

Prevalence of Soil-Transmitted Helminthes and Associated Risk Factors Among People of Ethiopia: A Systematic Review and Meta-Analysis

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ABSTRACT

BACKGROUND: A Soil-transmitted helminthic infection (STHs) remains a notable health problem in resource-limited countries.

OBJECTIVE: This systematic review and meta-analysis aimed to determine the overall prevalence of STH infections in Ethiopia.

METHODS: Articles written in English were searched from online public databases. Searching terms taken separately and jointly were “prevalence,” “soil-transmitted helminths” “nematode,” “Geo-helminths,” “roundworm,” “Necator,” “Ancylostoma,” “Ascaris,” “Trichuris,” “hookworm,” “whipworm,” “*S. stercoralis*,” “associated factors,” and “Ethiopia.” We used STATA version 14 for meta-analysis and Cochran’s Q test statistics and the I^2 test for heterogeneity.

RESULT: From 297 reviewed articles 41 fulfilled the inclusion criteria. The pooled prevalence of STH infections in Ethiopia was 36.78% *Ascaris lumbricoides* had the highest pooled prevalence 17.63%, followed by hook worm 12.35%. *Trichuris trichiura* 7.24% when the prevalence of *S. stercoralis* was 2.16% (95% CI: 0.97-3.35). Age, sex, residence, family education level, lack of shoe wearing habits and open defecation were identified as risk factors for STH infection. Eating unwashed and uncooked fruit and vegetables increased the risk of STH infection by 1.88 times while untrimmed finger nail and lack of hand washing habits increase the risk of STH infection by 1.28 and 3.16 times respectively with 95% CI.

LIMITATION: Lack of published studies from Afar, Gambela, Somali, and Benshangul gumuz regions may affect the true picture. The other limitation is that the search strategy will be restricted articles published only in the English language but there might be articles that published using another language.

CONCLUSION: *Ascaris lumbricoides*, hookworms and *Trichuris trichiura*, are the most prevalent soil-transmitted helminthes infections in Ethiopia. Age, sex, residence, family education level, lack of shoe wearing habits Open defecation untrimmed finger nail and lack of hand washing habits significantly associated with STH infection. When eating unwashed, uncooked fruit and vegetables were not significantly associated with STH infection. Strategic use of anti-helminthic, health education, and adequate sanitation, taking into account this epidemiologic information is helpful in the control of STH infections in Ethiopia.

KEYWORDS: Ethiopia, meta-analysis, prevalence, risk factors, soil-transmitted helminthic infections, systematic review

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Introduction

Soil-transmitted helminthes (STH) are among the leading causes of global health problems especially among the poorest and deprived communities where implementation of control measures is difficult.¹ Globally more than 2 billion people are infected by at least one of the commonest species namely: *Ascaris lumbricoides* (the roundworm), *Trichuris trichiura* (the whipworm) *Strongyloides stercoralis* (threadworm), and the hookworms; *Ancylostoma duodenale* and *Necator americanus*.² Recent estimates suggested that 819 million people worldwide are infected among *A. lumbricoides*, 465 million with *T. trichiura*, and 439 million with hookworm infection,² and 4 billion

are at risk of infection.³ More than 613 million school-age children in the world are at risk of STH infection.³

Preschool-age children (PSAC), school-age children (SAC),³ and women of reproductive age are WHO-identified risk groups.⁴ School-age children between the ages of 5 to 15 in most developing countries are at the highest risk of chronic helminth infection and helminth-associated morbidities.⁵ More than 568 million SAC live in areas where these parasites are intensively transmitted and require treatments. Although the global target is to eliminate morbidity due to STH infections in children by 2020,³ these infections are still huge health problems in developing countries including Ethiopia affecting millions of



SAC. Child under nutrition (mainly involving stunting, wasting, and underweight) has also been a serious global public health problem in the developing world including Ethiopia.⁶

The prevalence of STH infection was 25.4% in Rwanda.⁷ In a study done in South Asia *Ascaris* was the commonest STH identified with an overall prevalence of 18% followed by *Trichuris* 14% and hookworm 12%.⁸ Hookworm prevalence was highest in Laos, Vietnam, and Cambodia. There was geographical overlap in countries with high prevalence rates for *Trichuris* and *Ascaris* (Malaysia, Philippines, Myanmar, Vietnam, and Bangladesh). When available data from school-aged children (SAC) were analyzed, the prevalence of *Ascaris* 25% and *Trichuris* 22%, were higher than among the general population while that of hookworm was 10%.⁸ The pooled prevalence estimate of STH was 54.8% with *A. lumbricoides* had the highest prevalence of 44.6% while, *T. trichiura*, hookworms, and *S. stercoralis* recorded pooled prevalence estimate of 31.9%, 23.0%, and 3.4%, respectively in Nigeria.⁹

Ethiopia is among sub-Saharan African countries with the highest-burden and where the disease remains an important public health problem particularly among school and pre-school age children.¹⁰ The national prevalence of hookworms, *A. lumbricoides*, and *T. trichiura* in Ethiopia were 16%, 37%, and 30%, respectively.¹¹ In Ejaji (Shoa, Oromia) STHs were detected in 38.2% of the children, 17.9%, 16.5%, and 10.0% of the children were infected with the hookworms, *A. lumbricoides* and *T. trichiura*, respectively.¹² In a study done in Gena Bossa, the prevalence of STH was 38.3%. In Debre Tabor, the prevalence of STH was 11.8%, 7% of *A. lumbricoides*, 3.2% of hookworm, and 1.2% of *T. trichiura*.¹³

Transmission results from ingestion of eggs and contact with fecally contaminated soil. *A. lumbricoides* and *T. trichiura* are primarily spread through fecal transmission (usually ingestion of parasite eggs in feces), whereas hookworm and *S. stercoralis* are through skin penetration of infective larvae. Poverty, poor environmental sanitation, unsafe human waste disposal systems, and lack of safe water supply, low socio-economic status of the country, poor personal hygiene, frequent outdoor exposures, and the presence of environmental conditions considered as risk factors for soil-transmitted helminthic infections.¹⁴

In Ethiopia, singly there are a lot of research papers are available regarding the national magnitude of soil transmitted helminthic infections and associated risk factors in different parts of the country. In addition there are also few systematic review and meta-analysis evidences about prevalence and associated risk factors of STH in Ethiopia. However, the evidences were not recent and conducted in a single study setting (either school age children or pregnant women). Hence, due to absence of recent and comprehensive systemic review about prevalence of STH infections in Ethiopia, this meta-analysis was conducted in order to produce the pooled prevalence of soil transmitted helminthic infections and associated risk factors from available studies in Ethiopia.

Methods

Country profile

Ethiopia is located in the Horn of Africa and covers 1 104 300 km². The total land area is 1 000 000 km² (386 102 square

miles). Five countries border to Ethiopia: Eritrea to the North, Djibouti, and Somalia to the East, Sudan and South Sudan to the West, and Kenya to the South.¹⁵ The current population of Ethiopia is 113 881 451 in, 2020, based on Worldometer¹⁶ elaboration of the latest United Nations data, which is equivalent to 1.47% <https://www.worldometers.info/world-population/>. About 21.3% of the population is urban (24 463 423) people in 2020. Economically, although Ethiopia has been labeled an “emerging third world nation,” it still is struggling. The economy depends greatly on agriculture, which is responsible for 43.2% of the Gross Domestic Product and 80% of the country’s exports.¹⁵

Search strategy

The systematic review and meta-analysis were performed according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. We conducted an extensive search in PubMed, Google Scholar, Science direct, World Cat, and Cochrane Library.¹⁷ The search terms were used separately and in combination using Boolean operators like “OR” or “AND.” By using core search terms and phrases, such as “soil-transmitted helminths” OR “nematode” OR “*Necator*” OR “*Ancylostoma*” OR “*Ascaris*” OR “*Trichuris*” OR “hookworm” OR “roundworm,” OR “Geo-helminths” OR “whipworm,” “Associated factor” AND Ethiopia Since it was one of the objectives of the study to determine the prevalence and distribution of STH infections across Ethiopia, study selection was restricted to studies with clearly stated sample sizes, the number of positive samples, and study locations as well as associated risk factors (conducted between December 1, 2019 and January 13, 2020).

Criteria for inclusion and exclusion of studies

In this systematic review, different age groups like school-age children, pre-school-age children, pregnant women as well other groups from the community were involved. The articles collected through the searches were evaluated for inclusion in the meta-analysis based on the following criteria: (i) only studies containing primary data on STH, (ii) only studies conducted in the English language, (iii) cross-sectional studies, (iv) studies that reported prevalence and risk factors (v), and journals studied from 2009 to 2019 were included in the study; however, duplicate publications or extension of analysis from an original study were excluded and studies, where the full publication was obtained or completely lacked or incompletely presented needed raw data, were excluded from the study.

Data extraction

The data extraction protocol consists of the name of the country, study area, year of the study, type of study, sample size, age of participants, number of positive cases, species of STH parasites, and potential risk factors associated with individual species of STH, and diagnostic methods employed. If the year of the study did not state which year the study took place, the year of

publication was used instead. Also, if the study was conducted over a range of years then the latest year of the stated range was used.

Quality assessment

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to assess the overall quality of evidence.¹⁸ The quality of each study was declared using the 3 major assessment tools (methodological quality, comparability, and outcome and statistical analysis of the study). Two points were given to each criterion. Publications with a total score of 5 to 6 points were considered to be high, 4 points to be moderate, and 0 to 3 points to be low-quality publications.¹⁸ The association between soil-transmitted helminth parasitic infections and associated risk factors was calculated in the form of the log odds ratio. The odds ratio was calculated for the common associated risk factors of the reported studies by using STATA version 14 software.

Risk of publication bias

The risks of publication bias across studies were assessed using funnel plot symmetry and Egger's test. Egger's test (P -value $< .05$) was used to determine the presence of publication bias across studies.

Data analysis

The pooled prevalence of STH was calculated by dividing the total positive cases by the total study subjects included in this meta-analysis. Cochran's Q test and I^2 statistics were used to assess heterogeneity among the studies.¹⁹ There was a clear heterogeneity in the prevalence of STH parasitic infections across studies included in this meta-analysis; we used a random-effects model to estimate the pooled effect size. To sort out the causes of heterogeneity, we conduct a subgroup analysis based on the region of the study, the nature of study participants, study year, and sample size included in individual studies. The presence of publication bias was assessed using Egger's test and the symmetry of the funnel plot. The cause of publication bias was assessed using a sensitivity test and regression test. Forest plot format was used to present the pooled point prevalence with 95% CI. A log odds ratio was used to decide the association between associated risk factors and STH parasitic infections among respondents included in the studies. The meta-analysis was conducted using Stata software (version 14, Stata Corp, College Station, TX), where $P < .05$ was considered statistically significant.

Results

Literature search and selection

A total of 297 articles on the prevalence and associated risk factors of soil transmitted helminthic infections in Ethiopia

were retrieved. Eighty-four of these articles were excluded due to duplicates. From the remaining 213 articles, 61 were excluded after review of their titles (titles were not related to soil transmitted helminthic infections) and 48 were excluded after review of abstracts (lack of full information about soil transmitted helminthic infections). The remaining 104 full-text articles were accessed and assessed for eligibility based on the inclusion criteria and information indicated in the data extraction protocol. As a result, 58 articles were further excluded in the data extraction protocol. From the remaining 46 articles 5 of them were removed due to lack OR, 95% CI, and the number of positive cases (meaning the report was only based on estimated prevalence percent). Thus, only 41 (13.8%) of the studies met the eligibility criteria and were included in the final systematic review and meta-analysis study (Figure 1).

Characteristics of the eligible studies

Table 1 presents the characteristics of the studies meta-analyzed. Forty-one (41) studies were eligible and thus were included in the meta-analysis. Studies were conducted between 2009 and 2019 and all of them were cross-sectional studies. Fifteen, sixteen, and ten of the studies were carried out between 2009 and 2012, 2013 and 2015 as well as 2017 and 2019, respectively. This review is based on the criteria of 5 regions, such as Amhara (15 articles), Oromia (8 articles), Southern part of Ethiopia (13 articles) Tigray (4 articles), and from Harari one article were involved. Five studies were carried out within the hospital, another 5 were within the community, and 31 were in school settings. The prevalence of STH infections among eligible studies ranged between 0.47% and 74.3% (Table 1).

Quality of studies included in the meta-analysis

The quality score of each original study ranged between 4 and the highest 6 (Table 1). The overall quality of the articles included in this meta-analysis is very good.

Risk of publication bias across studies included in the meta-analysis

The funnel plot symmetry demonstrates the presence of publication bias among studies included in this meta-analysis (Figure 2). Similarly, the Egger's test results ($P < .05$) indicate publication bias among studies.

Pooled prevalence of soil-transmitted helminthic infections

A random-effects model was employed to estimate the pooled prevalence of STH infections in Ethiopia. The overall national prevalence of STH infections was 36.78% (95% CI: 28.79-44.77) (Figure 3).

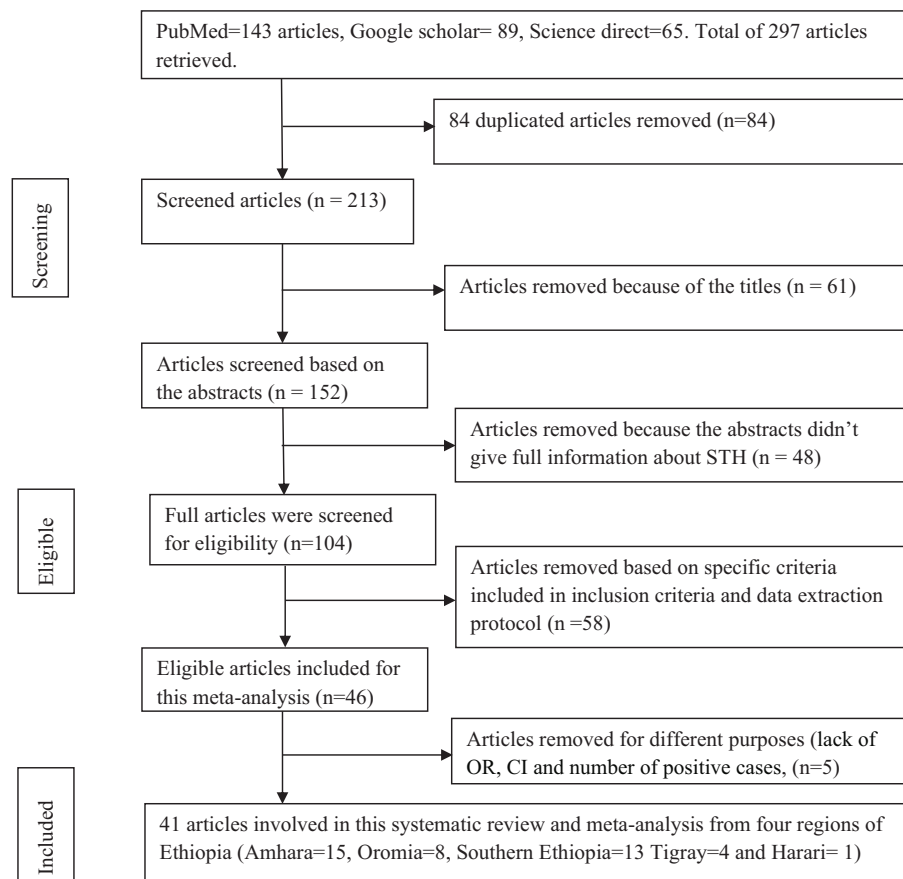


Figure 1. PRISMA flow diagram of articles considered for the review on STH infections among the Ethiopian population.

Table 1. List and characteristics of 41 eligible studies.

AUTHOR	STUDY YEAR	REGION	STUDY SETTING	SAMPLE SIZE	CASE	PREVALENCE (95% CI)	QUALITY ASSESSMENT
Alemu et al	2009	Amhara	School based	319	138	43.3 (37.8-48.9)	6
Mekonnen et al	2009	Oromia	Community-based	1021	600	58.8 (55.7-61.8)	6
Alelign et al	2010	Amhara	School-based	384	211	54.9 (49.8-59.9)	6
Tekeste et al	2010	Amhara	School-based	316	87	27.5 (22.7-32.8)	4
Adissu and Asmamaw	2011	Amhara	School-based	365	76	20.8 (16.8-25.4)	4
Getachew et al	2011	Oromia	Hospital-based	388	159	41.1 (36.0-46.0)	6
Teklemariam et al	2011	Tigray	School-based	480	32	6.7 (4.6-9.3)	5
Abera and Nibert	2012	Amhara	School-based	385	169	43.9 (38.9-49.0)	6
Abossie and Seid	2012	SNNPR	School-based	400	290	72.5 (67.8-76.8)	5
Alemu et al	2012	SNNPR	School-based	405	67	16.5 (13.1-20.5)	5
Debalke et al	2012	Oromia	School-based	366	233	63.7 (58.5-68.6)	5
Gelaw et al	2012	Amhara	School-based	304	36	11.8 (8.4-16.0)	6
Mathewos et al	2012	Amhara	School-based	261	144	55.2 (48.9-61.3)	4
Terefe et al	2012	Harari	School-based	644	3	0.47(0.001-0.01)	5
Ephrem et al	2012	Oromia	Community-based	234	111	47.4 (40.9-54.0)	4
Seid et al	2013	Tigray	School-based	442	29	6.6 (4.4-9.3)	5
Abdi et al	2014	Amhara	School-based	408	273	66.9 (62.1-71.5)	6

(Continued)

Table 1. (Continued)

AUTHOR	STUDY YEAR	REGION	STUDY SETTING	SAMPLE SIZE	CASE	PREVALENCE (95% CI)	QUALITY ASSESSMENT
Derso et al	2014	Amhara	Hospital-based	384	53	13.8 (10.5-17.7)	5
Afewerk et al	2014	Amhara	School based	384	252	65.6 (60.6-70.4)	5
Alemayehu and Tomass	2014	SNNPR	School-based	374	278	74.3 (69.6-78.7)	5
Andualem	2014	Amhara	School based	358	125	34.9 (29.9-40.1)	5
Shumbej et al	2014	SNNPR	Community-based	377	88	23.3 (19.2-27.9)	4
Alemu et al	2015	Amhara	Community-based	401	98	24.4 (20.3-28.9)	5
Emana et al	2015	Oromia	School based	302	117	38.7 (33.2-44.5)	6
Samuel et al	2015	Oromia	School-based	321	41	12.8 (9.3-16.9)	6
Tadege and Shimeli	2015	SNNPR	School-based	374	197	52.4 (47.5-57.8)	6
Zerdo et al	2015	SNNPR	School-based	410	165	40.4 (35.5-45.1)	6
Feleke and Jember	2016	Amhara	Hospital based	783	459	58.6 (55.1-62.1)	6
Ibrahim et al	2016	Oromia	School based	340	151	44.4 (39.0-49.9)	5
Mengist et al	2016	Oromia	Hospital-based	372	92	24.7 (20.4-29.4)	5
Tekalign et al	2016	SNNPR	Community-based	377	265	70.3 (65.4-74.9)	6
Alemu et al	2017	SNNPR	School-based	391	121	30.9 (26.4-35.8)	6
Eyamo et al	2017	SNNPR	School-based	384	200	52.0 (46.9-57.2)	4
Teshale et al	2017	Tigray	School-based	410	26	6.3 (4.2-9.2)	6
Sitotaw et al	2017	Amhara	School-based	406	63	15.5 (12.1-19.4)	6
Weldesebet et al	2017	SNNPR	School-based	600	57	9.5 (6.5-11.2)	5
Alemu et al	2018	SNNPR	School-based	351	70	19.9 (15.9-24.5)	6
YarinbabErgat and Darcha	2018	SNNPR	School based	303	116	38.3 (32.8-44.0)	4
Gebrehiwet et al	2018	Tigray	Hospital-based	448	241	53.4 (49.0-58.5)	5
Molla and Mamo	2018	SNNPR	School-based	443	239	54 (49.2-58.7)	6
Workineh et al	2019	Amhara	School based	340	45	13.2 (9.8-17.3)	6

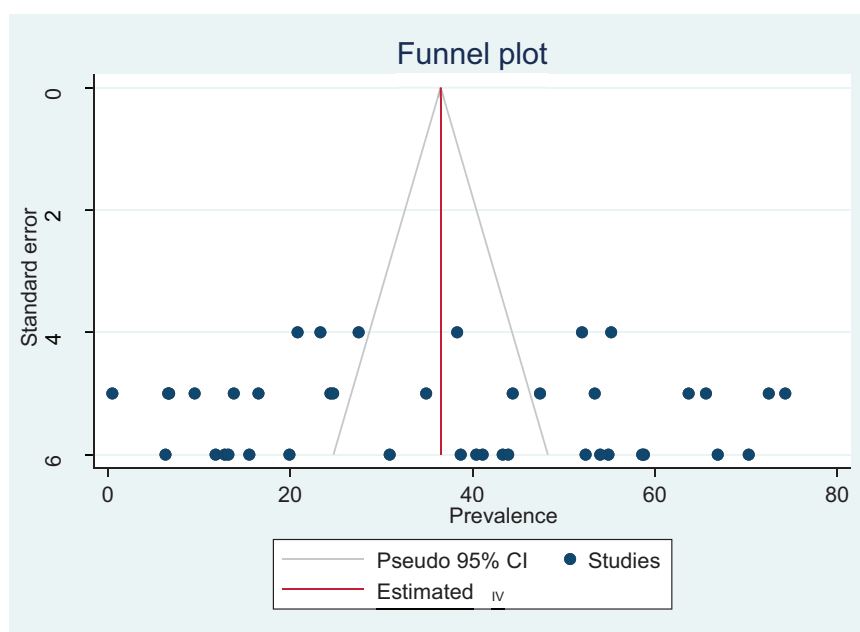


Figure 2. Funnel plot indicate publication bias across studies in this meta-analysis.

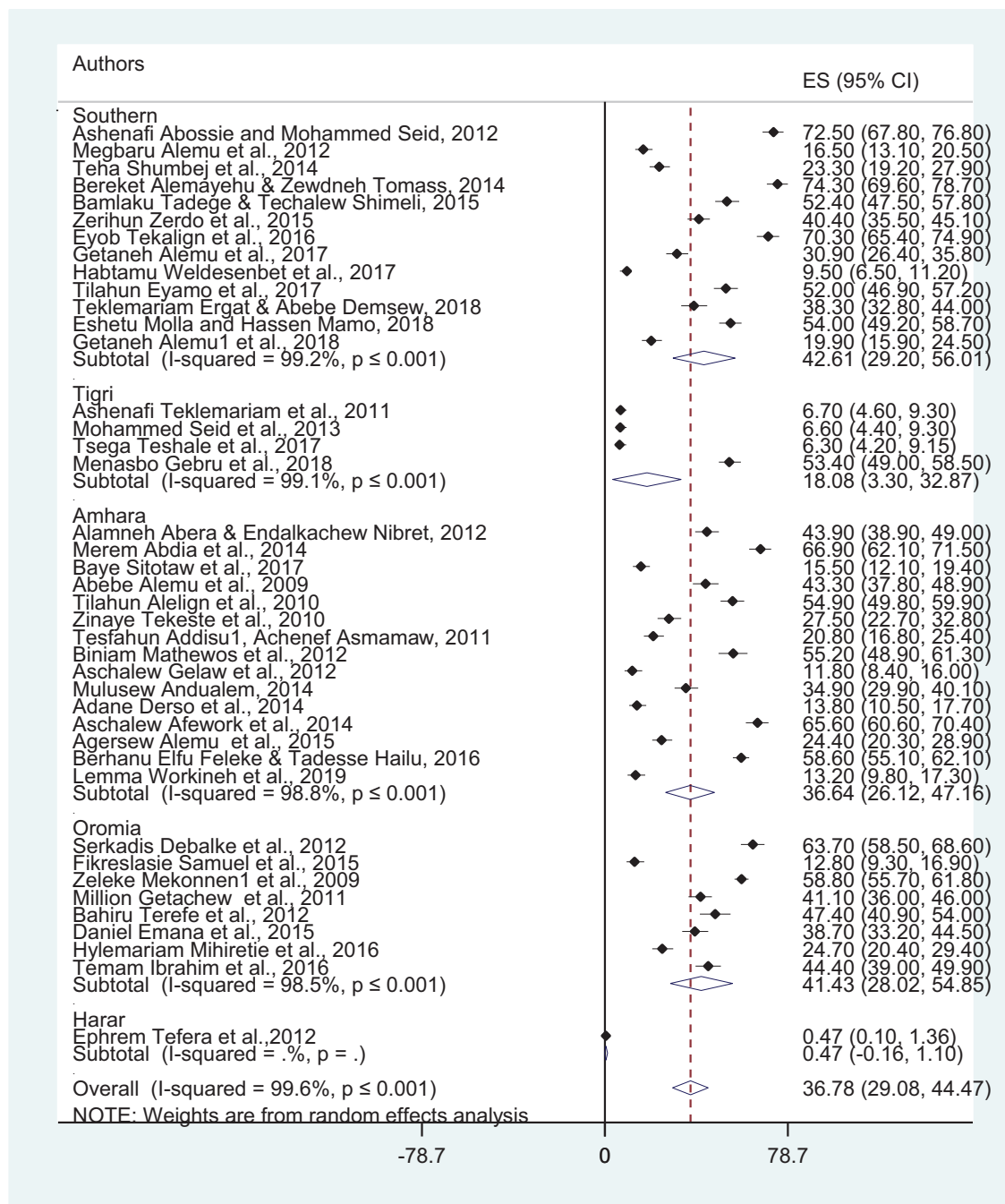


Figure 3. Forest plot for the overall prevalence of STH infections in Ethiopia.

Subgroup analysis. High pooled prevalence of STH infection was reported from SNNPR 42.61% (95% CI: 29.20-56.01), followed by Oromia 41.43% (95% CI: 28.02-54.85) and Amhara 36.64% (95% CI: 26.12-47.16), whereas the low prevalence of STH infections was observed in Harar 0.47% (95% CI: 0.10-1.36) followed by Tigray region 18.08% (95% CI: 3.30-32.87) (Figures 3 and 4).

In the study setting highest pooled prevalence estimate was 44.84% (95% CI: 26.14-63.53) in the community-based studies followed by hospital-based studies 38.31% (95% CI: 20.03, 56.59) and the least was 35.22% (95% CI: 26.89-43.56) in school-based studies (Figure 5).

In the study period the highest pooled prevalence estimate was recorded between 2013 and 2016; 40.73% (95% CI: 28.79-52.66) followed by the study period between 2009 and 2012 with pooled prevalence estimate was 37.59% (95% CI: 23.47, 51.72) and the least was recorded in between 2017 and 2019; 29.21% (95% CI: 17.94, 40.48) (Figures 6-8).

Common STH infections in Ethiopia. *A. lumbricoides* had the highest pooled prevalence estimate of 17.63% (95% CI: 14.30-20.96) followed by hookworms 12.35% (95% CI: 9.91-14.79), *T. trichiura* 7.24% (95% CI: 5.84-8.63) and *S. stercoralis* 2.16% (95% CI: 0.97-3.35), respectively (Figures 6-9).

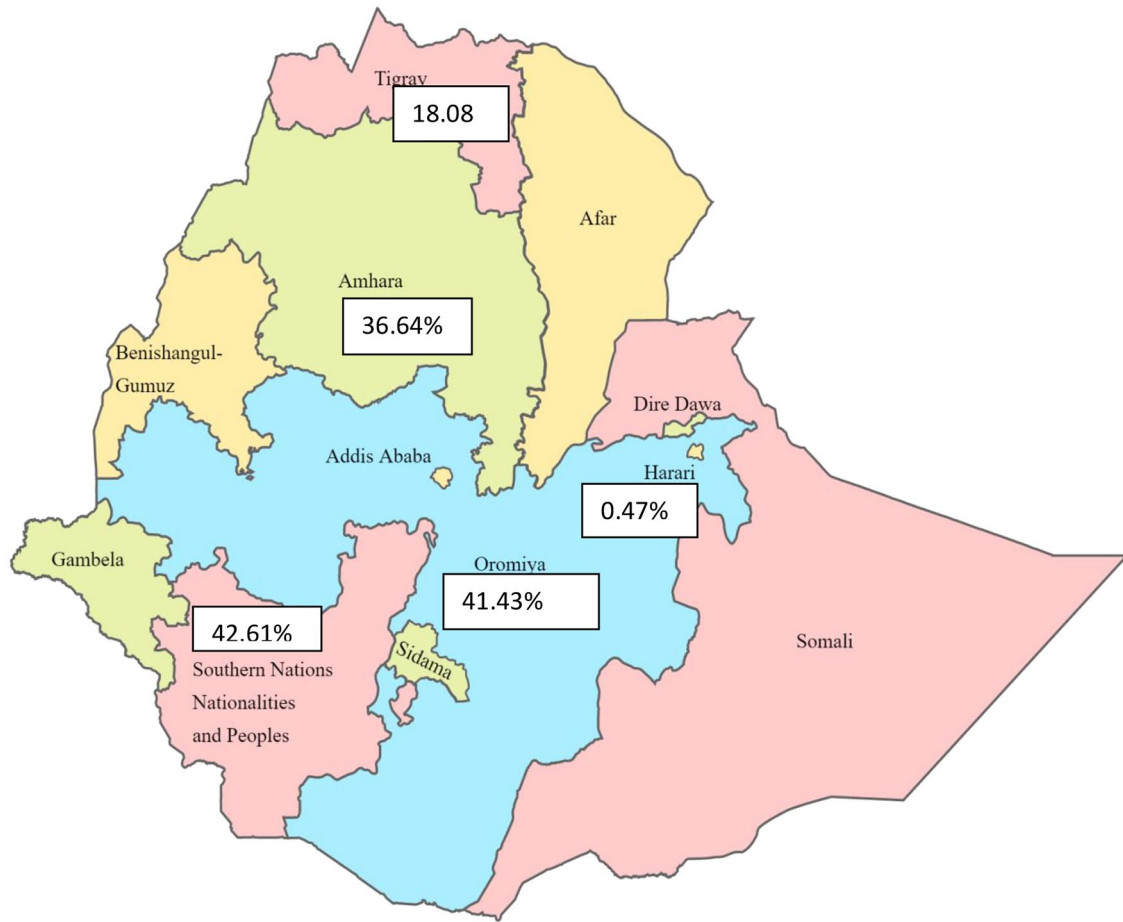


Figure 4. Regional distribution of STH in Ethiopia.

Factors associated with STH infections in Ethiopia

In this Meta-analysis, we have reviewed several potential risk factors associated with STH infections in Ethiopia. Age, sex, residence, open field defecation, lack of hand washing habit, the habit of eating raw and unwashed fruit and vegetables, shoe wearing habits, family education level, and fingernail trimming and cleanness habits were associated with STH infections.

The association between age and STH infection in people of Ethiopia was computed from 14 studies (1, 3, 8, 12, 14, 22, 27-29, 33, 35, 37, 38, 41). Age (children up to 14 years) was significantly associated with the prevalence of STH parasitic infections. The odds of having STH in children (up to 14 years) were 2.23 times higher than those in adults (95% CI: 1.68-2.77) (Figure 13).

The association between residence and STH infections was analyzed from 5 studies (11, 20, 21, 28, and 41). People who live in a rural setting were 1.22 times (95% CI: 0.00-2.44) more likely to be infected with STH parasitic infections than people who live in urban areas (Figure 12). The pooled results of 18 studies (3, 7, 8, 9, 12, 18, 21-24, 26, 28, 33-35, 37, 39, 41) showed that lack of handwashing habits were strongly associated with infection with STH infections in Ethiopia. The odds

of having STH parasitic infections was 3.16 times (95% CI: 2.05-4.27) higher among people who did not wash their hands after defecation than people who wash their hands (Figure 15).

The association between the habits of eating raw, unwashed fruits and vegetables with STH parasitic infections was evaluated from 6 studies (26, 28, 30-32, 35). But in this study people who had habits of eating raw, unwashed fruits and vegetables are not significantly associated with STH (Figure 17). The association between fingernail trimming and cleanness habits and STH parasitic infection in the people of Ethiopia was computed from 7 studies (7, 8, 15, 22, 29, 33, 41). The pooled results showed that individuals with poor fingernail trimming and cleanness habits were 1.28 times (95% CI: 0.65-1.91) more likely to be infected with STH parasitic infection than their counterparts (Figure 18).

The association between family education level and STH parasitic infection in the people of Ethiopia was computed from 4 studies (21, 28, 30, 34). The pooled results showed that uneducated families were 1.76 times (95% CI: 0.17-3.35) more likely to have STH parasitic infections than those who were educated (Figure 19). The pooled results of 9 studies (3, 8, 17, 21, 23, 28, 35, 38, 39) showed that lack of shoe-wearing habits was strongly associated with STH parasitic infection among

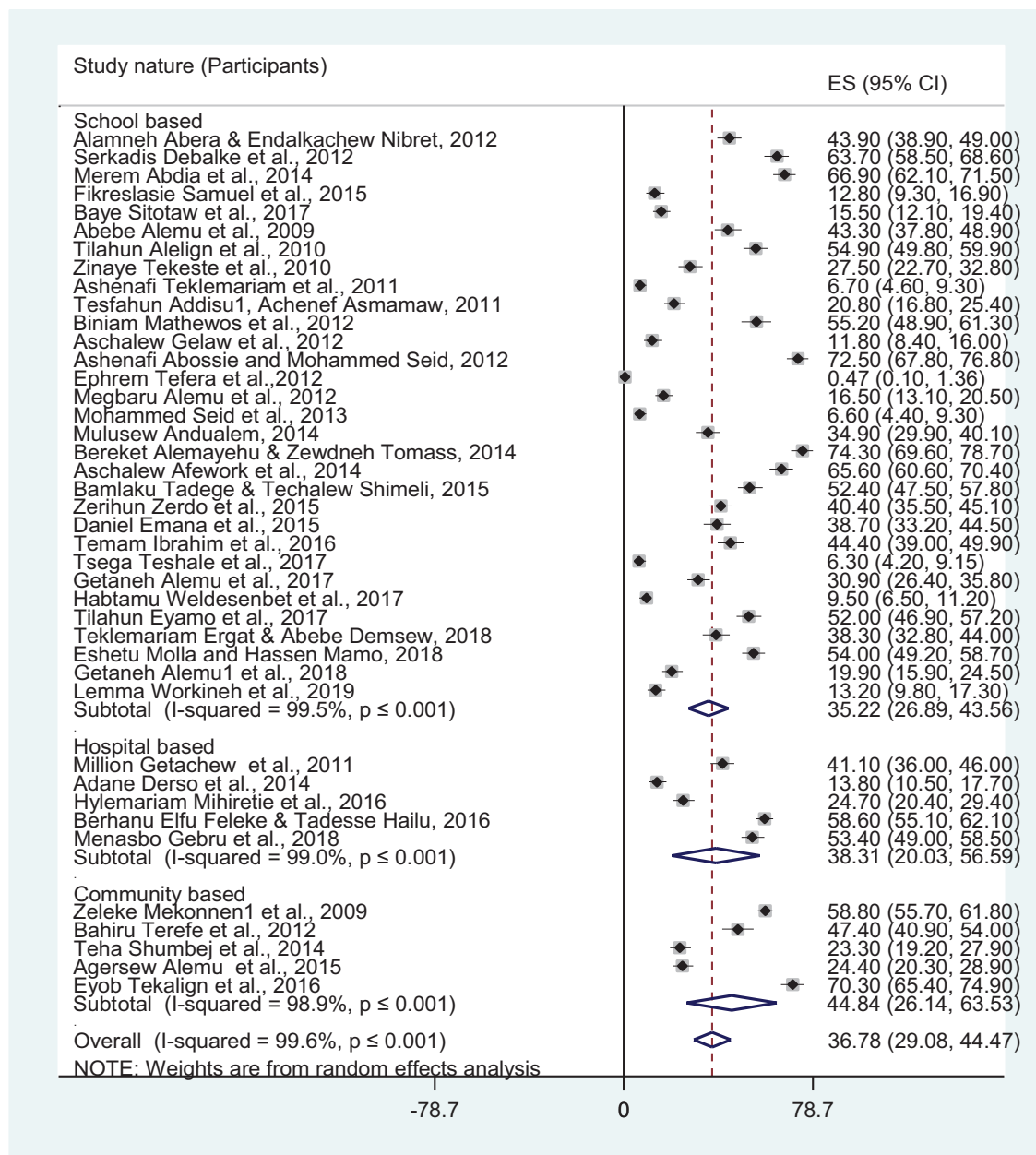


Figure 5. The overall prevalence of STHs in Ethiopia by study nature (participants).

people in Ethiopia. In the analysis lack of shoe-wearing habits in the people were 2.52 times (95% CI: 1.22-3.82) more likely to be infected with STH parasitic infections than who had the habit of wearing shoe (Figure 20).

The association between open field defecation and intestinal protozoan parasitic infection among people in Ethiopia was conducted in 14 studies (7, 9, 16, 21, 24, 26, 28-31, 34, 35, 38, 41). People who practiced open field defecation were 2.25 times (95% CI: 1.44-3.06) more likely to have STH parasitic infections than those who did not practice open field defecation (Figure 21).

Discussion

The present study was designed to complement global efforts toward the control of neglected tropical diseases by providing useful epidemiological data that will aid their control. The

study provides information on endemic species of STHs, their national and regional prevalence, their distribution with regions, species, periods, and settings. The findings will (i) help in assessing successes of sporadic STHs control programs in Ethiopia which usually target children and pregnant women (ii) provide information that will serve as a guide for targeted and cost-effective control which is a subject of debate globally.²⁰

The overall pooled prevalence of STH parasitic infection in the present study was 36.78%. The study was following the result in Chench town 36.8%²¹ and Gena Bossa 38.3%.²² The result was higher than the report in Rwanda 25.4%.⁷ However, the prevalence was less than 54.8%⁹ reported in Nigeria and Indonesia at 57.4%.²³ This variation could be due to the topographic and study period difference in which the communities

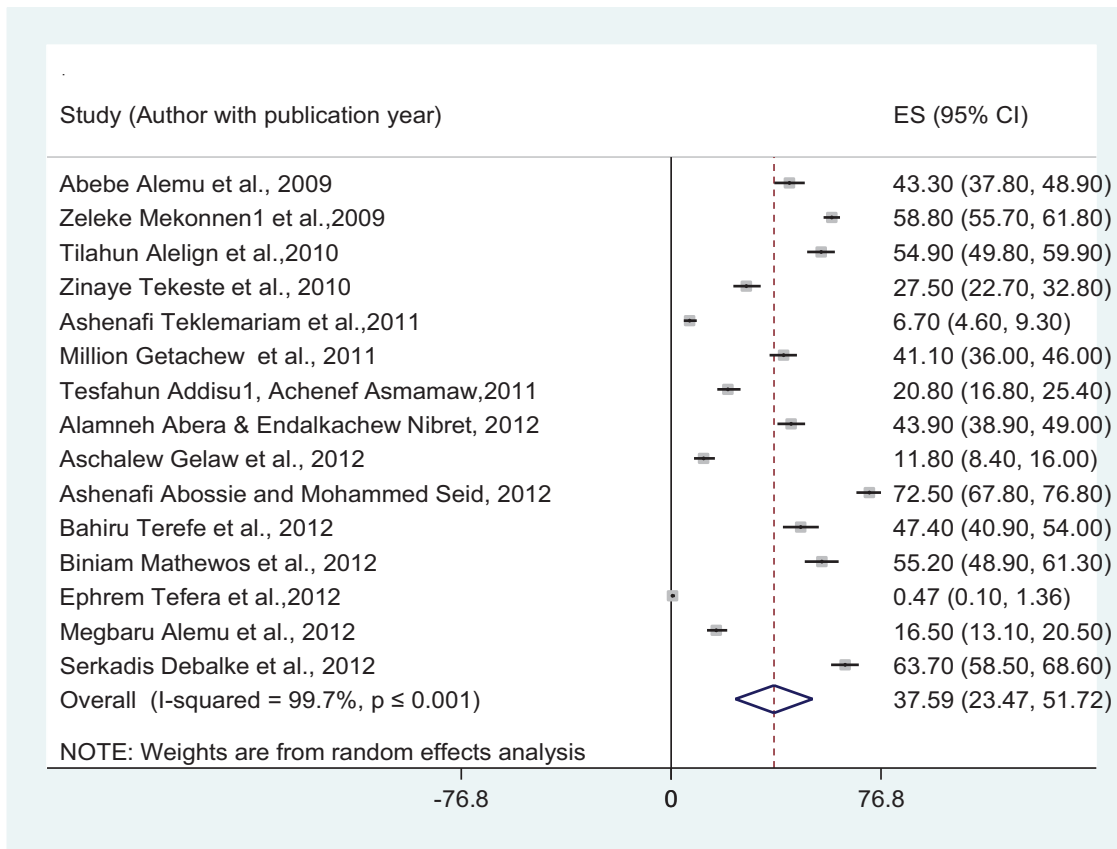


Figure 6. Pooled prevalence of STH infections from 2009 to 2012.

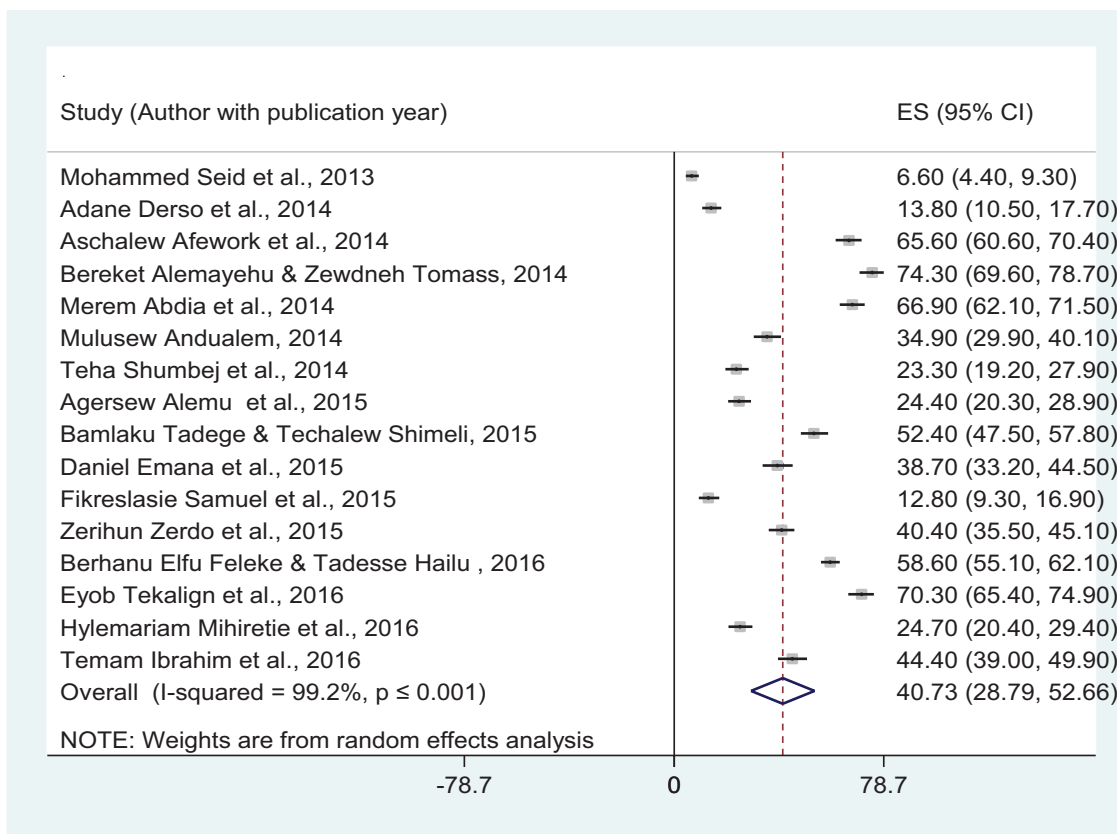


Figure 7. Pooled prevalence of STH infections from 2013 to 2016.

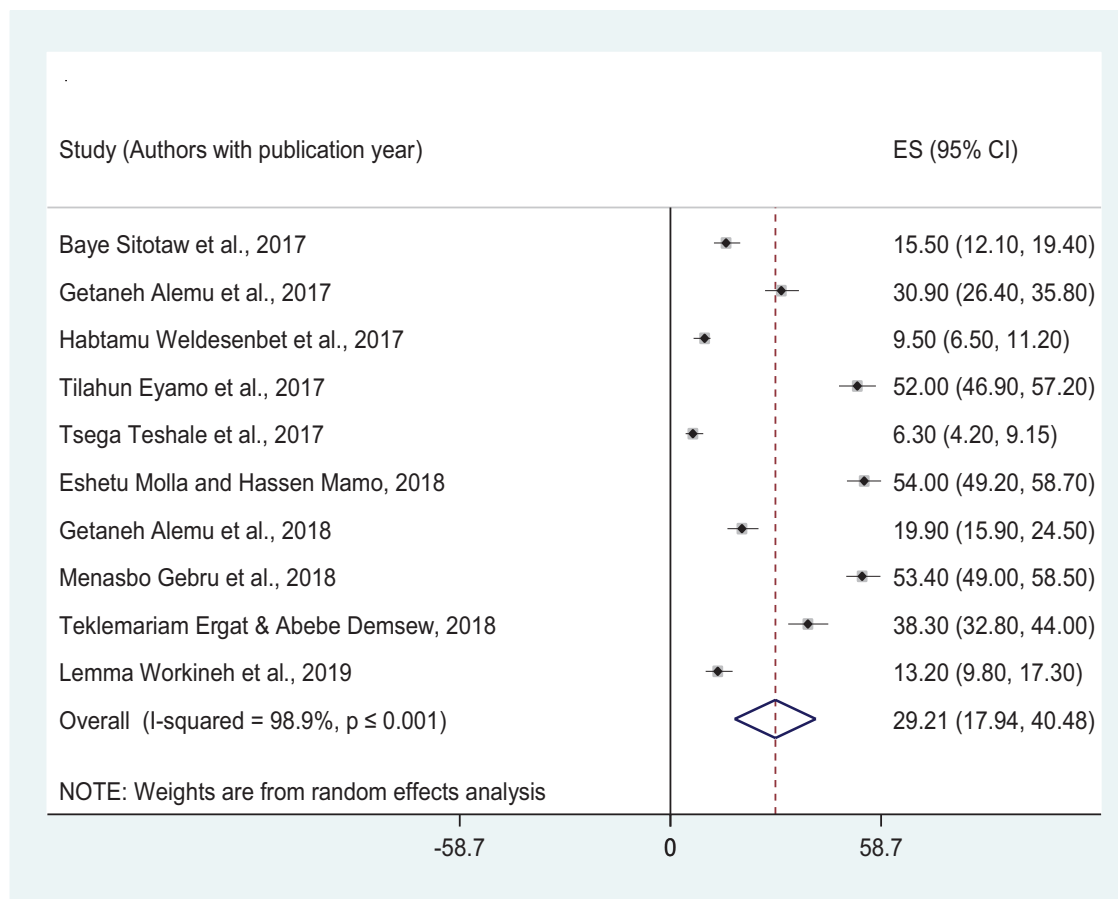


Figure 8. Pooled prevalence of STH infections from 2017 to 2019.

would improve their living standard, personal and environmental hygiene through time.

From regions the highest pooled prevalence estimate of STH was 42.61% in Southern Ethiopia. The finding in Nigeria with the prevalence of STH was 54.8%.⁹ The result in Rwanda STH infections was 65.8%.²⁴ On the other hand, the result was greater than the report in Cameroon 24.1%,²⁵ and the result in Nigeria 8.3%.²⁶ This variation may be due to environmental factors such as temperature, humidity, soil moisture, and rainfall. Other factors may be differences in levels of hygiene and sanitation, environmental contamination²⁷ as well as the specificity and sensitivity of the diagnostic methods employed by the individual studies. This suggests that this region may be the most endemic for STHs in Ethiopia. Since cost-effective control requires knowledge of the community for the correct choice of anthelmintic strategy, this information may be useful for stakeholders in STHs control. The lower prevalence was 0.47% reported in the Hareri region. The finding was almost similar to the result in central Kenya 0.2%.²⁸ The low prevalence may be attributable to the extremely high temperature in these regions which may not support the environmental survival of eggs and larvae of these parasites.

Studies carried out in communities and in hospitals other than school-based were recorded the highest pooled prevalence estimates probably due to the sporadic STHs control programs in Ethiopia, which usually target school and hospitalized

children. However, the burden of these parasites is not restricted to children.⁹

In the study period 2009 to 2012 (37.59%) pooled prevalence estimate was recorded; however, the average coverage increases from 2003 to 2013 as a trend in the region of Southeast Asia.²⁹ This may be due to limited access of mass drug administration to different areas and lack of awareness creation to the society. The pooled prevalence was increased between 2013 and 2016 (40.73%); this can be mass drug administration was not given properly and the stakeholders gave less attention to the infection. However, in the period from 2017 to 2019, the pooled prevalence estimate was (29.21%) which is less than the other study periods. This might be due to awareness creation of the societies, access to education to school children, and proper mass drug deworming programs for school-age children.

The species of STH infection reported in Ethiopia during the period under review are similar to those reported in other sub-Saharan African countries like Kenya.³⁰ This finding shows that these parasites are still endemic in the region suggesting that extra efforts are required to achieve the WHO's goal of eradication in sub-Saharan Africa by 2020.

A. lumbricoides was the most prevalent species 17.8% of STHs reported during the period under review which is in agreement with the study in South Asia 18%,⁸ in South Africa

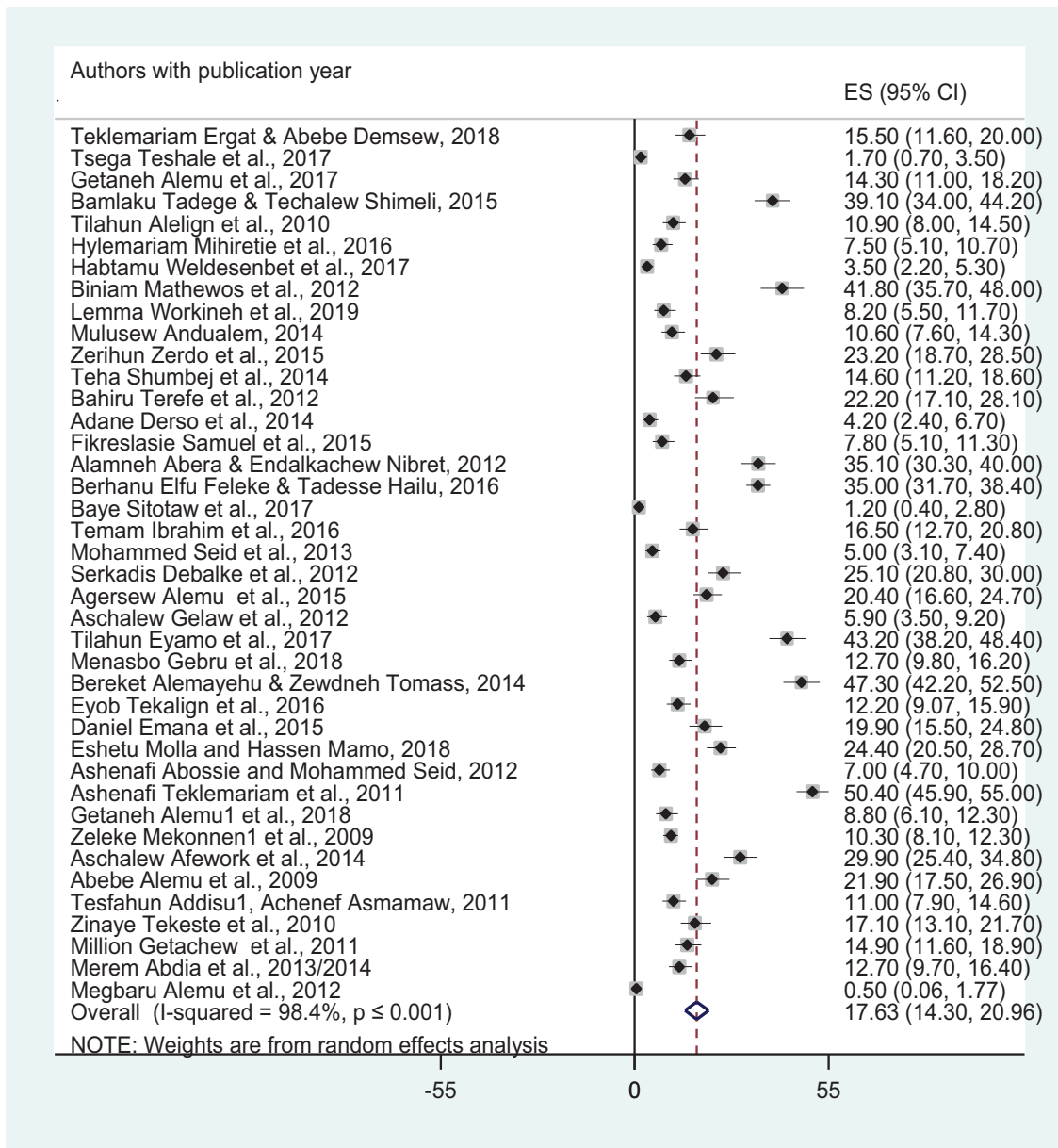


Figure 9. Prevalence of *A. lumbricooides*.

18.3%³¹ and the study in Ejaji Ethiopia 16.5%.¹² But, it is greater than the study in Debre Tabor the prevalence of 7% of *A. lumbricooides*.¹³ The high prevalence of *A. lumbricooides* observed by the present study may be attributable to high environmental contamination resulting from a large number of infected people, the durability of *Ascaris* eggs under varying environmental conditions³² the high fecundity³³ as well as the sticky nature of the shell of *Ascaris* egg³⁴ which aids its attachment on human hands, fruits, and vegetables.

In the current study pooled prevalence estimate of hookworm was 12.4%. This result was comparable with the study done in Arba Minch Zuria district, the prevalence was 14.5%.³⁵ However, the result was greater than the report in Debre Tabor 3.2%¹³ and the report from Babile 6.7%.³⁶ On the contrary to the present finding, higher rates of hookworm were reported near Lake Awassa 62.5%,³⁷ Langano 64.7%,³⁸ and Southwest

Ethiopia 40.8%.³⁹ This variation might be due to altitude, environmental, socio-economic, and behavioral differences of the residences.

The pooled prevalence estimate of *T. trichiura* was 7.24% in this study and this is in line with the result in Ejaji 10.0%¹² and the study in Yirgacheffe 7.2%.⁴⁰ Nevertheless, the result was greater than the result conducted in rural areas of southern Thailand at 2.1%,⁴¹ in rural western Uganda 0.2%,⁴² and Maysbri 2.2%.⁴³ On the contrary, the result was lower than the study conducted in South Asia (14%)⁸ and Nigeria 31.9%.⁹ This difference could be due to the environmental and study period difference. People living in tropical and subtropical areas of the world are at the highest risk of infection by *T. trichiura*. In addition to this populations without reliable access to safe water and sanitation elsewhere are also at increased risk of this infection.

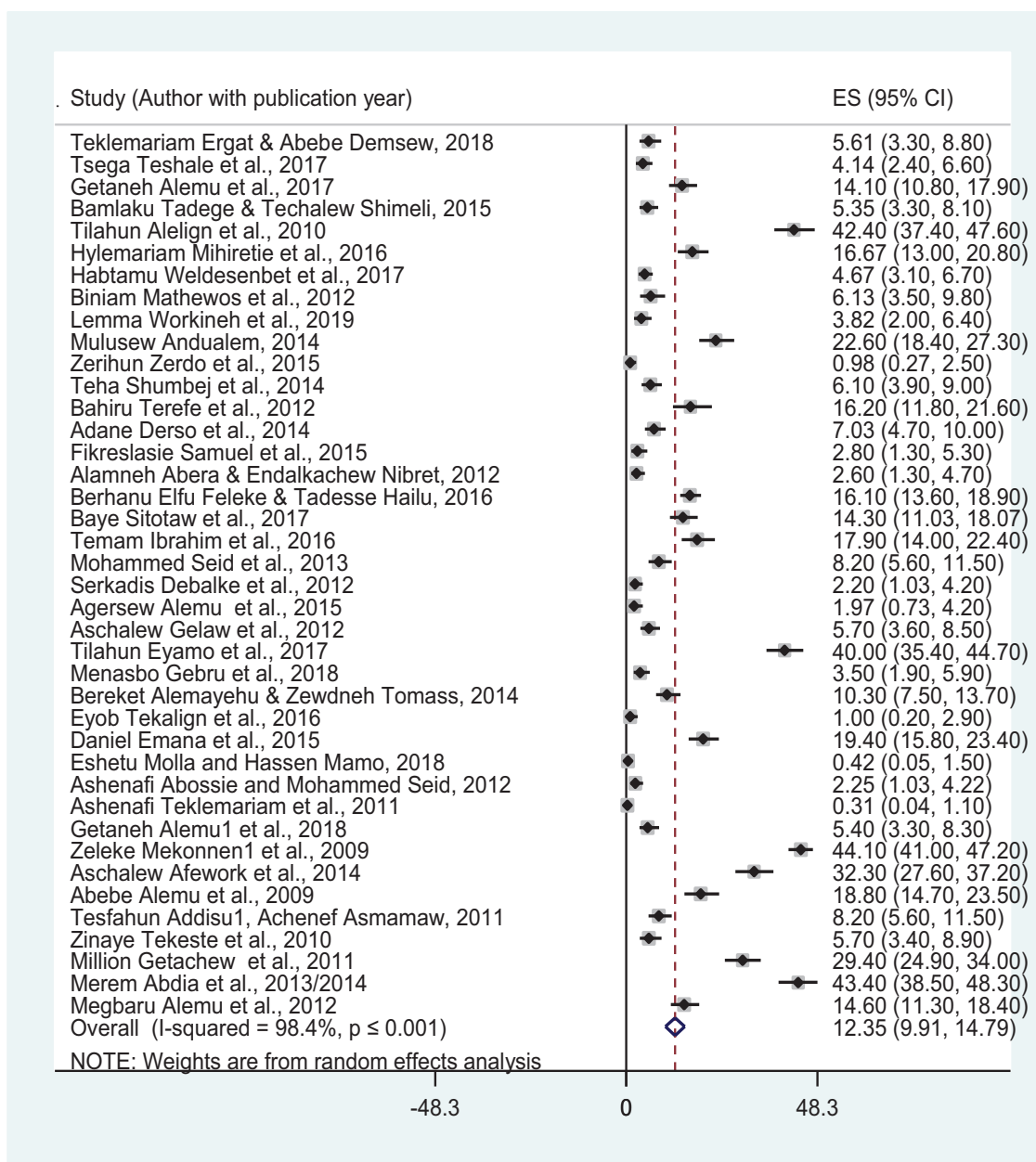


Figure 10. Prevalence of hookworm.

In this study the prevalence of *S. stercoralis* was 2.16%. And the result is in agreement with the study in Nigeria 3.4%.⁹ The study done in Gena Bossa Ethiopia 3.3%²² and the result reported from Bahir Dar town is 2.6%⁴⁴ However, it was lower than the result in Mecha town 7.5%.⁴⁵ The low prevalence of *S. stercoralis* may be due to its' peculiar characteristics that require different diagnostic methods than other STH, and for this reason, is frequently not identified.

Associated risk factors of soil-transmitted helminths

The AOR of age that is associated with soil-transmitted helminth parasitic infection in the Meta-analysis was 2.23 (95% CI: 1.68-2.77) (1, 3, 8, 12, 14, 22, 27-29, 33, 35, 37, 38, 41). This finding was in agreement with the findings in Umolante

district (Southern Ethiopia)⁴⁶ infections are more prevalent in the age groups 10 to 14 years in the study area. This is an indication that younger children are more exposed since they usually play in the open fields⁴⁷ and they frequently involve themselves fully in activities that bring them in contact with the source of infection.⁴⁸ Another study conducted elsewhere also showed the highest infection rates among the age groups 5 to 14 years.⁴⁹ However, a report from Mizan Aman town has shown that younger children were more infected with intestinal parasites.⁵⁰ This is perhaps, children in these age groups are more engaged in outdoor activities like farming as a result they have more exposure to those STH parasitic infections.

The AOR of sex in the current systematic review was 0.88 (95% CI: 0.39-1.37) (7, 11, 14, 21, 31, 41). This finding was in line with the finding in the Umolante district (Southern

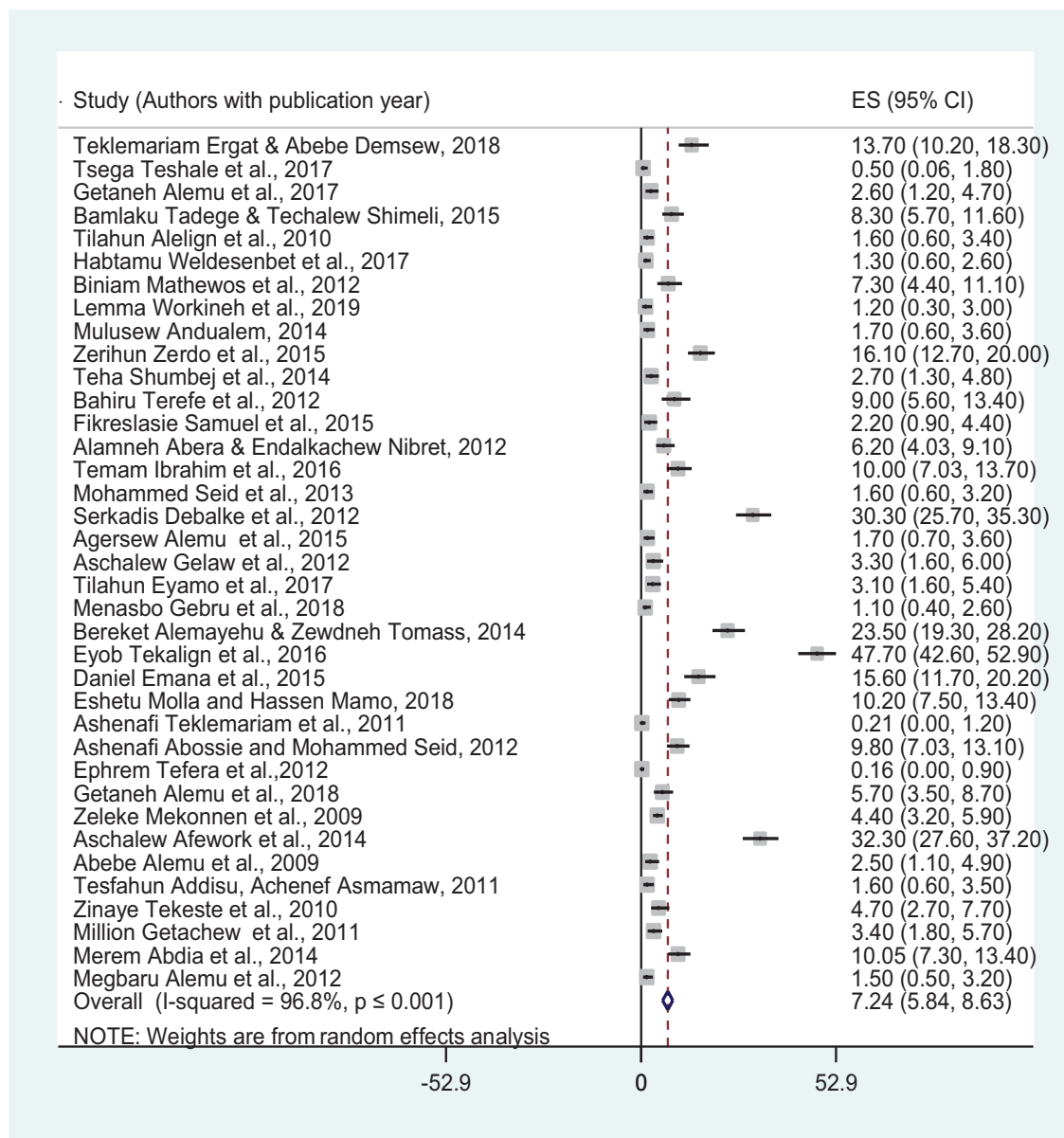


Figure 11. Prevalence of *Trichuris trichura*.

Ethiopia)⁴⁶ and Jimma town.⁵¹ This might be due to environmental factors, such as frequent exposure of an individual to the soil, the probability to contact with fecal materials, lack of safe water supply, and poverty.

Besides, people who live in a rural setting were having an AOR of 1.22 (95% CI: 0.00, 2.44) (11, 20, 21, 28, 41). The result was similar to the result in Sekela Primary School, Western Ethiopia⁵² and with the report in Brazil.⁵³ This could be due to the reason that rural people have less access to water, lack of environmental sanitation, and poor personal hygiene.

Among associated risk factors, hand washing habit before the meal was 3.16 (95% CI: 2.05-4.27) folds higher among people that didn't have regular hand washing habit (3, 7, 8, 9, 12, 18, 21-24, 26, 28, 33-35, 37, 39, 41). This finding was in line with the previous study conducted in Nigeria,⁵⁴ in Indonesia,²³ in Sekela Primary School, Western Ethiopia,⁵² and in Bazou

(West Cameroon) lack of hand washing habit before the meal was also reported as a risk factor for STH infection.⁵⁵ This might be due to the reason that proper hand washing practices break the chain of transmission for soil-transmitted helminthic parasitic infection.

Concerning the odd ratio of eating raw and unwashed fruits and vegetables is 1.88 times (95% CI: 1.45-2.31) greater from people eating cooked and washed fruit and vegetables (26, 28, 30-32, 35). But not significantly associated with STH. The result is following the result in Sekela Primary School, Western Ethiopia,⁵² and the results in Birbir town.⁵⁶ This could be due to washing fruits and vegetables before consumption reduces the risk of acquiring parasitic infection.

The association between fingernail trimming and cleanness habits and STH parasitic infection in the people of Ethiopia was computed from 7 studies (7, 8, 15, 22, 29, 33, 41). The

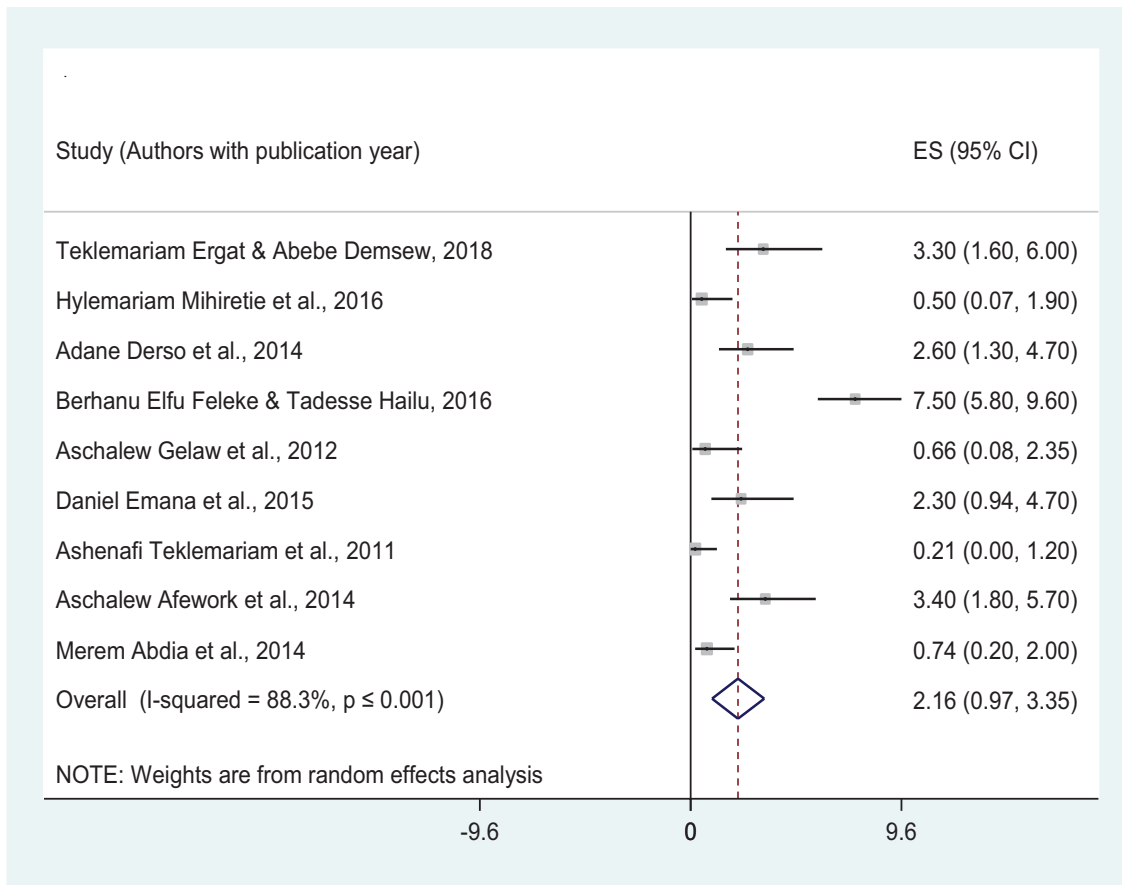


Figure 12. Prevalence of *S. stercoralis*.

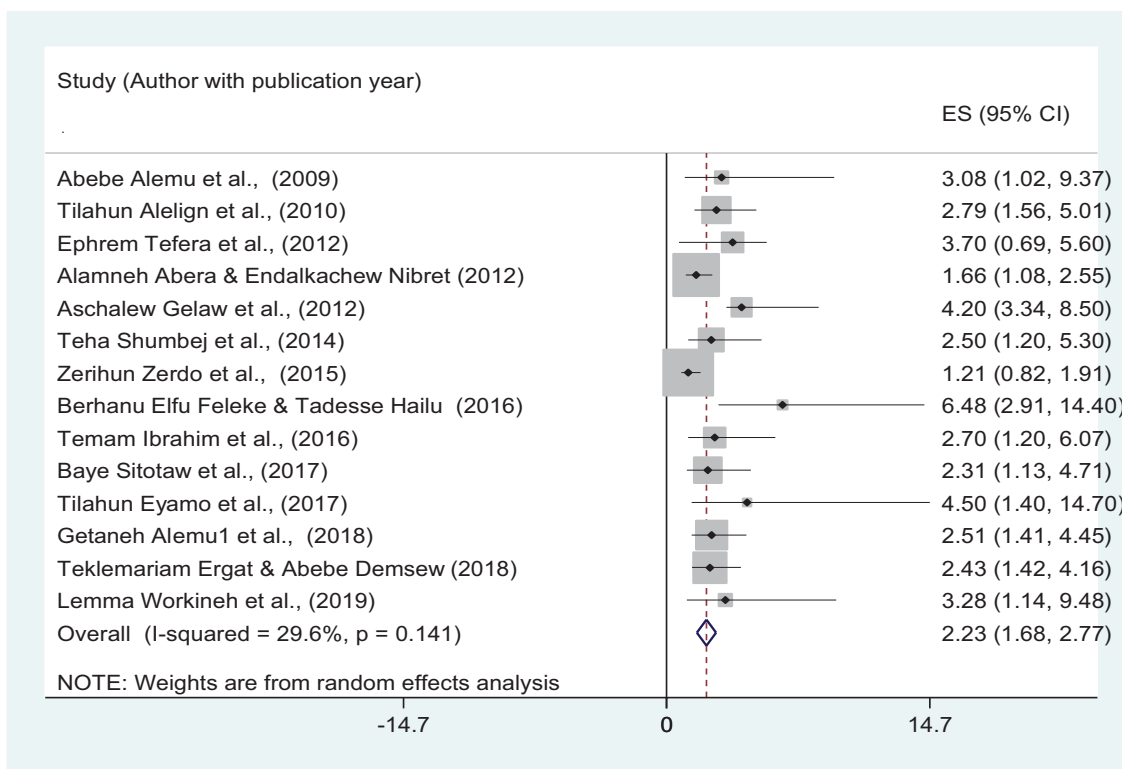


Figure 13. Pooled prevalence OR of age.

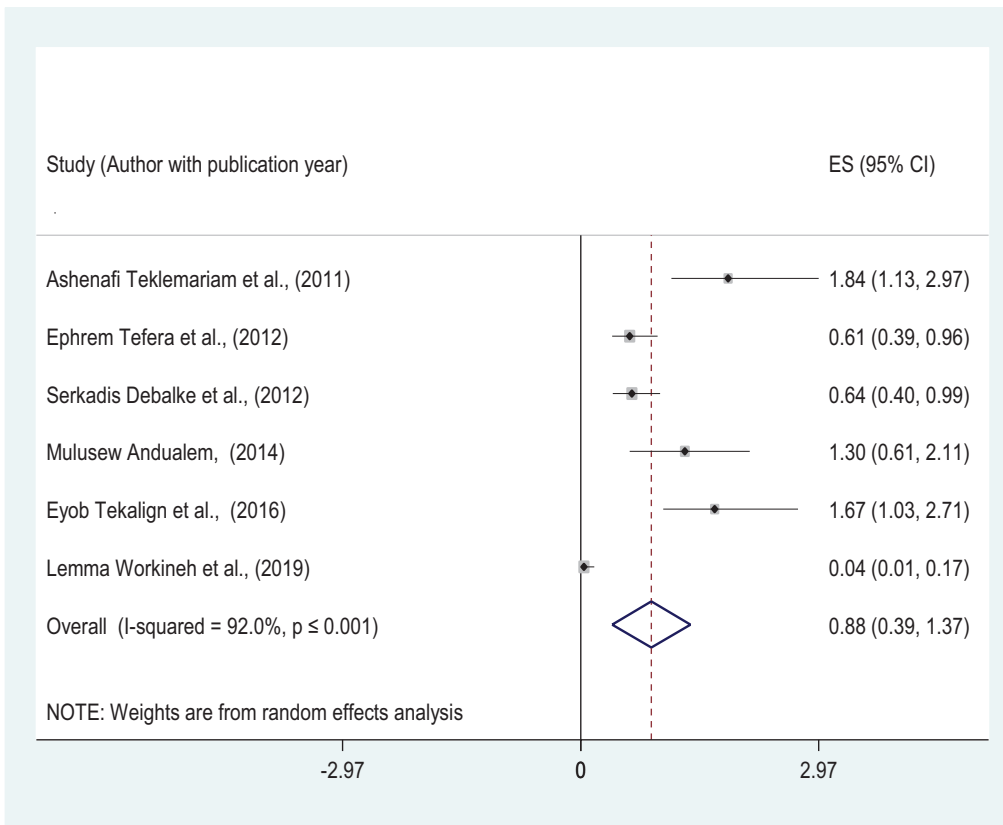


Figure 14. Pooled prevalence in sex.

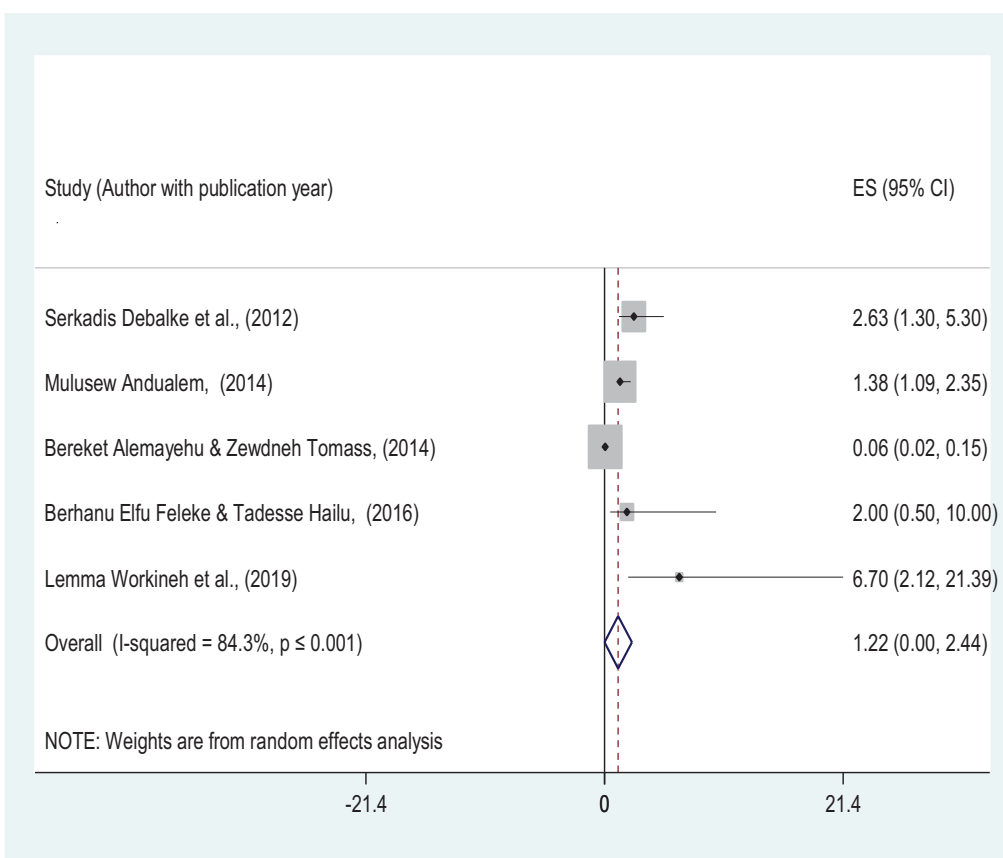


Figure 15. Pool prevalence of residence.

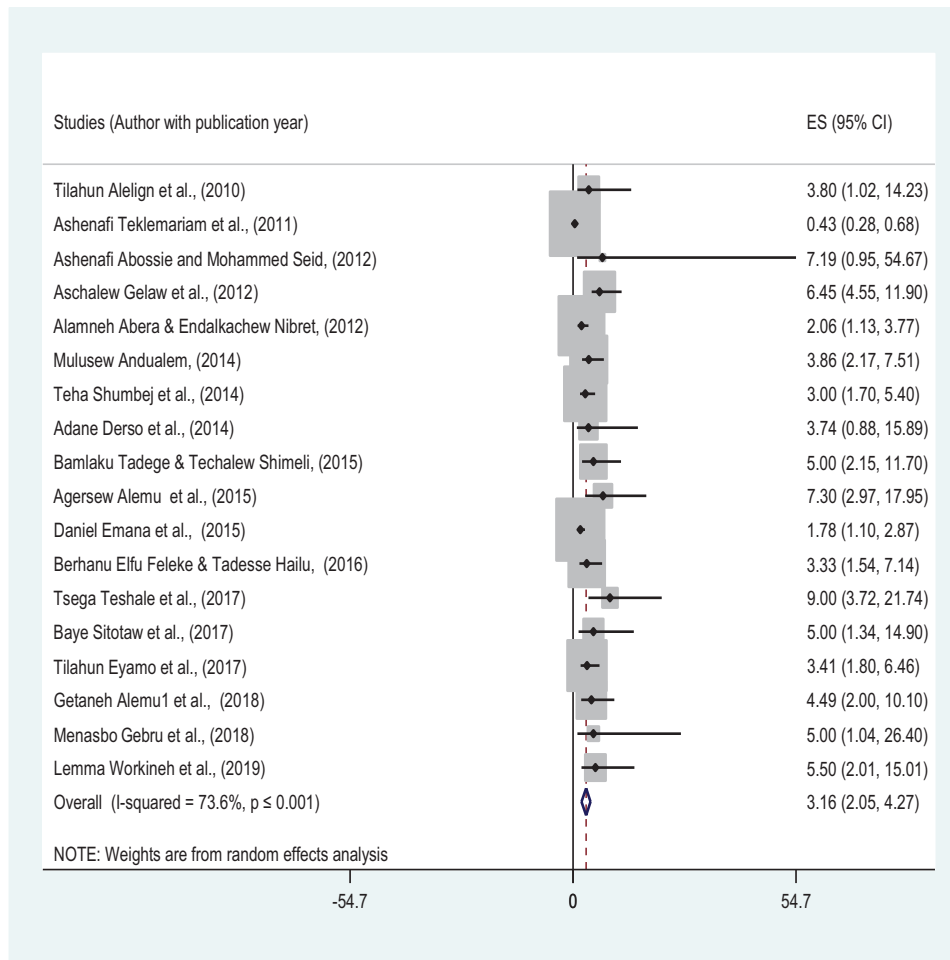


Figure 16. Lack of handwashing habits.

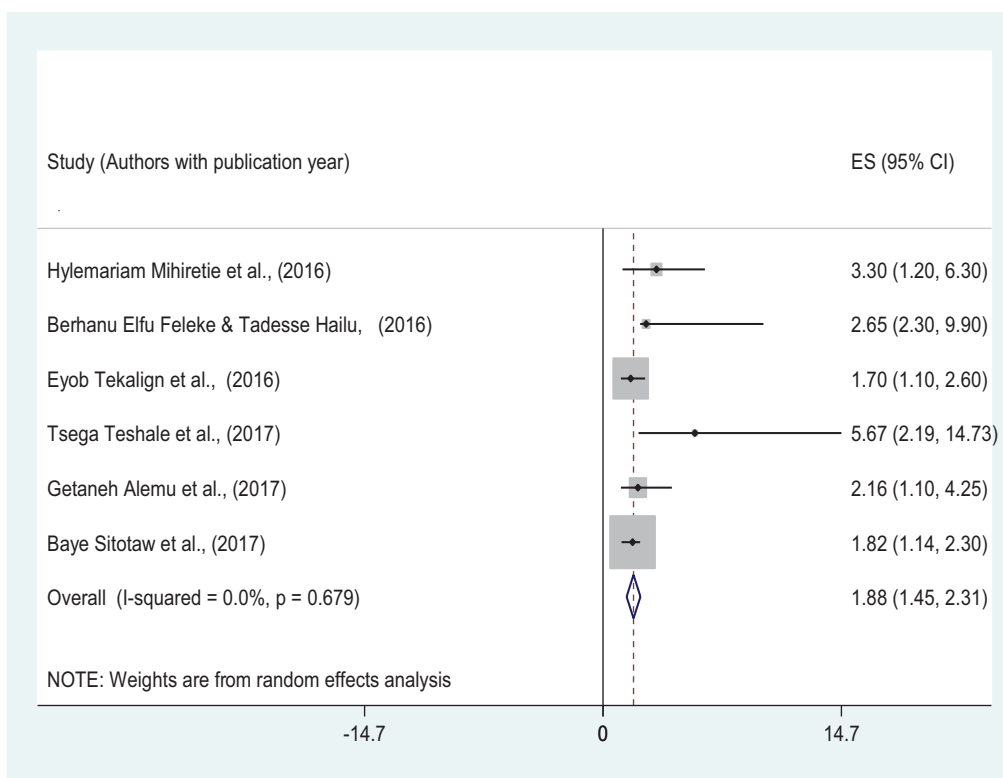


Figure 17. Habits of eating raw, unwashed fruits, and vegetables.

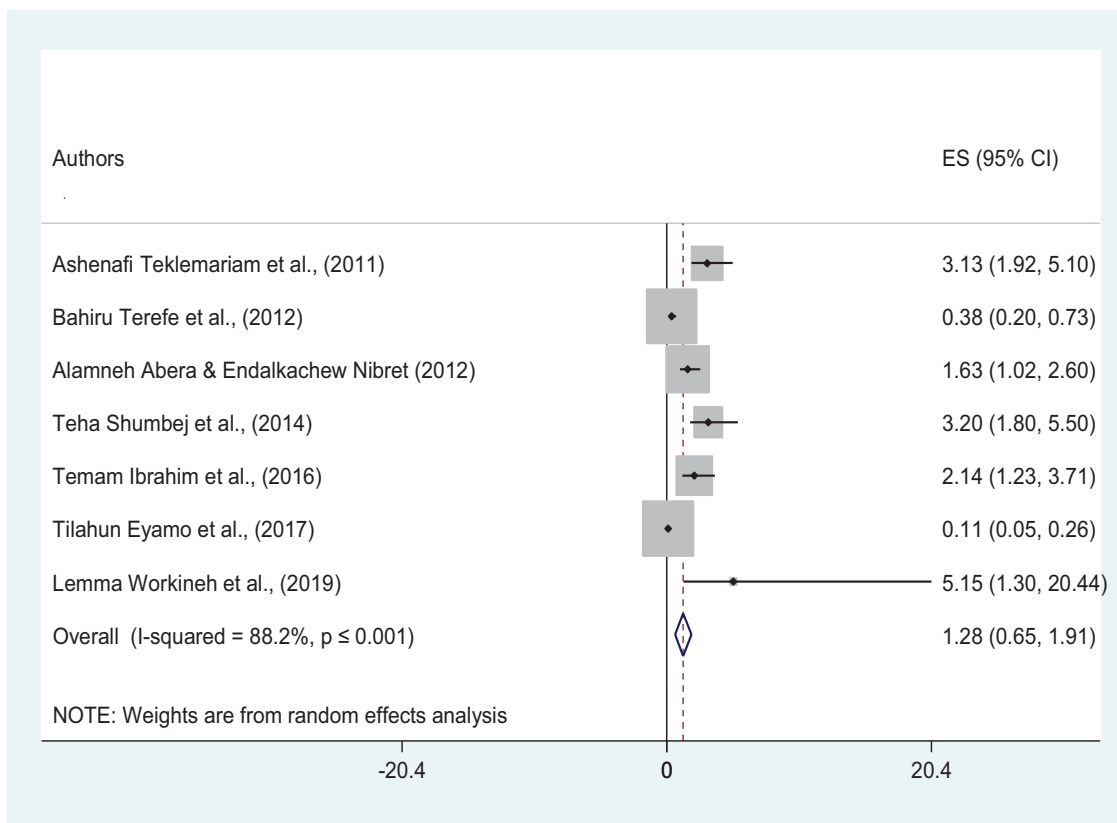


Figure 18. Pooled of untrimmed fingernail.

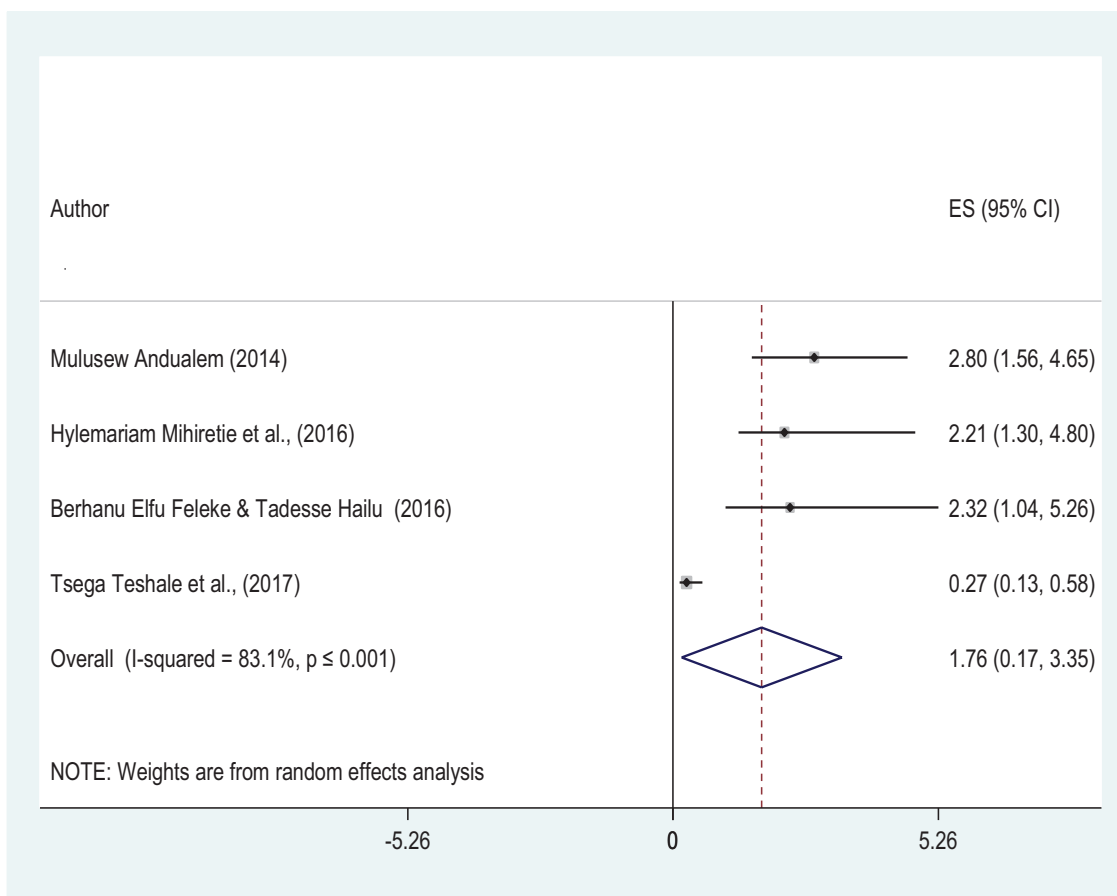


Figure 19. Family education level.

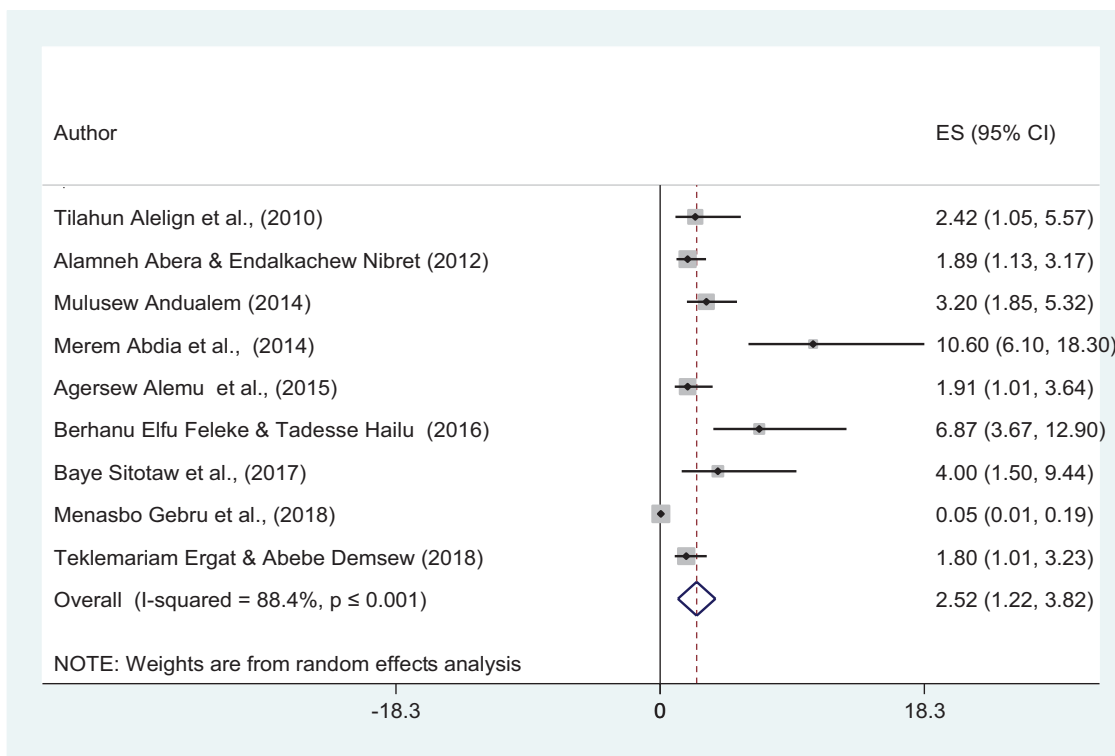


Figure 20. Lack of shoe-wearing habit.

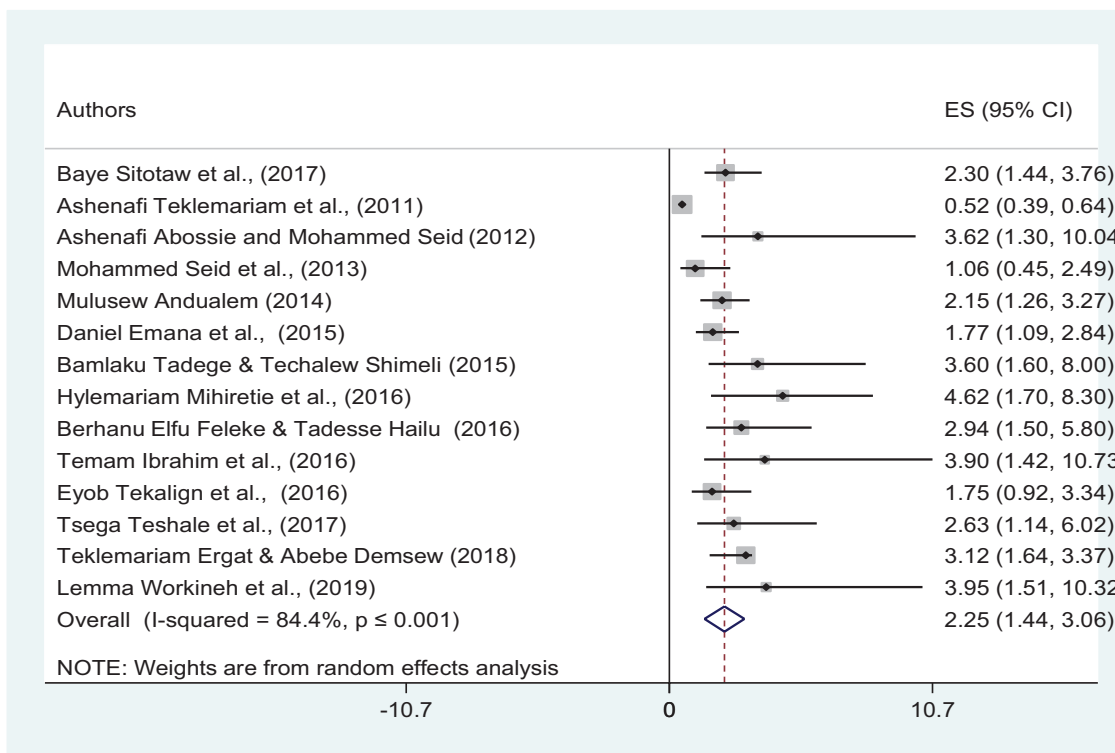


Figure 21. Open field defecation.

pooled results showed that individuals with poor fingernail trimming and cleanness habits were 1.28 times (95% CI: 0.65-1.91) more likely to be infected with STH parasitic infection

than their counterparts. This finding is in agreement with the result in Sekela Primary School, Western Ethiopia,⁵² and the finding in Tilili town.⁵⁷ This is probably due to lack of

awareness, poor hygiene practice, and socio-demographic factors of the people.

The association between family education level and STH parasitic infection in the people of Ethiopia was computed from 4 studies (21, 28, 30, 34). The pooled results showed that uneducated families were 1.76 times (95% CI: 0.17-3.35) more likely to have soil-transmitted helminth parasitic infections than those who were educated. The finding is almost similar to the result in Sekela Primary School, Western Ethiopia,⁵² the finding in Kenya,⁵⁸ and the result in East Wollega.⁵⁹ This might be due to educated family aware their children to practice personal hygiene, not to play with soil, hand washing practice before a meal and after defecation.

The pooled results of 9 studies (3, 8, 17, 21, 23, 28, 35, 38, 39) showed that lack of shoe-wearing habits was strongly associated with STH parasitic infection among people in Ethiopia. In the analysis lack of shoe-wearing habits in the people were 2.52 times (95% CI: 1.22-3.82) more likely to be infected with STH parasitic infections than those who had the habit of wearing a shoe. This finding was similar to the study finding from Sekela Primary School, Western Ethiopia,⁵² and the result in Motta town.⁶⁰ This could be primarily due to poverty, frequent outdoor exposures, and the presence of environmental conditions in the country.¹⁴

Moreover, people who did not have private latrine were 2.25 times (95% CI: 1.44-3.06) more likely to be infected by STH infections when compared to those who possess private latrines (1, 2, 4, 6, 9, 10, 18, 19, 20, 26, 27, 28, 30, 31). This finding was in agreement with findings in Indonesia²³) and the study conducted in South Western Cameroon⁶¹ also showed that open defecation is a risk factor for STH infections. This might be due to the absence of latrines that exposed people to parasites because of the existing improper defecation system.

Limitation of the Study

There are potential limitations to this study. The data were obtained from 5 regions of Ethiopia (Amhara, Harari, Oromia, SNNPR, and Tigray regions) and even small numbers of studies were taken from each region. However, there is a lack of published studies from Afar, Gambela, Benshangul gumuz, and Somali regions which in turn may not fully represent the prevalence of soil-transmitted helminths and associated risk factors in Ethiopia. The other limitation of this study was an inability to directly compare studies due to the differences in diagnostic techniques.

Conclusions and Recommendations

STH infections are greatly prevalent and well distributed across Ethiopia and within the community; hospital and school settings with the highest prevalence reported in community-based studies. *A. lumbricoides* was the most prevalent of the STH species. The Pooled prevalence estimates of STH in Ethiopia were the most prevalent in the study area SNNPR

and from 2013 to 2016. Among associated risk factors, hand washing habit before the meal was 3.16 folds higher among people that didn't have regular hand washing habit. Moreover, People who did not wear shoes always were 2.52 times more likely to be infected with STH than their counterparts. We recommended to the Ethiopian government Community-based strategic drug administration than school-based and its effective implementation is vital to the control of soil-transmitted helminthic infections. Although the infection is common to all age groups, pregnant women and children need special attention. We also recommended that improved personal and environmental sanitation, health education, and good handling of affected individuals are very important for the control of soil-transmitted helminthic infections.

Availability of Data and Materials

The data set in this study is available from the corresponding author on reasonable request.

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