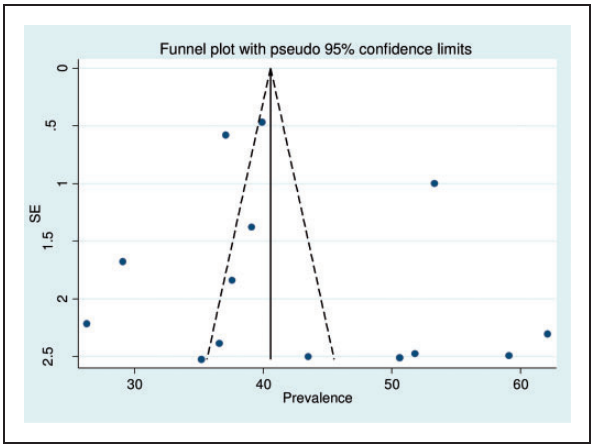

Figure 3. Funnel Plot of Pooled Prevalence of Goiter Among School-Age Children in Ethiopia.

Discussion

This systematic review and meta-analysis was conducted to estimate the burden of iodine deficiency disorders (IDDs) in Ethiopia using total goiter rate as an indicator. Particularly, this review assessed the prevalence of goiter among school-age children (6-12 years). School children are a target for IDD surveillance mainly due to their vulnerability, and ease of access through schools.[1] A total of fourteen studies reporting the prevalence of goiter in school-age children were included in this meta-analysis. All included research articles reported the prevalence of goiter by physical examination of the thyroid gland using joint criteria of WHO/UNICEF/ICCIDD.[26]

This review incorporated a total sample of 26,282 school-age (6–12 years) children in Ethiopia. The pooled prevalence of goiter was 42.9% (95% CI: 38.8–46.9). Our finding is slightly higher than the previous review which reported 40.5%.[24] The difference could be related to the difference in the study population, the previous review included children and adolescents while ours focus on school-age children only. According to the world health organization guideline, a total goiter rate of 30% or more among school-age (6–12 years) children signals the existence of severe public health problems.[1] This high prevalence of goiter indicates the presence of severe iodine deficiency disorder in a population that

Table 3. Subgroup Prevalence of Goiter Among School-Age Children in Ethiopia, 2019 (n = 13).

Variables	Description	Number of Studies	Sample Size	Prevalence (95% CI)
Regional states	Oromia	6	3,247	46.7 (39.9–53.5)
	SNNPR*	1	358	35.2 (30.3–40.2)
	Benishangul-Gumuz	1	395	26.3 (21.9–30.6)
	Amhara	3	1,872	42.9 (24.9–60.8)
	National studies**	3	20,410	43.4 (36.2–50.6)
Sample size	<600	8	3,189	45.6 (36.7–54.5)
	≥600	6	23,093	39.7 (34.6–44.8)
Year of study	Before 2015	8	23,531	42.8 (37.9–47.6)
	After 2015	6	2,743	43.0 (32.7–53.4)
Total		14	26,282	42.9 (38.8–46.9)

*South nations nationalities, and peoples' region.
**Nationwide studies including multiple regions of Ethiopia.

could have significantly affected the children's physical growth and brain development. Furthermore, a negative impact on the overall health and socio-economic growth of the country is inevitable.

Subgroup analysis by region showed that the highest prevalence (46.7%) was observed in Oromia region and the lowest (26.3%) was observed in Benishangul-Gumuz region. This variation between regions could relate to a difference in the number of studies readily available and include in this systematic review. However, since this review contains data of three national studies that included multiple regions in Ethiopia with a total sample of 20,410 children; it could be representative of the national burden of the problem.

Prevention and control of iodine deficiency disorders primarily aim at ensuring adequate iodine intake to maintain normal thyroid function. Increased iodine intake can be implemented through food fortification with iodine. Salt is the most commonly used vehicle since it is inexpensive and widely available. Salt iodization is relatively easy to implement, regulate and to monitor. World health organization recommended eliminating iodine deficiency disorders by iodizing all salt for human consumption.[44,45] This brought strategies of iodizing salt and many countries adopted this strategy. Globally, the proportion of people consuming iodized salt increased from <20% in 1990 to 70% by the year 2000, which contributed to a considerable reduction in the prevalence of iodine deficiency worldwide.[19,46] Universal salt iodization program in Ethiopia was started in 1989, but it suffered a problem in the 2000s due to the Ethiopian-Eritrean war, which closed the borders to imports from the Red Sea for many products, including iodized salt.[47]

The government of Ethiopia adopted a strategy for the virtual elimination of iodine deficiency disorders by the year 2015 through universal salt iodization.[22] Many studies assessing household coverage of iodized salt suggests still there is low coverage of iodized salt in the country. In 2015, Ethiopian national coverage of adequately iodized salt (≥15 ppm, using the titration method) was 26%.[48] Another national micronutrient survey reported in 2014 found only 43% of households have adequately iodized salt.[49] To achieve IDD elimination goal households with adequately iodized salt should be greater than or equal to 90%.[1] This result shows the country is far away from the stated IDDs elimination goal and more efforts are needed from the government to avail adequately iodized salt and to in turn reduce or eliminate iodine deficiency disorders.

To achieve this goal the country should be committed and strongly adhere to the world health organization recommendation of salt monitoring. World health organization recommended monitoring procedures for salt iodine level target at three levels. The first is monitoring at the factory level. It is the internal monitoring of the iodine level by the factory itself. All batch of produced salt should be tested for iodine level and registered daily. However, responsible government authority should check the result periodically at least once in a month and compare it with the factory's result. The second monitor target is at the importation level. All imported batch of salt should be monitored and responsible authority should be delegated. The third and fourth monitoring sites are wholesale and retail, and community and district level.[26] In Ethiopia, household surveys of salt iodine levels were conducted at a different time and reported a low level of adequately iodized salt.[47,49–53] Recognizing that salt can lose its iodine content to some extent in the market chains from production site to the household level, the monitoring of adequate iodization at productions and importation sites should greatly be strengthened.

Limitations of the Study

This systematic review included papers published in the English language only.

Conclusion

This review revealed that more than two in five of the school-age children in Ethiopia suffer from severe iodine deficiency disorder as manifested by the high prevalence of goiter, which is a major public health concern that needs urgent intervention. To reverse this trend the government should strengthen and monitor progress towards the universal salt iodization program.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the study design, execution, acquisition of data, analysis and interpretation or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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