Epidemiology of intestinal parasitic infections in Ethiopian children: A systematic review and meta-analysis

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Research article

**Keywords**: Prevalence, Intestinal parasites, Ethiopia, Meta-analysis

**Posted Date**: October 9th, 2019

**DOI**: https://doi.org/10.21203/rs.2.15732/v1

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**Version of Record**: A version of this preprint was published on January 28th, 2020. See the published version at https://doi.org/10.1186/s12889-020-8222-y.
Abstract

Background: Numerous studies have been carried out on assessing the prevalence of intestinal parasites infections (IPIs) among preschool and school age children in Ethiopia, however, there was no study to gather and systematically analyze this information for policy makers.

Methods: We searched Medline via PubMed, Scopus, Science Direct, Web of Science (ISI), and Google Scholar and local peer-reviewed journals published from inception to 2019 for studies describing prevalence of IPIs among preschool and school age children. We conducted meta-regression to understand the trend and the source of heterogeneity and pooled the prevalence using ‘metaprop’ command using STATA software (Intercooled, version 14, STATA Corp, College Station, TX).

Results: Eighty three (83) studies examining 56,786 fecal specimens were included. The prevalence of IPIs was 48% (95%CI: 42% to 53%) and showed a gradual, but significantly decreasing trends 17% (95% CI: 2.5% to 32%) for each consecutive 6 years) and was similar in males and females. The pooled prevalence in years 1997–2002, 2003–2008, 2009–2014 and >2014 was 71% (95% CI: 57% to 86%), 42% (95% CI: 27% to 56%), 48% (95% CI: 40% to 56%) and 42% (95% CI: 34% to 49%), respectively. Poly-parasitism was observed in 16% (95% CI: 13% to 19 %,) of children while, single parasite infection was observed in 36% (95% CI: 30% to 41%).

Conclusion: IPIs are highly prevalent and well distributed across the regional states of Ethiopia. Southern and Amhara regional states carry the highest burden. We observed a gradual, but significant decreasing trends in prevalence of IPIs among Ethiopian children over the last two decades.

Background

Parasitic infections caused by intestinal helminthes and protozoan are among the most prevalent infections in developing countries and carrying high burden of morbidity and mortality in these areas [1]. Specifically, economically disadvantaged children living in tropical and sub-tropical regions with a limited or no access to safe drinking water, inadequate sanitation, and substandard housing are the most affected ones [2]. Epidemiological evidence suggests that an estimated 3.5 billion people in the world, majorly children were infected with intestinal parasites caused by helminthes and protozoa [3]. Majority of the infections were due to Ascariasis, hookworm, and Trichiuriasis [4, 5]. More than 267 million preschool-age children and 568 million school-age children live in areas where these parasites are intensively transmitted [6]. Cryptosporidium species, Entamoeba histolytica and Giardia duodenalis were the most common protozoan infections in children under five years in sub-Saharan Africa [7].

The regional distribution and prevalence differences of IPIs among children are mainly due to differences in degree of fecal contamination of water and food, climatic, environmental and socio-culture [8–10]. The prevalence among under-five, preschool and school children were reported as 17.7% in Riyadh, Saudi Arabia[11], 52.8% in an urban slum of Karachi, Pakistan [12], 19.6% in Zambia [13] and 30% in Khartoum, Sudan [13]. In Ethiopia, prevalence varies across the regions in the country. For instance, the prevalence was 85.1% in Wondo Genet (Southern region) [14], 48.1% in Aynalem village (Tigray region) [15], 17.4% in Debre Birhan (Amhara region) [16], 26.6% in Hawassa (Southern region) [17], 24.3% in Wonji Shoa Sugar Estate (Oromia region) [18], 18.7% in Woreta (Amhara region) [19], 25.6% in Dembiya (Amhara region) [20] and 41.1% in Jimma town (Oromia region) [21].
School age children the most affected ones due to their dirty habits of playing or handling of infested soils, eating with soiled hands, unhygienic toilet practices, drinking and eating of contaminated water and food [22]. IPIs lead to malnutrition, mal-absorption, anemia, intestinal obstruction, mental and physical growth retardation, diarrhea, impaired work capacity, and reduced growth rate constituting important health and social problems [10, 18, 23, 24].

Numerous epidemiological studies have been performed on assessing the prevalence of intestinal parasite infections (IPIs) among children in Ethiopia, but there is lack of systematically gathered and analyzed information for policy makers. Therefore, the aim of this study was to provide a summary on prevalence, geographical distribution and trends of IPIs among preschool and school age children to forward possible recommendations for the policy makers to design new control, diagnosis and treatment strategies.

**Methods**

*Search strategy and data extraction*

We searched Medline via PubMed, Scopus, Science Direct, Web of Science and Google Scholar using searching terms “prevalence” OR “incidence” AND “intestinal parasite” OR “helminthes” OR “protozoa” AND “Ethiopia”. Searching was carried out on articles published from inception to 2019 and limited to English language and human studies. A manual search for additional relevant studies using references from retrieved articles and related systematic reviews was also performed to identify original articles we might have missed. Conference abstracts and unpublished studies were excluded. We did our analyses according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [25] and guided by PRISMA checklists [Additional file 1]

*Participants, inclusion and exclusion criteria*

Two authors independently (LCH&DE) assessed the inclusion criteria and disagreement was solved by discussion. We included the studies if they met the following criteria: the study design was an observational study (prospective cohort, case-control, retrospective cohort, or cross-sectional) or controlled clinical trial of which documented the baseline prevalence or incidence of IPIs. We exclude studies reporting case reports, case series, studies that compared the sensitivity and specificity of different methods used for diagnosis of intestinal parasites and studies not reported either prevalence or incidence of IPIs as outcome of interest. We included all studies reported the prevalence or incidence of IPIs in preschool and/or school age children or both. The terms preschool and school age children were defined according to the original studies. Accordingly, preschool age children were defined as children of age below 5 years while, school age children were children of age 5 and above. Poly-parasitism was defined as concurrent infection with different species of intestinal parasites either helminthes or protozoa.

*Data extraction and Quality assessment*

The two authors (LCH and DE) defined protocol for data extraction and assessed them independent for eligibility and disagreements were resolved by discussion. We extracted information on name of the first author and year of publication, study design, population studied (preschool age children, school age children or both), gender, region & sites of study, Method(s) for identification of the parasites, total sample size and the number of the
positives (percentage). The Grading of Recommendation Assessment, development and Evaluation (GRADE) approach was used to assess the overall quality of evidence [26]. Accordingly, studies were given one point each if they had probability sampling, larger sample sizes of more than 200, and repeated detection. Publications with a total score of 3–4 points were considered as high quality, whereas 2 points represented moderate quality and scores of 0–1 represented low quality.

**Statistical analysis**

We used forest plots to estimate pooled effect size and effect of each study with their confidence interval (CI) to provide a visual summary of the data. A random-effects model was used in this meta-analysis because of anticipated heterogeneity. All reported P values were 2-sided and were statistical significant if P < 0.05. Statistical heterogeneity among studies was assessed as the P value (Cochran's Q statistic), where a P < 0.05 and I² ≤ of 25–50% were considered as low heterogeneity and I²>50% indicated substantial heterogeneity. We also used Begg's Funnel plot and Egger's regression test for evaluating the possibility of publication bias. A potential source of heterogeneity was investigated by subgroup and meta-regression analysis. The factors included were geographical regions and cities of Ethiopia, age of children (Preschool vs. school age children), and years of publication (1997–2002, 2003–2008, 2009–2014 and > 2014). We conducted meta-analysis using ‘metaprop’ command using STATA software, version 14, STATA Corp, College Station, TX.

**Results**

**Literature searches and selection**

We identified systematically 1,198 publications, of which 83 were eligible for inclusion in the final analyses. The details of our search strategy were depicted in Figure 1. Our initial research of electronic databases such as Medline via PubMed, Scopus, Science direct, Web of Sciences and Google scholar yielded 1195 articles and 3 articles manually from which 186 records remained after removing 1012 duplications. Up on screening the articles, 99 articles were further excluded; 90 were irrelevant because they were not specifically about preschool or school age children, 6 studies were about sensitivity and specificity of diagnosis of IPIs, 3 articles were review articles. Up on further access to the full texts of 87 articles, 4 were excluded for the following reasons; 2 were meta-analyses and 2 articles lacked outcome of interest. Finally, 83 published between 1997 and 2019 fulfilling the inclusion criteria were included in the final analyses.

The sample size of the included trials ranged from 100 [27] to 15455[28] with a total number of 56,786 participants [14, 16, 17, 21, 24, 27–40, 42–44, 46–63, 65–91, 93–107]. Most of the studies were reported from Amhara regional 33(40%) followed by Oromia region 21(25%). The rests were reported from South region 18(22%), Tigray region 9(11%), Benishangul-Gumuz region 1(1%) and Addis Ababa city 1(1%). With regard to the study design, majority of the studies were cross sectional in design (79 studies), 2 were controlled clinical trials, 2 were prospective follow up cohort studies and 1 was case-control. Sixty six studies were about IPIs in school age children, 13 were in preschool age children (under-five) and 4 were studies involved both preschool and school age children. According to our quality assessment criteria, 34 publications were of high quality with a score of 3, 12 had a score of 2 indicating moderate quality and the remaining 37 were of low quality with a score of zero or one [Table1 at the end of manuscript on page 26–31].

**Prevalence estimate and heterogeneity analysis**
A range of parasites were detected in the studies including *Ascaris lumbricoides*, *Hookworm*, *Trichuris trichiuria*, *Strongyloides stercoralis*, *Enterobius vermicularis*, *Schistosoma mansoni*, *Hymenolepsis nana*, *Taenia species*, *Giardia lamblia/intestinalis/duodenalis*, *Entamoeba histolytica/dispar* and *Cryptosporidium species*. A total of 27,354 of the 56,786 children examined during the period under review were infected with one or more species of intestinal parasites yielding an overall prevalence of 48% (95% CI: 42% to 53%) with substantial heterogeneity ($I^2 = 99.50\%$, regression coefficient: $-0.23$, 95% CI: $-0.38$ to $-0.09$, $p = 0.002$, Fig. 2). Subgroup analysis showed that the prevalence of IPIs was 56% (95% CI: 39% to 73%) in Southern region, 51% (95% CI: 43% to 58%) in Amhara region, 40% (95% CI: 31% to 50%) in Oromia region, 31% (95% CI: 27% to 35%) in Benishangul-Gumuz region, 41% (95% CI: 28% to 54%) in Tigray region and 23% (95% CI: 19% to 28%) in Addis Ababa city Fig. 3 and 4. The age related prevalence was 52% (95% CI: 46% to 58%) in school age children and 30% (95% CI: 18% to 34%) preschool age children ($p = 0.002$) as shown in Fig. 5.

The pooled prevalence of IPIs in year 1997–2002, 2003–2008, 2009–2014 and >2014 was 71% (95% CI: 57% to 86%), 42% (95% CI: 27% to 56%), 48% (95% CI: 40% to 56%) and 42% (95% CI: 34% to 49%), respectively [Fig. 6]. We did meta-regression analyses to search for the sources of heterogeneity. The results of the analyses showed that age (regression coefficient: 0.38, 95% CI: 0.15 to 0.60, $p = 0.002$) and year of publication (regression coefficient: $-0.17$, 95% CI: $-0.32$ to $-0.02$, $p = 0.023$) might be sources of heterogeneity, whereas we detected no significance difference in geographical distribution (regression coefficient: 0.025, 95% CI: $-0.11$ to 0.06, $p = 0.56$) as shown Fig. 7.

**Prevalence of IPIs by area of residence, gender and poly-parasitism status**

Thirteen studies (N = 12,356) reported the proportion of IPIs based on residence area. The pooled prevalence of overall IPI was not significantly differ between rural and urban areas; rural 22% (95% CI: 10% to 30%, Additional file 2) and urban 23% (95% CI: 14% to 32%, Additional file 3). Forty two studies (N = 36,218) had separate data on the prevalence of IPIs for males and females. The pooled prevalence for males was 24% (95% CI: 20% to 28%, Additional file 4) while, it was 22% (95% CI: 18% to 25%, Additional file 5) for females. Poly-parasitism was observed in 16% (95% CI: 13% to 19%, Additional file 6) of children and 36% (95% CI: 30% to 41%, Additional file 7) of children were infected with a single species of parasite.

**Discussion**

The essence of current systematic review and meta-analysis of IPIs data analysis among Ethiopian children was to support the efforts undertaken to control and eliminate neglected tropical diseases by nurturing or supplementing useful national epidemiological data. We hope that the findings of current study provide valuable information to the policy makers, National Health Bureau and other concerned bodies about national and regional distribution and their prevalence in Ethiopia. The pooled prevalence of IPIs in Ethiopian children was 48% (95% CI: 42 to 53%). The prevalence is higher in Southern (56%) and Amhara regions (51%) and lower in Addis Ababa city (23%). We observed a significant decrease in the prevalence of IPIs among children in Ethiopia over the last two decades (22 years). The burden of infection was higher among school age children compared to preschool age children (52% vs.30%, $p = 0.002$), however, it was similar in males and females as well as in urban and rural inhabitants. Poly-parasitism was observed in around 16% of children while, single infection was documented in 36% of the children participated in the study.
The overall pooled prevalence estimate (48%) observed in the present study is almost similar to the study from Nigeria (54.8%) [109], 50.5% Rwanda [110], 47.6% Afghanistan [111], 42.5% Syria [112] and 40.5% in Palestine [113]. However, the study is higher than 24.1% in Cameroon [114], 25.4% in Rwanda [115], in Iran 38% [116], 31.7%–37.2% in Turkey [117] and 26.5% in Egypt [118]. The difference might be attributed to socio-economic status, poor hygiene and sanitary facilities, weather, climate and environmental factors. For example, a study in Ethiopia showed that *Ascaris* infections were more common in children living in households with lower incomes (prevalence ratio = 6.68, 95% CI = 1.01–44.34) and that *Giardia* infections were more common in children living in households that used an unprotected water source (prevalence ratio = 1.95, 95% CI = 0.96–3.99) [32]. In addition, most Ethiopian communities have developed the habit of consuming uncooked meat, which might increase the risk of exposure to human helminthes. Many of population of Ethiopian where the studies were conducted involved in irrigation activities for the cultivation of vegetables during the dry season. This irrigation canals create media for the reproduction of vector snails, which might be the cause of the appearance of endemicity of Trematodes infections in the area. It might also be attributed to the specificity and sensitivity of the diagnostic methods employed by the individual studies.

The meta-regression of prevalence of IPIs over time showed significant decreasing trends in each 6-years block by 17% (95% CI: 2.5% to 32%) and this declined prevalence was probably due to socioeconomic development, improvement in sanitation and large-scale deworming programs. Many studies from around the world have reported a significant decreasing trend in the prevalence of overall IPIs in recent years, such as the global burden of disease study [5], study from Burkina Faso [119], Nepal [120], Brazil [121] and other from 43 Sub-Saharan [122]. Despite many initiatives and efforts to introduce mass deworming program and improvement in water quality and sanitation, IPIs are still prevalent and the decrease in trend is less than that of other countries (Ethiopia 42% in 2016–2019 vs. Nepal 20. 4% in 211–2015 and Brazil 23.8% in 2010–2011). This might be possibly due insufficient financial supports in implementation of the strategies that have been known to reduce the infection such as access to safe water supply, personal hygiene and sanitation, deworming and public health awareness. The funding supports so far in Ethiopia were from non-governmental organizations (NOGs) targeting research and short-term objectives and therefore, lacked sustainability. Once the project was finalized and left the country, reinfection would be possible. In addition, lack of political commitment, social and environmental factors might also contribute for the higher prevalence of IPIs in the country. Inadequate community involvement and ownership of control activities are also another possible reason.

The prevalence of IPIs in school age children was (52%), which was significantly higher than in preschool age children (30%). This is similar to the study by Jayarani 2014 [123] and Workneh 2014 [45], but opposite to the study by Daryani 2017 [116]. School children carry the heaviest burden of the intestinal parasite associated morbidity due to their dirty habits of playing or handling of contaminated soils, eating with soiled hands, unhygienic toilet practices, drinking and eating of contaminated water and food [22] compared to preschool children who usually cared by families. The current control efforts in Ethiopia usually target school aged children, but a significant proportion of preschool age children (30% in this study) were also infected and can be source for the re-infection of treated school aged children. Therefore, it worthy revising the national control program based on regional and national prevalence which included preschool children and other population at risk.

In the present study, the prevalence of IPIs in females (22%) was similar to males (24%), which is similar to the study by Gelaw 2013 [47], but in contrast to study by Daryani 2017 [116] in Iran. In Iran, report indicated that more
females have (30.9%) have IPIs than males (16.5%). The difference might be due to cultural and behavioral difference between the two countries.

The distribution of IPIs in this study was relatively similar in both urban and rural areas. This might be due to absence of proper human waste disposal systems, the shortage of safe water supply, the social and poor environmental or personal hygiene in many unplanned urban areas in Ethiopia in addition to similarity of eating habit and life style of both urban and rural areas of the country. So far, reports from Africa and South Asia countries are conflicting. Some were reported higher infection rates of IPIs in rural areas compared to urban areas [124–128] and others reported higher rate of infections in urban children [129]. In fact, comparable data on IPIs in urban and rural settings are very limited. For instance, only 13 studies out of 83 studies included in this meta-analysis were reported prevalence of IPIs in both urban and rural areas and therefore, indicating more work to be done in the future to resolve this issue.

We estimated the geographical distribution and identified high risk areas that should be prioritized for mass drug administration (MDA) and other control interventions, which complement global efforts towards elimination of IPIs infections by 2020. In addition, this work also highlighted the need for survey in areas where data are not available such as Somalia region, Afar region, Harari, Dire Dawa city and Gambella region or scarce (Addis Ababa city and Benishangul-Gumuz region).

There are a few limitations of the present meta-analysis, which may affect the results. It is prudent to interpret the results of this study as 37(44.6%) of the included studies were low quality based on our quality assessment criteria. In all of studies included in this review, single stool sample examination were used despite multiple stool samples recommendation for standard diagnosis and therefore, possible underestimation of the prevalence. There is also substantial heterogeneity observed between the studies that affect the interpretation of the results. However, we did meta-regression analyses on various sources including geographical distribution, age category and year of publication. These might come from age category (P = 0.002) and year of publication (P = 0.023) but not from geographic distribution (p = 0.56).

Conclusions

IPIs are highly prevalent and well distributed across the regional states of Ethiopia. Southern and Amhara regional states carry the highest burden. Although school age children have higher prevalence of IPIs compared to preschool children, the prevalence is still unacceptably higher among preschool children. We observed a gradual, but significant decrease in prevalence of IPIs among Ethiopian children in the last two decades with no significant difference between males and females. The prevalence in the most recent six years was around 42% compared to 71% in the late 1990s. Place of residence has no effect on the burden of IPIs among Ethiopian children. About 16% of the children had concurrent poly-parasitism infections.

Abbreviations

IPIs, Intestinal parasite infections; MDA, mass drug administration; NGOs, non-governmental organizations; GRADE, Grading of Recommendations Assessment, Development and Evaluation; CI, confidence interval; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; STHs, soil-transmitted helminthes.
Declarations

Ethics approval and consent to participate: None applicable

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request

Competing interests: The authors declare that they have no competing interests.

Funding: we did not receive any funding support for this work

Authors’ contributions: LCH and ZM conceived the study. LCH and YA extracted the data, and independently decided for inclusion or exclusion, and in events of disagreement, ZM helped to resolve. LCH and DE performed all the statistical analyses. LCH and YA prepared manuscript with the help from DE. All authors read and approved the final manuscript.

Acknowledgements: We thank Dr. Kefiyalew Getahun for his contribution in constructing geographical map of Ethiopia

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Tables

Table 1 Characteristics of the 83 eligible studies of intestinal parasite infections in Ethiopia
| No. | Study design | Population | Male | Female | Study site(s)Region | Methods | No. sample | No. positive (%) | Quality assessment |
|-----|--------------|------------|------|--------|---------------------|---------|------------|------------------|-------------------|
| rege [40] | Cross-sectional | School children | 187 | 216 | Tikur Wuha, Gojam, Amhara region | Kato-Katz | 403 | 235 (58.3%) | 2 |
| 2017 | Cross-sectional | School children | 207 | 201 | Zegie Peninsula, Gojam, Amhara region | Formalin-ether | 408 | 282 (69.1%) | 3 |
| a [79] | Cross-sectional | School children | 193 | 192 | Bahir Dar, Amhara region | Formal-ether | 385 | 170 (44.2 %) | 3 |
| yehu [53] | Cross-sectional | School children | 191 | 193 | Girar Jarso and Dera, North Shewa, Oromia Region | Direct and formalin-ether and modified Ziehl-Neelsen | 384 | 81 (21.1%) | 2 |
| e [35] | Cross-sectional | School children | 218 | 187 | Gondar town, Amhara region | Direct, formal-ether and Kato-Katz | 405 | 92 (22.7 %) | 3 |
| v [47] | Cross-sectional | School children | 170 | 134 | University of Gondar Community School, Amhara region | Direct and formalin-ether | 304 | 104 (34.2%) | 3 |
| ñie [81] | Cross-sectional | School children | 191 | 209 | Gamo Gofa Zone, South region | Direct and formol-ether | 400 | 324 (81.0%) | 3 |
| ñwos [59] | Cross-sectional | School children | 139 | 122 | Gorgora and Chuahit towns, Gondar, Amhara region | Direct, formal-ether and Kato-Katz | 261 | 174 (66.7%) | 2 |
| ñ [20] | Cross-sectional | Preschool children | 106 | 119 | Dembiya, Gondar Zone, Amhara region | Direct and formalin-ether and modified Ziehl-Neelsen | 225 | 58 (25.8%) | 3 |
| yehuet [80] | Cross-sectional | Both | 154 | 132 | Holetta, Sendafa and Chancho, Oromia region | PCR | 312 | 48 (16.8%) | 2 |
| n [77] | Cross-sectional | School children | 187 | 216 | Tikur Wuha Elementary School, Amhara region | formol-ether and Kato-Katz | 403 | 235 (58.3%) | 3 |
| gebriel [82] | Cross-sectional | School children | 177 | 182 | Dona Berber, Bahir Dar, Amhara region | Formal-ether | 359 | 235 (65.5%) | 3 |
| å [83] | Cross-sectional | School children | 196 | 195 | Arbaminch Zuria, South region | Formal-ether | 391 | 182 (46.5%) | 2 |
| å [85] | Cross-sectional | School children | 180 | 171 | Birbir town, Gamo Gofa, South region | Direct and formalin-ether | 351 | 95 (27.1%) | 3 |
| nnen [19] | Cross-sectional | Preschool children | 152 | 158 | Woreta health center, Gondar, Amhara region | Direct and Kato-Katz | 310 | 58 (18.70%) | 3 |
| [42] | Cross-sectional | School children | 228 | 232 | Mizon-Aman town Bench Maji, South region | Direct and formalin-ether and Kato-Katz | 460 | 353 (76.7 %) | 3 |
| å [84] | Cross-sectional | Preschool children | 183 | 218 | Dembiya District, Gondar, Amhara region | Kato-Katz | 401 | 141 (35.2 %) | 3 |
| ayehu | Cross-sectional | School | 287 | 216 | Wolaita Zone, Kato-Katz and | 503 | 363 (72.2%) | 3 |
| Study/Region | Type | Participants | Positive | Percentage | Percent Positive | Reference |
|--------------|------|--------------|----------|------------|-----------------|-----------|
| South region | Cross-sectional | School children | 255 | 295 | 365(66.4%) | [60] |
| Jimma town, Oromia region | Cross-sectional | School children | 238 | 262 | Kato-Katz | [86] |
| Rural area of Bahir Dar, Amhara region | Cross-sectional | School children | 225 | 171 | Formol ether | [87] |
| Ten zones of the Amhara region | Cross-sectional | School children | 7418 | 8037 | Formol ether | [28] |
| Debre Birhan hospital, North Shewa, Amhara region | Cross-sectional | School children | 238 | 262 | Jimma, Oromia region | [28] |
| Rural area of Gomma, Jimma, Oromia region | Cross-sectional | Preschool children | 118 | 118 | Kato-Katz | [16] |
| Debre Birhan hospital, North Shewa, Amhara region | Cross-sectional | Preschool children | 133 | 99 | Direct and the formol-ether | [88] |
| Adare Hospital and Millennium Health Centre, Hawassa, South region | Cross-sectional | Preschool children | 81 | 77 | Kato-Katz and formol-ether | [17] |
| Guma and YachiYisa in Gomma, Jimma, Oromia region | Cross-sectional | School children | 172 | 145 | University of Gondar and formol-ether | [89] |
| Khasay Abera Humera hospitals, Amhara region | Cross-sectional | Preschool children | 85 | 37 | Direct, formol-ether and Kato-Katz | [90] |
| Pawe Town, Benishangul-Gumuz | Cross-sectional | School children | 194 | 228 | Direct | [91] |
| Lake Tana Basin, Amhara region | Cross-sectional | School children | 361 | 159 | Region | [32] |
| GonchaSisoEnese, Gojam, Amhara region | Cross-sectional | Preschool children | NA | NA | Formol-ether | [69] |
| Jimma town, Jimma, Oromia | Cross-sectional | School children | 271 | 315 | Direct and formol-ether | [31] |
| Wonji Shoa Sugar, Oromia region | Cross-sectional | Preschool children | 195 | 179 | Kato-Katz | [492] |
| 53 schools of Amhara region | Cross-sectional | School children | NA | NA | Kato-Katz | [93] |
| South Gondar, Amhara region | Cross-sectional | Both | 1130 | 1228 | Formol-ether | [43] |
| [94]  | Clinical trial | School children | NA | NA | 14 schools of Jimma town, Oromia region | Kato-Katz | 840 | 437 (52%) | 3 |
| [49]  | Clinical trial | School children | 152 | 217 | Mekele University, Tigray region | Direct, formal-ether and Kato-Katz | 369 | 267 (73%) | 3 |
| [50]  | Cross-sectional | School children | 288 | 312 | Mekele, Tigray | Direct, formal-ether and Kato-Katz | 600 | 421 (72%) | 3 |
| [75]  | Cross-sectional | School children | 282 | 433 | Mendera, Jimma, Oromia region | McMaster | 715 | 346 (48.4%) | 2 |
| [95]  | Cross-sectional | School children | 364 | 280 | Babble town, Harrerge, Oromia region | McMaster | 644 | 89 (13.8%) | 2 |
| [24]  | Cross-sectional | School children | 341 | 323 | Angolela Woreda, Amhara region | Formol-ether | 664 | 202 (30.4%) | 3 |
| [96]  | Cross-sectional | School children | 186 | 223 | Bahir Dar, Amhara region | Formol-ether | 409 | 237 (58%) | 2 |
| [21]  | Cross-sectional | School children | 114 | 146 | Jimma Health Center, Jimma, Oromia region | Direct and formol-ether | 260 | 129 (49.6%) | 3 |
| [34]  | Cross-sectional | School children | 157 | 162 | Zarima town, Gonder, Amhara region | Direct and Kato-Katz | 319 | 263 (82.4%) | 2 |
| [97]  | Cross-sectional | School children | 201 | 183 | Demba Girara, Wolaita, South region | Direct and Kato-Katz | 384 | 328 (85.4%) | 1 |
| [98]  | Cross-sectional | School children | 161 | 121 | Asendabo Town, Jimma, Oromia region | Direct and Kato-thick | 282 | 243 (86.2%) | 0 |
| [71]  | Cross-sectional | School children | 251 | 241 | Birbir, Bale Zone, Oromia region | Direct and formol-ether | 492 | 131 (26.6%) | 0 |
| [76]  | Cross-sectional | School children | 189 | 217 | Gedeo, Wolaita and Kambata and Amaro, South region | Direct | 406 | 170 (41.9%) | 0 |
| [55]  | Follow up cohort | Preschool children | NA | NA | Butajira town, South region | Formol-ether | 905 | 44 (4.9%) | 3 |
| [44]  | Cross-sectional | School children | 172 | 168 | Delo-Mena, Bale Zone, Oromia region | Direct and formol-ether | 340 | 89 (26.2%) | 1 |
| [46]  | Cross-sectional | School children | NA | NA | Boloso Sorie, South region | Formol-ether | 421 | 292 (69.4%) | 1 |
| [39]  | Cross-sectional | School children | 271 | 144 | Babile town, Harrerge, Oromia region | Formal ether | 415 | 113 (27.2%) | 0 |
| [54]  | Cross-sectional | Preschool children | 149 | 147 | Police hospital, Armed Forces General hospital, and Tikur Anbessa Hospital, Addis Ababa | Direct, formol-ether and Modified Ziehl-Neelsen | 296 | 69 (23.3%) | 0 |
| [99]  | Cross-sectional | School children | 439 | 439 | Gonder town, Gonder, Amhara region | Kato-Katz | 878 | 437 (49.7%) | 0 |
| [62]  | Cross-sectional | School children | 1012 | 998 | Central Tigray, Tigray region | Direct | 2000 | 571 (28.6%) | 0 |
| [72]  | Cross-sectional | School children | 319 | 303 | Tigray, Tigray region | Kato-Katz | 622 | 165 (26.5%) | 0 |
| Study | Design | Group | Sample Size | Positive | Prevalence | n |
|-------|--------|-------|-------------|----------|------------|---|
| tekyi [14] | Cross sectional | Preschool children | 140 | 288 | 245 (85.1%) | 1 |
| see [58] | Cross sectional | School children | 167 | 381 | 263 (69%) | 0 |
| eb [67] | Cross sectional | School children | 218 | 419 | 282 (67.3%) | 1 |
| a [61] | Cross sectional | School children | 267 | 457 | 109 (23.9%) | 0 |
| lke [100] | Cross sectional | School children | 161 | 366 | 166 (45.4%) | 1 |
| ie [101] | Cross sectional | School children | 481 | 800 | 285 (35.6%) | 0 |
| lu [27] | Cross sectional | School children | 63 | 100 | 66 (66%) | 0 |
| almak [33] | Cross sectional | Preschool children | 487 | 924 | 530 (57.4%) | 1 |
| teh [48] | Cross sectional | School children | 282 | 687 | 470 (68.4%) | 1 |
| [74] | Case-control | Both | 135 | 230 | 74 (32.2%) | 1 |
| [68] | Cross sectional | School children | 206 | 402 | 219 (54.5%) | 1 |
| miamir [73] | Cross sectional | School children | 252 | 480 | 199 (41.5%) | 0 |
| w [36] | Cross sectional | School children | 358 | 704 | 562 (79.8%) | 2 |
| l [38] | Cross sectional | School children | 479 | 150 | 139 (92.7%) | 0 |
| a [30] | Cross sectional | School children | 479 | 698 | 304 (43.3%) | 0 |
| [52] | Cross sectional | School children | 352 | 520 | 465 (89.4%) | 1 |
| i [102] | Cross sectional | School children | 397 | 772 | 401 (51.5%) | 3 |
| ie [57] | Cross sectional | School children | 177 | 384 | 233 (60.7%) | 0 |
| r [29] | Cross sectional | School children | 192 | 399 | 311 (77.9%) | 0 |
| a [103] | Cross sectional | Preschool children | NA | 587 | 301 (51.3%) | 1 |
| dbej | Cross Preschool | 165 | 377 | 104 (27.6%) | 3 |
| Sectional | Cross sectional | School children | Region | Method | Prevalence | Comments |
|-----------|----------------|----------------|--------|--------|------------|----------|
| [104]     |                | Finchawa and Tullo, South region | Formol-ether | 374 | 254(67.9%) | 3 |
| alem [106]| Cross sectional | Motta, Gojam, Amhara region | Direct and formal-ether | 358 | 245(68.4%) | 0 |
| [105]     |                | Adama town, Oromia region | Kato-Katz | 358 | 127 (35.5%) | 1 |
| el [108]  | Cross sectional | Ambo town, Oromia region | Formol-ether | 375 | 47(12.6%) | 3 |
| de [107]  | Cross sectional | Medebay Zana, Tiray region | Kato-Katz | 410 | 52(12.7%) | 1 |
| te [66]   | Cross sectional | Gorgora, Amhara region | Kato-Katz | 326 | 110(36.8%) | 2 |

Abbreviations: NA, not available; PCR, Polymerase chain reaction

**Figures**
Figure 1

Flow diagram showing the selection process
Figure 2

Begg's funnel plot and Egger test for heterogeneity of intestinal parasite infections among Ethiopian children
Figure 3

Regional distribution of intestinal parasite infections in Ethiopian children from 1997-2019
Figure 4

Forest plot showing the geographic distribution of intestinal parasite infections in Ethiopia Children
Figure 5

Forest plot showing age related distribution of intestinal parasite infections in Ethiopia children
Figure 6
Forest plot showing trend of intestinal parasite infections in Ethiopia children
Figure 7

Meta regression result of A. the geographic distribution B. the distribution by age C. distribution by year of publication of Intestinal parasite infections among Ethiopian children

Supplementary Files

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