Prevalence of *Schistosoma mansoni* infection among children in Ethiopia: A systematic review and meta-analysis

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Abstract

Background

Schistosomiasis is a neglected tropical disease caused by mainly *Schistosoma mansoni* and *Schistosoma hematobium*. The disease is very common in Africa including Ethiopia. *Schistosoma mansoni* is a major public health problem in Ethiopia especially among children. This review is aimed to indicate the prevalence of *Schistosoma mansoni* among children at national and regional level.

Methods and material:

The PRISMA guidelines were followed. Electronic search of PubMed, Google Scholar, Web of Science, Scopus, MEDLINE and Google search were carried out using key terms. Articles published from the proceeding of professional associations such as Ethiopian medical laboratory association, Ethiopian public health association and annual national research conferences were searched to find eligible studies. Data was extracted independently by two investigators, and pooled using a random effects model. Data was extracted using Microsoft excel and final analyzed using STATA version 12. Quality of included studies was assessed using JBI quality assessment criteria.

Result

Over all 41 studies involving 15968 children were included in this meta-analysis. The pooled prevalence of *Schistosoma mansoni* infection was 37.75% (95%CI:29.97–45.53). High heterogeneity was observed with I^2 of 99.3%, p = 0.000. According to subgroup analysis, the pooled prevalence was high in SNNPR (46.27%: 95%CI: 21.77–70.77) followed by Amhara region (41.9%: 95%CI: 28.45–54.54) Tigray region (38.14%: 95%CI:24.22–52.05) and Oromia region (26.54%: 95%CI: 16.89–36.20). Year from 2011 to 2015 contribute for the highest prevalence of *Schistosoma mansoni* among children (44.46% (95%:30.88–58.03).

Conclusion

This study revealed 37.75% *Schistosoma mansoni* infection among children. High prevalence of schistosomes among children highlights the importance of improving and implementing appropriate control strategies such as mass drug administration in Ethiopia.

Introduction

Schistosomiasis a neglected tropical parasitic disease caused by blood dwelling digenetic trematodes of the genus *Schistosoma* that affects mainly the poor and marginalized communities with poor sanitation and inadequate health care service [1]. Among the different *Schistosoma* species responsible

schistosomiasis, the three namely *S. haematobium*, *S. japonicum* and *S. mansoni* impose the major public health problem [2].

Human infection occurs by skin penetration with a cercarial stage of the parasite during contact with contaminated water. The epidemiology of Schistosomiasis is characterized by a highly variable focal distribution that differs in prevalence and intensity of infection even from village to village and this is governed by the interplay of the human, snail, and human-water contact [3]. The adult Schistosomes live the host blood vessel for several years by successful evasion of the immune system, at the mean time the female worm excretes hundreds to thousands of eggs per day. The egg will either leave the body by excreta or trapped in tissue causing the main pathology of schistosomiasis [4]. Proximity to large dam reservoir, irrigation scheme, poor personal hygiene, living near open freshwater bodies and poor waste management is reported to be a risk for contraction schistosomiasis [5].

Schistosomiasis is the second widely distributed parasitic disease next to malaria with the highest morbidity and mortality [5]. It is endemic in 76 countries and territories with 200 million people being infected and 779 million people being at risk of infection worldwide [5, 6]. About 85% of the infections occur in Africa with an estimated annual death of 280,000 people [7]. Globally schistosomiasis is responsible for 1.5 million years lived with disability (YLD) (8). The disease is very common among children with high morbidity and mortality in addition to this; it results in anemia, malnutrition, decreased aerobic capacity, growth delay, cognitive and memory impairment [4].

Approximately 207 million people required preventive treatment for schistosomiasis in 2016 worldwide. Different global and national diseases monitoring and control initiatives are ongoing to control schistosomiasis [9, 10]. These programs are mainly based on mass drug administration (MDA) with praziquantel. Achievement is evaluated base on successful treatment of 75% school age children (SAC) [11, 12]. Success of MDA is affected by number of children attending school and children who did not attend school at the time of MDA implementation will be excluded [13, 14].

In Ethiopia, Schistosomiasis is a major public health problem. In 2013 nearly 36 thousand people were infected with schistosomiasis in Ethiopia [15]. In the country, nearly 37.3 million people are at risk of infection, comprising 3.4 million pre-school children, 12.3 million school-aged children and 21.6 million adults [16]. In Ethiopia more than 14 million SAC require MDA [17]. The Federal Ministry of Health (FMOH) of Ethiopia mapped 346 schistosomiasis endemic districts and implemented MDA through integrated training, drug distribution, mobilization, technical staff involvement and resource mobilization. In 2016 about 2.5 million SAC were targeted for MDA and 1.86 million were treated, this showed 74.4% effectiveness of the MDA program [16]. To control and eliminate schistosomiasis in Ethiopia Providing a national view of the occurrence of the disease and identifying endemic areas are highly significant. Indicating the prevalence of *Schistosoma mansoni* among children at national and regional level is vital for high achievement of the MDA program. It is also important to indicate the endemic areas and to know the current status of the infection.

Materials And Methods

Search strategy and selection criteria

Systematic search of potentially eligible studies was carried out from September 01/2020 to November 31/2020 in PubMed, Google Scholar, Web of Science, Scopus, ResearchGate, MEDLINE and Google search using a combination of the key words “prevalence; magnitude; epidemiology; Schistosoma mansoni; intestinal schistosomiasis; Schistosomiasis; pre-school children; school-age children, children and Ethiopia”. Articles published from the proceedings of professional associations like the Ethiopian medical laboratory association, Ethiopian public health association and annual national research conference were searched. The reference lists of the retrieved studies and reviews were further searched for additional reports.

The included studies were identified after two reviewers independently screened the title, abstract and the full-text of the articles obtained from the search and the results were cross-checked by the third reviewer. The final selection was based on the full-text evaluation.

Data extraction and quality assessment

The outcome variable for this study was prevalence of *Schistosoma mansoni* among children in Ethiopia.

Data were extracts by the two reviewers independently using Microsoft excel extraction sheet.
The sheet contains information including name of the primary author, year of publication, study design, diagnostic methods, study group, sample size, number of male participants, and number of female participants, number of positive cases and the region where the study was conducted.

The quality of each study was evaluated following the Joanna Briggs Institute (JBI) critical appraisal checklist for prevalence studies [18]. Studies were assessed according to the appropriateness of the method used, validity and accuracy of the diagnostic methods, adequacy of the sample size, sampling procedure, and appropriateness of the study design and the statistical analysis. Each selected study was assessed using 10 quality control items and for each item fulfilled, a score of 1 was given while a 0 was given for each unfulfilled item. An aggregate of all the scores was generated and converted into an index. Based on the quality indices generated, studies were classified as having low (0.0–0.3), moderate (0.4–0.6) or high (0.7–1.0) quality.

Eligibility criteria

The reviewers carefully screened the title, abstract and full text of each published article for its relevance, and eligibility. Original studies reporting the prevalence of *Schistosoma mansoni* infection among children were included in this systematic review and meta-analysis. Studies were excluded if they were reported in a language other than English, used inappropriate study design, inappropriate sample size, were conducted in a selective population, and not included relevant extractable data. Case reports, reviews, and studies conducted on adults or all ages of humans were also excluded.

Data synthesis and statistical analysis

The pooled prevalence was calculated by using the Metan commands in STATA version 12. The pooled effect size was presented in the form of a forest plot. To account between studies variability, the meta-analysis was carried out using the random effect model. The amount of between-studies heterogeneity was quantified using I^2 statistics, which describes the proportion of total variation of the effect estimates resulting from the between-studies heterogeneity and values can be from 0 up to 100%. The I^2 values of 25%, 50%, and 75% were considered low, moderate and high heterogeneity, respectively [19].

The potential influence of the covariates on the pooled effect estimate was investigated by subgroup analysis.

Subgroup analysis was done by the region where the studies were conducted, year of publication, sample size, and sex of study participants.
Publication bias was assessed by visual inspection of symmetry of the funnel plot and egger's test statistics. P-value ≤ 0.05 and asymmetry of the funnel plot showing the presence of potential publication bias [20].

Result

Selection and identification of studies

A total of 746 articles were identified through online searching and references screening. After initial screening of the title and abstract of the identified studies, full text of potentially eligible studies was retrieved for detail assessment. A total of 681 articles were ineligible and excluded. The remaining 65 articles were assessed in detail. About 24 studies were excluded as they lack one or more variables that must be extracted for analysis leaving 41 potentially eligible studies for the final meta-analysis. Preferred Reporting Items for Systematic Review and Meta-analysis statement (PRISMA checklist 2009) was followed [21] (Fig. 1).

Characteristics of included studies

Forty-one studies involving a total of 15968 children; 8282 male and 7684 females as a study participant were included in this meta-analysis. The age of the study participants ranged from 6 month up to 18 years old. The studies were conducted from 2001 to 2020 in five national regional states of Ethiopia. Nineteen of the studies were in Amhara region, 10 in Oromia region, 6 in Southern Nation Nationalities and people Region (SNNPR), 5 in Tigray region and 1 in Somali region of Ethiopia. All the included studies had a cross-sectional design and had estimated point prevalence. The sample size of the studies ranged from 150 to 689. Majority of the studies used Kato Katz thick smear as a diagnostic method (Table 1).

Table 1
Characteristics of included studies

Author/reference	Year	Region	Sample size	Diagnostic methods	Prevalence
Tiruneh A *et al* [22]	2020	SNNPR	389	Kato-Katz thick smear	19.3
Alemu A *et al* [23]	2011	Amhara	319	Kato-Katz thick smear	37.9
Alemu A *et al* [24]	2016	Amhara	401	Kato-Katz thick smear	11.2
Assefa A *et al* [25]	2013	Tigray	457	Kato-Katz thick smear	23.9
Tefera A *et al* [26]	2020	Oromia	328	Kato-Katz thick smear	28.7
Tadege B *et al* [27]	2017	SNNPR	384	Kato-Katz thick smear	31
Alemayehu B *et al* [28]	2015	SNNPR	384	Kato-Katz thick smear	81.3
Alemayehu B *et al* [29]	2017	SNNPR	503	Kato-Katz thick smear	58.6
Mathewos B *et al* [30]	2014	Amhara	261	Kato-Katz thick smear	33.7
Feleke D *et al* [31]	2017	Amhara	279	Formol-Ether concentration and direct wet mount	80.5
Gashaw F *et al* [32]	2015	Amhara	550	Kato-Katz thick smear	49
Amsalu G *et al* [33]	2015	Amhara	380	Kato-Katz thick smear	45
Alebie G *et al* [34]	2014	Amhara	384	Kato-Katz thick smear	82.8
Desta H *et al* [35]	2014	Tigray	469	Kato-Katz thick smear	42.4
Wubet K *et al* [36]	2020	Amhara	362	Formol-Ether concentration	15.2
Workineh L *et al* [37]	2019	Amhara	422	Kato-Katz thick smear	24.9
Worku L *et al* [38]	2014	Amhara	385	Kato-Katz thick smear and Formol-Ether concentration	89.9
Alemu M *et al* [39]	2014	SNNPR	405	Kato-Katz thick smear	12.6
Bajiro M *et al* [40]	2017	Oromia	500	Kato-Katz thick smear	27.6
Bajiro M *et al* [41]	2018	Oromia	233	Kato-Katz thick smear	26.6

Author/reference	Year	Region	Sample size	Diagnostic methods	Prevalence
Ansha M *et al* [42]	2020	Oromia	298	Kato-Katz thick smear	11.4
Hailu T *et al* [43]	2018	Amhara	409	Ritchie's concentration	13.7
Ibrahim T *et al* [44]	2018	Oromia	340	Kato-Katz thick smear	12.94
Bekana T *et al* [45]	2019	Oromia	317	Kato-Katz thick smear	42.9
Teshale T *et al* [46]	2018	Tigray	410	Kato-Katz thick smear	38.5
Teklemariam A *et al* [47]	2014	Tigray	480	Formol-ether concentration	23.13
Fentie T *et al* [48]	2013	Amhara	520	Kato-Katz thick smear	16.7
Mitiku H *et al* [49]	2010	Oromia	375	Kato-Katz thick smear	12
Legesse L *et al* [50]	2010	Tigray	381	Kato-Katz thick smear and Formol-Ether concentration	63
Jemaneh L *et al* [51]	2001	Amhara	687	Kato-Katz thick smear	19.4
Endris M *et al* [52]	2010	Amhara	354	Kato-Katz thick smear	43.5
Essa T *el al* [53]	2013	Amhara	579	Kato-Katz thick smear	20.6
Addisu T *et al* [54]	2015	Amhara	365	Kato-Katz thick smear	15.9
Tulu B *et al* [55]	2014	Oromia	340	Formol-Ether concentration	12.6
Kemal M *et al* [56]	2019	Somali	236	Kato-Katz thick smear	25
Bajiro M *et al* [57]	2016	Oromia	500	Kato-Katz thick smear	24
Reta B *et al* [58]	2013	Amhara	342	Kato-Katz thick smear	70.47
Erko B *et al* [59]	2012	SNNPR	299	Kato-Katz thick smear	74.9
Haile S *et al* [60]	2012	Oromia	324	Kato-Katz thick smear	67.6
Woldegerima E *et al* [61]	2018	Amhara	372	Kato-Katz thick smear	35
Tesfie A *et al* [62]	2020	Amhara	245	Kato-Katz thick smear	83.3

Prevalence of Schistosoma mansoni **among children in Ethiopia**

The prevalence of *Schistosoma mansoni* infection among children in the included studies ranged from 11.4% reported in Oromia region by Ansha M. *et al*, 2020 [42] to 89.9% reported from Amhara region by Worku L. *et al* 2014 [38]. This meta-analysis showed pooled prevalence of *Schistosoma mansoni* infection among children as 37.75% (95% CI:29.97–45.53) using random effect model. High heterogeneity was observed across the included studies with I^2 value of 99.3%, p = 0.000 (Fig. 2).

Subgroup analysis

Subgroup analysis was conducted by sex, categorized sample size, publication year and the region where the studies were conducted. According to the region, the highest pooled prevalence of *Schistosoma mansoni* infection among children was from SNNPR (46.27%, 95%CI: 21.77–70.77) followed by Amhara region (41.9%, 95%CI: 28.45–54.54), Tigray region (38.14%, 95%CI: 24.22–52.05) and Oromia region (26.54%, 95%CI: 16.89–36.20). According to publication year of the included studies, the highest pooled prevalence of *Schistosoma mansoni* infection was observed in studies conducted from 2011 to 2015 (44.46%, 95%:30.88–58.03) followed by 2006 to 2010 (39.46, 95%CI: 7.58–71.34) and 2016 to 2020 (32.09%, 95%CI: 22.84–41.34). The pooled prevalence was higher among studies that have a sample size less than or equal to the average sample size compared to those that have sample size greater than the average sample size (43.93% vs 27.01%) (Table 2). The pooled prevalence was higher in males (37.73%, 95%CI: 29.77–45.68) (Fig. 3) compared to females (30.76%, 95%CI, 23.40-38.11) (Fig. 4).

Table 2
Prevalence of *Schistosoma mansoni* infection among children in Ethiopia by subgroups.

Variable	Characteristics	Number of studies	Sample size	Prevalence	I^2, p value
Region	**SNNPR**	6	2,364	46.27% (95%CI: 21.77–70.77)	99.5%, 0.00
	Amhara	19	7,616	41.9% (95CI: 28.45–54.54)	99.5%, 0.00
	Tigray	5	2,197	38.14% (95%CI:24.22–52.05)	98.1%, 0.00
	Oromia	10	3,555	26.54%, (95%CI: 16.89–36.20)	98.2%, 0.00
Sample size	**≤ 390**	26	8,676	43.93% (95%CI: 32.47–55.40)	99.5%, 0.00
	> 390	15	7,297	27.01% (95%CI: 20.47–33.56)	97.9%, 0.00
Publication year	**2001 to 2005**	1	687	19.4% (95%CI: 16.44–22.36)	-
	2006 to 2010	3	1,110	39.46 (95%CI: 7.58–71.34)	99.4%, 0.00
	2011 to 2015	18	7,243	44.46% (95%:30.88–58.03)	99.5%, 0.00
	2016 to 2020	19	6,928	32.09% (95%CI: 22.84–41.34)	98.9%, 0.00

Publication bias

The publication bias was assessed by visual inspection of the funnel plot and using egger's test statistics. Logit of proportion and its standard error were used to evaluate the presence or absence of bias. The result showed the absence of publication bias with p-value of 0.582.

Discussion

Schistosoma mansoni infection continued to be a major public health problem world-wide especially among children who are expected to have frequent water contact with 200 million cases [63]. To our knowledge, this study is the first comprehensive systematic review and meta-analysis of primary studies to indicate the prevalence of *Schistosoma mansoni* infection among children at national level. We performed compressive review and meta-analyses of 41 cross-sectional studies reporting the prevalence of *schistoma mansoni* infection among children in Ethiopia. Ethiopia is continuously implementing the MDA program with large scale periodic treatment since 2010 to reduce the burden of schistosomiasis and other intestinal parasitic infections. The country had also planned to reduce the national prevalence

of schistosomiasis below one percent [16]. However, this systematic review and meta-analysis showed the pool prevalence of *Schistosoma mansoni* infection among children as 37.75% (95%CI: 29.97–45.53). This result indicates as schistosomiasis being still a public health problem among children in Ethiopia. High between study heterogeneity was noted with I^2 value of 99.3%. In order to account this heterogeneity, subgroup analysis was done according to sex, sample size, year of publication and by regions where the studies were conducted. According to subgroup analysis the pooled estimate of *Schistosoma mansoni* prevalence was found to be higher among male children than females (37.73% vs 3076%). The high prevalence in male might be due to high swing activity of males than females, outdoor activities of male children in rural areas than females.

The pooled prevalence of *Schistosoma mansoni* infection among children was highest in SNNPR 46.27% (95%CI: 21.77–70.77) followed by Amhara region 41.9%, (95%CI: 28.45–54.54), Tigray region 38.14%, (95%CI: 24.22–52.05) and Oromia regional state 26.54%, (95%CI: 16.89–36.20). This variation may be due to the difference in implementation of the mass drug administration program, difference in efficacy of praziquantel, behavioral activities, environmental and personal sanitation, epidemiology of the snail vector, habit of open defecation, utilization of night soil as a fertilized and the geographical difference. The other explanation may be the SNNPR are rich in water bodies which can be favorable for the intermediate snail species. The pooled estimate was found to be high in studies conducted 2011 to 2015 (44.46%, 95%: CI: 30.88–58.03) followed by 2006 to 010 (39.46%, 95%CI: 7.58–71.34) and 2016 to 2020 (32.09% 95%CI: 22.84–41.34). The reduced prevalence from 2016 to 2020 might be due to implementation, monitoring and evaluation of the schistosomiasis control program such as mass drug administration program in school. High coverage of the mass drug administration which mainly focus on school children. In addition, it might be due to awareness creation in the community about keeping sanitation and hygiene of water bodies.

The studies were group as studies having above and below the average sample size (the average sample size was 390). The pooled prevalence was 43.93%, (95%CI: 32.47–55.40) in studies with sample size of ≤ 390 and 27.01% (95%CI: 20.47–33.56) in studies with sample size > 390. The between studies heterogeneity remained high even after subgroups analysis. The symmetry of funnel plot and the statistical analysis with the egger's test statistics ruled out the absence of publication bias with p value of 0.582. Our study has limitations such as; between-study heterogeneity among enrolled studies was remarkable. We did not assess the factors that associated with the prevalence of *Schistosoma mansoni* infection.

Conclusion And Recommendation

This meta-analysis summarized a high prevalence of *Schistosoma mansoni* among children in Ethiopia, suggesting as *Schistosoma mansoni* infection in a major public health problem in the country. The pooled prevalence of the infection is highest in SNNPR. Males were more affected than females. This systematic review identified a wide range of the prevalence of *Schistosoma mansoni* among children in Ethiopia from 2001 to 2020. To eliminate/control schistosomiasis in the country, the Ethiopian Federal

Ministry of Health should work with different stakeholders and recognize *Schistosoma mansoni* infection as a major health problem in the country, design cost effective monitoring and control programs, increases the geographical coverage of MDA and improve the delivery of the drug to the MDA sites.

Abbreviations

MDA
Mass Drug Administration
SAC
School Age Children
SNNPR
Southern Nation Nationalities and People's Region.

Declarations

Author's contribution

Habtye B designed the study and wrote the protocol. Yonas E, Habtye B and Tegegne E did the systematic review. Habtye B did the statistical analysis. Habtye B wrote the frist draft, which was critically revised by Yonas E and Tegegne E. All authors commented on the drafts and approved the final version.

Competing interests

The authors declared no competing interests.

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Availability of data

All the necessary materials are available within the manuscript.

Consent for publication

Not applicable.

Ethical approval and consent to participate

Since this study is systematic review and meta-analysis and does not involve human and animal studies, Ethical approval and consent to participate are not applicable.

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Figures

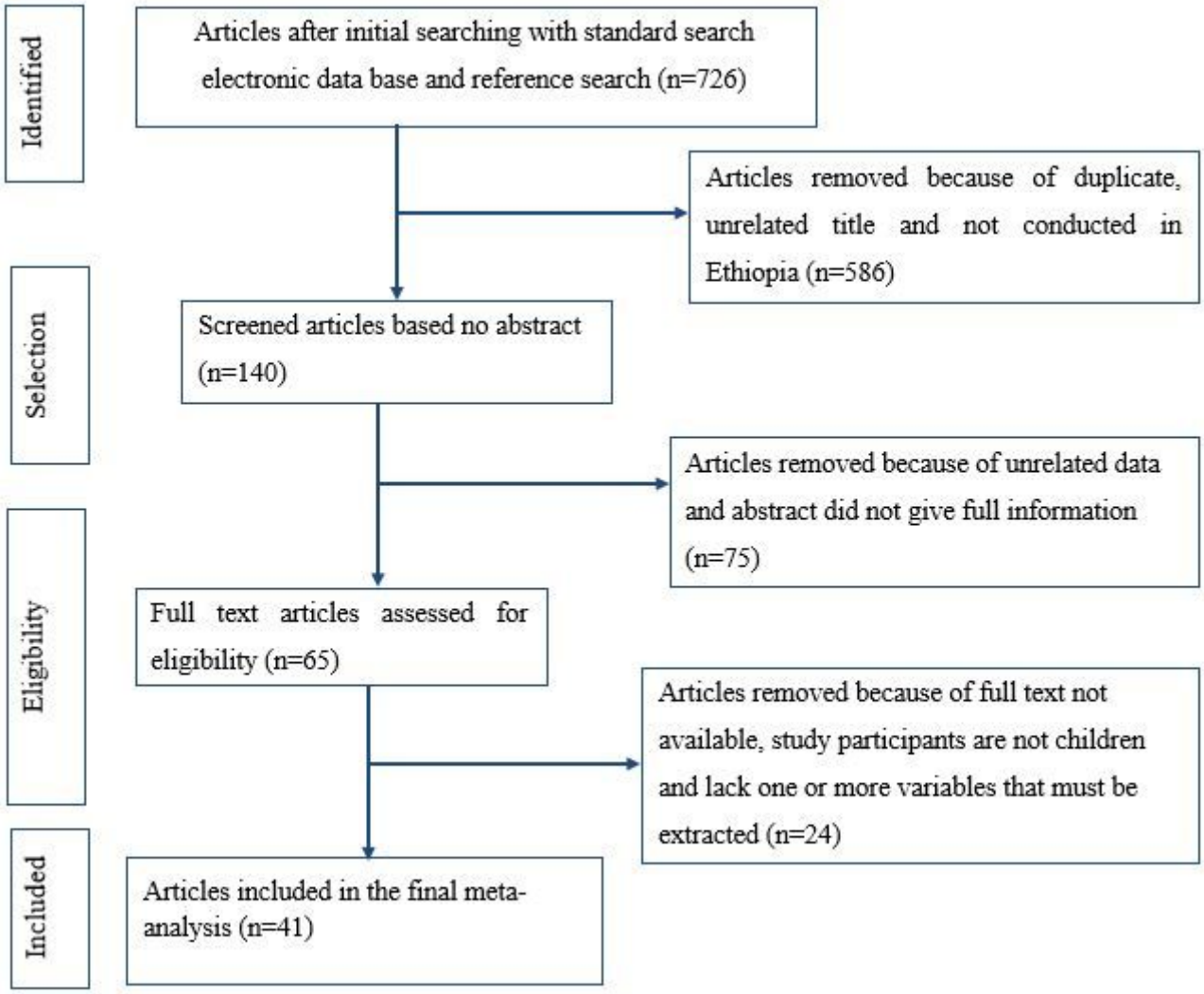

Figure 1

Flow chart of selection of studies

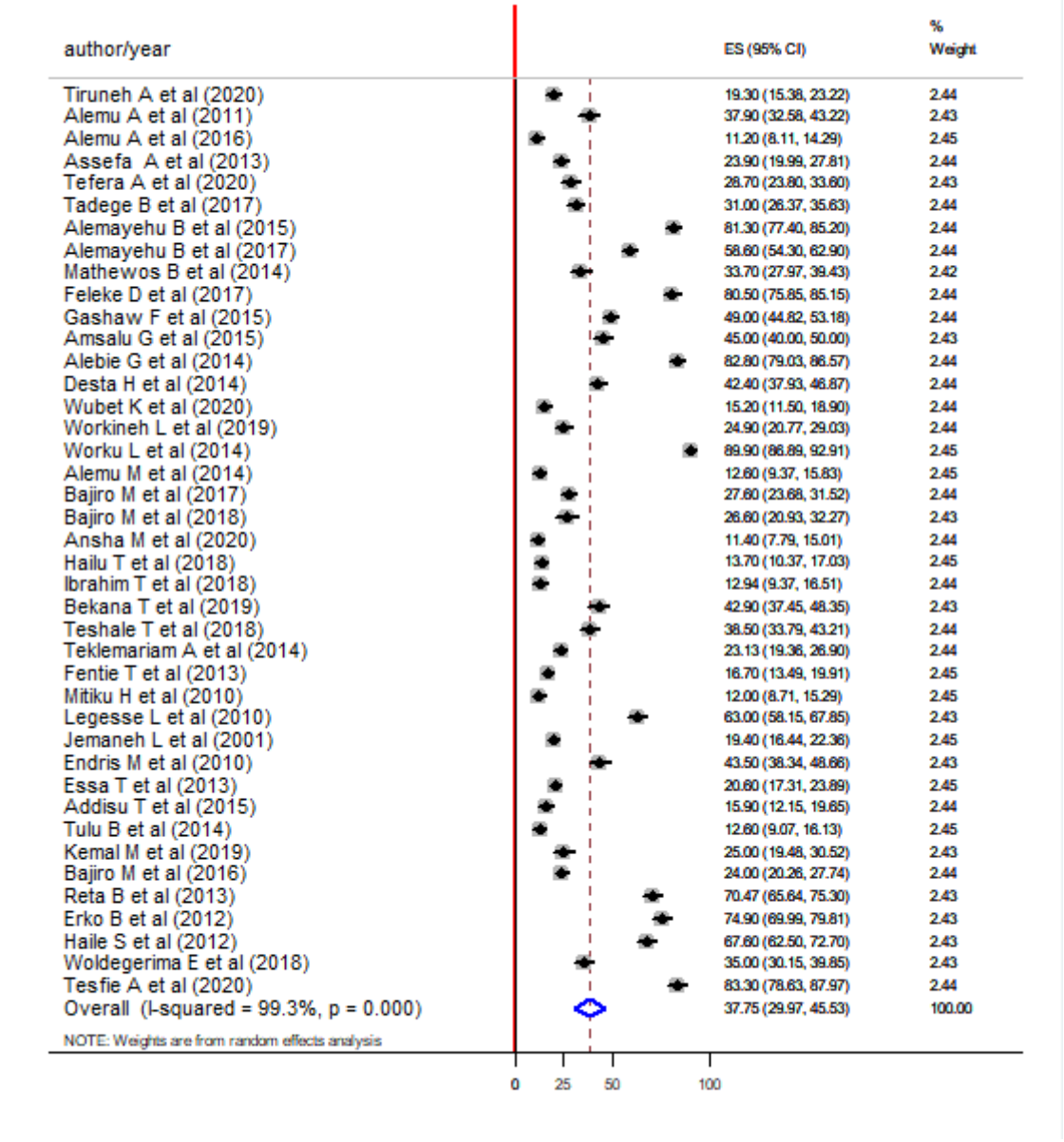

Figure 2

Forest plot showing the pooled prevalence of Schistosoma mansoni infection among children in Ethiopia.

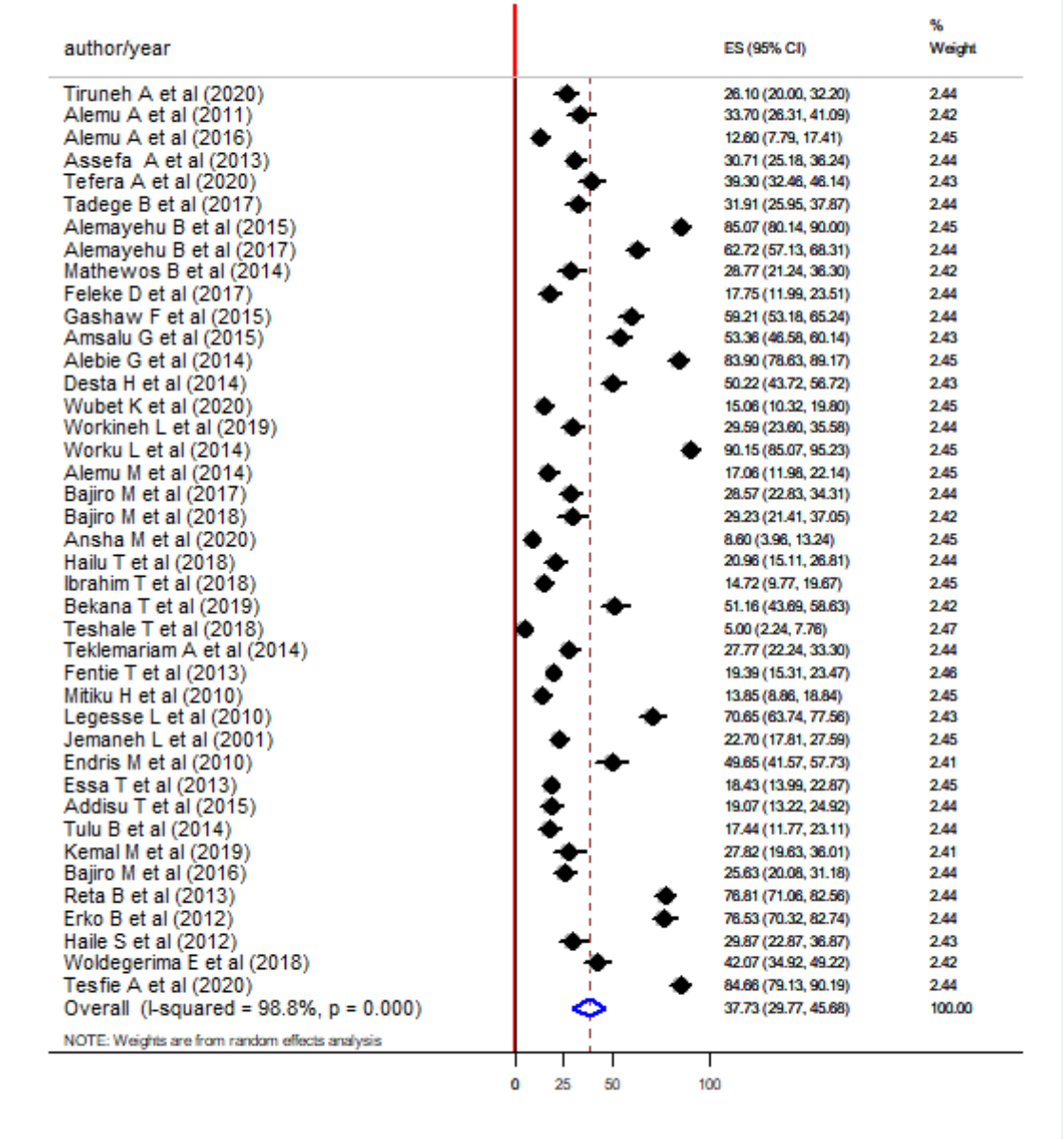

Figure 3

Forest plot showing pooled estimate of Schistosoma mansoni infection in male.

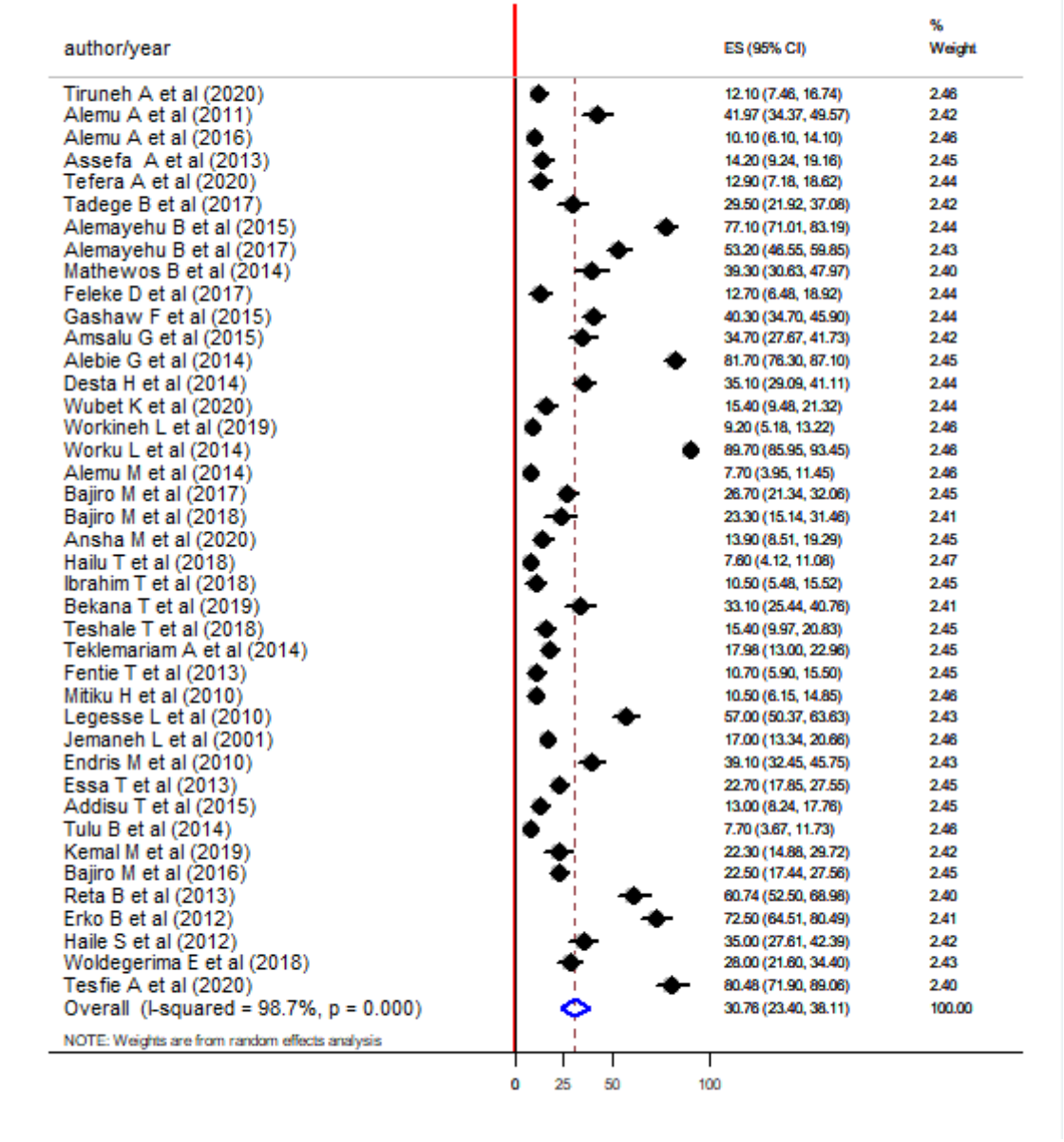

Figure 4

Forest plot showing pooled estimate of Schistosoma mansoni infection in female.

Supplementary Files

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