Prevalence of Soil-transmitted Helminth Infections Among School-age Children in Ethiopia: a Systematic Review and Meta-analysis

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Research

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Abstract

Background: In Ethiopia, soil-transmitted helminthiasis (STHs) infections remain the leading cause of morbidity among school-age children despite the progress in the implementation of control measures. Study findings regarding prevalence of STH among school-age children have been inconsistent and pooled prevalence of STH infections did not account double or triple infections of STH. Therefore, this systematic review and meta-analysis estimates the pooled prevalence of STH by accounting double or triple infections among school-age children in Ethiopia.

Methods: Databases and search engines such as PubMed, Web of Science, EMBASE, CINAHL, Google Scholar, Science Direct, and the Cochrane Library were systematically searched. Based on the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was employed to determine the prevalence of STH infections among school-age children. Published articles in the period between 1980 and 2020 were included in the analysis. Three authors independently extracted all data using a data extraction format sheet. STATA Version 16 statistical software was used for analysis. The Cochran's Q-test was used to evaluate the heterogeneity of the studies and a random-effects model was done to determine pooled prevalence estimate.

Results: The overall pooled estimate of STHs was 33% (95% CI:26-39%). The prevalence did not show statistically differ between before, 32.0% (95% CI:25-39%) and after, 33% (95% CI:26-39%) National NTDs control and elimination programme. The pooled prevalence of ascariasis before and after the implementation of NTDs programme was found to be 18% (12.0%, 24%) and 18% (9.0%, 27.0%), respectively with a total pooled estimate of 18.0% (13.0%, 23.0%). The prevalence of trichuris trichuria was also found to be 8.0% (4.0%, 12.0%) before the programme and 15.0% (4%, 26%) after the programme with a total pooled estimate of 10.0% (5.0%, 14.0%). The prevalence of hookworm was 14.0% (9.0%, 19.0%) before the programme and 9.0% (3.0%, 14.0%) after the programme with a total pooled estimate of 12% (8.0%, 17.0%).

Conclusion: The overall polled prevalence of STHs in Ethiopia was found at moderate level based on the WHO classification. The recommended control strategies for STHs infections in school-age children at this level of prevalence such as providing preventive chemotherapy or treat all school-age children (enrolled and non-enrolled) once a year, improving sanitation and water supply and providing health education should be strengthen to mee the target of the national and WHO plan.

Author Summary

In Ethiopia, soil-transmitted helminth infections (STH) remain the leading cause of morbidity among school children despite the progress in the implementation of control measures. Study findings regarding prevalence of STH among school-age children have been inconsistent and pooled prevalence of STH infections did not account double or triple infections of STH. The overall pooled estimate of STHs was 33% (95% CI:26-39%). The pooled prevalence of ascariasis before and after the implementation of NTDs programme was found to be 18% (12.0%, 24%) and 18% (9.0%, 27.0%), respectively. The difference is not statistically significant. The prevalence of trichuris trichuria was also found to be 8.0% (4.0%, 12.0%) before the programme and 15.0% (4%, 26%) after the programme. The prevalence of hookworm was also found to be 14.0% (9.0%, 19.0%) before the programme and 9.0% (3.0%, 14.0%) after the programme. The pooled prevalence of STHs in Ethiopia was found at moderate level based on the WHO classification. Providing preventive chemotherapy or treat all school-age children (enrolled and non-enrolled) once a year, improving sanitation and water supply and providing health education should be strengthened.

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Introduction

Soil-transmitted helminthiasis (STHs) is an intestinal parasitosis caused by *Ascaris lumbricoides* (the roundworm), *Trichuris trichiura* (the whipworm), *Strongyloides stercoralis* (threadworm) and the Ancylostoma duodenale and Necator americanu (hookworms) which are transmitted through soil contaminated with faecal matter(1-4).The transmission of STHs occurs in warm and humid environment where sanitation and hygiene practice is poor and people walking barefoot in contaminated soil (2, 5, 6).

STHs infections remain the leading cause of morbidity, particularly in resource limited countries (1, 7). Globally, more than 1.5 billion people are infected with STHs infections and the highest burden is occurring in sub-Saharan Africa, the south Americas, China and East Asia (8). School and pre-school-age children are the most at risk population groups and globally, over 835 million live in areas where STHs intensively transmitted (7).

The STHs infections have an effect on the quality of life in multiple ways from loss of appetite to delay in physical development. Heavier infections can cause a range of health problems like diarrhea, intestinal pain, malnutrition, weakness, impaired physical and mental development which in turn can result to poor school performance in children, reduced work productivity in adults and adverse pregnancy outcomes (9-12).

Different studies on the prevalence of STHs among school-age children in Ethiopia reported different figures which ranged from 15.0–63.0% (13-18). The government of Ethiopia advocated different control intervention measures: improved water supply, improved sanitation, hand hygiene, health education and school-based deworming in endemic districts to reduce the burden of STHs (19).

In 2015, the government of Ethiopia developed National Neglected Tropical Diseases (NTDs) control programme master plan to achieve elimination STHs diseases as a major public health problem by 2020. The plan also aims to attain transmission break by 2025 by reducing prevalence of heavy infection to less than 1% in endemic areas by creating integration of different interventions, increased co-ordination between mass drug administration and the water, sanitation and hygiene programmes as well as capacity building to ensure sustainability (19).Thus, this systemic review provides an insight on prevalence of STHs before and after implementation of this control programme.

In Ethiopia, the national NTDs mapping indicated three forth of the population (79 million) are living in STHs endemic areas (19).However, there is no evidence that showed national pooled prevalence of STHs infection among school-age children (5-14 years) after the implementation of national NTDs control programme. Understanding the pooled prevalence of STHs among this vulnerable groups at different time is paramount important for the successes of the intervention which is essential to ensure efficient allocation of resources. Moreover, the available studies that reported the prevalence of STHs in different areas at different times have the limitation to report the type of STHs infections (single, double, or tripled). For instance, STHs was reported by adding positive results of each helminth without considering the double and/or triple infection. They also lack consistency to describe or define school-age children. Some reports extended the age range up to 25 years and some others maintain the World Health Organization (WHO) school-age children (SAC) definition between 5 to 14 years who are at risk-population groups for STHs and target for deworming programs (20, 21). The limitation of the findings even goes up to systematic review and meta-analysis level. For example, the recent systematic review and meta-analysis finding (22) is not aligned with the title since the authors included studies which have children above 15 years old who are not the group of school-aged children, the global target of mass drug administration (MDA) treatment, according to the WHO (23).

Thus, this systematic review and meta-analysis has tried to address the limitations of the above studies. However, three articles authored by Gemechu et al 2020, Tigist et al 2020 and Leta 2020 which includes 15 years of School-age children were included in this meta-analysis due to their sample sizes are very substantia. Besides, in this systematic review, mathematical model which considers the double and triple infections was used to estimate the prevalence of STHs for each study (24). This model addresses the limitations of authors that have not reported double and triple infection in each study. Therefore, the aim of this systematic review and meta-analysis was to determine the pooled prevalence of ascaris, hookworm and Trichuris trichiura among school-age children (5 to 14 years) in Ethiopia. In addition, the review also tried to provide an insight on prevalence of STHs after implementation of national STHs intervention programs. This could be used as the baseline evidence to evaluate the progress of the new roadmap developed by WHO to end NTDs by 2030 for sustainable development (25).

Methods

Study setting

Ethiopia is located in the sub-Saharan African region. The projected population of Ethiopia in 2020 is estimated to be 115 million, of which nearly 28 million are school-age children (5-14 years) (26). The gross domestic product per capital in 2019 was $855.7 and health expenditure per capita (US$) in 2018 was 24.2, according to the World bank report (27). According to the Global Burden Diseases finding in 2019, the national Universal Health Coverage effective coverage was 46.5% (28). The Ethiopian Health tier system has three levels. The first level of health services is the primary level of care which is provided in primary hospitals, health centers, and health posts. Health posts are serving approximately 5,000 people at kebele level, health centers are an institution serving approximately 25,000 people and primary hospitals providing healthcare services to 60,000-100,000 people. The second level of care is general hospitals which is providing health services for 1-1.5 million people and the tertiary level of care is given in specialized hospital which is serving 3.5-5 million people (29). The Federal Ministry of Health of Ethiopia) developed an NTD Master Plan and Roadmap for combating the country's most common NTDs. Since 2007, Ethiopia has launched a large-scale nationwide MDA against STH. The MDA aims to cover children aged 5-14 years (in school and out of school children). The MDA has been implemented as NTD programme since 2013 (19).

Study design and search strategy

A systematic literature review and meta-analysis was conducted to estimate the pooled prevalence of STH, ascaris, hookworm, and trichuris trichiura infections, among school-age children (5 to 14 years) in Ethiopia. However, strongyloides stercoralis not included in this review because of the helminth peculiar characteristics: the parasite requires different diagnostic methods unlike the three soil-transmitted helminthiases (ascaris, hookworm, and trichuris trichiura), and most frequently, the previous conducted studies did not identify this parasite (30). Pooled estimates for ascaris, hookworm and trichuris trichiura were computed for those papers that did not reported STHs infections, double infections and triple infections. More than 75% of the included articles in this review did not report clearly type of infection that was used to measure STHs infection. To address this limitation and estimate the prevalence of each STH infection, mathematical methods was used. Published articles in the period between September 1980 and December 2020 were included in the study.

The review process followed the PRISMA guidelines. Published articles were searched from the following databases: PubMed/MEDLINE, Web of Science, CINAHL, Google Scholar, Science Direct and Cochrane Librarybetween October, 2019 and December, 2019. The search used the following keywords “prevalence of STH”, “soil-transmitted helminthes”, “intestinal helminthes”, “geo-helminths”, “roundworm”, “whipworm”, “threadworm”, “hookworms”, “school-age children”, “determinants”, “associated factors” and “Ethiopia”. Searches were also narrowed down by names of the regions and city administrations. The Boolean operators like “OR” or “AND” were used separately and in combination to search published articles. The general mesh term used for searching process was ("A. lumbricoides” OR “T. trichiura” OR “hookworm” OR “nematodes” OR “whipworm” OR “roundworm” OR “helminth” OR “soil-transmitted helminths” OR “geohelminths” OR “nemathelminths” AND “Ethiopia").

Inclusion and exclusion criteria of studies

After collecting the title of all articles in excel format sheet, screening was done by reviewing the title to identify the relevance and to remove duplication. Abstracts and full text detail review were done to ensure the presence of outcome of the study and other inclusion criteria. Inclusion of articles for the review was guided by the PRISMA checklist. The inclusion criteria are:

1. The study was conducted in Ethiopia with clearly stated study location
2. Published articles reported in English language only,
3. The study population was school-age children (5 to 15 years)

4. The study clearly stated sample sizes and numbers of positive samples were reported
5. The outcome of interest was the presence of STH infections with specific species (Ascaris lumbricoides, Trichuris trichiura, and the hookworms) using cross-sectional study design.
6. Fully accessed published articles.

Data extraction

All potentially relevant articles were retained and the full text of these studies examined to determine which studies satisfied the inclusion criteria. Data from all studies that met the final inclusion criteria were extracted. Data extractions were carried out independently by the two reviewers. Data from eligible studies were extracted to determine pooled prevalence estimates and distribution of STHs, ascaris, hookworm and trichuris trichiura infections among school-age children in Ethiopia. Author name, year of study, months of study, year of publication, sample size, number of positives cases, regions of study, study design, species of STHs identified were the data extracted from the eligible articles.

Outcome measures

Positive results from stool sample of school-age children for the three helminths (Ascaris lumbricoides, Trichuris trichiura, and Hookworm) were the outcome measures to determine the prevalence of STH, ascariasis, trichuris trichiuriasis and hookworm infection.

Quality assessment

Three independent researchers reviewed the papers to maintain the quality of the review. When there were variations between the reviewers, they come and sit together for the discussion and reached consensus. The Joanna Briggs Institute critical appraisal checklist for studies reporting prevalence data was also used to ensure data quality. Cochran's Q-test was done to evaluate heterogeneity of the studies. Heterogeneity was quantified using the formula $I^2 = 100 \times (Q\text{-}df)/Q$, where Q is Cochran's heterogeneity statistic and df is the degree of freedom which is the difference between the number of studies and one. I-square values of 0, 25, 50 and 75% were used to classify a study as no, low, moderate and high heterogeneities respectively.

Statistical analysis

Data were entered through Microsoft Excel version 2010 (MS Corporation, Washington, USA). Statistical and meta-analysis was done using STATA version16 software. To compute the prevalence of STH from each soil-transmitted helminth, mathematical method was used (24, 31) Prevalence of STH, ascaris, trichris trichirua and hookworm infections for each study with 95% Confidence Interval (95% CI) was computed. The prevalence of each STH infection (P_{ath}) was estimated using the following equation (24, 31).

$$P_{ath} = \frac{(a + t + h) - (a \times t + a \times h + t \times h) + (a \times t \times h)}{1.06}$$

Where,

a = prevalence of ascariasis (expressed as proportion)

t = prevalence of trichriasis (expressed as a proportion)

h = prevalence of hookworm infection (expressed as proportion)

Taking into account both within-study and between-studies variability random-effects model was used to estimate pooled prevalence of STH, ascaris, hookworm and trichris trichirua infections. Summary tables and forest plots were used to present the pooled estimates of STH, ascaris, hookworm and trichris trichirua prevalence with 95% confidence intervals. Group analysis was done between studies before and after implementation of NTDs to show the progress of the intervention in reducing the prevalence of STHs.

Results

Study selection

A total of 3647 published articles (3106 from PubMed, 221 from Science director and 320 from Google scholar) were identified for systematic review and meta-analysis. Seven hundred twenty-nine articles of the total identified paper were rejected due to duplication. Then, 3565 articles rejected by their title disagreement. The remaining 82 articles reviewed thoroughly to check its eligibility and from these remaining 82 articles, 4 articles were rejected due to their study design (1 study was randomized control trial and the rest three were literature review). Other 16 articles were also rejected due to age distribution where researchers in these articles extended school-age up to 25 years. After the whole critical review process, 32 articles found to be eligible for systematic review and meta-analysis (Figure 1).

Characteristics of articles included in the STH, the ascaris, hookworm and Trichris Trichirua

There were 32 articles that fulfilled the inclusion criteria and included in the review and meta-analysis for STHs. All of them were school based cross-sectional studies. The studies were from Amhara (Fourteen), SNNP (nine), Oromia (six), Tigray (two) and national (one). The sample size on those studies ranges from 280 to153,238 (Table 1).

Table 1
Summary of published articles of soil-transmitted helminth infections among School-Age children in Ethiopia included in the systematic review and meta-analysis

Author	**Region**	**Sample size**	**Positive samples**			
			STHs	**Ascaris L.**	**Trichuris T**	**Hookworm**
Abera et al 2013 (32)	Amhara	791	282	99	7	224
Abossie et al 2014 (13)	SNNP	400	245	242	39	9
Addis T &Muche A 2011 (33)	Amhara	365	67	40	6	30
Addisu et al 2020 (34)	Oromiya	384	99	38	19	24
Alelign et al 2015 (16)	Amhara	384	199	53	9	180
Alem et al 2018 (35)	SNNP	391	104	56	10	55
Alemu et al 2019 (36)	SNNP	351	70	36	25	19
Amare et al 2013 (37)	Amhara	405	62	51	7	10
Chalachew et al 2020 (38)	Amhara	806	300	72	-	237
Debalke et al 2013 (3)	Oromiya	369	176	92	111	30
Dessie et al 2019 (39)	Tigray	422	32	23	4	8
Fentie T etal 2013 (40)	Amhara	520	216	96	62	122
Gelaw et al 2013 (41)	Amhara	304	31	18	10	6
Gelaye et al 2014 (42)	Amhara	669	26	23	2	3
Girum Tadesse 2005 (18)	Oromia	415	53	16	15	28
Grime et al 2017 (43)	SNNP	3,729	804	179	23	689
Hailegebriel et al 2017 (44)	Amhara	359	119	49	10	82
Hailegebriel et al 2018 (45)	Amhara	382	99	52	7	56
Hiwot et al 2020 (46)	SNNP	**850**	**479**	**159**	**360**	**37**
Jemaneh L. 2001 (47)	Amhara	687	421	295	102	259
Leta et al 2020 (48)	National	153,238	33253	19614	9041	11646
Mahmud et al. 2013 (49)	Tigray	583	55	28	1	31
Nute et al 2018 (50)	Amhara	15,455	5275	2596	587	3183

Author	Region	Sample size	Positive samples			
Samuel et al 2017 (51)	Oromiya	321	37	25	7	9
Tadege et al 2017 (52)	SNNP	374	189	166	41	29
Tekelmariam et al2018 (53)	Oromiya	280	125	67	83	6
Tigist et al 2020 (54)	SNNP	3162	1731	1423	800	193
Wondwosen A. et al 2020	SNNP	1080	250	121	49	29
Worku et al 2014 (55)	Amhara	385	173	62	3	143
Yarinbab&Darcha2019 (56)	SNNP	303	176	118	105	31
Zeleke et al 2020 (57)	Oromiya	404	222	115	141	46
ZinayeTekeste et al2013 (58)	Amhara	326	76	54	15	18

Prevalence of STH, ascariasis, hookworm and trichuris trichirua

The pooled estimate of STH prevalence found to be 33.0% with 95% CI of (26.0%, 39.0%). Both the prevalence table and the forest plot showed that the prevalence of STH range from 3.9% which is found in Amhara region to 61.3% which is found in two regions (Amhara and SNNP) (Table 2, Figure 2). To estimate the pooled prevalence of ascariasis, hookworm and trichuris trichuria, subgroup analysis was done taking in to account after implementation of NTDs Control and elimination programme in Ethiopia. Pooled prevalence of STHs before and after the implementation of the program were 32.0% (25.0, 39.0%) and 33.0% (26.0, 39.0%), respectively. The pooled prevalence of ascariasis before and after the implementation of NTDs programme was found to be 18% (12.0%, 24%) and 18% (9.0%, 27.0%), respectively with a total pooled estimate of 18.0% (13.0%, 23.0%). The difference is not statistically significant (Figure 3). The subgroup analysis result of trichuris trichuria was also found to be 8.0% (4.0%, 12.0%) before the programme and 15.0% (4%, 26%) after the programme with a total pooled estimate of 10.0% (5.0%, 14.0%) (Figure 4). In the same way, the sub group analysis result of hookworm was 14.0% (9.0%, 19.0%) before the programme and 9.0% (3.0%, 14.0%) after the programme with a total pooled estimate of 12% (8.0%, 17.0%) (Figure 5). From the given prevalence of ascaria, hookworm and trichuris trichuria infection, the least was for trichuris trichuria.

Considering the individual study, the minimum prevalence of ascariasis was reported from Amhara with a prevalence of 3.4% (2.1%, 4.8%) and a maximum prevalence of 60.5% (55.7%, 65.3%) where the maximum is reported from SNNPR. For trichuris trichuria, the minimum prevalence was reported in Tigray with a prevalence of 0.2% (0.1%, 50%) and a maximum prevalence was 42.4% (39.0%, 45.7%) in SNNPR. Regarding to hookworm, both the minimum and the maximum prevalence was found in Amhara region with a prevalence of 0.4 % (0.1%, 1.0%) and 46.9% (41.9%, 51.9%) (Table 2).

Table 2

Prevalence of soil-transmitted helminth infections among school-age children in Ethiopia included in the systematic review and meta-analysis

Author	Sample size	Prevalence (95% CI)			
		STH	Ascaris L.	Trichuris T	Hookworm
Abera et al 2013	791	35.5(32.2,38.9)	12.5 (10.2-14.8)	0.9 (0.2-1.5)	28.3 (25.2-31.5)
Abossie et al 2014	400	61.3(56.3,66.1)	60.5 (55.7-65.3)	9.8 (6.8-12.7)	2.3 (0.8-3.7)
Addis T & Muche A 2011	365	18.4(14.5,22.7)	11.0 (7.8-14.2)	1.6 (0.3-2.9)	8.2 (5.4-11.0)
Alelign et al 2015	384	51.8(46.7,56.9	13.8 (10.4-17.3)	2.3 (0.8-3.9)	46.9 (41.9-51.9)
Alemetal 2018	391	26.6(22.3,31.3)	14.3 (10.9-17.8)	2.6 (1.0-4.1)	14.1 (10.6-17.5)
Alemu et al 2019	351	19.9(15.9,24.5)	10.3 (7.1-13.4)	7.1 (4.4-9.8)	5.4 (3.0-7.8)
Amare et al 2013	405	15.3(11.9,19.2)	12.6 (9.4-15.8)	1.7 (0.5-3.0)	2.5 (1.0-4.0)
Chalachew M. et al 2020	806	37.2(33.9-40.6)	8.9(7.0-10.9)	-	29.4 (26.3-32.5)
Debalke et al 2013	369	47.7(42.5,52.9)	24.9 (20.5-29.3)	30.1(25.4-34.8)	8.1 (5.3-10.9)
Dessie et al 2019	422	7.6(5.2,10.5)	5.5 (3.3-7.6)	0.9 (0.02-1.9)	1.9 (0.6-3.2)
Fentie T etal 2013	520	41.5(37.3,45.9)	18.5 (15.1-21.8)	11.9 (9.1-14.7)	23.5 (19.8-27.1)
Gelaw et al 2013	304	10.2(7.0,14.2)	5.9 (3.3-7.6)	3.3 (1.3-5.3)	2.0 (0.4-3.5)
Gelaye et al 2014	669	3.9(2.6,5.6)	3.4 (2.1-4.8)	0.3 (0.1-0.7)	0.4 (0.1-1.0)
GirumTadesse 2005	415	12.8(9.7,16.4)	3.9 (2.0-5.7)	3.6 (1.8-5.4)	6.7 (4.3-9.2)
Grime et al 2017	3,729	21.7(20.3,22.9)	4.8 (4.1-5.5)	0.6 (0.4-0.9)	18.5 (17.2-19.7)
Hailegebriel et al 2017	359	33.1(28.3,38.3)	13.6 (10.1-17.2)	2.8 (1.1-4.5)	22.8 (18.5-27.2)
Hailegebriel et al 2018	382	25.9(21.6,30.6)	13.6 (10.2-17.1)	1.8 (0.5-3.2)	14.7 (11.1-18.2)

Author	Sample size	Prevalence (95% CI)			
Hiwot H. et al 2020	850	56.4(53.0-59.7)	18.7(16.1-21.3)	42.4(39.0-45.7)	4.4 (3.0-5.7)
Jemaneh L. 2001	687	61.3(57.5,64.9)	42.9 (39.2-46.6)	14.8 (12.2, 17.5)	37.7 (34.1-41.3)
Leta et al 2020	153,238	21.7(21.5-21.9)	12.8(12.6-13.0)	5.9(5.8-6.0)	7.6)7.5-7.7)
Mahmud et al. 2013	583	9.4(7.2,12.1)	4.8 (3.1-6.5)	0.2 (0.1-0.5)	5.3 (3.5-7.1)
Nute et al 2018	15,455	34.1(33.4,34.9)	16.8 (16.2-17.4)	3.8 (3.5-4.1)	20.6 (20.0-21.2)
Samuel et al 2017	321	11.5(8.2,15.5)	7.8 (4.9-10.7)	2.2 (0.6-3.8)	2.8 (1.0-4.6)
Tadege et al 2017	374	50.5(45.3,55.7)	44.4 (39.3-49.4)	11.0 (7.8-14.1)	7.8 (5.0-10.5)
Tekelmariam et al2018	280	44.6(38.7,50.7)	23.9 (18.9-28.9)	29.6 (24.3, 35.0)	2.1 (0.4-3.8)
Tigist D et al 2020	3162	54.7(53.0-56.0)	45.0(43.3-46.7)	25.3(23.8-26.8)	6.1(5.3-6.9)
Wondwosen A. et al 2020	1080	23.1(20.6-25.7)	11.2(9.3-13.1)	4.5(3.3-5.8)	2.7(1.7-3.6)
Worku et al 2014	385	44.9(39.9,50.1)	16.1 (12.4-19.8)	0.8 (0.1-1.7)	37.1 (32.3-42.0)
Yarinbab & Darcha 2019	303	58.1(52.3,63.7)	38.9 (33.5-44.4)	34.7 (29.3-40.0)	10.2 (6.8-13.6)
Zeleke M et al 2020	404	55.0(50.1-59.8)	28.5(24.1-32.9)	34.9(30.3-39.5)	11.4(8.3-14.5)
ZinayeTekeste et al2013	326	23.3(18.8,28.3)	16.6 (12.5-20.6)	4.6 (2.3-6.9)	5.5 (3.0-8.0)
Pooled	28,970	31.0(24.0, 38.0)	18.0(12.0, 23.0)	7.0(3.0, 11.0)	13.0(8.0, 18.0)

Discussion

This review estimated the overall polled prevalence of STHs in Ethiopia was at moderate level (33%) based on to the WHO classification. A. lumbricoides (18%) was the most prevalent STH, followed by hookworms (12%) and T. trichiura (10%). Astematic review in other African countries also reported ascaries as the dominant STH (1, 59).

The polled prevalence from this review is higher compared to the reports from other sub-Saharan African countries (60, 61). But Previous studies in other sub Sharan countries have demonstrated sustained regular MDA significantly reduce prevalence of STH infection (62) intensity of infection (63) and co-infections (64, 65). Sartorius, Benn et al. a geospatial analysis from 2000 to 2018 concluded in significant reduction of STH (with almost 72% of endemic implementation unit predicted to have achieved the WHO 2030 target) over two decades in most sub-Saharan countries (66). The review mentions that Ethiopia as one of the few countries lagging behind (66).

This is an indication that despite the significant achievement in scaling up STH implementation since 2004 using mebendazole or albendazole that are organized once or twice per year for school children and the implementation of WASH program the frequency of STH did not improve significantly. A study by Hailegebriel et al has also documented the pooled prevalence of STH in Ethiopia 33.4%, the limitation of this meta-analysis is the included studies does not fully represent WHO definition for SAC (22). but lower than STH reported from Kenya, and Nigeria (1, 67).

The recommended control strategies for STH infections in school-age children at this level of prevalence such as providing preventive chemotherapy or treat all school-age children (enrolled and non-enrolled) once a year, improving sanitation and water supply and providing health education should be strengthen to meet the target of the national and WHO plan.

It is understood that WHO recommended deworming school-age children as a part of a larger national strategy for the integrated control and elimination on NTDs (24). In line with this, the government of Ethiopia launched school-age children deworming programme as a strategy to control STHs infection since 2014 (19). Moreover, the national NTDs control programme was scaled up by integrated the deworming program with other water, sanitation and hygiene program in 2015 to reduce prevalence of heavy infection to less than 1% in STHs endemic areas (19). In this review, the pooled estimate prevalence of each parasite (*Ascaris lumbricoides*, *Trichuris Trichiura* and hookworm) as well as STHs remain high in Ethiopia. The possible reasons for high prevalence of STHs could be explained by the low key socioeconomic (sanitation and GDP) and intervention indicators were concentrated in Ethiopia (66, 68) exposes the school-aged children for STHs if they live in faecally contaminated environments. Wolf et al reported that high prevailing faecal contamination might explain interventions' poor effectiveness in reducing diarrhoea (69).It is not only the high magnitude of each parasite's and STH's prevalence that required consideration, but also the larger range of the confidence interval. Except *A. lumbricoides*, which has fair range of interval, all the other have extended interval of the prevalence. This showed that each study included in the systematic review and meta-analysis has its own limitations, which could be in terms of sample size, measurement, and publication bias. It is supported with availability of high heterogeneity during forest plot analysis.

The prevalence of STHs infection in this review found to be lower than a systematic review and meta-analysis result done in Nigeria (70). The difference might be associated with time span of the individual studies included in the review. In the Nigerian case the included studies ranged from 1980-2015 whereas for the current review although the criteria to include the papers stated to be started from 1980, the actual included papers were between 2001 and 2019. Most of the STHs control strategies and actions have been done after 2000and this is plausible to encounter this difference between the two findings (24). However, comparing the pooled prevalence of each parasite of this review with systematic review and meta-analysis finding in Nepal found to be higher (71). This high prevalence in Ethiopia compared to Nepal can be explained in different ways. The deference might be due to the difference of intervention strategies between countries. It might be also explained that Ethiopia is found in the tropical region which has conducive and favorable environment for the proliferation of the parasite (72). The other difference between these two findings is that in the case of Nepal the pooled prevalence for each parasite significantly reduced over time while for Ethiopia the opposite is true.

With the presence of all available intervention strategies in the country that includes health extension program, mass deworming administration and integrating the WASH service with NTDs control and elimination strategies(73), it is expected to reduce the prevalence of each parasite and STHs. But according to the subgroup analysis done considering the NTDs program launching time as a reference, there is not statistically significant difference before and after NTDs control program. Open defecation practice of Ethiopian general population and children reached up to 32.9% and 14.4% respectively (74). The other possible explanation might be due to the current mass drug administration protocol might not consider all school-age children since the protocol only account 17.7 million school-age children by considering the areas with low infection prevalence(75). In the 2019 report proportion (%) of implementation unit achieving effective (>=75%) coverage of school aged children in Ethiopia was 63.7% (76). This low coverage can have an implication on the prevalence of STHs. It is also known that culturally the majority of the people resident in Ethiopia walk barefooted or wear their shoes inconsistently (77-79) and this could also increase the risk of acquiring STHs in school-age children. The other explanation for this issue could be no mechanism for controlling of reinfection after the administration of deworming for those school-age children.

For the policy and practice perspective the evidence from the review indicates for enhanced and tailored intervention packages with the development of more efficient treatment protocols as the MDA programme progresses towards the last stages. For instance, increased clustering of infections may indicate the existence of residual transmission hotspots where more expansion of deworming programmes to include adults in hookworm dominated areas and increasing to biannual frequency in A lumbricoides dominated areas might have larger effects and other interventions such as improved sanitation and WASH protocols may be necessary.

Strength and limitations

This review used a mathematical model to estimate prevalence of STH from each helminth prevalence that considers double and/or triple infection. The review followed the school-age children definition which is mostly ignored by many researchers to account children found in the age interval between 5-14 years.

As the limitation, only four regions of the country are represented and to get the representative STHs picture of the country studies from other regions would be included.

Conclusion

According to the systematic review and meta-analysis finding, the pooled prevalence of all individual parasites and STHs found to be high. All estimates also found to be with wider 95% CI which indicates the presence of limitations of each study. Even though there was no statistically significant difference between before and after implementation of national NTDs control program the magnitude of the prevalence of STHs remain high after implementation of the NTDs control program. The effectiveness of the programme might be hindered due to poor sanitation practices in the country. Large scale study (national survey) is recommended to get clear prevalence of STHs and other parasites. Thus, integrated water, sanitation and hygiene with mass drug administration interventions should be strengthen in reducing STHs among school age children.

Abbreviations

MDA: Mass Drug Administration; NTDs: Neglected Tropical Diseases; SAC: School Age Children; SNNP: Southern, Nation, Nationalities and People's Region; STHs: Soil-transmitted helminthiasis; WASH: Water Sanitation and Hygiene; WHO: World Health Organization.

Declarations

Ethics approval and consent to participate

This is a secondary data analysis of published. Therefore, it is not applicable.

Consent for publication

Not applicable

Competing interests

None declared

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Author Contributions

Conceived and designed the experiments: MA, GG, AM, and WE. Performed the experiments and Analyzed the data: MA, GG, AM, and WE. Drafting the manuscript and wrote the paper: MA, GG, AM, and WE

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Figures

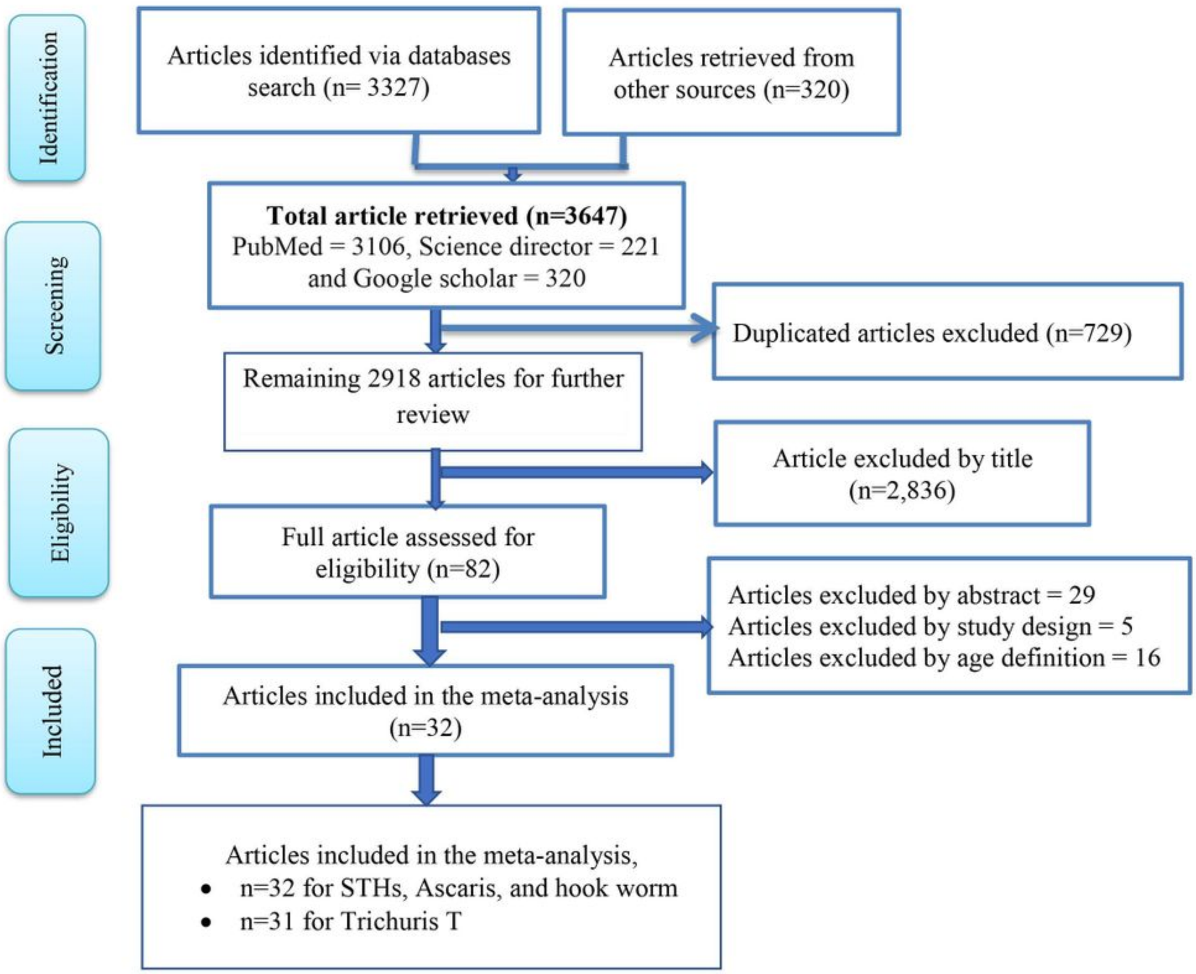

Figure 1

PRISMA or flow diagram for the selection process of eligible articles for systematic review and meta-analysis, 2020.

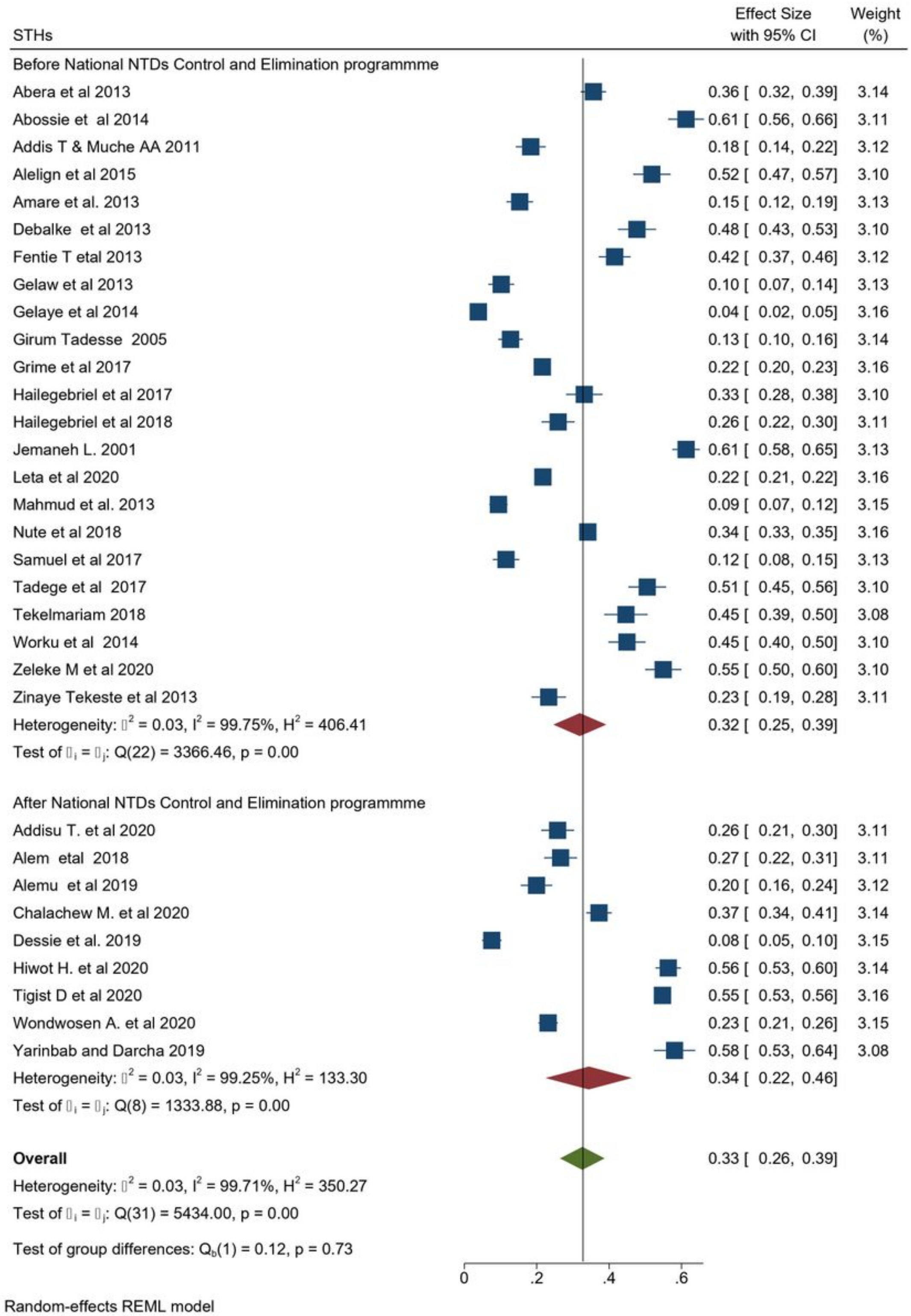

Figure 2

Forest plot showed the pooled prevalence of STHs among School-Age children in Ethiopia included in the systematic review and meta-analysis

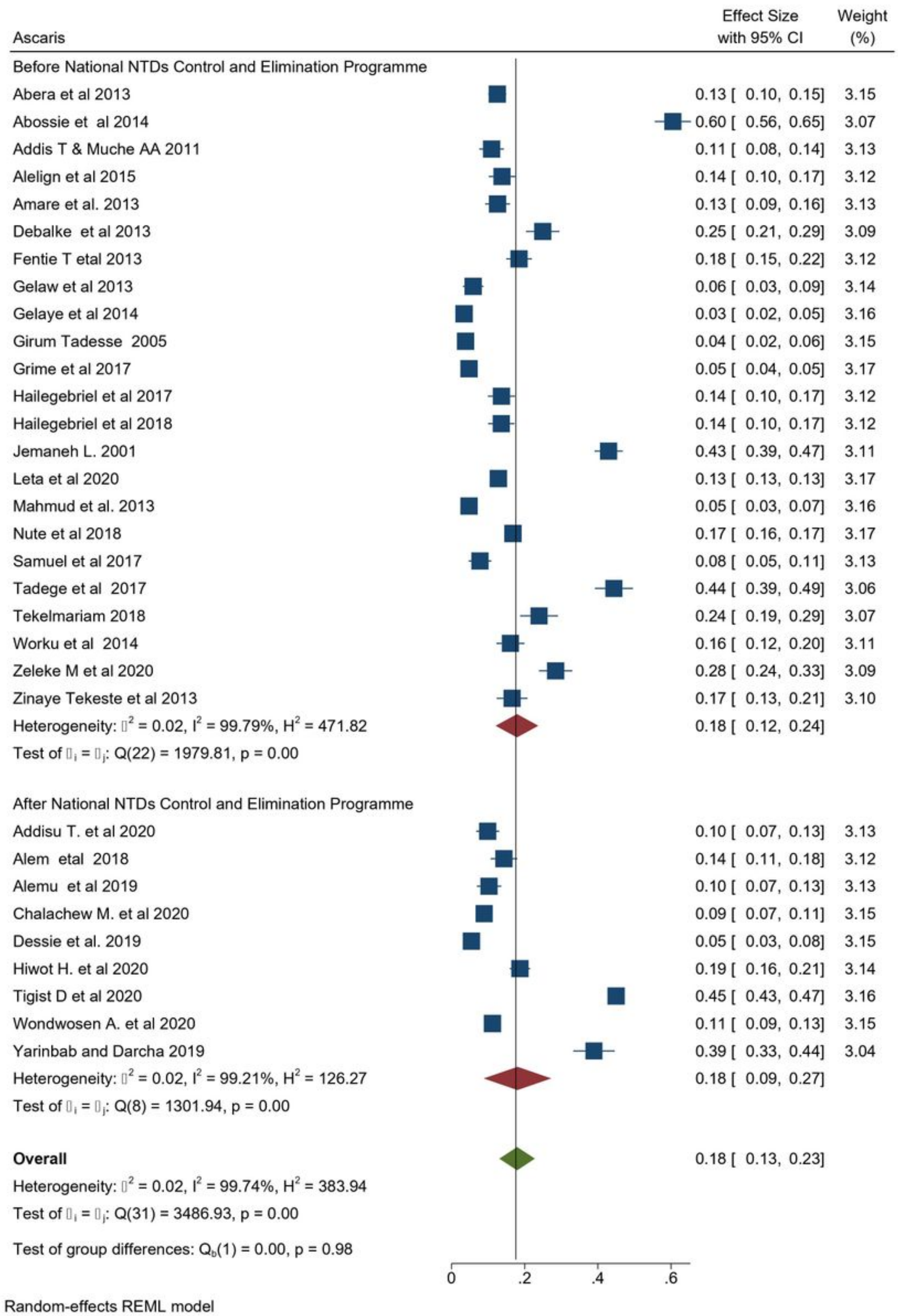

Figure 3

Forest plot showed the pooled prevalence of ascaria among school-age children in Ethiopia included in the systematic review and meta-analysis, subgroup analysis

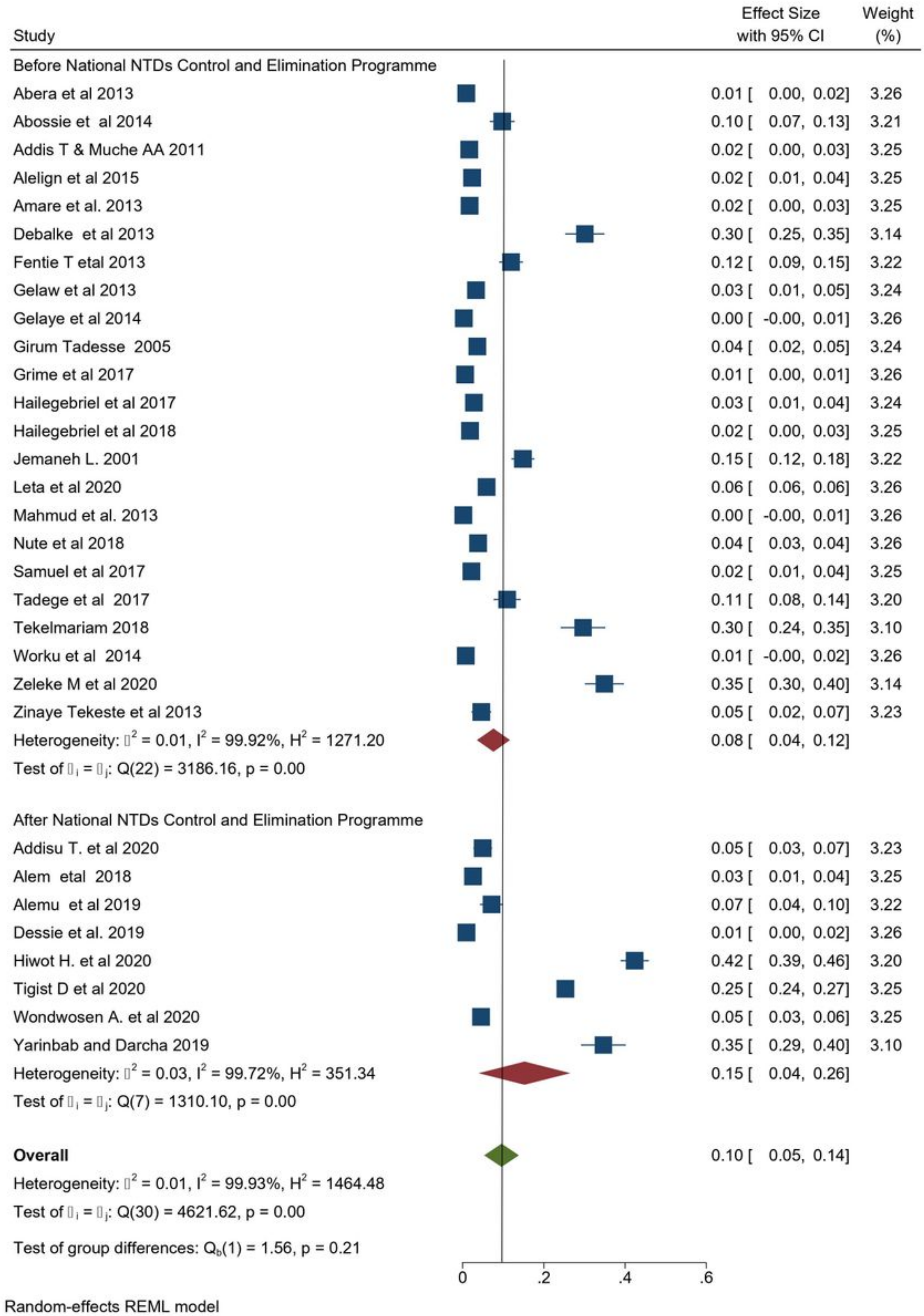

Figure 4

Forest plot showed pooled prevalence of trichuris trichuria among school-age children in Ethiopia included in the systematic review and meta-analysis, subgroup analysis

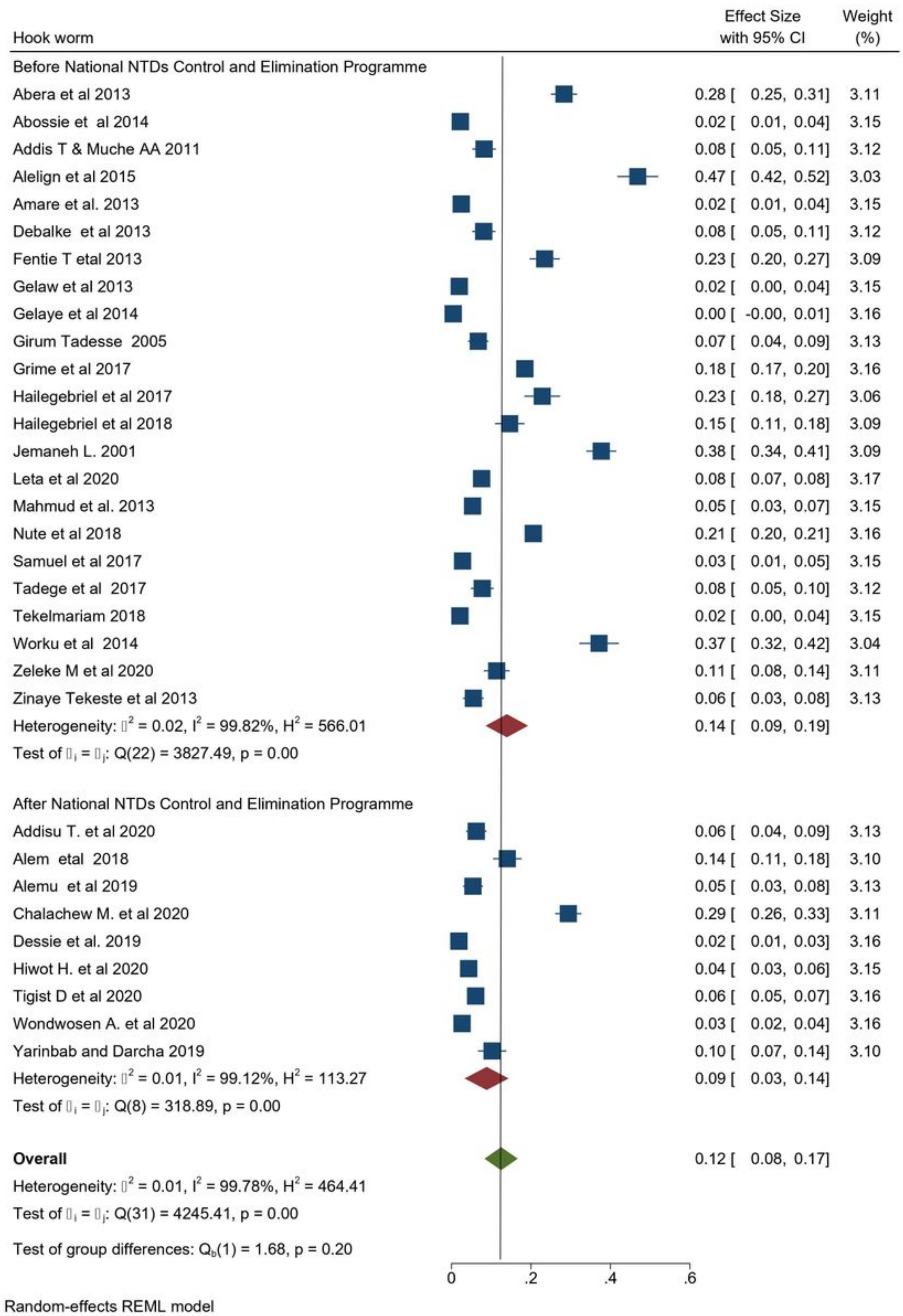

Figure 5

Forest plot showed the pooled prevalence, Hookworm among school-age children in Ethiopia included in the systematic review and meta-analysis, subgroup analysis

Supplementary Files

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- PRISMAchecklist.doc